CDC 2M051B

Missile and Space Systems Electronic Maintenance Journeyman

Volume 1. Air Launched Cruise Missile Fundamentals

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CONGRATULATIONS on enrolling in career development course (CDC) 2M051B, *Missile and Space Systems Electronic Maintenance Journeyman*. This CDC will help you obtain knowledge required for upgrade as well as promotion. This is a self-study course that the Air Force intends 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 information about the cruise missile organizational structure, technical orders and maintenance data collection, and maintenance fundamentals.

Unit two provides the cruise missile description and information about various cruise missile systems, which include electrical, environmental, propulsion, and navigation.

Unit three provides information about missile maintenance operations, repair, diagrams, and troubleshooting.

Finally, unit four provides information about missile handling, serving, and checkout support equipment. It continues with aircraft pylon and rotary launcher systems, and concludes with missile generation knowledge.

A glossary is included for your use.

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NOTE:

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

Page

Please read the menu for Unit 1 and begin ➔

Unit 1. Cruise Missile Career Field

WELCOME TO THE Air Launched Cruise Missile (ALCM) fundamentals career development course (CDC). ALCM are one of the two major nuclear capable weapon systems you may work on in your career. The other weapon system is the Intercontinental Ballistic Missile (ICBM), which is discussed in the 2M051A CDC set. This course will primarily focus on the ALCM. The ALCM weapon system was designed to augment our nation's defenses by extending the range and effectiveness of the manned bomber force. Cruise missiles can carry a nuclear or a conventional warhead and, though the explosive packages are very different. The nuclear capable ALCM and the conventional ALCM (CALCM) are very similar in the way they are carried and launched. However, even though both systems have some common ground equipment and both may be worked on in the same integrated maintenance facility (IMF), you will find there are some key differences. We will cover both systems together over the course of this CDC set and point out any differences as each topic or subject is discussed.

This unit contains three sections, which provide career field fundamentals. The first section on organization and duties explains your work structure. The second section is technical orders and maintenance data collection, which are critical maintenance documents. The last section in this unit is general maintenance fundamentals to familiarize you with your work environment.

1–1. Organization and Duties

Being new to this career field, and more than likely to the Air Force (AF), you probably have many questions about how you climb the ranks as an "X1" and what different avenues and places this job may take you. You have already completed the first steps – completing your technical training and being awarded a maintenance badge as a 2M031 missile and space systems electronic maintenance apprentice. The remainder of your AF career is in your hands. This section will explain your organizational structure, the munitions squadron organization, and the various duties performed as a 2M0X1.

001. Organizational structure

As an Air Force member, knowing and understanding your chain of command is vital. Each level in the chain is responsible for all lower levels, and accountable to all higher levels. Looking at your chain of command will help you understand where you fit in the organization and help you understand how each level contributes to the mission. Here, we will look at your major command, your numbered Air Force, and each of the major bomb wings you could be assigned.

Air Force Global Strike Command

Air Force Global Strike Command (AFGSC) is your major command (MAJCOM) with its headquarters at Barksdale Air Force Base (AFB), Louisiana. As a MAJCOM, AFGSC is assigned a major part of the Air Force mission. The mission of AFGSC is to provide the President of the United States and combatant commanders with strategic deterrence, global strike, and combat support. In support of that mission, AFGSC assets are poised to conduct strike operations anywhere on the globe, using land-based ICBM forces, as well as long-range bombers, such as the B–52 and B–2 bombers. In conducting its operations, AFGSC's mission has three specific areas of focus:

1. Safety
2. Security
3. Credibility

Safety

The safety of our nuclear assets and our people is critical to AFGSC's mission. As a technician, your actions could cause catastrophic failure if safety is compromised in any facet of your duties – a perfect reason to follow technical order guidance so you ensure not only your own safety, but also that of your co-workers. AFGSC maintains an aggressive inspection tempo to focus on nuclear safety and task safety.

Security

The security of our nuclear assets is just as important as safety. Security Forces airmen are not the only ones responsible for security; we all have a role to play in security. As a missile maintainer, you will have a direct impact on the security of our nuclear weapon system by following proper security procedures as outlined in your technical order. Being aware and remaining vigilant will enhance security.

Credibility

Credibility is a prime concern for AFGSC. This MAJCOM is entrusted with two-thirds of the nation's nuclear triad: land-based ICBMs and long-range bombers. As such, the American people must have faith that these weapons are properly secured and maintained in a safe manner. As a missile maintainer, your day-to-day actions reflect the pride and precision that needs to be delivered to ensure public support. A false step can damage the credibility of AFGSC, as well as the Air Force, and the United States as a whole. For us to continue this mission, the American people must have confidence that we can do it safely and securely.

Eighth AF

Eighth Air Force is one of two active-duty numbered air forces (NAF) under AFGSC. It too is headquartered at Barksdale AFB and is responsible for the bomber force. The other NAF under AFGSC is the Twentieth AF responsible for the ICBM force, which is discussed in the 2M051A CDC. NAF are tactical echelons that provide operational leadership and supervision. Eighth AF is designated as U.S. Strategic Command's Task Force 204, providing on alert, combat-ready forces to the President. The mission of "The Mighty Eighth" is to safeguard America's interests through strategic deterrence and global combat power. Eighth Air Force controls long-range nuclear-capable bomber assets (B-52 and B-2) throughout the U.S. and overseas locations. Its flexible, conventional and nuclear deterrence mission provides the capability to deploy forces and engage enemy threats from home station or forward positioned locations, anywhere, any time. The Eighth Air Force motto is "Peace Through Strength."

Bomb wings

Wings typically encompass the responsibility of the base services along with the designated mission. The Eighth AF has three long-range nuclear-capable bomber wings: the 2nd Bomb Wing, the 5th Bomb Wing, and the 509th Bomb Wing.

Each of these wings has bomber aircraft capable of flying anywhere around the world and stands ready to deliver a wide range of munitions. These bombers serve as part of the Air Force's conventional and strategic combat force. Each of these bomber wings have a role that contributes to Eighth AF and further up to AFGSC.

2nd Bomb Wing

The 2nd Bomb Wing conducts the primary mission of Barksdale AFB, Louisiana, with three squadrons of B-52H Stratofortress bombers, the 11th Bomb Squadron, which is the training squadron, the 20th Bomb Squadron and the 96th Bomb Squadron.

5th Bomb Wing

The 5th Bomb Wing is a B-52H Stratofortress wing at Minot Air Force Base, North Dakota. Known by its nickname, the Warbirds, the 5th Bomb Wing is the host wing at Minot AFB. The bomb wing’s mission is to *provide* full-spectrum deterrence and outstanding support for the 91st Missile Wing (a tenant wing of the host base), and B-52 firepower on demand if deterrence fails.

509th Bomb Wing

The 509th Bomb Wing is a B-2 Spirit wing and the host wing at Whiteman Air Force Base, Missouri. The bombers have a wide range of precision-guided munitions.

Maintenance group

The maintenance group supports the primary mission with weapon system maintenance. Some support areas include maintenance training, equipment maintenance, and quality assurance. The munitions squadron you are assigned to as a cruise missile maintainer is subordinate to the maintenance group.

002. Munitions squadron organization

As a cruise missile maintainer, you’ll be assigned to a munitions squadron at your first duty station. Your unit will provide you with an organization chart, which shows the hierarchy of your unit. Squadron leadership is listed first, then the flights, and their subordinate sections. Sometimes sections are further divided by work shift. Your squadron will have a few different flights each having a different function, which contributes to the mission. We will highlight the major areas of a munitions organizational squadron; however, there may be some variations in your organization. This lesson will give you a typical overview.

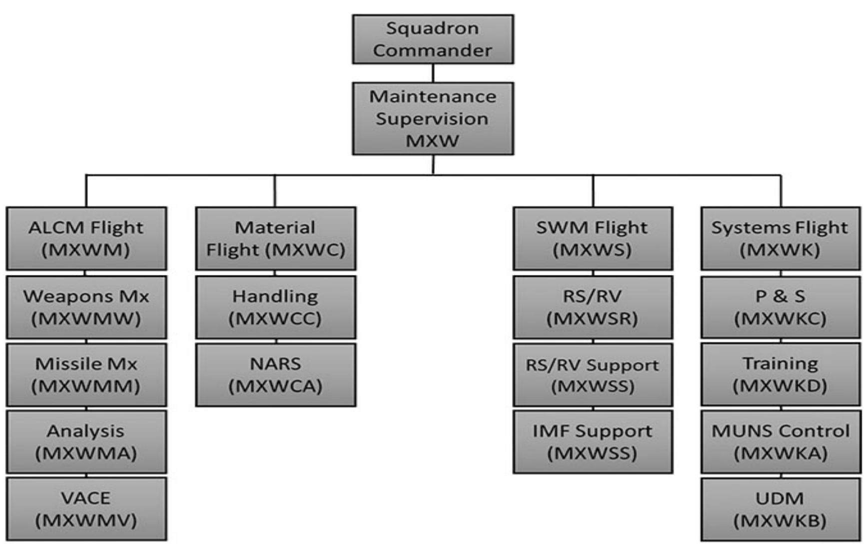


Figure 1–1. Munitions Squadron (Minot AFB).

Munitions squadron

Functions and responsibilities of the munitions squadron (fig. 1–1) include receipt, storage, maintenance, assembly, disassembly, delivery, and load of conventional munitions and nuclear weapons. A munitions squadron also manages performance of off-equipment maintenance and management of mission equipment directly supporting training and combat operations.

Commander

The commander is the overall leader in charge of the munition's squadron and is the top echelon of the squadron chain of command. The commander is accountable for all production within the unit and reports to the group.

Maintenance supervision

Maintenance supervision (MXW) provides overall management and supervision of daily activities of munitions maintenance production and support. MXW consists of the operations officer and maintenance superintendent. Maintenance supervision falls below the Commander and is in charge of the flights.

Air Launch Cruise Missile flight

The ALCM flight (MXWM) consists of four different sections: missile maintenance, weapons maintenance, verification and checkout equipment (VACE) and analysis. Weapons maintenance conducts nuclear warhead maintenance, installs the warhead in the missile, and mates/demates the missile to the common strategic rotary launcher (CSRL) or pylon. Weapons maintainers belong to the AF specialty code (AFSC) 2W2X1. Performance of weapons maintenance operations supports the missile maintenance workflow. The other ALCM flight sections (missile maintenance, VACE, and analysis will be explained in the next lesson on duties.

Systems flight

The systems flight (MXWK) provides broad command and control, direction, and support for *all* munitions activities to include training, resources, munitions information systems, facilities, and mobility programs. Typical sections in this flight are munitions control, plans & scheduling, training and mobility. The AFSC 2R0X1 scheduling personnel perform plans and scheduling using maintenance information systems data to provide a maintenance schedule, which the designated level will review and approve. The mobility section oversees and maintains unit deployment readiness.

Materiel flight

Materiel flight (MXWC) consists of the nuclear accountability and reporting section (NARS) and handling section. NARS personnel support the Maintenance Accountable Systems Officer's responsibility of custody, accountability, and control of nuclear weapons and nuclear material. The handling section will be discussed in the next lesson about duties.

Special weapons maintenance flight

The special weapons maintenance flight (MXWS) performs on-equipment and off-equipment maintenance on assigned nuclear weapons, reentry systems/vehicles, and associated equipment. The sections in this flight are reentry systems/reentry vehicles (RS/RV) and support. The RS/RV section consists of 2W2X1's and supports nuclear warhead operations for the ICBM. Support will be discussed in the next lesson about duties.

003. Duties of a 2M0X1

This lesson focuses on the different duty sections you can work as a 2M0X1 though it is not all encompassing. Once you complete your 5-skill level training, you can be assigned to a multitude of other positions throughout your organization as well as the AF. Your 7-level upgrade opens even more assignment possibilities. Your first priority will be to complete your CDC. Your supervisor and training section will oversee your CDC progress until completion.

You will likely work in either the missile maintenance section or the support section during your upgrade process. Once you complete your CDC and on-the-job training, you will be able to be assigned too many different sections in the munitions squadron. In this lesson, the word "section" and the word "shop" are used interchangeably. Let's go over the common duty sections you can be assigned to and other positions to be familiar with.

Missile maintenance section

You will start your career in the missile maintenance section and work under the supervision of a team chief until you complete your 5-level upgrade training. As a missile maintainer, you are responsible for completing on/off equipment maintenance on missile systems, missile-pylon and CSRL interface electronics, and associated support equipment. Missile maintenance works under a schedule based on periodic preventative maintenance, meaning tasks are based on determined time frequencies. Typical daily tasks include missile transfer, removal and replacement of components, fueling operations, environmental control system (ECS) leak checks, ignitor circuit testing, missile diagnostic testing, and final assembly. Occasionally you will also work unscheduled issues that randomly occur and require maintenance. Once you obtain your 5-level, you'll become eligible to move to other duty sections.

Verification and checkout equipment section

The VACE section performs periodic and unscheduled on/off equipment maintenance, repair, modification, and calibration of assigned missile electronic/electrical test equipment. It is also responsible for the following:

- Inspections.
- Isolating faults.
- Replacing components and wiring.
- Disassembly, modification, reassembly, test, and calibration of automated and semi-automated test equipment, interconnect and test adapter group components, equipment cooling components, and air-monitoring and control equipment.

This shop also performs maintenance on locally assigned automated or semi-automated test equipment for conventional and nuclear munitions at the discretion of the munitions flight chief. Assignment to the VACE section is normally reserved for personnel who have extensive experience in missile maintenance and are ready to apply their sharpened skills in another area of the career field. People selected for this position *must* attend an in-residence 5-level course at Vandenberg AFB to specifically train in basic electronics repair and the troubleshooting and operation of the electronic systems test set (ESTS) and Missile Radar Altimeter Test Assembly (MRATA).

Missile analysis section

The missile analysis section reviews, analyzes, files, and disseminates information that is used to improve the ALCM capability. The analysis section keeps the munitions flight chief informed of technical deficiencies and trends in ALCM's system performance. Missile analysis is also responsible for the following:

- Compiling data from all sources as directed by the munitions flight chief.
- Reviewing source data on a timely basis to identify potential problems or hardware deficiencies.
- Analyzing the performance of systems selected by the munitions flight chief to identify potential adverse trends.

- Disseminating analysis products on a schedule consistent with munitions flight chief and higher headquarters requirements.
- Maintaining historical documentation on weapon systems, missiles, line replaceable units (LRU), shop replaceable units (SRU), and test equipment.

Support section

Another potential section to enter upon completion of upgrade training is the support section. This section maintains control and accountability of tools and equipment. Support performs various supply functions including ordering and receiving equipment, maintenance of equipment custody accounts, inventory, and bench stock monitoring. The section also maintains the consolidated technical order library, and performs precision measurement equipment monitoring, pickup, and delivery. Depending on your base, this section may also be in charge of your unit's vehicles.

Handling section

This section performs periodic and unscheduled maintenance on pylon and CSRL loading adapters. This section may also be referred to as adapter maintenance. They repair, receive, and ship assigned loading adapters and provide the capability to store and handle missiles/weapons. Handling personnel are trained on special purpose vehicles specializing in certified tow and trailer mate/demate operations.

Munitions control section

Munitions control is the central hub in your unit for planning, coordinating, directing, and controlling munitions and weapons activities. Quite often during maintenance routines you'll utilize munitions control to coordinate with external organizations such as the flightline maintenance activities, security forces, fire department, and the command post to ensure effective flow of information and scheduling, and efficient use of available resources to accomplish the mission. This section continuously monitors ongoing scheduled and unscheduled munitions and weapons maintenance activities. Munitions control provides supervisors and upper management accurate and timely information on the status of all explosive operations, emergencies, and contingency actions. They collect information, make notifications, direct and oversee actions to be taken in response to all emergencies, contingency actions, work stoppages, manning, and equipment shortfalls while constantly pushing specific and reliable, up-to-date information to unit leadership. Munitions control technicians *must* have a working knowledge of all munitions' functional areas, adapt well to stress, and speak in a clear and concise manner.

Training section

The mission of the training section is to provide trained, mission ready Airmen to meet unit requirements. To that end, this section manages and provides initial, recurring, and other training as directed. Additionally the training section provides centralized ancillary training, such as nuclear surety training, to maintenance technicians and supervisors.

Other positions

Some duties are outside of the munitions squadron and include technical training instructors and quality assurance evaluators, which we will cover next. There are also various positions authorized based on your skill level and job availability, within various MAJCOMs.

Quality assurance evaluator

Quality assurance (QA) is an even more selective organization to work in. Personnel in QA evaluate and inspect unit technicians, technical orders, equipment, and other areas as necessary to make sure everyone is doing their job correctly. As a QA evaluator (QAE), you act as the eyes and ears of the maintenance group commander; therefore, QAEs are selected from the best technicians, supervisors, and unit training instructors.

Having sharp, highly skilled technicians in QA is necessary since these personnel must evaluate if personnel are performing the job correctly or not. Experience in missile maintenance and training is *desirable* for selection to be in QA.

Technical training instructor

A select few technicians will have the opportunity to serve and excel as technical training instructors. These instructors teach knowledge and skills within the air-launched missile maintenance course to airmen fresh out of basic military training (BMT). Instructors are a select group of individuals, as they are chosen from the best technicians and are personally appointed through a rigorous evaluation and selection process. Ultimately, training instructors have the prestigious opportunity to share their knowledge with new trainees and mold them into future missile maintainers.

Skill level authorized positions

As you progress in your career, it would benefit you to broaden your experience. An increase in skill level opens up more duty location opportunities but does *not* guarantee duty selection. A listing of skill level authorized locations for 2M0X1's is available on the Assignment Management System (AMS) website. It can be accessed via a link in the AF portal website https://www.my.af.mil. AMS is also, where announcements for available jobs are posted. The postings provide a description of duties and criteria for applicants.

Self-Test Questions

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

001. Organizational structure

1. Which AFGSC assets are poised to conduct strike operations anywhere on the globe?

2. Which two NAF fall under AFGSC?

3. Which bomb wings have three squadrons of B-52H Stratofortress bombers and are located in Barksdale AFB?

4. Which bomb wing has a fleet of B-52H Stratofortress bombers and provides support to the 91st Missile Wing?

5. Which bomb wing has a fleet of B-2 Spirit bombers?

6. Which type of squadron is subordinate to the maintenance group?

002. Munitions squadron organization

1. Who is the overall leader in charge of the munitions squadron?

2. Who provides overall management and supervision of daily activities of munitions maintenance production and support?

3. Which flight contains the missile maintenance and analysis section?

4. Which flight contains the munitions control and mobility sections?

5. Which flight is responsible for maintenance on re-entry systems and vehicles?

003. Duties of a 2M0X1

1. What duty section is responsible for completing on/off equipment maintenance on assigned missile systems, missile-pylon and CSRL interface electronics, and associated support equipment?

2. What duty section performs periodic and unscheduled on/off equipment maintenance, repair, modification, and calibration of assigned missile electronic/electrical test equipment?

3. What duty section is responsible for maintaining historical documentation on weapon systems, missiles, line replaceable units (LRU), shop replaceable units (SRU), and test equipment?

4. What duty section performs supply functions and maintains the technical order library?

5. What duty section performs loading adapter maintenance as well as certified tow and mate/demate operations?

6. What duty section provides supervisors and upper management accurate and timely information on the status of all explosive operations, emergencies, and contingency actions?

7. What duty section manages and provides initial, recurring, and other training?

8. What position serves as the eyes and ears of the maintenance group commander?

9. What position teaches air-launched missile maintenance skills to Airmen fresh out of BMT?

1–2. Technical Orders and Maintenance Data Collection

Technical orders and maintenance data collection documents play a big role in cruise missile maintenance and are a part of your typical workday. Technical orders contain many requirements you may unknowingly comply with because you may *not* have personally read the requirement but were trained or instructed to do so, such as filling out an Air Force Technical Order (AFTO) Form 350, Reparable Item Processing Tag, for removed components. 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 directs, or you may find errors in the - technical order, these are reasons to recommend technical order improvements.

Maintenance data collection includes all of the documentation we generate or record to provide a historical snapshot of maintenance performed on a weapon system – this may include the use of tags and stickers used on equipment and parts. As a missile maintainer, you must be familiar with their uses in support of maintenance.

We will briefly discuss the technical order system, though a more in-depth description of technical order is addressed in the 2M0X1A CDC. We will also go over maintenance data collection.

004. Technical order system

Technical orders are the *primary* method the AF uses to document and direct how a task is to be accomplished. You will use technical orders throughout your career to accomplish many tasks from missile maintenance to equipment and vehicle inspections. Technical orders were specifically written for you to do your job in a safe and correct manner for maximum production. In this lesson, we'll briefly learn what the technical order system is as well as some reports used with this system to make improvements to the technical data.

