CDC 2M051A

Missile and Space Systems Electronic Maintenance Journeyman

Volume 2. Spacelift Orientation and Maintenance Fundamentals

Air Force Career Development Academy

Air University

Air Education and Training Command

2M051A 02 1904, Edit Code 06

AFSC 2M051A

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The career development course (CDC) you are about to begin will help you obtain knowledge required for upgrade and promotion. This is a self-study course that the Air Force intends for you to complete during your off-duty time. Satisfactory completion of this course satisfies the knowledge portion of the Air Force's dual channel, enlisted specialty-training program and is a prerequisite for upgrading to the 5-skill level.

Unit one provides an introduction into Spacelift, including the organizations, launch vehicles, and the infrastructure for those launch vehicles. This unit will explain some common spacecraft characteristics. While not necessarily part of Spacelift, this unit will give you a basic understanding of the Air Force Research Laboratory (AFRL) and Air Force Operational Test and Evaluation Center (AFOTEC).

Unit two describes publications used in the career field. We will look at standard publications, how to identify and find them. We will examine current technical orders, along with procedures on how to correct mistakes in them. Additionally, you will learn about our maintenance information systems and how to correct supply deficiencies.

Unit three presents some maintenance fundamentals. You will learn electrostatic discharge procedures, fault isolation using the technical order, general electrical principals and how hydraulic and pneumatics systems function.

Finally, unit four will provide information on the support base electronic test benches used in the electronics laboratory and the coding equipment in the codes vault. These are two sections you may have the opportunity to work in.

A glossary is included for your use.

Code numbers on figures are for preparing agency identification only.

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To get a response to your questions concerning subject matter in this course, or to point out technical errors in the text, unit review exercises, or course examination, call or write the author using the contact information provided in this volume.

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For Guard and Reserve personnel, this volume is valued at 20 hours and 5 points.

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.

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Please read the unit menu for unit 1 and continue ➔

Unit 1. Spacelift and Research & Development

THE INTERCONTINENTAL BALLISTIC missile (ICBM) force is only one aspect of this job you may have the opportunity to work in. The Air Force (AF) has devoted a lot of resources (people and money) into space programs and the continued research and development of our weapon systems. This continual investment is just another indication that you are part of a dynamic career field that cannot only play a critical role in missions beyond the ICBMs in underground silos, but also can support critical security and communication missions into space.

This unit will introduce you to the organizations that serve as our mainstay in the space program, ensuring that every mission is accomplished safely and effectively. We will then look at the different launch platforms and infrastructure used to launch spacecraft into orbit. The spacecraft is the ultimate payload and the sole purpose for these platforms; therefore, we will discuss the missions and characteristics of different spacecraft. Finally, we will discuss what missions the Air Force Research Laboratory (AFRL) and the Air Force Operational Test and Evaluation Center (AFOTEC) perform.

1–1. Spacelift Organization and Units

By starting your career in ICBMs, along with the information in the previous career development course (CDC) volume, you are likely familiar with Air Force Global Strike Command (AFGSC), as well as its structure and responsibilities. If you have the opportunity to work in Spacelift, you will transition to Air Force Space Command (AFSPC). We will start with some basic terms and ideas to get you up to speed, and then move into the Spacelift organizations and units.

201. Space domain overview

Nearly every military mission the United States (US) undertakes is enhanced by space. It provides Global Positioning System (GPS) information, satellite communications, advanced warning of missile attacks, Spacelift capabilities, and space control operations for combat forces. There is little doubt that the use of space capabilities acts as a significant force multiplier. Any degradation to these systems could have a significant impact on the success of a military operation. In this lesson, we will concentrate on Spacelift and the essential United States military programs that Spacelift directly supports.

Spacelift description

Spacelift is defined as the ability to deliver satellites, payloads, and other material into space. Spacelift operations are conducted to deploy, sustain, augment, or reconstitute satellite constellations that support US military operations. The Air Force is responsible for operating US launch facilities, and designates Spacelift as one of the 17 key operational functions—assured access to space. Spacelift has four basic purposes:

1. Servicing and maintaining existing or newly deployed space systems.
2. Deploying space systems to fulfill new requirements for satellite service.

3. Sustaining existing space systems whose individual satellites are nearing the end of their useful life, predicted to fail, or have already failed.
4. Augmenting existing space systems with redundant or additional capabilities to enhance space system performance or increase system survivability.

Space domain dependence

Humanitarian aid through the full spectrum of military operations is dependent upon the space domain. For example, more than half of all precision munitions utilize GPS. Remotely piloted aircraft that provide our critical intelligence, surveillance, and reconnaissance missions are controlled using satellite communications. Space capabilities have been integrated into our forces, which grants them more awareness, and provides a distinct advantage over our adversaries. With these advantages, we can protect the country's interests more effectively, and with fewer casualties than in past conflicts.

202. Mission of space organizations

AFSPC is comprised of thousands of dedicated men and women, military and civilian, responsible for helping place satellites (spacecraft) into orbit and monitoring the military's cyberspace. In this CDC, "spacecraft" and "satellite" are interchangeably. Let us start at the top, AFSPC, and work our way down to the smaller units.

Air Force Space Command mission and organization

AFSPC is headquartered at Peterson Air Force Base (AFB), Colorado and is responsible for units located around the world. The establishment of AFSPC occurred on 1 September 1982 to consolidate all Air Force space activities, Spacelift, and ICBMs. In 2009, AFSPC transferred ICBM forces AFGSC, and at the same time gained cyberspace forces.

The mission of AFSPC is to provide resilient and cost–effective space and cyberspace capabilities for the joint force and the nation. AFSPC has three primary missions:

1. Space/cyberspace control.
2. Space/cyberspace support.
3. Space/cyberspace force enhancement.

When you become a 5-level (Journeyman) technician, you may have the opportunity to work as a part of the space support mission. To accomplish its space mission, AFSPC is responsible for launching and operating US military satellites. These satellites are launched aboard Atlas and Delta evolved expendable launch vehicles (EELV) from facilities at Cape Canaveral Air Force Station (CCAFS), Florida and Vandenberg AFB, California. When stationed at either of these locations, you may perform a variety of duties in support of the space mission. Two numbered Air Forces (NAF) are assigned to AFSPC: Fourteenth Air Force operates the Air Force's worldwide space resources, and Twenty-Fourth Air Force exercises control over cyberspace operations. Figure 1–1 shows AFSPC's organizational chart.

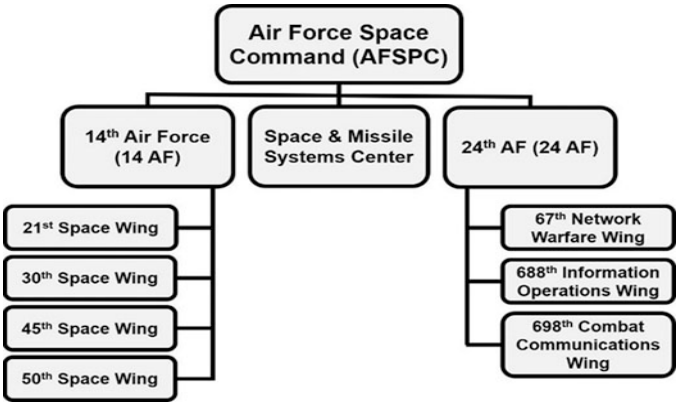


Figure 1–1. Air Force Space Command organizational chart.

As a major command (MAJCOM), AFSPC is also responsible for organizing, training, and equipping space units. AFSPC establishes the acceptable standards and configuration management for launch and range systems, facilities, and support infrastructure. Additionally, it organizes trains, equips, and administers forces in support of North American Aerospace Defense Command (NORAD) and United States Strategic Command (USSTRATCOM). Through the process of continuous improvement, AFSPC is able to provide support for combat forces, making space operations reliable and efficient for the war fighter.

Fourteenth Air Force mission and organization

Fourteenth AF is the Air Force component assigned to USSTRATCOM for space operations. The mission of Fourteenth AF is to organize, train, equip, provide command and control, and employ Air Force space forces to support operational plans and missions for US combatant commanders and their subordinate commands. The following table provides information on each of the major units of Fourteenth AF.

Major Units of Fourteenth Air Force

Unit	Mission
21st Space Wing (SW)	Located at Peterson AFB, Colorado: Conducts missile warning and space control operations. Provides installation support and protection to Peterson AFB. The 21st Space Wing has units throughout the country and the world from Hawaii to Massachusetts and from England and Spain to Diego Garcia in the Indian Ocean.
30 SW	Located at Vandenberg AFB, California: Operates the western range. Launches satellites into polar orbit. Assists with operational test launches. Provides Spacelift and tracking facilities, conducts launch operations, manages the Department of Defense's (DOD) space program, and supports commercial launches for the National Aeronautics and Space Administration (NASA) and foreign governments.
45 SW	Located at Patrick AFB, Florida: Provides launch and tracking facilities. Operates CCAFS and the eastern range. Supports commercial launches for NASA and foreign governments. Conducts launch operations and management of the DOD space program.
50 SW	Located at Schriever AFB, Colorado: Manages the global satellite network. Commands operational DOD satellites. Controls the Defense Satellite Communications System, North Atlantic Treaty Organization (NATO) III, and fleet satellite communications. 50th Space Wing detachments operate around the globe.

Twenty-Fourth Air Force mission

Twenty-Fourth AF, headquartered at Lackland AFB, TX, operates the Air Force's portion of the global information grid and conducts sustained cyberspace operations. This NAF supports, but does not directly engage in Spacelift operations. Therefore, the remainder of our discussion on space systems focuses on Fourteenth AF organizations and assets.

203. Functions of space units

Nearly all DOD spacecraft in orbit today were launched from either the east or west coast launch facilities due to the fact that they provide unique launch-to-orbit capabilities. By taking advantage of their geographic location, payloads of various weights can be placed in specific orbit profiles. These profiles satisfy mission objectives and, therefore, are the reason for the locations of the east and west coast launch facilities (fig. 1–2).

Figure 1–2. East and west coast launch facilities.

The integration of all the agencies involved in launch operations requires a full-time, on-site Air Force launch team, responsive to the requirements of the AFSPC commander. The wings, which are directly subordinate to Fourteenth AF, act as the launch agencies to manage, direct, control, and support space systems checkout and launch operations for AFSPC and other programs, when designated.

Now that you know the roles and responsibilities of the various space organizations, let's focus on the space units you might be assigned to—30 SW and 45 SW.

30th Space Wing

The 30th Space Wing is the host unit for Vandenberg AFB. As you know, Vandenberg is DOD's west coast launch facility. The 30th Space Wing uses military, federal civilian employees, and contractor employees to provide support services to DOD and non-DOD government tenants and aerospace contractors, as well as government and commercial launch support.

The wing manages the launch base and range infrastructure, range systems, as well as launch vehicle and spacecraft systems processing. It also provides facility and infrastructure support to satellite owners that are utilizing launch vehicles at Vandenberg AFB. The 30th Space Wing is responsible for enforcing compliance with Headquarters (HQ) AFSPC standards and configuration management for launch and range systems, facilities, and support infrastructure in the western US. When requested by the Space Surveillance Center, they also provide support to the space surveillance network.

The wing is responsible for operating the western range, which supports various aeronautical and sea-based operations conducted within the western range areas across the Pacific and Indian Oceans.

Vandenberg Air Force Base

Vandenberg AFB is situated along 26 miles of coastal desert covering more than 98,000 acres, and is the only US military launch facility that can launch satellites into polar orbit. A spacecraft in a polar orbit will constantly rotate around the earth, moving between the north and south poles. To you, as the observer standing in a stationary position, the spacecraft would appear to be moving. Since a satellite in polar orbit will eventually cover the entire earth's surface, Vandenberg AFB is a critical launch facility, particularly for weather satellites. Additionally, Vandenberg AFB is the only site used for tests of operational ICBMs, as well as other ballistic missile systems still under development. It conducts ICBM tests along the 4,200-mile corridor of the western range towards the Kwajalein Atoll.

The four groups under the 30th Space Wing are the 30th Launch Group, 30th Mission Support Group, 30th Medical Group, and 30th Operations Group.

The organization chart shown in figure 1–3 is abbreviated and may not show all components of each organization. You will be concerned mostly with the 30th Launch Group.

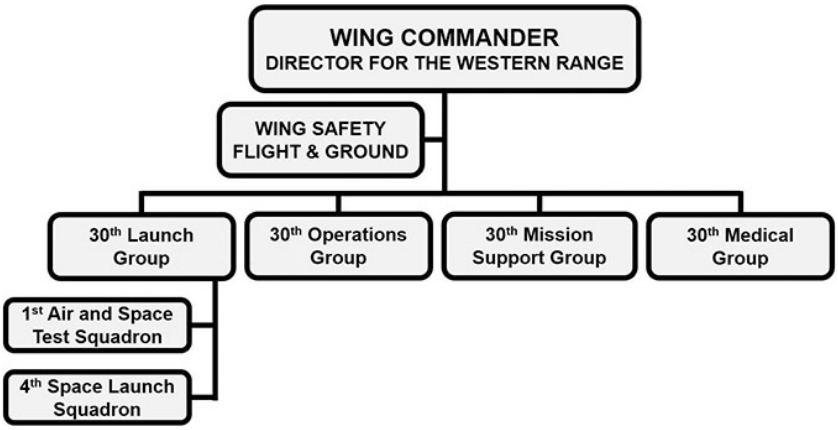


Figure 1–3. 30th Space Wing organizational chart.

30th Launch Group

The 30th Launch Group processes, tests, and launches boosters and satellites. It provides mission assurance, protects critical launch resources, performs launch operations, oversees mission integration, and develops future launch leaders. Two squadrons—1st Air and Space Test Squadron (ASTS) and 4th Space Launch Squadron (SLS)—are the main components of the group.

1st Air and Space Test Squadron

The 1st Air and Space Test Squadron is the only full-service Air Force developmental test and evaluation organization for missiles, launch vehicles, and payload/launch vehicle integration. It specializes in the reuse of deactivated ICBMs for a variety of new missions, including space and target launch. Today, the 1st Air and Space Test Squadron also performs test and integration functions for experimental space systems, Spacelift vehicles, targets, and interceptors (National and Theater Missile Defense).

4th Space Launch Squadron

The 4th Space Launch Squadron leads the Air Force's EELV program on the west coast. The squadron is responsible for the Delta IV and Atlas V launch vehicles, which provide the nation's sole medium and heavy lift capability into polar orbit. Insight into EELV operations enables the squadron's mission of providing continuous risk assessment and mission assurance on the Delta IV and Atlas V launch vehicle families for the 30th Space Wing and the Space and Missile Systems Center (SMC).

The 4th Space Launch Squadron also provides management and oversight of launch base satellite processing to ensure reliability, safety, security, resource protection, and environmental compliance. They provide technical surveillance to enable mission assurance for supported programs and on-site acquisition management, and engineering. The 4th Space Launch Squadron has contractual oversight for satellite program offices and other payload customers as delegated. In addition, they are responsible for spacecraft and booster processing maintenance and infrastructure sustainment, and take the lead in coordinating construction, modification, and repair activities. These activities support facility operations by reviewing, analyzing, and providing recommendations on proposed building modifications.

If assigned to the 4th Space Launch Squadron as a mission assurance technician (MAT), you will use your ICBM experience from previous assignments to provide technical oversight of contractor launch processing activities. You will observe contractors, and ensure adherence to technical requirements and maintenance practices. The 4th Space Launch Squadron is a blended organization comprised of military, government civilians, and contractors.

45th Space Wing

The 45th Space Wing provides support services at Patrick AFB, CCAFS, Antigua Air Station (located in the West Indies), and Ascension Auxiliary Air Field (located in the South Atlantic), and provides launch services to a variety of users.

The 45th Space Wing supports Spacelift and missile tests for the Air Force, DOD, NASA, and other agencies from CCAFS. The wing is responsible for operating the eastern range, which supports various aeronautical and sea-based operations conducted within the vast eastern range areas. The wing is also responsible for facilities, launch vehicles, and spacecraft that have reached operational maturity, as well as launching DOD spacecraft and certain NASA programs into low, medium, and high altitude geosynchronous and geostationary orbits.

Unlike other orbit types, when a spacecraft is in a geosynchronous or geostationary orbit, it matches the rotation speed of the earth. To you, as the observer, the spacecraft would stay at the same position in the sky, meaning it would appear to be stationary.

Patrick Air Force Base

Patrick AFB is the administrative hub of the 45th Space Wing, and the home for most of the wing's many tenants. It is located between the Banana River and the Atlantic Ocean on Florida's east coast, about 69 miles east of Orlando. The base was initially established by the Navy during World War II, and was activated on October 1, 1940 as the Banana River Naval Air Station, serving as a base for anti–submarine sea patrol planes during the war. The station was renamed Patrick AFB in 1950, named for Major General Mason M. Patrick, Chief of the American Expeditionary Forces Air Service during World War I.

Cape Canaveral Air Force Station

CCAFS has been the scene of more than 3,000 launches since 1950. The station covers over 15,000 acres located 20 miles north of Patrick AFB. The first US mission in space took place there in 1958 with the launch of the satellite *Explorer*. In 1961, Al Shepard became the first American astronaut to complete a suborbital space flight during the Mercury space program, which was launched from Cape Canaveral. The nerve center for Cape Canaveral, and the entire eastern range, is the range control center from which all launches, as well as the status of range resources are monitored. The range safety function is also performed in the range control center.

Active launch sites include Spacelift complex (SLC) 41 where preparation and launch of the Atlas V occurs. Delta IV vehicles are launched from SLC-37. Weather rockets are launched from the Meteorological Rocket Launch Facility. DOD satellites are prepared for launch at three facilities:

1. Navstar Processing Facility.
2. Satellite Processing and Integration Facility.
3. Defense Satellite Communications System Processing Facility.

Using the extra 1,000 feet per second advantage that the earth's easterly rotation provides, CCAFS can launch payloads with maximum weight into circular, elliptical, equatorial, or deep space trajectories.

The 45th Space Wing is composed of four groups that report to the wing commander. Those groups include the 45th Operations, Launch, Mission Support, and Medical Groups. The organizational chart in figure 1–4 is abbreviated and may not show all components of each organization. You will be concerned mostly with the 45th Launch Group.

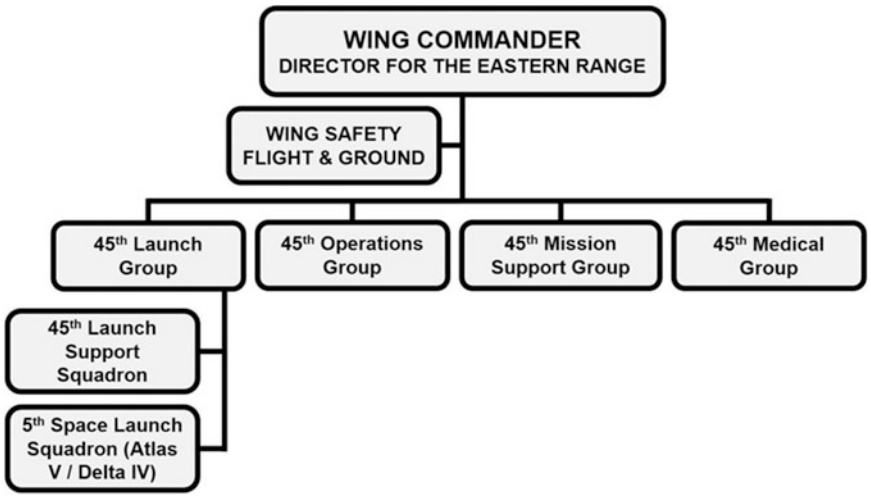


Figure 1–4. 45th Space Wing organizational chart.

45th Launch Group

The 45th Launch Group operates the 45th Launch Support and 5th Space Launch Squadrons. The group is responsible for program management and overall operation of these organizations.

5th Space Launch Squadron

Re–activated on 1 December 2003, the 5th Space Launch Squadron is responsible for mission assurance and risk assessment on the Atlas V and Delta IV launch vehicle families.

Launch complex 37, located at Cape Canaveral, is the launch site for Delta IV vehicles. Critical additional facilities for the Delta IV program include the mobile service tower, horizontal integration facility, and Delta operation center. The 5th Space Launch Squadron's Atlas V program launches from Launch Complex 41. Critical facilities for this program include the Atlas V spaceflight operation center and the vertical integration facility.

Both families of launch vehicles are designed to handle payloads from the DOD, the National Reconnaissance Organization, and NASA, along with commercial satellite sectors.

The 5th Space Launch Squadron also provides management and oversight of the launch base satellite processing to ensure reliability, safety, security, resource protection, and environmental compliance. They also provide technical oversight to assure mission success for supported programs and on–site acquisition management. The 5th Space Launch Squadron provides engineering, and contractual oversight for satellite program offices and other payload customers, as delegated.

If assigned to the 5th Space Launch Squadron you will provide the technical oversight for the government on contractor launch processing activities, using your experience from previous ICBM maintenance assignments. The MATs stationed at Vandenberg AFB, use their experience following technical requirements and maintenance practices to provide oversight of contractor processing activities, and provide a critical eye for procedure compliance and safety. The 5th Space Launch Squadron is a blended organization comprised of military, government civilians, and contractors.

45th Launch Support Squadron

Activated on 30 June 2005, the 45th Launch Support Squadron (LSS) is responsible for launch go/no–go readiness for all DOD spacecraft launching from Cape Canaveral.

The 45th Launch Support Squadron is responsible for operations and maintenance (O&M) for launch and payload processing infrastructure. They oversee training on spacecraft launch operations and certification of engineers, operators, and maintenance personnel. They provide direct supervision of Air Force contracting teams performing maintenance, checkout, and operations of critical flight hardware and infrastructure.

The 45th Launch Support Squadron maintains the unique capability of operating the only DOD spacecraft processing facilities capable of placing spacecraft into geosynchronous orbit. The squadron leads all launch processing, launch vehicle generation, spacecraft integration, and launch complex refurbishment. Squadron personnel are highly trained to launch nationally important satellites into orbit aboard small, medium, and heavy boosters.

In addition to spacecraft processing and maintenance of spacecraft infrastructures, the 45th Launch Support Squadron provides the expertise bridge from current day operations to future space initiatives.

Self–Test Questions

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

201. Space domain overview

1. What is Spacelift's purpose regarding existing space systems whose individual satellites are nearing the end of their useful life, predicted to fail, or have already failed?

2. When considering Spacelift, humanitarian aid all the way through the full spectrum of military operations is dependent upon what?

202. Mission of space organizations

1. Whose primary mission is it to provide space and cyberspace force enhancement?

2. At what sites are the Atlas and Delta evolved expendable launch vehicles launched from?

3. What is the Air Force component assigned to USSTRATCOM for space operations?

4. Match the space wing in column B to its mission in column A. Each item in column B may be used once, or not at all.

Column A	*Column B*
____ (1) Conducts missile warning and space control operations.	a. 60 SW.
____ (2) Operates the western range.	b. 50 SW.
____ (3) Operates CCAFS and the eastern range.	c. 45 SW.
____ (4) Manages the global satellite network.	d. 30 SW.
	e. 21 SW.

203. Functions of space units

1. Vandenberg AFB is a critical launch facility, particularly for launching what type of satellite?

2. What does 1 ASTS specialize in?

3. The 4th Space Launch Squadron is responsible for the Delta IV and Atlas V launch vehicles, which provide the nation's only capability to do what?

4. Who uses their previous ICBM knowledge to provide technical oversight of government contractors when they perform launch processing activities?

5. What wing is responsible for launching DOD spacecraft and certain NASA programs into low, medium, and high altitude geosynchronous and geostationary orbits?

6. At what site are Delta IV launch vehicles launched?

7. What does the 45th Launch Support Squadron oversee?

1–2. Launch Vehicles and Spacecraft

The Spacelift program uses a variety of launch vehicles to put spacecraft (satellites) into orbit. The payload weight, type of spacecraft, and the orbit needed determine which Spacelift vehicle is used. The EELV program is a government procured commercial launch service. Currently, the program uses the Atlas V and Delta IV launch vehicles. In this section, we will focus on the Atlas V and Delta IV vehicles, as well as the mission and characteristics of the spacecraft launched with them.

204. Atlas V vehicle configuration and infrastructure

The Atlas launch vehicle is based on the design of the MX–1593, which was a study conceived by the US Air Force (USAF) to investigate the feasibility of ICBMs. Tested in 1959, the Atlas was the United States' first successful launch of an ICBM. Atlas has since evolved into the modern Atlas V launch vehicle that we know today. The Atlas V was developed by the Lockheed Martin Company to reduce the cost and effort needed to launch payloads into orbit.

Mission

The Atlas V was designed for the USAF EELV program, which supports DOD and commercial spacecraft needs. Atlas V can accommodate single or multiple payloads on the same mission, and can launch payloads to polar orbits, sun-synchronous orbits, geosynchronous and geosynchronous transfer orbits, and low-earth orbits.

Configuration

The Atlas V launch vehicle comes in two configurations, the 400- and 500-series (fig. 1–5). Both consist of three major assemblies:

1. Common core booster (CCB),
2. Centaur upper stage, and
3. Payload fairing (PLF).

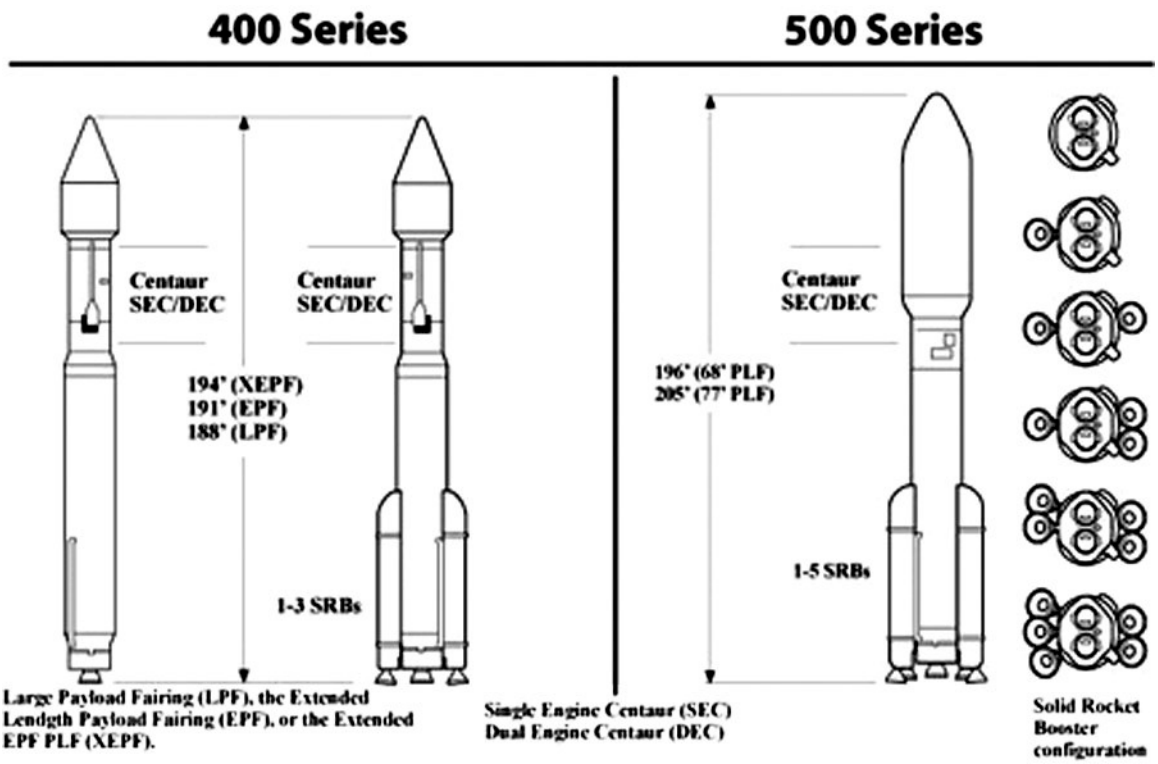


Figure 1–5. Atlas V launch vehicles.

Common core booster

The Atlas V CCB is a single body booster that houses one RD–180 engine with two nozzles, and provides attachment points for up to five strap-on solid rocket boosters, depending on configuration. This is the core of the launch vehicle and applies to all Atlas V configurations. The table below lists and describes CCB components.

Common Core Booster Components	
Component	**Description**
Propellant tank	There are two propellant tanks, one for rocket propellant (RP)–1 fuel and the other for liquid oxygen. The primary tank structure (both pressurized and unpressurized) is composed of stiffened isogrid panels machined from aluminum alloy plate formed to the 12.5-foot vehicle inside diameter. Intertank skirts separate the tanks.
Engine (RD–180)	The RD–180 is a two-thrust chamber, total propulsion unit. The RD–180 employs a hot gas generator, main turbopump assembly, and a single turbine.
Solid rocket boosters	Up to five solid propellant rocket boosters that are attached to the CCB provide thrust augmentation. They are approximately 5 feet in diameter and 66 feet long, from nose tip to nozzle exit, and have a gross weight of roughly 51 tons. The solid propellant is cast in a 7–point star configuration.

Centaur upper stage

The development of the Centaur upper stage began in 1958, and was intended for use with the Atlas program. The first development flight took place in 1962, which was then followed by research and development flights boosted by the Atlas rocket. The first Atlas/Centaur operational flight was the launch of the Surveyor Lunar Lander in 1966. Since then, the Atlas/Centaur has been used for the Mariner Planetary missions, Intersite Communications Satellites, and Pioneer Planetary missions, and others. The Centaur upper stage provides the propulsion, guidance, and control capability to place spacecraft into selected orbits.

The Centaur structural system is comprised of four major structural elements:

1. Propellant tank.
2. Stub adapter.
3. Centaur forward adapter.
4. Tank insulation.

The cryogenic liquid oxygen and liquid hydrogen propellant tanks are constructed of thin-wall stainless steel. The propellant tanks are separated by a double-wall barrier called a bulkhead. The avionics package is located on the Centaur forward adapter, which also serves as the spacecraft adapter. The inter-stage adapter is the interface between the CCB and the Centaur, and it provides shelter for the Centaur engines, as well as structural integrity for the vehicle. The Centaur uses either one or two Pratt & Whitney engines. The reaction control system contains monopropellant (hydrazine) thrusters and hydrazine and helium storage bottles.

Payload fairing

The PLF is the aerodynamic shroud that protects the payload and/or upper stage from external environments and contamination. The 400-series PLF is 13.5 feet long, and the 500-series is about 18 feet long. Both are constructed of an aluminum skin, stringers, and a frame. Its structure is made from a carbon-fiber-composite with a vented aluminum honeycomb core, and encloses both the spacecraft and Centaur upper stage during prelaunch and ascent. The payload adapter connects the payload to the standard interface plane, which is located at the top of the Centaur forward adapter.

Atlas V infrastructure

The Atlas V SLCs are located at Vandenberg AFB and CCAFS. Both sites have the capability to launch the 400- and 500-series configurations. Some of the major structures are the launch operations building (LOB), mobile service tower (MST) and crane, umbilical tower (UT), payload environmental control system (ECS) building, fixed launch platform (FLP), launch support building (LSB), and technical support buildings.

Launch operations building

The LOB is built into a berm that houses monitoring and radio frequency test equipment for the vehicle’s telemetry system.

Mobile service tower

The MST is a 260-foot tall, enclosed steel structure that contains retractable launch vehicle servicing and checkout platforms. An overhang provides access to the Atlas/Centaur launch vehicle and payload. A truck-and-drive system moves the MST 250 feet along rails, from its parked position to the service position around the launch platform. The primary functions of the MST include erecting the Atlas V and Centaur, mating encapsulated spacecraft to the launch vehicle, and providing work areas for personnel and equipment during spacecraft mate and flight readiness checkouts. Also included is the use of its 60-ton bridge crane to erect the Atlas V CCB, solid rocket boosters, Centaur second stage, spacecraft assembly, and associated adapters.

Umbilical tower

The UT provides a structure to service the launch vehicle and spacecraft with consumables. The launch vehicle and spacecraft electrical, environmental control, and fluid disconnects are installed on the rotating booms (service arms), which are released from the launch vehicle during the initial launch release sequence. The UT provides support for two rigid umbilical booms, and a ground wind damper that steadies the launch vehicle in high winds. There are also platforms for servicing, a lightning mast that provides a 45-degree cone of protection, and a hydrogen vent stack for the Centaur fuel tank.

Launch support building

The LSB is a reinforced concrete and steel structure and is the platform on which the Atlas V launch vehicle is assembled, tested, and launched. The LSB provides the ramp used to move the Atlas, Centaur, and other spacecraft into position to be erected. It also provides a protective shelter for shop areas, storage, locker rooms, environmental control equipment, electrical switchgear, instrumentation, fluid and gas transfer equipment, launch control equipment, and other launch-related service equipment.

Fixed launch platform

The FLP supports the launch vehicle during its integration on the pad, as well as during fueling, final preparation for launch, and liftoff of the vehicle. It is positioned on top of the launch exhaust duct on the LSB. Within the FLP, three retractable launch heads support the launch vehicle using two-inch diameter breakable bolts. The launch heads are designed to extend to the launch vehicle, and then to retract out of the way immediately upon liftoff.

205. Delta IV vehicle configuration and infrastructure

Delta is a family of expendable launch systems that has provided Spacelift capability in the US since 1960. The Boeing Company's Delta design emphasizes reliability rather than performance. Numerous upgrades and modifications over its 375–plus launch history, as well as the need to reduce the cost and effort required to launch payloads into orbit, led Boeing and Lockheed Martin to merge into United Launch Alliance in 2006. Delta IV vehicles are currently produced at a facility in Decatur, Alabama.

Mission

The Delta IV launch vehicle was designed specifically for the USAF EELV program and the commercial satellite business. It is intended to reduce the cost and effort needed to launch payloads into orbit. The Delta IV is primarily designed to satisfy the requirements of the US military.

Configuration

The Delta IV has five different configurations, each consisting of three major assemblies (fig. 1-6):

1. First stage common booster core (CBC).
2. Second stage.
3. PLF.

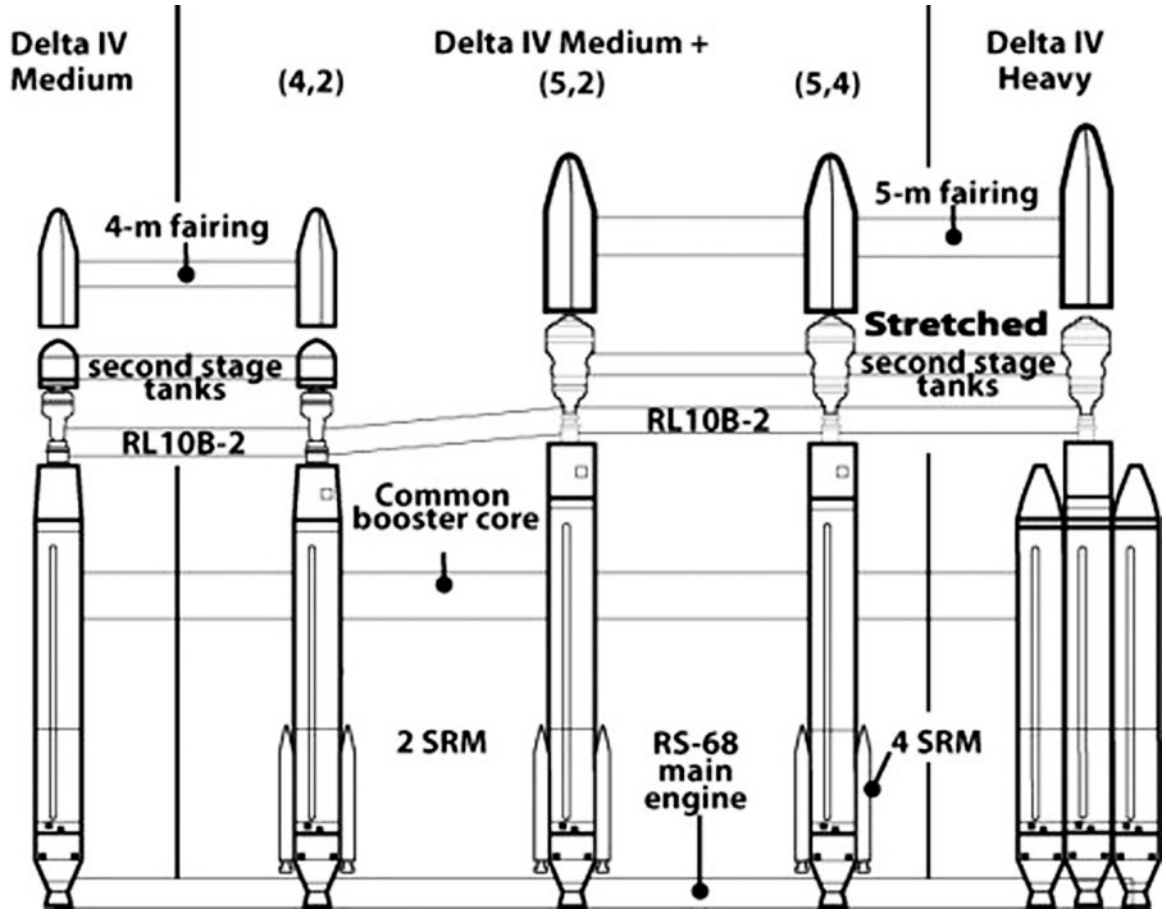


Figure 1–6. Delta IV launch vehicle.

The following table contains a list and description of Delta IV vehicle configuration components.

Delta IV Configuration		
Component	**Description**	
Common booster core	A typical first stage of the Delta IV consists of one CBC powered by a Rocketdyne RS–68 engine. The Delta IV "Heavy" variant first stage will have three CBCs. Depending upon the configuration, it also provides attachment points for up to four strap-on solid rocket motors.	
	Propellant tanks	There are two propellant tanks, one for liquid hydrogen and one for liquid oxygen. The primary tank structure is built from an aluminum isogrid. A composite cylinder called the centerbody separates the tanks.
	Engine (RS–68)	The RS–68 is a liquid hydrogen/liquid oxygen engine. The engine itself employs a gas generator, two turbopumps, a regeneratively cooled combustion chamber, and a single ablative nozzle.
	Solid rocket motors	Solid rocket motors, or graphite epoxy motors (GEM), are high–performance rocket motors used to provide additional thrust for the Medium + class launch vehicles. Either two or four GEMs can be added to the vehicle, depending on the mission requirements. GEMs consist primarily of a nose cone, a casing that contains propellant grain, and a nozzle at the aft end of the motor. The overall length of the GEM is 53 feet with a 5-foot diameter.
Second stage	A Pratt & Whitney RL10B–2 engine powers the second stage. Depending on the launch vehicle configuration (13-foot or 16.5-foot payload fairings), two different inter-stages are used to mate the first and second stages.	

Delta IV Configuration		
Component	**Description**	
	Propellant tanks	There are two cryogenic propellant tanks, one for liquid hydrogen and the other for liquid oxygen. 13-foot length or 16.5-foot length are the two variants.
	Engine (RL10B–2)	The RL10B–2 is a cryogenic liquid hydrogen fueled rocket engine, which features an extendable carbon nozzle to improve specific impulse, as well as electro–mechanical gimbaling for reduced weight and increased reliability.
Payload fairing	The payload fairing is the aerodynamic shroud that provides protection to the payload and/or second stage from external environments and contamination. It provides acoustic, radio frequency, and static protection from the time the spacecraft is encapsulated until the Delta IV passes through the atmosphere. A variety of different payload fairings is available. Both 13-foot and 16.5-foot variants are used and are constructed from composite materials.	

Delta IV infrastructure

The Delta IV is launched from two launch sites. On the east coast, Launch Complex 37 at CCAFS is used. On the west coast, polar–orbit and high–inclination launches use Vandenberg AFB's SLC–6 pad. Launch facilities at both sites are similar. An MST is located at Vandenberg's launch pad. The launch pad also has a mobile assembly shelter (MAS), a fixed umbilical tower (FUT), a launch table, a launch mate unit (LMU), and a fixed pad erector (FPE).

Mobile service tower

The MST provides service access to the rocket as well as protection from the weather. The crane at the top of the MST allows the payload and solid rocket motors to be attached to the launch vehicle. The MST moves over rail tracks on hydraulically powered trucks, and then meets with the FUT and MAS to form an environmental enclosure for the launch vehicle. The MST is rolled away from the Delta IV rocket several hours before launch.

Mobile assembly shelter

Located only at Vandenberg's SLC–6, the MAS is a large structure that meets with the FUT and MST to provide an environmental enclosure for the launch vehicle. The launch vehicle is completely enclosed by the MAS.

Fixed umbilical tower

Next to the launch vehicle is a FUT. Large swing arms carry electrical, hydraulic, environmental control, and other support functions to the vehicle through umbilical lines. The swing arms retract in less than 12 seconds in order to prevent them from coming in contact with the vehicle during launch.

Launch table

The launch table is located under the launch vehicle, and is equipped with six tail service masts to meet the needs of all five vehicle configurations. There are two for each CBC. The launch table supports the vehicle on the pad, and the tail service masts provide further support and fueling functions for the CBCs.

Launch mate unit

The LMU mounts the launch vehicle to the launch table. The LMU is a large steel platform that provides a foundation for the rocket. It is attached to the launch vehicle by bolts that are severed at launch.

Fixed pad erector

In front of the launch table is a FPE. This structure utilizes two 4-stage telescoping hydraulic erector cylinders, which are installed in the FPE pit, and are used to erect the assembled launch vehicle from

the horizontal position to the vertical position on the launch table. The FPE hydraulic pumping unit is located in a concrete building near the FUT. The FPE is capable of lifting in excess of 200 tons.

Horizontal integration facility

The horizontal integration facility (HIF) is located some distance from the launch pad. The HIF is a large building that allows the Delta IV CBCs and 2nd stages to be mated and tested before they are moved to the launch pad. The HIF has a two-bay booster processing area and an office area. HIF activities include receipt and inspection of boosters, ordnance installation, 2nd stage nozzle extension deployment system checkout, and 2nd stage-to-CBC integration and checkout.

A specially built elevating platform transporter (EPT) is used for moving the Delta IV among the various facilities at the pad. The EPTs are rubber-tired vehicles powered by either diesel engines or electric power. Diesel EPTs are used for moving the vehicles from the HIF to the launch pad, while electric EPTs are used in the HIF since precise movements are important.

206. Spacecraft systems

Spacecraft are the specialized satellites that consist of a payload and a number of subsystems. There are numerous satellites in space used for a variety of reasons, but to better illustrate their missions, they are grouped into categories. While all satellites are different, they generally consist of the same design characteristics, which are discussed in this lesson.

Mission

The mission and importance of satellite systems is unquestionable in today's military environment. While you are reading this text, numerous satellites are in orbit performing a wide variety of missions. AFSPC operates the Air Force Satellite Control Network (AFSCN)—the largest and most sophisticated military space network in the world. The AFSCN is tasked with maintaining a multitude of DOD satellites, which provide the national command authorities, armed forces, and government agencies with voice, video, and data services. Remote tracking stations handle hundreds of satellite contacts daily. These satellites provide information that is vital to the defense of the US.

Listed in the table below are the most common AFSPC-supported satellites and the mission each one performs.

Most Common AFSPC Supported Satellites	
Type	**Mission**
Communication	Provide secure and reliable command and control of American military forces throughout the world.
Navigation	Enhance the global deployment of air, land, and sea forces, as well as provide pinpoint weapons system accuracy.
Weather	Employed to detect fluctuating weather patterns, provide information on precipitation rates, cloud density, and sea conditions to the worldwide command centers.
Research	Carry a variety of instruments to study the earth's environment from the upper atmosphere to the edge of the magnetosphere. Each one belongs to one of the following categories—solar, geophysical, or astronomical.
Surveillance and Early Warning	Provide warning and threat assessments to commanders worldwide, regardless of the location of a conflict.
Military Satellite Systems	Are employed to monitor the world situation in real-time to avoid surprises and ensure compliance with arms control agreements.

Characteristics

While mission requirements drive the design of satellites for many different purposes, all satellites have essentially the same type of subsystems, which includes structural, electrical, thermal control, propulsion (boost), attitude control and telemetry, tracking, and command elements.

Structure

The design of a satellite's structure, or "bus," is to provide a strong and stable platform for payload instruments and subsystems. The bus carries the payload that performs the assigned mission for each satellite. The bus subsystem also provides the mechanical interface with the launch vehicle, sustains launch loads, and serves as a precision alignment platform when required for components like antennas, sensors, actuators, and thruster jets.

Electrical

Of all the subsystems that make up a satellite, the electrical power subsystem is by far the most important. With few exceptions, a satellite without electrical power is useless space junk. The electrical subsystem provides for the generation, storage, control, and distribution of electrical power to all other satellite subsystems. There are three sources of electrical power used on satellites:

1. solar power,
2. battery power, and
3. nuclear power.

It is important to note that nuclear power has seen only limited use in space so far. It is primarily used with missions that are lengthy, have increased power requirements, or will operate at a great distance from the sun.

Thermal control

The thermal control subsystem is how the satellite maintains its temperature. Significant variations in temperature occur within a satellite due to heat generated by its own components, friction of the vehicle leaving the atmosphere, and heating effects of the sun. Conversely, a satellite "cold soaks" when it is not exposed to sunlight. Thermal controls can be broken into two categories—passive and active. The table below lists and describes these two types of thermal controls.

Thermal Controls		
Type	**Description**	
Passive	Passive thermal controls use the principles of conduction, reflection, and radiation to maintain the satellite's temperature. These controls can be thermal coatings, thermal insulation, or heat sinks.	
	Thermal coatings	These coatings either conduct or reflect heat.
	Thermal insulation	Insulation minimizes the heat loss or gain in a space environment.
	Heat sinks	Heat sinks conduct heat to or away from specific components that require temperature control.
Active	With active controls, satellite temperatures are continuously monitored. When specific temperatures are reached, mechanical devices are actuated or electric heaters are cycled on or off to maintain the temperature. Active controls can be broken down as follows:	
	Heat pipes	Transports heat energy from internal equipment to a radiator surface using a chemical fluid, usually methanol or ammonia.
	Thermal louvers	Highly polished thermal louvers that open or close, to allow heat in, or to escape from, the satellite (fig. 1–7).
	Electric heaters	Turn on or off depending on the temperature.

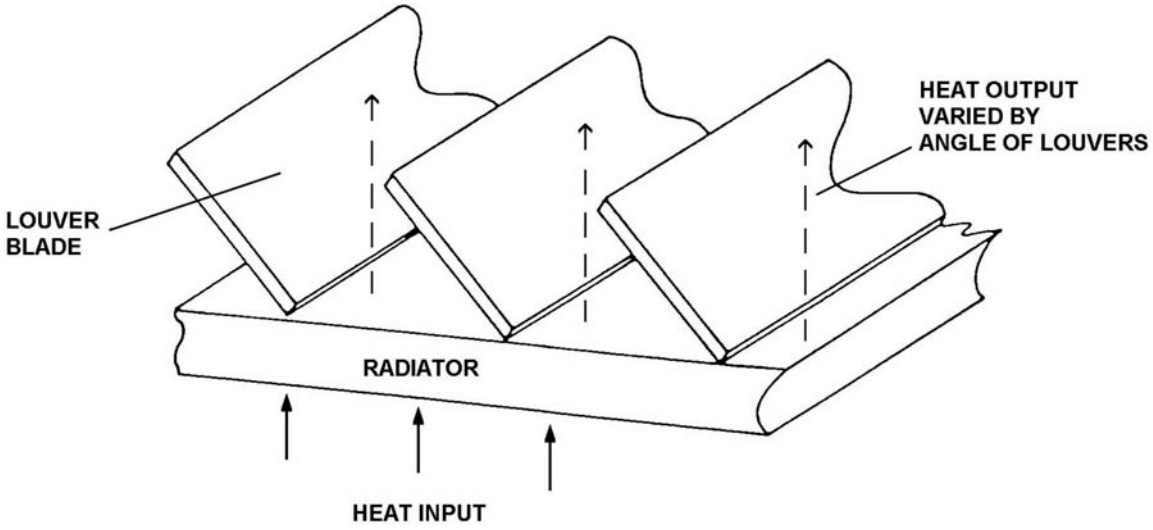


Figure 1–7. Thermal louvers.

Propulsion

The spacecraft's propulsion system normally takes over after it separates from the launch vehicle. This system provides the thrust for orbit changes, adjustments, and orientation of the satellite's spin during spinning phases. The propulsion system also helps control the attitude, spin rate, and nutation. Nutation is the irregular "nodding" motion that is sometimes a part of a body's spin motion on its axis.

A typical propulsion system consists of propellant tanks and thrusters that are interconnected and isolated by latching valves. The mission profile in the design phase of a satellite determines what propulsion system or combinations of propulsion systems are employed. The following table lists and describes the two types of propellant.

Propulsion Systems		
Propellant	**Description**	
Liquid	Liquid propellant systems are more expensive, but are used more often than other systems. Liquid allows precise control of the satellite's thrust and can be fired multiple times.	
Electrical	Uses electrical energy to generate or increase the force of the propulsive jet. There are three types of electrical propulsion systems:	
	Electro-thermal	Uses electrical energy to heat a gaseous propellant.
	Electrostatic	Uses electrical energy to ionize a gaseous propellant and an electrostatic field to accelerate positive ions to produce thrust.
	Electromagnetic	Use an electromagnetic field to accelerate neutral, gaseous plasma to produce thrust.

Attitude control

Attitude control is required to ensure sensors, communications antennas, optics, and other satellite instruments remain pointing in the right direction. Do not confuse "attitude" with "altitude." Attitude is which direction the satellite is pointing, not the height of an object above the earth. Attitude control systems serve two functions:

1. Station keeping – overcoming the motion of the satellite generated by atmospheric drag, gravity, and solar winds.
2. Stabilize – rotates the satellite to keep it pointing in the right direction.

Telemetry, tracking, and command elements

Once a satellite has reached its desired orbit, it remains electronically linked with the controllers on earth. Radio and microwave signals are used to maintain and operate the satellite from the ground. This system provides the means of monitoring and controlling the satellite's operation. The table below lists and describes the elements of satellite monitoring and control.

Satellite Monitoring and Controlling Elements	
Element	**Description**
Telemetry	Telemetry data has two purposes. First, it transmits information depending on the mission of the satellite (i.e. meteorological or astronomical data). Second, it transmits information on the general health of the satellite, such as pressures, temperatures, flow rates, voltages, electrical currents, and other events present in the satellite's subsystems.
Tracking	Enables the gathering of telemetry data and establishes a link for commanding the spacecraft.
Commanding	Commands are up-linked to the vehicle to maintain satellite health, execute attitude and orbit adjustments, calibrate and adjust payloads and clocks, and perform other tasks needed for the success of the satellite's mission.

Self–Test Questions

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

204. Atlas V vehicle configuration and infrastructure

1. What are the major assemblies of the Atlas V launch vehicle?

2. What components are in the CCB's engine?

3. What are the major structural elements of the Centaur upper stage?

4. What structure contains enclosures that have retractable launch vehicle servicing and checkout platforms?

5. What is the name of the platform where the Atlas V launch vehicles are assembled, tested, and launched?

6. What supports the launch vehicle during fueling and final preparation for launch?

205. Delta IV vehicle configuration and infrastructure

1. What two liquids are contained in the CCB's propellant tanks?

2. What powers the Delta IV second stage?

3. What are the two varieties of Delta IV payload fairings?

4. At what stage of the launch sequence is the MST rolled away from the Delta IV?

5. What completely encloses the launch vehicle within the FUT and MST?

6. What supports the launch vehicle on the pad?

7. Where are the Delta IV CCBs and second stages mated, and tested before moving to the launch pad?

206. Spacecraft systems

1. Match the satellite mission in column A with their category in column B. Items in column B may be used once.

Column A	*Column B*
____ (1) Provides secure and reliable command and control.	a. Weather.
____ (2) Provide pinpoint weapon system accuracy.	b. Surveillance and early warning.
____ (3) Provide information on sea conditions.	c. Communications.
____ (4) Solar, geophysical, or astronomical.	d. Research.
____ (5) Provide warning and threat assessment to commanders worldwide.	e. Military.
____ (6) Ensure compliance with arms control agreements.	f. Navigation.

2. Satellites use what sources of power?

3. What chemical fluids are usually used in heat pipes to transport heat energy from internal equipment to a radiator surface?

4. What are the types of electrical propulsion systems?

5. Define *station keeping.*

6. What two sources of information are included in telemetry data?

1–3. Research and Development

Research and development plays a pivotal role in keeping our weapon systems on the cutting edge of technology and keeping the nation one-step ahead of our adversaries. Through two different agencies, the Air Force modernizes and tests weapon systems and Spacelift capabilities to ensure that we can continue to meet the demands of the highly complex operational environment that our nation's military exists in—AFRL and AFOTEC.

207. Mission of research and development organizations

Through the AFRL and AFOTEC, our weapon systems are modernized, and new weapon systems are developed and tested. Let's take a look at the mission of each of these prestigious organizations.

Air Force Research Laboratory

The AFRL is headquartered at Wright–Patterson AFB, Ohio, but maintains several laboratories throughout the country. It was created in 1997 through the consolidation of four major laboratories and the Air Force Office of Scientific Research (AFOSR).

Mission

AFRL's mission is to lead in the discovery, development, and integration of warfighting technologies for America's air, space, and cyberspace forces. It has full–spectrum laboratories, responsible for planning and executing the Air Force's science and technology program. Together with industrial and academic experts, the AFRL develops and delivers a wide range of revolutionary technologies that ensure we have the world's best air, space, and cyberspace forces.

Organization

The AFRL's headquarters division is located at Wright–Patterson AFB, but it also contains nine separate directorates responsible for different weapon system components. The directorates are listed in the table below along with their responsibilities.

AFRL Directorates	
Directorate	**Responsibilities**
Air Force Office of Scientific Research	AFOSR, operating out of Arlington, Virginia, specializes in long–term, broad–based research in aerospace–related science and engineering to further aid the efforts of other directorates.
Directed Energy	Headquartered at Kirtland AFB, New Mexico, focuses on directed energy and optical technologies, including high-energy microwaves, lasers, adaptive optics, and imaging, as well as the effects of each.
Information	Operates out of Rome, New York, and specializes in the exploitation of information and defensive information warfare, as well as developing intelligent operating systems.
Materials and Manufacturing	Operates from Wright–Patterson AFB and Tyndall AFB, Florida. It researches technologies to support the aerospace component of manufacturing and materials. It supports current systems by finding better materials and ways to make the same product.
Munitions	Operates out of Eglin AFB, Florida. It develops, demonstrates, and transitions science and technology for air-launched munitions used for defeating ground fixed, mobile and relocatable, air and space targets to assure pre-eminence of US air and space forces.

AFRL Directorates	
Directorate	**Responsibilities**
Aerospace Systems	Operating out of Wright Patterson AFB and Edwards AFB, California, this directorate develops air and space vehicle propulsion and power technologies. Focus areas include turbine and rocket engines, advanced propulsion systems, and the associated fuels and propellants.
Sensors	Headquartered at Wright–Patterson AFB, and operating out of Hanscom AFB, Massachusetts, and Rome, New York, the sensors directorate works on new technologies that US warfighters need to find and engage the enemy and eliminate their ability to hide or threaten our forces. Its core technology areas include, radar, active and passive electro–optical targeting systems, navigation aids, automatic target recognition, sensor fusion, threat warning, and threat countermeasures.
Space Vehicles	Has operating locations at Kirtland AFB and Hanscom AFB. It develops and transitions space technologies. Primary focus areas include radiation-hardened electronics, space power, space structures and control; space based sensing, space environmental effects, autonomous maneuvering, and balloon and satellite flight experiments.
Human Performance Wing	The 711th Human Performance Wing is located at Wright–Patterson AFB. It is the first human–centric warfare wing to consolidate research, education, and operational consultation under one roof. The wing's primary mission areas are aerospace medicine, and science and technology, as well as how humans are integrated with different weapon systems.

Air Force Operational Test and Evaluation Center

AFOTEC, located at Kirtland AFB, New Mexico is a direct reporting unit under Headquarters United States Air Force (HQ USAF); they do *not* fall under a MAJCOM or NAF. It is the Air Force's independent test agency responsible for testing new systems being developed for the Air Force and for other services and agencies under operationally realistic conditions.

AFOTEC employs more than 600 personnel, and has five detachments located at Edwards AFB, California, Peterson AFB, Colorado, Eglin AFB, Florida, Nellis AFB, Nevada, and Kirtland AFB, New Mexico, as well as many other operating locations throughout the nation.

Mission

AFOTEC's mission is to test and evaluate new warfighting capabilities. They do this in the most operationally realistic environment possible to get the most accurate test results. These tests inform national agencies about new systems and influence the decision to divert national resources to their development.

Test teams conduct tests at selected sites; collect, analyze, and evaluate the data; and then prepare formal reports. The teams are managed by AFOTEC, but tests are conducted by personnel from the operating and support commands that will eventually employ the systems.

Test program

AFOTEC's independent and objective evaluations of how well systems will meet operational requirements provide a vital link between the developer and the user. They are key elements of the system acquisition approval process.