Description

The AF technical order system you'll use throughout your career provides clear and concise instructions for the safe and effective operation and maintenance of AF military systems. They also provide a wealth of other information that will assist and guide you through your daily maintenance activities. Such information can include system theory, task procedures, illustrations, and periodic maintenance requirements. Two of the common types of technical orders you will work with are:

1. Methods and procedures—are general in context and are *not* issued against a specific military= system aircraft, weapon, or vehicle. A good example is the technical order (TO) 00-25-234, *General Shop Practice Requirements for the Repair, Maintenance and Test of Electrical Equipment*. 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.
2. Operations and maintenance (O&M)–cover the installation, operation, troubleshooting,= repairing, removing, calibrating, servicing, or handing of AF military systems or end items.

Operations and maintenance technical order use

O&M technical orders are the kind that provides your maintenance procedures like the TO 21M-AGM86-2-1, *Organizational Maintenance Instructions –Missile AGM-86B*. You *must* ALWAYS use your technical order to perform maintenance.

Your technical order *must physically* be in your possession or immediate work area, open to the applicable task being performed and on the current step. Some steps may be completed out of order but all steps required for the procedure must be completed. However, some technical orders have hardness critical procedures, which must be followed exactly in the order, presented. Compliance with technical orders is mandatory as suggested by the term “orders”. They are published under the authority of the Secretary of the Air Force (SECAF) and failure to comply with a technical order could be considered failure to obey a lawful order, under Article 92 of the Uniform Code of Military Justice (UCMJ).

Improvement reports

Occasionally, you may find something in a technical order that is incorrect, unclear, incomplete, improperly sequenced, or you may know of a better way to do a procedure. When you find these problems, you can identify them and submit corrections by using an AFTO Form 22, Technical Manual (TM) Change Recommendation and Reply. These improvements are to correct errors or omissions of a technical nature, which prevent adequate performance of functions required for mission accomplishment. You can also submit an AFTO Form 22 to correct minor inaccuracies of a non-technical nature that affect the meaning of instructions. Do *not* submit AFTO Forms 22 for typographical or printing errors that do not cause misinterpretation or would normally be corrected during scheduled reviews.

Prior to submittal, your supervisor will review your form to ensure it is a valid recommendation. Next, the AFTO Form 22 will be sent to the designated review authority within the unit. Usually, QA is the review authority. They will assess the recommended change in terms of mission impact, personnel and aerospace system safety, the potential for damage to equipment, work simplification, and the urgency of the need for change. Your local manpower office can help determine manpower savings, if any. Additionally, the reviewer will check the proper category is assigned and downgrade the category or disapprove the recommendation when appropriate. If the report is valid, the reviewing authority will submit 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. The severity of the outcome if the technical order deficiency is not corrected determines the category of the report. The three categories are described in the following paragraphs.

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. This type of report demands immediate action. The technical content manager (TCM) will respond by either issuing an interim time compliance technical order (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 48/72 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 it could jeopardize the safety or success of mission accomplishment or could result in over $5,000 or 250 man-hours of annual savings to the Air Force. All TCTO deficiencies are submitted as urgent. Identification of, or replacements for, Environmental Protection Agency (EPA) hazardous material and ozone depleting chemicals are submitted as urgent.

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 must be made unless the report is disapproved or downgraded, or action cannot be completed within 40 calendar days.

Routine

Routine reports require action on technical order deficiencies, which do not fall into emergency or urgent categories. These can even include minor typographical errors, word omissions or printer errors, but only if they cause a critical misinterpretation or affect the meaning of instructions that impede completing 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 a technical order. Then, identify all locations on one AFTO Form 22. Another exception is when your AFTO Form 22 improves an inspection manual, dash 6 (–6) technical order. Your report may include all locations that need to be changed, such as the work cards. A brief summary of the deficiency and recommended change are required in the narrative section of the form. Complete the AFTO Form 22 digitally and submit it electronically. 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 stamped, approved by all agencies, make sure you get a copy. If your change is a true process improvement, it may be submitted in the Airmen Powered by Innovation Program after the change has been implemented.

005. Maintenance data collection documents

The weapon systems we maintain are crucial to our nation’s defense, it is imperative that we maintain detailed documentation of all maintenance actions performed on each missile and its support equipment. There are various methods used to document the maintenance, inspection, or reporting performed within the missile organization, and each collection method is important to the life cycle of the weapon. Maintenance data collection creates a record of all actions performed and allows us to track each maintenance activity performed on the missile and/or equipment. Certain types of data actually shows the status of the system which allows management to be more effective in the decision making process. Normally, maintenance data collection is accomplished by using the applicable forms, tags, and the Integrated Maintenance Data System (IMDS). IMDS is an information management database system covered in the 2M051A set CDC. In this lesson, we will focus on the tags we use: condition tags and calibration stickers.

Tags

Tags are used in maintenance to show status of equipment and components removed from the missile. Tags are also required when shipping items. The data on all tags are very important; this information allows the component or equipment to be processed correctly. One of the primary tags you’ll use is the AFTO Form 350, it is a two-part form required on items removed for maintenance shop processing. These items include engines, end items, components removed from end items, and subassemblies. A completed AFTO Form 350 serves to identify the origin of an item and contains key data elements needed to document shop actions**.** The AFTO 350 tag will be placed on all components removed from a missile and will *always* be filled out with a pencil. If you ever have questions while filling out the AFTO Form 350 Tag refer to TO 00–20–2, *Maintenance Data Documentation*, for information on how to properly fill it out.

Condition tags

Condition tags are used to display the status of a component or piece of equipment. These tags have colored borders to allow easy identification of items and allow the technician to distinguish between unserviceable, reparable, and serviceable components and equipment. You will always fill out two condition tags for each item: one is attached to the container or packaging and one to the component. The color of the condition tag provides a quick visual reference as to the serviceability of the component or equipment. Data recorded on the tag is crucial to ensuring users can determine the contents are as described on the form; therefore, be sure data such as part number, national stock number, the name of the item, and the quantity are accurate and legible. Only personnel on the special certification roster can sign condition tags under the "inspector's name" block. For your guidance concerning the proper use of condition tags, reference TO 00–20–3, *Maintenance Processing of Reparable Property and the Repair Cycle Asset Control System*. The table below is a quick list of the different condition tags by color and shows how they are easily identifiable:

Condition Tag Types			
Color	**Form/Tag number**	**Condition**	**Condition Code**
Yellow	DD Form 1574	Serviceable	A
Green	DD Form 1577-2	Unserviceable (but reparable)	F
Red	DD Form 1577	Unserviceable (condemned, not reparable)	H
Blue	DD Form 1576	Test/Modification (scheduled time changes)	D
Brown	DD Form 1575	Suspended/Litigation (received, but does not meet standards)	J or L
Red outline	DD Form 2332	Quality Deficiency (used with Brown Tag)	Q

Calibration stickers

The cruise missile is designed to operate under specific hardware conditions and uses calibrated equipment to maintain, test, and troubleshoot the missile. On a daily basis, we use calibrated equipment to perform many of the functions and procedures it takes to make sure our missiles will be successful. Over time, calibration equipment used during maintenance may become corrupt or its accuracy suspect, so items are regularly scheduled to receive calibration verification by the precision measurement equipment laboratory (PMEL) shop or other organization. Stickers are placed on this equipment to identify the calibration date, any limitations placed on the item, and a due date for its next calibration. Some calibrated equipment examples include torque wrenches, gauges, and multimeters. The calibration stickers are physically placed on calibrated equipment or their cases, if needed. It is critical that you, as the technician, verify all of your calibrated equipment is serviceable, current on calibration, and most importantly, is calibrated to the specifications outlined in the technical order. The reference for calibrated equipment documentation is TO 00–20–14, *Air Force Metrology and Calibration Program*. There are many types of calibration stickers and calibration documentation. The calibration stickers you will typically encounter are listed below.

- AFTO Form 256 – No Calibration Required
- AFTO Form 108 – Certification Label (shows when equipment was calibrated and its due date)
- AFTO Form 99 – Limited Test Measurement and Diagnostic Equipment (TMDE) Certification Label (shows calibration and limitations)

Self-Test Questions

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

004. Technical order system

1. What must you do when using operations and maintenance technical data while performing maintenance?

2. What form is used to correct unclear, incomplete, or improperly sequenced technical order discrepancies?

3. What are the three categories for submitting an AFTO Form 22?

4. What are *all* TCTO deficiencies submitted as on an AFTO Form 22?

005. Maintenance data collection documents

1. What tag is placed on components removed from a missile that identifies the origin of the item and contains data elements for shop actions?

2. What type of tags are used to display the status of a component or piece of equipment and is colored to allow easy identification?

3. Which condition tag color is used to identify a piece of equipment that is serviceable?

4. Which condition tag color is used to identify a piece of equipment that is unserviceable and *cannot* be repaired?

5. Which condition tag color is used to identify a piece of equipment that has been received but does not meet standards?

6. What must you verify on calibrated equipment?

1–3. General Maintenance Fundamentals

In this section, we will discuss some general maintenance fundamentals that will help you understand your new work environment and culture. In order to do your job, you need to be fully aware of nuclear weapon safety concepts, weapon storage area (WSA) facilities and support systems, and maintenance security measures.

006. Nuclear weapons safety

Safety is paramount! There are two things in the AF that are not replaceable are you and nuclear weapons.

WARNING: *Each* individual *must* be aware **AT ALL TIMES** of the dangers around them and the personnel who are working with them.

Nuclear weapons safety includes following nuclear surety concepts. Nuclear surety encompasses safety, security, and control measures on nuclear weapons and weapons systems. The key concepts regarding nuclear surety that you need to be aware of are the protection of nuclear weapons, adherence to weapons system safety rules (WSSR), and verification of nuclear certified equipment (NCE).

Protecting nuclear weapons

Nuclear weapons *require* special consideration because of their political and military importance, their destructive power, and the potential consequences of an accident or unauthorized act. Protecting nuclear weapons as a critical national resource and ensuring the safety of people and property are of paramount importance in nuclear surety policies and procedures. Nuclear weapons cannot be expended until a nuclear control order giving proper release is received and authenticated. The Department of Defense (DOD) Directive 3150.02, *DoD Nuclear Weapons Surety Program*, directs positive control measures to ensure the following:

- Ensure adequate security of nuclear weapons, pursuant to the provisions of DOD Manual 5210.41, *Nuclear Weapon Security Manual.*
- Prevent nuclear weapons involved in accidents or incidents, or jettisoned weapons, from producing a nuclear yield.
- Prevent INADVERTENT pre-arming, arming, launching, or releasing of nuclear weapons in all normal and credible abnormal environments.
- Prevent DELIBERATE pre-arming, arming, launching, or releasing of nuclear weapons, except upon execution of emergency war orders or when directed by competent authority.

Some of the ways we ensure security, such as maintaining Two-Person Concept and the use of No Lone Zones, are written into our WSSR.

Weapons system safety rules

WSSR are comprised of general and specific rules applied to nuclear weapons systems for conducting approved operations while ensuring *maximum* safety consistent with operational requirements. A key component of WSSR is that, while preventing unauthorized use of nuclear weapons, they allow for timely employment when ordered. Safety rules are updated or certified current at a *minimum* of every 5 years following an operational safety review by the Nuclear Weapons Systems Safety Group (NWSSG). A set of safety rules for each AF weapon system is provided in AFI 91-111 through 91-117. Different weapons systems (bomber versus ICBM) or specific operations (storage versus logistics movements) will have different rules based on their capabilities. It is mandatory to follow these rules at all times when a nuclear weapon system is involved. A commander can deviate from a specific safety rule *only* during an emergency.

DOD Directive 3150.02 defines an emergency as an unexpected occurrence or set of circumstances in which personnel or equipment unavailability, due to accident, natural event, or combat, may demand immediate action that may require extraordinary measures to protect, handle, service, transport, jettison, or employ nuclear weapons.

General safety rules

General safety rules *primarily* apply safety policy and pertain to all nuclear weapons and their systems. Safety rules always apply, even during war. The general weapon systems safety rules are as follows:

- Nuclear weapons shall *not* be used for training or for troubleshooting.
- Nuclear weapons shall *not* be intentionally exposed to abnormal environments except in an emergency.
- Nuclear weapons may be used for exercises except when explicitly prohibited by specific safety rules.
- Personnel with physical access to nuclear weapons must be qualified under the personnel reliability program (PRP).
- The total number of personnel performing nuclear weapon system operations shall be held to the minimum consistent with the operations performed.
- Only certified procedures, personnel, equipment, facilities, and organizations shall be employed to conduct nuclear weapons system operations.
- Permissive action link (PAL) operations shall be conducted in accordance with plans and procedures prescribed by the applicable combatant command and technical publication.
- Nuclear weapons will be transported as determined by the combatant commander or military department. Movements will be kept to a minimum consistent with operational requirements and custody transfers shall be by the courier receipt system to ensure positive control.
- At *least* two authorized persons *must* be present during any operation with a nuclear weapon. These individuals must be able to detect incorrect or unauthorized procedures and must have a knowledge and understanding of the applicable safety and security requirements.

Specific safety rules

Specific safety rules are procedural or administrative safeguards unique to each individual nuclear weapon system that are identified during safety studies and operational safety reviews. An example of a specific safety rule for cruise missiles is that nuclear weapons and conventional munitions will *not* be stored in the same facility.

We have only covered some of the weapon system safety rules that you will need to become familiar with. Detailed safety rules are covered in the AFI 91–1XX series publications. It will greatly benefit you to become familiar with these rules, as they are fundamental to many operations you perform. You must take an active role to comply with these vital safety rules, as a violation can be detrimental. Nuclear weapons are a powerful, dangerous asset that we as missile maintainers are privileged with handling.

Nuclear certified equipment

NCE includes system specific and common specialized or non-specialized support equipment, which has been scrutinized in the design process to ensure it meets nuclear surety standards discussed previously. Items that fall under the nuclear certification process include equipment, aircraft, facilities, vehicles, and hardware/software to name a few. An items nuclear certification status is identified in the master nuclear certification list (MNCL) which is accessible via the internet at https://wwwmil.nwc.kirtland.af.mil/MNCL/index.cfm. The MNCL is the sole authority for determining the certification status of nuclear certified items.

Besides some general certification guidelines and an organized listing of items, the MNCL also identifies any restrictions on those items such as a vehicle's towing capacity, maximum hoist weights, and known equipment limitations. You must perform positive identification on NCE/items to ensure you can use it for your operation.

Positive identification

Positive identification is a verification action in which the physical equipment identification elements are matched *against* the MNCL data, which is performed prior to equipment use. Verification is conducted to *determine* that the equipment to be used is the exact piece that is certified for nuclear operations. The certification status "Nuclear" on the MNCL indicates the equipment system type has completed all nuclear certification requirements. However, it does not indicate individual equipment serviceability, which is determined with the applicable technical data and forms documentation. If a discrepancy exists in positive identification, the equipment is to be considered *NOT* certified until the discrepancy is resolved; this means the item *cannot* be used for nuclear operations.

Positive identification is made by utilizing all possible identification elements on the piece of equipment. Identification elements include but are not limited to equipment nameplates, labels, appropriate markings, or official documents. Hardware identification elements are the part number, National Item Identification Number (NIIN), and model number. Software identification elements are the Computer Program Identification Number (CPIN) and part number. Nomenclature may also help with identification.

All data on the MNCL *must* match that of the identification marking in order to verify the certification of the item to be used properly. However, absence of a single data element does not void the certification of the item if all other items on the identification marking are correct, the equipment is still certified for use.

Restrictions

Restrictions are clearly identified on the MNCL (see fig. 1–2). Nuclear certified equipment/items may be restricted from use with nuclear weapons at any time and for any reason, such as damage, modification, and changes to the intended use. Restrictions do not remove nuclear certification but are intended to limit or stop use of equipment with nuclear weapons. A restriction can be placed on a system or fleet such as a limit to the maximum towing capacity for tow vehicles. A restriction can be placed on individual equipment by using individual identification such as a serial number.

WEAPON SYSTEM	NOMENCLATURE	HARDWARE TYPE	MODEL NUMBER	NIIN	PART NUMBER	CERT STATUS	LAST UPDATED
NON-SPECIALIZED	TRAILER, MUNITIONS HANDLING	MUNITIONS HANDLING EQUIPMENT	MHU-141/M	01-031-5868	748500	NUCLEAR	26 Feb 2018
	REMARKS: LIGHTWEIGHT DRAWBARS NIIN 01-326-9755, P/N 1-987630-3, AND NIIN 01-461-4296, PART NUMBER 3528 ARE AUTHORIZED.						
	RESTRICTIONS: MAXIMUM LOAD 5,700 LBS. TANDEM TOW LIMITED TO 2 TRAILERS; TRAILER WITH THE GREATER WEIGHT IN FRONT, LOADED SYMETRICALLY. MAX TANDEM TOW SPEED 15 MPH. ALCM/ACM RESTRICTIONS: TANDEM TOWING PROHIBITED, MAX SPEED 10 MPH ON STRAIGHT ROADS, 5 MPH IN TURNS. SERIAL NUMBER 7G0832 IS NOT AUTHORIZED.						

Figure 1–2. MNCL example.

007. Weapons storage area facilities and support systems

The weapons storage area (WSA) is an area on base with additional security measures, usually with fences around it and security police everywhere. It is a restricted area where nuclear assets and missiles are stored and maintained. As a cruise missile maintainer, you need to be familiar with the facilities and systems in this area because this is your physical work environment. Each facility is designed for different missile maintenance functions and facility systems have different support roles.

Facilities

For our purposes, we define the WSA as everything within the fenced area. Within the WSA there are many different facilities, but we'll concentrate' on the facilities you are most likely to encounter on a daily basis: the IMF, unarmed weapons storage facility (UWSF), and weapons storage structures.

Integrated maintenance facility

Upon your assignment to a munitions squadron, you will work in the IMF (fig. 1–3). It's where 90 percent of cruise missile maintenance is performed. It is specifically designated and positioned aside from other areas for explosive operations such as testing, maintenance, storage, shipping and receiving. Since explosive operations occur in this facility, it has construction features to limit the spread of potential explosive effects and is classified as an explosive operating building. This building is required to have all-weather access roads and must be located in a WSA. All IMFs are designed along a similar facility layout concept, which consists of office areas and maintenance bays or rooms.

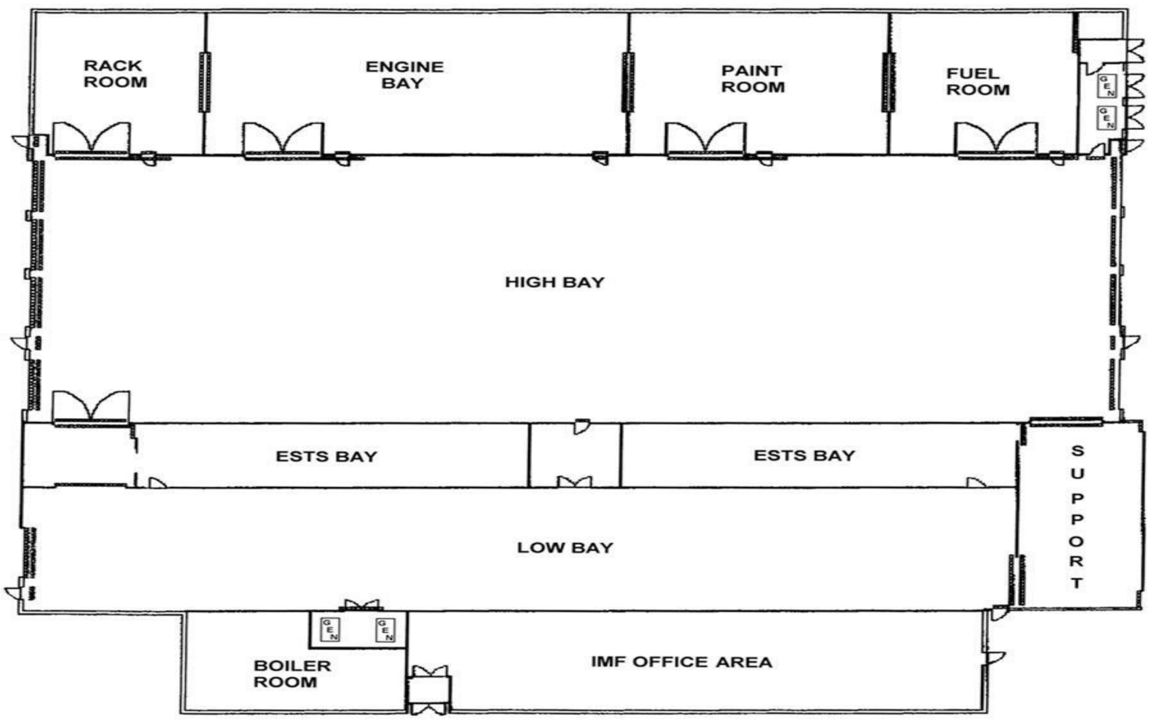


Figure 1–3. Example IMF (Barksdale AFB).

Office area

The office area is the first stop when entering the IMF. These offices support administrative functions for different duty sections. You will mainly use these areas for shift safety briefings, task assignment, maintenance documentation, ancillary training, and maintenance breaks.

Low bay

The IMF also contains a low bay. The low bay is a large area used for cruise missile maintenance. Maintenance stands are located along one side of the low bay, with the other side being used to facilitate the movement of missiles. Maintenance tasks that typically occur in the low bay are missile disassembly, component removal & replacement, and final assembly.

High bay

The high bay is the largest area within the IMF. All nuclear operations are performed in this area. Typical operations that occur in the high bay include warhead buildup, installing/removing payloads into/out of missiles, and mating/de-mating missiles to/from pylons or CSRL. Additionally, load frames are attached to the ceiling of the high bay for maintenance and electrical checkout of the pylons and CSRL in the loaded and unloaded configuration. The pylons and CSRL are suspended from the load frames in the same manner that the aircraft will support them. Most importantly, warheads *must* be removed from missiles in the high bay *prior* to being moved to other IMF areas to maintain proper security and safety measures.

Fuel room

The fuel room is an area specially designed for fueling and defueling cruise missiles with jet propellant (JP)–10. Normally, there is a fuel/defuel set and two fuel stands located in this room. The fuel room is also used for priming the missile engine with PF-1.

Electronic system test set room

The ESTS room contains test equipment connected by test adapter group (TAG) cables to (1) the missile test stand for single-missile testing, and (2) the high bay for performing electrical checkout of empty and loaded pylons and CSRL. Electrical checkout and repair of some pylon or CSRL components are performed in the ESTS room. The ESTS room is environmentally controlled and monitored to maintain the area within the ESTS' operating parameters for temperature and humidity. It is also a dust-free environment to prevent damage to sensitive equipment.

Engine bay (Barksdale AFB only)

This room contains support stands used during cruise missile engine time change or other required maintenance. Missile engine storage, receipt, and shipment are also performed in this room.

Paint room

The paint room facilitates major repainting of cruise missiles when needed which also includes preparatory tasks like sanding and priming. When not used for painting, it is typically used for missiles in final assembly.

Support room

The support room is where tools, support equipment, and chemicals are stored when *not* signed out for maintenance operations.

Unarmed weapons storage facility

The UWSF is normally located near the IMF. It's used primarily as a storage area for missiles without their warheads installed. It is also used as an area for crating and uncrating missile shipments. The UWSF is designed along the *same* guidelines as the IMF's low bay. The UWSF is normally a large bay with two large roll up doors located at each end.

Weapons storage structures (igloos)

These structures are designed for the protection, containment, and storage of nuclear weapons or critical components. It is mandatory that all bulk high explosives, solid propellants, and pyrotechnics be stored inside an igloo. Items stored include warheads, gravity weapons, and missiles with warheads installed, pylons, or CSRL loaded with missiles that have nuclear warheads installed, or any critical item that must be maintained under positive control such as limited life components used during warhead maintenance. These structures are also used to store pylons and CSRL adapters with or without missiles that do *not* have, nuclear warheads installed (fig. 1–4).

Figure 1–4. Example weapon storage structure.

Weapon storage area facility systems

Now that you know about the facilities located in the WSA, you will learn about some of the systems associated with these facilities. You will also learn what precautions to take because these buildings could contain nuclear weapons.

Static ground and lightning protection systems

For safety, buildings that are able to contain cruise missiles are designed with safety devices that isolate the missiles from static electricity or lightening damage.

Static electricity

Arcs of static electricity that terminate at a missile can cause damage to it by setting off pyrotechnic devices, frying electronic components, or igniting the fuel and causing the missile to explode. The missile is *grounded* in order to safely discharge static electricity. For this reason, a grounding bar made of copper lines the walls of *every* room where missiles are handled. The grounding bar has wire-bonding points attached that connect to an earth ground. When static sensitive items are connected to the grounding bar, the bar acts as a conductor in which static electricity can travel to an earth ground. In other words, the termination point is moved from the missile to an earth ground.

Lightning

Lightning is another form of static electricity that occurs naturally, but with a stronger discharging force. Lightning can travel through telephone lines or even building electrical wiring. Once it reaches the end of this wire path, it can jump to a nearby object. This object can be either metal or nonmetal (e.g., missile, table, another wire, or even a person). Lightning protection systems are installed on buildings so, in the event lightning strikes the building, the system can conduct the discharge safely to an earth ground. Lightning protection systems typically consist of metallic rods installed on the top of the facility and connected to conductor cables, which route the lightning charge to ground rods buried deep into the earth.

Hydraulic, electrical, and pneumatic systems

During checkout of the missile and its related support systems, a number of functions, normally provided by the missile or carrier aircraft, must be supplied from the facility systems.

Hydraulic

Depending on the configuration, the load frame power drive unit requires either hydraulic pressure or electric power to rotate the CSRL during maintenance and electrical checkout. Hydraulic pressure is provided by the aircraft hydraulic system test stand, commonly known as the hydraulic mule or mule. The hydraulic fluid supplied by the mule is at the same rate and pressure as supplied by the aircraft. Likewise, the electric mule provides electric power.

Electrical

During the electrical checkout of the missile systems, the ESTS provides the power necessary to run the missile components. The facility generators provide the ESTS with this specific power. These generators transform and convert commercial power into the electrical power requirements that the ESTS needs in order to perform a weapon system checkout. Normally, the carrier aircraft provides the missile with this power until launch. Before the missile is launched, the missile battery is activated to provide the missile with power until the generator comes on line for power production during guided flight.

Pneumatic

The pneumatic systems consist of air compressors, interconnecting airlines, and pressure regulators. The air compressors provide compressed air that can be used at any of the regulators located within the IMF. The cooling control unit (CCU) is the primary user of the compressed air. However, this air is also used to power pneumatic tools used during maintenance operations.

Bulk fuel storage system

Normally, a large supply of fuel used by cruise missiles is stored in fuel tanks located near the IMF. There are four tanks. Two of these tanks are for fueling and the other two for defueling. These tanks are hermetically sealed under a nitrogen blanket to *isolate* them from the environment and prevent water from mixing with the fuel.

The tanks are connected to the IMF by underground plumbing. This plumbing is used for fuel and nitrogen transfer. Eight pipes make up the plumbing individually connecting each tank to the IMF. The tanks are located a *minimum* distance of 50 feet from the IMF for safety.

008. Maintenance security measures

In this lesson, we will briefly discuss several maintenance security measures affiliated with cruise missile maintenance. Security will always be a hot topic when performing our job. As a technician working in the WSA, you’ll have a lot more responsibility than you were probably accustomed to as a civilian. Not only must you pay close attention to securing certain items under your control, but you are also required to watch your teammates to ensure they maintain the exact same top-notch security standards. Security measures consist of security systems, weapons physical security, no-lone zones, two-person concept, and individual responsibilities.

Security systems

Due to the massive destructive power of nuclear weapons, the AF has taken decisive steps to ensure positive control is maintained on these weapon systems. Security systems installed in the IMF and structures include sensors and alarms. The sensors and alarms are hard wired directly to two different areas that are monitored by security forces. If the sensors or alarms are activated, additional security forces will be dispatched to the area.

Sensors

Sensors detect the presence of an unauthorized intruder. The three types of sensors installed are motion, volume, and heat detectors. Security forces personnel activate the sensors when the area is cleared of all personnel and is ready to be secured. If any of these sensors sense the following conditions, they immediately transmit a signal that security forces personnel will respond to rapidly:

- **Motion** — sense motion (movement)
- **Volume** — sense acoustic changes (sound)
- **Heat** — sense LOCALIZED temperature changes (body heat)

Alarms

Alarms are installed on the inside of doors that lead into an area where nuclear weapons are stored. The alarms will activate whenever the door is opened or if the alarm box is tampered with.

Weapon physical security

As part of the physical security, two high fencerows surround the WSA with enough space between the fences so that security forces can drive their vehicles between them as part of their regular surveillance patrol. Cameras are also installed along the perimeter to provide surveillance monitoring of the WSA.

The weapon storage structures have serial numbered *seals* installed on the outside of access doors as a visual indication of tampering. If the seal is broken, it indicates that someone has opened the access door. Two locks are installed on each access door, each with a separate key, and two authorized individuals control each key separately. No single individual should ever possess keys to both locks. Alarms and sensors are installed inside all structures as previously mentioned.

No-lone zones and two-person concept

A no-lone zone is an area where the two-person concept must be enforced because it contains a nuclear weapon, nuclear weapon system, or certified critical component. The two-person policy means that two qualified and authorized personnel must work together in the performance of their duties. The two-person policy comes into effect whenever you enter a no-lone zone. It is for tamper prevention to ensure a lone individual *cannot* perform an incorrect act or unauthorized procedure on nuclear weapons. Before a single person can enter a no-lone zone, there *must* be a two-person team already occupying the zone and they *must* be aware of the person entering the zone. If the no-lone zone is unoccupied, the person will *not* be allowed to enter unless accompanied by another authorized person. If a violation of this rule is detected, security forces must be notified of the violation as soon as possible. The two-person concept *requires* that each person be certified under PRP, knowledgeable in the task to be performed, familiar with applicable safety and security requirements and each capable of promptly detecting an incorrect act or improper procedure with respect to the task to be performed. Both members must have completed required nuclear surety and PRP training. Without this certification, you *cannot* be in a no-lone zone unless escorted by a certified two-person team.

Individual responsibilities

You play a critical role in ensuring nuclear surety and safeguarding the critical nuclear weapons systems by following the responsibilities listed below:

- Promote nuclear surety culture and inform supervisors if you are *not* qualified to perform a particular task.
- Report nuclear safety hazards, deficiencies, or security problems to supervisors and unit safety representatives.
- Comply with the two-person concept.
- Immediately identify unreliable personnel to supervisors.
- Report information that could affect your own ability or reliability to perform a task due to medical or other problems.

Self-Test Questions

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

006. Nuclear weapons safety

1. What is of paramount importance in nuclear surety policies and procedures?

2. What term is described as being comprised of general and specific rules applied to nuclear weapons systems for conducting approved operations while ensuring maximum safety consistent with operational requirements?

3. What is a key component of weapons systems safety rules?

4. Which type of weapons system safety rules primarily apply safety policy and pertain to *all* nuclear weapons and their systems?

5. What should never be used for training or troubleshooting?

6. Which type of weapon system safety rules are procedural or administrative safeguards *unique to each* individual nuclear weapon system that are identified during safety studies and operational safety reviews?

7. What identifies nuclear certification status of equipment/items and is accessible via the internet?

8. What term is described as a verification action in which the physical equipment identification elements are matched against the MNCL data and is performed prior to equipment use?

9. What term is described as intended to limit or stop use of equipment with nuclear weapons?

007. Weapons storage area facilities and support systems

1. What is the purpose of the construction features of the IMF as an explosive operating building?

2. What does the design facility layout concept of *all* IMF consist of?

3. Which part of the IMF supports administrative functions for different duty sections such as maintenance documentation?

4. What kind of maintenance tasks typically occur in the low bay?

5. Which part of the IMF is used to remove warheads from missiles prior to movement to another IMF area?

6. Which part in the IMF is specially designed for fueling and defueling missiles with JP-10?

7. Why is the ESTS room a dust-free environment?

8. Along what same guidelines is the UWSF designed?

9. What lines the walls of every room where missiles are handled and acts as a conductor for static electricity to travel to earth ground?

10. Which WSA facility system is installed on buildings in the event of lightning strike?

11. What facility system uses generators to supply the ESTS with power to test the missile?

008. Maintenance security measures

1. What are the three types of sensors used in the WSA used to detect?

2. Where are seals installed to serve as a visual indication of tampering on weapons storage structures?

3. What *must* happen before a single person can enter a no-lone zone?

Answers to Self-Test Questions

001.

1. ICBM and long range bombers.
2. Eighth and Twentieth AF.
3. 2nd Bomb Wing.
4. 5th Bomb Wing.
5. 509th Bomb Wing.
6. Munitions squadron.

002.

1. The Squadron Commander.
2. MXW supervision.
3. ALCM flight.
4. Systems flight.
5. Special weapons maintenance flight.

003.

1. Missile maintenance.
2. VACE.
3. Analysis.
4. Support.
5. Handling.
6. Munitions control.
7. Training section.
8. QAE.
9. Technical training instructors.

004.

1. Have it physically in your possession or immediate area, open to the task, and on the current step.
2. The Air Force Technical Order (AFTO) Form 22, Technical Manual (TM) Change Recommendation and Reply.
3. Emergency, urgent and routine.
4. Urgent.

005.

1. An AFTO Form 350.
2. Condition tags.
3. Yellow.
4. Red.
5. Brown.
6. Serviceability, current calibration, and calibration to TO specifications.

006.

1. Protecting nuclear weapons as a critical national resource and ensuring the safety of people and property.
2. Weapon system safety rules.
3. While preventing unauthorized use of nuclear weapons, they allow for timely employment when ordered.
4. General WSSR.
5. Nuclear weapons.
6. Specific WSSR.

7. The MNCL.
8. Positive identification.
9. Restrictions.

007.

1. To limit the spread of potential explosive effects.
2. Office areas and maintenance bays or rooms.
3. Office area.
4. Missile disassembly, component removal/replacement and final assembly.
5. The high bay.
6. The fuel room.
7. To prevent damage to sensitive equipment.
8. The low bay.
9. A grounding bar.
10. Lightning protection systems.
11. Electrical system.

008.

1. Motion, volume, and heat detectors.
2. The outside of access doors
3. There must be two other people already occupying the zone and they must be aware of the person entering the zone.

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. (001) In the Air Force Global Strike Command (AFGSC) mission, what is provided to the President of the United States and combatant commanders?
   a. Safety, security, and reliability.
   b. Close air support, global strike, and rapid response.
   c. Combat security, strategic deterrence, rapid response.
   d. Strategic deterrence, global strike, and combat support.

2. (001) Which bomb wing supports a missile wing and provides B–52 firepower on demand?
   a. 2nd.
   b. 5th.
   c. 91st.
   d. 509th.

3. (001) The munitions squadron is subordinate to which type of group?
   a. Missile.
   b. Munitions.
   c. Operations.
   d. Maintenance.

4. (002) Which flight contains the missile maintenance section?
   a. Systems.
   b. Materiel.
   c. Munitions.
   d. Air launched cruise missile.

5. (002) Which flight provides broad command and control, direction, and support for *all* munitions activities?
   a. Control.
   b. Systems.
   c. Mobility.
   d. Special weapons maintenance.

6. (002) Which flight performs maintenance on reentry systems/vehicles?
   a. Special weapons maintenance.
   b. Air launched cruise missile.
   c. Handing.
   d. Munitions.

7. (003) Which of following options is *not* a typical task in the missile maintenance section of the munitions squadron?
   a. Missile testing.
   b. Patchboard repair.
   c. Fueling operations.
   d. Ignitor circuit testing.

8. (003) Which is *not* a quality munitions control personnel *must* possess to perform their duties?
   a. Adapt well to stress.
   b. Think critically and problem solve.
   c. Speak in a clear and concise manner.
   d. Knowledge of *all* munitions functional areas.

9. (004) What is the *primary* method the Air Force (AF) uses to document and direct how a task is going to be accomplished?
   a. Technical orders.
   b. Directives.
   c. Guidelines.
   d. Doctrines.

10. (005) Which tag serves to identify the origin of an item removed from a missile and will *always* be filled out with pencil?
    a. Department of Defense (DD) Form 577.
    b. DD Form 2332.
    c. Air Force Technical Order (AFTO) Form 256.
    d. AFTO Form 350.

11. (006) During positive identification, what are the physical equipment identification elements matched against to determine nuclear certification status?
    a. Weapons system safety rules.
    b. Master nuclear certification list.
    c. Certification reliability program list.
    d. National program identification list.

12. (007) Which location in the integrated maintenance facility (IMF) supports administrative functions?
    a. Low bay.
    b. High bay.
    c. Office area.
    d. Electronics systems test set room.

13. (007) Which location in the integrated maintenance facility (IMF) is used for cruise missile maintenance including component removal and replacement?
    a. Low bay.
    b. High bay.
    c. Storage room.
    d. Support room.

14. (007) Which facility in the weapons storage area (WSA) stores missiles without warheads and is designed along the same guidelines as the integrated maintenance facility (IMF)?
    a. Support building.
    b. Entry control facility.
    c. Weapons storage structure.
    d. Unarmed weapons storage facility.

15. (007) Along the walls of every room missiles are handled, a grounding bar is installed as a safety device to
    a. enforce the facility structure.
    b. supply electricity to the missile.
    c. safely discharge static electricity.
    d. route lightning strikes to an earth ground.

16. (007) Which of the following is *not* a facility system that preforms functions normally provided by the missile or aircraft?
    a. Monorail.
    b. Electrical.
    c. Hydraulic.
    d. Pneumatic.

17. (007) What prevents water from mixing with fuel in the bulk fuel storage system tanks?
    a. Drain pans.
    b. Moisture screens.
    c. A nitrogen blanket.
    d. Spill containment rings.

18. (008) What are the three types of *sensors* used to detect the presence of an unauthorized intruder?
    a. Volume, door, and sounds.
    b. Door, movement, and sounds.
    c. Motion, volume, and body heat.
    d. Weight, air temperature, and body heat.

19. (008) What do weapon storage structures have installed on the outside of access doors that serve as a visual indication of tampering?
    a. Seals.
    b. Locks.
    c. Alarms.
    d. Dead bolts.

20. (008) In order to be a part of a two-person team, you *must first* obtain certification under which program?
    a. Security.
    b. Buddy care.
    c. Personal reliability.
    d. Positive identification.

Please read the unit menu for Unit 2 and continue ➔

Unit 2. Cruise Missile Systems

IN THIS UNIT, you'll learn about the ALCM and CALCM and its systems. Specifically, we will describe the missiles and cover each of the following systems:

- Electrical distribution system
- Safe, arm, and fuzing (SAF) system
- Environmental control systems (ECS)
- Propulsion system
- Flight control system (FCS)
- Navigation system

Keep in mind, we'll only be skimming the top of each of these areas to give you an idea of how each system works; you will encounter a more in-depth look during your initial hands-on job training in the low-bay, and even further once you begin your 7-level CDC material.

The ALCM and CALCM share so many similar characteristics and elements, differences will be noted in the text. This approach is the basis for the following discussions of the ALCM and CALCM SAF system and ECS.

2–1. Missile Description and Electrical Distribution System

The lessons in this section cover vital information that is essential for your understanding of the cruise missile systems. We begin our discussion with a description of the missile. We will then go over the electrical distribution system that is needed to operate internal missile components.

009. Air launched cruise missile and conventional air launched cruise missile description

The ALCM and CALCM are categorized as air-to-ground missiles (AGM). The ALCM is designated as the AGM-86B and carries a nuclear payload while the CALCM is designated as the AGM-86C and carries a conventional payload. Both the ALCM and CALCM were designed for deep penetration into enemy territory and additionally increase the survivability of the B-52H carrier aircraft. Each B-52H aircraft is capable of carrying up to 20 missiles total. Twelve missiles are carried externally on two wing-mounted pylons carrying six missiles each. Eight missiles are carried internally on a CSRL within the aircraft bomb bay (fig. 2–1).