Operational tests are designed to address critical issues regarding a system's performance in combat–like environments when operated by field personnel. They seek to answer questions about how safe, effective, reliable, maintainable, compatible, and supportable new systems will be.

The results of AFOTEC's tests, normally conducted on prototype and pre–production models, play an important role in acquisition decisions. Test results also identify deficiencies requiring corrective actions.

Self–Test Questions

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

207. Mission of research and development organizations

1. Match the description in column A with the Air Force Research Laboratory Directorate in column B. Items in column B may be used once.

Column A	*Column B*
____ (1) Specializes in long–term, broad–based research in aerospace–related science and engineering to further aid efforts by the other directorates.	a. Information Directorate.
____ (2) Focuses technologies on optical technologies.	b. Directed Energy Directorate.
____ (3) Develops intelligent operating systems.	c. Air Force Office of Scientific Research.
____ (4) Supports current systems by finding better ways to make the same product.	d. Human Performance Wing.
____ (5) Specializes in defeating fixed, mobile/relocatable, and air and space targets.	e. Aerospace systems Directorate.
____ (6) Develops air and space vehicle propulsion and power technologies.	f. Munitions Directorate.
____ (7) Specializes in aerospace medicine, science, and technology.	g. Materials/Manufacturing Directorate.

2. What agency does AFOTEC report to?

3. What is AFOTEC’s mission?

4. What are operational tests conducted by AFOTEC designed to address?

Answers to Self–Test Questions

201

1. Sustainment.
2. Space domain.

202

1. AFSPC.
2. CCAFS, Florida, and Vandenberg AFB, California.
3. 14 AF.
4. (1) e.
   (2) d.
   (3) c.
   (4) b.

203

1. Weather.
2. The reuse of deactivated ICBMs for a variety of new missions.
3. Place medium and heavy lift satellites into polar orbit.
4. MATs.
5. 45 SW.
6. Launch Complex–41.
7. Spacecraft launch operations, as well as training and certification of engineers, operators, and maintenance personnel.

204

1. CCB, Centaur upper stage, payload fairing.
2. A hot gas generator, main turbopump assembly, and a single turbine.
3. Propellant tank, stub adapter, Centaur forward adapter, and tank insulation.
4. MST.
5. LSB.
6. FLP.

205

1. Liquid hydrogen and liquid oxygen.
2. A Pratt & Whitney RL–10B2 engine.
3. 13-foot and 16.5-foot variants.
4. Several hours before launch.
5. MAS.
6. Launch table.
7. HIF.

206

1. (1) c.
   (2) f.
   (3) a.
   (4) d.
   (5) b.
   (6) e.
2. Solar, battery, and nuclear power.
3. Methanol or ammonia.
4. Electro–thermal, electrostatic, and electromagnetic.
5. Overcoming the motion of the satellite generated by atmospheric drag, gravity, and solar winds.
6. Information on the mission of the satellite and information on the general health of the satellite.

207

1. (1) c.
   (2) b.
   (3) a.
   (4) g.
   (5) f.
   (6) e.
   (7) d.

2. HQ USAF.
3. Test and evaluate new warfighting capabilities.
4. Critical issues regarding a system's performance in combat–like environments when operated by field personnel.

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. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (201) The ability to deliver satellites, payloads, and material into space is defined as
   a. spacecraft deployment.
   b. satellite deployment.
   c. space launch.
   d. Spacelift.

2. (201) One of the four basic purposes of Spacelift includes deploying space systems to fulfill new requirements for
   a. satellite service.
   b. key operation functions.
   c. systems predicted to fail.
   d. systems that have already failed.

3. (202) Which numbered Air Force mission is to organize, train, equip, provide command and control, and employ Air Force space forces to support operational plans and missions for US combatant commanders and their subordinate commands?
   a. Second.
   b. Fourteenth.
   c. Twentieth.
   d. Twenty-fourth.

4. (202) The control of the Defense Satellite Communications System is the responsibility of
   a. Second Air Force.
   b. Eighth Air Force.
   c. 45th Space Wing.
   d. 50th Space Wing.

5. (203) Select the wing that is responsible for operating the *western* range.
   a. 341st Missile Wing.
   b. 91st Missile Wing.
   c. 30th Space Wing.
   d. 45th Space Wing.

6. (203) Select the Air Force's only full service developmental test and evaluation organization for missiles and launch vehicles.
   a. 576th Flight Test Squadron.
   b. 2nd Range Operations Squadron.
   c. 1st Air and Space Test Squadron.
   d. Space & Missile Systems Center.

7. (203) Which organization is responsible for the Air Force evolved expendable launch vehicle program on the *west* coast?
   a. 17th Test Squadron.
   b. 576th Flight Test Squadron.
   c. 4th Space Launch Squadron.
   d. 5th Space Launch Squadron.

8. (203) Select the installation that is the *administrative hub* of the 45th Space Wing.
   a. Patrick AFB, Florida.
   b. Peterson AFB, Colorado.
   c. Vandenberg AFB, California.
   d. Cape Canaveral Air Force Station, Florida.

9. (203) Who uses experience from previous intercontinental ballistic missile assignments to provide technical oversight of contractor launch processing activities?
   a. Mission assurance technicians.
   b. Quality assurance evaluators.
   c. Security forces personnel.
   d. Contractor personnel.

10. (204) Which launch vehicle was designed for the Air Force (AF) evolved expendable launch vehicle program and supports Department of Defense (DOD) and commercial spacecraft needs?
   a. Delta IV.
   b. Atlas IV.
   c. Delta V.
   d. Atlas V.

11. (204) How many attach points are provided on the common core booster (CCB) for strap-on solid rocket boosters?
   a. 3.
   b. 4.
   c. 5.
   d. 6.

12. (204) Select the fuel used in the propellant tank of the common core booster (CCB).
   a. JP–1 and methane.
   b. RD–180 and hydrazine.
   c. RP–1 and liquid oxygen.
   d. PGM–17 and liquid hydrogen.

13. (204) The Atlas payload adapter connects the payload to the standard interface plane located at the top of the Centaur
   a. intertank skirt.
   b. forward adapter.
   c. interstage adapter.
   d. turbopump assembly.

14. (204) Select the structure that erects the Atlas and Centaur and mates the encapsulated spacecraft to the launch vehicle.
   a. Launch table.
   b. Umbilical tower (UT).
   c. Mobile service tower (MST).
   d. Fixed launch platform (FLP).

15. (204) Which Atlas structure provides a lightning mast?
   a. Umbilical tower (UT).
   b. Launch mate unit (LMU).
   c. Mobile assembly shelter (MAS).
   d. Launch operations building (LOB).

16. (204) Select the Atlas structure that provides a ramp used for moving the Atlas, Centaur, and spacecraft into position to be erected.
    a. Mobile service tower (MST).
    b. Launch support building (LSB).
    c. Launch operations building (LOB).
    d. Horizontal integration facility (HIF).

17. (204) Which structure contains three retractable launch heads to hold the Atlas launch vehicle?
    a. Launch mate unit (LMU).
    b. Launch control center (LCC).
    c. Fixed launch platform (FLP).
    d. Launch operations building (LOB).

18. (205) Delta IV is *primarily designed* to satisfy requirements of
    a. the National Aeronautics and Space Administration (NASA).
    b. the United States military.
    c. international launches.
    d. commercial launches.

19. (205) Which fuel does the Delta IV second stage RL–10B–2 rocket engine burn?
    a. Hydrazine.
    b. Liquid oxygen.
    c. Liquid hydrogen.
    d. Rocket Propellant–1.

20. (205) In order to provide an environmental enclosure for the Delta IV launch vehicle, the mobile assembly shelter meets with the
    a. fixed pad erector (FPE).
    b. fixed umbilical tower (FUT).
    c. launch mate unit (LMU) and the fixed pad erector (FPE).
    d. fixed umbilical tower (FUT) and the mobile service tower (MST).

21. (205) During a launch, in how many seconds do the swing arms of the Delta IV fixed umbilical tower (UT) retract?
    a. Less than 12.
    b. 12 to 15.
    c. 16 to 20.
    d. 21 to 25.

22. (205) Which powers the elevating platform transporter in the Delta IV horizontal integration facility (HIF) where *precise* movements are important?
    a. Electricity.
    b. Diesel engines.
    c. Gasoline engines.
    d. Hydraulic pressure.

23. (206) Select the largest and most sophisticated military space network in the world.
    a. Department of Defense Control Network.
    b. Air Force Spacecraft Control Network.
    c. Air Force Satellite Control Network (AFSCN).
    d. United States Satellite Network.

24. (206) Which spacecraft thermal control is considered an *active* thermal control?
    a. Heat sink.
    b. Electric heater.
    c. Thermal coating.
    d. Thermal insulation.

25. (206) Select the type of spacecraft propulsion system that uses electrical energy to heat a gaseous propellant.
    a. Electro-thermal.
    b. Solid propellant.
    c. Electromagnetic.
    d. Liquid propellant.

26. (206) Which is considered *spacecraft telemetry data*?
    a. Astronomical data.
    b. Payload calibrations.
    c. Altitude adjustments.
    d. Communications protocols.

27. (207) Where is the Air Force Research Laboratory (AFRL) headquartered?
    a. Eglin AFB, Florida.
    b. Kirtland AFB, New Mexico.
    c. Wright-Patterson AFB, Ohio.
    d. Hanscom AFB, Massachusetts.

28. (207) Select the Air Force Research Laboratory (AFRL) directorate that works on new technologies to find and engage the enemy and eliminate their ability to hide or threaten our forces.
    a. Sensors.
    b. Information.
    c. Space vehicles.
    d. Human performance.

29. (207) What type of *flight experiments* does the Air Force Research Laboratory (AFRL) Space Vehicles Directorate conduct?
    a. Satellite.
    b. Aerospace vehicle.
    c. Air-delivered munition.
    d. Unmanned aerial vehicle.

30. (207) The Air Force Operational Test and Evaluation Center (AFOTEC) reports to
    a. Twentieth Air Force.
    b. Headquarters, United States Air Force (USAF).
    c. Air Force Space Command (AFSPC).
    d. Air Force Materiel Command (AFMC).

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Publications and Maintenance Programs

PUBLICATIONS ARE the primary method the Air Force uses to document how the mission is, or should be, accomplished. Often, you unknowingly comply with requirements you have never personally read because your supervisor has instructed you to do so or you have been trained to do so. The directions you were provided likely came from an Air Force publication. Compliance with publications and directions is a habit in the Air Force, but it is vital that you understand where this direction comes from as it can change frequently. In time, you will figure out that there are sometimes better ways of doing things than what the technical order (TO) directs; however, you are bound to follow that direction in all circumstances. The only way to improve maintenance efficiency is to submit a technical order improvement report.

To become a successful maintenance technician you need to learn several skills that are basic to your specialty. In this unit, we will explore a few maintenance support programs that you need to understand, as you will use those programs or be involved in them. Understanding the sections in this unit is critical to ensuring your ability to do more than just turn wrenches.

This unit will introduce you to standard publications and guide you through the Air Force's technical order system and the process of submitting a technical order improvement report. The next section will help you understand the deficiency reporting process, and the Integrated Maintenance Data System (IMDS).

2-1. Standard Publications and Technical Orders

There are literally thousands of publications within the DOD and the Air Force. Most standard publications can be found at the click of a mouse, but the technical order system is different. This section will familiarize you with standard publications and will examine the technical order system and how a typical technical order is laid out. This section concludes with a look at the technical order improvement program.

208. Categories and types of standard publications

All standard publications are divided into two main categories: directive and non-directive. This simply tells you whether a publication contains information that MUST be adhered to or whether the information is simply a guide or handbook on how to do something. We will breakdown each category then see how these publications are numbered to make it easier for you to find one. Most publications can be found on the Air Force publications website, so we will look at what that website can offer.

Directive

Directive publications are those necessary to meet the requirements of safety, security, or other areas where common direction and standardization benefit the Air Force. Air Force personnel must comply with these publications as the heading of each of these publications normally contains the following statement: "COMPLIANCE WITH THIS PUBLICATION IS MANDATORY."

Supplements

Before we discuss other types of directive publications, it is prudent to discuss supplements first. Supplements are publications that extend or add material to other publications issued by higher headquarters or other agencies. The key thing to remember about supplements is that they *cannot* contain guidance that is less restrictive than the publication it is supplementing. For example, Air Force Instruction (AFI) 36-2903, *Dress and Personal Appearance of Air Force Personnel*, requires you to wear an outer garment with a knit cap; local supplements cannot authorize you to wear a knit cap without an outer garment.

Policy directives

Air Force policy directives (AFPD) are orders from the Secretary of the Air Force (SECAF) and contain directive policy statements to initiate, govern, and/or regulate actions within specified areas of responsibility or activities. The SECAF is the only approval authority for AFPDs and thus, subordinate units cannot supplement them. An example of an AFPD is AFPD 21-1, *Maintenance of Military Materiel*. This AFPD simply establishes policy and assigns responsibilities for the maintenance of air and space equipment.

Policy memorandum

The difference between an AFPD and an Air Force policy memorandum (AFPM) is simple—a memorandum is published in lieu of a directive when there is insufficient time to process one. These address critical issues such as national security, safety, and so forth when action must happen now, but there is not enough time to finish the directive. An AFPM expires 180 days after publication, so an AFPD must be in development during the 180-day period.

NOTE: Policy directives and memorandums *cannot* be supplemented.

Mission directives

Air Force mission directives (AFMD) are important because they spell out the mission, organization, and responsibilities of Air Force units. Only the unit described in the title of the directive may supplement an AFMD. Subordinate units may issue their own mission directives.

Instructions

Instructions are what you will see most of the time. AFIs are orders from the SECAF and are certified and approved by Air Force HQ staff. AFIs direct action, ensure compliance, and/or give detailed procedures to standardize actions Air Force-wide. AFIs may be supplemented at any level; however, as you have learned, supplements can only make the AFI more restrictive. An example of an AFI is AFI 21-202, Volume 1, *Missile Maintenance Management*. It directs how missile maintenance is managed and compliance with it is mandatory.

Other echelons below AF-level can establish their own instructions as well. For example, Air Force Global Strike Command Instruction (AFGSCI) 21-105, *Corrosion Prevention and Control Program*, directs how technical training is developed and managed. There is no AF-level instruction to govern technical training development, so there is nothing to supplement. AETC developed its own instruction.

Manuals

Air Force manuals (AFMAN) are usually extensions of AFIs, providing additional guidance for performing standard tasks, or supporting education and training programs. An AFMAN does *not* necessarily have to fall under an AFI, but can stand alone. A good example is AFMAN 36-2203, *Drill and Ceremonies*, which contains extensive instructions with illustrations on how to perform drill. Your military training instructor at basic training used this publication extensively.

Operating instructions

Operating instructions (OI) are developed for the same purpose as instructions; however, OIs are only developed for a particular unit's use. When OIs are established, just like AFIs, they direct action and prescribe detailed procedures, but they are only applicable to the unit that created it. They are directive and are mandatory for all personnel in that unit and/or subordinate units.

Non-directive

Non-directive publications are informational and suggest guidance that you can modify to fit the circumstances. Complying with non-directive publications is expected, but *not* mandatory. Air Force personnel use these publications as reference aids or "how-to" guides. Here are some examples of non-directive publications: pamphlets, indexes, official bulletins, handbooks, visual aids, doctrine, and other non-directive publications.

Pamphlets

Air Force pamphlets (AFPAM) are informational, "how-to" publications that may include information for implementing Air Force guidance. They may provide guidance regarding reports, but may not prescribe reports. They may reference forms and provide guidance on completing them, but cannot prescribe the use of the form.

Indexes

Air Force indexes (AFIND) are informational publications used to reference publications and other indexes. Indexes are never supplemented; however, commands may issue their own.

Official bulletins

Bulletins are extremely useful sources of information to keep you up-to-date on office closures and special events that may affect you. They contain temporary announcements, notices, and instructions. Bases usually issue one official bulletin at regular intervals (e.g., weekly, or as needed).

Handbooks

Handbooks are reference books of a particular subject or a compilation of factual data and instructional material not subject to frequent change. A good example of an Air Force handbook (AFH) is AFH 33-337, *The Tongue and Quill*. This handbook contains information on how to communicate effectively in the Air Force, from writing official memorandums to preparing elaborate speeches.

Visual aids

Visual aids are posters or graphic illustrations. They are issued for display on walls, bulletin boards, desks, or other base facilities. There are two kinds of visual aids: permanent and temporary. Permanent visual aids explain or instruct, such as a chart portraying military insignia. Temporary visual aids inform or motivate, such as a poster promoting safe driving. As a rule, temporary visual aids should only be displayed 180 calendar days or less and this expiration date should be printed at the bottom.

Doctrine documents

Air Force doctrine documents (AFDD) are statements of officially sanctioned beliefs and warfighting principles that describe and guide the proper use of air, space, and cyberspace forces in military action. These documents are authoritative, but broad in nature and require judgment in applying them. They can be either doctrine documents or tactics, techniques, and procedures documents.

Other nondirective publications

Other nondirective publications include recurring and nonrecurring publications, directories, handbooks, and catalogs. While we will not discuss them here, you can find detailed explanations of them in AFI 33–360, *Publications and Forms Management*.

Non-Air Force publications

Non-Air Force publications, as the name implies, are produced by federal agencies outside of the Air Force and are directive, or of interest to, the Air Force. They *do not* include commercial, foreign, state, or local government publications. Common sources of non-Air Force publications include the DOD, Department of Health and Human Services, Department of Labor, other military branches, and the Joint Staff, to name a few.

Publication numbering system

Before you try to locate a specific publication, it will help to understand basic concepts of how standard publications are numbered. Let us look at AFI 21-202, Volume 1, *Missile Maintenance Management*, for a walkthrough of how a standard publication is numbered.

- "AF" indicates at what level the publication was directed and published. In this case, the Air Force is the authority for this publication, but other publications could be any echelon, such as "Air Education and Training Command (AETC)" or "91st Missile Wing (MW)," and so forth.
- "I" indicates what type of publication it is. "I" means instruction, but substitute "MAN" for manual, "PAM" for pamphlet for other types of publications. In our case, "AFI" means it is an "Air Force Instruction."
- "21-" indicates the series of publication. "21" means "Maintenance." Figure 2-1 shows a breakdown of the different series of publications in use.
- "202" indicates the control number assigned by the publishing authority.
- "Volume1" indicates the volume in a series of volumes if necessary.

• 10 Operations	• 40 Medical Command
• 11 Flying Operations	• 41 Health Services
• 13 Space, Missile, Command, And Control	• 44 Medical
• 14 Intelligence	• 46 Nursing
• 15 Weather	• 47 Dental
• 16 Operations Support	• 48 Aerospace Medicine
• 20 Logistics	• 51 Law
• 21 Maintenance	• 52 Chaplain
• 23 Materiel Management	• 60 Standardization
• 24 Transportation	• 61 Scientific/Research And Development
• 25 Logistics Staff	• 62 Developmental Engineering
• 31 Security	• 63 Acquisition
• 32 Civil Engineering	• 64 Contracting
• 33 Communications and Information	• 65 Financial Management
• 34 Services	• 71 Special Investigations
• 35 Public Affairs	• 84 History
• 36 Personnel	• 90 Special Management
• 37 Information Management	• 91 Safety
• 38 Manpower And Organization	• 99 Test And Evaluation

Figure 2-1. Publication series.

Air Force publications website

Today, most Air Force publications can be found on the internet in electronic format. This eliminates having paper copies of publications that, for all you know, could be outdated. The Air Force publications website is located at http://www.e-publishing.af.mil . This site is a powerful reference tool for you and it contains just about any unclassified Air Force standard publication, as well as thousands of blank forms prescribed by those publications.

It also contains several Air Force supplements to DOD publications. The publications on this website are maintained as the most current version as well, so you can always access the internet to get the up-to-date information you need instead of relying on paper copies, or the electronic copies on your computer, which may not be maintained and updated.

Some publications contain sensitive information that should not be disclosed to the public and are thus not in electronic format on the website. When you need one of these publications, simply contact the office of primary responsibility as listed on the website for an electronic copy of it.

When you ask your supervisor a question about something, and they tell you to "look it up," this website should always be your starting point. Do not be offended when they tell you to "look it up," instead of simply giving you the answer; they are helping you learn a valuable resource.

209. Technical order system description

Throughout your career, you will need to use technical orders to accomplish tasks. Technical orders provide clear, concise instructions on how to perform maintenance safely and effectively. They also provide a wealth of other information that will help guide you through your maintenance activities. In this lesson, we will look at the different types of technical orders, how technical orders are numbered, and some general policies for using technical orders. We will see how a technical order is normally laid out in a later lesson.

Types of technical orders

There are several different types of technical orders that you will encounter in your career. Let us breakdown each of them. Refer to figure 2-2 for a diagram showing the different types of technical orders.

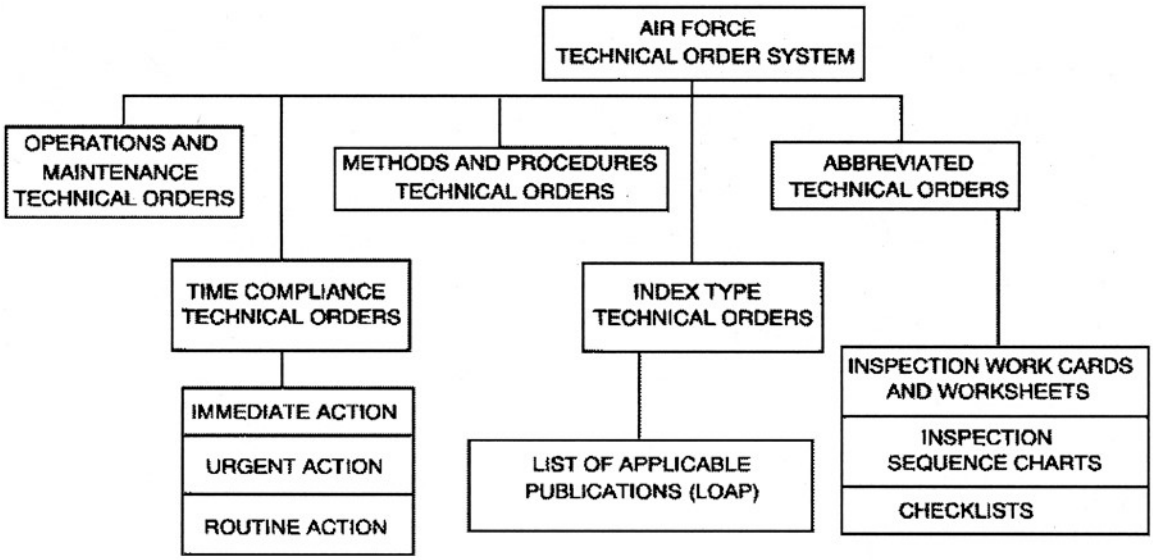


Figure 2-2. Types of technical orders.

Operations and maintenance

Operations and maintenance (O&M) technical orders are what you usually use to follow step-by-step procedures while performing your tasks. They cover the installation, operation, troubleshooting, repairing, removing, calibrating, servicing, or handling of Air Force military systems and end items. O&M technical orders must be available and used wherever maintenance is being performed. Some examples of O&M technical orders are the technical order used to install a manifold gage on the brine chiller or the technical order used to operate the guidance and control test bench.

Methods and procedures

Methods and procedures technical orders (MPTO) are general in content and are not issued against a specific military system, aircraft, weapon, or vehicle. They might have specific information on how to accomplish a task, but they are not required to be available and used on the job site.

An easy way to identify methods and procedures technical orders in *most* instances by the "00" at the start of the TO number. A good example is the technical order (TO) 00-25-234, *General Shop Practice Requirements for the Repair, Maintenance and Test of Electrical Equipment*. When you handle electrostatic discharge (ESD) sensitive components, you use procedures outlined in this technical order, but you do not need to have the book open in the immediate area, referencing what you are doing. Another example is the TO 32-1-101, *Use and Care of Hand Tools and Measuring Tools*, which tells you how to properly use and care for tools. When you use a wrench, you do not need to open this technical order and follow the procedure on how to use a wrench.

Index

Indexes identify needed technical orders, group technical orders pertaining to specific items of equipment, and show the status of all technical orders. A technical order index is the quickest and easiest method to find a technical order when you do not know its number. Using a list of applicable publications index, you can find any technical order applicable to a specific weapon system and its related items.

Abbreviated

Abbreviated technical orders are excerpts from one or more basic technical orders that organize and simplify instructions. They can come as inspection workcards, inspection sequence charts, or checklists. The table below lists and describes the types of abbreviated technical orders.

Types of Abbreviated Technical Orders

Type	Description
Inspection workcards	Workcards that tell you what periodic inspections need to be done on the weapon system. They are developed in sets by type of inspection and normally are broken down by work area or zone. Workcards provide the required guidance, including applicable safety warnings, cautions, and notes and the specific criteria for an inspection to pass or fail
Inspection sequence charts	Breakdown an inspection workcard and show a planned work schedule or sequence in which inspection workcards can be used.
Checklists	Provide abbreviated step-by-step procedures for performing maintenance on the weapon system in the sequence deemed most practical. A checklist will cover not every task or maintenance practice.

Time compliance technical orders

The time compliance technical order (TCTO) is the method of directing and providing instructions for modifications to a weapon system and to perform one-time inspections within a specified time limit. The key point about any TCTO is that there is a time constraint placed on the completion of these procedures and inspections. Any modification or upgrades, such as security modernization or environmental control system replacement, are published in a TCTO directing the upgrade. Another example is if a problem was noted with a transporter erector, a TCTO might be issued to direct a one-time inspection. Procedures would be included on how to perform that inspection to ensure that the vehicle is safe to use. TCTOs are grouped according to their importance and urgency.

The three levels of TCTO urgency, from highest to lowest, are immediate, urgent, and routine action. The table below lists and describes these three levels.

Levels of Time Compliance Technical Orders	
Level	**Description**
Immediate	This is the highest level of TCTO issued. Issued to prevent the use of equipment or procedures until hazardous safety conditions, which could result in fatalities, serious injury to personnel, or extensive damage to or destruction equipment, can be resolved. The words “IMMEDIATE ACTION” is printed in red at the top center of the page and a series of red Xs are printed around the border of the cover page (fig. 2-3).
Urgent	Issued when potentially unsafe conditions exist that could result in personnel injury, damage to property, or when the condition could reduce combat efficiency if not properly attended to. If an urgent action TCTO is not complied with within its set time limit, the equipment or item must be removed from service until the TCTO is accomplished on it – no exceptions. The words “URGENT ACTION” are printed on the top of the page with a series of red diagonals and red Xs around the border of the cover page (fig. 2-4).
Routine	All other TCTOs not covered by immediate or urgent action TCTOs. Though routine, there is still a time limit imposed on completing the procedures or inspections. These could be issued for a system upgrade or to address deficiencies that if not corrected, could become something more serious. Have no significant identifying markings.

X X X **IMMEDIATE ACTION** X X X

TO 1F-16-1140
DATA CODE: 0162903
19830201

DEPARTMENT OF THE AIR FORCE
TECHNICAL ORDER

INSPECTION OF CONSTANT SPEED DRIVE (CSD) ACCUMULATOR MOUNTING BRACKETS, PART NO. 16P1531-23, F-16A/B AIRCRAFT

NOTE

This technical order formalizes IMMEDIATE action TO 1F-16-1140, data code 0162903, dated **DATE**. Remove from active files.

1. APPLICATION.

1.1 Identification. This technical order is applicable to the following aircraft:

Model	Serial Numbers
F-16A	AF78-0001, 78-0003, 78-0005, 78-0008, 78-0026, 78-0056 through 78-0059, 78-0061, 78-0064, 78-0128, 78-0146, 78-0152, through 78-0154, 78-215, 78-0224, 78-0225, 78-0278, 79-0334 through 79-0336, 79-0339, 79-0363, 79-0364, 79-0379, 79-0380, 79-0402, 80-0479, 80-0481, 80-0482, 80-0488, 80-0508, 81-689, 81-0732, through 81-0768, 81-0770, 81-0772.
F-16B	AF78-0077, 78-0081, 78-0084, 78-0088, 78-0095 through 78-0097, 78-0100, 78-0104, 78-0166, 78-0302, 79-0419, 79-0423, 79-0425, 79-0430, 80-0638, 81-0812, 81-0814, 81-0816

1.2 KIT APPLICABILITY. Kits are not required by this TCTO.

1.3 VERIFICATION. Kit verification has been waived by **OFFICE SYMBOL**, in accordance with TO 00-5-15.

Distribution B. Distribution authorized to U.S. Government agencies only (reason) (date of determination). Refer other requests for this document to (controlling/originating DoD office).

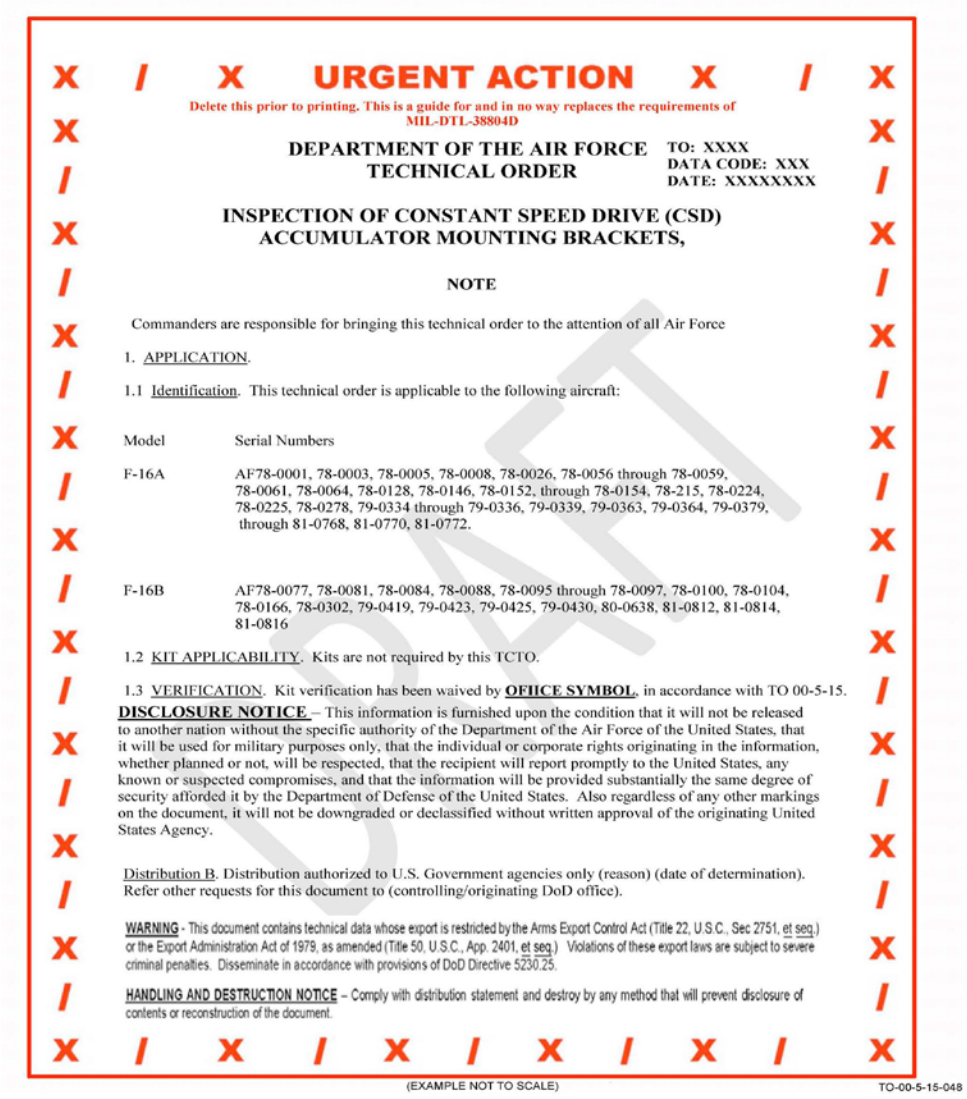
WARNING - This document contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C., Sec 2751, et seq.) or the Export Administration Act of 1979, as amended (Title 50, U.S.C., App. 2401, et seq.) Violations of these export laws are subject to severe criminal penalties. Disseminate in accordance with provisions of DoD Directive 5230.25.

HANDLING AND DESTRUCTION NOTICE – Comply with distribution statement and destroy by any method that will prevent disclosure of contents or reconstruction of the document.

X X X X X X X X X X X

(EXAMPLE NOT TO SCALE) TO-00-5-15-047

Figure 2-3. Immediate action TCTO cover page



Delete this prior to printing. This is a guide for and in no way replaces the requirements of MIL-DTL-38804D

URGENT ACTION

DEPARTMENT OF THE AIR FORCE
TECHNICAL ORDER

TO: XXXX
DATA CODE: XXX
DATE: XXXXXXXX

INSPECTION OF CONSTANT SPEED DRIVE (CSD) ACCUMULATOR MOUNTING BRACKETS,

NOTE

Commanders are responsible for bringing this technical order to the attention of all Air Force

1. APPLICATION.

1.1 Identification. This technical order is applicable to the following aircraft:

Model	Serial Numbers
F-16A	AF78-0001, 78-0003, 78-0005, 78-0008, 78-0026, 78-0056 through 78-0059, 78-0061, 78-0064, 78-0128, 78-0146, 78-0152, through 78-0154, 78-215, 78-0224, 78-0225, 78-0278, 79-0334 through 79-0336, 79-0339, 79-0363, 79-0364, 79-0379, through 81-0768, 81-0770, 81-0772.
F-16B	AF78-0077, 78-0081, 78-0084, 78-0088, 78-0095 through 78-0097, 78-0100, 78-0104, 78-0166, 78-0302, 79-0419, 79-0423, 79-0425, 79-0430, 80-0638, 81-0812, 81-0814, 81-0816

1.2 KIT APPLICABILITY. Kits are not required by this TCTO.

1.3 VERIFICATION. Kit verification has been waived by **OFIICE SYMBOL**, in accordance with TO 00-5-15.

DISCLOSURE NOTICE – This information is furnished upon the condition that it will not be released to another nation without the specific authority of the Department of the Air Force of the United States, that it will be used for military purposes only, that the individual or corporate rights originating in the information, whether planned or not, will be respected, that the recipient will report promptly to the United States, any known or suspected compromises, and that the information will be provided substantially the same degree of security afforded it by the Department of Defense of the United States. Also regardless of any other markings on the document, it will not be downgraded or declassified without written approval of the originating United States Agency.

Distribution B. Distribution authorized to U.S. Government agencies only (reason) (date of determination). Refer other requests for this document to (controlling/originating DoD office).

WARNING - This document contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C., Sec 2751, et seq.) or the Export Administration Act of 1979, as amended (Title 50, U.S.C., App. 2401, et seq.) Violations of these export laws are subject to severe criminal penalties. Disseminate in accordance with provisions of DoD Directive 5230.25.

HANDLING AND DESTRUCTION NOTICE – Comply with distribution statement and destroy by any method that will prevent disclosure of contents or reconstruction of the document.

(EXAMPLE NOT TO SCALE)

TO-00-5-15-048

Figure 2-4. Urgent action TCTO cover page

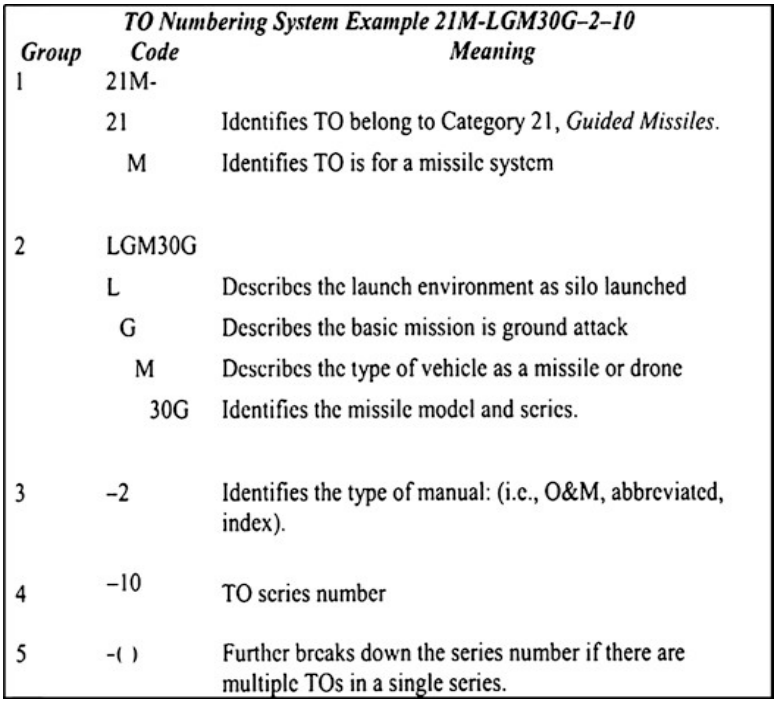
Preliminary

While not classified as a type of technical order, it is important to address the preliminary technical order. When a new piece of equipment or procedure is developed, the tech data is called a preliminary technical order. It *cannot* be used to perform the task yet because it needs to have its procedures verified. This is accomplished by operational personnel with oversight from the technical content manager (TCM). You may have the opportunity to conduct a validation-verification (val-ver) with 20 AF and the technical order manager. Once the procedures have been tested and approved, the preliminary technical order will become an O&M technical order to be used for maintenance on the weapon system.

Technical order numbering system

Understanding how technical orders are numbered will help you immensely when it comes to finding the right one. Each technical order category has its own numbering pattern, so we cannot cover all possible number combinations in this text.

Technical order numbers are composed of groups separated by dashes and each group is further divided into parts. Each part of a group consists of one or more numbers or letters. Use figure 2-5 as an example of the numbering system. The following table provides additional information about the grouping of numbers used in technical order numbering.



TO Numbering System Example 21M-LGM30G–2–10

Group	*Code*	*Meaning*
1	21M-	
	21	Identifies TO belong to Category 21, *Guided Missiles*.
	M	Identifies TO is for a missile system
2	LGM30G	
	L	Describes the launch environment as silo launched
	G	Describes the basic mission is ground attack
	M	Describes the type of vehicle as a missile or drone
	30G	Identifies the missile model and series.
3	–2	Identifies the type of manual: (i.e., O&M, abbreviated, index).
4	–10	TO series number
5	-( )	Further breaks down the series number if there are multiple TOs in a single series.

Figure 2-5. Technical order numbering system example 21M-LGM30G-2-10.

Technical Order Numbering System	
Group	**Description**
1	The first set of numbers/letters before the first dash identifies the category of technical order. The category sets the standard for how the rest of the technical order is numbered. This number corresponds to the supply code assigned to the major system that it applies to. This is how an index technical order is built. It will give you all the technical order under that category. Other technical order categories you will encounter are 32 (which covers special tools) and 33 (which covers test equipment). Our example uses category 21 and our lesson will focus on how category 21 is broken down. Category 21 is for guided missiles and will always be accompanied by an “M” for missile.
2	Under category 21, the first digit in-group 2 identifies the launch environment, second digit identifies the basic mission of the missile, and the third identifies the missile vehicle type. Ours is LGM30G; “L” meaning silo launch, “G” meaning its mission is ground attack, “M” meaning guided missile or drone (which is the only vehicle type). 30G identifies the missile model number and missile production series. “30” indicates Minuteman and “G,” starting from A, indicates it is the seventh in the Minuteman production series.
3	Under category 21, group 3 identifies the type of inspection, instruction, or procedure. In our case, the “-2” indicates an organizational maintenance manual an O&M technical order. Substitute a “-4” for an illustrated parts breakdown, or “-06” for work unit code (WUC) manuals.
4 & 5	These two groups, if used, are assigned series numbers used to distinguish one TO in a series from another.

Looking back at our example, TO 21M-LGM30G-2-10, we know that it pertains to a guided missile, silo launched, with a ground attack mission by a Minuteman missile. We know it is an O&M technical order used for launch facility and support building procedures.

Refer to TO 00-5-18, *AF Technical Order Numbering System*, for more information on breaking down other publication categories or what other identifiers under category 21 mean.

Technical order use

The last thing to understand about the technical order system are some specific rules on using a technical order.

Compliance

As stated earlier, compliance with technical orders is mandatory. They are just what they are called – "orders." They are published under the authority of the SECAF and failure to comply with a TO could be considered failure to obey a lawful order, under Article 92 of the Uniform Code of Military Justice (UCMJ).

If using a technical order (except for a methods and procedures technical order), it must be available and used in the work area. There are different interpretations of this, but if you are performing a maintenance task, your technical order should be open to the procedure you are performing and you should refer to it and know exactly what step you are on.

Sometimes this is not possible when working in a tight space and for other safety reasons you might be working with another person. In this case, use the command and response technique: one technician reads the step; the other does the step, and then verbally responds that the step was complied with. This ensures steps are not missed and the technician performing the task knows what step in the technical order he or she is on.

Lastly, before completing a task, make sure that you read your procedure to check that you did not miss any steps. This can save countless headaches and helps ensure that the job was done completely and correctly.

Conflicts

Sometimes when following a technical order, you might come across information that is contradicted in another publication. The following are some rules to remember when dealing with conflicts:

- If a technical order contradicts information in an AFI, the technical order always has precedence. AFIs should *not* contain procedures on how to perform tasks on maintaining Air Force equipment.
- If a technical order contradicts Air Force Occupational Safety and Health (AFOSH) standards, go with whichever requirement is stricter. This ensures the highest safety standards are followed to prevent personnel injury.
- If a specific system technical order contradicts a general technical order, the specific system technical order always has precedence.
- Inspection workcards take precedence over technical manuals for accept and reject criteria.

Technical order waivers

Remember that the technical orders must be complied with in all cases. You may encounter situations where the technical order is incorrect. Some technicians might find a better way to do something and instead of following the technical order, use their method instead–this is wrong. If you encounter a deficiency in the technical order, you cannot proceed with the task without a technical order waiver. Inform your supervisory personnel, who should then up-channel it to the proper authorities. In most cases, the NAF can issue technical order waivers. If a technical order waiver becomes necessary, always ensure that it is followed up with a TO change as the waiver will not be authorized indefinitely. This is how we get errors in the book corrected, as we will see in a later lesson.

210. Typical technical order format and illustrated parts breakdown

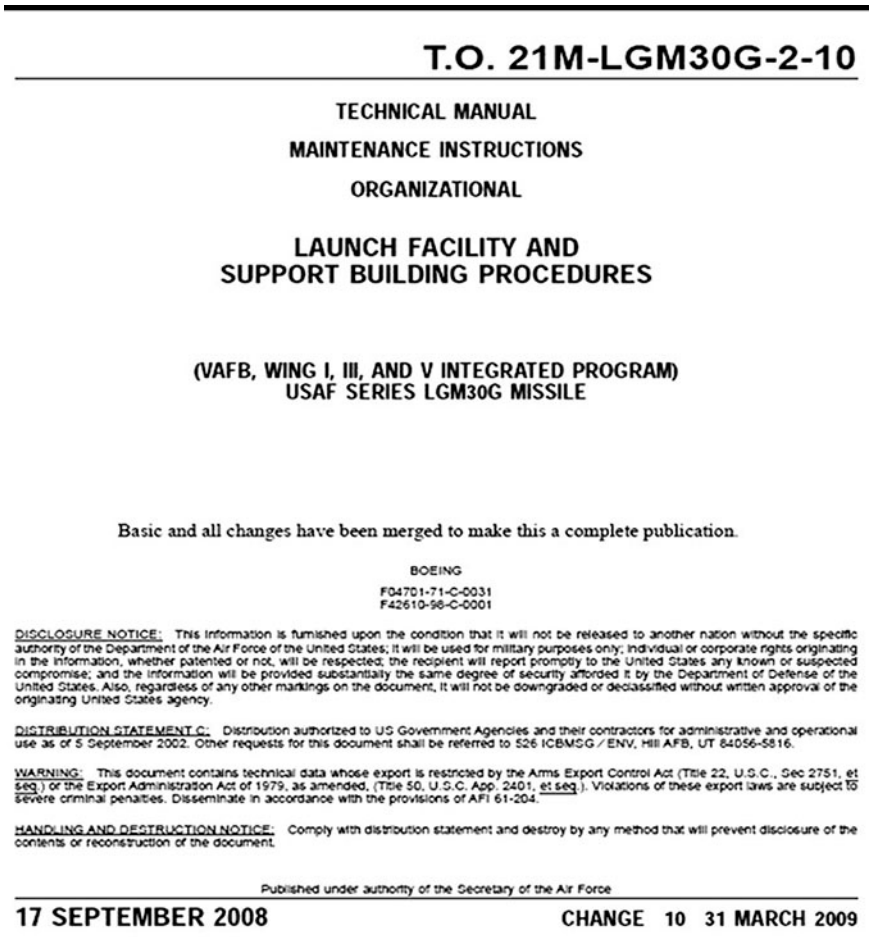
For ease of use, technical orders are divided into organized sections so you can readily find task related information to complete the maintenance successfully. The lesson will provide a breakdown of a typical technical order by section and identify its usefulness to you as an operator or maintenance technician.

Opening pages

Once you open a technical order, there are several administrative items to understand. These items will help you understand the specific layout of a technical order, where to find information in it, how to use it, and safety precautions that must be observed while performing maintenance.

Title page

The first page is the title page. This gives you information such as the technical order number and the title so that you know you have the right book. In the bottom left hand corner, you will find the basic date of the technical order—this is when it was first published. The bottom right hand corner gives you the latest change number and when it was changed. This is particularly important to ensure that you have the most updated book. The technical order library should not issue a technical order that is not current, but it has occurred and the only saving grace was that the user knew the change number the book should have been on. Figure 2-6 shows you a title page and its contents.



T.O. 21M-LGM30G-2-10

TECHNICAL MANUAL

MAINTENANCE INSTRUCTIONS

ORGANIZATIONAL

LAUNCH FACILITY AND
SUPPORT BUILDING PROCEDURES

(VAFB, WING I, III, AND V INTEGRATED PROGRAM)
USAF SERIES LGM30G MISSILE

Basic and all changes have been merged to make this a complete publication.

BOEING

F04701-71-C-0031
F42610-96-C-0001

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Published under authority of the Secretary of the Air Force

17 SEPTEMBER 2008 CHANGE 10 31 MARCH 2009

Figure 2-6. Title page.

List of effective pages

The list of effective pages lists every single page in the technical order and tells you the correct change number for the page. When you want to see the pages that were changed in the latest change, check the change number for each page in the “Change No.” column and you will see what pages were changed recently. This is particularly important when reviewing your technical order to ensure familiarization with the task before a dispatch. Your work center should inform you of applicable changes, but if you are not sure how to perform a task with the changes in it, find out before performing the task. Figure 2-7 shows a portion of a list of effective pages.

T.O. 21M-LGM30G-2-10

INSERT LATEST CHANGED PAGES. DESTROY SUPERSEDED PAGES.

LIST OF EFFECTIVE PAGES

NOTE The portion of the text affected by the changes is indicated by a vertical line in the outer margin of the page. Changes to illustrations are indicated by shaded or screened areas, or by miniature pointing hands.

Dates of issue for original and changed pages are:

Original	0	17 September 2008	Change	6	28 January 2009
Change	1	21 October 2008	Change	7	26 February 2009
Change	2	25 November 2008	Change	8	3 March 2009
Change	3	10 December 2008	Change	9	19 March 2009
Change	4	19 December 2008	Change	10	31 March 2009
Change	5	8 January 2009			

TOTAL NUMBER OF PAGES IN THIS PUBLICATION IS 430 CONSISTING OF THE FOLLOWING:

Page No.	*Change No.	Page No.	*Change No.	Page No.	*Change No.
Title	10	3-112 Blank	0		
A	10	4-1 - 4-16	0		
i - vi	0	4-17 - 4-18	6		
vii - viii	8	4-18.1 Added	6		
ix	0	4-18.2 Blank	6		
x Blank	0	4-19 - 4-40	0		
xi - xiii	0	4-40.1 Added	6		
xiv	1	4-40.2 Blank	6		

Figure 2-7. List of effective pages.

Table of contents, list of illustrations, and tables

These three sections provide a quick reference to locate procedures or illustrations.

Introduction

Surprisingly, the introduction is often the most forgotten section of a technical order, but where the majority of noncompliance errors occur. The introduction covers a variety of general procedures common throughout the technical order. The general procedures are listed here to avoid duplication throughout the technical order.

For example, the introduction of TO 21M-LGM30G–2–11 requires ground paths of electrical equipment to be inspected for any defects, dirt, corrosion or nonconductive coating that can impede conductivity. There is no other mention of this inspection in the technical order, but is a step to be completed every time an electrical ground is connected. As you can see, it is easy to miss a step and be in noncompliance with the technical order.

Safety summary

Almost every technical order will contain a safety summary. This gives you broad safety precautions to follow that are not identified in the technical order. There might also be a summary of all cautions and warnings throughout the technical order so that you can see upfront the safety issues related to your specific tasks. This section *must* be reviewed before starting any maintenance task.

Chapters

Chapters are broken down even further into related information. The typical breakdown consists of a description, special tools and test equipment, checkout/troubleshoot, repair/servicing, and diagrams.

Description

Normally, the description provides a brief, general description of operation and functions of vehicles, equipment, and components. Most technical orders have a description section that will explain to you how the system operates. This information can help you better understand why the system may or may not be operating as designed.

Special tools and test equipment

If you are using a technical order to perform maintenance, you must know what equipment, tools, and materials will be used for the job. The special tools and materials section provides a list of tools and materials and indicates what particular application they are used for (fig. 2-8).

Table 2-1. Special Tools and Material List

Nomenclature	A/N Type Designation/ Model No./National Stock No.	Use and Application
EQUIPMENT:		
Access Hatch Traverse Plate	1450-00-816-0242AH PN 25-32753-1	Used to traverse work cage of launch tube access door.
Adapter, 3/4-inch female to 1-inch male	5120-00-227-8104	Adjusting suspension system leveling jacks.
Adapter, Drill Motor, PAH Handcrank Actuator	Local manufacture (Figure 2-1) or equivalent	Used with drill motor to open/close PAH primary door.
Adhesive	Bostik 1008, USM Corp. Chem. Div, Middletown, MA	Used to repair water diverter system.
Air-Conditioning Unit	4120-00-055-8127	Used to provide fresh air supply and/or purge launch facility.
Alcohol, Isopropyl	Federal Specification TT-I-735	Used to remove hydraulic fluid from equipment.

Figure 2-8. Special tools and material list.

A list of test equipment will tell you the same thing as well as what other equipment is authorized to be used in its place if the original is not available (fig. 2-9). These tables help you in determining if you have the right tool or chemical for completing the procedure by comparing what you physically have to what the technical order lists as a requirement. This is important to know because the procedures you are accomplishing may not contain this information.

Table 2-2. Test Equipment

Nomenclature	A/N Type Designation/ Model No./National Stock No.	Alternate	Use and Application
Breakout Box	OO-ALC Dwg. 7027463		Used to check security monitor switches in launcher closure and launcher closure lock.
Carbon Monoxide Detector Tubes	Drager PNs 6733051, 6728511, CH25601, CH19701, CH20601, 8101951, 8103321	Equivalent with measurement range including 25 ppm	Test for Carbon Monoxide (CO).
Connector-Adapter, Test Probe	25-48703-1	MS3102E20-15P	Used for continuity checking of IZ switch in security pit vault door.
Connector-Adapter, Test Probe	25-48703-2	MS3102E20-15P	Used for continuity checking of IZ switch loop from security pit.

Figure 2-9. Test equipment.

Checkout/troubleshooting and repair/servicing

Normally, the checkout/troubleshooting and repair/servicing chapters are the largest portions of the technical order. They contain the procedures for operation or maintenance.

Diagrams

The last section in a technical order covers diagrams. There are illustrations of components, schematic diagrams, and wiring diagrams that cover all aspects of a system. You can use these diagrams for a variety of situations. Follow the schematics for troubleshooting and understanding system operation. The figures usually have a reference from a procedure to show you where to find a particular piece of a component or where a component is located. The wiring diagrams are useful when performing maintenance on a component and you need to ensure that it is wired correctly.

One important note is that you are *not* authorized to troubleshoot the system using schematic diagrams alone. They must be used in conjunction with operation and checkout procedures or trouble analysis procedures. Failure to comply could result in *death or injury* to personnel or *damage* to equipment.

Glossary

Like all good books, a glossary is provided in the final section of the technical order to ensure proper interpretation of acronyms and unique words.

Technical order changes

It is likely that any technical order that you use will have changes posted to it. These come from improvement reports, as you will see later. You can look at the list of effective pages to see what change number each page is on, but when you refer to that page, there is an easy way to tell what exactly was changed with the latest change.

You will see a straight black line on the outside margin next to the paragraph(s) that changed (fig 2-10). When familiarizing yourself with the task before departing base, pay close attention to this line and make sure that you are familiar with how to perform the changed procedure.

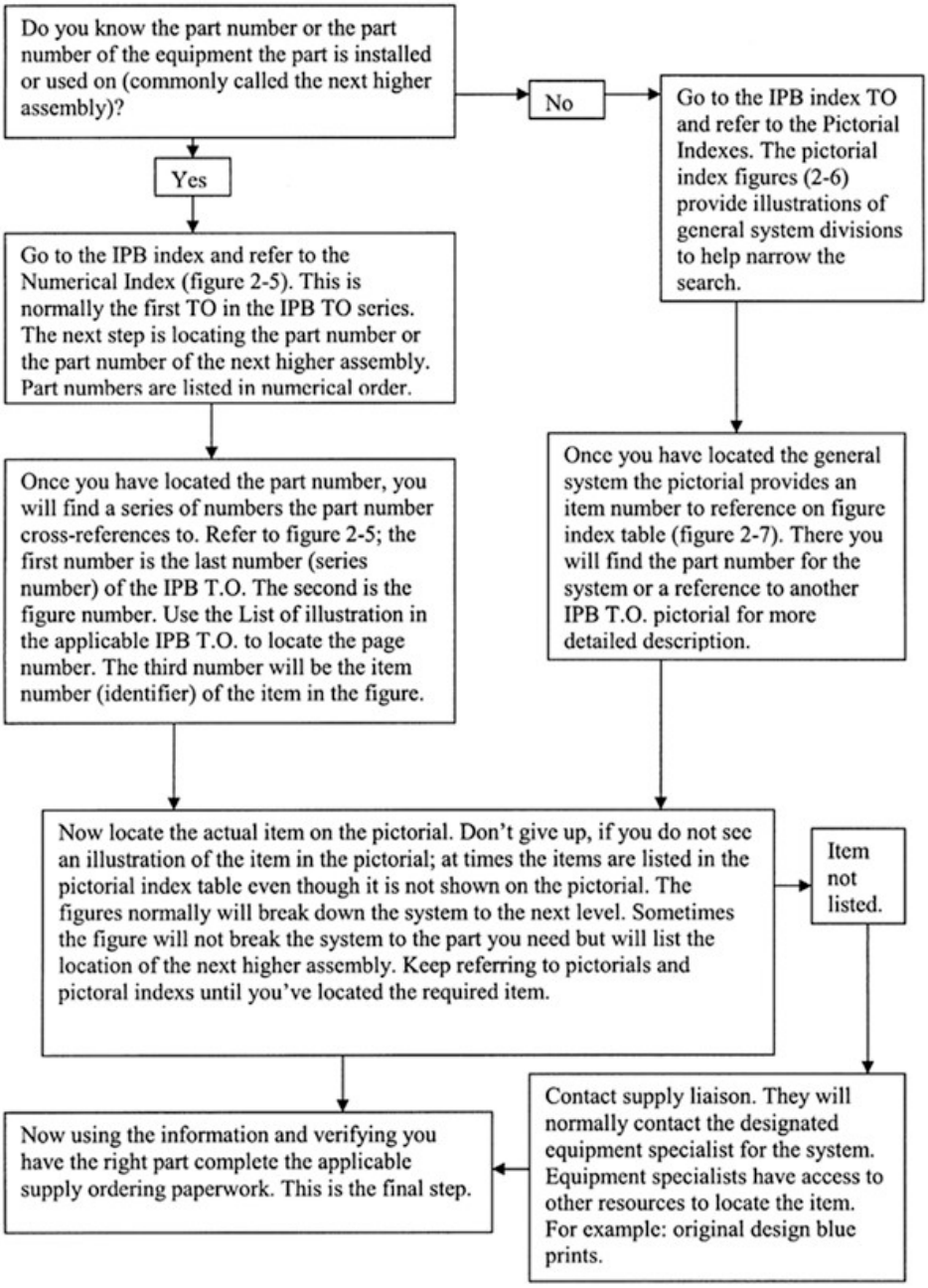


Figure 2-10. Changed content.

Illustrated parts breakdown

An illustrated parts breakdown (IPB) provides detailed parts breakdown of a piece of support equipment or weapon system component. What is so important about the use of an IPB? The IPB is a shopping catalog to order replacement parts. It provides you with a part number numerical index if all you have is the part number or NSN. The IPB also provides a visual representation pictorial index for when you do not have a part number or NSN to ensure the proper part is ordered.