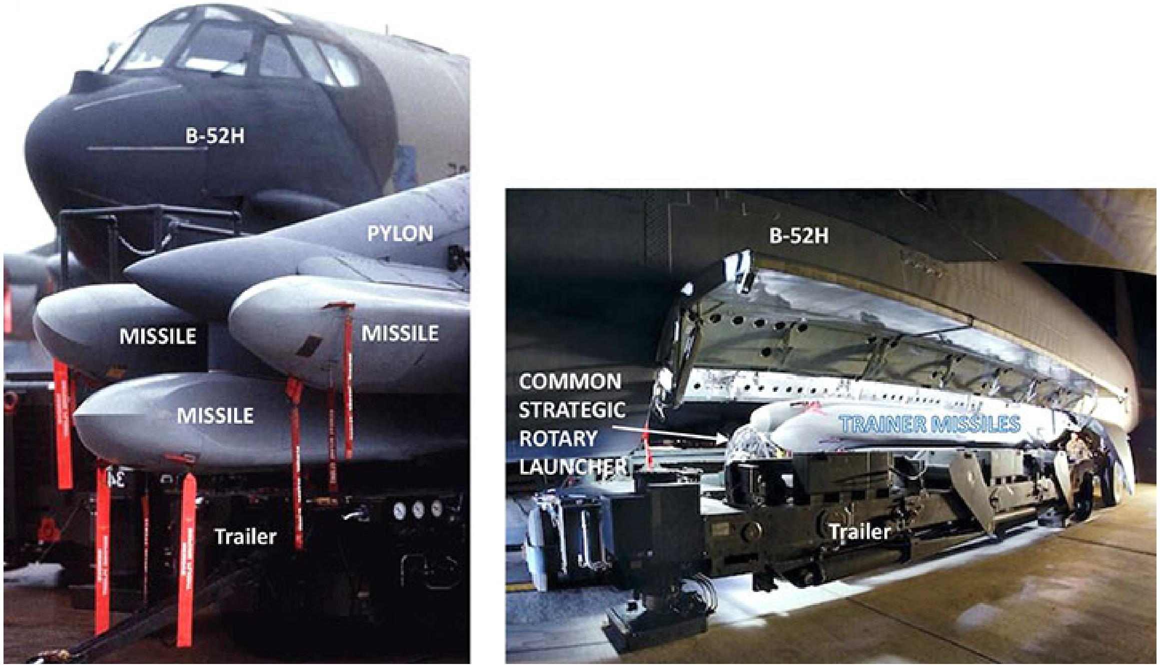


Figure 2–1. Aircraft and missiles.

A high-performance turbofan engine with a 600-pound thrust propels the missile along a preprogramed flight path with excellent accuracy at speeds of approximately Mach 1. On the way to the missile launch point, the aircrew accomplishes payload pre-arming. The missile accomplishes the rest of the arming sequence during its flight to the target destination.

Phases of operation

The AGM has four phases of operation: ground checkout, captive carry, transition flight, and free flight.

1. Ground checkout refers to when the missile is being tested in the IMF by the ESTS.
2. Captive carry refers to the missile loaded to the aircraft via the loading adapters (pylons/launcher) *en route* to the missile launch point.
3. Transition flight occurs at the start of aircraft missile separation until missile free flight is achieved.
4. Free flight is the last phase when the missile is flying to the target destination.

Shape characteristics

The missile's unique trapezoidal shape has several purposes. This shape is designed so the missile can be carried on a pylon with the *least* amount of drag for the carrier aircraft. The shape also enables the missiles to fit properly in the bomb bay of a B-52 on a CSRL. Additionally, the trapezoidal shape supports low cross radar specifications. Radar absorbent material is also used to assist in providing a small radar screen image. This material is installed in all areas of the missile where severe changes in body shape would create radar return problems such as the raceways, engine inlet, and fin. Finally, the nose cap has a sharp contour, leading to reduced radar profile, improved air vehicle performance, and reduced corrosion exposure.

Figure 2–2. Missile in flight.

Flight control surfaces

The flight control surfaces on the missile are the wings, fin, and elevons (fig. 2–2). These surfaces are in the stowed positon for captive carry and ground transportation. At preprogramed times after launch, these surfaces are deployed by ballistic actuators. The wings provide lift and horizontal stability. The elevons provide movement in pitch (climb/dive) and roll. The fin provides lateral stability. *Only* the elevons are moveable *after* deployment during missile flight. Manual deployment and stowing of the flight surfaces can be conducted during maintenance.

Major body sections

The ALCM and CALCM are divided into three general body sections—forward, center, and aft. Each of these major body sections is further broken down into subsections. The missile sections are depicted in figure 2–3. The ALCM SRUs are shown in figure 2–4. The CALCM has additional components that are *not* depicted.

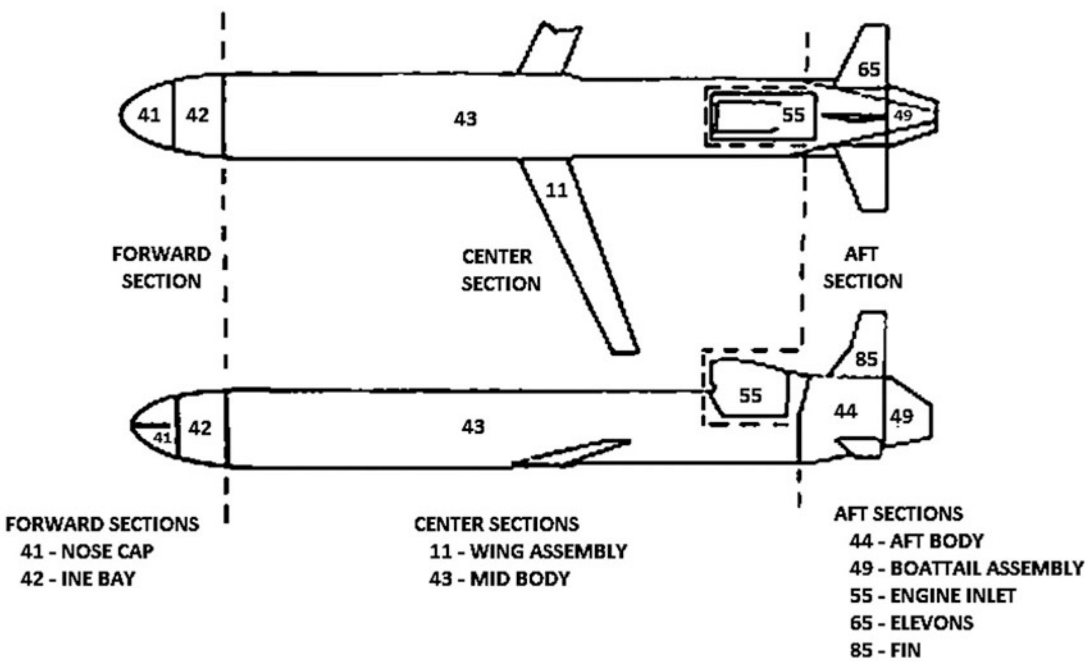


Figure 2–3. Missile body sections.

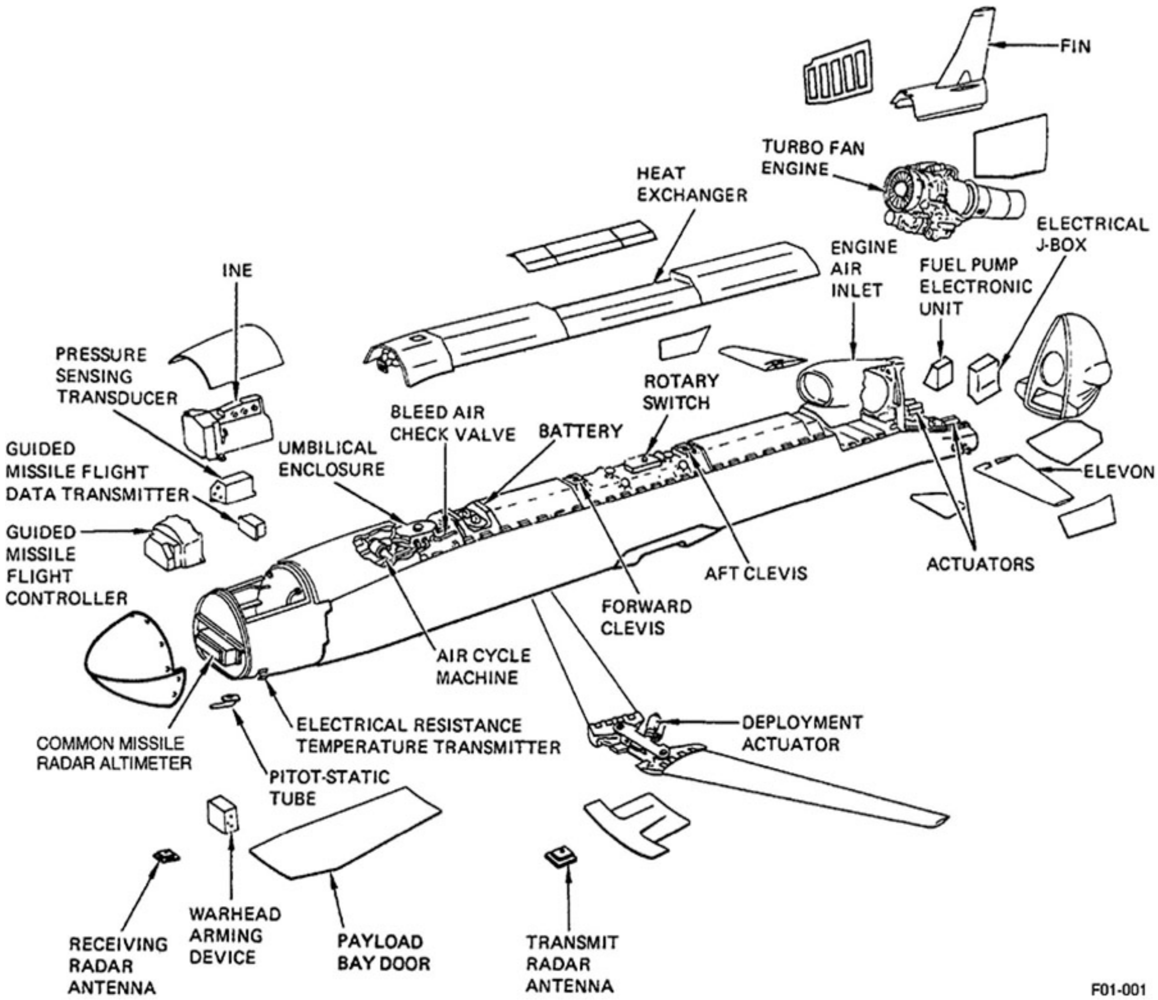


Figure 2–4. ALCM shop replaceable units.

010. Electrical distribution system

The purpose of the electrical power system is to supply power to the missile components during all phases of operation. These phases include ground checkout, captive carry, transition flight, and free flight. This is accomplished using many different components and wire harnesses. During ground checkout, the power is provided by the IMF. During captive carry, the power is supplied by the carrier aircraft. Launch transition power is provided by the missile battery just before release from the aircraft until the engine driven generator takes over establishing free flight. During free flight, the generator continues to power the missile until the target is reached or fuel runs out. The major components of the electrical distribution system are the dual-section thermal battery, generator/regulator, power junction box (J-box), umbilical enclosure assembly (UEA), rotary switch, and associated wire harnesses (fig. 2–5).

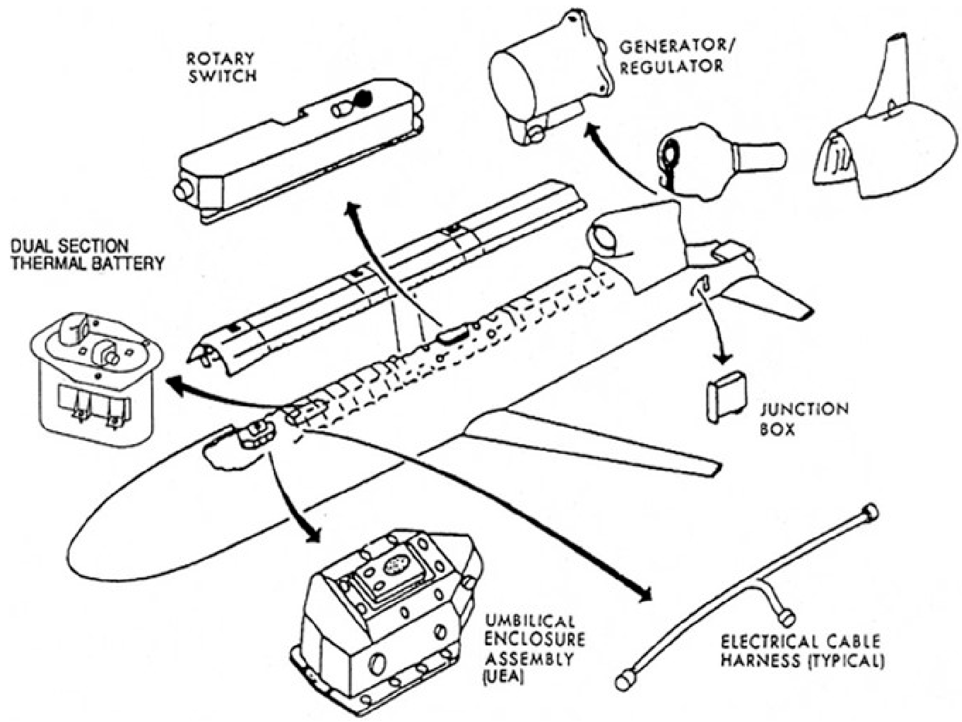


Figure 2–5. Electrical power components.

Dual-section thermal battery

The purpose of the dual-section thermal battery is to provide power during the missile launch sequence from removal of carrier power until the generator achieves its operating speed. The battery is encased in a cavity behind the UEA on the ALCM (fig. 2–6). Access to the battery is gained by removing the rotary switch, umbilical, and forward raceway covers. On the CALCM models –25, –27, and –28, the battery is located in the center section's dry bay. On CALCM models –29 and –30, the battery is mounted to the equipment shelf located in the payload bay (fig. 2–7).

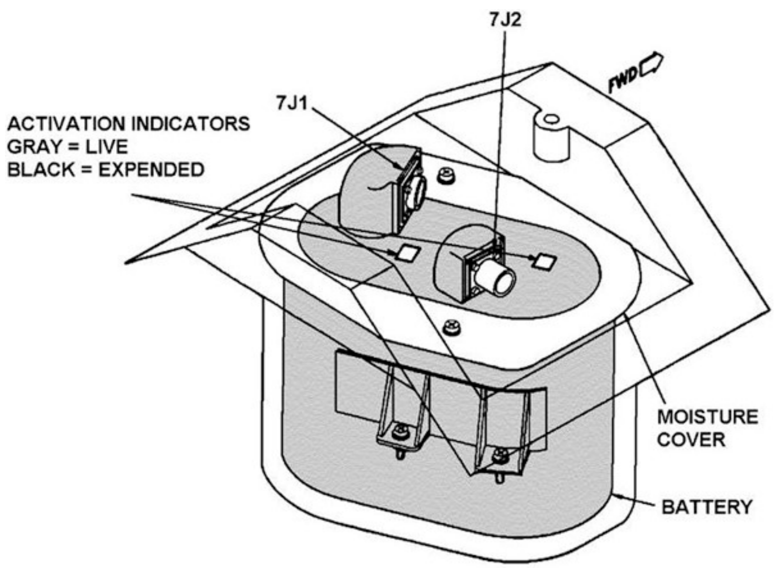


Figure 2–6. AGM-86B thermal battery location.

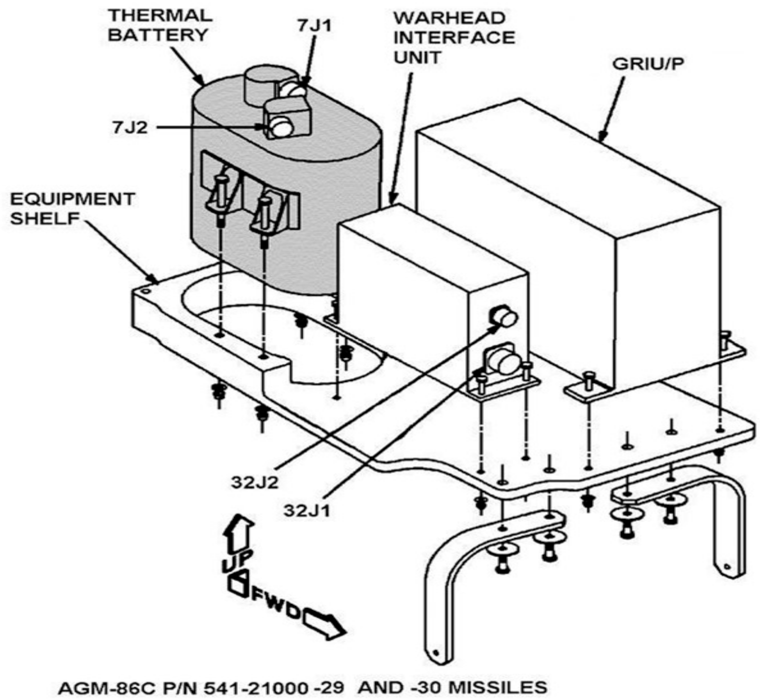


Figure 2–7. AGM-86C P/N 541-21000-29 and -30 thermal battery location.

The battery has two sections. One section of the battery provides constant load (CL) power to the electronics and navigation equipment. The other section supplies pulse load (PL) power to the flight control actuators and the electro-explosive devices (EED). The squib-activated battery can reach a maximum output of 28 volts direct current (VDC) in less than two seconds. The battery case temperature rises above 400 degrees Fahrenheit (° F). The battery case also has a temperature sensitive activation indicator to identify if it has been expended (fig. 2–6). Generator/regulator

The generator, mounted on the lower right hand (RH) side of the engine, is a brushless, ram air-cooled device with an integral voltage regulator (fig. 2–8). The function of the generator/regulator is to provide all of the missile's 28 VDC power requirements during free flight. This power is main load power. If an engine flameout occurs, the engine and generator revolutions per minute (rpm) drop to below operating speed to ensure no electrical power exists at the warhead when the missile crashes.

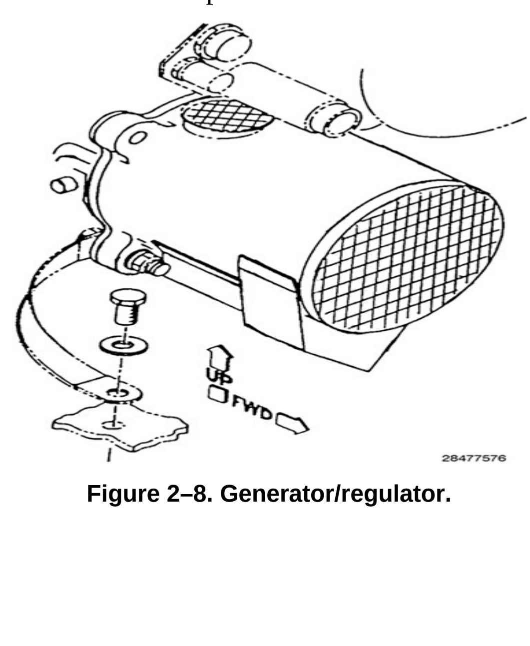


Figure 2–8. Generator/regulator.

Electrical junction box

The electrical J-box is located in the aft engine compartment on the left hand (LH) aft end side of fuel tank 4 (fig. 2–9). Its function is to receive power (carrier power or air vehicle power), distribute it to missile equipment, and isolate power sources from each other after power transfer. For example, after the generator takes over from the battery, the J-box prevents generator provided power from going to the battery and battery residual power from being distributed to the missile. It provides power distribution in conjunction with the UEA.

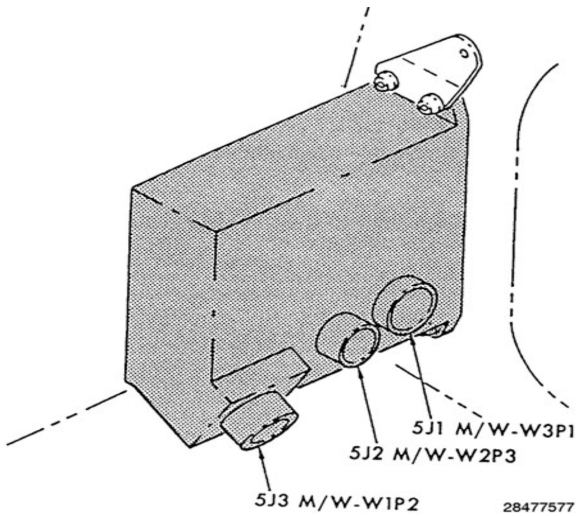


Figure 2–9. Electrical power junction box (J-Box).

Umbilical enclosure assembly

The UEA is located in the forward raceway section at the aft end of the payload bay (fig. 2–10). Its functions are to provide electrical interface to the pylon/launcher or ESTS during testing; distribution of power and signals to other components; separation of signal categories; and termination for cable shielding.

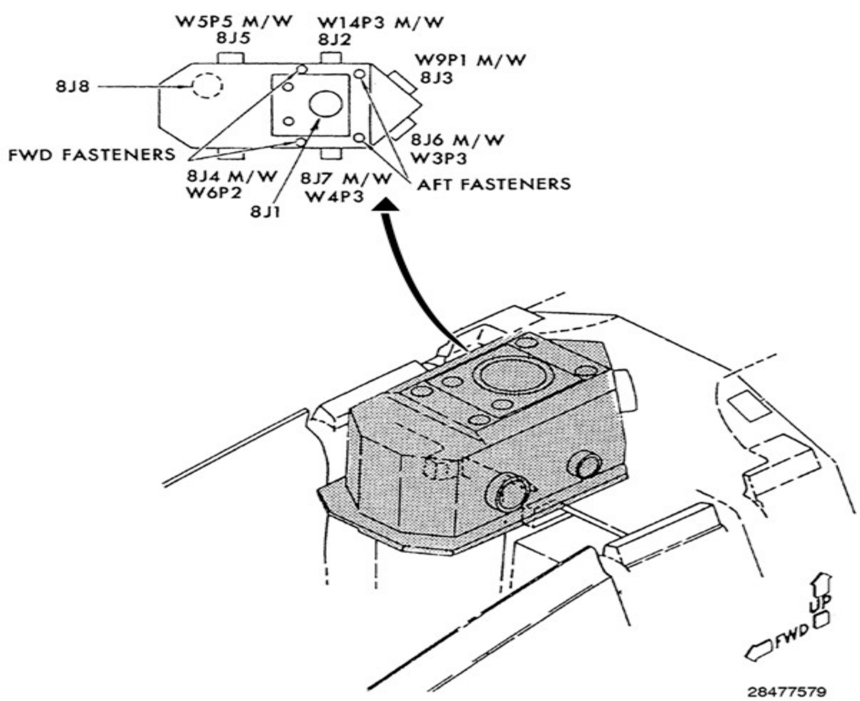


Figure 2–10. Umbilical enclosure assembly.

Rotary switch

The rotary switch is the last major component of the electrical power system. The switch is located in the center raceway on top of the missile between the clevises (fig. 2–11). The function of the rotary switch is to provide electrical isolation between the power source and the EEDs and warhead until after launch.

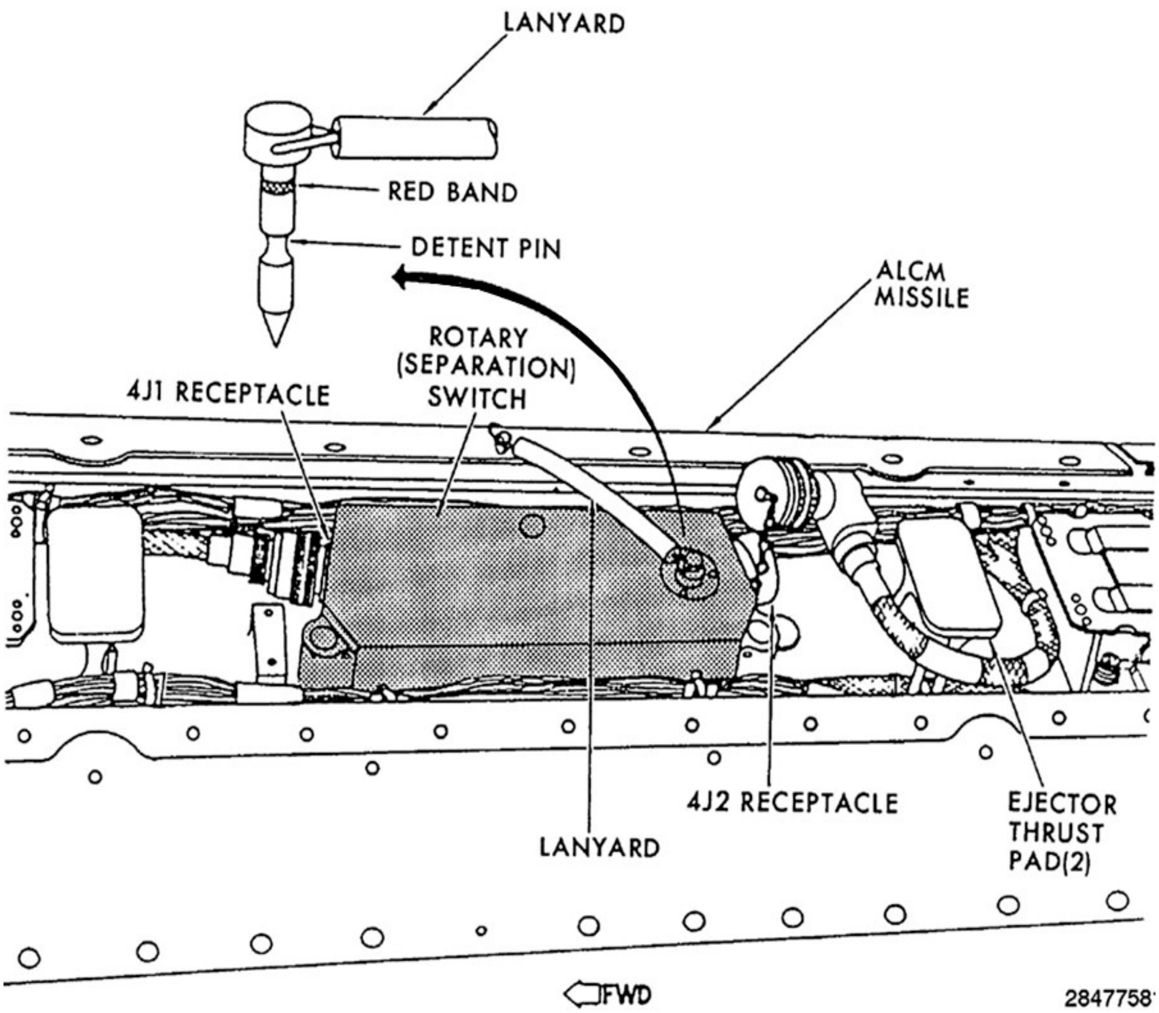


Figure 2–11. Rotary switch.

Wiring harnesses

Electrical distribution to and from the missile components is routed through the wiring harnesses. Missile electrical distribution wiring is divided into four categories as shown in the table below.

Distribution Wiring Categories		
Category number	**Purpose**	**Cable wire (W)**
1	Power and control cables	W1–W5, and W10
2	Flight control and guidance cables	W6, W9, W25, W26, and W28
3	Warhead monitor and control cables	W13–W15
4	Ordnance cables	W10 and W12B

Self-Test Questions

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

009. Air launched cruise missile and conventional air launched cruise missile description

1. How many total missiles can a B-52H carry?

2. What are the missile's four phases of operation?

3. What characteristic allows the missile to be carried on a pylon with the least amount of drag for the carrier aircraft?

4. What are the flight control surfaces of the missile?

010. Electrical distribution system

1. What is the purpose of the electrical power system?

2. Where is electrical power supplied from during ground checkout of the missile?

3. What is the function of the dual-section thermal-battery?

4. What is the function of the generator/regulator?

5. The UEA serves what function or purpose?

6. Which component provides electrical isolation between the power source, the EED, and warhead until after launch?

2–2. Safe, Arm, and Fuzing System and Environmental Control System

The lessons covered in this section are the SAF system and the ECS. The SAF system ensures certain events take place in a given sequence to allow the detonation of the warhead. The ECS system maintains internal components at a safe operating temperature and protects the engine.

011. Safe, arm, and fuzing system

The SAF system is designed to provide positive control of the warhead, arming, and fuzing. This positive control means preventing inadvertent detonation, but also provides reliable detonation at the designated target. The SAF system also provides monitor circuits for the aircrew to monitor the system. The SAF system interacts with the aircraft, as well as the missile navigation and electrical distribution systems. A sequence of events must occur at specified times to arm and then detonate the warhead. Any malfunction or failure of an event to take place at the proper time prohibits detonation. The main components of the SAF system are the warhead arming device (WAD), impact fuze assembly, and warhead (fig. 2–12). The CALCM has additional SAF elements (fig. 2–13). However, we must first touch on the rotary switch (from the electrical system) and the inertial navigation element (INE from the navigation system) which are key components that support the SAF system.

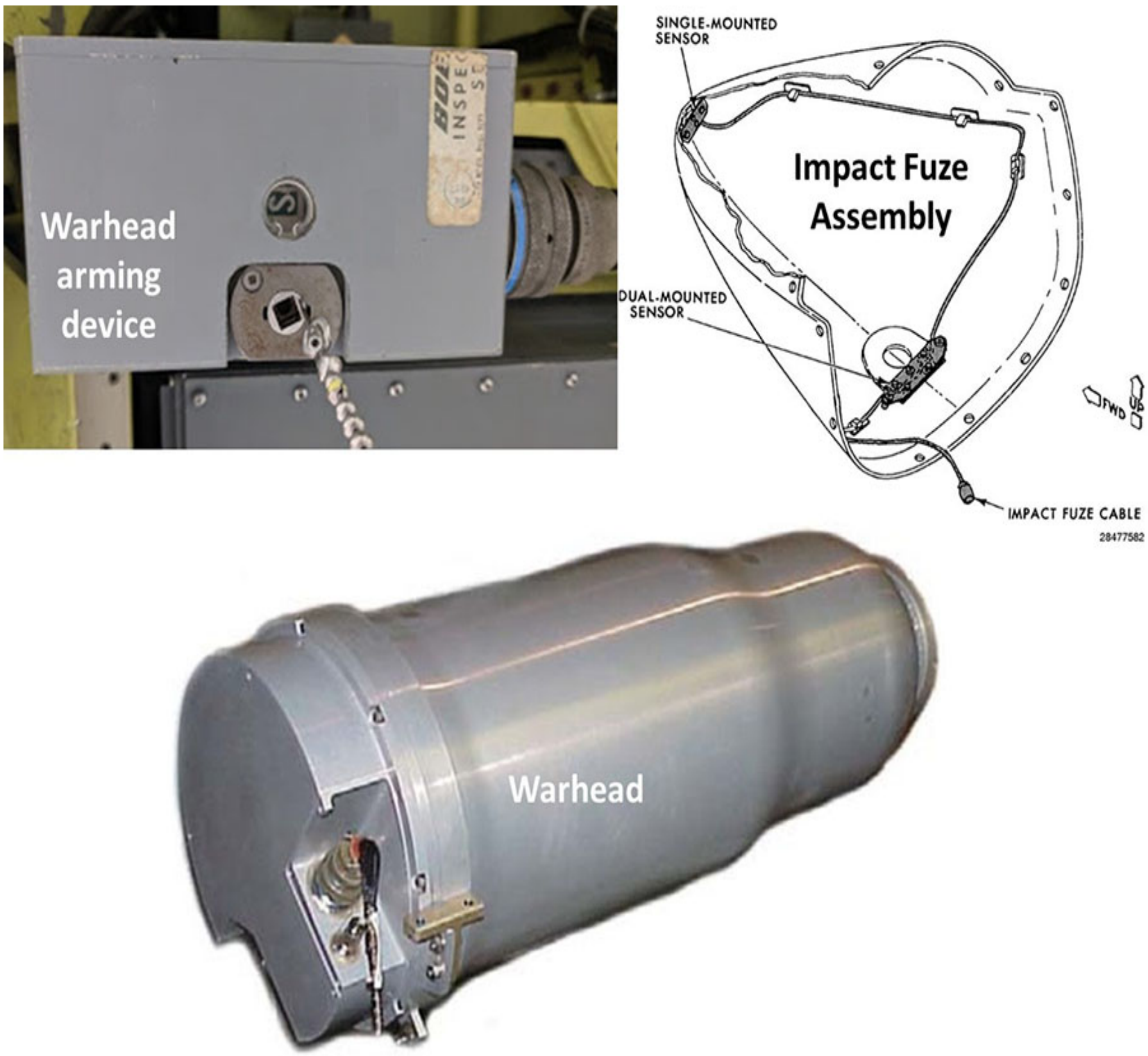


Figure 2–12. Safe, arm, and fuzing components.

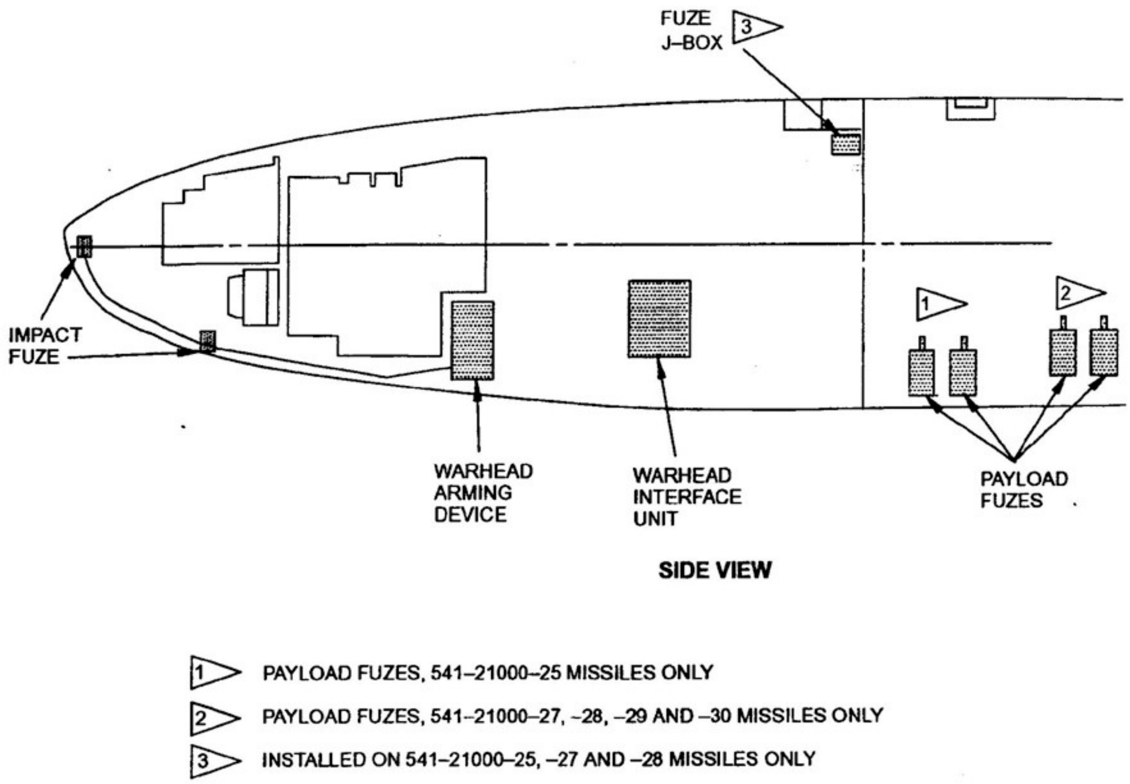


Figure 2–13. CALCM safe, arm, and fuzing subsystem hardware.

Rotary switch

In respect to the SAF system, the rotary switch isolates power from the warhead until launch. A detent pin installed in the rotary switch provides this isolation. At launch, the detent pin is removed, afterward power can be sent to the WAD. The pin removal also results in generation of the separation arm command for the INE. The rotary switch is a monitored element of the ORDNANCE ALARM circuit.

Inertial navigation element

The INE plays an important role in the SAF system by sequencing the events needed to arm and fuze the missile. The INE is located in the INE bay at the forward section of the missile. The INE is also a monitored element of the ORDNANCE ALARM circuit.

Warhead arming device

The WAD (fig. 2–14) is probably the *single most important* component of the SAF system, with the exception of the payload. It is located in the aft bulkhead of the INE bay and is a monitored element of the ORDNANCE ALARM circuit. This electro-mechanical device is designed to provide safing control and monitoring functions. It also serves as the electrical interface between the warhead and other system components.

There is a window on the bottom of the WAD to check the safe or armed condition. A white “S” on a green background indicates safe. A black “A” on a red background indicates armed. Mechanical safing is conducted by insertion of a safing pin. Additionally the WAD can be electrically safed by the aircraft and is armed by the INE.

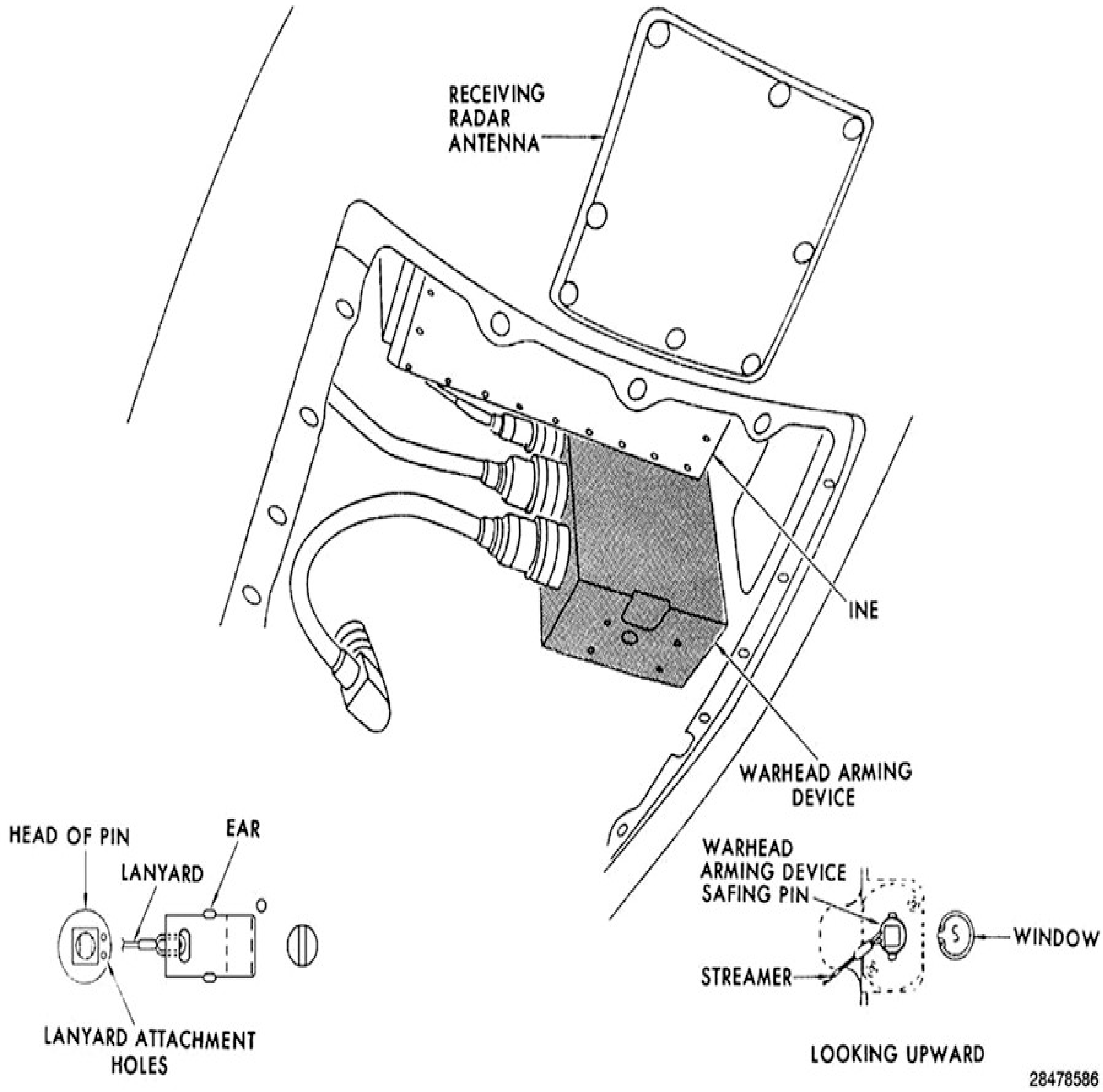


Figure 2–14. Warhead arming device.

Impact fuze assembly

The impact fuze assembly consists of three sensors all located in the nose cap panel at forward section of the missile. A single sensor is located in the tip of the nose cap (fig. 2–15). The double sensor is located on the bottom of the nose cap near the INE bay-mating surface. The function of the assembly is to provide secondary and backup fuzing of the warhead. Normally, the INE commands warhead detonation as the missile passes over the target (primary inertial fuzing). As a backup, in the event the warhead fails to detonate as programmed, the impact fuze causes detonation on impact provided the INE has issued the commands to cause the entire arming device relays to close. Secondary fuzing occurs when the missile is programmed to detonate on impact *only* (fig. 2–16).