Follow the flow chart in figure 2–11 and use figures 2–12 thru 2–16 to go through a typical scenario of using the IPB.

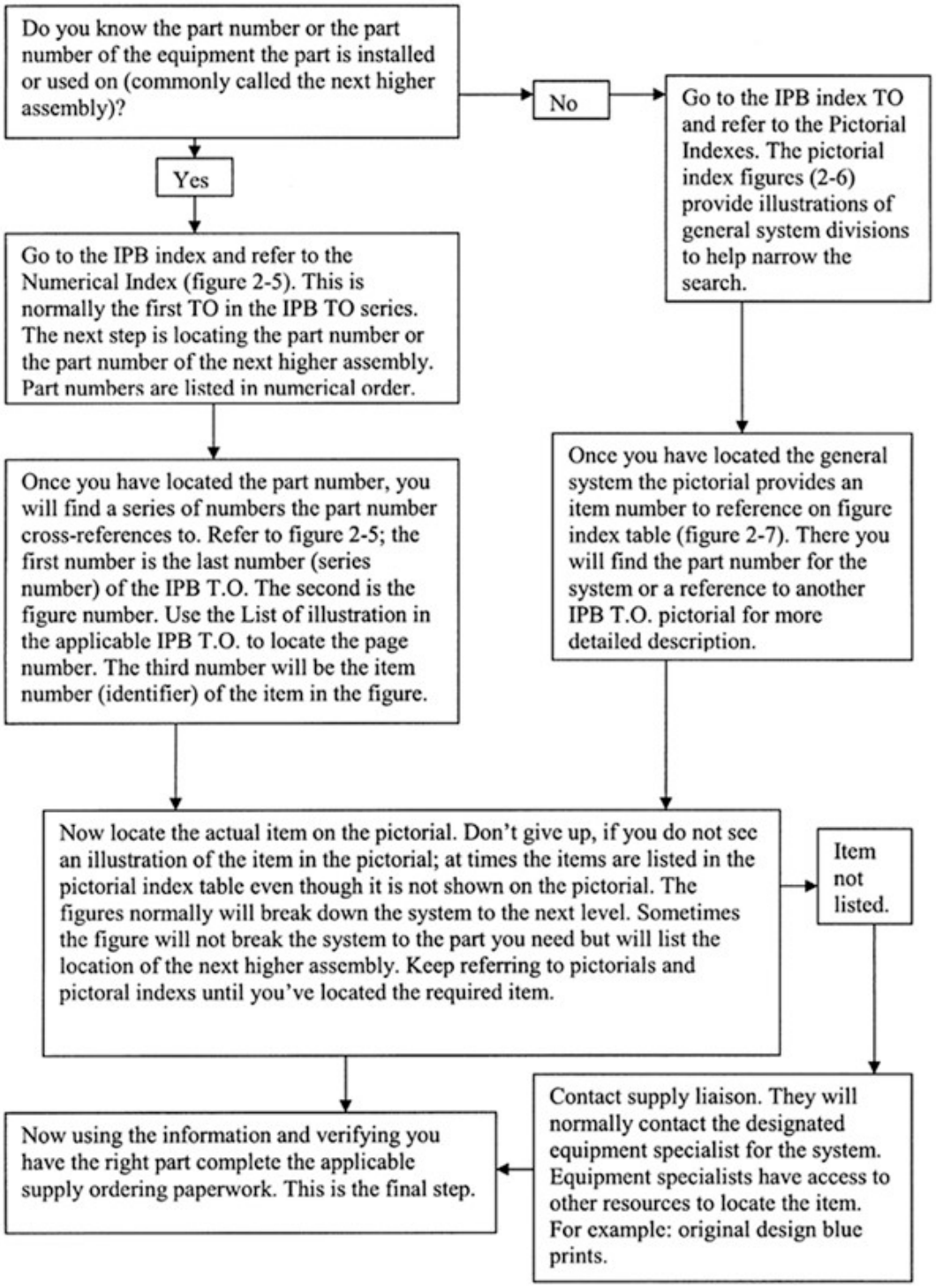


Figure 2–11. Illustrated parks breakdown flow chart.

PART NUMBER	T.O. FIGURE & INDEX NO.	PART NUMBER	T.O. FIGURE & INDEX NO.	PART NUMBER	T.O. FIGURE & INDEX NO.
MS27212-2-4	4-282-28	MS27488-22	7-96-342	MS28774-014	3-104-11
MS27212-2-4	7-95-96	MS27491-16	F 2-48-70F	MS28774-016	2-244-32P
MS27212-2-5	2-5-19	MS27491-16	F 4-285-45	MS28774-024	2-245-27
MS27212-2-5	3-3-27	MS27497E10F35PA	7-96-35	MS28774-024	3-104-27
MS27212-2-5	4-284-45	MS27497T10F35PA	7-96-190	MS28774-024	4-154-48C
MS27212-2-6	F 4-182-50	MS27499E12A4S	2-66-120	MS28774-127	2-245-23
MS27212-2-7	4-283-107	MS27499T20B16P	4-345-14	MS28774-127	3-104-23
MS27212-2-8	2-62-57	MS27500E16A26S	F 2-21-104	MS28774-130	2-244-32C
MS27212-2-8	4-237-37	MS27500E16A26S	F 3-30-125	MS28774-439	7-22-90
MS27212-2-9	4-285-29	MS27500E18A32P	F 2-21-104	MS28774-440	3-103-64D
MS27212-20	3-225A-26	MS27500E18A32P	F 3-30-125	MS28774-8	3-7-8
MS27212-3	4-182-50B	MS27501F11C	F 4-292-11	MS28775-007	F 2-199-8
MS27212-3-3	2-6-129	MS27501F15C	4-225-70M	MS28775-011	2-38-3
MS27212-3-3	3-263-65	MS27502F15C	7-97-5	MS28775-011	3-48-11
MS27212-3-4	2-342-33	MS27506B14-2	4-225-70M	MS28775-011	7-24-51C
MS27212-3-6	2-266-22	MS27508E16A26P	2-21-96	MS28775-012	2-245-39
MS27212-3-7	3-261-36	MS27508E16A26P	3-30-109	MS28775-012	3-63-17
MS27212-4	4-182-50B	MS27508E18A32S	2-21-97	MS28775-012	4-226-19
MS27212-5-4	2-51-166	MS27508E18A32S	3-30-110	MS28775-012	F 6-50-22B
MS27212-5-7	2-6-102	MS27511F16C	F 5-38-543	MS28775-013	2-244-32Q
MS27212-5-7	3-4-39	MS27511F16C	F 6-10-500	MS28775-013	3-62-30
MS27212-5-8	3-4-33	MS27595-136	2-204-31	MS28775-014	2-244-32E
MS27212-54	F 3-37-54	MS27641-3	7-94-46	MS28775-014	3-63-23
MS27221D1	4-208-45	MS27641-6	7-94-66	MS28775-014	7-19-39
MS27245-1	4-338-77	MS27656T11F35S	2-13-57	MS28775-015	2-204-34
MS27283-18	2-222-46	MS27656T15B18S	7-97-5	MS28775-016	2-244-32N
MS27294-1	4-286-28	MS27718-22-1	4-166-13	MS28775-017	7-19-19
MS27400-3	4-282-17	MS27723-22	4-351-10	MS28775-020	2-244-32F
MS27401-33	6-83-20	MS27734-23	2-346-26	MS28775-020	3-104-6
MS27404-4	F 4-366-7	MS27769-3	4-103B-14	MS28775-023	2-244-44
MS27404-4D	4-289-10	MS27769-3	F 7-28-120A	MS28775-023	3-104-2
MS27404-6D	F 2-1-2	MS27769C6	4-347-4	MS28775-024	2-245-28
MS27404-6D	3-1-1A	MS27903-2	4-292-37	MS28775-024	3-104-28
MS27404-6D	F 4-154-6	MS27965	4-365-218	MS28775-024	7-19-38
MS27404-8D	F 4-154-11	MS27965-18	F 4-365-1	MS28775-027	4-157-1
MS27466E17A55P	4-288-44	MS27977-1N	F 4-97-71	MS28775-027	7-18-4
MS27466E17A55PA	4-288-43	MS27977-10	F 4-98A-6	MS28775-116	2-245-30
MS27467E17A55S	4-288-65	MS27977-2	4-98A-5	MS28775-116	3-104-30
MS27467E17A55SA	4-288-64	MS27977-3	F 4-98A-5	MS28775-121	2-245-38
MS27467T11F35P	4-292-13	MS27977-3N	F 4-97-71	MS28775-121	3-104-38
MS27467T15B18P	4-225-70M	MS27977-63N	F 4-97-71	MS28775-127	2-245-24
MS27467T9B98S	F 4-105B-11	MS27977-65N	F 4-97-71	MS28775-127	3-104-24
MS27473E12A4S	F 2-21-103	MS27977-9	4-98A-6	MS28775-130	2-244-32B
MS27473E16A26S	F 2-21-103	MS28173-8	F 3-35-18	MS28775-133	2-69-18
MS27473E16A26S	F 3-30-124	MS28720-12	F 4-25-60	MS28775-136	2-204-30
MS27473E18A32S	F 2-21-103	MS28720-6	F 3-103-168	MS28775-149	7-19-13
MS27473E18A32S	F 3-30-124	MS28720-8	3-103-169C	MS28775-216	2-251-72
MS27473E20A39P	F 2-21-103	MS28741-10-0232	7-53-41	MS28775-224	2-244-35
MS27473E20A39P	F 3-30-124	MS28741-10-0500	7-55-2	MS28775-242	4-269-7
MS27473T14F5S	7-96-219	MS28741-10-0514	7-55-3	MS28775-242	F 6-50-22B
MS27473T20B16S	4-336-12	MS28741-10-1200	7-55-4	MS28775-340	F 3-73-33
MS27474T16F35S	F 5-38-543	MS28741-10-1700	7-55-5	MS28775-348	7-28-124
MS27474T16F35S	F 6-10-500	MS28741-20-0700	7-55-37	MS28775-440	3-103-64E
MS27484T10F35S	7-96-160	MS28741-20-1200	7-55-6	MS28775-441	7-28-111
MS27484T10F35SA	7-96-203	MS28741-4-0180	7-56-72	MS28775-443	4-24-14
MS27484T10F98S	7-96-34	MS28741-40-0500	7-55-1	MS28775-452	7-51-38
MS27484T12F35P	7-96-300	MS28759-4-0114	2-337-18	MS28777-12	2-203-23
MS27484T12F35S	7-96-184	MS28759-4-0140	2-337-19	MS28777-12	4-181-31
MS27484T12F98S	7-96-158	MS28759-4-0140	4-154-26A	MS28777-12	7-55-33
MS27484T14F18S	2-6-161	MS28759-4-0760	7-55-34	MS28777-20	7-55-40
MS27484T14F18S	F 3-2-198	MS28759-4-1500	7-55-7	MS28777-4	2-209-59
MS27484T14F18S	7-96-229	MS28759E0160	4-368-22	MS28777-4	4-154-19
MS27484T14F35S	7-96-201	MS28759E0230	4-368-40	MS28777-6	2-203-14
MS27484T16F35P	7-96-225	MS28773-04	7-45-41	MS28777-6	4-154-32
MS27484T16F35S	7-96-223	MS28774-011	2-245-17	MS28778-10	2-244-28Q
MS27484T16F35SB	7-96-213	MS28774-011	3-104-17	MS28778-10	7-56-58
MS27484T8F98S	7-96-33	MS28774-012	2-251-73	MS28778-12	2-203-6
MS27488-20	F 4-103A-34	MS28774-014	2-245-11	MS28778-12	4-180-3

Figure 2–12. Numerical index.

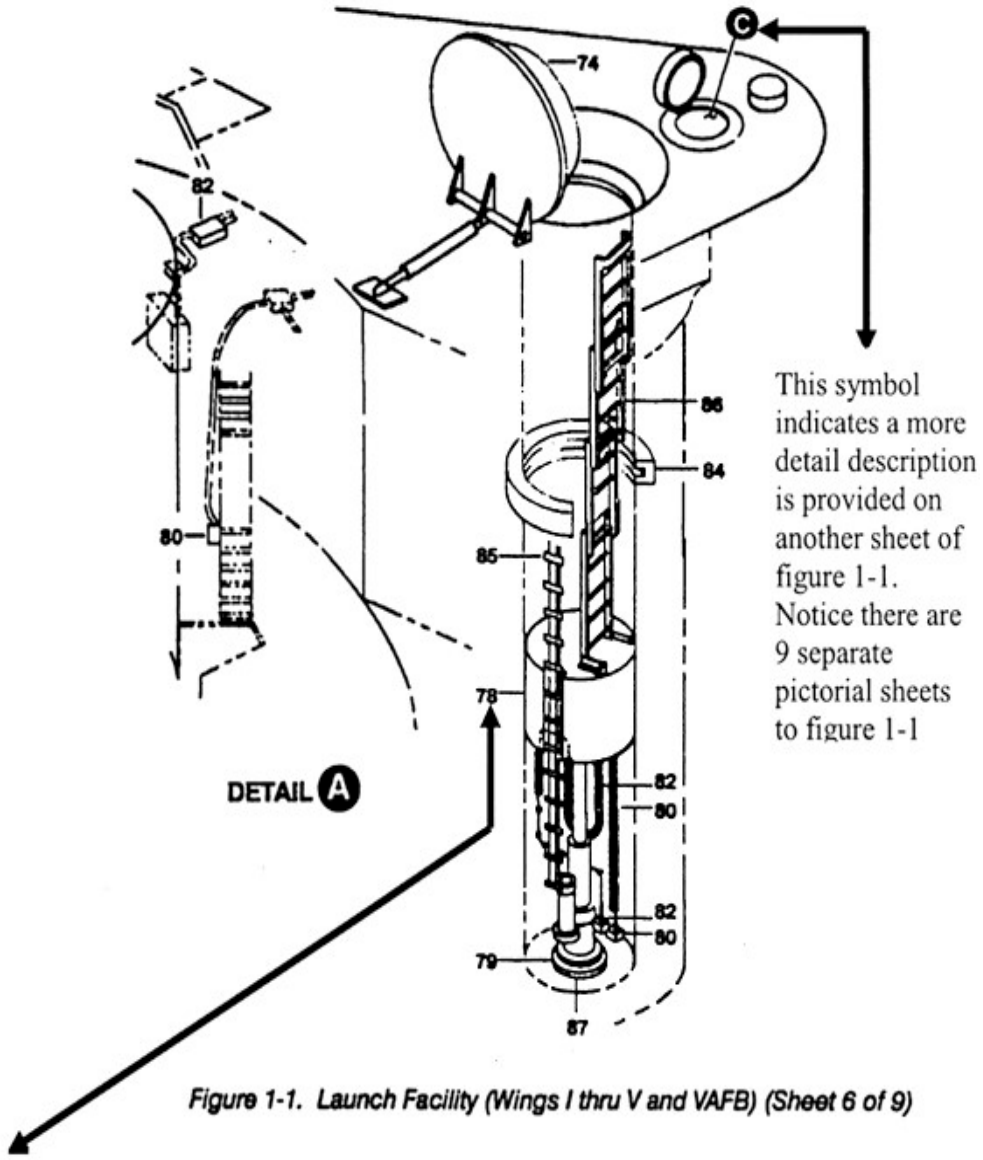


Figure 1-1. Launch Facility (Wings I thru V and VAFB) (Sheet 6 of 9)

The pictorial index provides an index number to cross reference a location of a detailed pictorial description of the assembly. If a technician was attempting to order a secondary door lock door, they would select the index number 78. Then they would refer to the figure index listing to find a more detailed pictorial.

Figure 2–13. Launch facility pictorial index.

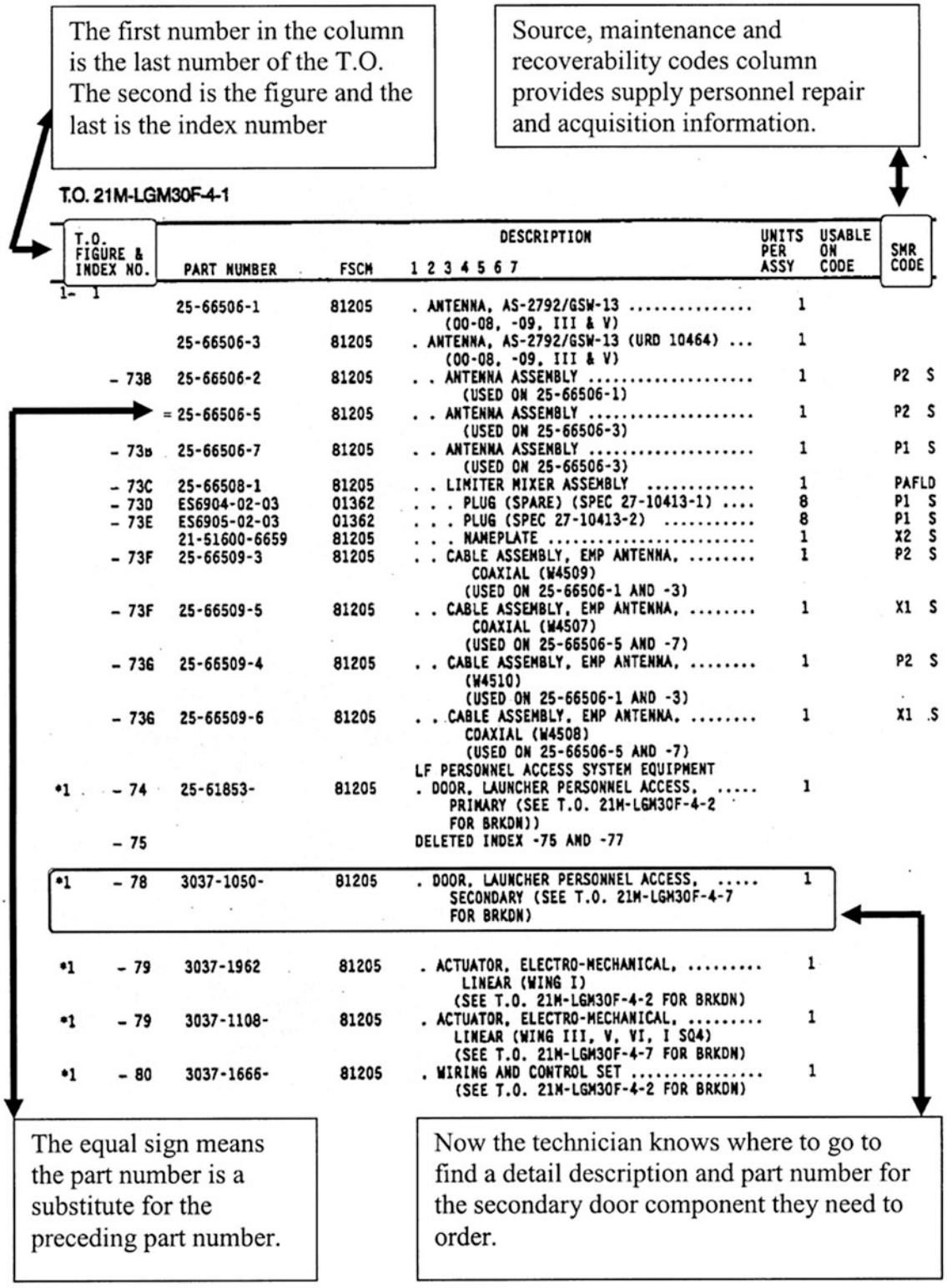
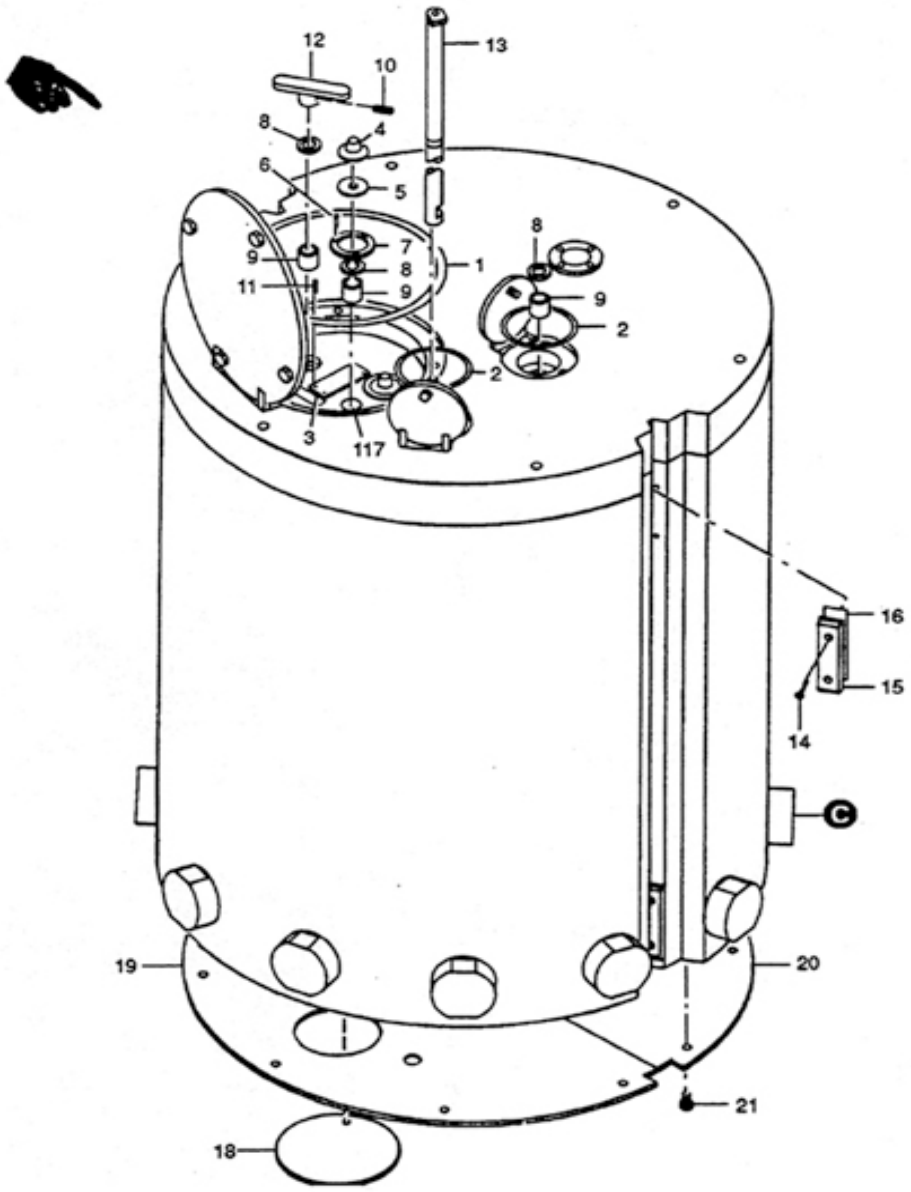


Figure 2–14. Launch facility index table.

T.O. 21M-LGM30F-4-7



The T.O. 21M-LGM30F-4-7 table of contents for the secondary door directed the technician to this figure. Once again the technician will find the index number for the part and refer to the figure index listing (Fig 2-9) for the part number and quantity required.

Figure 2–15. Secondary door pictorial index.

Referring to index number 3, a technician can obtain a secondary door cover plate screw part number. The technician can also refer to the UNITS PER ASSY column and realize that there are 4 screws installed on the cover plate.

T.O. 21M-LGM30F-4-7

T.O. FIGURE & INDEX NO	PART NUMBER	FSCM	DESCRIPTION 1 2 3 4 5 6 7	UNITS PER ASSY	USABLE ON CODE	SMR CODE
7- 38						
	3037-1377	81205	. DOOR SUBASSEMBLY, EMERGENCY DRIVE-UNLOCKING CRANK	2		A F
	3037-1383	81205	. . HINGE, DOOR, EMERGENCY DRIVE AND UNLOCKING CRANK	2		X2
	3037-1381	81205	. . DOOR, EMERGENCY DRIVE AND UNLOCKING CRANK	1		X2
	3037-1379	81205	. . BAR,HINGE DOOR EMERGENCY DRIVE AND UNLOCKING CRANK	1		
- 3	26-17129-1	81205	. PLATE COVER, SECONDARY DOOR	1	JKQR	P1 S
	NKS35457-34	07368	. SCREW (AP)	4	JKQR	P1 S
- 4	C82817	41729	. DIAL AND KNOB	2		
	=9155407	98747	. DIAL AND KNOB	2		
- 4	A317408	41729	. SCREW, LOCK SPINDLE	2		
- 5	C83273	41729	. WASHER, FLAT, FELT	2		
- 6	B68841ADH	41729	. SCREW, ROUND HD, 8-32X3/8IN	6		
- 7	B83248	41729	. FLANGE	2		
- 8	16030M1	80201	. SEAL, OIL, RAWHIDE	4		P1 S
- 9	AA1087	82978	. BUSHING	4		P1 S
- 10	MS51034-50	96906	. SETSCREW (1/4-20X.250IN, CONE POINT)	1		BIL S
- 11	3037-1814	81205	. KEY, LOCK CAM	1		P1 S
- 12	3037-1387	81205	. HANDLE ASSEMBLY, CAM SHAFT, UNLOCKING	1		X2
- 13	3037-1402	81205	. ADAPTER ASSEMBLY, MECHANICAL OVERRIDE ACCESS	1		X2
- 14	NKS24667-3E	07368	. SCREW	16		BIL S
- 15	3037-1374	81205	. GUIDE, BARRIER RECESS	8		P1 S
- 16	3037-1671	81205	. SHIM, GUIDE ADJUSTMENT	8		M
- 17	MS35457-62	96906	. SCREW	1		BIL S
- 18	3037-1372	81205	. ACCESS COVER, SUBASSEMBLY	1		P1 S
- 19	3037-1364	81205	. COVER, HALF-BOTTOM	1		X2
- 20	3037-1365	81205	. COVER, HALF-BOTTOM, CONNECTOR MOUNTING BOX	1		X2
	NKS[illegible]	[illegible]	. SCREW (AP)	10		BIL S
	=MS[illegible]	[illegible]	[illegible]	10		BIL S

Usability codes are used to identify parts manufactured for certain specific assembly. The code key below provides the unquic assembly's part number.

	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	X2 S
MS246[illegible]	[illegible]	96906	[illegible]CREW (AP)	4	GH[illegible]Q	P1 S
MS21318-8	96906		SCREW (AP)	4	EFKLMR	P1 S
29-32069-1	81205		. WIRE BUNDLE, ALARM SECONDARY DOOR	1	EJLO	

CODE	USED ON
E	3037-1050-53
F	3037-1050-67
G	3037-1050-77
H	3037-1050-78
J	3037-1050-79
K	3037-1050-86
L	3037-1050-87
M	3037-1050-88
N	3037-1050-89
P	3037-1050-90
Q	3037-1050-91
R	3037-1050-92

FOOTNOTE:
*1 EFFECTIVE FOR CODE K AND R FOR EEE0317 THRU EEE6000 EXCEPT EEE0349 AND EEE0350

Figure 2–16. Secondary door index table.

211. Technical order improvement report

Occasionally, you may find something in a technical order that is incorrect, unclear, incomplete, improperly sequenced, or you may know a better way to perform a procedure. The Air Force Technical Order (AFTO) Form 22, Technical Manual (TM) Change Recommendation and Reply, provides a way to correct, clarify, include, or correct the information. Sometimes taking the time to submit a technical order change can even earn you extra money. An AFTO Form 22 is one of the items used to support the Airman Powered by Innovation (API). The API program provides monetary award for cost savings ideas. If approved by the principle decision maker you are eligible to receive a $2,500 monetary recognition award. It is worth your time to find and fix technical order problems. This lesson covers the purpose, report categories, and procedures for submitting an AFTO Form 22.

Purpose

As we stated, technical order improvement reports are submitted to correct errors or omissions of a technical nature, which prevent the proper actions required for mission accomplishment. You can also submit an AFTO Form 22 to correct minor inaccuracies of a nontechnical nature that affect the meaning of instructions. Do *not* submit an AFTO Form 22 for typographical or printing errors that do not cause misinterpretation or would normally be corrected during scheduled reviews.

Prior to submittal, your supervisor reviews your form to ensure it is a valid recommendation. Next, the AFTO Form 22 is sent to the designated review authority within the unit—usually quality assurance (QA). The unit's review authority will assess the recommended change in terms of mission impact, personal and aerospace system safety, damage to equipment, work simplification, and the urgency of need for change.

Your local manpower office can help determine manpower savings, if any. Additionally, the reviewer checks that the proper category is assigned and downgrades the category or disapproves the recommendation when appropriate. If the report is valid, the reviewing authority submits the report to the proper control point at a higher echelon. Depending on the category of the report, you can expect to get a response from the control point within 60 days.

Report categories

The three categories for submitting an AFTO Form 22 are emergency, urgent, and routine.

Emergency

Emergency reports require immediate action to correct a technical order deficiency, which if not corrected, *would* result in a fatality or serious injury to personnel, extensive damage or destruction of equipment or property, or inability to achieve or maintain operational posture, including a field-level work stoppage. The responsible TCM issues either an interim TCTO or rapid action change within 48 hours (72 hours for work stoppage) of receiving the AFTO Form 22. The TCM may, with the approval of the control point, disapprove or downgrade the report. However, this must be done within the same 48 to 72-hour period and, as a minimum, a message or e-mail is sent to the originating point review authority stating the reason and new category.

Urgent

Urgent recommendations require action on a technical order deficiency, which if not corrected, *could* cause personnel injury, damage to equipment or property, or reduce operational efficiency. Urgent recommendations are also submitted if the safety or success of mission accomplishment could be jeopardized or the change could result in over $5,000 or 250 man-hours of annual savings to the Air Force.

Submit *all* TCTO deficiencies as urgent. Identification of, or replacements for, Environmental Protection Agency (EPA) hazardous material and ozone depleting chemicals are submitted as urgent as well. The TCM and the technical order management office will publish and distribute a technical

order update within 40 calendar days. No AFTO Form 22 reply is required to be made unless the report is disapproved or downgraded, or the action cannot be completed within 40 calendar days.

Routine

Routine reports require action on deficiencies that do not fall into emergency or urgent categories. These can even include minor typographical errors, word omissions, or printer errors, if they cause a critical misinterpretation or affect the meaning of instructions that impede the mission. The TCM will use the AFTO Form 22 to respond to all routine reports within 45 calendar days of receiving the report. Generally, updates will be published (including printing and distribution) by the responsible agency within one year of receipt of the report.

Procedures

Since each recommended improvement must be evaluated individually, only one improvement per AFTO Form 22 is usually submitted. An exception to this is when the same error occurs more than once in the same technical order. When this happens, identify all locations on a single AFTO Form 22. Another exception is when your AFTO Form 22 improves an inspection manual (–6 TO). Your report may include all locations that need to be changed, such as the workcards. Brief summaries of the deficiency and recommended change are required in the narrative section of the form. Complete the AFTO Form 22 digitally and submit via e-mail. Your reviewing authority will handle it from there and provide you feedback on the process as it occurs.

Be sure to follow-up with the reviewing authority and once an improvement is approved by all agencies, ensure that you get a copy so you can use the API program to your benefit.

Self-Test Questions

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

208. Categories and types of standard publications

1. A supplement *cannot* contain what type of information?

2. What is the main difference between a policy directive and policy memorandum?

3. What are the purposes of an instruction?

4. To whom does operating instructions apply to?

5. What rules apply when posting temporary visual aids?

6. What specific type and series of publication is AFI 32-7086, *Hazardous Materials Management*?

7. If a publication you are looking for contains sensitive information that should not be disclosed to the public, where could you obtain an electronic copy of it?

209. Technical order system description

1. What does an O&M technical order cover?

2. What is the main difference between O&M and methods and procedures technical orders?

3. What information does a list of applicable publications index provide?

4. What are TCTOs used for?

5. How can you identify an immediate action TCTO?

6. What action must occur if an urgent TCTO is not complied with before its time limit?

7. What must occur with a preliminary technical order in order for it to become a usable for maintenance on a weapon system?

8. What do the first two numbers in a technical order number tell you?

9. What is command and response?

10. What guidance is followed if the contents of a technical order conflicts with AFOSH standards?

11. How do you proceed if you find a technical order is incorrect and you cannot perform the task correctly?

210. Typical technical order format and illustrated parts breakdown

1. How does knowing when a technical order was last changed help you?

2. Where would you check if you want to know when the last change was posted to a certain page in the technical order?

3. Which technical order section is often the most forgotten?

4. When is the technical order safety summary section reviewed?

5. How will reading the technical order description help you as a technician?

6. What chapter would a technician use to ensure they had the proper equipment for a procedure in a technical order?

7. When can you use schematic diagrams for troubleshooting?

8. How can you identify what has changed on a technical order page?

9. What is an IPB?

10. If you did not know the part number of a piece of equipment, where would you begin your search in the IPB?

211. Technical order improvement report

1. You do *not* submit an AFTO Form 22 to correct what errors?

2. What should QA do if an improvement report is categorized incorrectly or if it is inaccurate?

3. What must a TCM issue within 48 hours of receiving an emergency AFTO Form 22?

4. When would typographical errors be corrected with an AFTO Form 22?

5. What information is required in the narrative section of an AFTO Form 22?

6. Why would you need a copy of the AFTO Form 22 once all agencies have approved it?

2-2. Maintenance Programs

In addition, to several maintenance practices you need to learn, there are several maintenance programs that enable us to complete our maintenance mission. How frustrating would it be to dispatch to a site to replace a component and discover that your replacement component was defective? The deficiency reporting process will help resolve that particular issue.

Alternatively, how would you feel if you were dispatched to a site to replace a component and found that the wrong part was ordered? This could have been prevented by proper use of the IMDS. The following lessons will outline information on what happens after a deficiency is discovered. They will also describe IMDS, which is the database that is used to capture nearly every action a technician completes in their day-to-day maintenance.

212. Deficiency reporting

Supervisors must be familiar with the materiel deficiency reporting procedures in TO 00–35D–54, *USAF Deficiency Reporting, Investigation, and Resolution*. The purpose of the deficiency reporting process is to provide the Air Force with a means of identifying deficiencies and resolving them with the resources available to the unit. The process also tells leadership at high levels whether deficiencies are being resolved within their organizations. The reporting also allows the program managers to assess the operational risk posed by the deficiency on the systems overall safety, suitability, and effectiveness.

For instance, if you repeatedly received a faulty weapon system processor (WSP), your leadership would take steps to find out why this kept happening. If the problem continued long enough, AFGSC would start looking into the repair processes at the depot. By highlighting a production error, the hope is our efforts will save money and time by fixing a broken process early rather than throwing good money at poor products. This lesson will introduce the deficiency reporting process and outline some key responsibilities in the process.

Definitions

The following paragraphs will introduce you to some terms you need to know in order to understand the deficiency reporting process.

Acceptance inspection

An acceptance inspection is performed by the receiving organization to determine the condition of newly received equipment. The inspection will be of sufficient depth to determine the ability of the item to perform its designed function. This is required for all items received from the Air Logistics

Complex (ALC). If there are problems noted during the inspection, a deficiency report must be drafted.

Action point

The action point is the interface between the support point and the submitting organization. The action point is responsible for all technical and administrative actions for resolution of deficiency reports (DR).

Defect

A defect is any problem or issue with a product where it does not perform as required. A defect can also be hardware missing from an equipment item that does not affect the operation of the item when you first receive it.

Deficiency report

A DR is a generic term used to record, submit, and transmit deficiency data. When a component or item is found to have a defect, a DR needs to be submitted to alert managers of the product. This will ensure your unit is reimbursed the costs of the component or item and ensures the unit has the right products in service. Using DRs can also alert managers that a particular part may not be the best choice to use and a substitute needs to be found.

Department of Defense action point

For those deficiencies that cross DOD component lines, the DOD action point is the published DOD source of supply (SOS) location. In those cases where the product was procured by other than the DOD SOS, the procuring activity can be considered the DOD action point.

End item

An end item is a system, equipment, or component that by itself performs a military function that contributes to the mission. An end item is usually made up of several smaller parts that are procured separately, and removed and replaced to return the end item to service.

Exhibit

The exhibit is the failed, deficient, or nonconforming item. This represents the deficient condition and the item must be segregated from other like components or equipment to ensure it can be properly investigated by the product managers.

Initial acceptance inspection

This is an abbreviated DR used to report critical and major defects found by the using activity during acceptance inspection on assets received from depot maintenance facilities.

Item manager

An item manager is an individual or office that has overall management responsibility of an item.

Material improvement project

A material improvement project (MIP) is a planned effort to investigate and resolve deficiencies, adverse trends, or to evaluate proposed improvements or enhancements. A MIP may be established whenever a deficiency, improvement, or enhancement is determined to warrant further investigation or consideration. It is used to monitor and control related actions.

Originator

The originator is an individual within a component (Army, Navy, Marines, Air Force, Coast Guard, Defense Logistics Agency, or Contractor General Services Administration) who discovers and reports a deficiency.

Originating point

The originating point acts as the focal point for communication and interaction with the screening point or action point. This person reviews reports to assure they are valid, complete, accurate, and properly addressed. He or she assigns report control numbers, ensures proper marking and handling of exhibits, transmits reports to the appropriate database, and monitors outstanding reports.

Quality assurance specialist

This individual has responsibility for the resolution of a quality related deficiency, or supports the investigation of quality related deficiencies.

Screening point

The screening point at each respective ALC serves as the focal point for the receipt and processing of DRs. This office reviews reports to assure they are categorized properly and are valid, complete, and accurate. The screening point also obtains correct or missing information from the originating point and processes DRs to the proper action point within or outside the organization.

Single point of contact office

This office serves as a one face, one phone number to the customer, to answer questions, or direct questions or DR related concerns that any customer may express.

Support point

This activity assists the action point (as requested) in processing, investigating, and resolving a deficiency.

System program office

This office serves as one face, one phone number to the customer, to answer questions, or direct questions or DR related concerns that a customer expressed during acquisition.

Defects

When a deficiency report is submitted, it is classified according to the possible outcomes of the defect. The three types of defects are listed and described in the table below.

Types of Defects	
Type	**Description**
Critical	A defect based on judgment and experience that is likely to result in hazardous or unsafe conditions for people using, maintaining, operating, or depending on the product. Additionally, it may be a defect based on judgment and experience that is likely to prevent performance of the tactical function of a major end item, such as a missile or space vehicle.
Major	This is a condition, other than critical, that is likely to result in failure, or reduces the usability of the item for its intended purpose.
Minor	A defect that is *not* likely to reduce the usability of the unit or product for the intended purpose, or is a departure from established standards having little bearing on the effective operation of the unit. A launch facility (LF) power supply drawer that is missing panel screws when you pick it up from supply point falls into this type of defect. The drawer will still function; however, it is missing hardware and the deficiency report will allow your unit to be reimbursed for the cost.

Types of deficiencies

The method and response to a deficiency not only depends on the criticality of the defect, but is also determined by what type of deficiency it is. In the table, some common deficiencies are listed and described.

Types of Deficiencies	
Type	**Description**
Acceptance Inspection	Just as the names suggests, anything that is not correct when the item is inspected prior to use. Examples such as LF electronic drawers, motor generators and chiller components.
Engineering Investigation	Report an unacceptable condition or request a failure analysis. Can be for: • Compatibility issues. • Anomalous behavior. • Component or item failures. • Software and application failures. • Provide improvement recommendations.
Product Quality	This is the most common type of deficiency. This applies when a component or equipment item does not fulfill its expected purpose or service due to deficiencies in design, specifications, material, manufacturing process, or workmanship. This is the case when you install or use a brand new component or equipment item and it fails right away or fails within its warranty service period. For example, a team dispatches to replace a weapon system processor at a launch control center (LCC). During checkout, the newly installed drawer fails.

Deficiency report categories

Deficiency reports are either classified as Category I or Category II. The following table will help you determine what category deficiency to report. If any doubt exists about how to categorize a deficiency, either your unit QA or wing safety office can help.

Deficiency Report Categories	
Category	**Description**
I	Deficiencies which: • Directly restrict combat or operational readiness. • If uncorrected, would cause death, severe injury, or severe illness. • In uncorrected, would cause major loss or damage to equipment or a system.
II	A deficiency that *does not meet* the criteria for a Category I, or is: • Found during an initial acceptance inspection. • A potential enhancement (applies to enhancements noted during the acquisition phase of a product). • Attributable to errors in workmanship, nonconformance to specifications, drawing standards, or other technical requirements. • A failure or condition that occurs during initial inspection, initial bench check, initial installation operational check, or initial operational use.

Responsibilities

The following table describes all of the steps in the deficiency reporting process and who is responsible to initiate it and resolve it.

Deficiency Reporting Process	
Actor	**Responsibilities**
Originator	Discovers and identifies impact of the deficiency. Secures the exhibit. Provides all available information to the originating point. Helps the originating point as requested.
Originating Point	Certifies the validity, completeness, and accuracy of the deficiency report. Validates the deficiency category. Ensures exhibit(s) is/are available, secured, and properly identified. Submits the validated report to the screening point in the appropriate database, within specified time limits. Acts as focal point for communications and interaction with the screening point.
Screening Point	Reviews deficiency reports for proper categorization, validity, correctness of entries, and accuracy. Determines and transmits the report to the appropriate database. Maintains the audit trail for each report. Provides exhibit disposition instructions to the originating point. Establishes routing and tracking mechanisms.
Action Point	Responsible for all technical and administrative actions necessary for deficiency report resolution. Coordinates with item managers, specialists, and engineers as necessary to evaluate and initiate a course of action for deficiency report resolution. Provides status updates, closing actions, and exhibit disposition instructions to the screening point. Maintains active oversight of all deficiency reports assigned to them.
Support Point	Assists the action point when requested. Conducts investigations, trend analysis, and recommends corrective and preventative actions.

213. Integrated Maintenance Data System

The IMDS is an automated data collection and information system that supports all maintenance efforts. It was designed and implemented to enhance readiness by improving the flow and availability of maintenance information. IMDS supports the commander and managers at all levels of the maintenance community. It also provides much of the maintenance data needed by using MAJCOMs (AFGSC, Air Force Materiel Command [AFMC], etc.), HQ USAF, and other agencies to manage and track maintenance resources worldwide. As a technician, you need to understand how IMDS is used in the maintenance complex, because you are a major contributor to the integrity of the data collected.

Objectives

When maintenance is performed, whether on-site or on base, extensive data must be collected to account for the time you spent, the parts used, the systems you worked on, and the steps you took to checkout or repair the system. When this data is entered into IMDS, it tells the story of what you did, what it took to do that job, and how long you spent doing it. IMDS data translates to commanders and managers how many personnel are needed to do the job, what high-failure parts are needed to keep on hand, and/or what systems are outdated and need upgrade. When you document this data on your paperwork, it is very important that you record everything as accurate as possible.

This only helps you as the technician and future technicians that will follow you. Here are some objectives of the IMDS program:

- Eliminate and/or reduce nonproductive administrative tasks, thereby improving efficiency in the organization.
- Ensure that Air Force material is serviceable, operable, and properly configured.
- Provide better capability for maintenance information programs and organizations to support Air Force peacetime and wartime missions.
- Provide more accurate maintenance data that is needed to develop technical requirements, concepts, and plans supporting weapon system development.
- Identify changing needs for the maintenance community in the areas of personnel, equipment, and subsystem technology (upgrades and modifications).
- Provide more responsive maintenance systems and methods to support changing operational needs.
- Support senior maintenance managers in their need to better organize and train the force to support the operational mission in the most effective and productive manner.

As you can see, IMDS will provide a wealth of information to managers to make your maintenance organization more productive, with the right personnel, equipment, and resources to do the job.

Functions

IMDS allows you to perform three basic functions–update the database, retrieve information from the database, and report the data required to those agencies that manage and track maintenance resources. The table below describes these functions.

IMDS Functions

Function	Description
Database updates	Allows you to enter new data, change existing data, and delete erroneous and obsolete data from the database.
Information retrieval	There are two types of retrievals provided. 1. Real-time retrievals are processed at the time of input and returned to the requesting terminal. Allows you to view current data. 2. Background retrievals are processed and sent to your remote line printer or the high-speed printer located at the data processing center. Allows you to view historical data.
Reporting	Reports required by higher headquarters are produced to the extent possible as a byproduct of the normal base-level operation of IMDS. It is then automatically extracted and transmitted to other maintenance information systems, such as the Reliability and Maintainability Information System (REMIS) or the Integrated Logistics System-Supply (ILS-S) on a periodic basis by IMDS interface programs. This eliminates one administrative task that makes your organization more efficient.

Subsystems

IMDS has several subsystems, or screen numbers as you might be familiar with that aid IMDS in meeting the objectives and requirements of the maintenance community. In the table below are some of them that will be used most often.

IMDS Subsystems	
Subsystem	**Description**
Maintenance Events	Allows the user to track maintenance actions and has both maintenance and supply data. The user can create, schedule, defer, reschedule, and cancel events. The user can also inquire into supply data related to recorded discrepancies.
Location	Allows the user to automate the location of missiles and aerospace ground equipment, as well as any other equipment deemed critical to the organization's operation.
Job Data Documentation (JDD)	Allows users to document, inquire, and retrieve information on maintenance actions. Work activity and job completion can be reported for all maintenance on-site and on base.
Operational Events	This subsystem can be described in three phases: Phase one (Mission Recording) is the scheduling phase where teams and workorders can be scheduled. Phase two (Mission Accomplishment) is the period from start to stop of an operational event. Phase three (Analysis Phase) provides the capabilities for periodic reports of mission accomplishment.
Maintenance Personnel	Allows the user to monitor manpower resources.
Training Management	Allows the user to schedule and forecast personnel training requirements. This is commonly used to schedule your recurring training, such as shotgun qualification, or gas mask training.
Base Supply System Interface	This interface provides the capability to order parts for unscheduled discrepancies. Additionally, numerous types of supply system inquiries can be made.
Automated Debriefing	Provides debriefing functions including deviation data, discrepancies discovered, and tracking and reporting of recurring discrepancies.

Data accuracy

The accuracy of the data put in the system is paramount. As a technician, it is critical that you provide the most accurate data. If you forget to record, for example, the diesel hours or fuel level from an LF, it is best that you be honest about it and not guess what the figures were. When you discover a discrepancy that requires parts, it will be your role as a team chief or technician to research the correct parts and ensure the part information is attached to the workorder when you create it.

WUCs are used to track the maintenance history on a certain component or end item. It is critical you use the correct WUCs of what you worked on. All this data projects future maintenance actions and gets you the resources needed to do the job. How many times have you been scheduled to complete a workorder, but could not because you had the wrong part? The accuracy of the data you provide will only help you as the technician.

To ensure data accuracy, your work center supervisors are responsible to review the data entered on a daily basis. This further ensures the accuracy and completeness of data entered into IMDS. Be prepared to come to work on a day off if your maintenance data is incomplete or inaccurate. Remember, the job is not done until the paperwork is done! If it is not done right, then the job is not done.

Self-Test Questions

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

212. Deficiency reporting

1. What is an acceptance inspection?

2. What is a defect?

3. Which item must be segregated from other like components until an investigation by the production manager occurs?

4. Who must generate a deficiency report when a discrepancy is discovered?

5. What type of defect is a condition that is likely to result in failure?

6. What type of deficiency would be used to determine failure analysis?

7. What is a product quality deficiency?

8. What deficiency report category is used when a defect, if uncorrected, *would* cause death, severe injury, or severe illness?

9. What deficiency report category is used for deficiencies that are found during the initial acceptance inspection?

10. Match the steps in the deficiency reporting process in column B to their responsibility in column A. Each item in column B may be used more than once.

Column A		*Column B*
____ (1)	Submits the validated deficiency report within time limits.	a. Originator.
____ (2)	Responsible for technical and administrative actions necessary to resolve deficiency reports.	b. Originating Point.
____ (3)	Provides exhibit disposition instructions.	c. Screening Point.
____ (4)	Discovers and identifies impact of deficiency.	d. Action Point.
____ (5)	Conducts investigations, trend analysis, and recommends corrective actions.	e. Support Point.
____ (6)	Secures the exhibit.	
____ (7)	Provides status updates and closing actions.	

213. Integrated Maintenance Data System

1. What does IMDS data translate into for commanders and managers?

2. What IMDS function allows you to enter new data or change existing data?

3. What types of information retrieval does IMDS provide?

4. What IMDS subsystem allows users to document, inquire, and retrieve information on maintenance actions?

5. What are the three phases of the IMDS operational events subsystem?

6. What IMDS subsystem is commonly used to schedule shotgun qualification training?

7. Who must review IMDS data entered on a daily basis?

Answers to Self-Test Questions

208

1. Guidance that is less restrictive than the publication it is supplementing.
2. A memorandum is published in lieu of a directive when there is insufficient time to process a directive.
3. Directs action, ensures compliance, and/or gives detailed procedures to standardize actions Air Force-wide.
4. All personnel in the unit or subordinate unit who developed them.
5. They should only be displayed for 180 days or less and the expiration date should be printed on the bottom.
6. Air Force Instruction, civil engineering series.
7. The office of primary responsibility listed on the website.

209

1. The installation, operation, troubleshooting, repairing, removing, calibrating, servicing, or handling Air Force military systems and end items.
2. Methods and procedures technical orders are not required to be available and used at the job site.
3. Any technical order applicable to a specific weapon system and its related items.
4. Directing and providing instructions for modifications or to perform one-time inspections, within a specified time limit.
5. “IMMEDIATE ACTION” is printed in red at the top center of the first page and a series of red Xs are printed around the border of the cover page.
6. The equipment or item must be removed from service until the TCTO is accomplished.
7. It must have a validation-verification performed.
8. The category of the technical order.
9. One technician reads the step; the other does the step, and then verbally responds to indicate that the step was complied with.
10. Whichever requirement is stricter.
11. Inform your supervisory personnel to obtain a technical order waiver.

210

1. It ensures that you have the most updated book.
2. List of effective pages.
3. Introduction.
4. Before starting any maintenance task.
5. It will help you obtain a better understanding why the system may or may not be operating properly by explaining to you how the system is designed operate.
6. Special tools and test equipment.
7. When used with trouble analysis procedures.
8. You will see a black line next to the paragraph(s) that changed.
9. It is an illustration providing detailed parts breakdown of a piece of support equipment or weapon system component.
10. Use the pictorial index to look for a picture of the item.

211

1. Typographical or printing errors that do not cause misinterpretation or would normally be corrected during scheduled reviews.
2. Downgrade the category or disapprove the recommendation.
3. An interim TCTO or rapid action change.

4. If they cause critical misinterpretation or affect the meaning of instructions that impede the mission.
5. Brief summary of deficiencies and recommended change.
6. So that you can use the API program to your benefit.

212

1. An inspection performed by a receiving organization to determine the condition of newly received equipment.
2. A problem or issue with a product where it does not perform as it is required.
3. Exhibit.
4. Originator-the individual within a component (Army, Navy, Marines, Air Force, Coast Guard, Defense Logistics Agency, or Contractor General Services Administration) who discovers and reports the deficiency.
5. Major defect.
6. Engineering investigation.
7. When a component or equipment item does not fulfill its expected purpose or service due to deficiencies in design, specifications, material, manufacturing process, or workmanship.
8. Category I.
9. Category II.
10. (1) b.
    (2) d.
    (3) c.
    (4) a.
    (5) e.
    (6) a.
    (7) d.

213

1. How many personnel are needed to do the job, what high-failure parts are needed to keep on hand, and/or what systems are outdated and need upgrade.
2. Database updates.
3. Real-time and background retrievals.
4. JDD.
5. Mission Recording, Mission Accomplishment, and Analysis Phase.
6. Training management.
7. Workcenter supervisors.

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. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

31. (208) Select the type of publication that extends or adds material to other publications issued by higher headquarters or other agencies.
    a. Civil engineering manuals.
    b. Air Force instructions (AFI).
    c. Policy directives.
    d. Supplements.

32. (208) Air Force policy directives (AFPD) *cannot* be supplemented by subordinate units because
    a. they supplement Air Force instructions (AFI).
    b. the Air Force Chief of Staff is the only approval authority.
    c. the Secretary of the Air Force (SECAF) is the only approval authority.
    d. they are directed by the unit commander and are not subject to supplements.

33. (208) Which organizational level are operating instructions developed for?
    a. Major command (MAJCOM).
    b. Element.
    c. Wing.
    d. Unit.

34. (208) What is the purpose of a *permanent* visual aid?
    a. Explain or instruct.
    b. Inform or motivate.
    c. Promote or endorse.
    d. Direct or implement.

35. (208) Doctrine documents
    a. support education and training programs.
    b. are published in lieu of a policy directive.
    c. direct action and provide detailed procedures.
    d. are broad in nature and require judgment in their application.

36. (208) You should reference the Air Force publishing website for publications rather than using a copy found on a computer or network drive because
    a. the website versions contain more information.
    b. the website maintains the most current version.
    c. paper copies are only used for the revision process.
    d. the website contains sensitive information that is not in your paper copies.

37. (209) A *methods and procedures* technical order contains
    a. status of all time compliance technical orders (TCTO).
    b. troubleshooting steps for specific military systems and end items.
    c. general information that applies to more than one weapon system.
    d. excerpts from one more technical orders that organize and simplify instructions.

38. (209) Select the quickest and easiest method of finding a technical order when you do not know its number.
    a. Look it up in an index-type technical order.
    b. Check the technical order internet repository.
    c. Look for it on the Air Force publishing website.
    d. Check other technical orders to find a specific reference to it.

39. (209) Which information does an *inspection workcard* contain?
    a. Step-by-step procedures.
    b. Specific pass or fail criteria.
    c. Planned work schedule or sequence.
    d. Abbreviated step-by-step procedures.

40. (209) What happens when an *urgent* time compliance technical order (TCTO) is *not* completed within its set time limit?
    a. The equipment or item must be removed from service.
    b. An improvement report must be filed to change the TCTO.
    c. A periodic inspection must be completed on the equipment or item.
    d. The item must be returned to the depot in order to complete the required actions.

41. (209) Before a *preliminary* technical order can be used for maintenance on a weapon system, it must
    a. be incorporated into the List of Applicable Publications.
    b. be approved for interim use by the base missile engineer.
    c. be accompanied by a technical order waiver from your supervisor.
    d. have its procedures verified with oversight from the technical content manager (TCM).

42. (209) When a conflict between a technical order and an Air Force Safety & Health Standard (AFOSH) exists, you must use
    a. whichever guidance is more restrictive.
    b. a combination of the two procedures.
    c. the technical order guidance.
    d. the AFOSH guidance.

43. (210) Which information is located in the *bottom right* hand corner of a technical order's title page?
    a. When the technical order was first published.
    b. The title and technical order number assigned.
    c. The technical order category and what it is used for.
    d. Latest change number and the date it was published.

44. (210) Which portion of the technical orders are the technicians *not* authorized to use to troubleshoot a system?
    a. Operation procedures.
    b. Checkout procedures.
    c. Schematic diagrams.
    d. Change pages.

45. (211) Select the priority that is selected on an Air Force Technical Order (AFTO) Form 22 for a technical order deficiency which, if not corrected, *would* result in a fatality or serious injury to personnel.
    a. Urgent.
    b. Category I.
    c. Emergency.
    d. Category III.

46. (211) An Air Force Technical Order (AFTO) Form 22 submitted for a deficiency in a time compliance technical order must be submitted using which priority?
    a. Emergency.
    b. Standard.
    c. Routine.
    d. Urgent.

47. (211) After the technical content manager (TCM) receives a routine technical order improvement report, the technical order is generally updated
    a. within 1 year.
    b. within 48 hours.
    c. with the next publication review.
    d. with the next publication revision.

48. (211) More than one correction can be submitted on a technical order improvement report under which circumstance?
    a. If authorized by quality assurance (QA).
    b. The report is an emergency priority.
    c. The same error occurs in more than one technical order.
    d. The error occurs more than once in the same technical order.

49. (212) The purpose of the deficiency reporting (DR) process is to identify
    a. shortcomings in unit resources.
    b. unit deficiencies in the procurement process.
    c. deficiencies and resolve them with unit resources.
    d. shortcomings and the deficiencies that cause them.

50. (212) The purpose of the receiving organization performing an acceptance inspection is to
    a. verify stock numbers of equipment received.
    b. determine the condition of newly received equipment.
    c. ensure that depot is performing only depot-level maintenance.
    d. ensure the number of items ordered are the quantity received.

51. (212) A *critical* defect is described as a defect that
    a. is not likely to reduce the usability of the unit or product for its intended purpose.
    b. cannot be corrected accept through a product design or specification change.
    c. impacts operational safety, suitability, or effectiveness of a system.
    d. is likely to cause hazardous or unsafe conditions.

52. (212) A *product quality* deficiency is a component that
    a. fails outside of its warranty period.
    b. limits or prevents the use of other equipment.
    c. fails immediately, or within its warranty period.
    d. fails an initial checkout, and may cause equipment damage.

53. (213) Select the Integrated Maintenance Data System (IMDS) function that allows the user to view *historical* data.
    a. Reporting.
    b. Database updates.
    c. Real-time retrievals.
    d. Information retrievals.

54. (213) Which Integrated Maintenance Data System (IMDS) subsystem allows the user to track maintenance actions and has both maintenance and supply data?
    a. Operational events.
    b. Maintenance events.
    c. Maintenance personnel.
    d. Job data documentation (JDD).