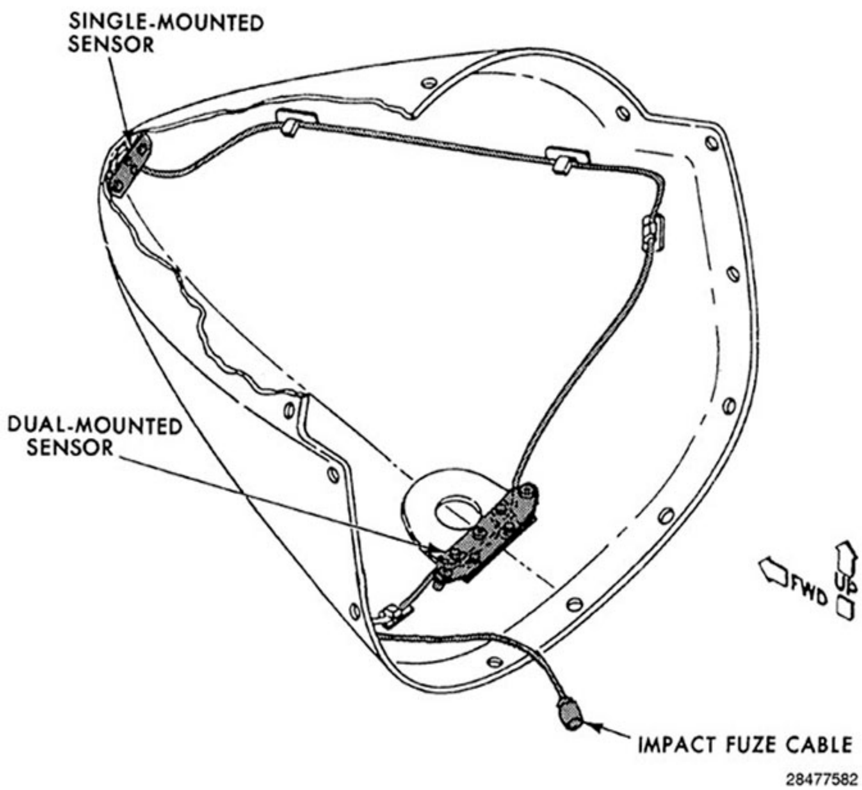


Figure 2–15. Impact fuze (sensor) assembly.

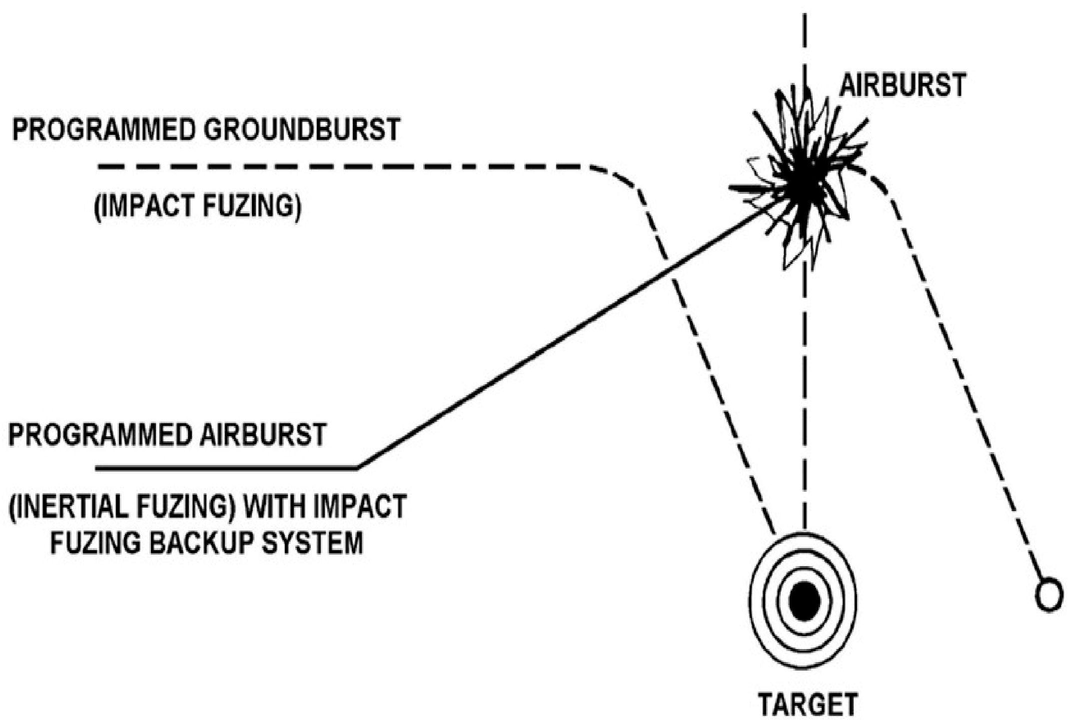


Figure 2–16. Fuze options.

Conventional cruise missile safe, arm, and fuzing elements

The SAF elements shown in the following table are *only* found on the CALCM, AGM–86C:

Safe, Arm, and Fuzing Elements and Description	
Element	**Description**
Warhead interface unit (WIU)	The WIU receives signals from the WAD. It has two independent circuits—each circuit powers and operates one fuze. The WIU performs the following functions: • Supplies plus (+) 60 VDC power to operate the FMU–139A/B fuzes. • Generates a turbine release discrete that causes the FMU–139A/B fuzes to operate in a continuous-power mode. • Passes the fuzing signal from the WAD to the proximity sensor fire input of the fuzes.
Fuze J-box	The fuze J-box receives the signals generated by the WIU and routes them to the FMU–139A/B fuzes on AGM–86C–25, –27 and –28 missiles. Because the fuze J-box is not installed on AGM–86C –29 and –30 missiles, the WIU routes signals directly to the fuzes.
FMU–139A/B fuze	The two FMU–139A/B fuzes respond to the signals generated by the WIU. Following a 20-second arm delay, the safe-and-arm devices in the fuze rotate to the ARM position. Upon receipt of a proximity sensor fire signal, ordnance in the fuze is detonated, which, in turn, detonates the payload. Safety provisions of the fuze include a safety pin and a gag rod that serves as a visual indicator. The fuze is in a safe condition if the red band on the gag rod is not visible. For a payload fuze to be acceptable for use with AGM–86C missiles, the interfix number on the label must be 006 or greater.

012. Environmental control system

The missile ECS consists of three subsystem—the forward ECS, aft ECS, and the desiccant system. Both the forward and aft ECS are used to cool heat-generating components. The desiccant system protects the engine by providing a moisture-free sealed environment until missile launch. The following paragraphs will go over the major components of each subsystem.

Forward environmental control system

The *primary* purpose of the forward ECS is to cool the INE. It is operated during each of the phases of operation—ground checkout, captive carry, transition, and free flight. The main three components are the thermal heat exchangers, UEA and air cycle machine. Figure 2–17 shows the components and their relative locations in the missile.

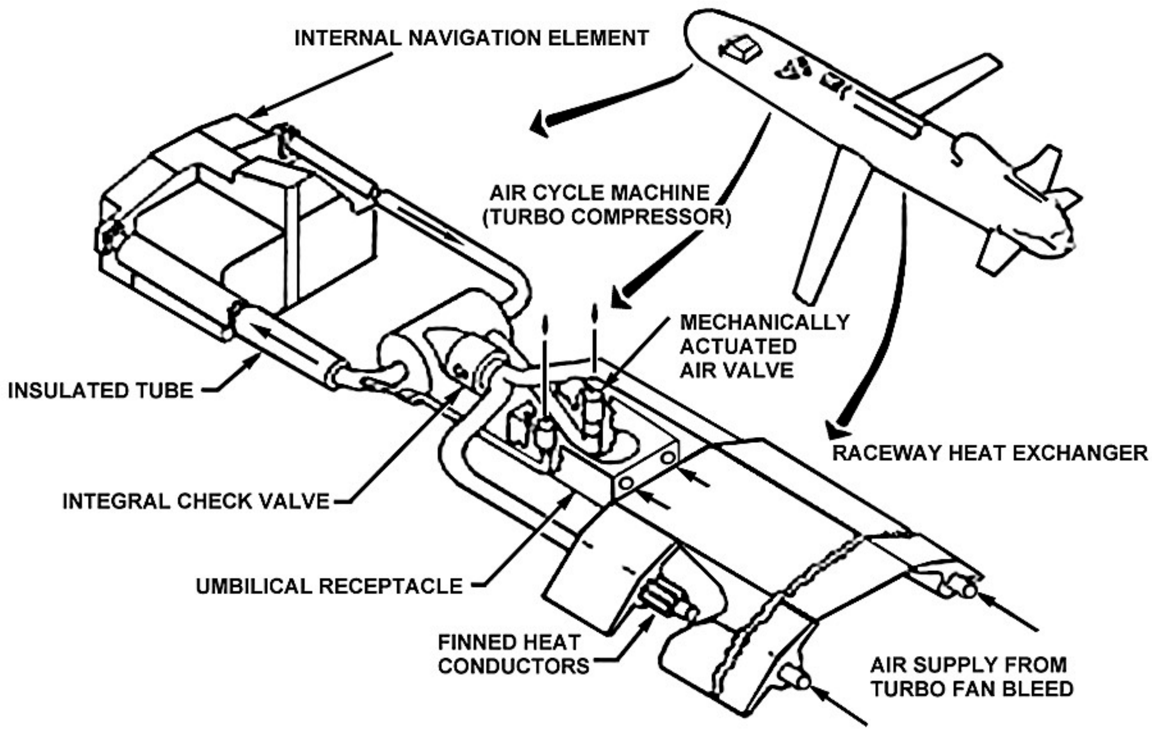


Figure 2–17. Forward ECS.

Thermal heat exchangers

There are two thermal heat exchangers and each run parallel to each other along the top of the mid body section of the missile. Their function is to cool the engine bleed air. They are *only* used when the missile is in flight each heat exchanger is a finned aluminum structure approximately 40 inches long and cools bleed air by transferring heat to the cool missile surface.

Umbilical enclosure assembly

Another major component in the forward ECS is the UEA (fig. 2–18). It is located behind the air cycle machine above the payload bay. Its function is to route airflow. There are two possible routes and the route selection depends on whether the umbilical cable is mated to the UEA. The umbilical cable is mated during ground checkout or is connected via the pylon/launcher.

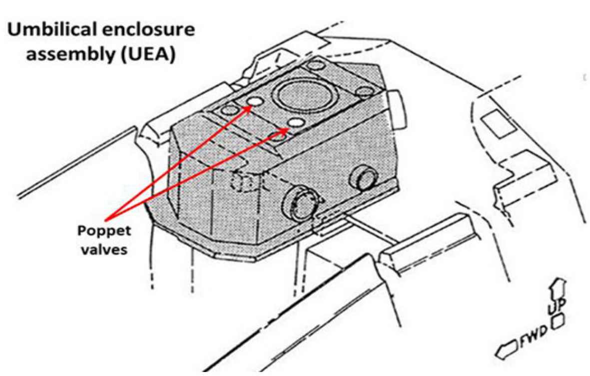


Figure 2–18. Umbilical enclosure assembly and umbilical cable.

Mated umbilical cable

Mating of the umbilical cable opens the two UEA poppet valves. The left valve routes supply air from the umbilical cable to the air cycle machine. The right valve directs return air from the air cycle machine to the umbilical cable return line.

No umbilical cable

During flight only, return air from the air cycle machine simply passes through the UEA to the raceway and then exits the missile out the boat-tail annulus (around the engine exhaust nozzle). Recall the thermal heat exchanger provides bleed air to the air cycle machine during flight.

Air cycle machine

The air cycle machine, also called the turbo-compressor, is the final component of the forward ECS (fig. 2–19). It is located in the top center of the payload bay. Its function is to regulate air routed to and from the INE. It consists of a turbine and compressor section. The turbine section cools supplied air (from the UEA or the heat exchangers) through expansion. However, if further air-cooling would damage the INE, then air is routed around the turbine section. The compressor section compresses INE return air to ambient pressure.

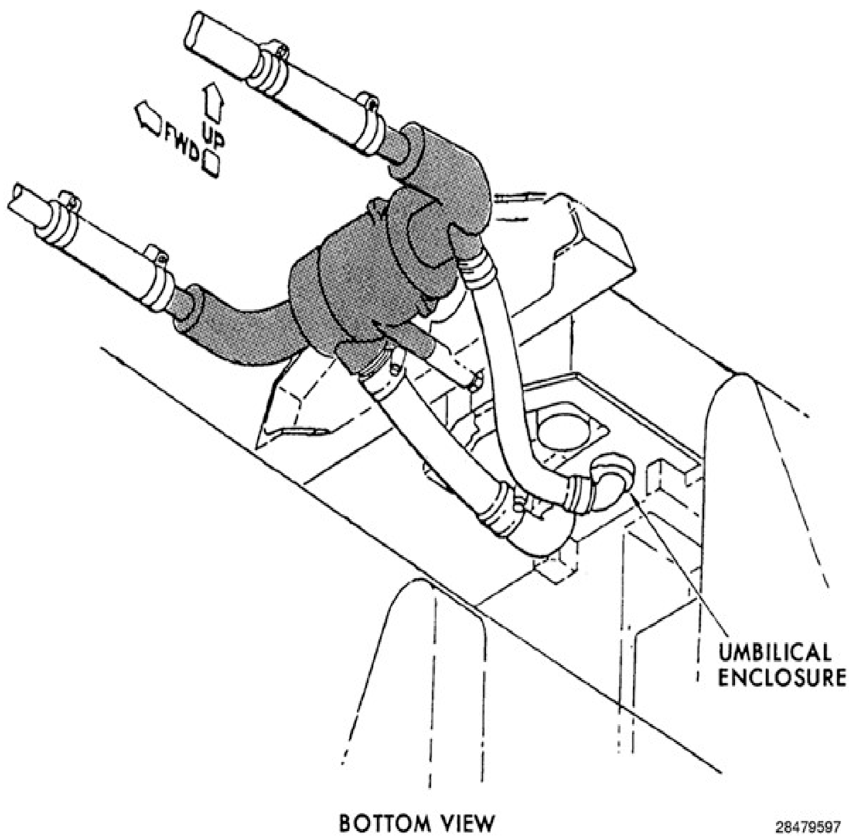


Figure 2–19. Air-cycle machine (turbo-compressor).

Airflow paths

There are two distinct airflow paths associated with the forward ECS (fig. 2–20). One path is applicable to captive carry and ground checkout, while the other is used *only* during missile flight. You will learn more about the airflow paths in your 7-level CDC.

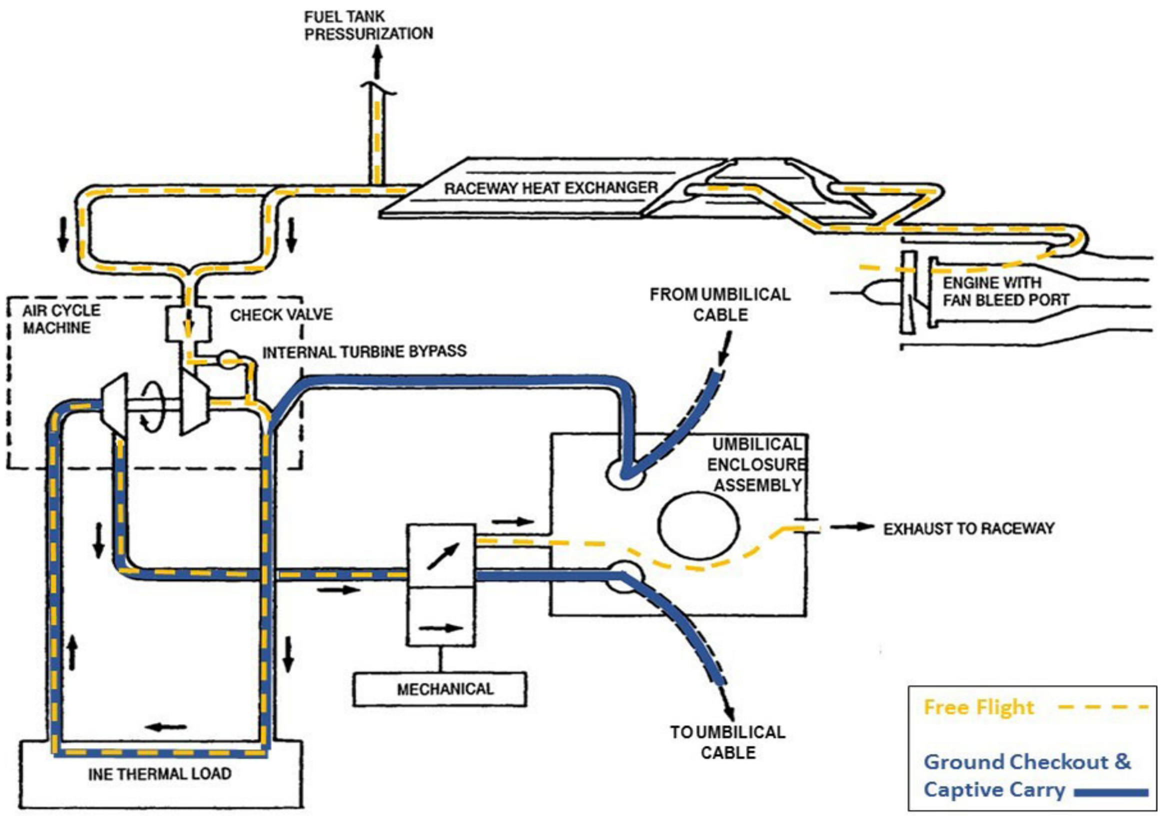


Figure 2–20. Forward ECS airflow paths.

Aft environmental system

The aft ECS is much less complex than the forward element. The purpose of the aft ECS is to cool the generator and engine compartment *only* during free flight. It has two components—the engine inlet and air inlet temperature sensor-tube extension.

Engine inlet (ram air inlet)

The engine inlet provides an entrance and ducting for the ram air necessary to cool the components of the engine compartment. This ram air inlet is a small rectangular opening immediately below the main engine intake (fig. 2–21). Ram air is ducted from the inlet into the inlet temperature sensor tube extension.

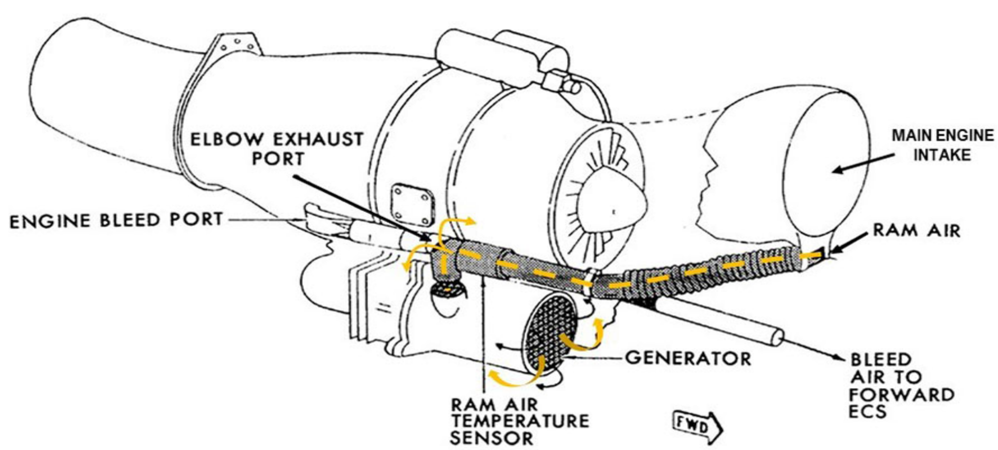


Figure 2–21. Aft ECS airflow path.

Temperature sensor tube extension

The temperature sensor tube extension routes most of the supplied ram air to cool the generator, which circulates it into the engine compartment. A small portion of the ram air is bled from the sensor-tube extension through the elbow exhaust port to cool the engine compartment. All of the air for the aft ECS is discharged out the boat-tail annulus.

Engine desiccant system

Since the missile is exposed to varying humidity, environmental, and altitude factors, problems with condensation were encountered with the engine and its internal components. A desiccant system was designed to compensate for this problem. The purpose of the desiccant system is to hermetically seal the engine and provide a moisture-free atmosphere. During launch, the system is designed to expose the engine inlet and exhaust to support missile free flight. The four major components that make up the desiccant system are the engine inlet seal, expanding tube release system, desiccant assembly, and engine desiccant seal.

Engine inlet seal

The engine inlet seal is installed over the engine air inlet to provide a moisture barrier for the engine intake (fig. 2–22). A plug is provided to seal the ECS ram air inlet. The seal is made of a flexible rubber substance with a thin film-like coating to prevent moisture impregnation. The inlet seal is pulled from the missile by a lanyard, secured to the launcher/pylon, as the missile falls away from the aircraft during launch to allow air intake.