55. (213) Select the Integrated Maintenance Data System (IMDS) operational event phase that provides the capability for periodic reports of mission accomplishment.
    a. Analysis phase.
    b. Mission recording.
    c. Automated debriefing.
    d. Mission accomplishment.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Maintenance Fundamentals

MAINTENANCE INVOLVES more than just turning wrenches. To become a successful maintenance technician you need to learn several other skills that are basic to your specialty. Simply turning wrenches will not solve many of the problems you encounter in the missile field. Just knowing how to turn wrenches will prevent you from gaining additional knowledge to understand how certain things function or how they may affect other systems or components. That total maintenance concept will help ensure our weapon system is always mission ready.

In this unit, we will explore a few maintenance practices that will help you succeed in this career field. We will take a close look at some of the precautions you must take to eliminate potential ESD damage to our system's sensitive components and are basic to good troubleshooting techniques. Then, we will gain an understanding of hydraulic and pneumatic systems. Understanding these sections is critical to ensuring your ability to do more than just turn wrenches. You must gain an understanding of how components and systems operate and how they work together.

3-1. General Maintenance Practices

There are several maintenance practices in the field that you need to learn in addition to knowing the ins and outs of your specialty. This section will focus on two of them, ESD and troubleshooting theory and techniques, but there are countless things you will learn throughout your career that will help you understand the maintenance process. The next two lessons will focus on some ESD procedures followed by common trouble shooting theory and techniques.

214. Electrostatic discharge control

The components that make up our weapon system range from something as simple as a transducer, to systems as complex as a command and control computer. The basic make-up of these systems is similar; they are electrical and are susceptible to ESD. In this lesson, we will cover a basic overview of the common ESD control procedures used in your career field.

Electrostatic discharge

Have you ever walked across carpet and reached out to open a doorknob only to be shocked? What you may not know is the static discharge between your hand and the doorknob may have reached 35,000 volts. These kinds of voltage spikes are a major concern when working around and with the sensitive electronic circuits used in our weapon system. Due to the hazards involved when handling these components, particularly in dry and arid climates, special handling procedures were developed for ESD sensitive devices. TO 00-25-234 covers the framework of control for ESD sensitive devices, and gives good examples of materials and circumstances that contribute to static electricity (fig. 3-1).

Typical Sources of Static Electricity	
Object or Process	**Material or Activity**
Work Surface	Finished wood Common vinyl or plastics Waxed, painted, or varnished surfaces
Floors	Sealed concrete Carpeted surfaces Waxed, finished wood Common vinyl tile or sheeting High pressure laminates made from insulated materials
Clothes	Virgin cotton Common synthetic personal garments Common synthetic clean room smocks Non-conductive or synthetic shoe soles
Chairs	Fiberglass Vinyl, plastic Finished wood Synthetic fabric
Packaging and Handling	Paper products Tapes, tape dispensers, stickers Common plastic bubble pack, foam Common plastic connector caps or plugs Common plastic bags, wraps, envelopes Common plastic trays, tote boxes, vials, part bins Sufficiently aged anti-static treated bags, wraps, envelopes
Assembly, Cleaning, Test, and Repair Areas	Spray cleaners Polyethylene bags, pouches Common plastic solder suckers Solvent brushes (synthetic bristles) Cleaning with high resistance fluids Solder irons or guns with ungrounded tips

Figure 3-1. Typical sources of static electricity.

Electrostatic discharge defined

Static electricity occurs when two items are rubbed together (friction) causing one item to lose electrons, and the other item to gain them. This causes an unbalanced amount of electrons to build up. This build up can be a positive or negative electrical charge depending on whether the item was gaining or losing electrons. A conductive material will evenly dissipate the charge over its surface, but a non-conductive material will not. This inability to dissipate the electrons causes the item to stay charged. When this item gets near another item that has a different potential, the electrons will flow from the negatively charged item to the positively charged one. This is known as ESD, which can seriously damage sensitive devices. Figure 3-2 shows some ESD voltages generated by personnel during certain activities.

Means of static generation	Electrostatic Voltages
	10 to 20 percent relative humidity
Walking across carpet	35,000
Walking over vinyl floor	12,000
Worker moving at bench	6,000
Opening and closing vinyl envelopes used to carry work instructions	7,000
Common plastic bag picked up from bench	20,000
Worker sliding in work chair padded with polyurethane	18,000

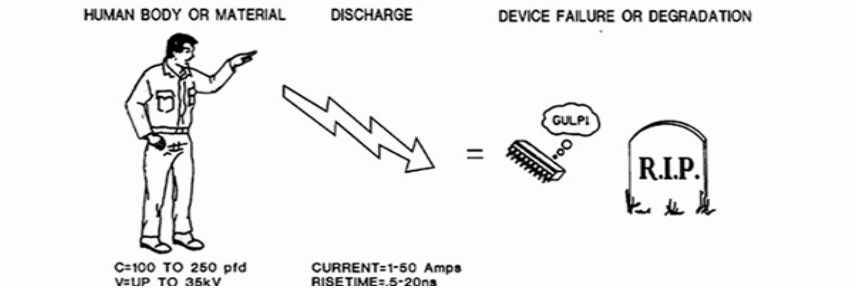


Figure 3-2. ESD voltages generated by personnel.

ESD sensitivity defined

ESD sensitive (ESDS) devices are those devices that will fail if they were subjected to voltages ranging from zero to 16,000.

Susceptible items

As a maintenance technician, you can expect to deal with ESDS items in three primary areas: cabling/connectors, line replaceable units (LRU), and circuit cards.

Primary Areas of ESD	
Primary Area	**Description**
Cables and connectors	Any cable or connector that is electrically connected to equipment that contain ESDS components.
LRUs	Any type assembly that forms an enclosure around ESDS components and is typically removed and installed as an entire assembly (example: electronic drawers).
Circuit cards	Items that directly carry discrete ESDS components.

Identifying electrostatic discharge sensitive devices

Whether you are removing a circuit card, replacing a LRU, or are just connecting a cable, you must know if the components you are dealing with are ESDS. Understanding how to locate and identify ESDS devices can save you a lot of grief. Here are a few tips to ensure you are not inadvertently exposing any sensitive items to ESD.

Markings

Be observant and check for ESD markings (fig. 3-3). Many pieces of equipment and even packaging items will have stickers on the exterior surface letting you know that ESDS components are contained within. These indicators should clue you in that special ESD handling precautions need to be taken.

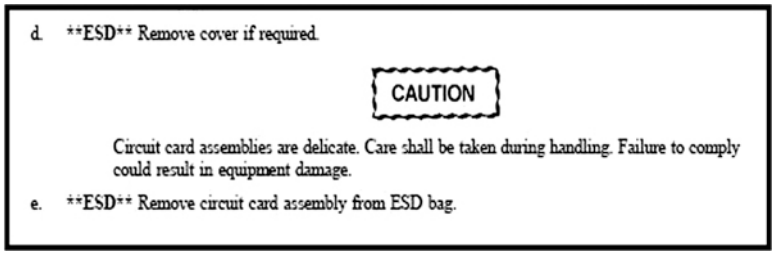
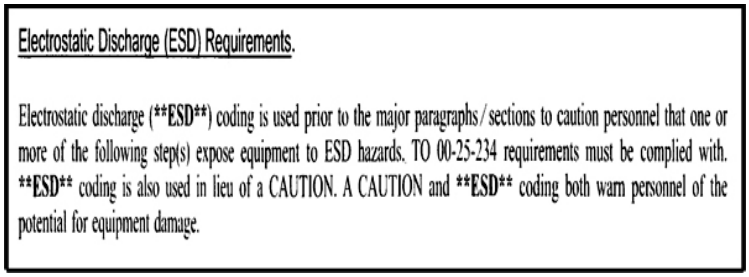


Figure 3-3. ESD markings.

Technical orders

Believe it or not, the serious nature of ESD exposure to our sensitive weapon system components warranted an additional chapter dedicated to ESD in our TO 21M-LGM30G-2-10, *Launch Facility and Support Building Procedures*. This chapter identifies all the ESDS components along with their unit reference designators (URD) within the LF and LCC. This information gives you a quick and easy way to check and see if an item is ESDS, and by using the URD, you can narrow down your schematic search to see if any cables you may be connecting or disconnecting lead to any of these ESDS items. Always exercise good ESD practices, as good rule of thumb, as outlined in the 2-10 and 00-25-234 technical orders.

Our maintenance technical orders contain special indicators that let you know when a step in a procedure deals with ESD requirements. In the introduction section (also called the forward), you may come across a paragraph as depicted in figure 3-4. If this paragraph exists, then you know there will be maintenance tasks in that particular technical order that involves working with ESDS items.

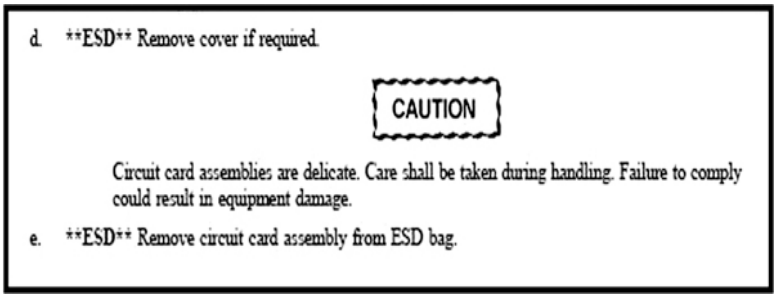


Electrostatic Discharge (ESD) Requirements.

Electrostatic discharge (**ESD**) coding is used prior to the major paragraphs/sections to caution personnel that one or more of the following step(s) expose equipment to ESD hazards. TO 00-25-234 requirements must be complied with. **ESD** coding is also used in lieu of a CAUTION. A CAUTION and **ESD** coding both warn personnel of the potential for equipment damage.

Figure 3-4. ESD requirement paragraph.

The **ESD** symbol will appear in the heading of each task with maintenance steps that involve ESDS items. You will know which steps in the task require ESD control, because the **ESD** symbol will appear at the beginning of each of those steps (fig. 3-5). This lets you know that you will be working with an ESDS item and you need to use proper ESD controls to accomplish the maintenance actions.



d. **ESD** Remove cover if required.

CAUTION

Circuit card assemblies are delicate. Care shall be taken during handling. Failure to comply could result in equipment damage.

e. **ESD** Remove circuit card assembly from ESD bag.

Figure 3-5. ESD requirement indicator.

Discrete parts

By now, you should already know that when you are removing or replacing circuit cards, special ESD control is paramount. In these cases, such as removing cards inside the auxiliary alarm panel (AAP), you will by applying greater ESD prevention measures. Therefore, always refer to your technical order before engaging in any activity that would lead you to working inside any equipment cabinet or LRU.

As a safety note, always verify power is removed before touching any circuits. Even with power removed, some components contain capacitors that could cause serious injury if not properly de-energized.

Electrostatic discharge control procedures

Many ESDS devices are electrically connected throughout a network of cabling and internal wiring. Therefore, you must know what each cable you might be removing or installing is electrically connected to. Additionally, if you ever perform maintenance on the AAP or take a job in the electronics laboratory you will be required to take additional precautions to prevent ESD. At a minimum, all new personnel involved with handling ESDS items shall receive initial ESD awareness and prevention training and annual refresher training thereafter.

Now we will discuss the two options you will have when working around or handling ESDS items.

Option 1

Option 1 refers to the ESD practice of equalizing your potential with the equipment item you are connecting or disconnecting cables to and from or when removing or installing conductive dust caps on LRUs before installing and after removing these items from the equipment rack. Compliance with this option is achieved by touching and maintaining contact with the metal surface (bare metal preferable) of the ESDS item's case with your bare skin before any other actions are taken. Both cable connections and LRU conductive dust cap installations are described below using option 1.

NOTE: Option 1 cannot be used for handling circuit cards.

Option 2

Option 2 refers to the ESD practice of utilizing a ground wrist strap to equalize your potential with the equipment item you are working on. The wrist strap is the single most important item for effective static control. Personnel must test their wrist straps before initial use each day and log the date, time, results, and user name. This log is for QA purposes.

Wrist strap testers will be located within the units. The tester checks for both electrical continuity and resistance. Once the wrist strap is snugly fit on the user's wrist or forearm and the banana jack plugged into the tester, the individual uses either hand to depress a metal contact plate. Typically a green light indicates the wrist strap passes; a red light could be the resultant of several factors such a dry skin, faulty wrist strap, or bad cord to name a few. As a safety precaution, wrist straps shall not be worn when working on energized components.

Cabling and connectors

The weapon system utilizes a common point ground; therefore, the cables connected to the equipment racks and everything within have equal potential. When you are required to remove or install a cable on an equipment rack or other equipment items that contain ESDS components you must first equalize your own potential with the equipment you are working with. The easiest way to do this is to use Option 1.

Touch the metal surface (bare metal preferable) on the equipment rack with one hand or arm, and with the other hand, hold the metallic back shell of the cable connector. Bare skin contact is the key term. Therefore, long sleeves only increase the potential for more static electricity. A good maintenance practice is to roll up your sleeves above the elbow or remove your Airman battle uniform (ABU) shirt all together before making any connections. If you pull your hand off the equipment rack to re-examine the cable, be sure you ground yourself again before attempting the connection.

Line replaceable units

In this scenario, we are just going to focus on the electronic drawers since this will more than likely be the LRU you will be handling the most. The drawer casing acts as a protective barrier or termed "Faraday Cage" for the discrete components inside, but the exposed connectors represent a hole in this cage and create a pathway for ESD pulses to travel. Therefore, you will always ensure all the connectors on the drawer have conductive dust caps installed when the drawer is not installed or in the process of being installed in the equipment rack.

To correctly apply Option 1 ESD control procedures for installing the drawer, you must equalize your potential with the drawer's metallic case with bare skin, then while maintaining contact, remove the dust caps. Again, a good maintenance practice would be to roll up your sleeves above the elbow or remove your ABU shirt all together. Follow your technical order for normal connector inspection and install the drawer into the equipment rack. Removal of the drawer is treated in the same fashion in that bare skin contact is maintained until the conductive dust caps are installed.

Circuit cards

Since circuit cards offer no protective barrier from ESD like the equipment drawer's casing provides the discrete components within, special ESD handling is required. Typically, when circuit cards are not installed in equipment items, they will be packaged in special combination of non-generating and static-shielding packaging. We will discuss the different types of packaging a little later in this lesson. For example, we will focus our discussion on the AAP circuit card removal and installation at a launch control facility (LCF) using the portable static control workstation. Typically, this procedure is done with the AAP installed on the drawer slides and will not require the use of a portable static control work station mat, only a wrist strap.

In order to apply option 2 ESD control procedures to this task, you utilize a portable static control workstation. This kit contains a thin foldable static dissipative mat, a wrist strap, a 10-foot cord, and a common point ground system (CPGS). The workstation must be properly grounded with the resistance being less than 10 ohms between the portable workstation CPGS and the facility ground point (fig. 3-6). Each technician's ground strap is connected to the CPGS. Typical ground points at the LF and LCF are predetermined and tested annually or during subsequent maintenance dispatches to these locations. This information is maintained in your section's ESD program. At this point, all technicians directly working inside the AAP shall at a minimum roll their sleeves up above their elbows, or remove their ABU shirts all together. Also, all non-essential static producing items shall be cleared away from the work area. Once the area is cleared and the portable workstation is tested, set the AAP on the mat, install the conductive dust caps (if not previously accomplished), and begin removing the screws to gain access to the circuit cards. Prior to removing the cover, you must don your wrist straps. Afterwards, you may safely remove the old circuit card, place it in an approved packaging container (usually the same container the new card came in), and install the new card. Once the cover makes metal-to-metal contact and the "Faraday Cage" is reestablished, the wrist straps may be removed.

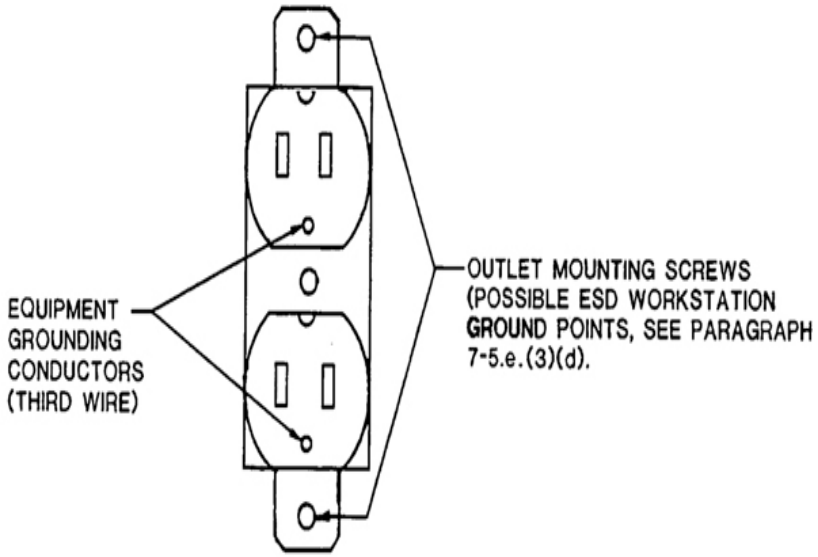


Figure 3-6. Typical ground point.

Support base maintenance

There are some differences between conducting ESD operations in the field and in the electronics laboratory. Below are a few of those differences based on working in a lab:

- Fixed static control workstations with larger surface areas than the portable static control workstation.
- The ground point resistance check requirement must be less than 1 ohm as opposed to less than 10 ohms when on site.
- Special provisions will be in place when a wrist strap cannot be worn in the work area due to potential hazardous voltages. These provisions include items such as static dissipative flooring, footwear, and seating.
- Special ESD-safe tools equipped with static dissipative systems such as soldering irons, compressed air guns, and vacuums to name a few.

Although we have discussed a few variances in the proper ESD control procedures, always refer to the technical order for the most up-to-date ESD practices.

Electrostatic control products

Whenever an ESDS item must be transported between workstations, work areas, or installations the item must be properly packaged in an approved ESD package and clearly marked. Now, some of the packaging materials used for ESDS items like circuit cards and the associated markings will be covered.

Packaging types

One of the handling procedures for ESDS items is the method of packaging. This typically means using combinations of the three types of packaging available. These three packaging options are listed and explained in the table below.

ESD Packaging Materials	
Type	**Description**
I	A metallic shield barrier (usually has a transparent silver appearance) made to withstand many phenomenon outside of ESD. This could include moisture, electromagnetic interference, and radio frequency interference. This type is used to cover type II non-generating packaging materials. This bag will have an ESD marking on its surface or would be the place you would adhere an ESD label. These bags may have zip lock seals or zippers, or may be vacuumed or heat sealed, or may have the opening flap folded over and sealed with an ESD sticker.
II	Typically a pink antistatic polyethylene film (non-generating plastic material) that prevents any static generating from occurring within. Can also be foam or, bubble wrap. This is the first layer of packaging material that will cover an ESDS item and can be placed inside both type I and III packaging.
III	A combination of the type I and II materials. The internal type II pink antistatic polyethylene (film, foam, or bubble wrap) is adhered to the inside of the type III metallic shielding bag. These bags may have zip lock seals or zippers, or may be vacuumed or heat sealed, or may have the opening flap folded over and sealed with an ESD sticker. Again, ESD markings will be visible on the exterior surface. This type of packaging is the preferred method for transporting and storing ESDS items due to its dual-purpose quality.

Packaging configurations

Anytime an ESDS item is stored locally or transported, ESD protective packaging is required. There are two variations of packing ESDS components that we will cover, with and without paperwork. Descriptions of them are given in the table below. Be sure to refer to your technical order for specific guidance.

For all options, the outer shielding bag shall be sealed by any method mentioned above with ESD markings applied.

ESDS Component Packaging options	
Option	**Description**
Without Paperwork	May be placed inside type III packaging alone.
	May be placed inside type II packaging and then placed into type I packaging.
With Paperwork	May be placed in type III packaging and then placed into type II or III packaging with paperwork placed between the two bags.
	May be placed inside type II packaging and then placed into type I packaging. The paperwork may be placed inside an additional non-charge generating pouch and adhered to the outside of the type I packaging.

Keep in mind; just because an ESDS item is faulty, you still need to package the item in accordance with TO 00-25-234.

Marking

As you have just read, the ESD labels will be on the outside of the type I and type III packaging. If this packaging is to be placed inside a box for shipping then another ESD label will be adhered to the outside of the box. This is to inform personnel that ESDS components are contained within.

Failure types

There are three classifications of electronic failures associated with ESD: catastrophic, intermittent, and latent. Each one is listed and described in the table below:

ESD Failure Types	
Type Failure	**Description**
Catastrophic	An ESDS component will not function at all. This type of failure is easy to detect because the electrical parts, assemblies, and equipment will not operate.
Intermittent	An ESDS component that functions on and off. This type of failure may be detected by noting the erroneous signals or errors that are given by the electrical equipment.
Latent	An ESDS component that functions properly in a normal environment, but may have been partially damaged. This type of failure is very hard to detect as the electrical item may pass normal inspections and checkout, but may fail when the electrical component is subjected to high gravity-forces, extreme temperature changes, or mechanical shock. This type of failure is considered the worst since there are no second chances to rectify the problem once a missile is launched.

Common ESD misconceptions

Many misconceptions about ESD exist in the career field. Here are three truths about these misconceptions.

1. Higher humidity will solve the ESD problem. The truth is lack of humidity does increase the likely hood of ESD generation, but high humidity on its own will not solve the ESD problem. Only practicing proper ESD procedures will solve an ESD problem.
   NOTE: The ideal humidity for working with ESD sensitive items is between 40 and 60 percent relative humidity.
2. Components are safe from ESD once mounted on a circuit board. The installation has not changed a thing; the components are still just as susceptible.
3. If the electrical assembly passes checkout the individual components must have been handled properly. Not true, there could always be a latent or intermittent failure waiting to occur when least expected.

Do not fall into the trap and assume there is a substitute for ESD control and training.

215. Interpreting diagrams

Before you can effectively dive into tracing and extracting circuits, it is important that you know some things about the different diagrams first. For instance, what is the purpose of these diagrams and how they can help you? What are some of the characteristics to remember about all diagrams that will help you read them easier? What different types of diagrams will you see and what makes them different? This lesson will answer those questions.

Purpose

Most of the systems you work on are complex and require some sort of diagram. These diagrams are very useful and serve three purposes as listed in the table below.

Three Purposes of Diagrams	
Purpose	**Description**
Show system components	Diagrams show system components by using a variety of symbols and abbreviations to represent the components. These components are not represented where they actually are on site, but in the most logical location on the diagram to allow you to understand it.
Understand system operation	A diagram provides a visual picture of how the components interact with each other. When this is combined with the system descriptions from the technical order, you have the ability to read the description and move through the diagram to gain a good understanding of system operation.
Aid in troubleshooting electrical systems	A diagram can provide a quick representation of a suspected circuit. It is a road map of sorts, allowing you to quickly trace the suspected circuit to the suspected cause as you follow the technical order procedures and take electrical readings.

Characteristics

Diagrams have several characteristics in common. Understanding these characteristics is pivotal to understanding and interpreting a diagram. These characteristics include “de-energized state,” legends, symbols, and abbreviations.

De-energized state

Unless otherwise indicated on the diagram, all diagrams are drawn and laid out as if the circuit is de-energized (power not applied) and the switches and contacts are in the de-energized position. The switches, components, and contacts will remain in that state until the system is energized. This makes it easier to understand system operation. When tracing circuits and understanding system operation, thinking of “energizing” a component is much easier than thinking of de-energizing it. If a component on a diagram is drawn energized where the others are not, the diagram will indicate it (fig. 3-7, Flag 1).

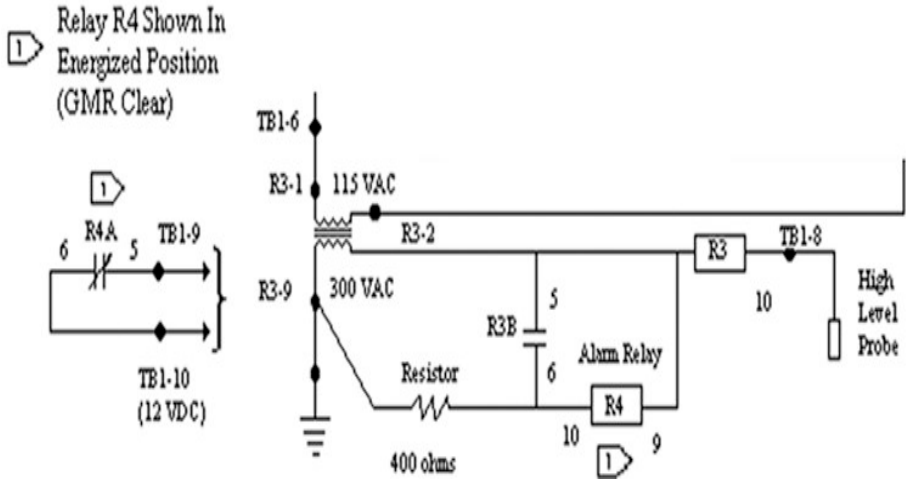


Figure 3–7. Energized component on a diagram.

Legends

Many diagrams will contain legends (fig. 3-8, bottom center). Legends include critical information too large to be incorporated into the picture. Some examples are unique part numbers, voltage tolerances, wing or system coding, unique diagram symbol definitions, and so on.

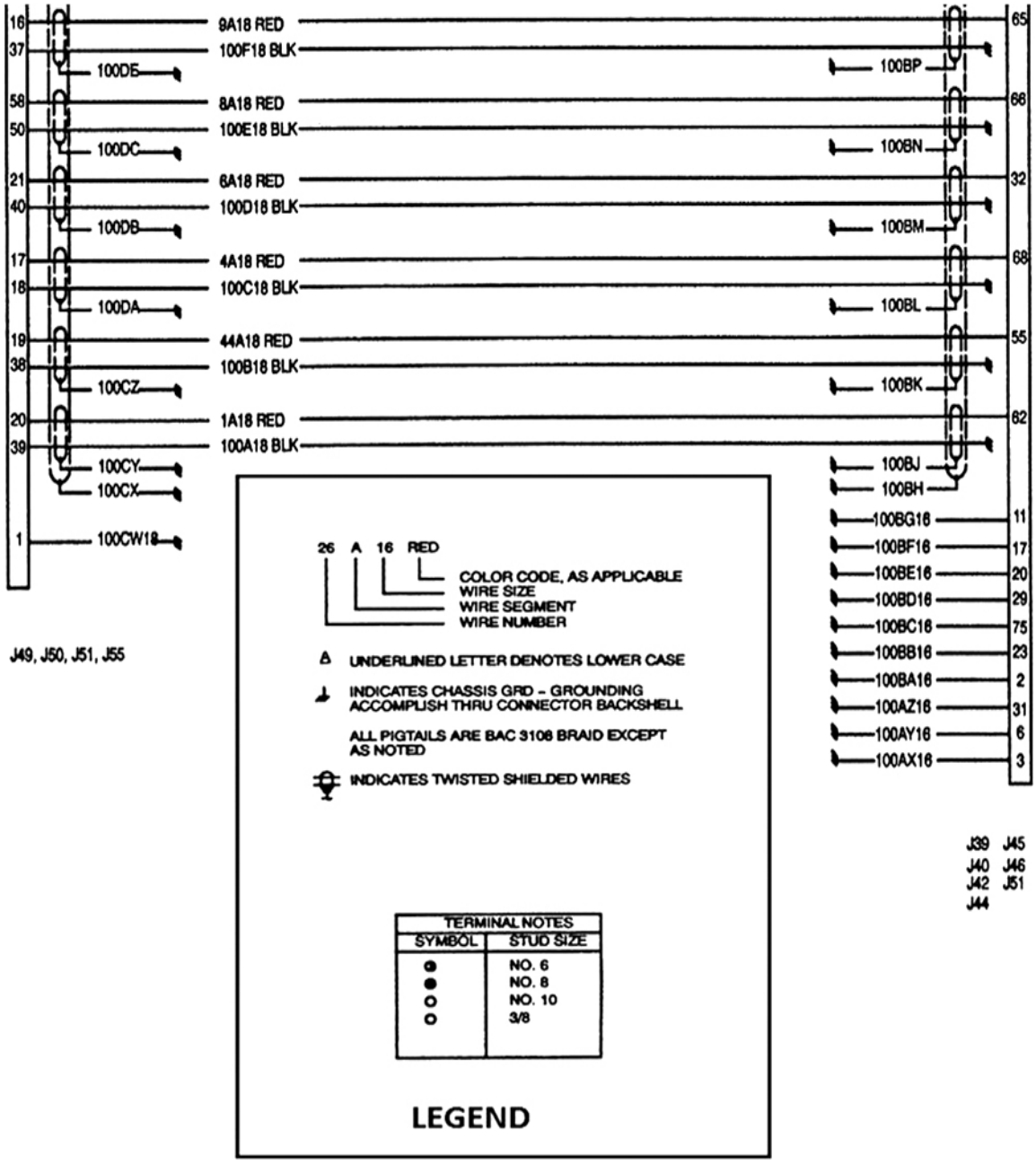


Figure 3–8. Legend.

Symbols

The most important key to reading and understanding wiring diagrams is an ability to recognize symbols. Graphic symbols are used to represent system components and parts; however, they do not necessarily represent a component's physical appearance, but rather its function. Symbols are in a way the language of the diagram. In order to be able to read diagrams, you must know the language.

With a sound knowledge of these symbols, you can install circuits, trace circuits, and locate malfunctions with ease. Figure 3-9 shows typical symbols for circuit components.

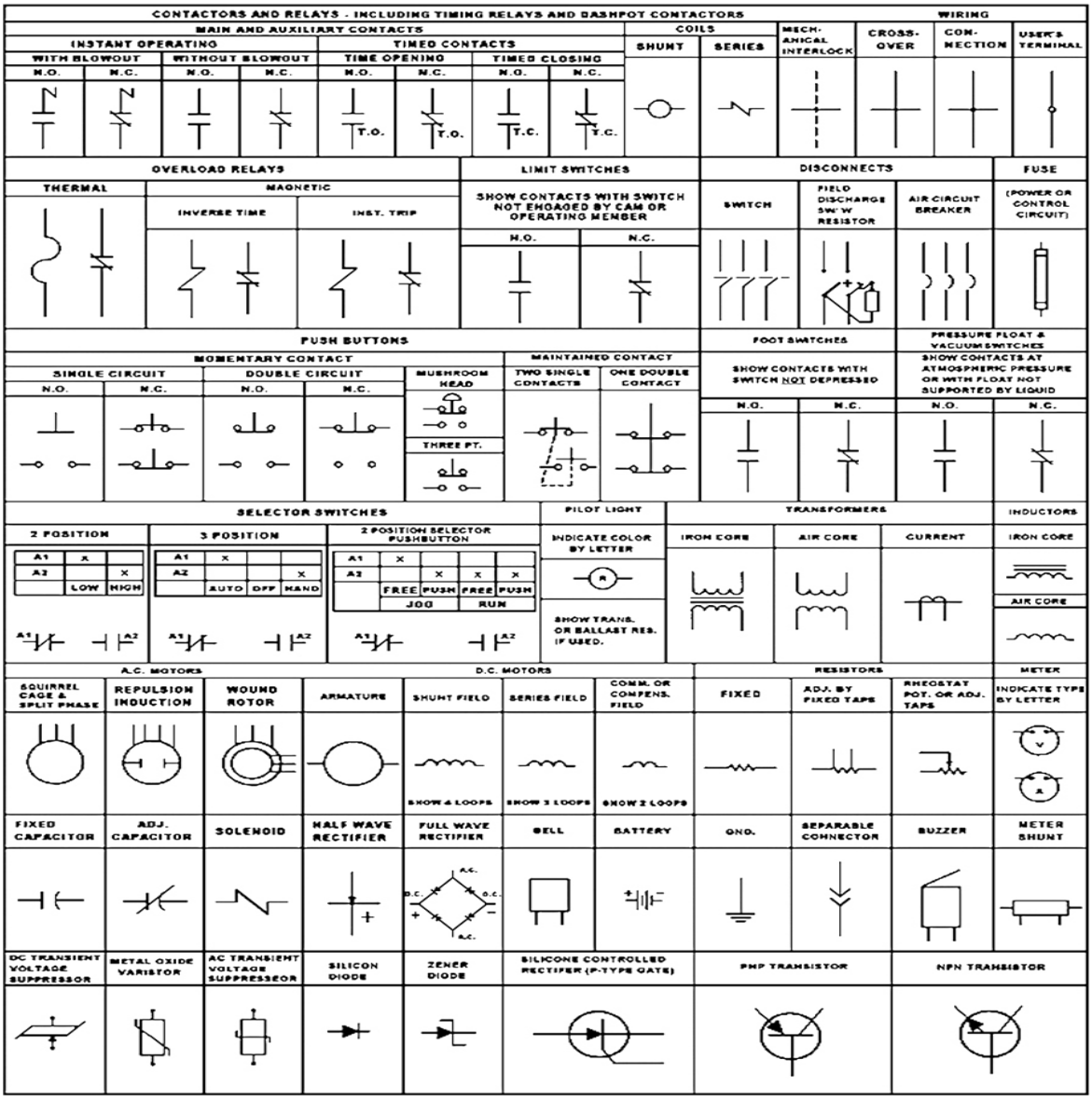


Figure 3-9. Diagram symbols.

Abbreviations

When developing diagrams, space is an issue. For this reason, not every item on a diagram can be spelled out; instead, abbreviations are used. Component designators are used to show components in short form. These designators can usually be found in a table in your technical order that lists each component on a diagram and what its designator and actual nomenclature is. The following table lists some abbreviations from the missile alert facility (MAF) and LF power system schematic.

Abbreviations and Designators	
Abbreviation	**Meaning**
TB40–15	Terminal board (TB) 40, Pin 15
FU3	Fuse Number 3
C2TS	Contactor 2, Transfer switch

Abbreviations and Designators	
Abbreviation	**Meaning**
K1–4	Relay 1, Pin 4
SW No. 2	Switch number 2
BC6	Battery charger, Pin 6
R100	Resistor number 100

Types of diagrams

Just as there are different types of maps, such as topographical and political, there are also different types of diagrams. Now that you have an understanding of how a diagram is drawn with the legends, abbreviations, and symbols, let's look at the three types of diagrams you will likely encounter: functional (block), wiring, and schematic.

Functional (block) diagrams

Functional diagrams (often called block diagrams) are designed to provide you with the big picture of the overall system. Throughout the remainder of this lesson, we are going to use the term block diagrams. As the name implies, they are drawn in the form of blocks, which represent major end items or components without showing the inner workings of each end item or component. Connecting lines are used to show the relationship between the different blocks. These are usually electrical connections and have arrows showing the direction the electrical path follows. These diagrams are very useful because they give you a quick, general view of a system. When provided, they can be used to identify individual circuits because the block is named after the circuit being represented. Figure 3-10 shows a typical block diagram.

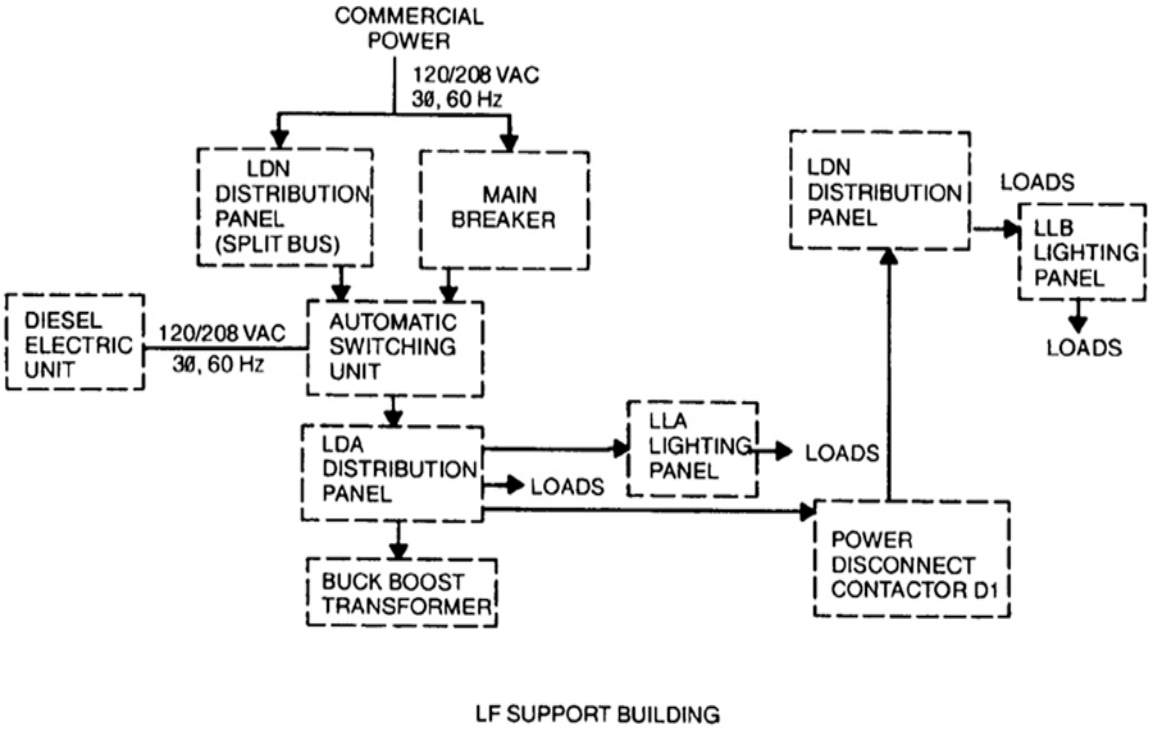


Figure 3-10. Common block diagram.

Wiring diagrams

Wiring diagrams are designed to show point-to-point connections between components (fig. 3-11). They are different from schematics and have very few electrical symbols, if any. Wiring diagrams are useful when troubleshooting electrical opens and shorts and when replacing components.

When used in troubleshooting, they provide quick wire number references for suspected circuits, allowing you to physically trace the circuit and verify a component is wired properly. When replacing a component, it is useful to know where a particular wire attaches to a component, if for some reason you fail to mark the wires yourself when disconnecting them.

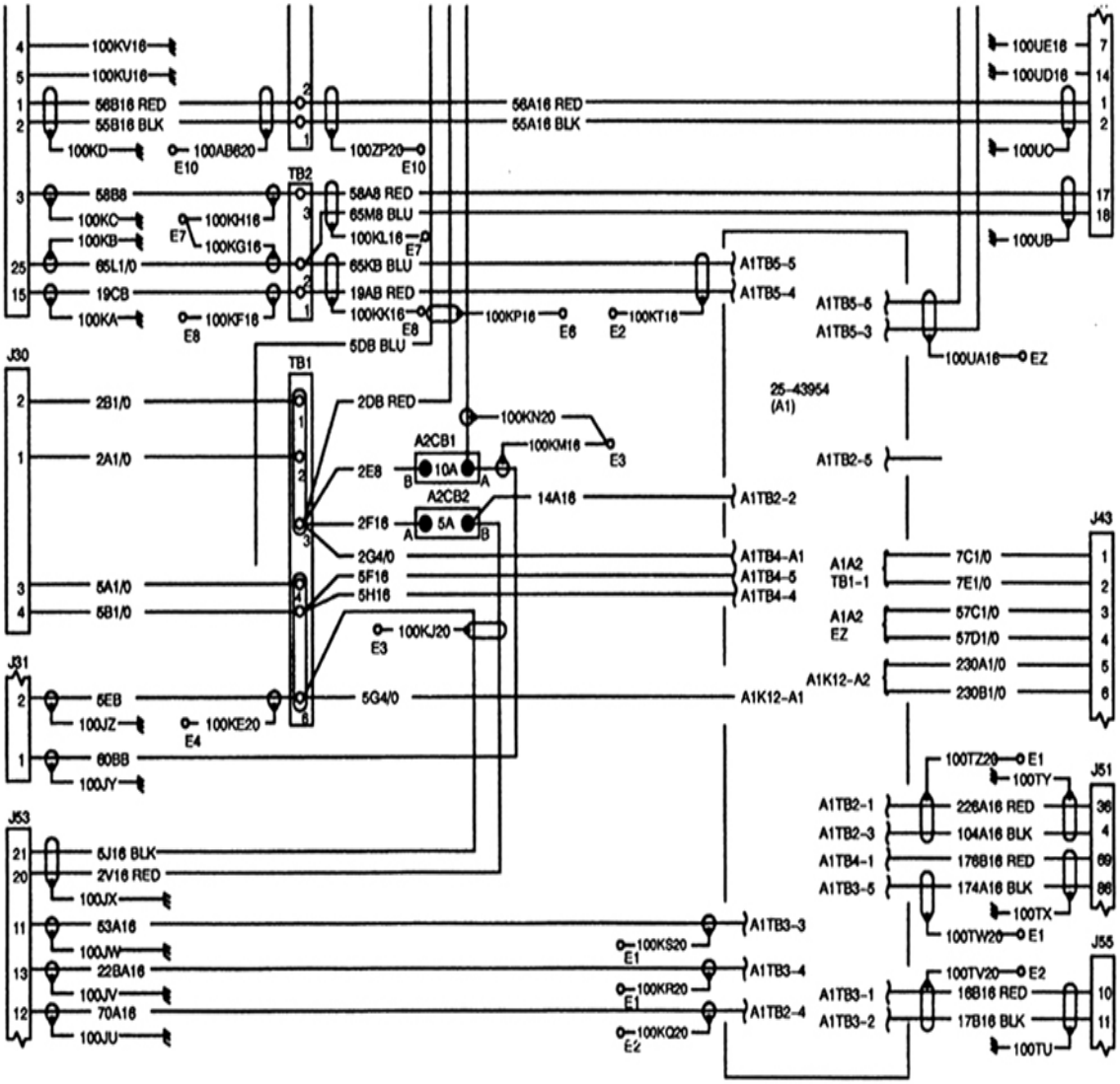


Figure 3–11. Typical wiring diagram.

Wiring diagrams are generally found in two forms: wire bundles (cables) or individual wire runs between connector plugs or jacks. Wire bundles have alphanumeric designators for their lengths and contain more than one wire. They are a convenient method of connecting dozens of individual wire runs in a single casing. This method saves time and increases system reliability because it eliminates having to make numerous individual wire runs between points. A disadvantage of the cable is that if a single wire is found to be broken, the entire cable must be replaced rather than repaired in order to maintain a high degree of reliability.

Notice at the beginning of the wire bundle (fig. 3-12), the specific wire you are looking for is labeled with the reference designator to where it is going. At the end of the bundle, it shows you where it came from. Individual wire runs contain the same information, but at the specific termination point of the wire.

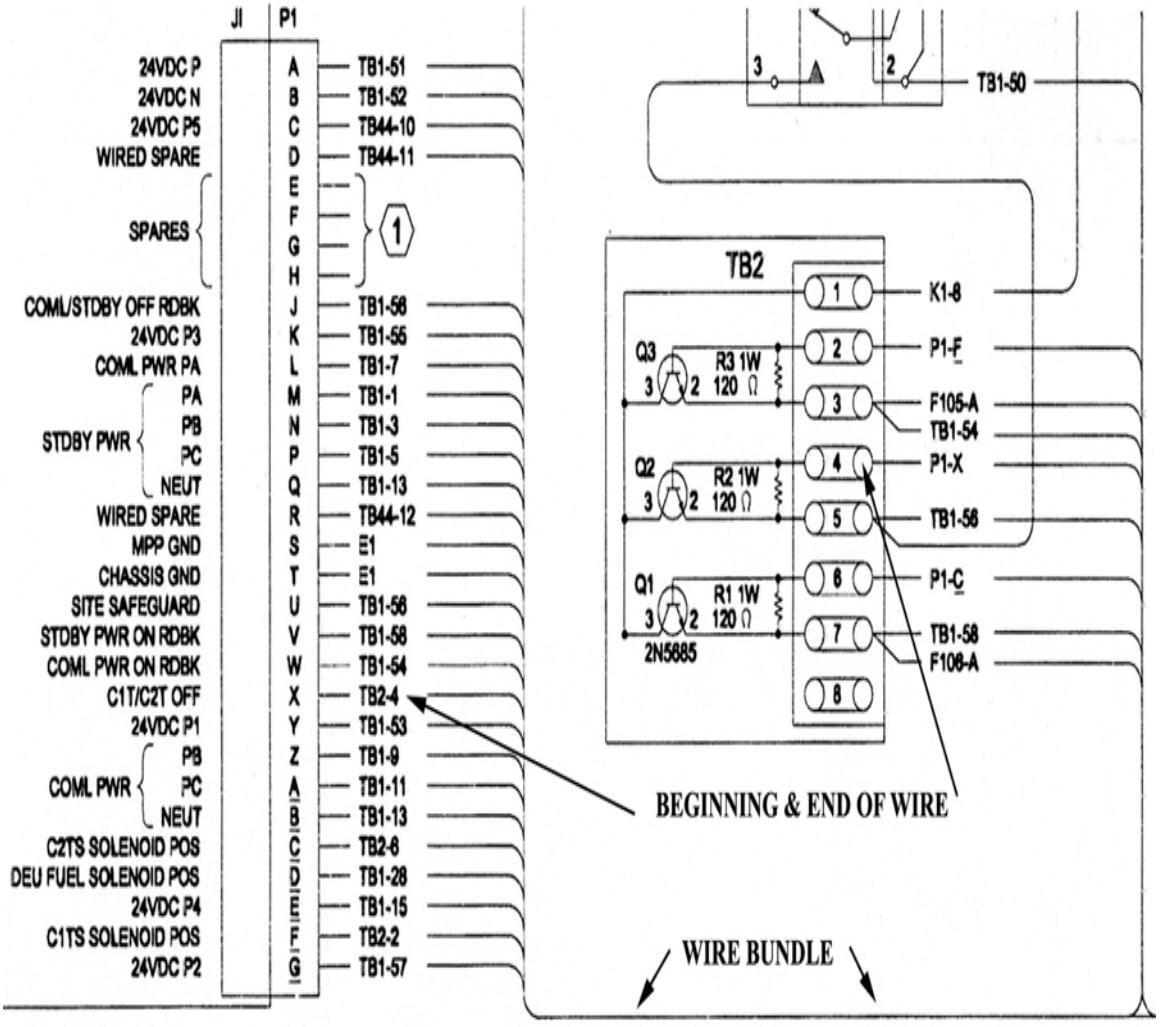


Figure 3-12. Wire bundle.

Schematic diagrams

Schematic diagrams are technical illustrations of the interconnection of components in a circuit. Most schematic diagrams include component values, perhaps tolerances, and standard symbols. A schematic diagram does not indicate the physical arrangement of the components, but shows how the components are interconnected. Schematic diagrams are formulated through the combination of connectors, wire and cable runs, and system components.

Even though schematic diagrams look complicated, they are designed so they are easy to read (fig. 3-13). They represent all of the operational elements necessary to make up a system or unit. Of all the diagrams, the schematic, is the most important and most useful for troubleshooting and extracting circuits. The schematic continues the idea of showing all circuit components in a straight line, without regard for physical location or relationship. As such, it gives you an overall view of a particular system, shows circuit operations, and shows where the functions within a circuit occur in an exact sequence. Since a schematic diagram usually includes different elements (solenoids, relays, contacts, meters, and mechanical linkage), it is easier to trace the circuit and its operation. The schematic diagram may also contain a legend that identifies the device numbers.

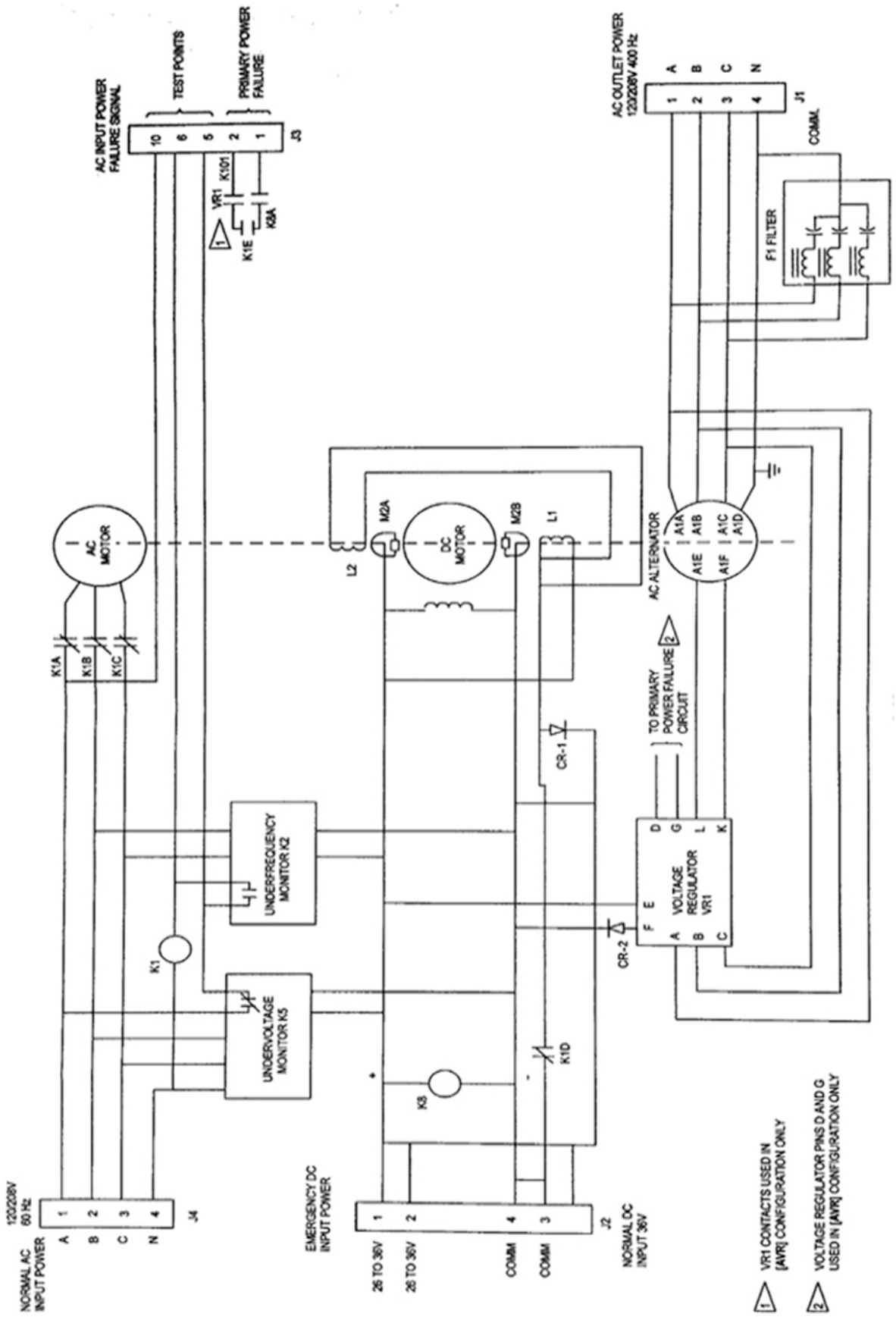


Figure 3-13. Schematic diagram.

216. Circuit tracing

The missile and space systems career field is diversified and contains many different types of associated equipment. The ability to trace and extract circuits is indispensable when you troubleshoot the electrical circuitry of the equipment. By using wiring diagrams, you can trace electrical circuitry and determine where to connect test equipment for checking electrical operation.

Tracing circuits

In tracing circuits on a schematic or wiring diagram for troubleshooting or repairing, it is often easier to extract (make a simple drawing) only the specific circuit in which you are interested. It is easier to work on a system with this simple drawing than with a large bulky wiring diagram. As you follow the circuit operation explanation in the appropriate technical order or manufacturer's manual, trace the circuit on the schematic diagram. It is a good idea to color code the circuit for easy identification and a clear understanding of that particular circuit. On your drawing, include all wire numbers, device code numbers, and area designations. The following table lists three well-established rules for tracing electrical circuits.

Tracing Electrical Circuits	
Rule	**Description**
1	Use the appropriate technical reference to understand circuit operation. This is the most important step in circuit extractions. If you do not understand how the circuit operates, you will encounter numerous problems during the extraction and troubleshooting process. Understanding circuit operation includes: knowing how each component operates, knowing the identification of the power source, knowing the units of resistance, and knowing the electron flow in the circuit.
2	Identify or highlight all circuit components on the schematic diagram. This enables you to locate the components when you begin the actual tracing.
3	Trace the circuit on the schematic diagram as you are reading the circuit operation. This procedure allows you to gain a clear understanding of the circuit. The easiest method is to locate the power or signal source of the circuit. Then, locate the unit or units of resistance on the schematic. A unit of resistance is defined as the component or components that provide action. Normally, the name of the circuit identifies the unit of resistance. For example, in a panel light circuit, the unit or units of resistance are the panel lights.

Remember as mentioned earlier, when tracing a circuit it is important to remember all switches, contacts, relays, and other electrical devices can be shown in the "energized" or "de-energized" position. Determine which way the circuit is drawn; this can normally be found in the legend of the schematic. Otherwise, consider the circuit to be shown in the de-energized state.

Now let us apply what you know about tracing circuits to the following this scenario. Refer to figure 3-14 for individual component locations. During LF security system checkout, you connect your test equipment to J10 on the filter assembly and perform a resistance checks on the various security system switch loops. During your check, you discover the primary door magnetic switch is showing OPEN when it is supposed to be CLOSED (assuming your test equipment is functional). Since your fault occurred during the primary door magnetic switch continuity loop resistance check, you can conclude that the fault must exist somewhere between primary door magnetic switch and J-10. These will be your start and end points. You may now begin extracting the suspected circuit using your schematic.

Once you have located both the primary door magnetic switch and the filter assembly J10 test receptacle on the schematic, you are now ready to identify the wires, components, and terminal points. Starting at the magnetic switch and tracing towards J10, the first component is the security pit J-box. Here we find that the switch is connected at TB5, pins 6 and 3. From there the connections go through cable w3052 in the transition box and out on cable w20 to J9, pins 1 and 2 on the filter assembly. The switch is then connected to J10 test receptacle. Now that you have traced and extracted the circuit, you may begin your troubleshooting steps to isolate the faulty component. Most technical

orders will guide you through the troubleshooting steps; however, in some situations you will have to use multiple schematics and a meter to isolate the problem. In the next section, we will look at some troubleshooting principles.

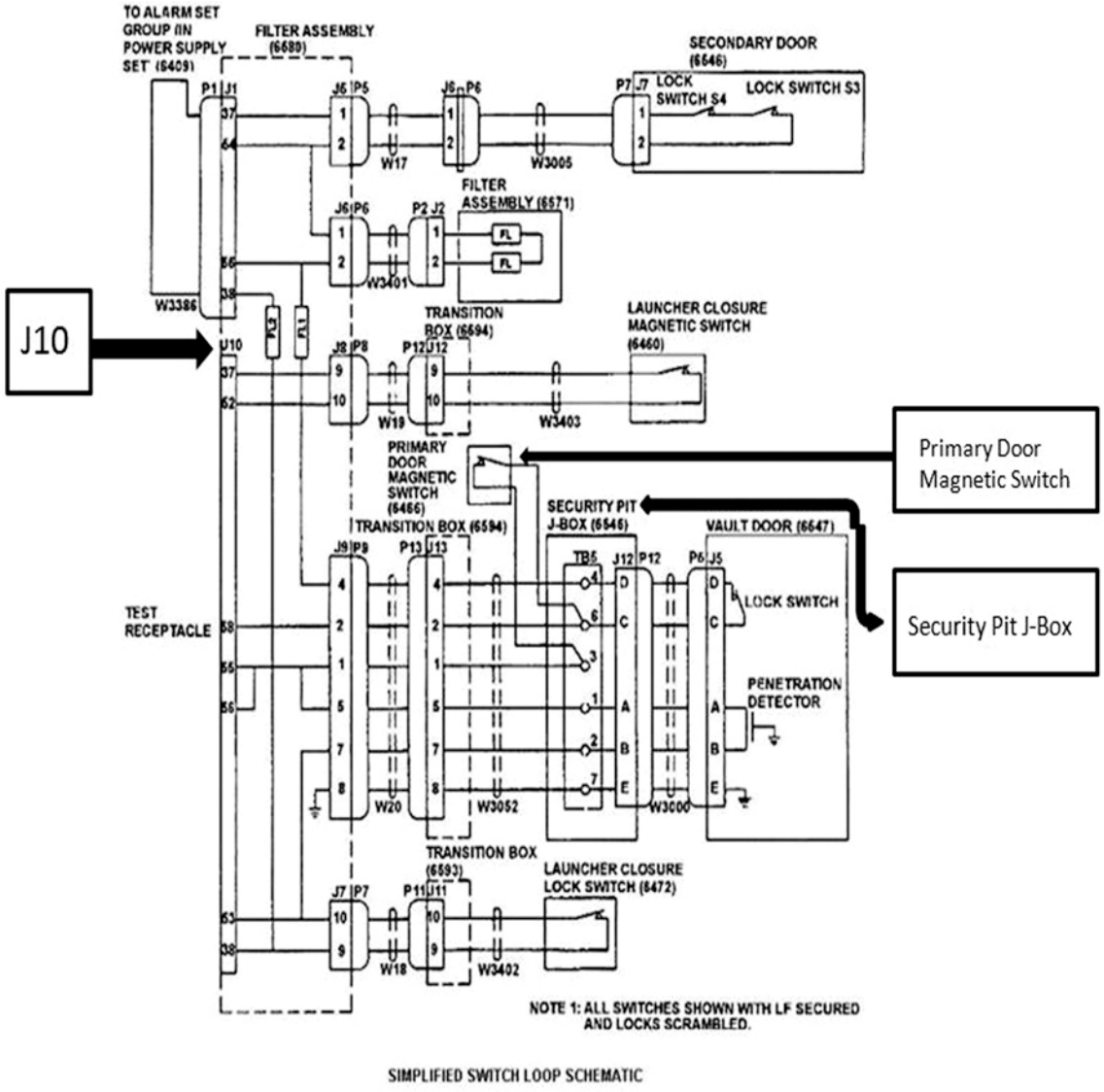


Figure 3–14. Simplified switch loop schematic.

217. Troubleshooting techniques

Electrical troubleshooting is the step-by-step process for analyzing, locating, and correcting malfunctions. Your ability to effectively troubleshoot equipment could mean the difference between the successful completion of the mission or its failure. In this lesson, we will cover the most effective method for isolating malfunctions in electrical circuits. We will discuss the different types of electrical malfunctions, as well as how to isolate them with a multimeter. Then we will look at some of the common electrical components in the weapon system and how to identify problems with them. Using these tools, coupled with your experience, will help you tackle any system malfunction.

Troubleshooting tips

The purpose of troubleshooting is to enable you to maintain equipment in peak operating condition. In order to be effective at it, you have to have the proper mental state and follow a logical order of fault isolation. In the table below, are some things to keep in mind as you get started.

Troubleshooting Recommendations	
What to do	**Reason**
Keep calm	You have been given the knowledge and skills needed to handle the problem, panicking will only make the fault harder to correct.
Use your experience wisely	Do not get stuck thinking there is only one answer or that since you have seen this fault before that you automatically know what is wrong. This will only cause you to overlook additional faults or the original fault entirely.
Follow a troubleshooting path	To troubleshoot effectively, you must follow a troubleshooting path until it leads to the fault. Randomly checking here and there, will only prolong your day and add confusion.
Be open to suggestions	Sometimes a new set of eyes can help identify an overlooked fault; it is not personal. Use the experience of others in conjunction with your own.
Be wary of fatigue	Troubleshooting can be taxing and at times frustrating for most individuals. Take breaks or give someone else a try. Most individuals have a hard time following a logical process when they are tired or frustrated.
Be rational	You must realize that the physical layout of the wires, components, and equipment in the LF and LCF are drastically different to what you may see on a schematic or wiring diagram.
Follow up and orientate yourself	If you are replacing a team in troubleshooting a fault, it is a good idea to verify that the system or circuits have been returned to their operational configuration. Sometimes a fault can be self-induced if a technician does not return wires back to the correct terminal connections. You may waste hours troubleshooting a fault that the previous team created or an additional fault to the one that already exists.
Use schematics and wiring diagrams	Your technical orders have schematics and wiring diagrams. Use them in conjunction with your procedures. When following procedures, know where in the system the procedure is having you check and analyze why. This will aid in your logical process and allow you to mentally eliminate components or circuits as potential problems.

Troubleshooting steps

The proper mental attitude will not fix the problem alone. It also requires a logical plan to identify the fault, a good understanding of basic electrical theory, and understanding of the specific equipment on which you are working. As mentioned earlier, electrical troubleshooting is defined as a step-by-step procedure of analyzing, locating, and correcting electrical malfunctions. There are seven logical, fundamental steps to effective troubleshooting, which are as follows:

1. Research the fault.
2. Perform a preliminary check.
3. Perform an operational check.
4. Analyze the malfunction.
5. Locate the malfunction.
6. Perform corrective action.
7. Perform a final operational check.

Research

Researching a fault before departing for the site can be a very effective measure in troubleshooting, since there are several tools available within the unit to help you gain some insight into a particular fault. Understand that this step might not be feasible if you were already out on a dispatch when the fault occurred; however, you should still contact your section supervisor or the missile maintenance operations center (MMOC) to assist you in obtaining the information.

Missile maintenance operations center

The MMOC has the capability to retrieve a fault history on every LF in the missile field. This data can tell you if a particular fault had previously occurred, if there were other indications associated with the fault, the date(s) and time(s) the fault occurred, and whether or not the fault was cycling

(meaning reporting on and off) or hard. In addition, the MMOC maintains a historical log on each of the LFs and LCFs in the missile field. Each time a fault is reported at an LF or LCF, the MMOC documents this information along with any actions that may have cleared the fault. They also track all maintenance actions performed at the various sites in the missile field. This includes the maintenance team's number, the date and time the team arrived on site, time-stamped maintenance updates provided by the teams approximately every three hours, and a short summary of the maintenance performed, to include fixes.

All this information may give you some detailed insight and possibly lead you to following a different fault flow in the technical order altogether.

Supervisors and shop personnel

At one point or another, someone you work with has probably dealt with a fault just like the one you are set out to troubleshoot. It never hurts to pick the brains of your supervisors and co-workers. Chances are they may have a remedy that requires another piece of equipment that you do not currently have on your load list. It is much better to spend the few extra minutes acquiring all the tools and equipment you will need to fix a site, than it would be to get to a point in your troubleshooting and realizing you need an additional piece of equipment to continue. You have to realize the LFs and LCFs are not exactly a short trip down the road, so expect to be waiting around a couple hours for a parts run. Then if you burn up too much time of your timeline, you can expect to be spending the night at the nearest MAF.

Technical order

If you take the time to research the fault utilizing the information provided by the MMOC and your co-workers, you will have a much better chance getting to the correct fault flow in the technical order. This is important because each fault flow requires different equipment items to remedy the problem. You definitely want to have to correct parts or you can expect a very long day and even a night away from home. You will learn more about fault isolation in the next lesson.

Perform a preliminary check

The second step in troubleshooting is to perform a preliminary check. This can involve several things, but remember that you cannot start probing or making corrections without first referring to your technical order. Here are some things to look for in your preliminary check. Use your senses of hearing, sight, smell, and touch!

Hearing

Listen to the system. Determine what components are operating or not operating. Listen for chattering relays or louder than usual motors. Just listen for anything that does not sound like it is supposed to. This will give you a good starting point for your troubleshooting.

Sight

Careful observation and a little bit of reasoning and some faults may be identified with very little testing. Look at the system. If visible, check electrical components for signs of damage from overheating. Look for charred cables. Also, check to see that components or parts are not lying around the suspected area. Check for corrosion on components. Check for fluid leaks. Check circuit breakers and switches to ensure they are in the proper position. Check alarm indicators. A good visual inspection starts you on the right road and might even reveal the fault itself. Just be careful! Sometimes what you see is the result of a fault and not the actual fault itself (i.e., a blown fuse is usually the result of a fault and not the fault itself).

Smell

Smell the system. Sounds funny, but when an electrical malfunction has occurred, you will likely be able to smell it when you enter the room or area.

Touch

Lastly, touch the different components if necessary. If you are unsure a motor is operating, putting your hand on it will tell you if it is operating.

As a safety precaution, keep in mind that the system might be energized and in the case of a locked rotor condition, the item may be very hot. Make careful checks, but remember that *you cannot* start probing or working on the system until you have utilized the technical order. This could prevent PERSONNEL INJURY or EQUIPMENT DAMAGE.

Perform an operational check

The third step in troubleshooting is to perform an operational check of the equipment to determine if an actual problem exists. However, you should understand that an operational check cannot necessarily be performed if the power to the equipment you are troubleshooting is off. Therefore, an operational check out is normally divided into a preoperational checkout and operational checkout.

The preoperational check is typically verifying the site is properly configured into a “known” state in preparation for the operational portion of the checkout. Anytime an operational checkout is to be performed, technicians must first verify all preoperational checks are performed or potential equipment damage or injury to personnel could occur. The reason being is you never know for sure if someone may have missed a step and failed to shut off a circuit breaker or possibly left a cable disconnected. For many pieces of equipment, the operational checkout steps in the technical order will refer you to the preoperational steps. For our learning purpose, we will consolidate the two. Here are some things to consider when performing an operational checkout:

- Ensure controls are positioned properly before the equipment is started. Also, check your settings on the test equipment; sometimes technicians create their own headaches. These precautions will prevent damage to equipment and possible injury to the operator.
- Make a listing of all symptoms you note so that the chances of overlooking possible malfunctions are reduced. If you find a problem, do *not* ignore it because you do not think it could be the problem.
- Accomplish a thorough visual inspection of the electrical components. This often reveals minor discrepancies that can be corrected and prevented from developing into major electrical problems. Check such items as the wiring harness for breaks, worn or cracked insulation, or any signs of rubbing against any metal parts. Check transformers, resistors, relays, and terminals for loose connections, evidence of overheating, cracks, corrosion, or any signs of damage. Inspect other components for obvious damage from overheating, wear, or abuse. Although, this step is similar to the one you performed in the preliminary check, we are assuming you have used your technical order to get an internal view of the electrical components.
- Make sure all cable connections are tight and properly configured for the test.
- Is it possible the test equipment is faulty and not the equipment under test. Having spare equipment to swap out can assist in eliminating this possibility.
- During the operation checkout, use your senses, such as sight, sound, smell, or touch again to detect the malfunction. There is a good chance the equipment was not powered up until this point and now you may hear, smell, or see an obvious problem.

If you encounter an abnormal indication during the operational checkout, make sure you are thoroughly noting all the normal and abnormal indications. You will need them in the next step: analyze the malfunction.

Analyze the malfunction

The fourth step in troubleshooting is to analyze the malfunction (fault). Part of your analysis should be to study the symptoms of the malfunction thoroughly and ask yourself these three questions:

1. What was the status of the facility preceding the malfunction?
2. What recent repair or modification actions have been accomplished?
3. Has a similar problem occurred on this or any other site in the past?

Answering these questions will be very easy if you took the time to research the fault in the first step. However, if you were unable to acquire this information, then you can always contact MMOC or your supervisor.

These questions will help you focus and even lead to a solution to the malfunction. Many time faults are associated with previous repair actions due to a multitude of reasons and are a viable starting point for determining the malfunction.

Consider what would cause the expected indication not to occur (for example; loss of power, signal or mechanically defective). A good block diagram would be useful here. If you recall the previous lessons, a block diagram allows a quick overview of how a system interacts.

Once you are aware of a malfunction, consult the proper systems or technical manual for normal circuit operation. This will help you get a better understanding of how the circuit involved would be operating normally. Also, check the troubleshooting flowchart or table in the manual for probable causes and remedies. This step alone might reduce your efforts to a few simple checks, instead of a lengthy and difficult search throughout the entire circuit. If the troubleshooting chart or table proves to be of no help, use the circuit description and wiring diagrams to extract that particular circuit.

After you have extracted the circuit, you must then check the circuit with the proper test equipment. To do this, you must determine the type of malfunction in order to determine the type of test equipment to use. For example if the equipment appears to have no power, then you might want to use a voltage meter to check the input power circuit.

Locate the malfunction

Once you have analyzed the malfunction, you are ready to locate the malfunction. Many times the technical order will be there to guide you in identifying the malfunction, but occasionally you will be on your own. You will discover in these instances, locating the cause of a malfunction can be the most difficult part of troubleshooting. It is also very rewarding once you have corrected the malfunction. Ultimately, if you extract the circuit, select the proper test equipment, and have a complete understanding of what you are doing, finding the cause of a malfunction can be easy. Here are some more common troubleshooting practices to assist you in locating the malfunction.

- Check out the easy fixes. For instance, look for tripped circuit breakers, blown fuses, and faulty power supplies. Failure to troubleshoot correctly could lead to a costly corrective action later on.
- On large systems, divide and conquer. This means to break the system down into logical portions to make troubleshooting more manageable. For example, if you suspect two circuits, troubleshoot one at a time. Trying to troubleshoot both simultaneously will only result in something being overlooked.
- Consider what is the most probable cause of the malfunction and check it first.
- Isolate the component totally to avoid erroneous readings. If you are looking for a reading across a 5K ohm resistor and the meter shows 100K ohms, you might be troubleshooting a circuit that is operating correctly. You may have been inadvertently reading across the coil of a relay.

Perform corrective action

After you have found the cause of the problem, it is time for repair. Use only authorized replacement parts as identified in the technical order. Do not try and make repairs with parts you may have may have in your backpack. If you do not have the correct parts, notify MMOC or your shop to have someone bring you the parts or create a workorder with the correct parts attached. Unauthorized maintenance actions are a technical order violation and serious punitive charges may be imposed.

Perform a final operational check

At this point, you have successfully troubleshot the system, located the malfunction, and have fixed it! Now it is time to verify your work. Using your technical order procedure, always perform a final operational checkout on the system you just repaired. If you fail to perform this step, you may not have fixed the actual problem or there may be other problems that you missed. If the operational checkout passes, your mission is complete and you have restored the broken system.

218. Electrical malfunctions

Our weapon system is comprised of a vast network of electrical signals. Everything from status monitoring down to initiating the final launch involves electrical circuits. In the event, one of our LFs or MAFs are degraded due to an electrical fault, it will be up to you to fix the problem. In this lesson, you will learn some common electrical malfunctions to include causes, symptoms, and procedures for locating each malfunction.

Types of electrical malfunctions

The most common types of electrical malfunctions are opens, shorts, grounds, and low power. As you read about the different types, pay particular attention to the various symptoms associated with each fault type to help your overall understanding.

Opens

An open is an incomplete path for current flow within the circuit. Opens can occur when a conductor becomes broken, a fuse opens, relay or switch contacts fail to close properly, or when any other device in the circuit fails to provide a complete electrical path.

Naturally, if there is an open there can be no current flow. Consequently, the unit will not operate. If the fault is an open, the following applies:

- Circuit is inoperative.
- Protective device will not activate.
- Indicator lamps do not illuminate or illuminate when they should not.

The possible location of an open can be anywhere in the circuit; however, with a digital multimeter you can find the open. Remember, to connect a multimeter in parallel with the circuit or component. This prevents the meter from affecting the circuit. When you use a digital multimeter set the meter to read voltage. The meter should indicate the difference in potential voltage when connected across two points that are positive and negative. This is because one lead is attached to a potential of, let’s say, 24 volts, while the other lead is connected to 0 volts potential. With that difference in potential between the two points, a reading of 24 volts will be indicated on the multimeter.

A multimeter connected between two negative points or between two positive points will indicate 0 volts. This is because there is no difference in potential between the two connection points. When both meter leads are connected to the same 24-volt conductor, or 0-volt conductor, there is no difference of potential for the meter to indicate. There must be a resistance or load in-between the two leads to measure a difference in potential. Figure 3-15 provides a visual representation to assist in clarifying this concept.

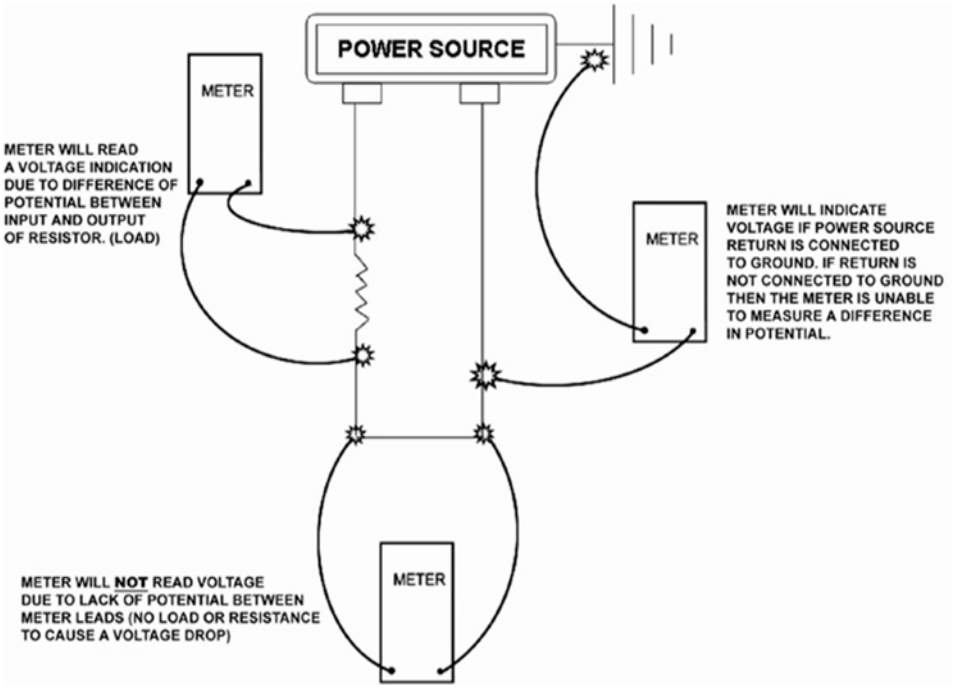


Figure 3-15. Voltmeter connections.

When using a voltage meter to locate an open, the equipment must have its power supply turned on. Prior to starting, it is very important to know if the return (negative) side of the circuit is connected to ground. This shows you where to connect the negative lead of the meter. If the return is not connected to the ground, then the meter must be connected directly to the return conductor or terminal.

For our training process, the example assumes the return is connected to the ground. Place the black lead on the negative conductor or frame. Place the red lead on the positive conductor of the first unit of resistance in the circuit. Check the remaining positive terminals in sequence, moving away from the power source until the voltage indication on the voltmeter changes from the applied voltage to 0 volts. The *open* electrical malfunction is located between the last applied voltage reading and the first point 0-voltage reading.

You can also use a multimeter setup to read resistance to find an open in a circuit. With this setup, you must observe the following two very important precautions:

1. Turn the power to the circuit being tested OFF. This is to prevent damage to the meter. Multimeter have their own power supply, therefore any voltage or current that is encountered by the meter could cause damage to its internal components.
2. As discussed earlier, isolate the circuit components and conductors to prevent erroneous readings. If you do not isolate the circuit, the multimeter will detect any devices that contain an appreciable amount of resistance. The resistance reading could fool you into thinking you have located the problem.

The multimeter indicates continuity (uninterrupted good connection) when the display reads 0.00 and overload (OL) when the circuit is open. When using a multimeter to locate an open in a circuit, place the meter leads across segments of the circuit until you find the open. The open is located between the last 0.00 indication and the first OL indication. Remember, whenever you use a multimeter to measure resistance, the power to the circuit must always be OFF.

Shorts

There are four types of electrical shorts: direct, cross, shorted control, and short to ground.

The following four indicators are basic symptoms that indicate some type of short has occurred:

1. Circuit inoperative.
2. Protective device actuated.
3. Circuits cannot be turned off.
4. Two or more circuits operate from one control device.

Direct short

Positive and negative conductors making direct contact cause a direct short. The short provides a shortcut for the current to get back to the power source, bypassing the unit of resistance. An example is a wrench across both terminals of a car battery. As the unit of resistance is bypassed, current flow increases to a point at which the protective device is actuated. Alternatively, in the case of the wrench, where there is no protective device, damage to the equipment will result.

The indications of a direct short are an inoperative circuit and the protective device has actuated. Also, if the excessive current remains in the circuit long enough, the insulation on the wires may begin to melt or even burn. You may smell smoke and see burnt conductors.

The location of direct shorts is between the positive and negative conductors and between the power source and unit of resistance (fig. 3-16). Use either a digital multimeter or an ohmmeter in order to locate all shorts, as these are the only true methods of isolating the exact location of a short. When symptoms indicate a direct short, isolate the positive conductors in the circuit. Turn off the power to the circuit, then using the multimeter, place one meter lead on the negative conductor. Move the other lead from one positive conductor to another in the circuit until the direct short is found. An OL resistance display on the multimeter indicates a good (no short) component. A 0.00 resistance reading on the multimeter indicates the location of the direct short.

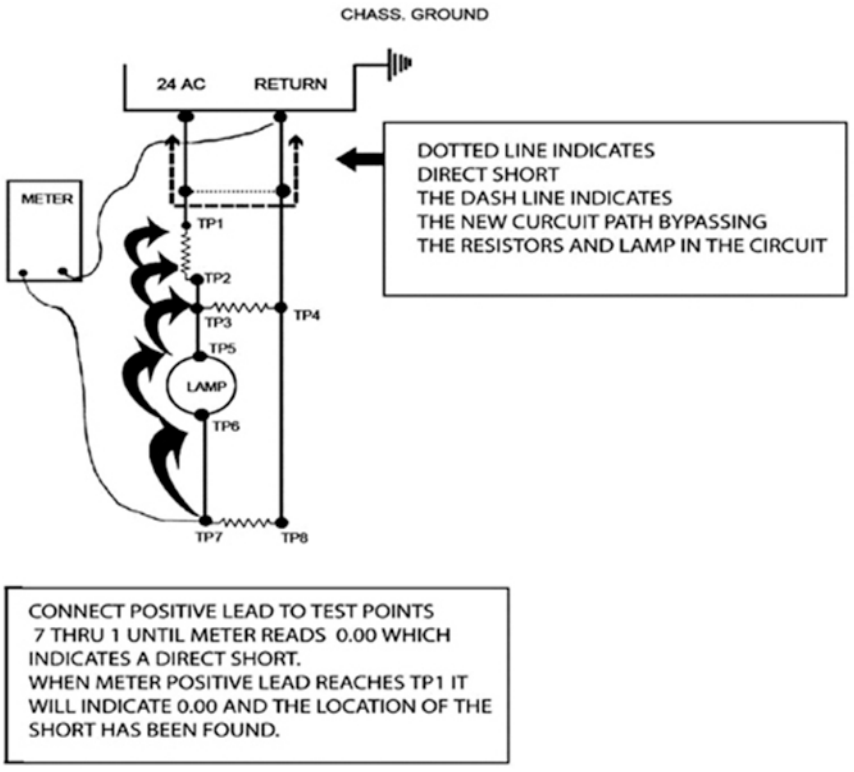


Figure 3-16. Direct short.

Cross short

The positive conductors of two or more independent circuits making contact cause a cross short. The contact causes units in all the shorted circuits to operate when only one control device is turned on (fig. 3-17).

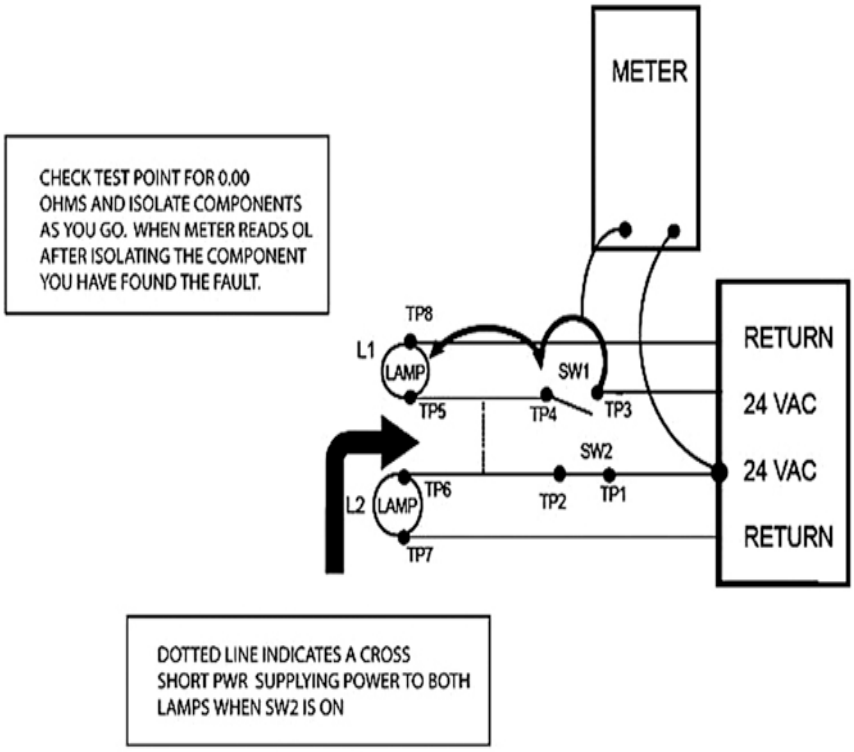


Figure 3-17. Cross short.

The symptom of a cross short is when two or more independent circuits operate from one control device. In addition, the protective device may or may not actuate. This depends on the current rating of each circuit. Cross short malfunctions are not as common as direct shorts, but are more complex to troubleshoot because they can affect more than one circuit.

The possible location of a cross short is between the control devices and units of resistance of two or more independent circuits. When you use a multimeter (setup for resistance) for locating electrical short malfunctions, the power to the circuit must be off. Isolate the positive conductors of the circuits involved. Place one meter lead on a positive conductor of one circuit and the other lead on the positive conductors of the other circuit or circuits, one at a time. If you do not find the cross short, move the first meter lead to another positive conductor in the first circuit. Then, move the other lead through the other circuit as you did before. Repeat these procedures until the location of the cross short is isolated. A 0.00 indication on the meter indicates the location of the cross short.

Shorted control

The contact of a switch or relay being welded closed (stuck together) causes a shorted control (fig. 3-18). Shorted controls are usually the result of over current conditions or dirty contacts. The symptoms of a shorted control are that the circuit continues to operate with the control device in the OFF position and the protective device does not actuate.

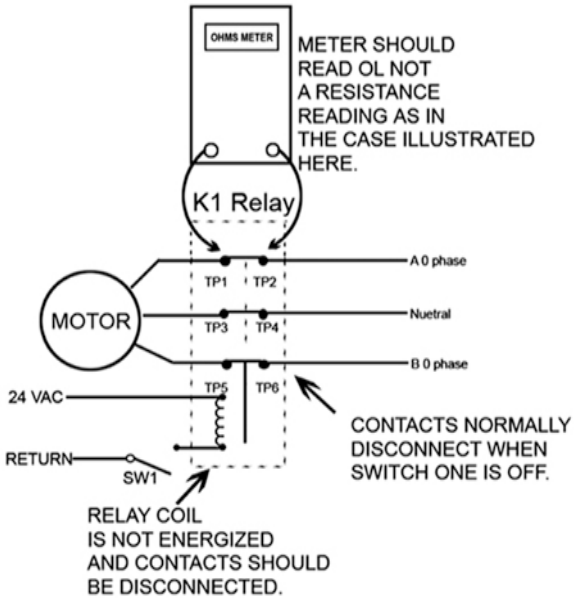


Figure 3-18. Shorted control.

When the symptoms indicate a shorted control, remove power to the circuit, and isolate the control devices. With the control device or switch in the OFF position and a multimeter set to read resistance, place the leads across the contacts of the control device or switch. An OL indication on the meter indicates proper switch or control device operation. A 0.00 display on the meter indicates a shorted control device or switch.

Short to ground

If a circuit conductor unintentionally makes contact with the conduit, frame, chassis, or any other metallic part of the wiring system that is connected to ground, the circuit becomes grounded (fig. 3-19). A short to ground has the same symptoms as a direct short; in that, the circuit is inoperative and the protective device is actuated. When the power bypasses the unit of resistance and goes to ground the protective device will activate if working properly.

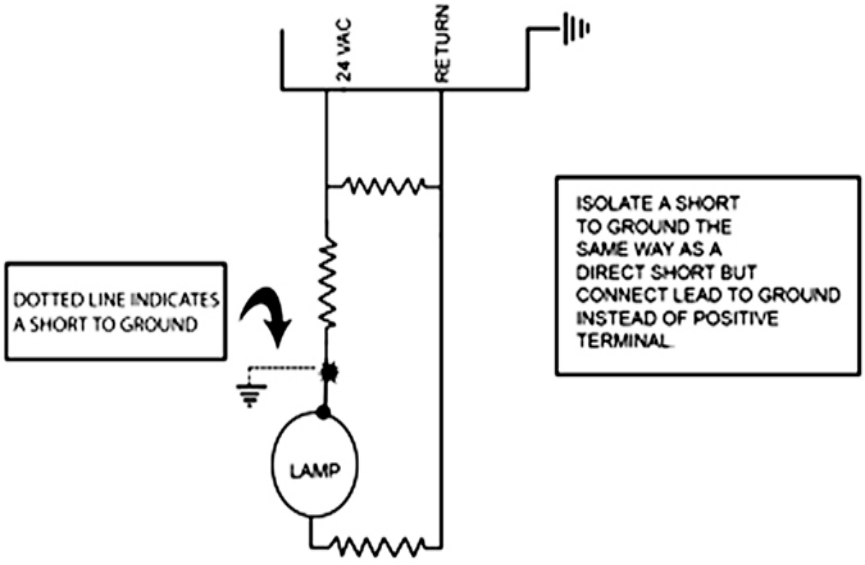


Figure 3-19. Short to ground.

The location of the short to ground can be between the circuit conductor and the frame or somewhere between the power source and unit of resistance. The key is the circuit must be shorted or have a path to ground. The procedures for locating a ground are identical to the procedures for locating a direct short with one exception. The frame is substituted for the negative conductor. When troubleshooting a short to ground in a direct current (DC) circuit it is recommended to check for a negative side fault first before attempting to locate a positive side fault. This is because a negative side fault may affect the measurements taken for a positive side fault.

Ground

A poor ground connection could very well be the reason for an electrical component not to operate. Causes for poor ground connections could be loose or missing hardware, surface corrosion, or other coatings on conductive surfaces. These conditions would require a good inspection of the ground points. Remember to feel for loose hardware during your physical check. When in doubt, use a multimeter to read resistance to test the connection. Connect one lead to the component's ground connector and the other lead to a clean facility ground point. The multimeter should indicate continuity. An OL indication could indicate one of the problems listed above. In this case, thoroughly cleaning the ground point should correct this problem.

Low power

Weak batteries are the common cause of low power; however, a loose connection, dirty switch contacts, or conductors too small to carry the load can also cause low power. The symptoms of a low power condition can be an electric motor that is running sluggishly, dim lights, or chattering relays.

The possible location of a low power condition could be anywhere in the circuit. When locating a low power condition, supply the required power to the circuit. Use a multimeter to measure the voltage drop across each wire, component, and connection in the circuit. A 0 volt reading on the meter indicates the wire, component (provided it does not normally have a voltage drop), or connection being tested is good. A voltage reading indicates the location of the low power.

Faulty components

Faulty components are often the cause for electrical malfunctions and require the troubleshooter to have a basic understanding of how to check their operation using an ohmmeter with power not applied.

Resistors

Resistors are easy to check, just isolate the resistor in the circuit, use an ohmmeter to measure across the input, and output ends of the resistor. Compare the resistor measurement value with the provided value in either in the technical procedures or schematics. If the values are different, you probably found the problem.

Fuses

Isolate the fuse and check it the same way as you do a resistor. If the fuse resistance measurement indicates an open the fuse is faulty.

Diodes

Diodes are designed to allow voltage or signals to travel in one direction and limit the signal traveling in the opposite direction. Therefore, when measuring the diode resistance you should expect more resistance in one direction than the other. If you get the same resistance both ways, the diode is not functioning properly. Important factors to remember are that many meters have special settings to measure diodes and resistance tolerances can be found in schematics and technical procedures.

Coils and windings

Coils and windings can be found in motors, transformers, and relays. They can be operationally checked the same way, using a multimeter set to resistance. Figure 3-20 shows a typical relay.

The relay in this figure contains an armature, a spring, and a coil. When the coil is energized, it acts as an electromagnet that pulls the armature from the normally closed (N/C) position to the normally open (N/O) position. When power is removed from the coil, the spring tension returns the armature to the N/C position (**NOTE:** This is only one example of a relay; there are several variations).

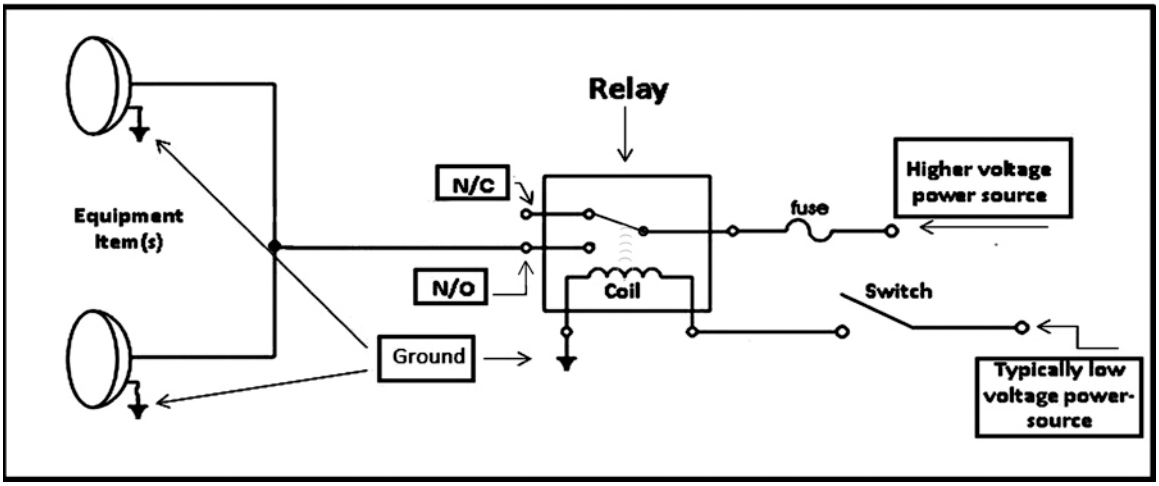


Figure 3-20. Typical relay with power not applied.

As always, isolate the component and measure resistance on each separate coil or winding. Resistance should be taken between both ends of the same coil or winding and compared to the resistance value in the technical order. You may also find a data plate giving you a nominal value or you might need to refer to manufacturer specifications to find it.

Next, check for a short to ground and a short between coils or windings. It is not uncommon for the insulation protecting the coils or windings to deteriorate over time or melt which can create a short. Relays with contactors require a resistance check to verify circuit continuity when the relay is actuated. In order to measure contactor resistance, you must manually close the relay contacts and measure between the input and output contactor terminals. If the meter does not read 0 ohms, the contacts could be dirty and should be handled in accordance with the technical order. If the meter indicates 0 ohms when the relay is not manually actuated then the contacts are probably welded together and a control short exist.

Switches

You can check switches with power on or off. If you check with power on, measure the difference of potential between the input and output, wire connection points on the switch. Approximately 0 volts indicates the switch is closed (no difference in potential between the incoming and outgoing terminals). If the switch is set to ON and your multimeter measures a large difference in potential, you have a problem with the switch.

If you are testing a switch without power applied, isolate the wiring and check resistance between the terminals with the switch closed. It should read 0 ohms. If you are testing the switch in the open position, it should read OL.

Putting troubleshooting into action

Troubleshooting an electric device or a circuit may be difficult if you do not approach the problem properly. One of the most troublesome circuits is one with a multiple-position switch in a three-phase system. For example, let’s say that the ammeter circuit shown in figure 3-21 is not working correctly. You can check this circuit de-energized, so you check the continuity through the circuit for the L1-L2, phase 1 position. Consult a switch schedule (also shown in figure 3-21) to find out which switch position will close the contacts in that circuit. Notice the ammeter switch schedule shows four positions: PH1, PH2, PH3, and OFF. A closed contact in the switch is indicated when a line appears

in the square below the contact numbers and across from the position. Since you are going to check the phase 1 position, determine from the switch schedule which contacts are closed in the PH1 position. The switch schedule shows contacts 5-6, 9-10, and 21-22 are closed. Therefore, a check across these contacts with the ohmmeter should show continuity. If there is no continuity through one of the sets of contacts, the switch needs repair or replacement. If the contacts indicate proper continuity, you will need to check further.

The extracted circuit in the figure tells us that current flows from the T1 transformer, through K-10, K20-A, S24 switch contacts 9-10, through ammeter M7,and back to the neutral side of T1 transformers. The figure shows contacts 21-22 and 6-5 short out T2 and T3 transformers while the switch is in the PH1 position. If the switch is not the source of trouble, check the whole circuit for continuity to include relays, transformers, and wiring.

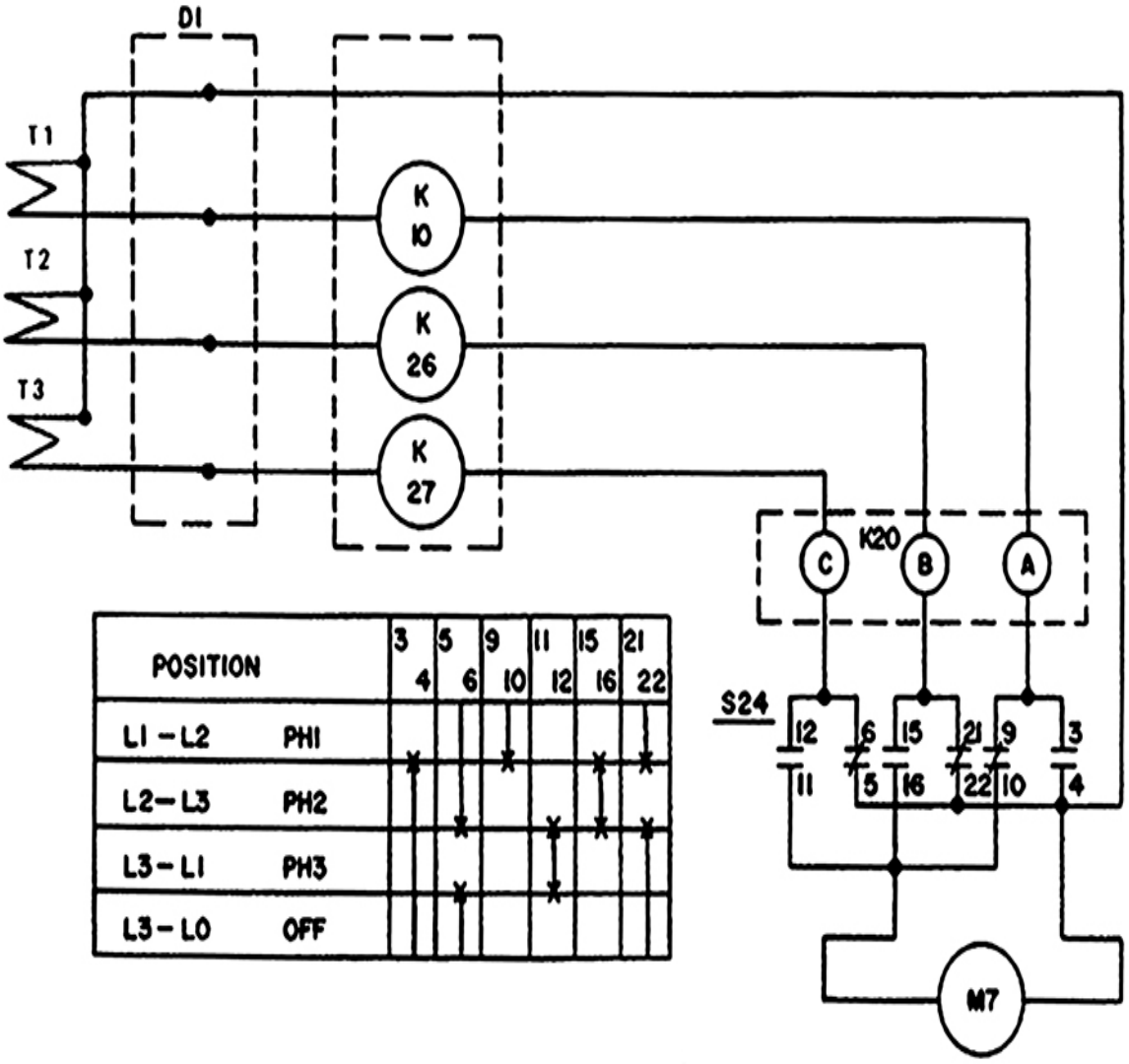


Figure 3-21. Extracted ammeter circuit for phase 1.

Self-Test Questions

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

214. Electrostatic discharge control

1. What technical order covers the framework for ESD control of sensitive devices?

2. What are the three primary areas you will deal with ESDS items?

3. What kind of indicator would clue you in to the existence of ESDS components?

4. What does this symbol (**ESD**) prepare you for when it appears before a maintenance step in the technical order?

5. What is the single most important item for effective static control?

6. What must be installed to ensure an electronic drawer's internal components are protected by an effective Faraday Cage?

7. What is the resistance reading you are looking for when measuring between the facility ground point and the portable workstation's CPGS?

8. Which type of packaging material is the first layer of material to cover ESDS components and is typically used in conjunction with other types of packaging?

9. What are the three classifications of ESDS failures and which one is usually the easiest to detect?

215. Interpreting diagrams

1. In what state are circuits generally portrayed on a diagram?

2. What are used by diagram authors to include critical information in a diagram?

3. Identify the electrical symbols.

a. _____

b. _____

c. _____

d. _____

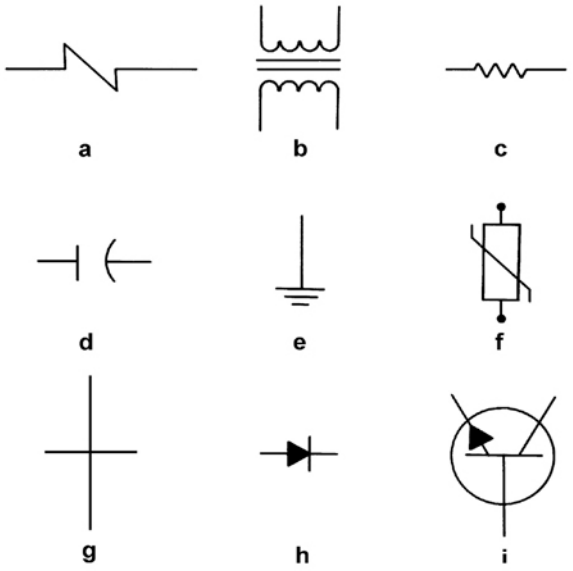
e._____

f._____

g. _____

h._____

i._____



4. Match the description in column A with the circuit diagram in column B. Items in column B may be used more than once.

Column A	*Column B*
____(1) Shows point-to-point connections between components.	a. Block diagram.
____(2) Technical illustrations of the interconnection of components in a circuit.	b. Wiring diagram.
____(3) Generally found in two forms.	c. Schematic diagram.
____(4) Shows the major end items or components without showing the inner workings.	
____(5) Provides overall view of a particular system.	

216. Circuit tracing

1. What benefit is there to using wiring diagrams when troubleshooting electrical problems?

2. What are two things you can do to make tracing circuits on a diagram easier for troubleshooting?

217. Troubleshooting techniques

1. What steps would you take if you were replacing a maintenance team to continue troubleshooting a fault?

2. What is the definition of electrical troubleshooting?

3. Match the description in column A with the troubleshooting step in column B. Items in column B may be used more than once.

Column A	*Column B*
____(1) Studying symptoms and ask yourself three questions.	a. Research.
____(2). Failure to perform this step may result in overlooked malfunctions.	b. Preliminary check.
____(3) Determine if an actual problem exists.	c. Operational check.
____(4) Use only authorized items listed in technical order.	d. Analyze the malfunction.
____(5) Initial use of your senses; hearing, sight, smell, and touch.	e. Locate the malfunction.
____(6) Utilize MMOC to obtain fault history.	f. Corrective action.
____(7) Can be the most difficult part of troubleshooting.	g. Final operational check.
____(8) Have spare test equipment available.	

218. Electrical malfunctions

1. What are the most common types of electrical malfunctions?

2. Match the description in column A with the electrical malfunction in column B. Items in column B may be used more than once.

Column A	*Column B*
____(1) A powered circuit conductor makes contact with the equipment chassis.	a. Open.
____(2) Positive conductors of two or more independent circuits making contact.	b. Direct short.
____(3) Cause may be loose or missing hardware.	c. Cross short.
____(4) Electrical malfunction is located between the last applied voltage reading and the first 0-voltage reading.	d. Shorted control.
____(5) Troubleshoot the negative side of a DC circuit fault first.	e. Short to ground.
____(6) Usually the result of over current conditions.	f. Ground.
____(7) Positive and negative conductors making contact.	g. Low power.
____(8) Symptoms could be electric motor running sluggishly.	
____(9) Electrical malfunction is located between the last 0.00 ohm resistance indication and the first OL indication.	

3. On what type of component would you expect more resistance in one direction?

4. How would you check the resistance across a relay’s contacts?

5. What would a large difference in potential across a switch contacts indicate if the switch was set to the ON position and power is applied?

3-2. Hydraulic and Pneumatic Systems

As you become qualified to preform your duties as a technician, you will encounter maintenance tasks that require the use of either hydraulics or pneumatics to complete the task. This lesson is designed to give you an understanding of the principles of those systems.

219. Hydraulic system theory

Have you ever wondered how a tiny hydraulic car jack (fig. 3–22) can lift the immense weight of an automobile simply by pumping the jack's handle? Have you ever seen construction equipment easily moving tons of dirt or rocks? Hydraulic systems are what make this possible, and in this lesson, we will cover the basics of how these systems operate.

Figure 3–22. Hydraulic automobile jack.

Hydraulic systems operate on the principle that a liquid cannot be compressed, and a force applied to one end of a contained body of liquid will be transferred equally throughout all parts of that body of liquid (fig. 3–23). The hydraulic system must be completely sealed off from the atmosphere, and have no leaks to be fully effective.

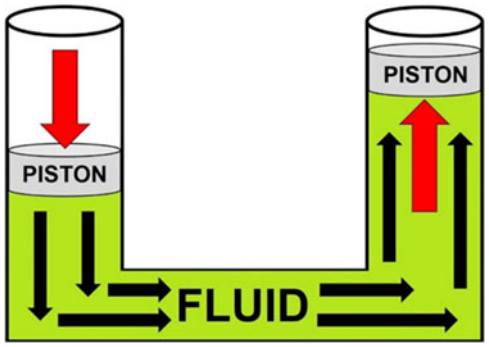


Figure 3–23. Simple hydraulic system.

As you can see from the figure, downward pressure on top of the left piston transfers through the liquid to the bottom of the right piston, forcing it upward. Simple, right?

Hydraulic system operation

As you have read, hydraulic system theory is very simple. Pressure on one part of a sealed body of fluid will be transferred to all other parts of the body of fluid in equal amounts.

The two pistons in figure 3-24 have exactly the same dimensions and surface area, and the cylinders that they ride up and down in have the same dimensions as well. This means that the downward force applied to one side of the system will be transferred to the other side of the system in an equal amount.

If the piston on the left moves downward six inches, the piston on the right will move upward exactly six inches. This hydraulic system has a 1 to 1 (1:1) ratio, and this particular configuration only illustrates how a hydraulic system functions, and does not offer any sort of mechanical advantage or multiplication of force. So how, then, can pumping the handle of the car jack with only the weight of a person's upper body lift an automobile that weighs 500 pounds (lbs.)? The primary function that a hydraulic system provides is to act as a *force multiplier*. Any tool that reduces the force needed to perform a task is a force multiplier.

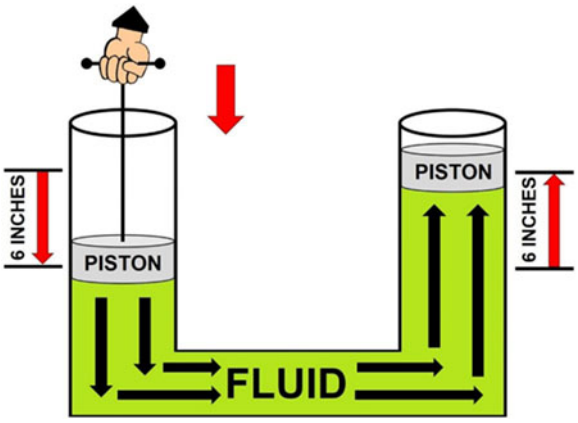


Figure 3–24. 1 to 1 ratio hydraulic system.

The hydraulic system represented in figure 3–25 is one where force is being multiplied, meaning that the output force is greater than the input force. To accomplish this, the area of the input piston must be smaller than the area of the output piston. We are going to apply 100 lbs. of force to the input piston, which has an area of two square inches (sq. in) 100 lbs. of force divided by the 2 square inch area of the input piston is 50 lbs. per square inch (psi). This 50 psi of force is exerted equally all throughout the fluid, and applied to the larger 12 sq. in. area of the output piston.

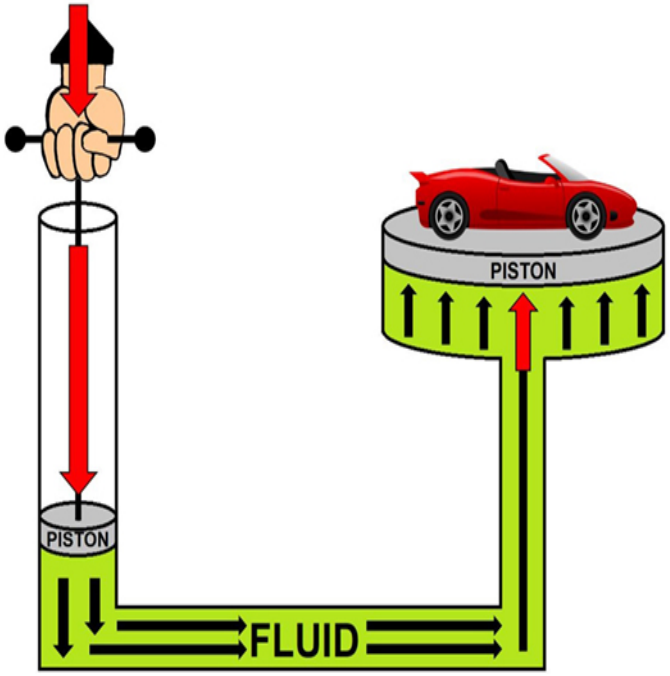


Figure 3–25. Multiplication of effort within a hydraulic system.

Some quick math will show that 50 psi of force, multiplied by the 12 sq. in. area of the output piston, equals 600 lbs. of lifting force exerted by the output piston. You have created 600 lbs. of upward force, which will overcome the automobile's weight of 500 lbs. **Note:** 500 lbs. of force would *not* be adequate to lift the automobile, because the input force would not be *greater* than the weight of the automobile; the two forces would be equal. If you would like to research this subject further, this information is derived from *Pascal's Law*.

Due to the difference in area between the input and output pistons, the output piston will only move a fraction of the distance that the input piston does. To find this ratio, divide the area of the larger piston by the area of the smaller piston. The 12 sq. in. area of the output piston, divided by the two sq. in. area of the input piston, equals six, or a 6:1 ratio. Now you know that in order for the output piston to move just one inch, the input piston will need to move six inches. If you wanted to raise your automobile five inches, your jack handle would need to move 30 inches! This is impractical, which is why hydraulic jacks are designed to be pumped many times versus the handle needing to move several feet.

Using a lever on a fulcrum to lift a heavy weight proves the same concept (fig. 3–26). Notice how the user must move the lever a very long distance, but the 1,000 lb. weight only moves upward a very short distance? The user must move the lever a great distance, but they are able to move heavy objects that they could never have moved with their own strength.

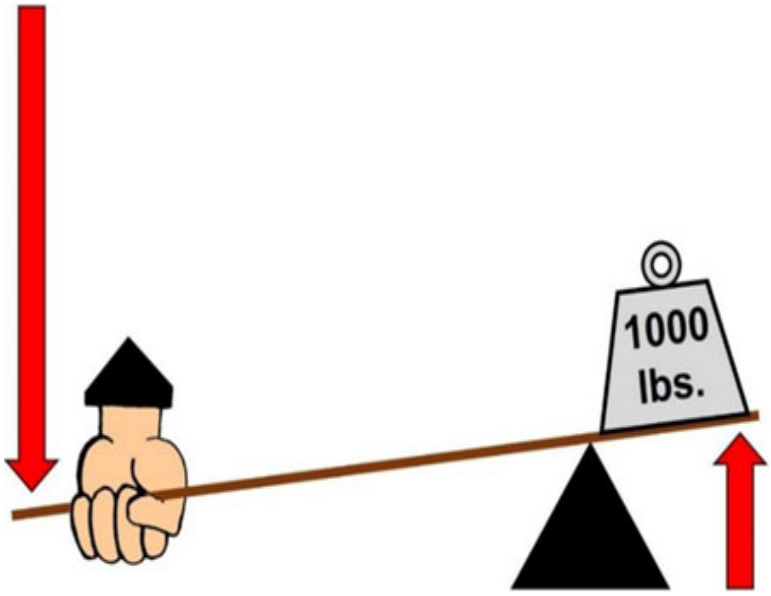


Figure 3–26. Lever system.

The automobile jack is a great example of a hydraulic system in action, but not all systems are operated by hand. For example, construction equipment (fig. 3–27) uses motor driven hydraulic pumps that actuate complex systems capable of lifting many tons. You will learn about these complex systems in your 7-level career development course.

Figure 3–27. Hydraulic systems on heavy equipment.

Hydraulic system precautions

When working with hydraulic systems, there are certain precautions that you and your team members should be aware of. These systems use fluid under extreme pressures to perform work. These pressures may be high enough to puncture skin. If you discover a leak, while the system in in operation, *never* attempt to plug the leak or cover it with another object. Remove power from the system or discontinue its use, and let your task supervisor know that you have discovered a leak.

If the need arises to clean up hydraulic oil, be sure to use the proper personal protective equipment (PPE), and dispose of soiled rags and absorbent material in accordance with your technical orders or other appropriate guidance.

In this lesson, you learned that hydraulic systems use pressurized liquid to do work, and you were familiarized with some of the applications that use them. In the next lesson, we will cover pneumatic systems.

220. Pneumatic system theory

Pneumatic systems operate on the same principles that hydraulic systems do, but a gas (usually air) is used as the medium to accomplish the work. Unlike a liquid, air can be compressed into a smaller volume. An example of this is when you inflate a football, basketball, bicycle tube, or even a balloon. You take the pressure of the outside air, and then compress it into a smaller *volume* inside of the football. In the simplest of terms, pneumatic systems perform work by using pressurized gas in a confined area to apply force to an object (fig. 3–28).

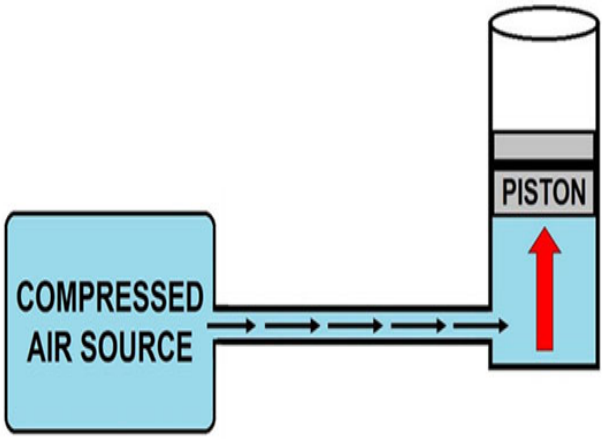


Figure 3–28. Basic pneumatic system.

Pneumatic system operation

The input force in a pneumatic system is equal to the pressure of the compressed air source. The compressed air source used in pneumatic systems is typically at a constant pressure, say 25 psi, which is then applied evenly throughout the system. A valve or other metering device will allow the air pressure to pass through and actuate the object that will be performing the work. When a pneumatic system is at rest, that is *not* performing work, there is no path between the compressed air source and the mechanism that is actuated by the compressed air (fig. 3–29). For example, the fluid in a hydraulic system only transfers force. A compressed gas, on the other hand, will continue to exert force within the system until the pressure is released (vented).

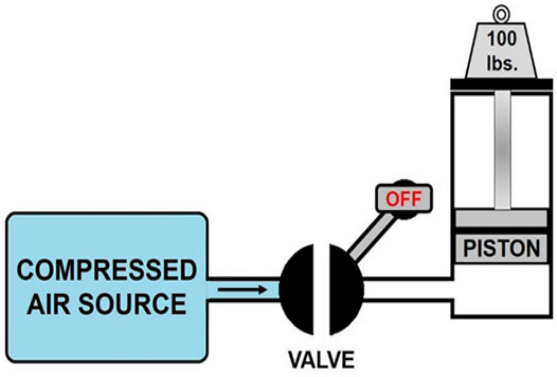


Figure 3–29. Pneumatic system at rest.

When air pressure is needed to actuate the mechanism performing the work, the valve or metering device will allow the compressed air to flow through (fig. 3–30). If a pneumatic system is being used on an assembly line in a factory, for example, this process could happen several times per second. Speed of actuation is where pneumatic systems outperform hydraulic systems. Pneumatic systems can actuate much quicker because gases have a lower resistant to flow than fluids. Pneumatic systems are typically used in factories and processing plants where quick, precise, and repetitive motions are needed.