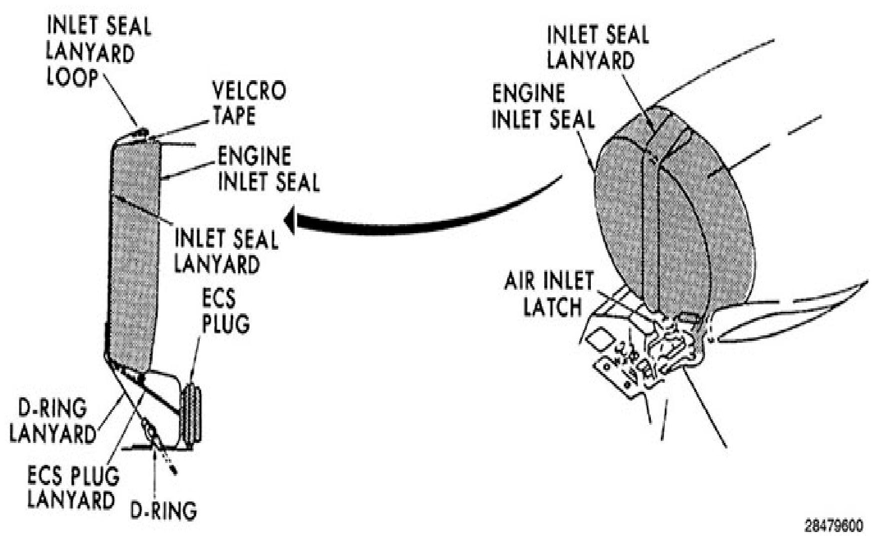


Figure 2–22. Engine inlet seal.

Expanding tube release system

The second major component of the desiccant system is the expanding tube release system (ETRS). It is used to deploy the desiccant assembly at launch. It is located in the boat-tail and made up of three subassemblies (fig. 2–23). It is composed of an inner ring, outer ring, and expanding tube located between the two rings. The outer ring is riveted to the boat-tail and the inner ring is attached to the outer ring by aluminum pins. The main purpose of this inner ring is to provide fastener attachment points for the desiccant assembly. The expanding tube contains a detonation cord and contains dual initiators to ensure proper deployment of the desiccant assembly at launch.

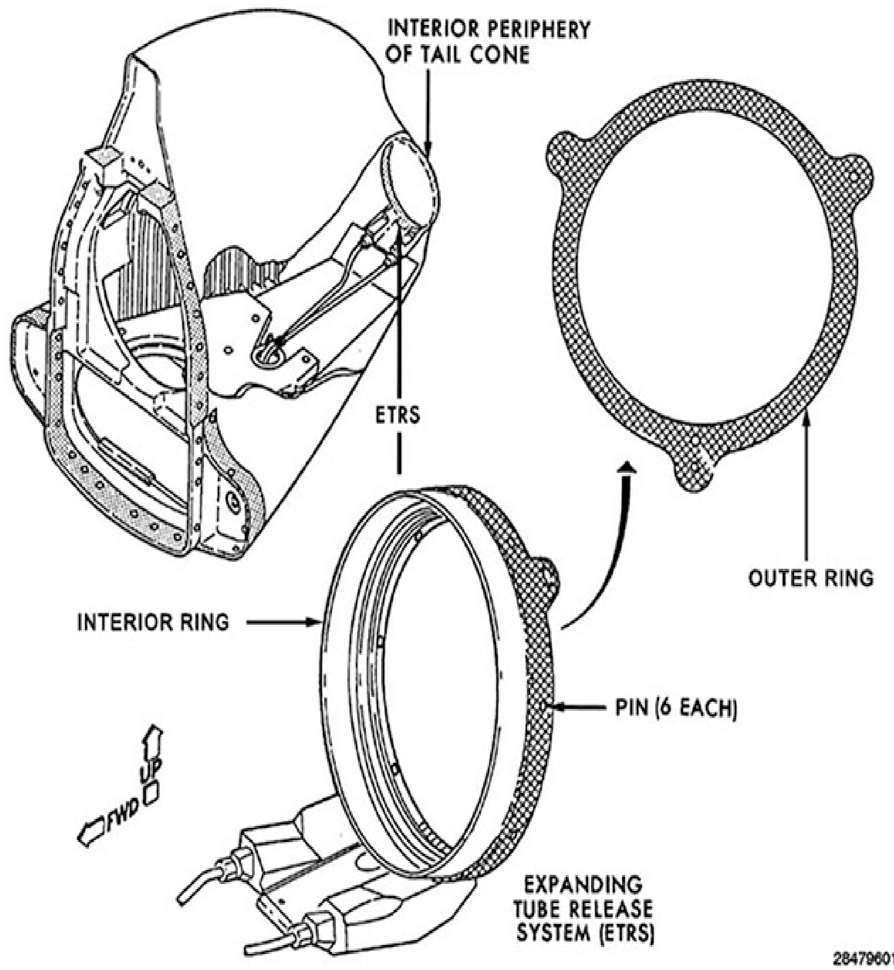


Figure 2–23. Expanding tube release system.

Desiccant assembly

The desiccant assembly (cover) seals the engine tailpipe and removes moisture from the sealed engine. It also provides an indication of the humidity level in the desiccant itself (fig. 2–24). The desiccant assembly consists of a canister, breather valve, and humidity indicator. The canister contains desiccant beads to absorb moisture. The breather valve and humidity indicator is made of a two-way check valve and visual indicator. The visual humidity indicator (fig. 2–25) detects moisture presence in the desiccant system. The canister contains a screen-like filter and retaining ring, as well as the desiccant beads. Color indicators in the various quadrants of the humidity indicator range from blue to lavender to pink, depending on the amount of moisture present. The color indicated determines what maintenance action is required.

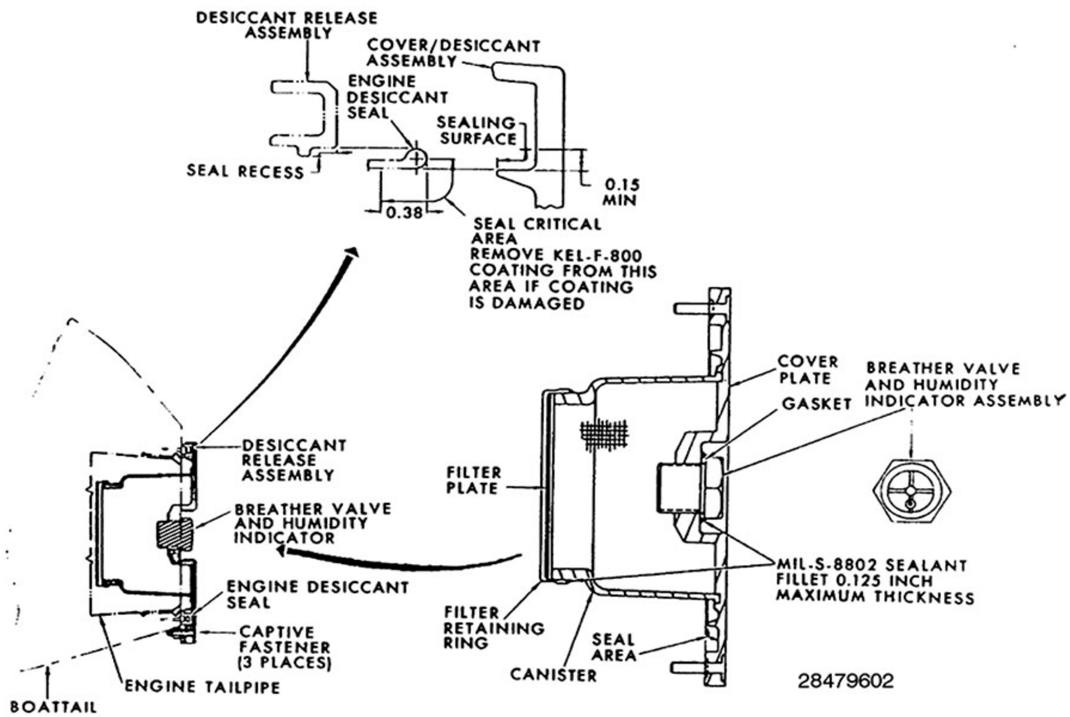


Figure 2–24. Desiccant assembly.

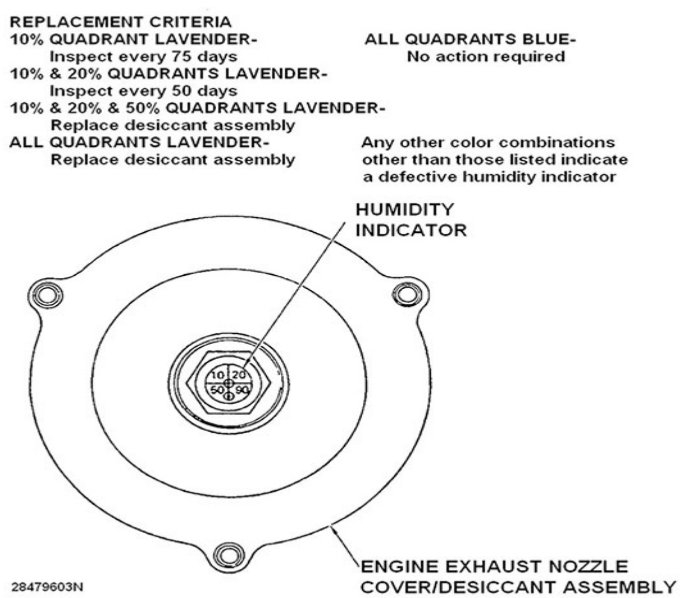


Figure 2–25. Desiccant humidity indicator.

Desiccant seal

The engine desiccant seal is installed on the engine tailpipe. It provides a seal between the tailpipe and desiccant assembly (fig. 2–26). Great care must be taken when handling the seal to prevent damage to the thin protective coating. *Any* damage to the coating requires rejection of the seal.

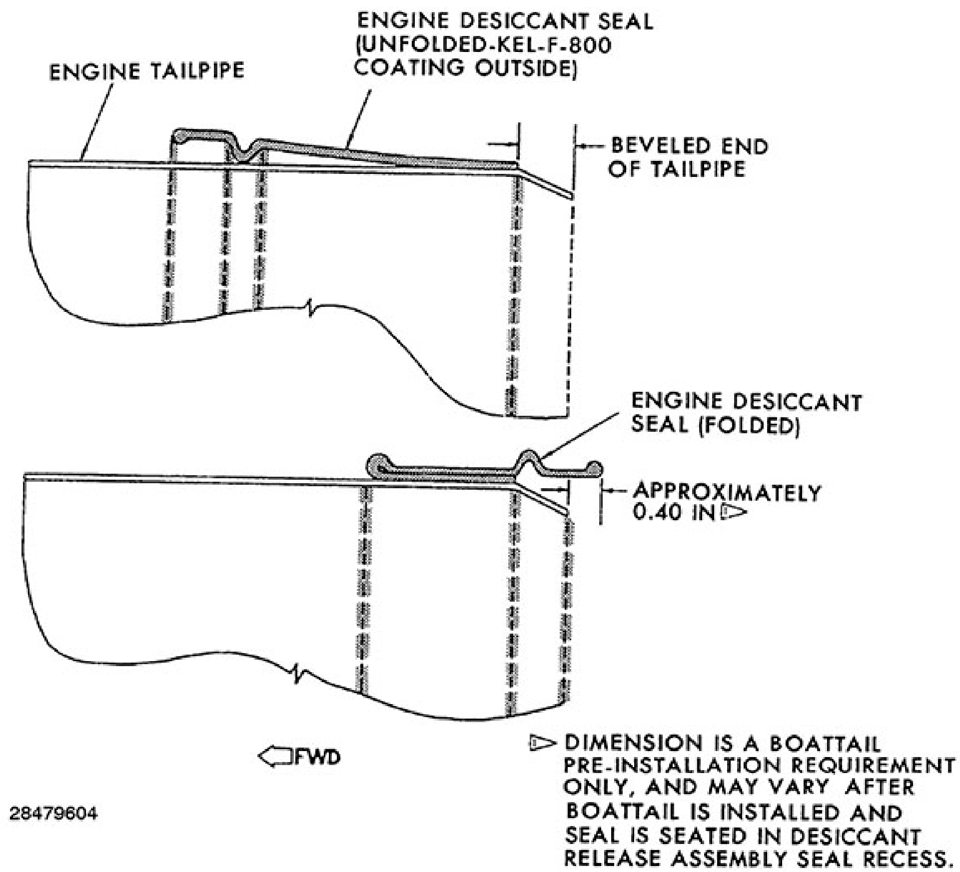


Figure 2–26. Engine desiccant seal.

Self-Test Questions

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

011. Safe, arm, and fuzing system

1. What is the SAF system designed to do?

2. Which component provides safing control and monitoring functions in addition to serving as the electrical interface between the warhead and other system components?

3. The impact fuze assembly consists of how many sensors and in which panel of the missile is it located?

4. What kind of fuzing is programmed to detonate on impact only?

012. Environmental control system

1. What is the *primary* purpose of the forward ECS?

2. What opens the UEA poppet valves?

3. What are the two sections of the air cycle machine?

4. What is the purpose of the aft ECS?

5. What does the engine inlet seal provide for the engine intake?

6. What detects moisture presence within the desiccant system?

2–3. Propulsion, Flight Control, and Navigation Systems

The three lessons in this section cover vital systems for getting the missile to target. We begin our discussion with the propulsion system. The second lesson covers the FCS and the final lesson goes over the navigation system. Let's get started and see how these systems contribute to the overall cruise missile flight process.

013. Propulsion system

The propulsion system is a vital system in the missile, without it the missile would never arrive at its intended target. Even though you will not work on this system beyond engine removal and replacement, it is important for you to have knowledge of the overall system. The propulsion system consists of the fuel containment and transfer (FCAT) system and the engine.

Fuel containment and transfer system

The ALCM's FCAT system is a four-tank, single sealed system that provides fuel to the engine during free flight (fig. 2–27). The system is also designed to store fuel for an extended period and allows for periodic servicing. This servicing consists of fueling and defueling operations. The CALCM FCAT system is very similar but will *not* be discussed, so the remainder of this FCAT discussion pertains to the ALCM *only*. The main components of the FCAT are the fuel tanks, pressure bulkheads, transverse slosh baffles, surface tension screens, negative gravity (g) sump, fuel pump, fuel motor, and fuel pump electronic unit. The FCAT system also includes the following valves: the bleed air check valve, air supply/service valve, air vent/vacuum valves, fill-and-drain valve, and the fuel supply/range safety/service valve.

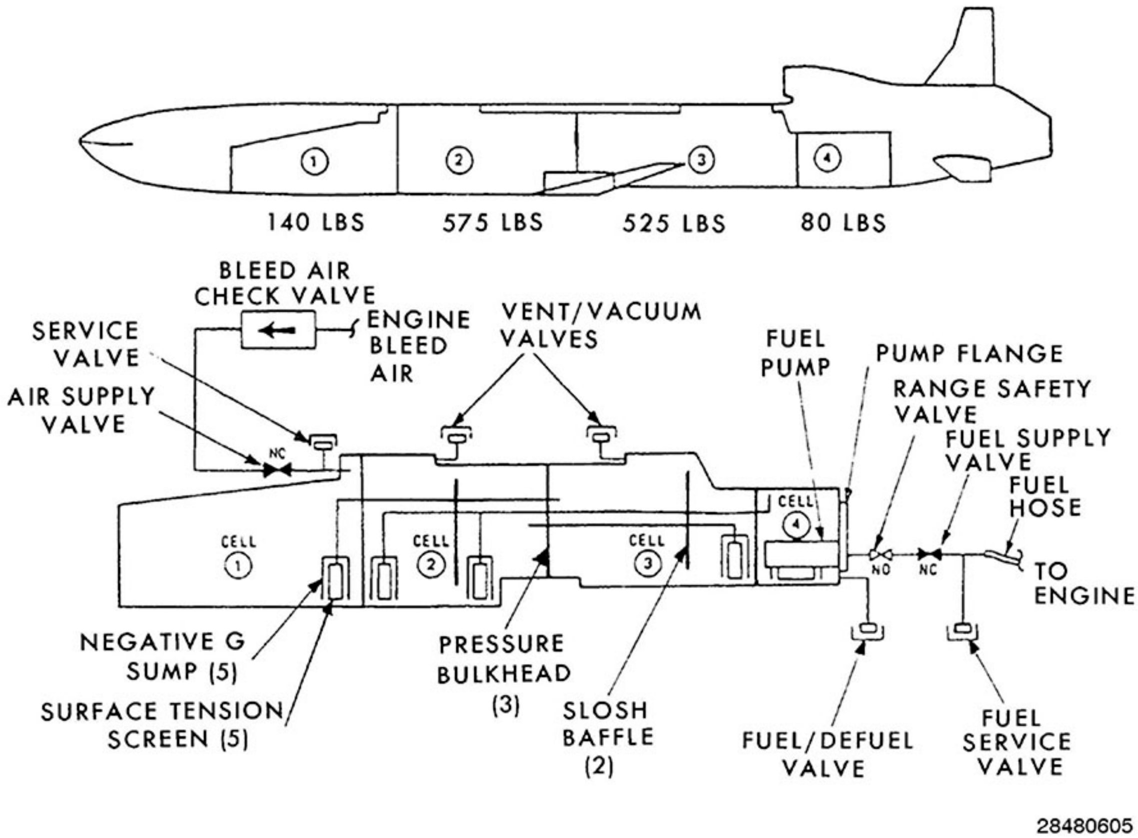


Figure 2–27. AGM–86B Fuel containment and transfer system.

Fuel tanks

The missile has four fuel tanks and each contains internal plumbing, external openings, and external mounting pads. Tank 1 is a *picklefork* shape because it surrounds the payload bay. Tanks 2 and 3 are in the center of the missile body. Tank 4 is below the engine inlet. Tanks 1 and 4 are the smallest.

Pressure bulkheads

The pressure bulkheads separate the fuel tanks. They are located behind tanks 1, 2, and 3. There is no pressure bulkhead behind tank 4; instead, you will find the fuel pump flange.

Transverse slosh baffles

Two transverse slosh baffles *reduce* longitudinal fuel slosh effects during missile flight. They are installed inside the center of tanks 2 and 3.

Surface tension screens

The purpose of the surface tension screens is to provide air-free fuel flow by preventing air from getting into the fuel transfer lines. The screens are a mesh, twilled double-weave wire cloth. When any portion of the screen gets wet, it causes the screen to wet throughout. This prevents air from getting into the fuel transfer lines. There are five screens. They are located in each tank with tank 2 containing two of the screens. As each tank empties, the screens dry, allowing bleed air to pass and pressurize the next tank.

Negative "g" sumps

The negative "g" sumps ensure fuel remains around the surface tension screens during negative gravitational force maneuvers. There are five sumps in the missile; each surrounds a surface tension screen.

Fuel pump

The purpose of the fuel pump is to transfer fuel from tank 4 to the engine. It is mounted to the pump flange.

Fuel pump motor

The fuel pump motor drives the fuel pump. A magnetically coupled alternating current (AC) type motor eliminates the need for a dynamic seal. This eliminates the possibility of fuel leakage from the pump assembly. It uses two magnets; one is installed on the pump and the other is on the motor.

Fuel pump electronic unit

This unit provides the AC power to operate the fuel pump motor. It does this by converting 28 VDC (pulse load power) to 24 volts alternating current (VAC). It is located on the rear wall of tank 4.

Bleed air check valve

This check valve provides one-way flow of bleed air to pressurize the fuel tanks. This bleed air is portioned off from the forward ECS at the bleed air duct, passes through the check valve, and is routed to the air supply/service valve. The check valve is located just behind the UEA. This valve also prevents the flow of air and fuel vapors back into the ECS system though its dual check functions.

Air supply/service valve

The air supply service valve performs two functions. First, it controls pressurization of the fuel tanks; second, it provides a connection for ground service venting and purging. This valve is located on the top of tank 1 (aft end of the payload bay). The air supply valve is opened by squib fire that shears the plug seal. Engine bleed air is then used to pressurize the tank. The service valve can be opened manually and is used during ground-fueling operations as a vent and purge connection point. This valve is also considered a double seal to prevent fuel leaks. The valve is the first seal and the metal cap over it is the second seal.

Air vent/vacuum valves

The air vent and vacuum valves are located on top of tanks 2 and 3, forward and aft of the clevises respectively, and serve two functions. First, they provide a venting function during missile fueling. Second, they are used to set *ullage* (the small portion of the tanks that is not filled with fuel). Ullage compensates for fuel expansion due to temperature changes. Both valves are manually operated and double sealed.

Fill-and-drain valve

The purpose of the fill-and-drain valve is to provide a connection for fueling and defueling the missile. It is located on the rear wall of tank 4 at the lower right-hand corner. It is also manually operated and double sealed.