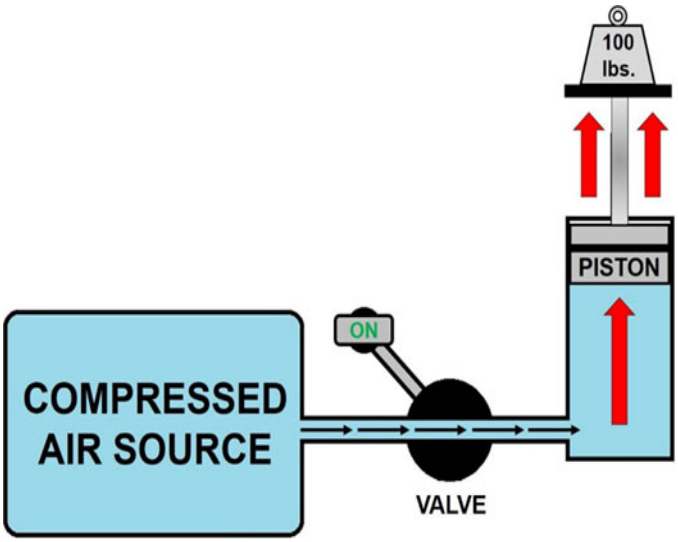


Figure 3–30. Pneumatic system performing work.

A key principle to remember is that there is typically no "back and forth" flow of air in a pneumatic system. The air that is used to perform the work is vented to the atmosphere once it has done its job, and new compressed air is supplied by the compressed air source when needed. This venting is also what makes pneumatic systems much louder than hydraulic systems. Good examples of this are the pneumatic drill that your dentist uses and the pneumatic impact wrench used in mechanic shops. Both produce high levels of noise.

You can apply some of the same math from Pascal's law to the pneumatic system in figure 3-30. To move the 100 lb. weight upward, *more* than 100 lbs. of force will need to be applied to the bottom of the output piston.

Let's say that the compressed air source supplies a constant 25 psi of pressure throughout the system. If the piston has an area of 2 sq. in, you would have 25 psi of pressure acting on that 2 sq. in. area. Twenty-five multiplied by 2 equals 50. Fifty lbs. of force is *not* enough to lift the 100 lb. weight. Even if you increased the area of the piston to 4 sq. in, the weight would not move. The reason for this is that 100 lbs. of force will only *equal* the weight to be lifted. Just like with the hydraulic car jack in the last lesson, the upward force must be greater than the downward force provided by the object you are trying to move. If a piston with a 5 sq. in. area were used, multiplied by the 25 psi supplied by the compressed air source, 125 lbs. of force would be applied to the bottom of the piston. The 125 lbs. of upward force will slowly move the 100 lb. weight. The greater the difference between the applied force and the force required, the faster the work will be accomplished.

As an example, think of yourself pushing a broken down automobile down a flat road. Alone, you can probably provide enough force to get the car rolling very slowly. However, if five of your friends join you behind the automobile to help, it would get rolling much easier, and you could get it rolling at a faster speed as well.

Pneumatic system precautions

There are dangers inherent to pneumatic systems that you and your team members should be aware of. If you discover a leak in a pressurized airline, do not attempt to cover or repair it. Shut down the system or discontinue its use, and let your task supervisor know that you have discovered a leak.

Pressurized air can stir up dust and debris, can accelerate objects to high speeds, and can be very loud. You may even use compressed air for cleaning. Always be sure to use the proper PPE, such as eye and hearing protection, prescribed in your technical orders.

In this lesson, you learned that pneumatic systems use pressurized air to perform work, and you became familiar with some of the applications that use these systems. You will learn about complex pneumatic systems when you complete your 7-level career development course.

Self-Test Questions

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

219. Hydraulic system theory

1. What attributes must a hydraulic system possess to be fully effective?

2. What characteristics would a 1:1 ratio hydraulic system possess?

3. Why would 100 lbs. of downward force on one side of a hydraulic system *fail* to move a weight on the output side of the system?

4. In what way is a lever and fulcrum similar to a hydraulic system?

5. If you discover a leak in a hydraulic system, what should you *never* attempt to do?

220. Pneumatic system theory

1. What happens to a volume of air when it is compressed?

2. Where does the compressed air or gas in a pneumatic system go after it has performed work?

Answers to Self-Test Questions

214

1. TO 00-25-234, *General Shop Practice Requirements for the Repair, Maintenance and Test of Electrical Equipment.*
2. Cabling/connectors, LRUs, and circuit cards.
3. ESD markings.
4. Will be working with ESDS items and to use proper ESD controls.
5. Wrist strap.
6. Conductive dust caps.
7. Less than 10 ohms.

8. Type II.
9. Catastrophic, intermittent, and latent. Catastrophic.

215

1. De-energized.
2. Legend.
3. (a) Solenoid; (b) iron-core transformer; (c) fixed resistor; (d) fixed capacitor; (e) ground; (f) metal-oxide varistor; (g) wiring crossover; (h) silicon diode; (i) NPN transistor.
4. (1) b.
   (2) c.
   (3) b.
   (4) a.
   (5) c.

216

1. You can trace electrical circuitry and determine where to connect test equipment for checking electrical operation.
2. Make a simple drawing of only the specific circuit you are interested in and color code the circuit.

217

1. Verify that the system or circuits have been returned to their operational configuration.
2. A step-by-step procedure of analyzing, locating, and correcting electrical malfunctions.
3. (1) d.
   (2) g.
   (3) c.
   (4) f.
   (5) b.
   (6) a.
   (7) e.
   (8) c.

218

1. Opens, shorts, grounds, and low power.
2. (1) e.
   (2) c.
   (3) f.
   (4) a.
   (5) e.
   (6) d.
   (7) b.
   (8) g.
   (9) a.
3. Diode.
4. Manually close the relay contacts and measure between the input and output contactor terminals.
5. There is a problem with the switch.

219

1. Sealed and no leaks.
2. If one piston moves downward six inches, the piston on the right will move upward exactly six inches.
3. The object to be moved exceeds 100 lbs.

4. It allows the user to move objects that are too heavy to move with their own strength.
5. Attempt to plug the leak or cover it with another object.

220

1. It will fill a smaller volume.
2. Vented into the atmosphere.

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. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

56. (214) Select the technical order (TO) that covers the handling and storage of electrostatic discharge (ESD) sensitive devices.
    a. 00–25–124.
    b. 00–25–234.
    c. 00–25–324.
    d. 00–25–334.

57. (214) Which technical order (TO) has a chapter that identifies the location of electrostatic discharge (ESD) sensitive components by unit reference designator?
    a. 21M-LGM30G–2–12–4.
    b. 21M-LGM30G–2–1–7.
    c. 21M-LGM30G–2–10.
    d. 21M-LGM30G–2–11.

58. (214) Newly assigned personnel who handle electrostatic discharge (ESD) sensitive items shall receive
    a. initial ESD handling training only.
    b. initial ESD awareness and prevention training only.
    c. initial ESD handling training and annual refresher training.
    d. initial ESD awareness and prevention training and annual refresher training.

59. (214) Which electrostatic discharge (ESD) option would *not* be authorized for circuit card removal?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

60. (214) Prior to initial use, personnel must test their wrist straps for serviceability and log the date,
    a. time, results, and user name.
    b. time, results, and team chief’s name.
    c. results, user name, and evaluators name.
    d. results, user name, and team chief’s name.

61. (214) Which electrostatic discharge (ESD) precaution is *required* prior to removing a circuit board from inside the auxiliary alarm panel (AAP)?
    a. Place the replacement circuit card on the portable static control workstation.
    b. Remove all essential items from the work area.
    c. Touch the AAP case with a bare hand.
    d. Roll sleeves up above the elbow.

62. (214) Which of the following support base maintenance statements concerning electrostatic discharge (ESD) operations is true?
    a. Wrist straps must be worn at *all* times.
    b. The fixed ESD work stations are smaller.
    c. The ground resistance measurement tolerance is more restrictive.
    d. There are ESD safe tools equipped with static generating systems.

63. (214) Which type(s) of electrostatic discharge (ESD) packaging is/are preferred?
    a. I.
    b. II.
    c. III.
    d. I and II.

64. (214) Select the electrostatic discharge (ESD) failure that is considered the worst type.
    a. Latent.
    b. Irregular.
    c. Intermittent.
    d. Catastrophic.

65. (215) To make understanding system operation easier, diagrams are usually drawn with
    a. the power source on the right and the diagram flowing left.
    b. the ground terminals removed to eliminate complicating the diagram.
    c. power *applied* and switches and contacts in the appropriate position.
    d. power *not* applied and switches and contacts in the appropriate position.

66. (215) Select the *major* characteristic of functional diagrams.
    a. Drawn in the form of blocks to represent major end items.
    b. The most useful for troubleshooting individual circuits.
    c. Show point-to-point connections between components.
    d. Provide quick wire reference numbers.

67. (215) During troubleshooting, a wiring diagram is a useful tool because it will
    a. give an overall view of a particular system.
    b. allow you to verify a component is wired properly.
    c. give fuse ratings and coil resistance measurements.
    d. contain component values, tolerances, and standard symbols.

68. (216) Using the correct technical reference to understand circuit operations is
    a. rule two for tracing electrical circuits.
    b. the most important step in circuit extraction.
    c. needed only when working with energized circuits.
    d. needed only when working on de-energized circuits.

69. (217) What should a replacement troubleshooting team verify before taking over a task?
    a. All previously accomplished steps are confirmed.
    b. The power is removed from the system or circuits.
    c. A thorough crossover is conducted between team chiefs.
    d. Verify the system is returned to its operational configuration.

70. (217) Before troubleshooting a system, you must
    a. listen for a chattering relay or unusual noises.
    b. ensure all power is removed and all grounds are installed.
    c. review the applicable technical order before taking any steps.
    d. identify what component is overheating, damaged, leaking, or producing alarm indications.

71. (217) While troubleshooting, verifying if any recent maintenance activities have occurred on a system will help
    a. locate the area to start probing actions.
    b. thoroughly study the symptoms of the malfunction.
    c. to determine if the problem is electrical or mechanical.
    d. alleviate some specific parts from the possible problem.

72. (217) When the technical order does not clearly help alleviate a problem, what can be the most difficult part of troubleshooting?
    a. Research.
    b. Operational checks.
    c. Locating the cause of the malfunction.
    d. Performing a preoperational checkout of the malfunctioning system.

73. (217) Which will a technician do to determine if the malfunction found during troubleshooting is corrected?
    a. An operational check.
    b. Final power application.
    c. Compliance and checkout.
    d. Research and documentation.

74. (218) Which voltage will a digital multimeter display if the leads are connected between two positive points with each point having a potential of 24 volts?
    a. 0.
    b. 12.
    c. 24.
    d. 48.

75. (218) When a circuit is inoperative and a protective device in the circuit has actuated, it is an indication of a
    a. cross short.
    b. direct short.
    c. shorted control.
    d. cross to ground.

76. (218) Which short has occurred when switches are welded closed and a circuit continues to operate with the control device in the OFF position?
    a. Direct short.
    b. Cross control.
    c. Shorted control.
    d. Control to ground.

77. (218) What will occur if a circuit conductor unintentionally makes contact with the conduit, frame, chassis, or any other metallic part of the wiring system that is connected to ground?
    a. Cross short or direct short.
    b. Cross short or shorted control.
    c. Short to ground or direct short.
    d. Short to ground or shorted control.

78. (218) What is indicated when a technician reads the same resistance at both ends of a diode?
    a. Diode is malfunctioning.
    b. Diode is working properly.
    c. Meter test leads are crossed.
    d. Meter is set at too high of range.

79. (218) Select the statement that is the *most* accurate in regards to testing a switch.
    a. Power must be applied.
    b. Power must be removed.
    c. Power may be removed or applied.
    d. Testing is only required if its coil winding is shorted.

80. (219) Hydraulic systems operate on the principle that a liquid
    a. can be contained.
    b. cannot be contained.
    c. can be compressed.
    d. cannot be compressed.

81. (219) When the area of the input piston is smaller than the area of the output piston, the output force of the hydraulic system is
    a. equal.
    b. faster.
    c. reduced.
    d. multiplied.

82. (220) Pneumatic systems work by applying force to an object using
    a. chilled gas.
    b. pressurized gas.
    c. low volume gas.
    d. combustible gas.

83. (220) Pneumatic systems operate at a faster rate than hydraulic systems because gases
    a. weigh less than fluids.
    b. ignite quicker than fluids.
    c. have a greater density than fluids.
    d. have less resistance to flow than fluids.

Please read the unit menu for unit 4 and continue ➔

Unit 4. Support Base Maintenance

AT SOME POINT in your maintenance career you are probably going to replace an electronic drawer to fix a fault or to take code components out to a site to perform a code change. All of these like-items require some form of testing, inspecting, calibrating, repairing, certifying, or coding. This all happens back at the support base, primarily in the electronics laboratory (E-lab) or the codes vault. As you progress through this unit, you will read about the various pieces of support equipment that serve to test and certify the weapon system's equipment, test equipment, and code components.

4-1. Electronic Test Equipment Description

This section is dedicated to the E-lab test benches and certifications. If you ever get the chance to work in the E-lab, you will quickly discover this is where all the weapon system electronic components are tested, inspected, calibrated, and repaired. E-lab also performs the missile guidance set (MGS) certification.

To begin, the first lesson will cover the Ground Minuteman Automated Test System (GMATS). The second lesson will cover the electrical facility base maintenance test equipment (AN/GSM-82) or 82-bench. The third lesson will talk about the nuclear certification test station. The fourth lesson will discuss some MGS inspections and cover the missile guidance set test set (MGSTS), and finally you will learn about the missile maintenance test set (MMTS).

221. Ground Minuteman Automated Test System

The main equipment test bench (fig. 4-1) that E-lab uses is the GMATS (AN/GSM-315A). This is the most important and complex piece of equipment in the E-lab. This machine is responsible for validating the majority of the electronic equipment drawers that are used in the Minuteman weapon system. In this lesson, your goal will be to grasp a general understanding of the components that comprise the GMATS and to get a basic understating of its function and operation. Figures 4-2 and 4-3 show the various bays that make up the GMATS. Let us start with a general system description.

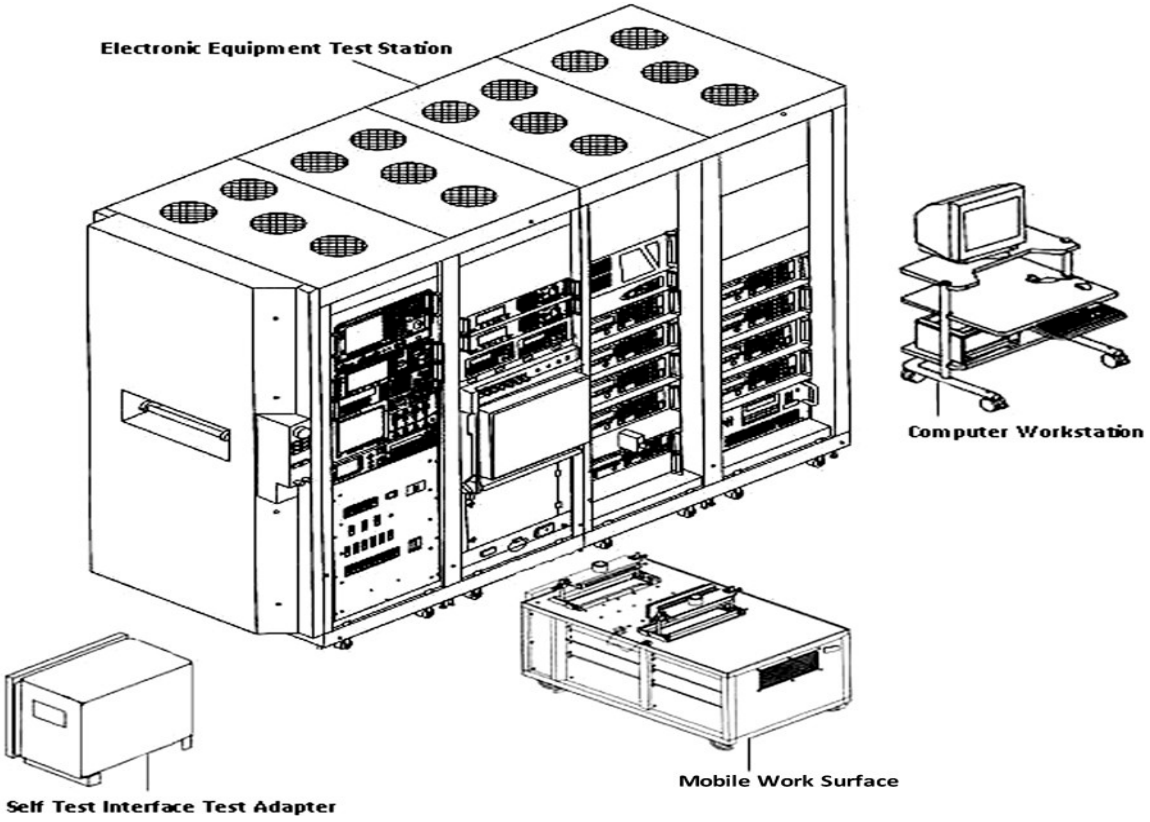
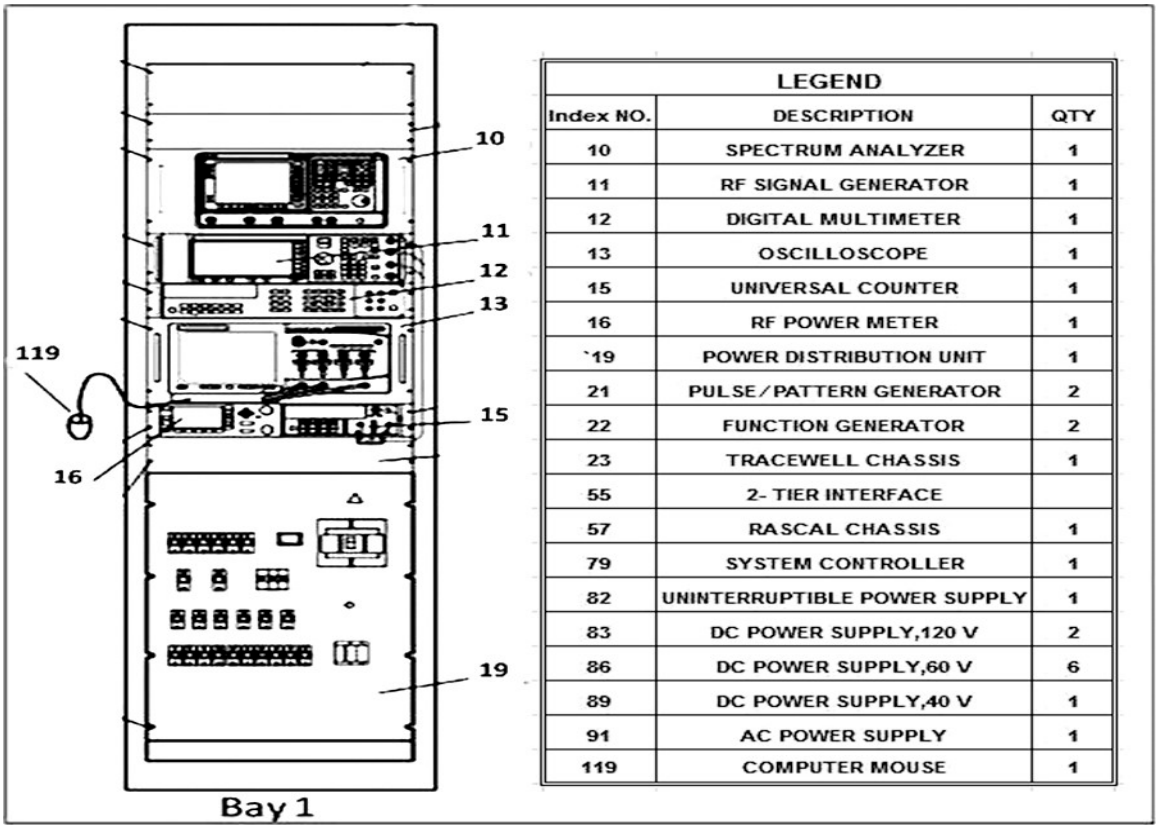
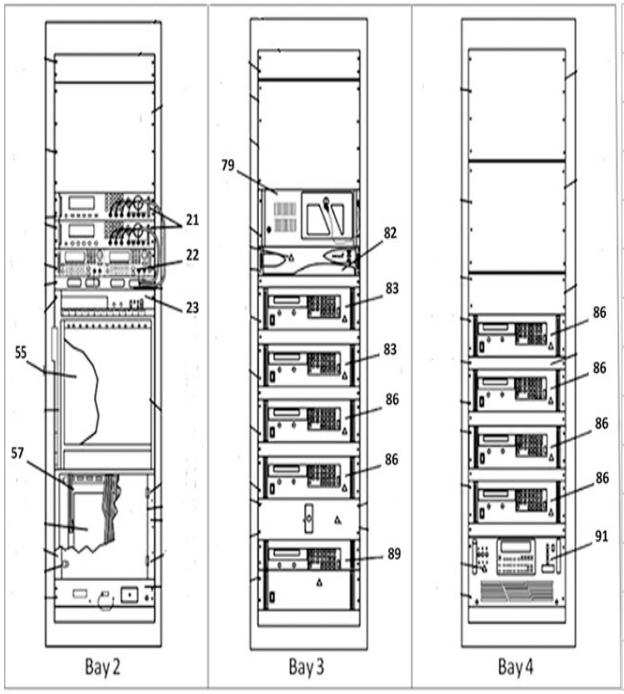


Figure 4-1. Ground Minuteman Automatic Test System.



LEGEND		
Index NO.	DESCRIPTION	QTY
10	SPECTRUM ANALYZER	1
11	RF SIGNAL GENERATOR	1
12	DIGITAL MULTIMETER	1
13	OSCILLOSCOPE	1
15	UNIVERSAL COUNTER	1
16	RF POWER METER	1
19	POWER DISTRIBUTION UNIT	1
21	PULSE/PATTERN GENERATOR	2
22	FUNCTION GENERATOR	2
23	TRACEWELL CHASSIS	1
55	2- TIER INTERFACE	
57	RASCAL CHASSIS	1
79	SYSTEM CONTROLLER	1
82	UNINTERRUPTIBLE POWER SUPPLY	1
83	DC POWER SUPPLY,120 V	2
86	DC POWER SUPPLY,60 V	6
89	DC POWER SUPPLY,40 V	1
91	AC POWER SUPPLY	1
119	COMPUTER MOUSE	1

Figure 4-2. Bay one.



LEGEND		
Index No.	DESCRIPTION	QTY
21	PULSE/PATTERN GENERATOR	2
22	FUNCTION GENERATOR	2
23	TRACEWELL CHASSIS	1
55	2-TIER INTERFACE	1
57	RASCAL CHASSIS	1
79	SYSTEM CONTROLLER	1
82	UNINTERRUPTIBLE POWER SUPPLY	1
83	DC POWER SUPPLY, 120 V	2
86	DC POWER SUPPLY, 60 V	6
89	DC POWER SUPPLY, 40 V	1
91	AC POWER SUPPLY	1
119	COMPUTER/ MOUSE	1

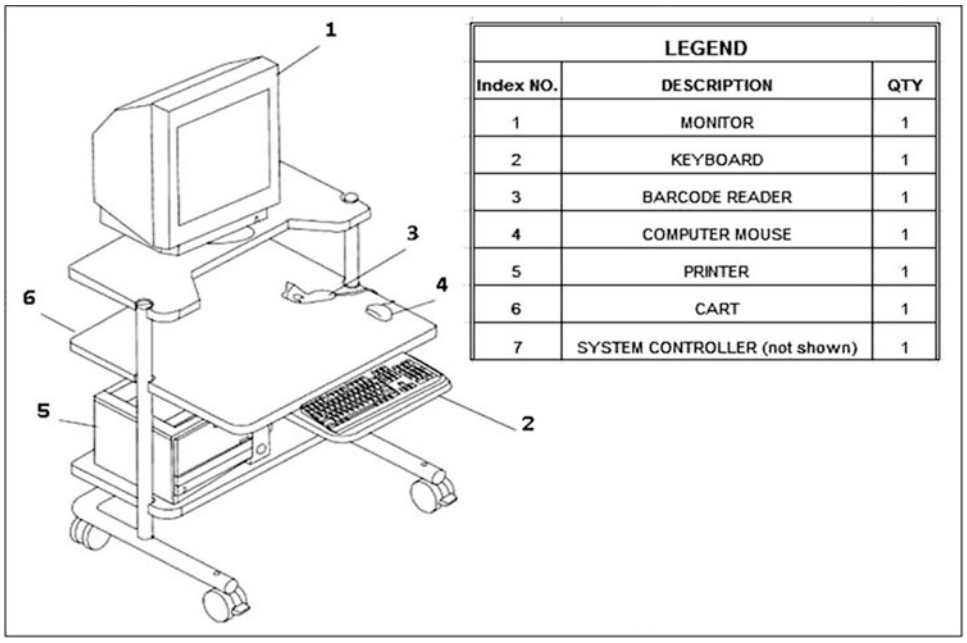
Figure 4-3. Bays two, three and four.

Computer group

The computer group provides overall control, internal and external data transfer, and communications between the various subsystems and peripheral devices in the test station. The components within this group include the following:

- Mouse.
- Printer.
- Monitor.
- Keyboard.
- Cart (fig. 4-4).
- Bar code reader.
- System controller (installed in Bay 3).

The legend in figure 4-4 lists the equipment used within the computer group. As previously mentioned, we will discuss these items in more detail in the 7-level CDC.



LEGEND		
Index NO.	DESCRIPTION	QTY
1	MONITOR	1
2	KEYBOARD	1
3	BARCODE READER	1
4	COMPUTER MOUSE	1
5	PRINTER	1
6	CART	1
7	SYSTEM CONTROLLER (not shown)	1

Figure 4-4. Computer workstation.

Power and switching group

The power and switching group provides the power to be applied to the unit under test (UUT) and the devices that control the power application. The following components are within this group:

- Racal chassis.
- Microcontroller.
- Tracewell chassis.
- AC power supply.
- Power distribution unit.
- Uninterruptible power supply (UPS).
- 36 volts direct current (VDC), 100- ampere (amp) (high current) power supply.
- 60 VDC, 35-amp power supply.
- 120 VDC, 18-amp power supply.

Instrumentation group

The instrumentation group consists of the devices within the GMATS used to measure and interpret data received from the UUT. The following components are within this group:

- Radio frequency (RF) signal generator.
- Oscilloscope.
- RF power meter.
- Universal counter.
- Spectrum analyzer.
- Function generator.
- Digital multi-meter.
- Pulse/pattern generator.

Mobile work surface

The mobile work surface (MWS) provides any additional support required for UUT testing. The UUT is mounted on the MWS, which has connections to receive and provide the UUT cooling air. Operational power for the UUT is provided from the test station through an interface test adapter (ITA) (fig. 4-5). Additionally, the MWS houses a shunt assembly that is used to calibrate the DC power supply. Voltage measured across the shunt (proportional to the current flow) is used to calibrate the test station power supplies. The shunt is capable of routing heavy current and is hardwired between the A6 circuit breaker and pins on one of the A6 connectors. The circuit breaker (100 amps) provides overload protection.

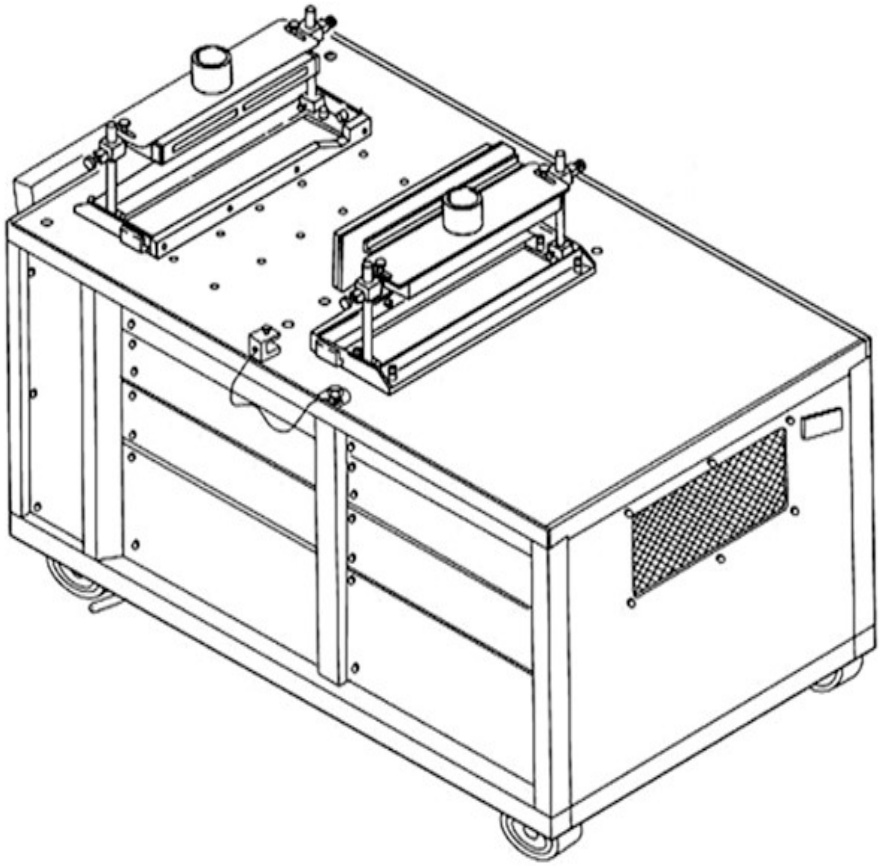


Figure 4-5. Mobile work surface.

Interface test adapter

NOTE: Each UUT (electronic drawer) that E-lab is capable of testing has its own specific ITA.

An ITA is connected to the test station via the front panel interface carrier assembly (ICA) connection (fig. 4-6). The ITA provides the interface between the UUT and the electronic equipment test station through interconnecting cables. Power from the electronic equipment test station is supplied to the UUT and the output of the UUT is returned to the electronic equipment test station through the interconnecting cables.

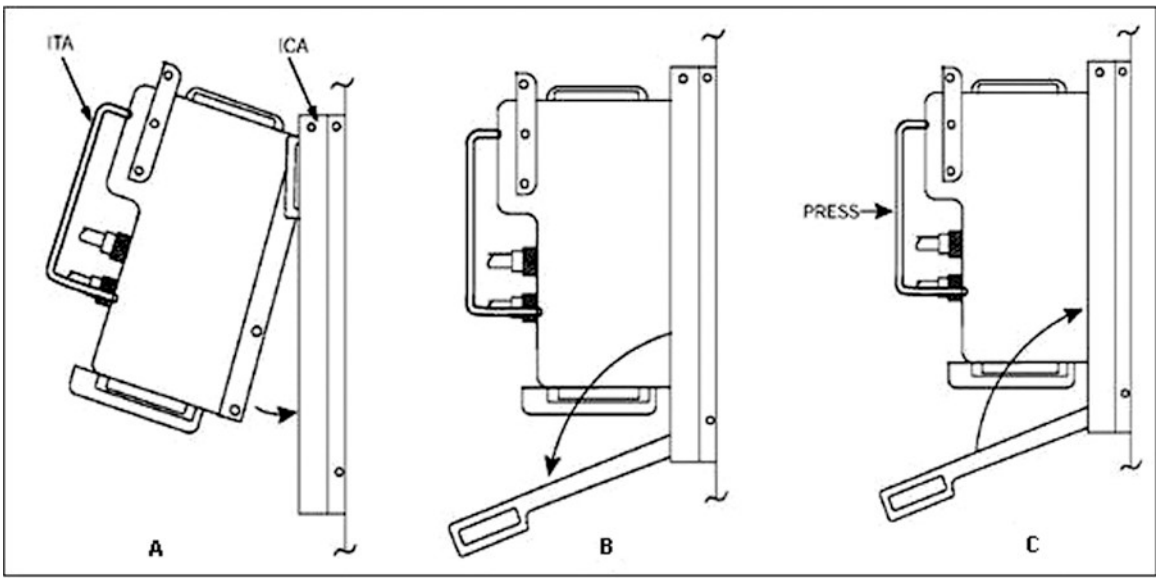


Figure. 4-6. Interface test adapter.

General function and operation

The GMATS was designed to replace several older benches and test equipment in the E-lab by consolidating their functions into one force-wide common test system. Its operational purpose is to test, troubleshoot, or calibrate a UUT. An example of a UUT could be a guidance and control coupler unit drawer that requires a functional checkout as part of an operational certification (OPCERT) before being installed in the LF. Testing is accomplished by interfacing the UUT with the electronic equipment test station through an ITA. A UUT specific ITA is connected to the ICA that is located on Bay 2 of the electronic equipment test station. Cables coming from the ITA are then connected to the UUT, which is secured in the MWS's holding fixture.

The MWS has a cooling manifold that supplies cooling air to the UUT during powered applications. After the set-up is complete, a windows-based graphical user interface (GUI) screen at the computer workstation enables the user to select and click on the desired pre-programmed testing option to begin the UUT testing sequence. These pre-programmed tests have been designed to isolate and identify faults (fig. 4-7).

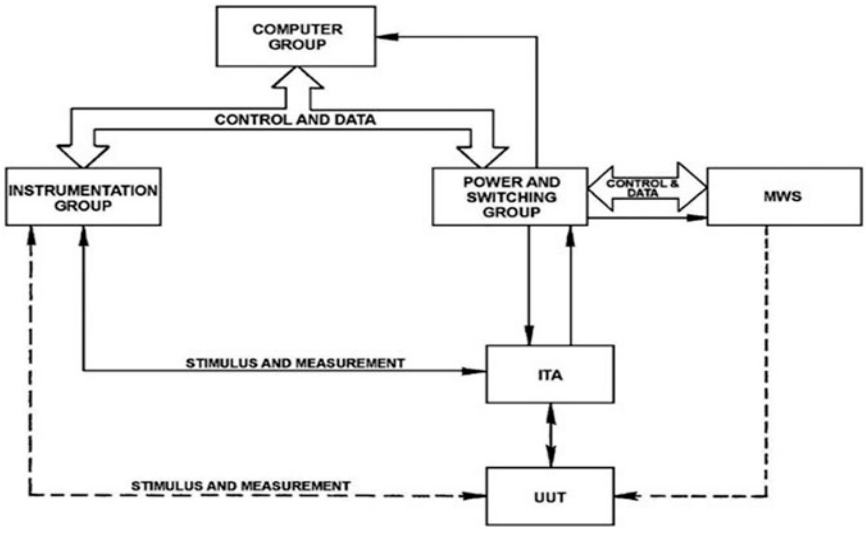


Figure 4-7. Overall functional block diagram.

Control of the electronic equipment test station is through the system controller. The user selects the appropriate test program to run on the GUI test screen. The system controller then sends commands through the general purpose interface bus (GPIB) interface to the Racal and Tracewell chassis, which contains printed circuit card assemblies (PCA) for signal switching control and the individual test instruments. The power supplies provide the UUT with operational power through the ITA that is connected to the ICA. The output of the UUT is sent back to the test station and analyzed by the test instruments.

222. Electrical facility base maintenance test equipment

Another piece of testing equipment you may have the opportunity to work with is the electronic facility-base maintenance test equipment, AN/GSM–82 (V), referred to as the 82 Bench. This particular unit is used for intermediate level testing of the Minuteman weapon system's drawers and support equipment. The goal for this lesson will be to help you obtain a general understanding of the 82 Bench and to shed some light on some of the testing functions it performs.

Physical layout and description

The 82 Bench is composed of a workbench, two holding fixtures, and an assortment of test adapters and test sets.

Workbench

The workbench (fig. 4-8) gives the technician a work surface for tools and technical orders, but it is primarily used as a power receptacle for individual test equipment and UUTs. A generator located in close proximity to the E-lab simulates site power and supplies the workbench with 120/208 volts alternating current (VAC), 60-hertz (Hz) and 400-Hz, three-phase power. The test equipment uses the 120 VAC, 60-Hz, single-phase power strips that are mounted to the workbench. The 120/208 VAC, 400-Hz, 3-phase power jacks are used for some UUT power requirements.

The workbench also functions as an ESD workstation. As you previously read about ESD, this bench requires an annual certification and -6 maintenance inspections.

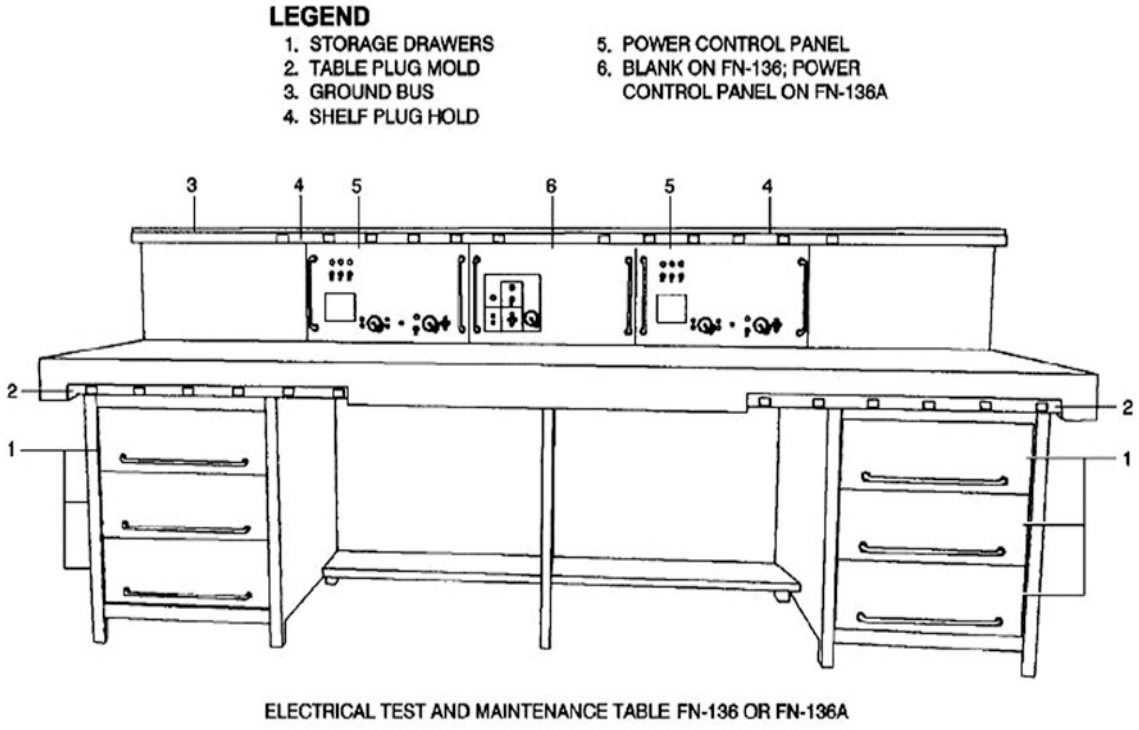


Figure 4-8. Workbench.

Holding fixtures

The MT-2812 and MX-4285 (electrical equipment drawer fixtures–cooling air) holding fixtures (fig. 4-9) are designed to hold electronic drawers, test adapters, and test sets for testing and enables cooling air to be supplied to the drawer. The cooling requirement of the drawer dictates which holding fixture will be used. The MT-2812 has one flexible air duct adapter, while the MX-4285 has two. Each holding fixture has air pressure monitoring switches mounted internally to regulate airflow.

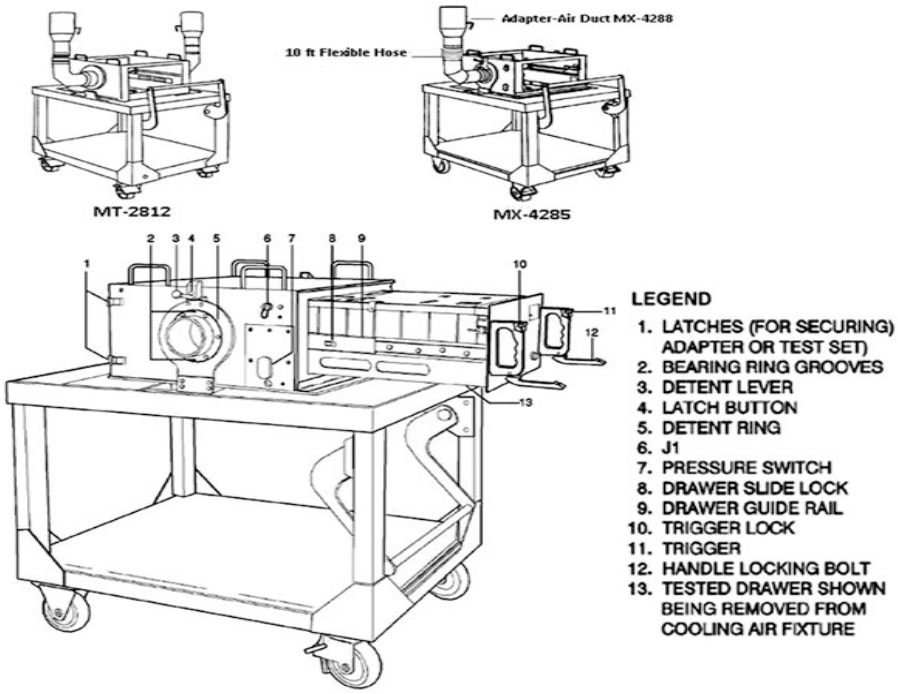
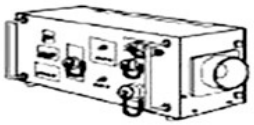


Figure 4-9. Holding fixtures.

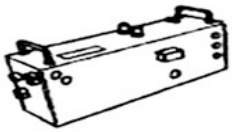
Test sets and adapters

The various test sets (fig. 4-10), adapters (fig. 4-11), and cables have specific functions depending on the type of UUT and actual test or checkout being performed. Some of these functions are to provide the following:

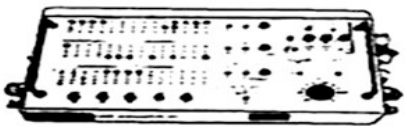
- Interface between the UUT and the test set.
- Active signal circuitry for equipment adjustments.
- Test controls, loads, test lamps, indications, and test points during testing or checkout.
- Modified top and bottom adapter covers with access points for adjustments/measurements/test connections during power applied electronic equipment drawer testing and to contain cooling air.



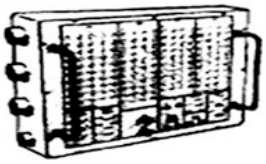
ELECTRICAL DUMMY LOAD DA-304, DA-305, AND DA-306



RECEIVER – TRANSMITTER ALARM SET TEST SET TS – 1826

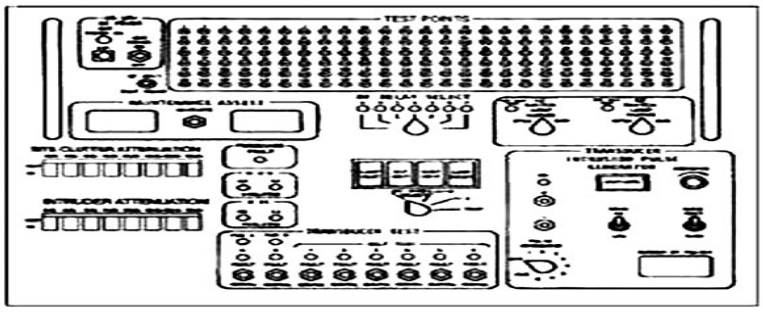


POWER SUPPLY TEST SET TS–1862A

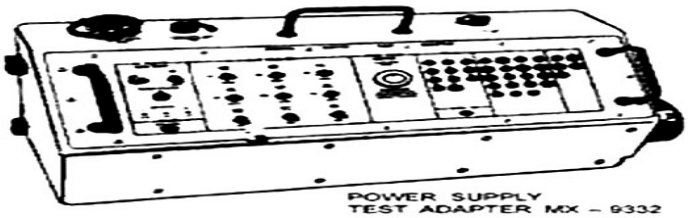


ELECTRICAL EQUIPMENT DRAWER TEST SET TS–2175

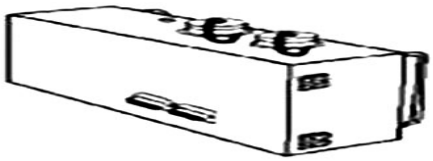
Figure 4-10. Typical test sets.



R/T ALARM SET TEST ADAPTER [1> MX-18317/GSM-82 (V)



POWER SUPPLY TEST ADAPTER MX – 9332



PROGRAMMER GROUP ADAPTER-CONNECTOR MX-4283

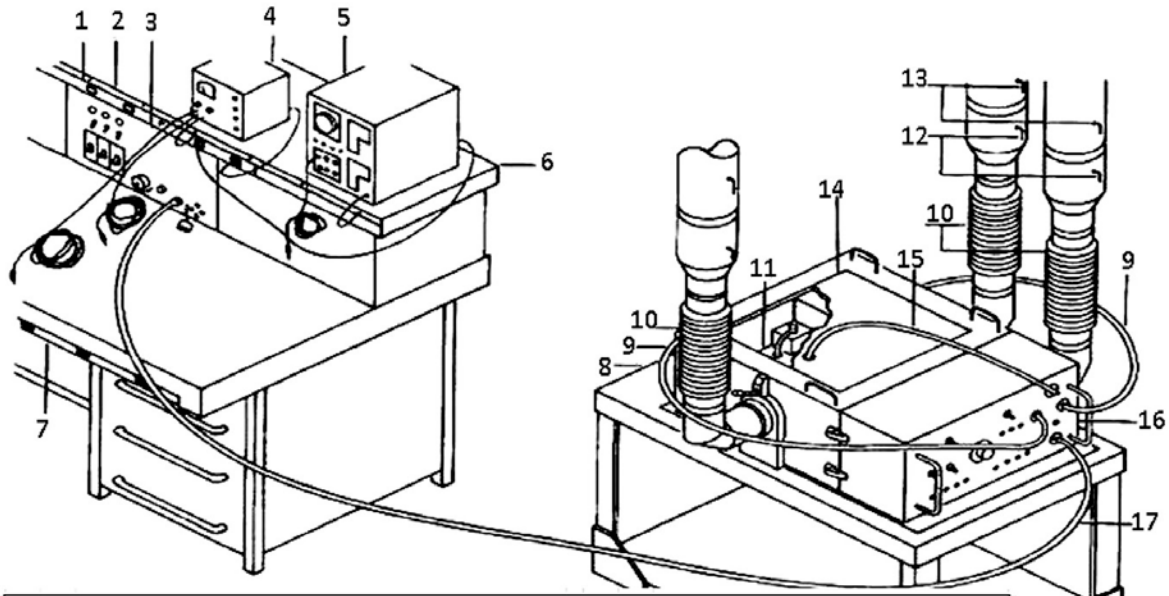
Figure 4-11 Typical test adapters.

Typical test configuration

As illustrated in figure 4-12, the holding fixture cart is positioned near the workbench. The test set or adapter (in this illustration, a dummy load is being used) is placed at the rear of the holding fixture and secured in place by four latches, two on either side. The power supply drawer (in this illustration) is inserted into the holding fixture, just as a typical drawer would be installed in an equipment rack at a LF or LCC. The power supply drawer plugs electrically mate with the dummy load connectors, once the drawer is fully seated in the holding fixture and the drawer handles are latched. This would be comparable to the drawer plugs electrically mating with the connecters on the power signal and distribution unit (PSDU) at an LF or LCC, once the drawer handles are locked into place. Next, the cooling hose or hoses are connected and the test and power cables are connected.

The 82 Bench set up enables the technician to remove the top or bottom cover of the drawer as part of the checkout or calibration. When cooling air is necessary and internal test connections, measurements, or adjustments are required, the drawer cover adapters are used to provide passage for cables/wires, tools, or testing devices to those internal points while maintaining a seal for the cooling air.

Although the 82 Bench is phased out for most electronic equipment drawer testing, it is still useful for certain checkouts on a couple of electronic power supply drawers and the receiver-transmitter alarm set drawer.



LEGEND			
1	MAINTENANCE (MNX) TABLE SHELF PLUG MOLD	10	10 FT FLEXIBLE HOSE
2	MNX TABLE GROUND BUS	11	POWER SUPPLY DRAWER
3	MNX TABLE POWER CONTROL PANEL	12	ADAPTER-AIR DUCT
4	DIFFERENTIAL VOLTMETER	13	FACILITY COOLING AIR SHUTOFF DAMPER
5	OSCILLOSCOPE	14	COVER-POWER SUPPLY TEST
6	ELECTRICAL TEST AND MNX TABLE	15	CABLE ASSEMBLY W17
7	TABLE PLUG MOLD	16	ELECTRICAL DUMMY LOAD
8	ELECTRICAL EQUIPMENT DRAWER FIXTURE-COOLING AIR	17	CABLE ASSEMBLY W14
9	CABLE ASSEMBLY W13 or W16		

Figure 4-12. Typical 82 Bench test set up.

223. Nuclear certification test station

It is the WSP's critical function in the weapon system that drives us to scrutinize its operational reliability and capability before it is ever installed into an operational LCC. As a major critical component of the Minuteman weapon system's command and control (C2) system, it is imperative that this piece of equipment be operationally certified. To accomplish this, the WSP and some of its circuit card assemblies are functionally certified and tested using the nuclear certification test station (NCTS). From this lesson, you should gain a general understanding of the NCTS. Let's begin with a general function of the NCTS.

Function

The NCTS is another piece of E-lab equipment that is primarily used to operationally certify OPCERT or verify the following C2 system components:

- OPCERTs the WSP.
- OPCERTs the single module computer 810 (SMC-810) circuit card assembly (CCA).
- OPCERTs the extended memory array dynamic (EMAD) CCA.
- Verifies the asynchronous/synchronous serial interface CCAs. More commonly known as the RMB32 modules.

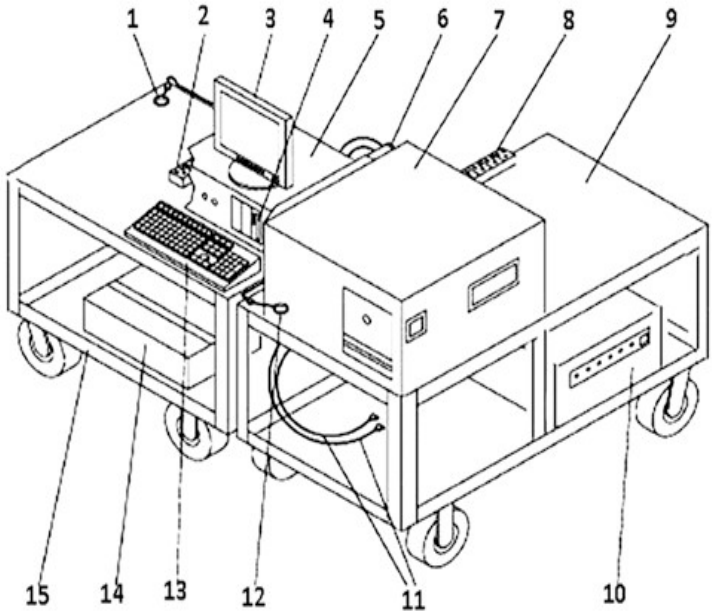
NOTE: The RMB32 modules do not require OPCERT prior to installation; however, they do require verification prior to being installed into the WSP.

The NCTS is also capable of programming the programmable read-only memories (PROM) mounted on the SMC-810.

Equipment description

The NCTS (fig. 4-13) consists of the following components:

- Computer processor assembly (CPA).
- Circuit card module test fixture (MTF).
- WSP test fixture (WTF).
- Two system circuit cards: a SMC-810 and a RMB32.
- Cable kit.
- Two mobile work platforms (MWP).
- Nuclear Certification Test Program (NCTP).



LEGEND			
1	ESD GROUND CONNECTION	9	MOBILE WORK PLATFORM
2	POWER STRIP	10	MODULE TEST FIXTURE ASSEMBLY (MTF)
3	MONITOR	11	TEST SET CABLE ASSEMBLY
4	CD DRIVE	12	ESD GROUND CONNECTION
5	PERSONAL COMPUTER	13	KEYBOARD
6	AIR INLET HOUSING	14	PRINTER
7	WSP TEST FIXTURE (WTF)	15	MOBILE WORK PLATFORM (MWP)
8	POWER STRIP		

Figure 4-13. Nuclear certification test station.

Computer processor assembly

The CPA is further broken down into the following items: the personal computer (PC), keyboard, monitor, and a dot-matrix printer.

The PC performs the certification procedures for the SMC-810, EMAD, and the WSP as well as a verification procedure for the RMB32 modules. It also contains programming and erasure procedures for the SMC-810. The PC utilizes 120 VAC, 60-Hz power single-phase and is connected to the MTF and WTF via test cables (fig. 4-14).

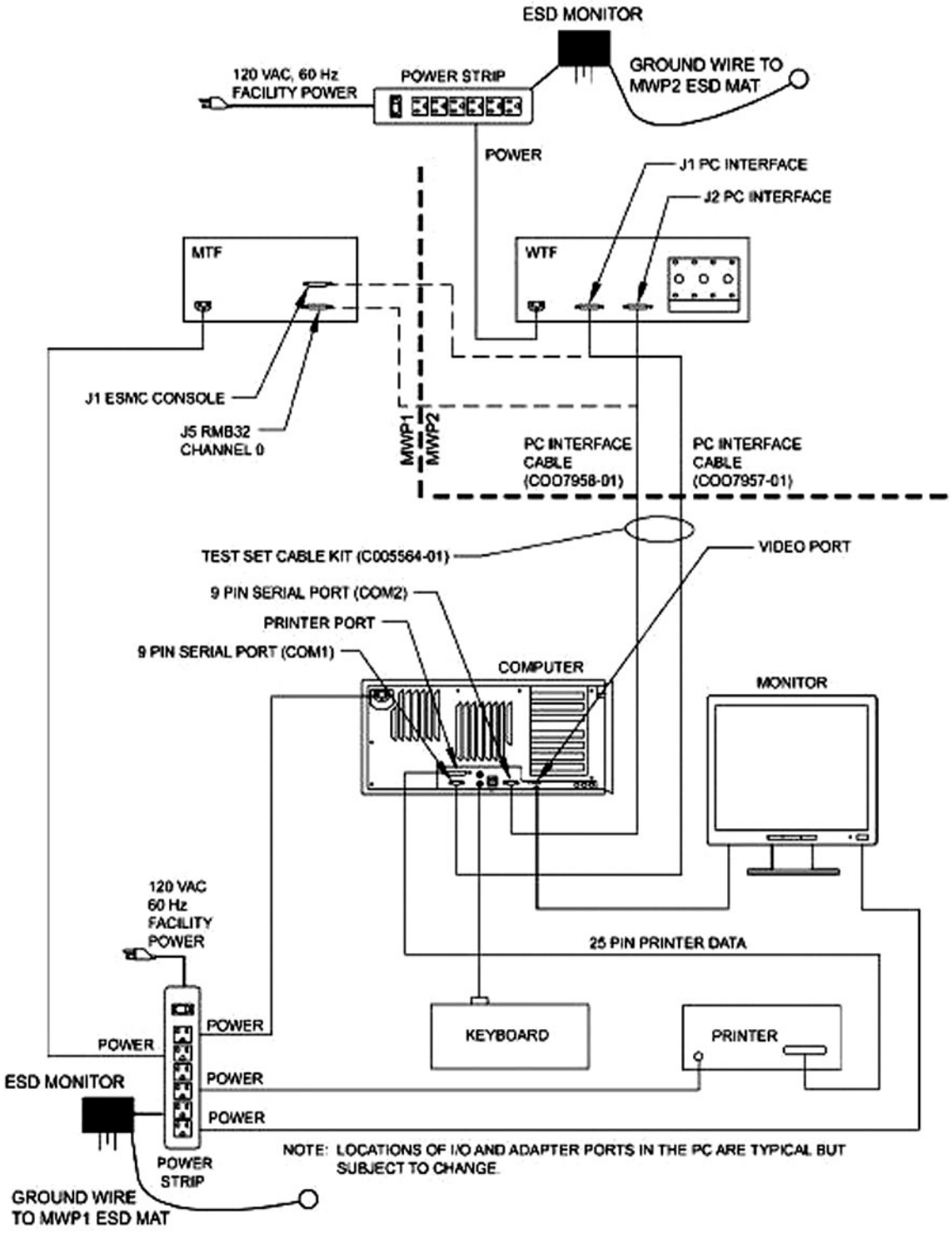


Figure 4-14. Nuclear certification test set diagram.

Circuit card module test fixture

The MTF provides the mechanical and electrical interface for certification and verification of the weapon system processor CCAs. The MTF contains a three-slot card cage and backplane, cooling fan and filter, system interface connectors, and a power and status indicator panel. The MTF is also powered by 120 VAC, 60-Hz single-phase power.

Weapon system processor test fixture

The WTF provides the mechanical and electrical interface to the WSP for certification. This allows the WSP to be installed in the fixture the same way you install the WSP at an LCC. The fixture also has an inlet duct for facility cooling air to be connected. The WTF contains a motherboard to provide communication interface between the CPA and the operational WSP, additional circuit cards to mimic specific functions of the operational weapon system, system interface connectors, and a control panel, to provide status and alarm indications. This fixture uses 120 VAC, 60-Hz single-phase power.

System circuit cards

The system circuit cards (SMC-810 and a RMB32) are provided as control circuit cards for use in the MTF and are required to be installed into the MTF during initialization and certification of the NCTS. The system circuit cards are configured the same as their operational counterparts and perform in the same manner as operational circuit cards. The SMC-810 and RMB32 system circuit cards will *never* be used in an operational WSP in a LCC.

Cable kit

The cable kit contains two cables that provide electrical signal connectivity between the CPA and either the MTF or WTF. Refer back to figure 4-14 for connectivity.

Work platforms

The NCTS equipment requires two MWPs. Each MWP is a portable work cart that is surfaced with an ESD work mat, an electrical power surge-protector strip, and an ESD monitor. A ground wire is connected to facilitate ESD control station grounding. One of the carts is designated as the WSP MWP and the other cart is designated as the PC MWP. Refer back to figure 4-13 for component locations.

Nuclear certification test program

The NCTP resides on a compact disk (CD). It provides the PC operating system, system fault diagnostic and fault indication (FD/FI) responses, certification tests, programming functions, and visual message generation.

Operation

The certification and verification process begins with the loading of the NCTP software into the PC from the CD. The operator selects functions from the menu displayed on the monitor and the process begins. As the program executes, commands are transmitted to the UUT by the MTF or WTF. The UUT processes and returns the data to the PC. Receipt of the processed data prompts the PC and resident program to compare the data to expected results as stored on the CD. This cycle continues until the UUT has been fully certified and verified or a fault has been identified.

224. Missile guidance set and test set

This lesson will discuss the procedures and equipment E-lab technicians' use while accomplishing maintenance actions in the MGS vault. The MGS vault is an on base secured area where new, faulty, and MGSs awaiting maintenance actions are stored. The MGS is stored in a shipping container (fig. 4-15) where temperatures are maintained between 45 and 145 degrees Fahrenheit. If you are ever assigned to the E-lab, you will use information contained in this lesson, so study it well and be prepared.

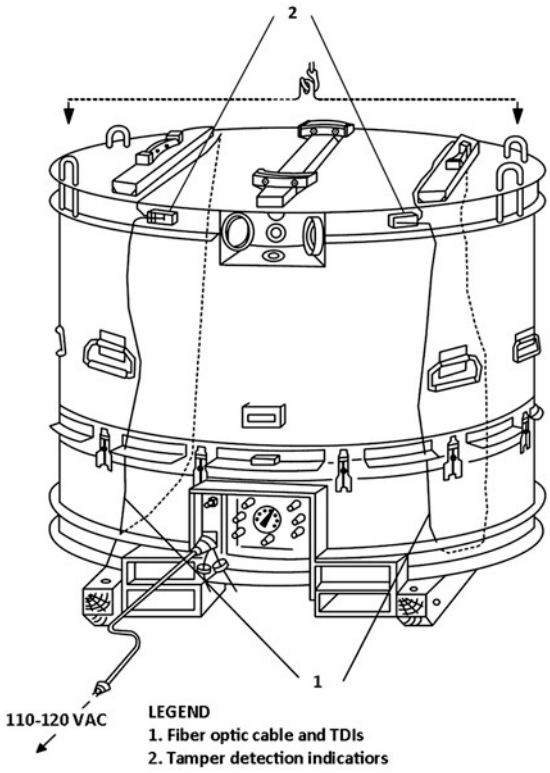


Figure 4-15. Shipping container.

Missile guidance set

If you recall from volume one, the MGS is electrically and mechanically mated to the top of the propulsion system rocket engine (PSRE) which is located forward of the third stage motor. The MGS is responsible for the guidance, navigation, and control of the missile and positioning of the re-entry system for re-entry vehicle jettison. While on alert at a LF, the MGS continuously monitors and reports missile status to the LCF. As you can see, the MGS is a vital part of the Minuteman weapon system and without it, we would not have a mission. Therefore, the MGS is identified as a critical component that requires special handling and certifications before being used in an operational environment.

Inspecting the Missile guidance set

The MGS requires a visual inspection prior to performing a MGS certification and preparing the MGS for component installation. Since the MGS is a hardness critical item (HCI), the inspection will be more detailed that just looking for general defects. These inspections will be broken down into a specific sequence, so it is important to follow them very closely. Also, the electrical components in an MGS are ESDS and you will need to comply with proper ESD handling procedures.

Missile guidance set radiation shielding

The external surfaces of the missile guidance computer (MGC) and missile guidance set control (MGSC) radiation shields are coated with hard-epoxy paint to protect the shield surface from scratches. If scratches are found, the base shielding must be inspected for damage. If damaged, the surface coating may have to be removed using acetone and a cloth (fig. 4-16).
Surface coatings shall not be removed using a wire brush or other abrasive items; damage to the surface coating could occur.

The MGS will be rejected and returned to depot for repair whenever the following occurs:

- A scratch is found in the base metal.
- There are nicks, gouges, voids, or cracks to the weld areas.
- A dent in the shield is found exceeding an 8 to 1 length to depth ratio.
- Distortion of the radiation shield is found, that allows a possible line-of-sight through a shield joint or cable access to the inner chassis of the unit.

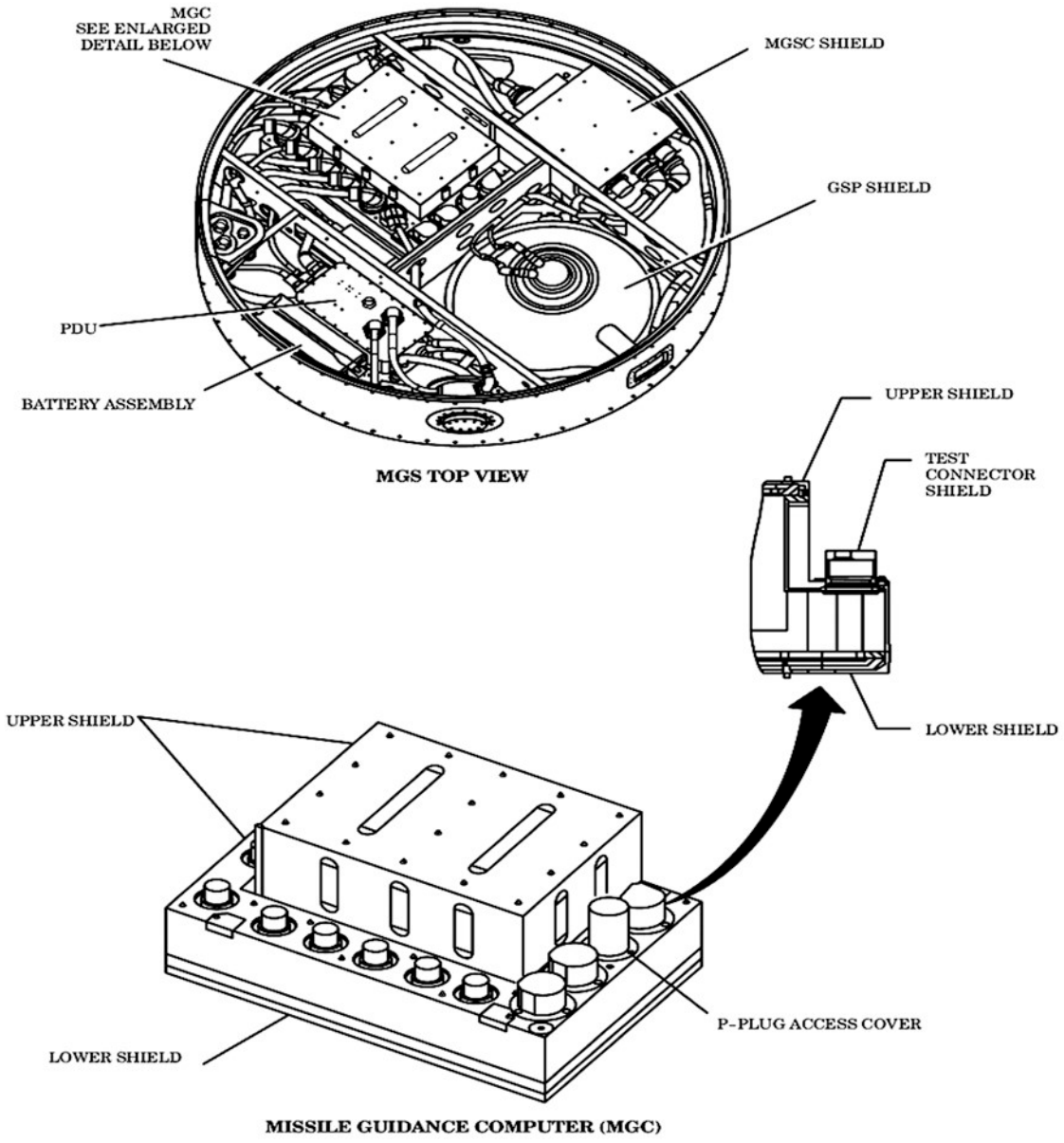
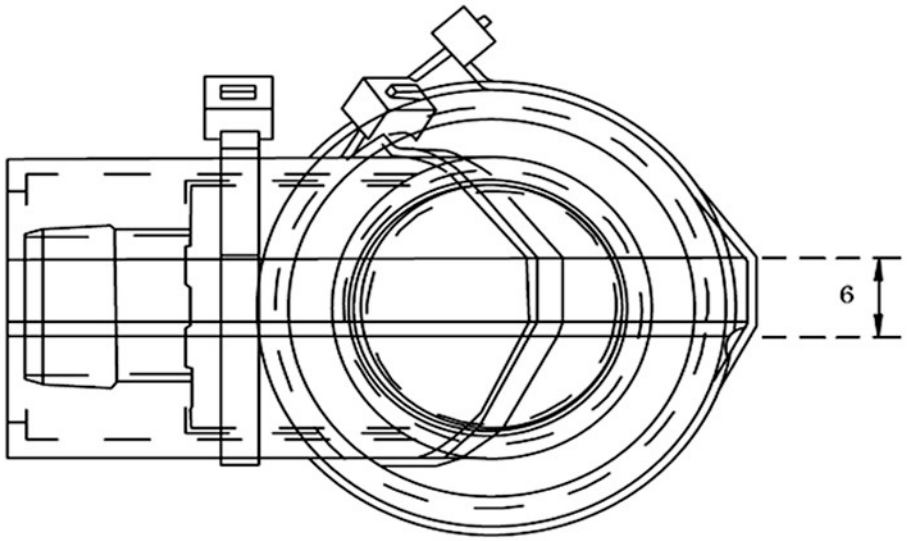


Figure 4-16. MGS radiation shielding.

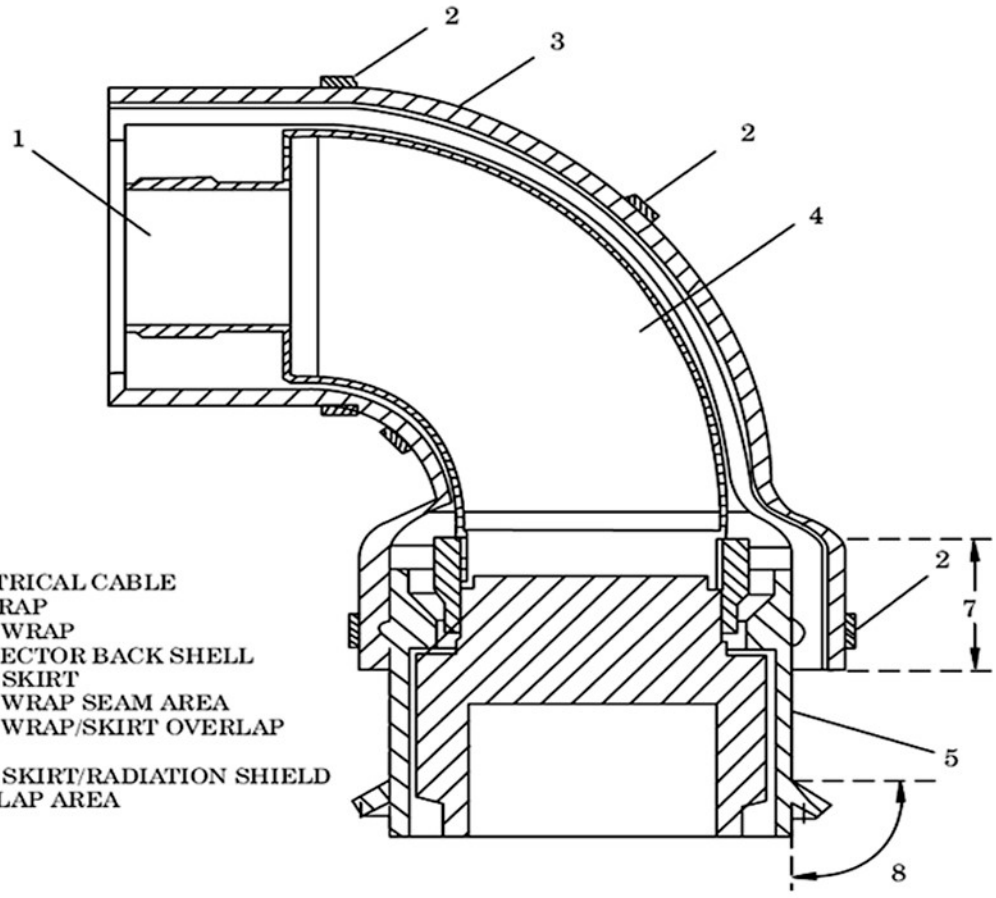
Inspecting elastomer connector shields

The elastomer connector shield (fig. 4-17, item 3) looks like rubber boots installed over the cable connectors, but in reality, they consist of a special material to protect the connectors from radiation effects. Any damage such as nicks, gouges, cuts, or abrasions degrade the effectiveness of the elastomer connector shield and must be repaired. The makeup of the elastomer connector shield material will at times secrete a white powdery looking substance.

This condition is called *acid bloom* and must be cleaned per the technical data. Therefore, it is important to look for acid bloom conditions while inspecting the elastomer connector shields.



TYPICAL INSTALLATION OF CONNECTOR BOOTS



LEGEND

1. ELECTRICAL CABLE
2. TIE WRAP
3. BOOT WRAP
4. CONNECTOR BACK SHELL
5. BOOT SKIRT
6. BOOT WRAP SEAM AREA
7. BOOT WRAP/SKIRT OVERLAP AREA
8. BOOT SKIRT/RADIATION SHIELD OVERLAP AREA

Figure 4-17. Typical elastomer connector shields.

Battery installation

The MGS is shipped without the battery. The battery is normally installed on base prior to installation of the MGS on the missile. When the battery arrives from the manufacture, it will require a checkout and additional assembly before being installed in the MGS. This entails an inspection for damage and an electrical check with a meter to verify the squib match ordnance did not fire. If the ordnance fired, then battery voltage will be present at the terminals. The ordinance should not fire until the missile is preparing to launch (fig. 4-18).

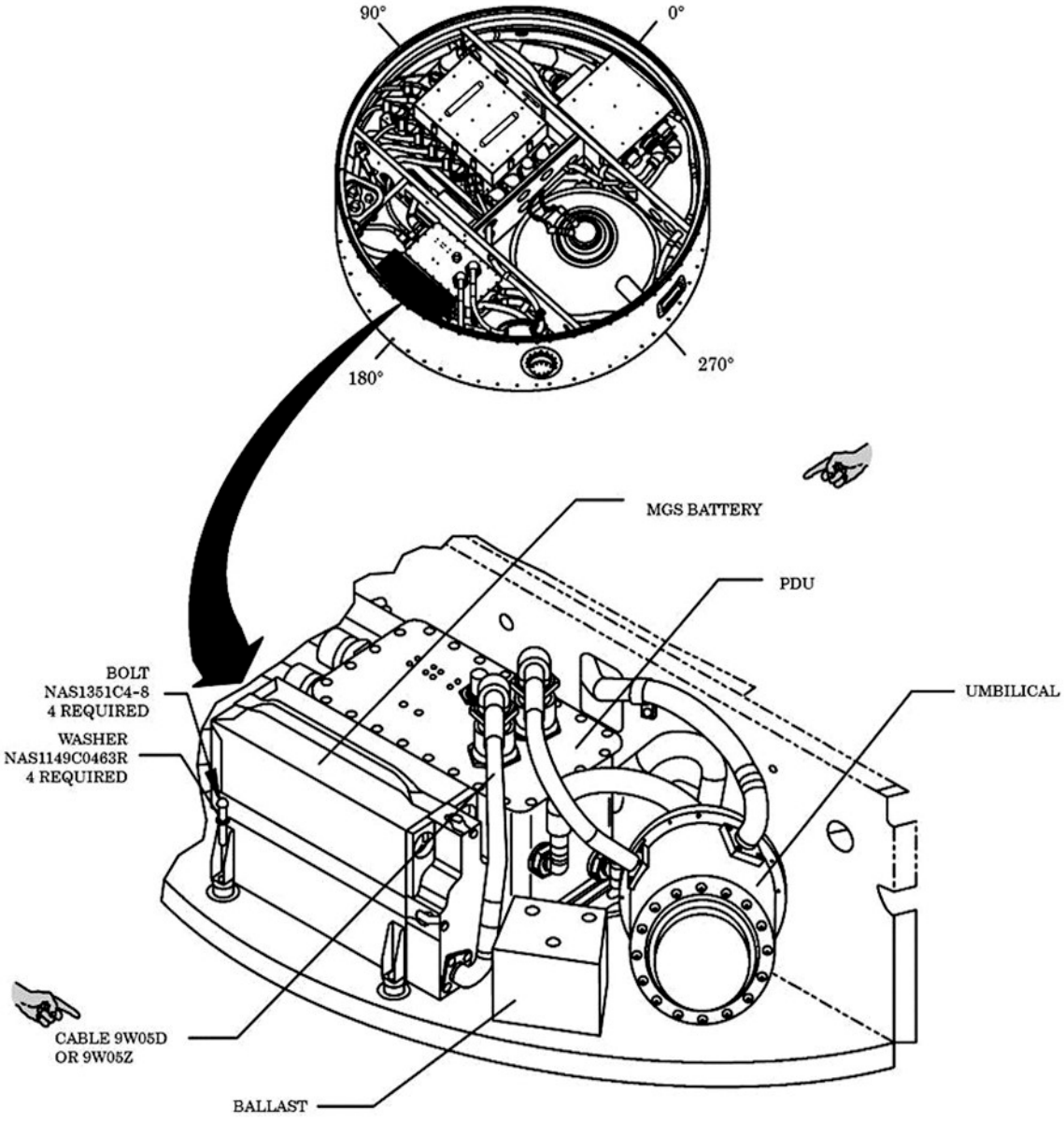


Figure 4-18. Battery assembly and installation.

Reentry system extender cable installation

The extender cables normally have to be installed on the MGS prior to dispatch. Figure 4-19 shows the installation location and safety wire requirements. Installation of the cables requires typical cable inspections and connector safety wire procedures. Remember to utilize proper ESD procedures, failure to do so could result in equipment damage.

The cables are safety wired to prevent loosening of the connectors during flight. Additionally, the cables require resistance checks using an explosive set circuitry test set (ESCTS) or commonly called a Hazi-meter (fig. 4-20).

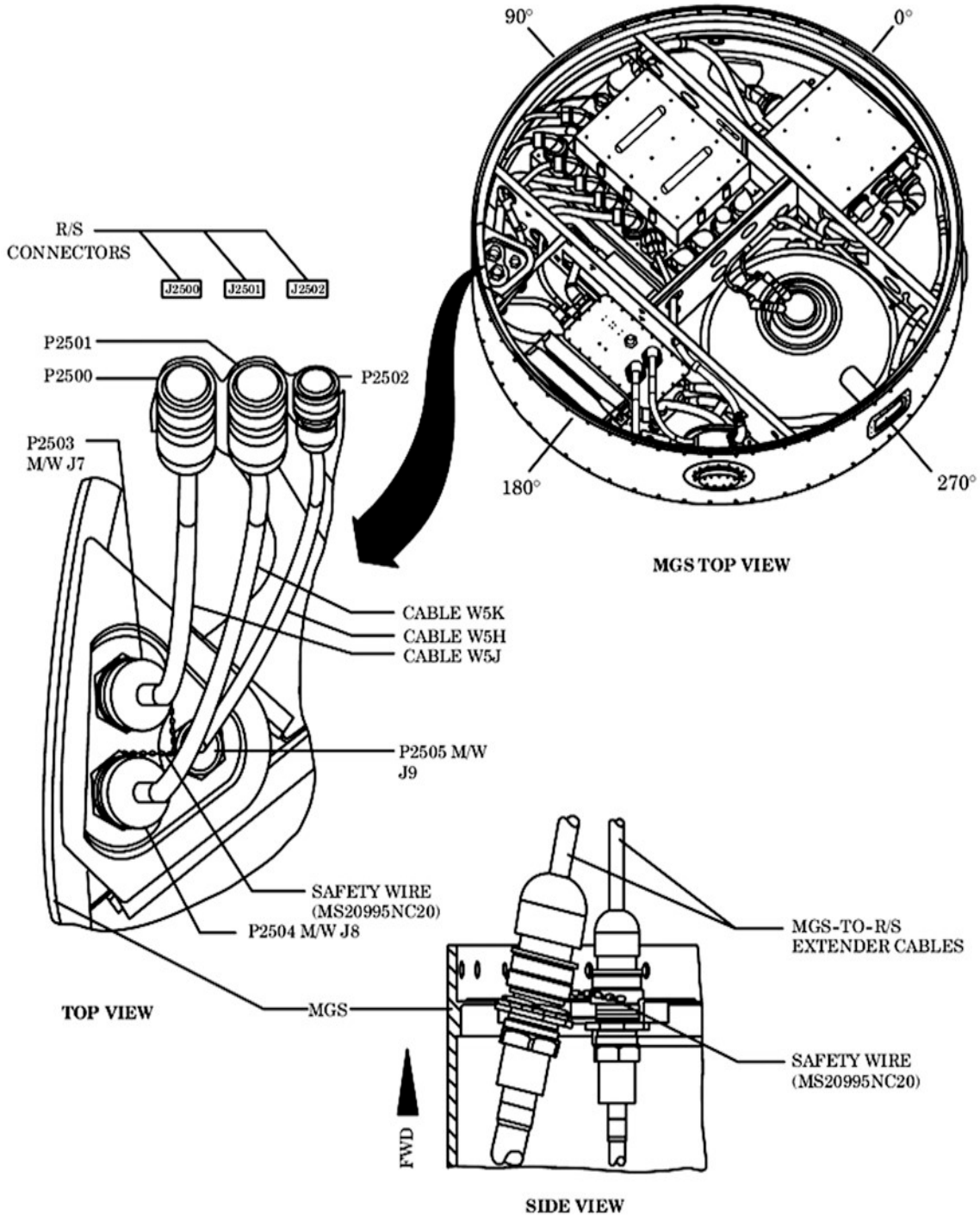


Figure 4-19. Extender cables installation.

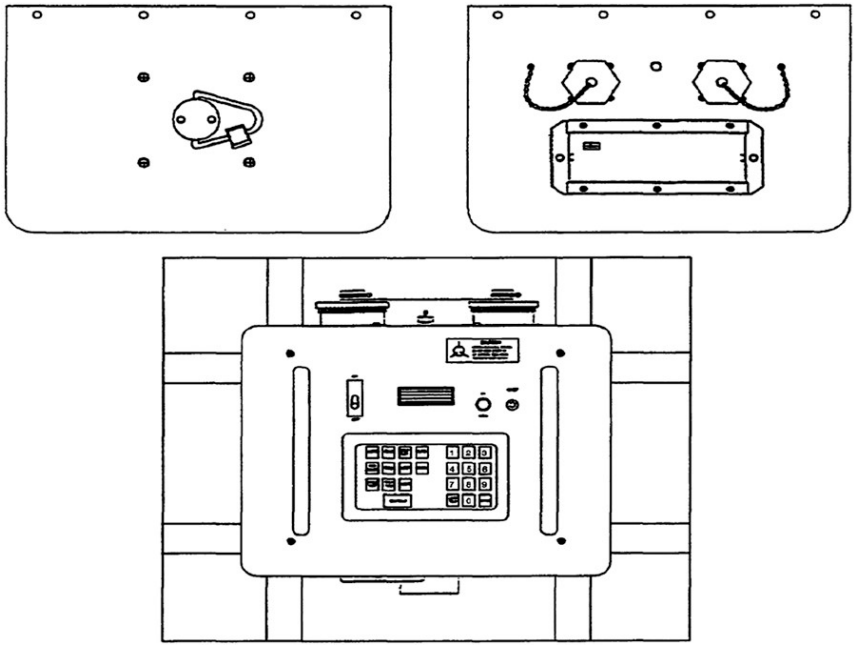


Figure 4-20. Explosive set circuitry test set.

Missile guidance set test set

The MGSTS is used at the missile support base (MSB) to perform the functional checkout phase of OPCERT on the MGS prior to installing the MGS on the missile. To ensure the MGSTS is ready to accomplish MGS OPCERT, it must satisfactorily complete the MGSTS self-test.

The MGSTS (fig.4-21) consists of the following components:

- Mobile console assembly.
- External cables.
- Umbilical plug assembly.
- Printer.
- Operating/test software media.
- Certification test controller (CTC).

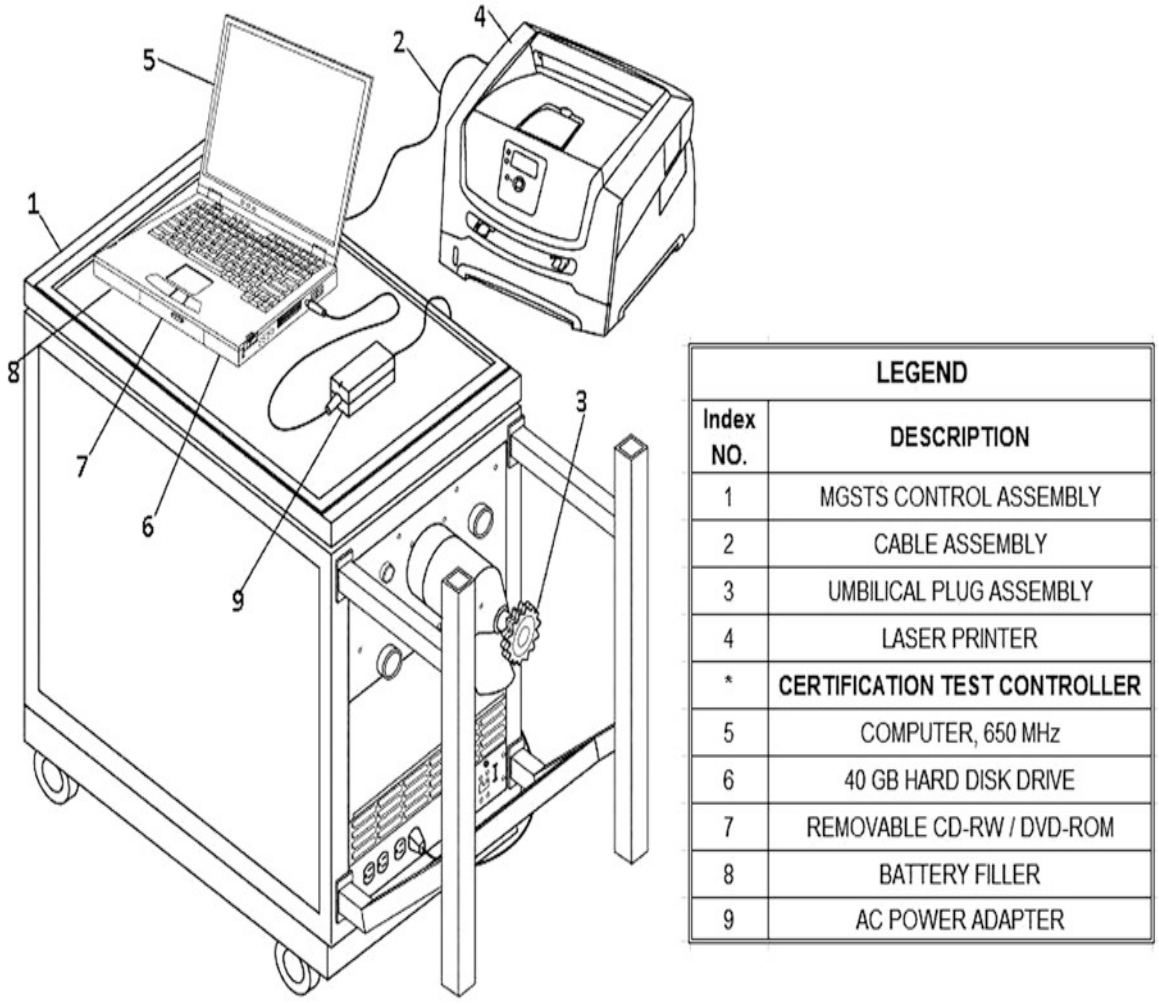
NOTE: The CTC is comprised of five components. Refer to figure 4-21 Legend, items 5-9.

Mobile console assembly

The console assembly top has a removable ESD control work mat and supports a CTC assembly. The console assembly also has the following items mounted to it:

- AC power control panel.
- Test point panel.
- Certification test adapter (CTA).
- Programmable DC power supply.
- Umbilical interface adapter (UIA) assembly.
- Power distribution panel.
- GPIB.

Assorted cables are used to connect all the components within the MGSTS.



LEGEND	
Index NO.	DESCRIPTION
1	MGSTS CONTROL ASSEMBLY
2	CABLE ASSEMBLY
3	UMBILICAL PLUG ASSEMBLY
4	LASER PRINTER
*	CERTIFICATION TEST CONTROLLER
5	COMPUTER, 650 MHz
6	40 GB HARD DISK DRIVE
7	REMOVABLE CD-RW / DVD-ROM
8	BATTERY FILLER
9	AC POWER ADAPTER

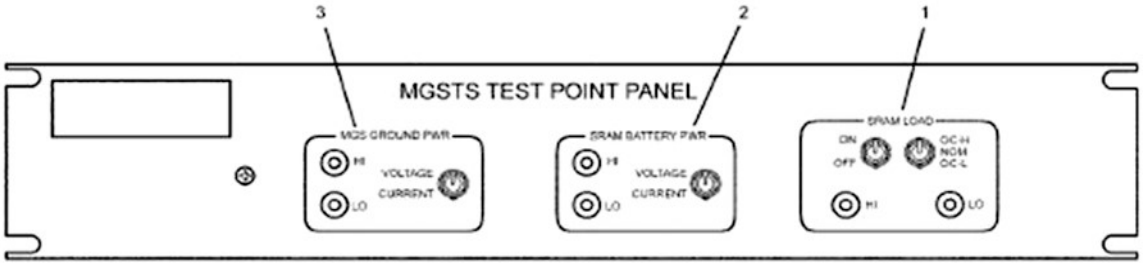
Figure 4-21. Missile guidance set test set.

Power control panel

This panel-mounted device has a line fuse, a lamp test control/indicator switch, a run time meter, power on and off control/indicator switches, a reset/silence switch indicator, an annunciator, and an emergency shutdown switch.

Test point panel

The test point panel (fig. 4-22) has six color-coded pairs of banana pin jacks. Two are for remote manual testing of voltage and current of the programmable DC power supply (MGS ground power supply). Two are for the VXI power module static random access memory (SRAM) battery power. Two are used for SRAM load verification and troubleshooting. Two toggle switches enable voltage or current checks to be made at the jacks and two other switches are used with the internal SRAM load circuitry for testing the SRAM current during the over-current safing test.

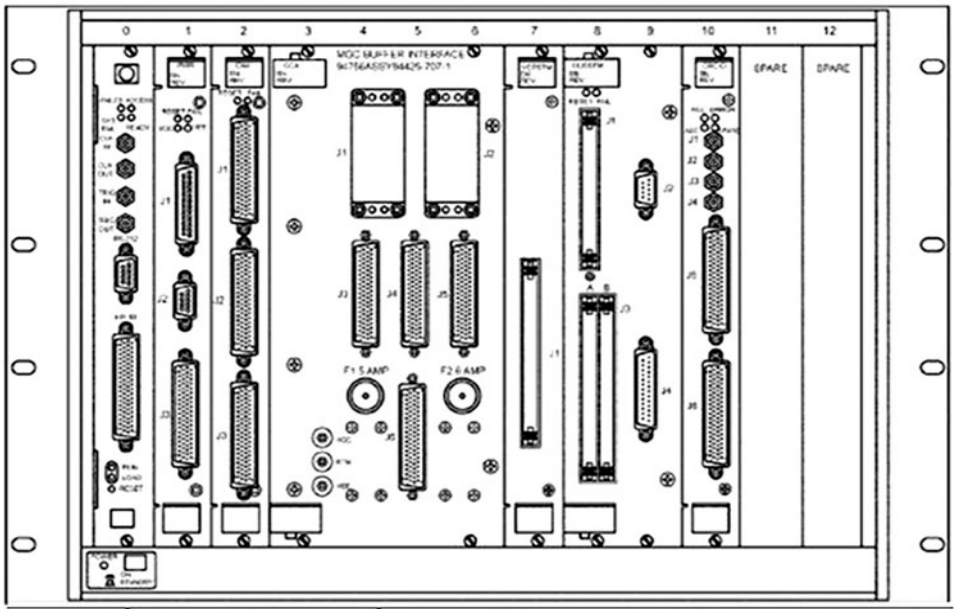


Item	Control / Indicator	Function
1	SRAM LOAD	Provides a nominal and overcurrent (true and false) load resistances for the measurement of current during the SRAM test and two overcurrent test selector switches.
2	SRAM BATTERY PWR	Selector switch for voltage or current measurements.
3	MGS GROUND PWR	Selector switch for voltage or current measurements.

Figure 4-22. Test point panel.

Certification test adapter

The CTA (fig. 4-23) is based on a VXI bus mainframe and uses seven C-size plug-in Instrument-on-A-Card (IAC) modules. The modular CCAs are each enclosed in protective shields with cutouts for access to the CCA mounted switches. The rear of the 13-slot VXI mainframe, which may be accessed through a door panel of the console assembly, includes a power supply, variable speed cooling fans, status displays, power control switch, and operator-replaceable fuses.

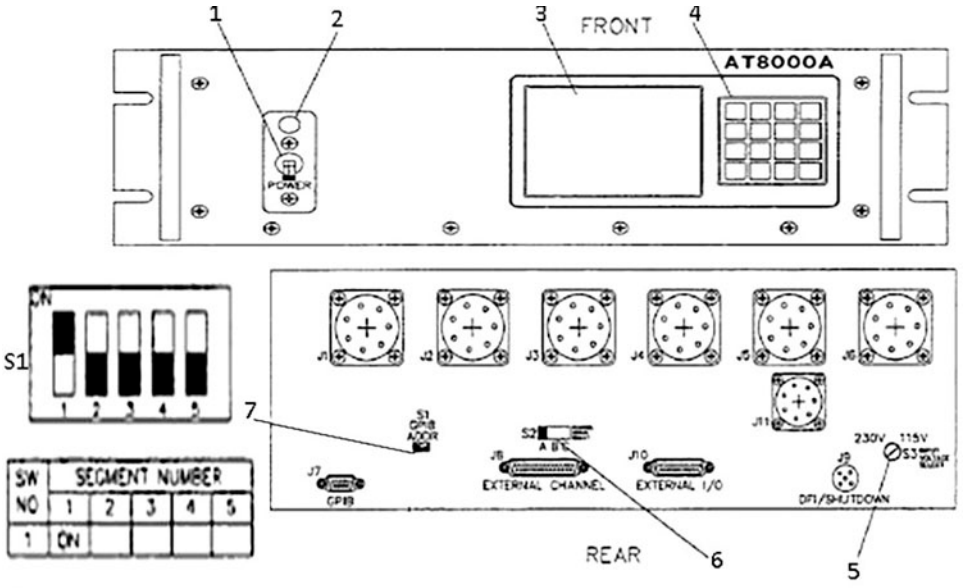


Slot Number	Part Number	Nomenclature
0	406–0272–001	VXI Command Module
1	34108765-001 / 002	Power Module
2	34108755–001	Direct Memory Access and Virtual Control Processor (DAV) Module
3–6	94425-707-1	MGC Buffer Interface (MBI) Module
7	34105580–001	Virtual Control Processor Self–Test Module (VCPSTM)
8 / 9	34105585–001	Direct Memory Access / Umbilical / Simulator Self–Test Module (DUSSTM)
10	23400-707-11	Cable / Radio and Character Input / Output (CRCIO) Module

Figure 4-23. Certification test adapter.

Programmable direct current power supply

The programmable DC power supply (fig. 4-24) consists of a sub-chassis with four programmable DC power modules and two programmable load modules that are attached to a rack-mounted front panel. The front panel is equipped with a digital display and a touch keypad that has a built-in test provision. Three power modules can output up to 32 VDC at 6.25 amps; the fourth can output up to 40 VDC at 5 amps. Load modules five and six can provide resistance from 0.1 to 99.9 ohms. Each power module has its own output power and sense connections.



Item	Control / Indicator	Function
1	POWER Switch	Controls power to the power supply.
2	Indicator Lamp	Indicates a power–on condition.
3	Display Readout	Displays programmed values of voltage, current, and resistance.
4	Keypad	No operator functions at the keypad are required.
5	INPUT VOLTAGE SELECT Switch	Provides for selection of facility power value (220V / 110V).
6	CHANNEL GROUP SELECT Slide Switch	Permits slots of chassis drawer to be assigned different ranges of channel addresses.
7	GPIB ADDR Switch	Sets the listen address (set to decimal 17 at the factory).

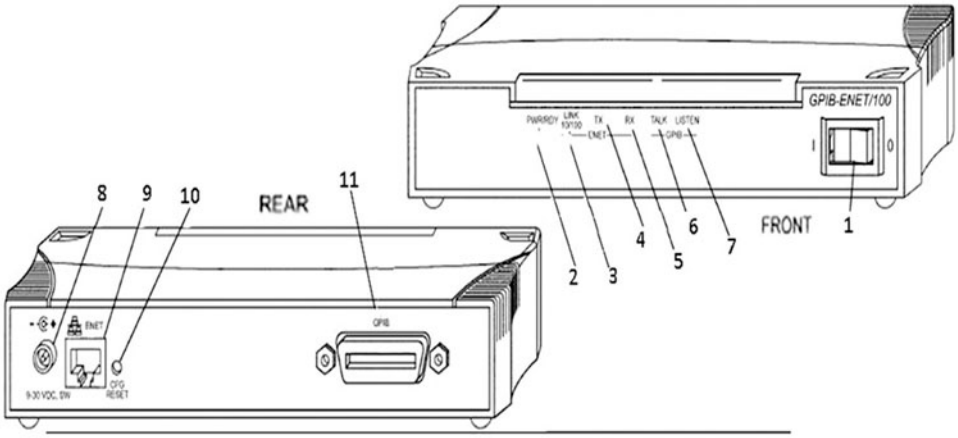
Figure 4-24. Programmable DC power supply.

Umbilical interface adapter assembly

This special purpose rack mount panel assembly provides interfaces for the loop-back connections of the MGS test cables as well as signal routing via branched cables.

General purpose interface bus panel assembly

The GPIB panel assembly provides the interface through which the CTC communicates to the various interconnected electronic devices of the MGSTS. The GPIB panel assembly is mounted internally behind a mounting plate located below the UIA assembly. The GPIB controller (fig. 4-25) is located behind the GPIB panel assembly. An Ethernet cable assembly, EW4, connects the MGSTS Computer Assembly to the GPIB controller through a connection on the UIA. All communications between the computer, CTA, and the programmable DC power supply are transmitted through the GPIB controller to the computer.



Item	Control/Indicator/Connection	Function
1	Power Switch	Power on and off the box.
2	PWR/RDY	Flashes rapidly at start up or while performing self-test and when acquiring network parameters. A steady yellow state indicates the box is ready for operation. Slow flashing pattern indicates an error has occurred.
3	LINK 10/100	Indicates the GPIB-ENET/100 detected a twisted pair (10Base-Tx or 100Base-Tx) link. The color indicates the connection speed. Yellow equals 10Mbits/sec and green equals 100Mbits/sec.
4	TX	Indicates the GPIB-ENET/100 is transmitting to Ethernet connection.
5	RX	Indicates the GPIB-ENET/100 is receiving network traffic.
6	TALK	Indicates the GPIB-ENET/100 is configured as a GPIB talker.
7	LISTEN	Indicates the GPIB-ENET/100 is configured as a GPIB listener.
8	Power Connection	Used with provided power adapter to connect to the AC Power Distribution Panel.
9	ENET	Connects the GPIB to the computer via the UIA.
10	CFG RESET	Used to reset the box to original factory settings.
11	GPIB	Connects the GPIB to the UIA.

Figure 4-25. General purpose interface bus controller.

Power distribution panel

The power distribution panel receives facility AC power via a front panel connector and provides duplex receptacles on front and rear as outlets for switched and un-switched MGSTS device power. A master circuit breaker is located on the front panel along with a power-on indicator.

External cables

The external cables are used to connect the MGSTS to the MGS and to provide 115 VAC and facility ground to the MGSTS.

Umbilical plug assembly

This special purpose multi-conductor assembly provides MGSTS connection to the MGS umbilical connector and is used in the MGS OPCERT. It does not include coolant lines, but does include the lines required for the MGSTS/MGS umbilical interface.

Printer

The printer provides the means for the operator to print out session log and test history files. It is connected directly to the computer by an Ethernet connection. If any printouts were commanded prior to connection of the printer, they will print after the printer is turned on. If the CTC power is cycled, any previously commanded printouts will be deleted.

Software

The software includes the customized Solaris OS, the GPIB driver, print driver, and the MGSTS computer software configuration item (CSCI) operating program and its support files.

Certification test controller assembly

The certification test controller (CTC*)* assembly is a computer that includes a removable hard disk drive (HDD), and a removable compact disk-read writeable (CD-RW) and digital video disk-read only memory (DVD-ROM). These devices are considered critical components and are used under prevailing OPCERT and decertification (DECERT) procedures until the device becomes defective. Once a device is found to be defective, it is replaced. Defective devices will never be repaired and used to OPCERT the MGS.

Missile guidance set test set maintenance

The MGSTS was designed with the maintenance philosophy of using a computer-based, software-driven self-test function to identify failures, and the removal and replacement of failed modules to accomplish organizational-level repair. Repair verification is accomplished by repeating the self-test. The self-test function monitors the status of built-in self-test results of any commercial off-the-shelf test equipment and, in addition, applies a dedicated computer software driver test to verify complete operation of the MGSTS.

Preventive maintenance is comprised of periodic inspection and cleaning of hardware, equipment chassis, cooling fans, and filters. No periodic lubrication is required. All rollers, hinges, locks, and casters have a lifetime lubrication design and should be replaced if trouble occurs. Step-by-step, procedures on what to clean and how to do it are provided in the MGSTS technical order.

Missile guidance set certification

A successful certification must be completed before the MGS is installed on the missile. Certain unique actions must be accomplished to prepare the MGS for certification, other than just the standard test equipment hook up. One unique action is the installation of the protective cover set (fig. 4-26). This installation is deemed a hardness critical procedure (HCP) and must be followed exactly as written. Failure to comply could result in weapon system degradation. The covers protect hardness critical components in the MGS, like the MGC radiation shield from inadvertent damage. Installation of the protective cover set also prevents tools, hardware, or other miscellaneous items from falling into the inertial measurement unit (IMU) housing.

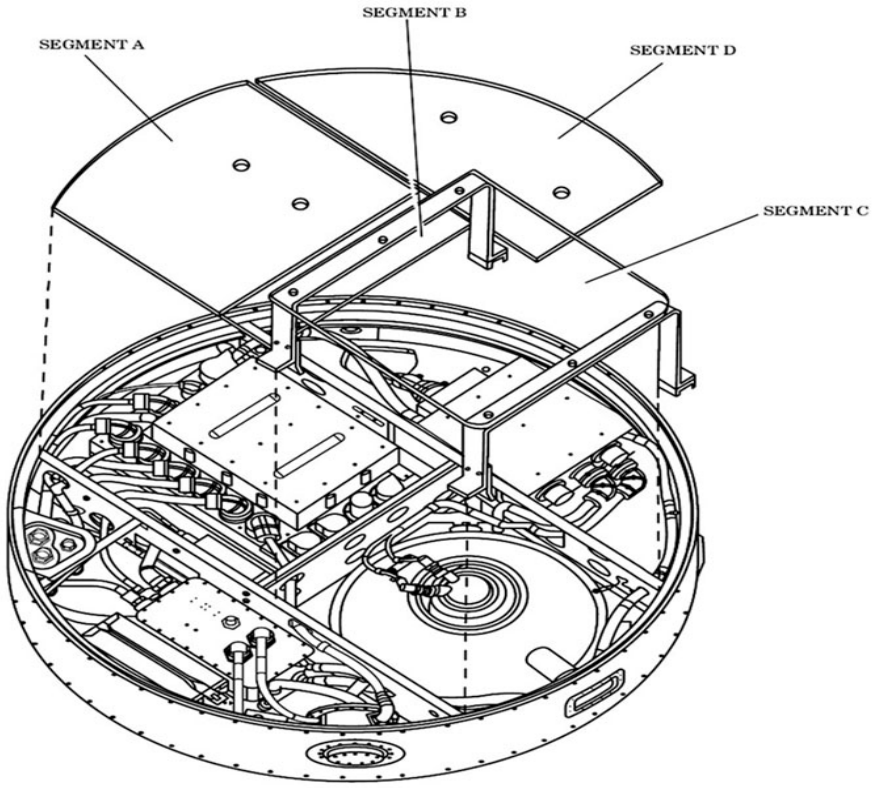


Figure 4-26. Protective covers.

If you recall reading about nuclear surety, then you will know that the two-person concept (TPC) control is required when working in or around the MGS, because it is a critical component. Furthermore, TPC must be maintained throughout the entire MGS certification process and must be maintained until the MGS is properly stored in the MGS vault or until it has been decertified. The MGS certification procedures consist of a pre- or post-certification MGSTS self-test and a MGS certification. Only one self-test is required per session, but it must be accomplished under TPC control. The certification is automated and will only require the operator to run the certification program and connect equipment when directed. Here are some things you must be aware of when performing the MGS certification procedure:

- Applying ground power to a MGS for more than 30 minutes during MGS certification can damage the MGS because there is no cooling system in use during the certification process.
- Do not perform MGS certification procedures on the same MGS more than six times in a 24-hour period. Failure to comply could result in equipment damage.
- In the event the MGSTS fails during the automated MGS certification procedure, ensure the 30-minute time limit is not exceeded. Failure to comply could result in equipment damage.
- If a failure occurs during the certification test the MGS, MGSTS, computer, and HDD serial numbers must be recorded. The failure message, date, time, and operator name must be recorded as well.

225. Missile maintenance test set

Another test set that the E-lab maintains and uses is the MMTS. The MMTS is a universal test set used for off-line testing of all Strategic Automated Command and Control System (SACCS) related LRUs including the KIV-7M cryptographic device. Essentially, the MMTS is used to test communication equipment. Your goal for this lesson is to gain an understanding of the MMTS function and operation. Let us begin with a couple terms and definitions to help you understand the information.

Terms and definitions

This is not an all-inclusive list of components used on the MMTS, rather some key items to aid you in understanding this lesson.

Configuration items

The configuration items (CI) are LRUs that are used to configure the MMTS to a known operational state prior to installing operational LRUs that require checkout or troubleshooting. In other words, the CIs are used to perform a self-test of the MMTS to ensure it is operating properly. The CIs are then individually swapped out with their operational LRU counterpart to aid in fault isolation as well as functional testing. An example would be a mass storage unit (MSU) at an LCC was returned to base because it was not recording data onto its floppy disk. The E-lab technician would configure the MMTS with its normal CIs and perform a self-test. Then, the technician would pull the "CI" MSU, replace it with the operational "LRU" MSU, and perform a test to determine if the MSU was faulty.

Keyboard send receive

The keyboard send receive (KSR) consists of a commercial off-the-shelf personal computer, keyboard, monitor, and mouse. The software program is loaded onto the computer via a MSU, then a help menu is displayed on the monitor, which allows the user to execute system testing. The KSR is separate from the visual display unit (VDU)/keyboard (KB), which is actually an all-in-one monitor and keyboard.

Description

The MMTS (fig. 4-27) consists of two test stands, which house the CIs or LRUs during LRU testing and troubleshooting. Connected to the back of the test stands are the wireway assembly racks, which house all the internal wiring and connectors that electrically connect the two test stands, printer, computer, and keyboard as well as provide for the software interface. The internal wiring is similar to the power signals distribution units on the equipment racks at a LF or LCC. The test stand is housed in the E-lab and is used for intermediate level fault isolation.

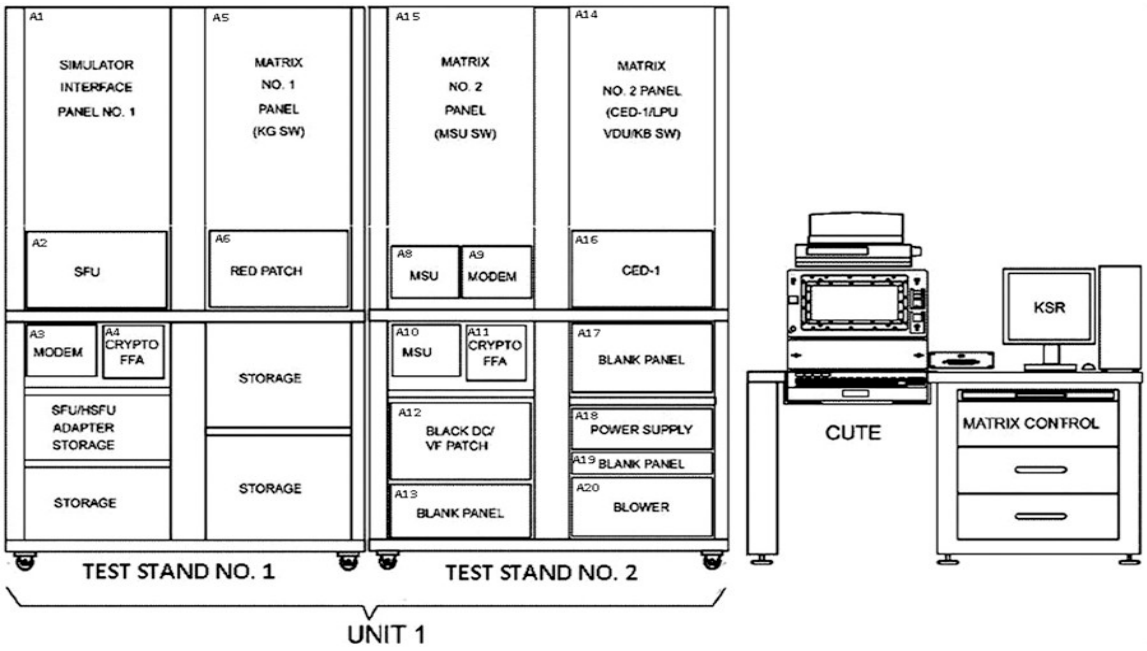


Figure 4-27. Missile maintenance test set.

Function

The MMTS test stands are normally equipped with CIs that are identical to the same types of LRUs that are used in operational locations, such as the LF, LCC, and wing command post (WCP). One of its functions is to test and troubleshoot suspected faulty LRUs. This is done by swapping the good CI with the questionable LRU to see if a fault occurs. The MMTS also tests LRUs before being sent out to an operational location. The following table is a breakdown of the CIs and their location on the MMTS:

MMTS CIs and Location

Assembly	CI Name	Location
Test stand No.1	Summary fault unit (SFU)	A2
	Modem No. 2	A3
	KIV-7M/FFA No.2	A4
	Red DC patch No 1	A6
Test stand No. 2	MSU No. 1	A8
	Modem No.1	A9
	MSU No. 2	A10
	KIV-7M/FFA No. 1	A11
	Control electronics drawer-1 (CED)-1	A16
	Power supply drawer (PSD) No. 1	A18
	Blower No. 1	A20
Collocated user terminal element (C-UTE)	Line printer unit (LPU)	
	Visual display unit (VDU)/keyboard (KB)	
	Matrix control assembly	
	Keyboard send receive (KSR)	

Operation

The MMTS can be used for off-line performance testing and troubleshooting of the following SACCS LRUs:

- CED-1.
- MSU.
- Red DC patch.
- SFU.
- Modem.
- VDU/KB.

The MMTS can be used for off-line performance testing of the following Air Force maintained units:

- CED maintenance panel.
- KIV-7M.
- Modem patching panel.

Performance testing and troubleshooting is performed by using an off-line diagnostic program, which is contained on a floppy disk. The program is loaded into the computer’s memory and then executed to exercise all the MMTS CIs. The test results are then printed out by the KSR. The MMTS CI is then removed and replaced by the LRU to be tested. The applicable computer diagnostic program is then run to exercise the LRU under test, and the test results are printed. If necessary, the top cover can be removed from an LRU under test to provide access for additional troubleshooting with an oscilloscope or multi-meter during exercising.

226. Simulated electronic launch-Minuteman

If you can possibly imagine, the Minuteman weapon system was first placed on alert status back in 1962. It is through the hard work and dedication of generations past, present, and future that has and will continue to keep this weapon system in full operational status. However, solid maintenance actions alone will not prove that an aging system such as this will perform as intended. Moreover, we do not want to launch a nuclear missile just to see if it works either. This is where special testing of our weapon system, such as the simulated electronic launch-Minuteman (SELM) comes into play. In this lesson, you will learn about the SELM process and function that tests the operational capability of our weapon system without physically launching a missile.

Mission

A SELM test is the testing of ICBMs in their deployed environment at operational wings, without actually launching them. From the execution of the launch procedures by a missile combat crew (MCC) through issuance of the first stage ignition signal, this test provides the most complete test of the deployed ICBM force. During a SELM test, launch command signals can come from an LCC or an airborne launch control center (ALCC). Six LFs and two LCCs are normally involved in a SELM test.

Process

The SELM test involves isolating the LCCs and LFs from an ICBM operational squadron and specially configuring these facilities to allow for testing of critical commands in the deployed environment. Trained technicians perform special maintenance procedures to isolate the test LFs and LCCs from adjacent facilities. These procedures also include installing the unique SELM test equipment designed to monitor and record launch critical signals during the test. SELM testing provides the capability to activate or simulate activation of several ICBM LF ordnance devices. These devices include the following:

- Launcher closure door.
- Upper umbilical critical leads disconnect.
- Missile suspension system articulating arms.
- Guidance and control umbilical release and retract.

The activation of ordnance devices occurs at two LFs during every SELM test, except for the launcher closure door; the launcher closure door only requires activation once a year. The remaining LFs will simulate the activation of ordnance devices.

Preparation

An ICBM wing begins preparing for a SELM test approximately four to five months before the actual test. As a 2M0X1 stationed at an operational ICBM wing, you will most likely participate in some portion of the SELM test preparation procedures. Some of the preparations an ICBM wing must undertake for a SELM include beginning to plan for SELM activities, assigning special leadership positions, selecting the maintenance team members, coordinating with outside agencies, conducting SELM and special training, and ensuring SELM testing equipment is operational.

Posturing

This part of the SELM testing involves having trained maintenance personnel configure the test facilities as specified in applicable technical data, AF publications, and the test execution order (TEO). A majority of the posturing procedures include the installation of the SELM test equipment throughout the test LFs.

Two pieces of SELM test equipment include:

- SELM control monitor (SCM).
- SELM test cable set.

Simulated electronic launch control monitor

Installed at the test LFs, the SCM routes certain ordnance signals to resistive loads. This prevents arming the missile ordnance, activating the first stage battery, and ignition of the first stage. Squib firing signals are sent to the ordnance devices through switches on the SCM. The switches permit the choice of simulated or actual ordnance firing. The SCM also produces a printout of the terminal countdown signals as they occur during a SELM test.

Simulated electronic launch test cable set

The SELM cable set consists of four cable cases. The cables are important; they are always lowered into the LER using the cable cases and safe maintenance practices. This is done to ensure the technicians do not damage the cables. When installed at the LF, the SELM cables connect the SCM to the missile, missile components, and other ground equipment circuits.

Last look inspection

Once the LFs are postured, a “last look” inspection team will verify the proper configuration of all SELM test equipment, SELM cable connections, and safing of the missile and applicable aerospace vehicle equipment (AVE). If for any reason a team must go into the LF after this inspection has taken place, another last look inspection must be performed.

Simulated electronic launch testing

SELM testing starts with the initiation of isolation verification and ends with confirmation of successful terminal countdown. Actual SELM testing is divided into two distinct phases: airborne test and ground test.

For SELM testing, normally 50 percent of the LF test sorties are simulated launch by MCCs from an ALCC on the first test day. On the second day of testing, MCCs in the LCCs simulate the launch of the remaining sorties. The sortie testing happens throughout the entire day; however, they are not simulated launch at the same time.

At LFs where ordnance activation is simulated, test evaluation teams are not required to be there during the actual SELM testing. However, the unit must have sufficient teams on standby to retrieve SELM test set printouts from these unmanned test LFs and to conduct a quick-look inspection within 24 hours of terminal countdown.

At LFs where ordnance is activated, a test evaluation team is stationed there to maintain communication with the MCC. After the test, the test evaluation team enters the test LF, performs a quick-look inspection of SELM test set printouts, and reports any out-of-tolerance conditions.

Reposturing

After completion of the SELM test, unit maintenance personnel begin the process of restoring the LFs and LCCs to their operational configuration. This is accomplished by removing the SELM test equipment and reconfiguring the test LFs and LCCs to their pre-test status.

Reporting

For effective SELM program management as well as for accurate evaluation of the performance of ICBM weapon systems, several types of reports are generated throughout the SELM testing process. These reports must be accurate, complete, and submitted within given time restrictions. Depending on importance of the information, some reports are due immediately, whereas others are submitted within days or even a month.

Self-Test Questions

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

221. Ground Minuteman Automated Test System

1. Which Ground Minuteman Automated Test System group is responsible for the overall control of the internal and external data transfer, and communications between the various subsystems and peripheral devices in the test station?

2. What assembly in the MWS is used to calibrate the test station power supplies?

3. Where is the ITA connected on the test station and what is its purpose?

4. What is the purpose of the manifold on the MWS?

222. Electrical facility base maintenance test equipment

1. What is the 82 Bench workbench primarily used for?

2. What is the difference between the two styles of holding fixtures?

3. What do the modified top and bottom adapter covers provide during power applied testing?

223. Nuclear certification test station

1. Which WSP CCA only requires verification before being installed?

2. Match the description in column A with the NCTS component in column B. Items in column B may be used once.

Column A	*Column B*
____(1) Provides mechanical and electrical interface for drawer.	a. CPA.
____(2) Used for initialization and certification of NCTS.	b. MTF.
____(3) Provides mechanical and electrical interface for CCAs.	c. WTF.
____(4) Surfaced with ESD mats and holds equipment.	d. System circuit cards.
____(5) Provides operating system and certification test.	e. Cable kit.
____(6) Contains erasure procedures for SMC-810.	f. MWP.
____(7) Provide electrical signal connectivity.	g. NCTP.

224. Missile guidance set and test set

1. Where is the MGS stored on base?

2. Why is the MGS inspection so detailed?

3. Why are the external surfaces of the MGC and MGSC painted and what might be required if a scratch is discovered?

4. What is the white powdery substance called that may at times secrete from the MGS elastomer connector shield material?

5. What must be accomplished on the MGSTS before being used to OPCERT the MGS?

6. Match the description in column A with the MGSTS component in column B. Items in column B may be used once.

Column A	*Column B*
____(1) Provides customized Solaris OS and system drivers.	a. Mobile console assembly.
____(2) Special purpose multi-conductor used in MGS OPCERT.	b. External cables.
____(3) Enables facility power to reach MGSTS.	c. Umbilical plug assembly.
____(4) Repaired devices will never be used to OPCERT MGS.	d. Printer.
____(5) Has a test point panel mounted to it for testing battery current.	e. Software.
____(6) Enables test sessions to be logged.	f. CTC assembly.

7. When performing the preparatory procedures for MGS certification, installation of what item is deemed a hardness critical procedure and what does it protect/prevent?

8. What are some things you must be aware of when performing the MGS certification procedure?

225. Missile maintenance test set

1. What type of testing is the MMTS used for?

2. What do the MMTS test stands house?

226. Simulated electronic launch-Minuteman

1. A SELM test is the testing of what?

2. During a SELM test, how often are the ordnance devices activated?

3. How are the SELM cables lowered into the LER?

4. What does a last look inspection team verify?

5. Where are test evaluation teams stationed during SELM testing where ordnance is activated?

4-2. Coding Equipment Description

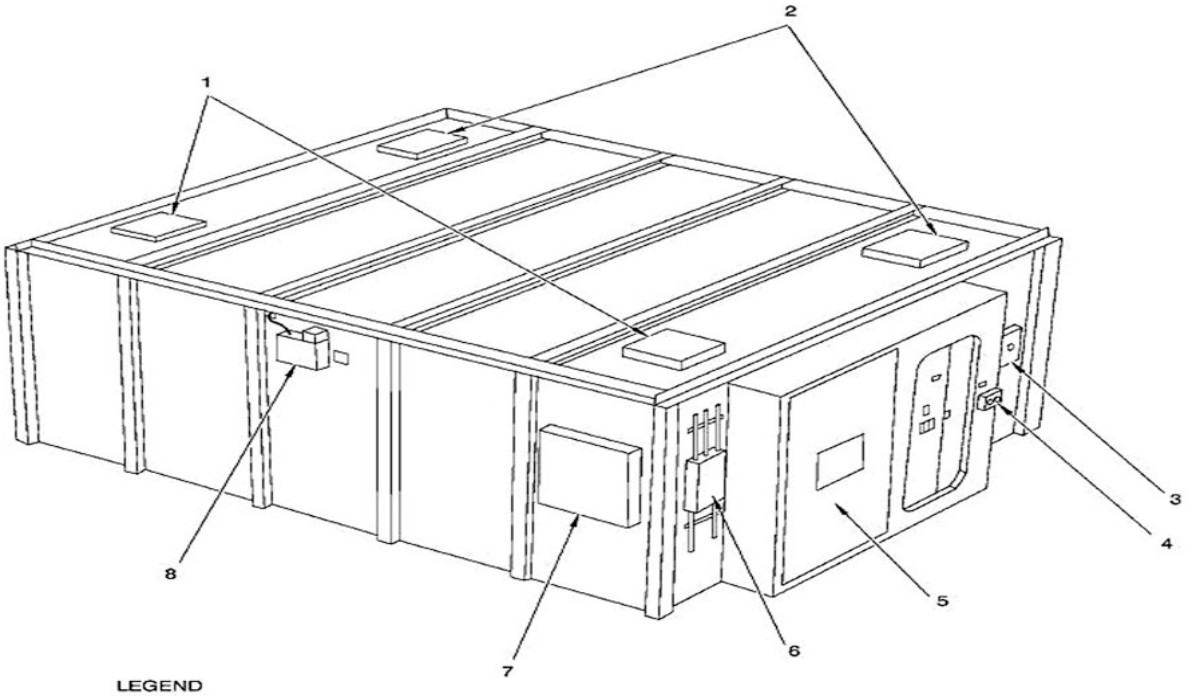
The ICBM code systems employ elements of security and safety for the Minuteman weapon system. However, code system integrity is dependent on both the design of the systems and the proper code control and handling. This section will introduce you to the wing code processing system (WCPS), which is responsible for preserving the security of our code components. We will also cover how the WCPS components are tested using the hardware certification verification equipment (HCVE).

227. Wing code processing system

Due to the very nature of the Minuteman weapon system, special provisions must be put in place to ensure our adversaries never have the opportunity to infiltrate any of our secure systems. At the same time, we need to have the capability to communicate and interface with our remote weapon systems. To do this, we must always enforce nuclear surety while maintaining positive control. It is through the WCPS that we are capable of producing, processing, and verifying codes and other launch related data before positioning these materials in the LFs, missiles, LCCs, or ALCCs. In this lesson, you learn about the ICBM Code Processing System (ICPS) that consists of the shielded enclosure (SE), the Common Certification/Operating System (CCOS) software, and the WCPS.

Shielded enclosure

The SE provides emissions security (EMSEC) protection for the WCPS and associated equipment by preventing electromagnetic and acoustic energy emanation during coding operations. The SE (fig. 4-28) is a welded, all-metal enclosure with cooling and ventilation ducts, an access door, power filters and system controls, a communication system, and a telephone system.



LEGEND
1. AIR VENTS (OUTLET DUCT)
2. AIR VENTS (INLET DUCT)
3. COMMUNICATION PANEL
4. DOOR SEAL AIR VALVE AND DOOR PRESSURE GAUGE
5. DOOR ACCESS PANEL
6. INPUT POWER
7. LINE FILTERS
8. FIBER OPTICS CARRIER

Figure 4-28. Shielded enclosure.

In the table below are some of the SE components and their function that provide additional EMSEC protection.

Shielded Enclosure Components	
Component	**Protection**
Pneumatic door	When the door is closed, pressurized air is applied to expand the door bladder to make positive metal-to-metal contact with the SE walls. This contact creates a good electrical shielding and provides EMSEC, electromagnetic, and acoustic isolation.
Power line filters	Provides EMSEC protection on the SE input power lines.
Air conditioning filters	In addition to removing dust and other pollutants, the filter's honeycomb construction provides a tuned waveguide to provide EMSEC integrity.
Fiber-optic communication link	A fiber-optic telephone carrier transfers data into and out of the SE. The data carried on the fiber-optic link is encrypted.

Common certification/operating system

The CCOS consists of a modified Hewlett-Packard operating system, certification and self-test functions, and software drivers needed to interface with all the WCPS subsystems.

Initial start-up

The initial start-up consists of booting up from a 9-Track tape (fig. 4-29). This is commonly referred to as a "cold start" up because the system disk is in an unknown state. Below are a few reasons why a cold start would be performed:

- The system crashed.
- The system disk was replaced.
- The software is being loaded for the first time.

When the CCOS system is booted up initially from the CCOS deliverable 9-Track tape, all WCPS interface subsystems are "marked down" (not available for use) until the subsystem is functionally certified. The four critical subsystems listed below must pass a certification test before any other program applications can be performed:

1. Computer, cathode ray tube (CRT)/keyboard.
2. Power supplies.
3. Analog-to-digital converter.
4. Disk drive assembly.

The CCOS performs certification tests of the subsystems in the order above if one or more were marked down. Once all four critical subsystems are certified, a full certification test menu is displayed to allow the operator to select additional CCOS certification tests.

Additionally, once the system software has been loaded, the normal start procedures can be used to bring the system on line.

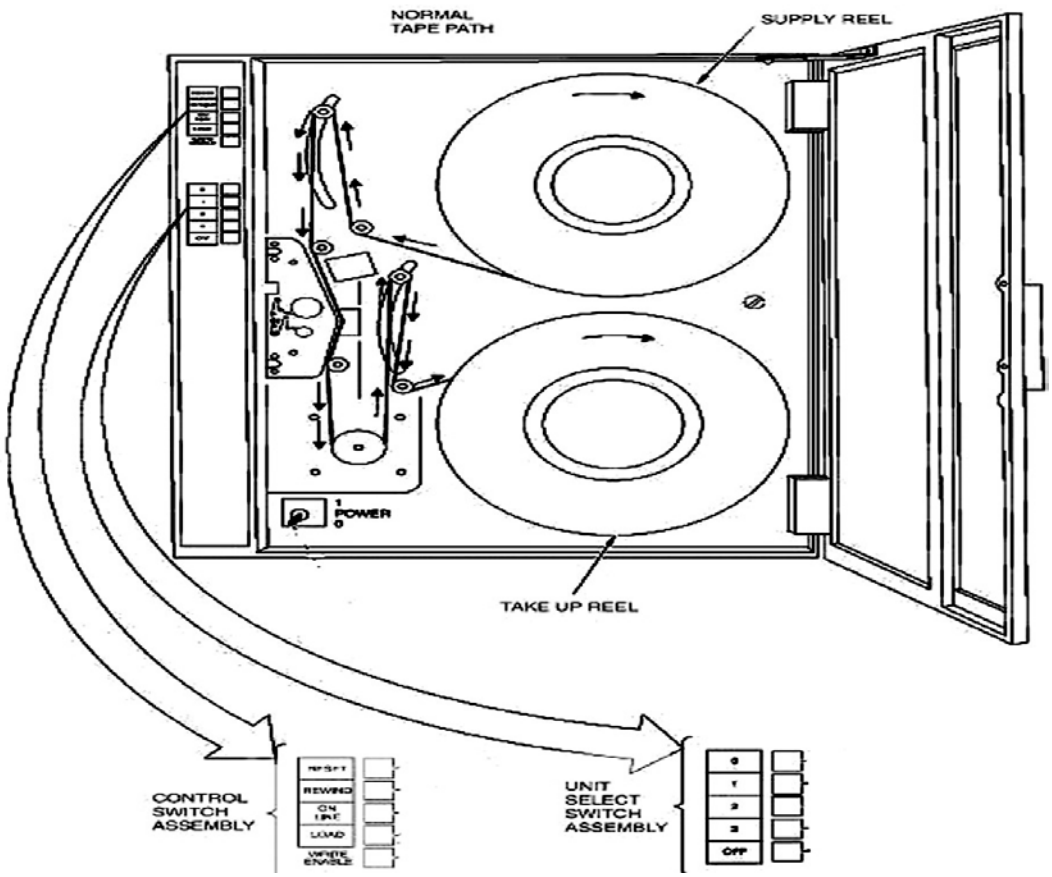


Figure 4-29. 9-Track tape.

Normal start-up

Normal start-up is defined as performing WCPS boot up from the system disk. At this time, the operators will configure the necessary switches for the disk load, turn the system on, and set the DISK/magnetic tape unit (MTU) switch for a disk load. The program verification system boot loader will read the CCOS program into computer memory, decrypt the operating system, and begin functioning.

Certifications

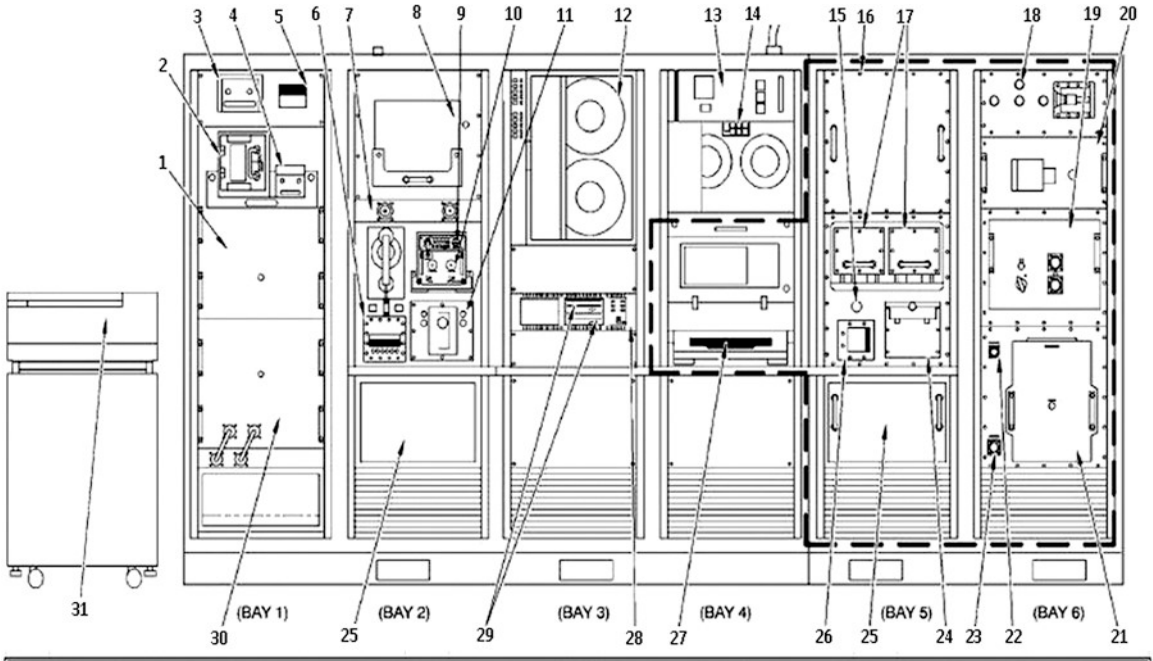
When the system is booted up from either the 9-Track or the system disk, the certification test menu will be representative of the state of the CCOS equipment status file. The following adapters must be installed to perform the applicable certification tests:

- Command signal decoder (ground) (CSD[G]) test adapter.
- Launch control panel (LCP) test adapter.
- Launch enable control group (LECG) verify test adapter.
- Test connector adapter.
- Weapon system controller (WSC) test adapter.
- Memory controller group (MCG) test adapter.
- KI-45 test adapter.
- Keying variable plug (KVP) test adapter.
- Permutation plug (P-plug) test adapter.

These CCOS certification tests are run on most of the WCPS subsystems and peripheral devices prior to using them for coding operations. This is basically, performing a self-test on the equipment before using it.

Wing code processing system

The WCPS console, which is housed inside the SE, consists of code processing equipment and auxiliary equipment. The WCPS prepares code, key, and software materials for the Minuteman weapon system. The code processing equipment is the heart of the WCPS and is contained in a six bay console (fig. 4-30). If you look closely at figure 4-30, you will notice a dashed line that encompasses bay 5, bay 6, and the CRT keyboard. These items are located, in what we call, the "red-sensitive" (EMSEC protected) area of the WCPS, because of the sensitive data that is processed there. The rest of the bays are located in the red area (non-EMSEC protected) of the WCPS.



LEGEND					
No.	Item	No.	Item	No.	Item
1	Memory controller group (MCG) test adapter	12	9-Track magnetic tape unit (MTU)	23	Code change verifier (CCV) test adapter
2	Bulk storage laoder (BS/L)	13	Console control panel	24	Cartridge drive unit (CDU)
3	Command signal decoder (ground) (CSD(G)) test adapter	14	7-Track MTU (not used)	25	Input/Output (I/O) extender (2)
4	Floppy disk drive	15	Keying variable plug (KVP) test adapter	26	Permutation plug (P-Plug) test adapter
5	Digital clock	16	Computer assembly	27	Cathode ray tube (CRT) / Keyboard
6	Modem control unit	17	TSEC/KI-45 Code processor equipment (2)	28	Disk drive assembly chassis
7	C164A interface panel (not used)	18	ICBM cryptography upgrade (ICU) integrated assembly	29	Disk drives
8	Air block plate - Bulk storage device/loader (BSD/L)	19	Launch control panel (LCP) test adapter	30	WSC test adapter
9	KIV-7M multi-channel programmable encryptor	20	Mechanical code unit (MCU) encoder drawer	31	Line printer
10	Form fit adapter	21	Launch enable control groug (LECG) verify test adapter assembly	- - -	Indicates red-sensitive (EMSEC) protected area of WCPS
11	Mass storage device/loader (MSD/L)	22	Test connector test adapter		

Figure 4-30. Wing code processing system.

Bay 1

Below are some of the items contained in bay 1 as well as some of their functions.

Memory controller group test adapter

The MCG test adapter provides a slide out surface drawer to hold the bulk storage/loader (BS/L) and floppy disk drive (FDD). Cables are provided to connect the BS/L and FDD to the WCPS.

Bulk storage/loader

Similar to a read/write drive on a computer, the BS/L is the unit where the head disk assembly (HDA) is inserted, so that the WCPS software can write/verify data to the HDA. The HDA is then transported to the LCC and installed in the BS/L located in the rapid execution and combat targeting (REACT) console. The HDA data is used for initial load of the WSP memory and for reload of the WSP in the event of a restart.

Command signal decoder (ground) test adapter

The CSD(G) test adapter is used to perform certification and self-tests on the CSD(G) interface. The adapter is removed to facilitate CSD(G) verification. A fixed code that is manually inserted into the CSD(G) is verified by the WCPS. The CSD(G) interface to the WCPS provides the capability to verify that the CSD(G) operates properly prior to installation at the LF.

Floppy disk drive

The WCPS provides an interface with the FDD. The FDD is used for writing to and verifying data on the floppy disk (FD). The FD contains data for use at the LCC.

Digital clock

The digital clock provides timekeeping for the WCPS and its software. It supplies time information to the computer interface bus, including year, month, day, hours, minutes, and seconds. The clock may be manually set with front panel controls or it can be set with commands from the computer.

Bay 2

Below are some of the items contained in bay 2 as well as some of their functions.

Modem control unit

The modem control unit enables data transfer into and out of the SE without compromising EMSEC protection.

Air block plate

The air block plate is used to seal the unused opening.

KIV-7M

The KIV-7M multi-channel programmable encryptor provides in-line data encryption and decryption for the communication link.

Form fit adapter

The form fit adapter provides a mounting location and electrical interface between the KIV-7M and the WCPS.

Mass storage device/loader

The mass storage device/loader (MSD/L) is interfaced with the WCPS to load data into a portable storage unit (PSU). The PSU is the removable part of the MSD/L and is used to store operational programs and add data files to the ALCC. When the MSD/L is not in use, an air block plate is installed.

Input/output extender

The WCPS contains two input/output (I/O) extenders, each of which can provide up to 16 additional I/O channels for the computer. One I/O extender is located in the red-sensitive (EMSEC protected)

area of the console (**Bay 5**) and provides interfaces with peripheral devices in the red-sensitive area. The other I/O extender is located in the red (non-EMSEC protected) area of the console (**Bay 2**) and provides interfaces with peripheral devices in the red area. The red I/O extender is electronically isolated from the computer during I/O operations involving red-sensitive peripherals.

Bay 3

Below are some of the items contained in bay 3 as well as some of their functions.

9-Track magnetic tape unit

The 9-Track MTU facilitates read/write operations. The MTU can read WCPS input data and write system backup tapes. As described earlier in this lesson, the 9-Tack MTU contains the loading program for a WCPS cold start. However, the 9-Track MTU may be loaded with other executable programs or used to record and store data for or from many other applications.

Disk drive assembly chassis and disk drives

The disk drive assembly (DDA) chassis houses the disk drives that contain program and storage data for the WCPS. One drive is the system drive for storing executable software and the other is a data drive that stores data required by the WCPS software.

Bay 4

Below are some of the items contained in bay 4 as well as some of their functions.

Console control panel

This panel contains the emergency shutdown circuit breaker for all six bays. It also has the power on switch to supply input power to the console components. A selector switch (DISK/MTU), enables the operator to select which magnetic data source will be used (9-Track or disk) for program loading into the computer. A reset switch can be used to interrupt computer functions and force a normal start boot up.

Cathode ray tube/keyboard

The cathode ray tube (CRT)/keyboard allows for operator interactions with the computer via a five by ten-inch display screen and a full 128-character keyboard. This is an integral unit and provides EMSEC protection for keyboard inputs and data display on the CRT screen.

Bay 5

Below are some of the items contained in bay 5 as well as some of their functions.

Keying variable plug test adapter

The KVP test adapter is used to perform the certification test on the KVP interface. The KVP is no longer used, but the interface with the WCPS is used. The KVP test adapter and interface must remain installed for EMSEC integrity.

Computer assembly

The computer assembly is responsible for providing control and data processing capabilities for the WCPS. The computer features a fully micro-programmed control processor, including all arithmetic functions, I/O, and operator panel control. For purposes of WCPS operations, the computer control panel is covered by a solid metal panel to preserve EMSEC integrity and prevent access to the computer operations or memory contents during code processing operations. The panel can be removed for maintenance and troubleshooting.

TSEC/KI-45 code processor equipment

The TSEC/KI-45s interface with the WCPS; one provides encryption and the other provides decryption. The TSEC/KI-45s are primarily used with the code processing system application

program to encrypt/decrypt data used by the ALCC. Either the TSEC/KI45 or the KI-45 adapter must remain installed at all times to preserve EMSEC integrity.

Cartridge drive unit

The cartridge drive unit (CDU) is a read/write cartridge that processes the 4-track magnetic tape cartridges (MTC) with code/key variable data. You will use these MTUs during code changes, or during tape load start up. We will be discussing this MTU in more detail in volume three.

Permutation plug test adapter

The P-plug test adapter is used for P-plug self-test and must be installed at all times to maintain console EMSEC integrity, except when an actual P-plug is installed or the P-plug certification test cable is installed.

The P-Plug interface provides a means of connecting a P-plug and reading its secure code into computer memory. These secure codes are an integral part of Minuteman launch command processing functions.

Bay 6

Below are some of the items contained in bay 6 as well as some of their functions.

ICBM cryptography upgrade integrated assembly

The ICBM cryptography upgrade (ICU) integrated assembly houses the TSEC/KS-60s and the CD-RW drive. Access to the CD-RW is through a hinged door on the front of the ICU integrated assembly. The ICU integrated assembly allows interface with external devices (fig. 4-31), such as the TSEC/KS-60, data management device (DMD), and simple key loader (SKL) via loose cables. The EMSEC caps are checked whenever functions are being performed in the red sensitive area of the WCPS console.

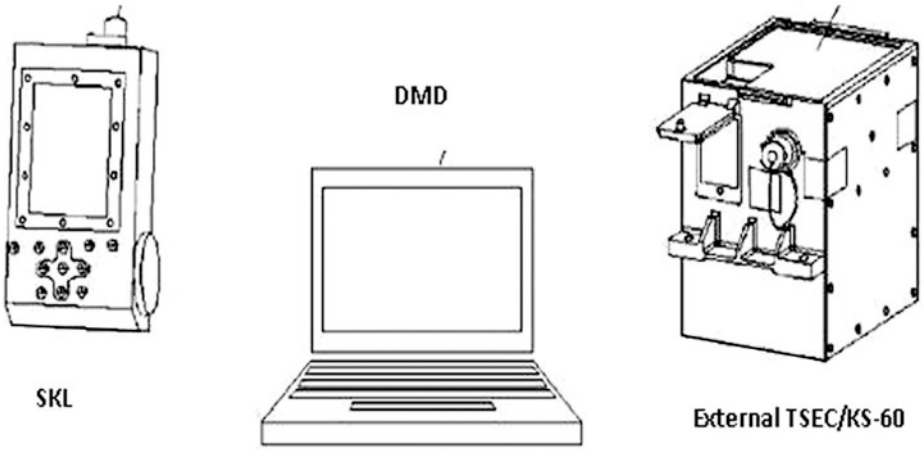


Figure 4-31. External devices.

Launch control panel test adapter

The LCP test adapter is used to perform the certification test of the LCP interfaces. The LCP test adapter is attached for the certification test in order to certify the interfaces for two different configurations of the LCP. Either the test adapter or an LCP mounted to the LCP adapter shall remain installed on the LCP interface at all times to maintain WCPS EMSEC integrity.

The LCP (fig.4-32) contains secure codes which are part of the execute launch command (ELC) and the inhibit command (INC). The secure codes are stored in the LCP in three encoded mechanical code units (MCU) designated A, B, and C. Once the LCP is properly configured for coding, the MCUs are inserted into the MCU drawer one at a time and encoded. Each encoded MCU is then set into the proper cavity of the LCP.

NOTE: Once a coded MCU has been installed in the LCP, the code will automatically dissipate if the MCU is partially or completely removed from the panel.

The LCP test adapter in bay 6 is removed and replaced by the LCP adapter (fig. 4-32). The LCP is then installed into the adapter. After all three MCUs are installed; the LCP adapter is slid into place to interface with the WCPS. The LCP is then tested through technical order-directed operator actions/inputs and WCPS software verification.

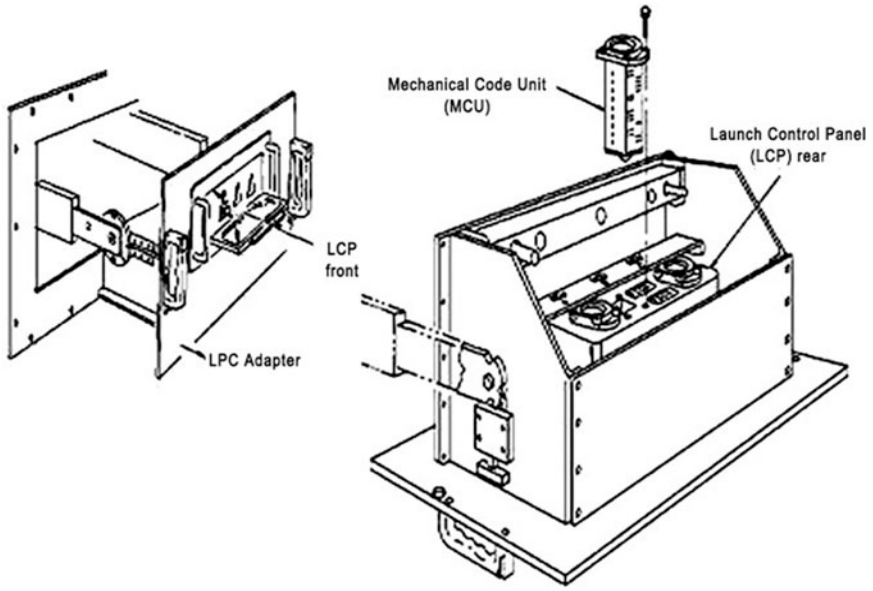


Figure 4-32. Launch control panel and adapter.

Mechanical code unit encoder drawer

The MCU encoder drawer (fig. 4-33) is an electro-mechanical device containing the necessary solenoids and switching circuits for inserting a secure code into an MCU when under control of the computer. The MCU encoder drawer encodes MCUs for use in the LCP and launch enable panel (LEP).

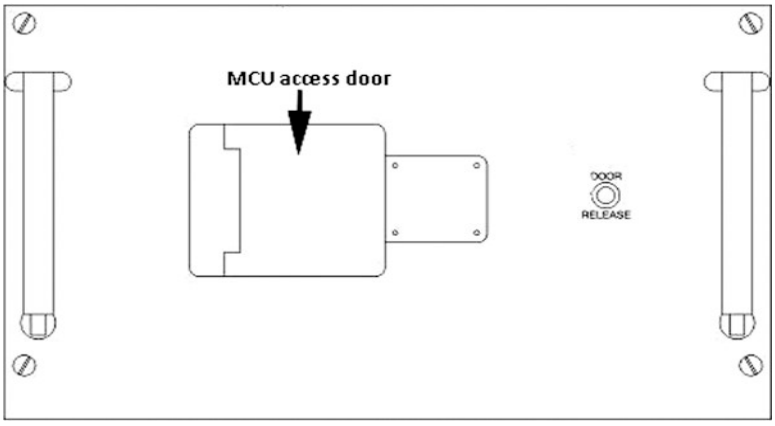


Figure 4-33. Mechanical code unit encoder drawer.

Launch enable control group verify test adapter assembly

The LECG test adapter is used to perform certification and self-tests of the LECG interface. The LECG interface module provides the capability to control the LECG functions. The LECG interface module also has a pattern generator that can be used to test other WCPS interfaces such as KVP,

LCP, and P-plug. The LECG test adapter remains installed on the LECG interface at all times to maintain WCPS EMSEC and self-test integrity, unless instructed by the application program to install the LECG.

The enable code is loaded into the WCPS computer, encoded on a MCU in the MCU encoder drawer, and installed in the LEP.

NOTE: Once a coded MCU has been installed in the LEP, the code will automatically dissipate if the MCU is partially or completely removed from the panel.

The LEP with an encoded MCU is then installed into the LECG signal panel (LECGSP); this forms the LECG (fig. 4-34). The LECGSP replaces the LECG test adapter in the WCPS bay 6 and is used to interface with the WCPS LECG housing. Finally, the LEP function is tested through TO-directed operator actions/inputs and WCPS software verification.

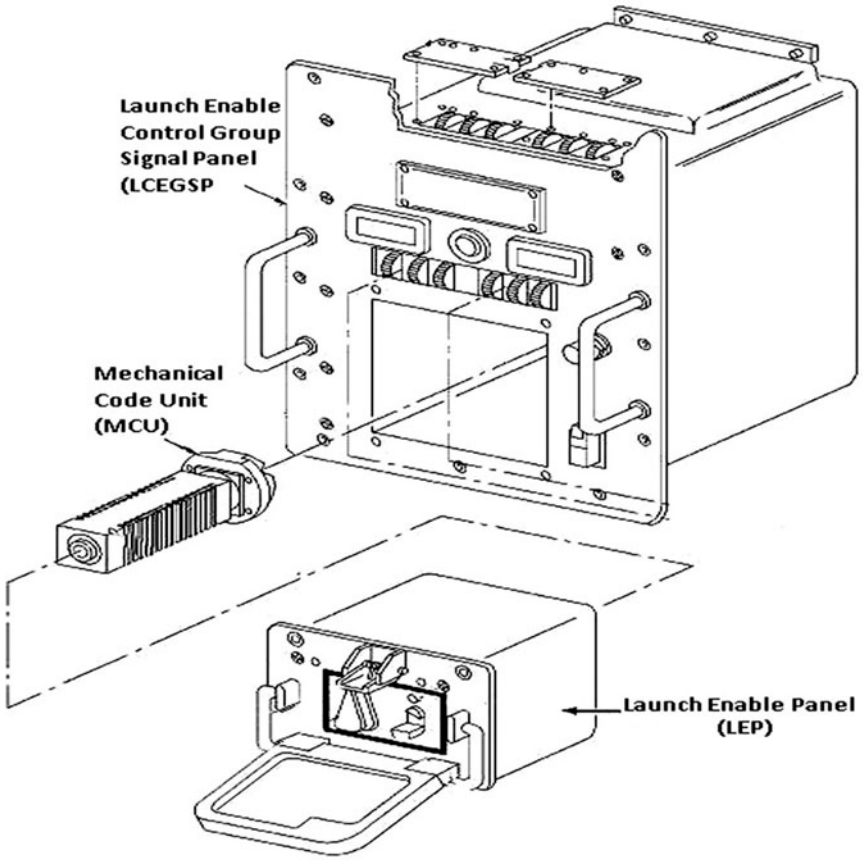


Figure 4-34. Launch enable control group.

Code change verifier test adapter

The code change verifier (CCV) test adapter is used to perform the certification test on the CCV interface. The WCPS is normally configured with the test adapter whenever the CCV is not in use. The CCV test Adapter or the CCV shall be installed at all times to ensure EMSEC integrity.

The CCV interfaces with the WCPS to load secure codes into CCV memory, verify the codes, and read trace data collected by the CCV during encoding operations at the LF. The CCV is a secure coding unit that changes and verifies the code in the command signal decoder (missile) (CSD[M]). It connects to the WCPS via the CCV interface.

Line printer

The line printer, under control of WCPS software, provides a printed copy of WCPS functional operation and record keeping information.

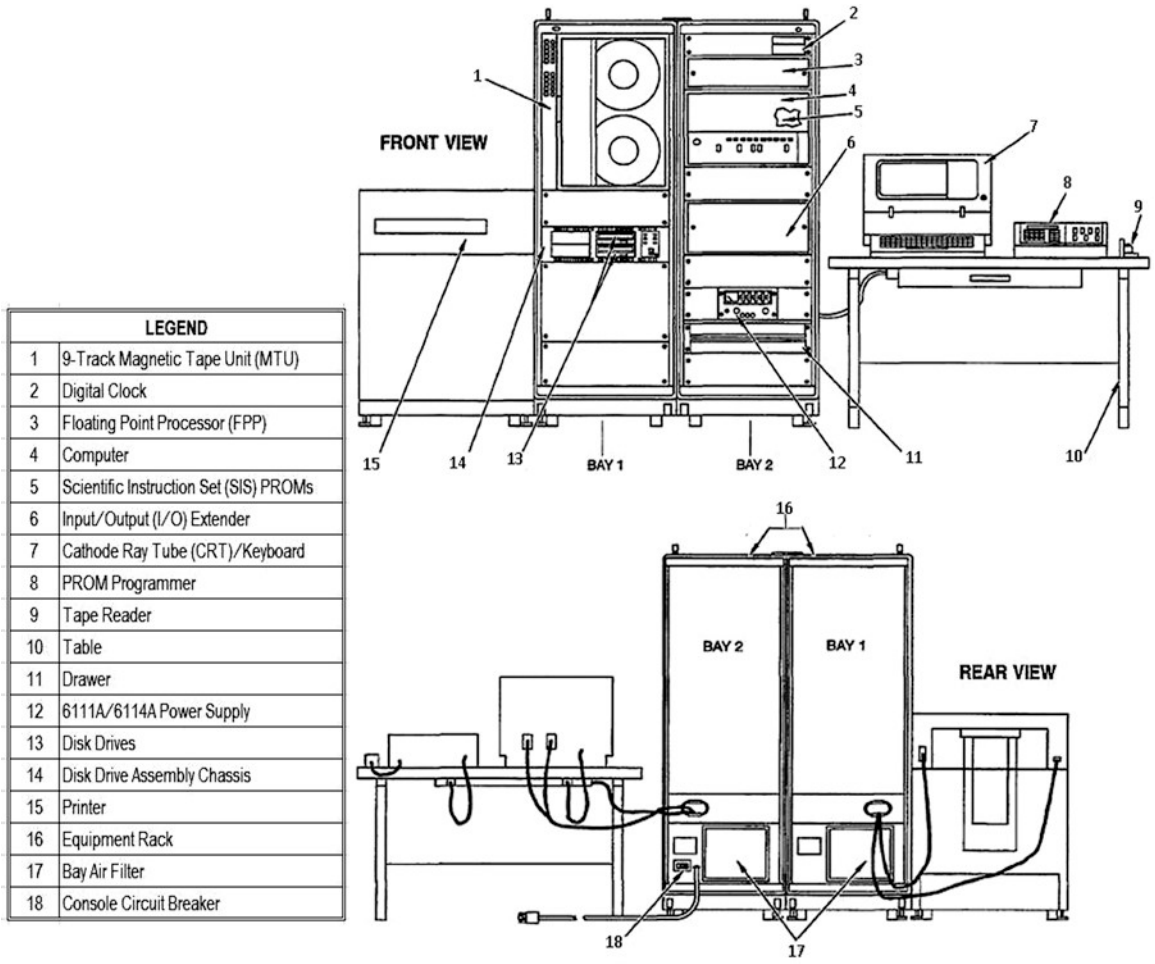
228. Hardware certification verification equipment

Although the HCVE is maintained in the codes vault, E-lab technicians utilize this test bench to troubleshoot faults associated with the WCPS. In this lesson, we will cover the basic description and function of the HCVE.

Description

The HCVE (fig. 4-35) tests and fault isolates the following WCPS equipment LRUs:

- DDA.
- Computer.
- Line printer.
- I/O extender.
- Digital clock.
- 9-track MTU.
- CRT/keyboard assembly.



LEGEND	
1	9-Track Magnetic Tape Unit (MTU)
2	Digital Clock
3	Floating Point Processor (FPP)
4	Computer
5	Scientific Instruction Set (SIS) PROMs
6	Input/Output (I/O) Extender
7	Cathode Ray Tube (CRT)/Keyboard
8	PROM Programmer
9	Tape Reader
10	Table
11	Drawer
12	6111A/6114A Power Supply
13	Disk Drives
14	Disk Drive Assembly Chassis
15	Printer
16	Equipment Rack
17	Bay Air Filter
18	Console Circuit Breaker

Figure 4-35. Hardware certification verification equipment.

Physical layout

The HCVE is a two bay console with a power panel, power cable, analog to digital converter (ADC) calibration power supply, and interconnection cables. The additional equipment not connected to the console is a worktable and a PROM programmer assembly.

Function

The function of the HCVE is to test the suspected faulty equipment in the WCPS. What makes the HCVE unique is that is does not follow the basic concept of a test station. Instead of connecting the UUT to the test station, the test station is the UUT. All the instruments listed in the above paragraph are assembled in the two bays as if they were in a WCPS. Any one piece of equipment can be the UUT with the rest of the instruments testing it. If you recall reading section 4-1, you might realize that the HCVE is similar to how the MMTS functions. The PROM programmer verifies and programs PROMs used in the WCPS.

Tests

There are three tests that can be performed. Which test is performed depends on the LRUs that are functional as well as some other factors. The three tests are off-line diagnostics, on-line diagnostics, and self-test.

Off-line diagnostics

The off-line diagnostic software performs comprehensive tests of the HCVE hardware and firmware. A specialized operating system enables the software to load directly from the 9-Track tape and into the computer memory, eliminating the need for a functioning DDA. There are 18 off-line diagnostic tests available. Refer to figure 4-36 for a look at the available off-line diagnostics.

	Diagnostic	Line Replaceable Unit (LRU)								
		Computer	FPP	I/O Extender	Disk Drive Assembly	9-Track MTU	CRT/Keyboard	Printer	Digital Clock	6111A/6114A Power Supply
Off-Line Diagnostics	Memory Reference	X				X	X			
	Alter-Skip Instruction	X				X	X			
	Shift-Rotate Instruction	X				X	X			
	Extended Arithmetic Group	X				X	X			
	Extended Instruction Group-Index	X				X	X			
	Extended Inst. Group-Word, Byte, Bit	X		X		X	X			
	Memory Expansion	X				X	X			
	Memory Protect	X		X		X	X			
	Semiconductor Memory	X				X	X			
	Floating Point Processor	X	X			X	X			
	BACI	X				X	X			
	Time Base Generator	X				X	X			
	General Purpose Register	X		X		X	X			
	DCPC	X		X		X	X			
	I/O Extender	X		X		X	X			
	9-Track MTU	X			X	X	X			
	Clock Interface	X		X		X	X			
	Printer Interface	X		X		X	X	X		

X = Required

1 = Optional, 9-Track MTU required if On-Line Diagnostics are not copied to a SYSTEM disk

Figure 4-36. Off-line diagnostics.

On-line diagnostics

The on-line diagnostic software performs many of the same tests as the off-line diagnostics, but in a more user-friendly environment. Consequently, additional hardware devices are required by the software (i.e., a working CRT terminal and a DDA). Some tests are not as extensive as others. The on-line diagnostic software sacrifices a portion of the low-level testing capability in exchange for user-friendliness.

There are 11 on-line diagnostic tests available, but remember in order to start on-line diagnostic tests, the CRT/keyboard and DDA (with associated hardware) must be operational. If you are loading the on-line diagnostics programs to a disk, then the 9-Track MTU and associated hardware must be operational. Refer to figure 4-37 for a list of the on-line diagnostics that are available.

	Diagnostic	Line Replaceable Unit (LRU)								
		Computer	FPP	I/O Extender	Disk Drive Assembly	9-Track MTU	CRT/Keyboard	Printer	Digital Clock	6111A/6114A Power Supply
On-Line Diagnostics	CPU Test	X			X	1	X			
	Memory Test	X			X	1	X			
	Firmware Test	X	X		X	1	X			
	Microcode Test	X			X	1	X			
	HPIB Test	X		X	X	1	X			
	Clock Test	X		X	X	1	X		X	
	Disk Test	X			X	1	X			
	9-Track MTU Test	X			X	X	X			
	Printer Test	X		X	X	1	X	X		
	CRT/Keyboard Test	X			X	1	X			
	ADC Module Test	X		X	X	1	X			X

X = Required

1 = Optional, 9-Track MTU required if On-Line Diagnostics are not copied to a SYSTEM disk

Figure 4-37. On-line diagnostic.

Self-test

The computer, CRT/keyboard, and printer have built-in test equipment that enable them to perform stand-alone self-tests. Whenever power is applied to the computer, it automatically initiates a self-test routine. The CRT/keyboard and printer on the other hand are user commanded self-tests. Figure 4-38 lists the LRUs that have a self-test capability.

	Diagnostic	Line Replaceable Unit (LRU)								
		Computer	FPP	I/O Extender	Disk Drive Assembly	9-Track MTU	CRT/Keyboard	Printer	Digital Clock	6111A/6114A Power Supply
Self-Tests	CRT/Keyboard Self-Test						X			
	Printer Self-Test							X		

X = Required

1 = Optional, 9-Track MTU required if On-Line Diagnostics are not copied to a SYSTEM disk

Figure 4–38. Self-test.

Self-Test Questions

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

227. Wing code processing system

1. What does the ICPS consists of?

2. What additional components of the SE provide additional EMSEC protection?

3. What are some of the reasons why a WCPS cold start would be performed?

4. What does the WCPS prepare for the Minuteman weapon system?

5. What is meant by “red-sensitive” area?

6. Which bay houses the CDU?

228. Hardware certification verification equipment

1. What is the HCVE used for?

2. What makes the HCVE unique?

3. What are the three types of HCVE testing?

Answers to Self-Test Questions

221

1. Computer group.
2. Shunt assembly.
3. The front panel ICA on the equipment test station; provides interface between the UUT and equipment test station.
4. Supplies cooling air to the UUT during powered applications.

222

1. As a power receptacle for individual test equipment and UUTs.
2. The MT-2812 has one flexible air duct adapter, while the MX-4285 has two.
3. Access points for adjustments, measurements, and test connections.

223

1. The asynchronous/synchronous serial interface or more commonly called the RMB32 modules.
2. (1) c.
   (2) d.
   (3) b.
   (4) f.
   (5) g.
   (6) a.
   (7) e.

224

1. In the MGS vault, in shipping containers to maintain temperature between 45 degrees and 145 degrees Fahrenheit.
2. Because the MGS is a HCI.
3. To protect the shield surface from scratches, the surface coating may have to be removed to inspect the shield surface.
4. Acid bloom.
5. Self-test.
6. (1) e.
   (2) c.
   (3) b.
   (4) f.
   (5) a.
   (6) d.
7. Protective cover set; protects the MGC radiation shield from damage and prevents tools, hardware, or other miscellaneous items from falling into the IMU housing.
8. Applying ground power to a MGS for more than 30 minutes during MGS certification can damage the MGS because there is no cooling system in use during the certification process. Do not perform MGS certification procedures on the same MGS more than six times in a 24-hour period. Failure to comply could result in equipment damage. In the event the MGSTS fails during the automated MGS certification procedure, ensure the 30-minute time limit is not exceeded. Failure to comply could result in equipment damage. If a failure occurs during the certification test the MGS, MGSTS, computer, and HDD serial numbers must be recorded. The failure message, date, time, and operator name must be recorded as well.

225

1. Off-line testing of all SACCS related LRUs including the KIV-7M cryptographic device.
2. The CIs or LRUs during LRU testing and troubleshooting.

226

1. ICBMs in their deployed environment at operational wings.
2. The activation of ordnance devices occurs at two LFs during every SELM test, except for the launcher closure door; the launcher closure door only requires activation once a year.
3. Cable cases and safe maintenance practices.
4. Proper configuration of all SELM test equipment, SELM cables connections, and safing of the missile and applicable AVE.
5. At the LF where ordnance is activated to maintain communication with the MCC.

227

1. The SE, CCOS software, and WCPS.
2. Pneumatic door, power line filters, air conditioning filters, and fiber-optic communication link.
3. The system disk was replaced, the system crashed, or the software was being loaded for the first time.
4. Code, key, and software material.
5. It is the area on the WCPS that has extra EMSEC protection because of the sensitive data that is processed there.
6. Bay 5.

228

1. Troubleshoot faults associated with the WCPS.
2. It does not follow the basic concept of a test station, instead of connecting the UUT to the test station, the test station is the UUT.
3. Off-line, on-line, and self-tests.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

84. (221) Which unit under test (UUT) specific item enables the UUT to be electrically connected to the electronic equipment test station through cables?
    a. Interface test adapter (ITA).
    b. Mobile workstation.
    c. Interface carrier assembly (ICA).
    d. General purpose interface bus (GPIB).

85. (222) Which power does the electronic laboratory's (E-lab) generator provide to the 82 workbench?
    a. 120/208 volts alternating current (VAC), 60-hertz (Hz) only.
    b. 120/208 VAC, 60-Hz and 400-Hz.
    c. 120 VAC, 60-Hz and 400-Hz.
    d. 120 VAC, 400-Hz only.

86. (222) Select the 82 workbench component that enables cooling air to be supplied to an electronic drawer.
    a. Unit under test manifold.
    b. Cooling air test adapter.
    c. Cooling air test set.
    d. Holding fixture.

87. (223) Which is *not* "operationally certified" by the nuclear certification test station (NCTS)?
    a. RMB32 modules.
    b. Weapon system processor (WSP).
    c. Single module computer 810 (SMC–810) circuit card assembly (CCA).
    d. Extended memory array dynamic CCA.

88. (223) Select the nuclear certification test station (NCTS) system circuit card(s) that will *never* be used in an operational weapon system processor at a launch control center.
    a. Extended memory array dynamic (EMAD) only.
    b. Single module computer 810 (SMC–810) only.
    c. EMAD and RMB32 modules only.
    d. SMC–810 and a RMB32 only.

89. (223) How many mobile work platforms does the nuclear certification test station (NCTS) require?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

90. (224) Which of the missile guidance set test set (MGSTS) components consists of devices that must be replaced, *not* repaired, if they become defective?
    a. External cables.
    b. Umbilical plug assembly.
    c. Mobile console assembly.
    d. Certification test controller assembly.

91. (224) During the missile guidance set (MGS) certification procedure, certification can be performed on the same MGS no more than
    a. four times in a 24 hour period.
    b. four times in a 48 hour period.
    c. six times in a 24 hour period.
    d. six times in a 48 hour period.

92. (225) Which *items* are the missile maintenance test set (MMTS) test stands normally equipped with that are identical to the line replaceable units installed at a launch control center (LCC)?
    a. Critical.
    b. Compatible.
    c. Configuration.
    d. Communication.

93. (226) During an intercontinental ballistic missile (ICBM) simulated electronic launch–Minuteman (SELM) test, the launch command signals can come from
    a. a wing command post and an airborne launch control center (ALCC).
    b. a launch control center (LCC) or an ALCC.
    c. a wing command post only.
    d. an LCC only.

94. (226) The *function* of the simulated electronic launch–Minuteman (SELM) control monitor is to
    a. route certain ordnance signals to resistive loads.
    b. monitor the missile guidance set (MGS) battery voltage.
    c. monitor the command signals sent to the propulsion system rocket engines (PSRE).
    d. monitor voltage level of vertical shock isolation system ordnance activation signals.

95. (226) What takes place *after* the launch facilities are postured for a simulated electronic launch–Minuteman (SELM) test?
    a. SELM evaluation.
    b. Last look inspection.
    c. SELM team chief inspection.
    d. Quality assurance (QA) evaluation.

96. (226) At which launch facilities (LF) are test *evaluation* teams stationed *during* a simulated electronic launch–Minuteman (SELM) test?
    a. Each LF tested.
    b. LFs where ordnance is activated.
    c. LFs where ordnance activation is simulated.
    d. LFs where all ordnances have been removed.

97. (227) Select the component of the shielded enclosure that has a honeycomb construction to provide emissions security integrity.
    a. Pneumatic door.
    b. Power line filters.
    c. Air conditioning filters.
    d. Fiber-optic communication link housing.

98. (227) Which components on the wing code processing system are in the “red-sensitive” area?
    a. Bays 1 and 2, and the cathode ray tube (CRT) keyboard.
    b. Bays 3 and 4, and the CRT keyboard.
    c. Bays 5 and 6, and the CRT keyboard.
    d. All components.

99. (228) Who uses the hardware certifications verification equipment to troubleshoot faults in the wing code processing system?
    a. Depot.
    b. Certified codes controllers.
    c. Electronics laboratory technicians.
    d. Electro-mechanical team technicians.

100. (228) Select the hardware certification verification equipment test that is the *most* user-friendly.
    a. Off-line diagnostics test.
    b. On-line diagnostics test.
    c. Automatic test.
    d. Self-test.

Glossary

Abbreviations and Acronyms

AAP	auxiliary alarm panel
ABU	Airman battle uniform
ADC	analog to digital converter
AETC	Air Education and Training Command
AF	Air Force
AFB	Air Force base
AFDD	Air Force doctrine document
AFGSC	Air Force Global Strike Command
AFGSCI	Air Force Global Strike Command instruction
AFH	Air Force handbook
AFI	Air Force instruction
AFIND	Air Force index
AFMAN	Air Force manual
AFMC	Air Force Materiel Command
AFMD	Air Force mission directive
AFOSH	Air Force Occupational Safety and Health
AFOSR	Air Force Office of Scientific Research
AFOTEC	Air Force Operational Test and Evaluation Center
AFPAM	Air Force pamphlet
AFPD	Air Force policy directive
AFPM	Air Force policy memorandum
AFRL	Air Force Research Laboratory
AFSCN	Air Force Satellite Control Network
AFSPC	Air Force Space Command
AFTO	Air Force technical order
ALC	air logistics complex
ALCC	airborne launch control center
amp	ampere
API	Airman Powered by Innovation
ASTS	air and space test squadron
AVE	aerospace vehicle equipment
BS/L	bulk storage/loader
C2	command and control
CBC	common booster core
CCA	circuit card assembly
CCAFS	Cape Canaveral Air Force Station
CCB	common core booster
CCOS	Common Certification/Operating System
CCV	code change verifier
CD	compact disk
CDC	career development course

CD-RW	compact disk-read writeable
CDU	cartridge drive unit
CED	control electronics drawer
CI	configuration item
CPA	computer processor assembly
CPGS	common point ground system
CRT	cathode ray tube
CSCI	computer software configuration item
CSD(G)	command signal decoder (ground)
CSD(M)	command signal decoder (missile)
CTA	certification test adapter
CTC	certification test controller
C-UTE	collocated-user terminal element
DC	direct current
DDA	disk drive assembly
DECERT	decertification
DMD	data management device
DOD	Department of Defense
DR	deficiency report
DVD-ROM	digital video disk-read only memory
ECS	environmental control system
EELV	evolved expendable launch vehicle
E-lab	electronics laboratory
ELC	execute launch command
EMAD	extended memory array dynamic
EMSEC	emissions security
EPA	Environmental Protection Agency
EPT	elevating platform transporter
ESCTS	explosive set circuitry test set
ESD	electrostatic discharge
ESDS	electrostatic discharge sensitive
FD	floppy disk
FD/FI	fault diagnostic/fault indication
FDD	floppy disk drive
FLP	fixed launch platform
FPE	fixed pad erector
FUT	fixed umbilical tower
GEM	graphite epoxy motor
GMATS	Ground Minuteman Automated Test System
GPIB	general purpose interface bus
GPS	Global Positioning System
GUI	graphical user interface
HCI	hardness critical item
HCP	hardness critical procedure

HCVE	hardware certification verification equipment
HDA	head disk assembly
HDD	hard disk drive
HIF	horizontal integration facility
HQ	headquarters
HQ USAF	Headquarters United States Air Force
Hz	hertz
I/O	input/output
IAC	Instrument-on-A-Card
ICA	interface carrier assembly
ICBM	Intercontinental Ballistic Missile
ICPS	Intercontinental Ballistic Missile Code Processing System
ICU	Intercontinental Ballistic Missile cryptography upgrade
ILS-S	Integrate Logistics System-Supply
IMDS	Integrated Maintenance Data System
IMU	internal measurement unit
INC	inhibit command
IPB	illustrated parts breakdown
ITA	interface test adapter
JDD	job data documentation
KB	keyboard
KSR	keyboard send receive
KVP	keying variable plug
lbs.	pounds
LCC	launch control center
LCF	launch control facility
LCP	launch control panel
LECG	launch enable control group
LECGSP	launch enable control group signal panel
LEP	launch enable panel
LF	launch facility
LMU	launch mate unit
LOB	launch operations building
LPU	line printer unit
LRU	line replaceable unit
LSB	launch support building
LSS	launch support squadron
MAF	missile alert facility
MAJCOM	major command
MAS	mobile assembly shelter
MAT	mission assurance technician
MCC	missile combat crew
MCG	memory controller group
MCU	mechanical code unit

MGC	missile guidance computer
MGS	missile guidance set
MGSC	missile guidance set control
MGSTS	missile guidance set test set
MIP	material improvement project
MMOC	missile maintenance operations center
MMTS	missile maintenance test set
MPTO	methods and procedures technical order
MSB	missile support base
MSD/L	mass storage device/loader
MST	mobile service tower
MSU	mass storage unit
MT	missile test
MTC	magnetic tape cartridge
MTF	module test fixture
MTU	magnetic tape unit
MW	missile wing
MWP	mobile work platform
MWS	mobile work surface
N/C	normally closed
N/O	normally open
NAF	numbered Air Force
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NCTP	Nuclear Certification Test Program
NCTS	Nuclear Certification Test Station
NORAD	North American Aerospace Defense Command
O&M	operations and maintenance
OI	operating instruction
OL	overload
OPCERT	operational certification
PC	personal computer
PCA	printed circuit card assembly
PLF	payload fairing
PPE	personal protective equipment
P-plug	permutation plug
PROM	programmable read-only memory
PSD	power supply drawer
PSDU	power signal and distribution unit
psi	pounds per square inch
PSRE	propulsion system rocket engine
PSU	portable storage unit
QA	quality assurance
REACT	rapid execution and combat targeting

REMIS	Reliability and Maintainability Information System
RF	radio frequency
RP	rocket propellant
SACCS	Strategic Automated Command and Control System
SCM	simulated electronic launch-Minuteman missile control monitor
SE	shielded enclosure
SECAF	Secretary of the Air Force
SELM	simulated electronic launch-Minuteman
SFU	summary fault unit
SKL	simple key loader
SLC	Spacelift complex
SLS	space launch squadron
SMC	Space and Missile Systems Center
SMC-810	single module computer 810
SOS	source of supply
sq in.	square inches
SRAM	static random access memory
SW	space wing
TB	terminal board
TCM	technical content manager
TCTO	time compliance technical order
TEO	test execution order
TM	technical manual
TO	technical order
TPC	two-person concept
UCMJ	uniform code of military justice
UIA	umbilical interface adapter
UPS	uninterruptible power supply
URD	unit reference designator
US	United States
USAF	United States Air Force
USSTRATCOM	United States Strategic Command
UT	umbilical tower
UUT	unit under test
VAC	volts alternating current
val-ver	validation-verification
VDC	volts direct current
VDU	visual display unit
WCP	wing command post
WCPS	wing code processing system
WSC	weapon system controller
WSP	weapon system processor
WTF	weapon system processor test fixture
WUC	work unit code

Student Notes

AFSC 2M051A
2M051A 02 1904
Edit Code 06