Fuel supply/range safety/service valve

The fuel supply/range safety/service valve controls fuel flow from tank 4 to the engine. It is a valve assembly bolted to the pump flange (forward engine bay). The following describes the portion/parts of the valve:

- The fuel supply (isolation) portion of the valve provides isolation of the fuel tank and engine until launch. It is a squib-activated device in which a ram shears the plug, opening the line.
- The range safety portion of the valve provides a means for fuel-flow shutoff during test launches. An exploding actuator uses expanding gas to force a ram to crimp the fuel line shut. This squib is installed prior to launch. It is *not* installed during normal day-to-day operations.
- The service valve provides a connection used during engine fuel priming. This valve is also manually operated and double sealed.

Turbofan engine

The missile engine is an air-breathing, liquid-fuel-burning jet engine known as a turbofan engine. This turbofan engine is a 600-pound thrust class engine that weighs approximately 149 pounds and is fueled by JP–10 (fig. 2–28). As a technician, you will be required to perform periodic maintenance on this engine, which will include removal and replacement to meet a projected time-compliance schedule. The key engine components we will cover include the fuel controller, fuel slinger, ignitors, oxygen bottle, and start cartridge.

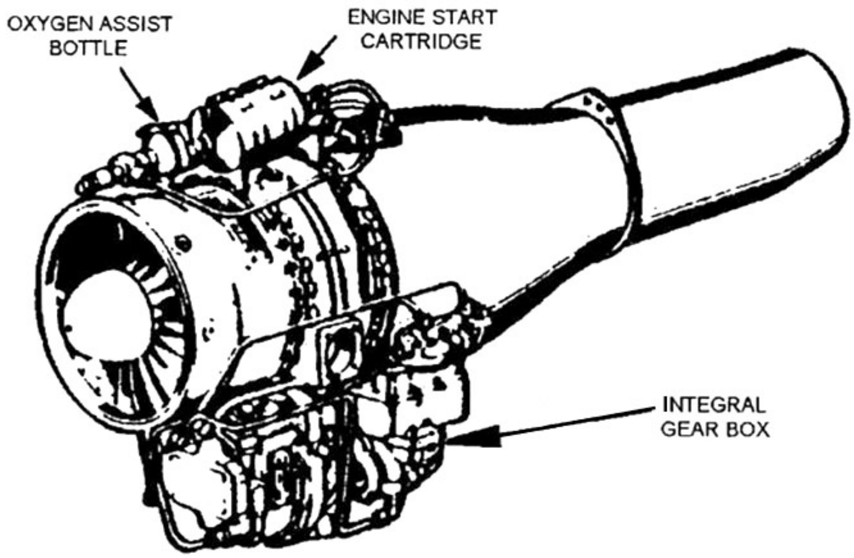


Figure 2–28. Engine.

Fuel controller

The fuel controller is located on the bottom of the engine and receives fuel supply from the FCAT system. It is for governing engine speed, automatically preventing the engine from exceeding its operating limits. It controls fuel flow, including fuel shutoff, to provide missile forward acceleration and deceleration during flight.

Fuel accumulator

The purpose of the fuel accumulator is to compensate for fuel expansion due to changes in temperature. This device is a chamber with spring-loaded bellows. The bellows are set about midway during the engine prime, an operation you will learn about in the next unit.

Igniters

The ignitors continuously fire to both start and sustain engine combustion.

Oxygen bottle

The oxygen bottle is located on top of the engine. It contains pure gaseous oxygen supplied to the engine combustion chamber during engine start to contribute to a stabilized combustion during initial acceleration. Simply stated, it aids high altitude engine start. An initiator is activated at launch to release the oxygen.

Start cartridge

The start cartridge is squib activated to output a high-pressure gas discharge that starts turning the engine turbine blades. This start cartridge is also located on top of the engine.

014. Flight control system

The FCS is designed to automatically control the commanded flight of the missile and is very similar to autopilot systems in larger aircraft. The function of the FCS, also known as the flight control element (FCE), is to provide stabilized flight from launch point to target. Numerous electronic, electrical, and mechanical components are utilized to accomplish this function. A working knowledge of how the FCS operates is essential to understanding the overall missile operation.

It is also equally important to remember individual systems cannot really be separated from the overall operation of the missile; this is particularly true of the FCS. It is, technically, a part of the guidance and control function and works hand-in-hand with the navigation system. All of the required flight commands on any one of the three flight axes come from the INE (of the navigation system). The purpose of the components in the FCS is to process data and control the missile pitch, roll, yaw, and engine throttle position. The major components that make up the FCS are the guided missile flight controller (GMFC), guided missile flight data transmitter (FDT), actuator controller, and electro-mechanical linear actuators (EMLA) (fig. 2–29).

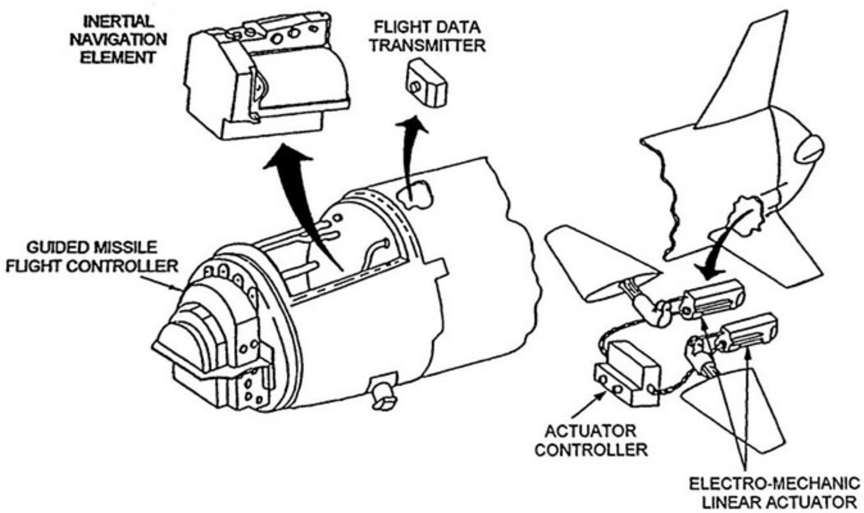


Figure 2–29. Flight control system components.

Guided missile flight controller

The GMFC is located on the forward bulkhead of the INE bay enclosed by the nose cap. The purpose of the GMFC is threefold: 1) it processes the flight control information from the INE, 2) adds the signals from the FDT, and 3) sends the throttle signals to the fuel controller and elevon signals to the actuator controller.

Flight data transmitter

The FDT is located in the payload bay at the top of the aft INE bulkhead (fig. 2–30). The unit contains three identical spring-restrained rate gyros, one accelerometer, and two circuit cards. The rate gyros measure angular acceleration in degrees per second in the X, Y, and Z-axes, and the accelerometer measures linear acceleration in gravitational forces (G) in the Z-axis. The function of these sensors is to *reduce* the correction signal as the missile approaches the proper altitude in relation to the flight command.

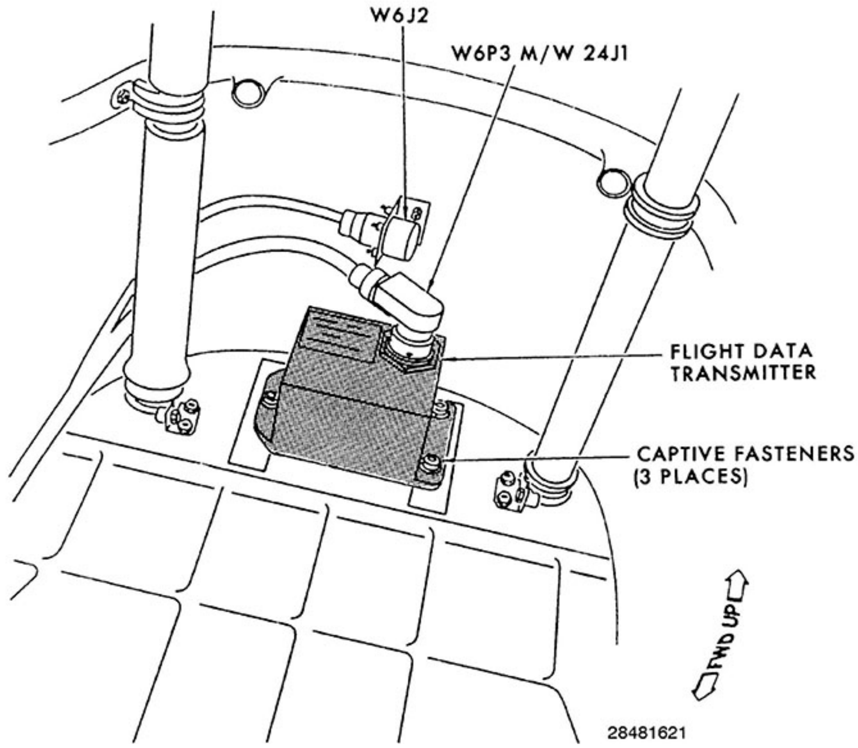


Figure 2–30. Guided missile flight data transmitter.

Actuator controller

The actuator controller (fig. 2–31) controls the movement of the elevons during ground checkout and free flight. It also monitors the linear actuators. The controller is located on the forward bulkhead of the elevon housing and contains two identical sets of circuits—one for each linear actuator.

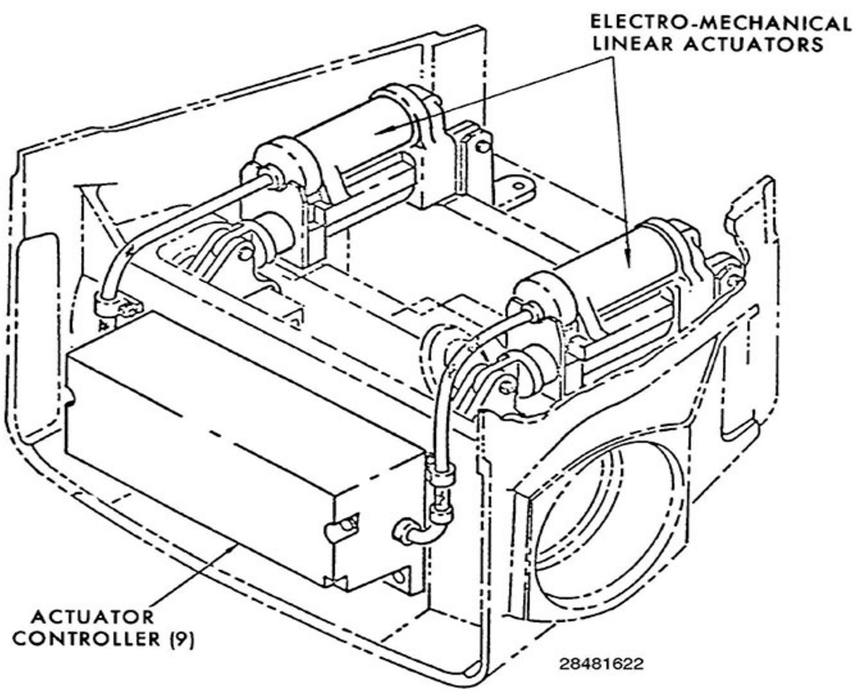


Figure 2–31. Actuator controller and electro-mechanical linear actuators.

Electro-mechanical linear actuators

The two EMLA are used to move the elevons in response to flight control command signals from the INE. The actuators are identical and, therefore, interchangeable.

015. Navigation system

The navigation system is the final system to be addressed in this unit. The purpose of the navigation system is to receive instructions from the carrier aircraft and to operate the missile systems to accomplish the instructions. The instructions include launch, flight-to-target, and detonation of the warhead. It is probably the most critical system functioning in the cruise missile in that it controls and commands all events. The ALCM and CALCM navigation system consists of the INE, air data element (ADE), common missile radar altimeter (CMRA), and FCS – the FCS was explained in the previous lesson. Additionally, CALCMs utilize a global positioning system (GPS).

Inertial navigation element

The INE is the *center* of missile navigation and guidance control (fig. 2–32). Its purpose is to provide centralized control of all missile flight functions, including all timing, control, and flight instructions to the missile and its payload. A digital computer mechanization for navigation, guidance, autopilot, and event sequencing is utilized to provide reliable and flexible mechanization of the various flight control modes. The INE consists of a missile computer, an inertial reference unit (IRU), better known as the platform, and a power-conditioning unit (PCU). The computer updates the missile position and monitors the missile conditions from captive carry to target destination. The IRU maintains a reference coordinate frame and senses velocity. Finally, the PCU provides regulated power to the internal computer and IRU.

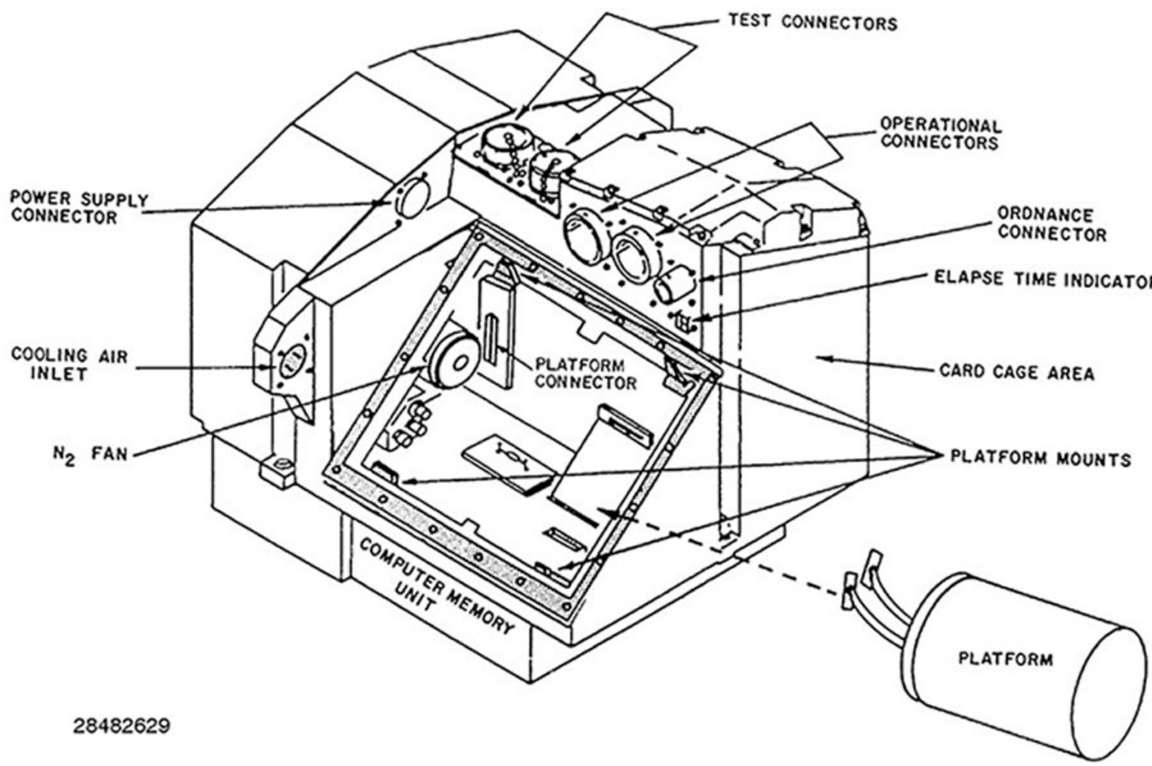


Figure 2–32. Inertial navigation element.

Air data element

The ADE consists of the total temperature and air data systems. It provides the INE with electrical analog signals representing static pressure, differential pressure, and free-stream air total temperature. The static pressure is barometric pressure or the representative altitude above sea level.

Differential pressure is the difference between static and pitot (ram) pressure. This information is used by the missile computer for calculations of altitude, Mach number (speed), and dynamic pressure. The computer then adjusts gains in the GMFC and issues commands to correct missile altitude, Mach number, or direction. The *main* components of the ADE are the pitot-static tube, pressure sensing transducer (PST), and the electrical resistance temperature transmitter (ERTT) (figs. 2–33 and 2–34).

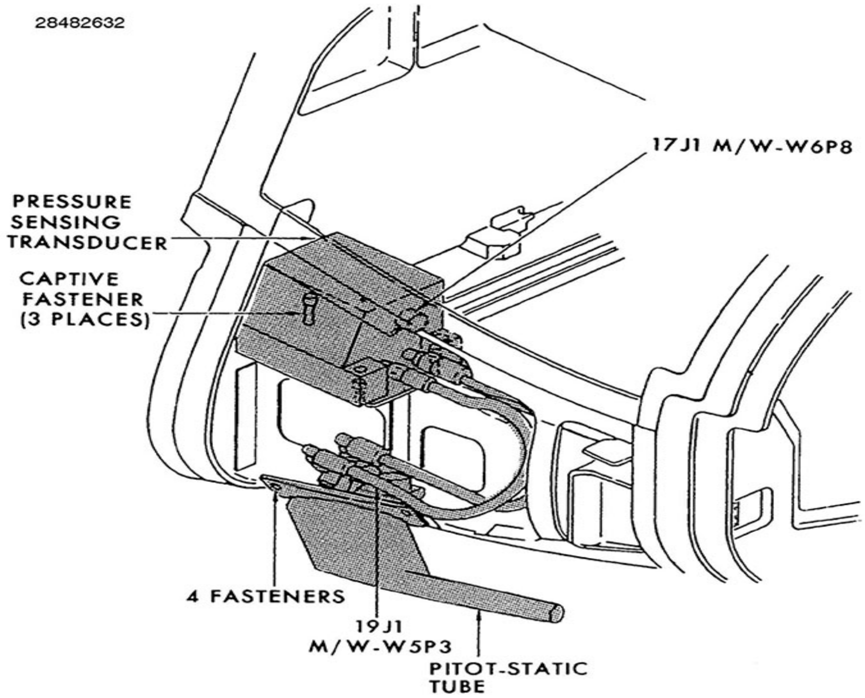


Figure 2–33. Pitot-static tube and Pressure sensing transducer.

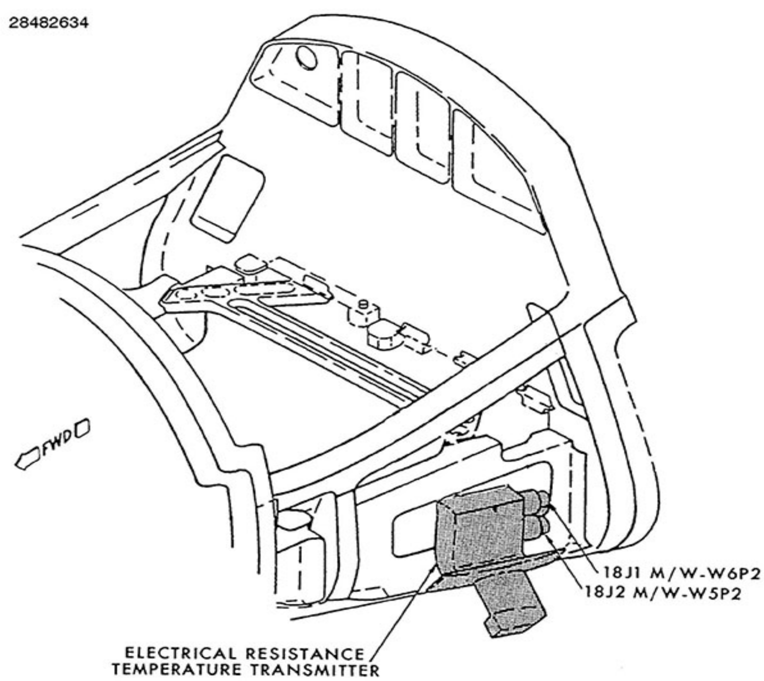


Figure 2–34. Electrical resistance temperature transmitter.

Pitot-static tube

This component senses pitot and static pressure and routes it to the PST through flexible tubes. It is located in the lower right-hand side of the INE bay. The pitot pressure port is located on the tip of the tube. The two static pressure ports are about 2 inches from the end of the tube. A heater is constructed as part of the tube to de-ice it within 45 seconds of power application.

Pressure sensing transducer

The PST converts the pressures from the pitot-static tube to analog signal equivalents. These signals are sent to the INE. The PST is located inside the INE bay on the right-hand bulkhead.

Electrical resistance temperature transmitter

The ERTT measures freestream air total temperature. It converts this temperature to analog signal equivalents and sends it to the INE. It also has a heater that provides de-icing within 45 seconds. The ERTT is located on the lower left-hand side of the INE bay.

Common missile radar altimeter

The CMRA consists of the radar altimeter electronics and two antennas. The CMRA serves *two* purposes. First, it measures absolute clearance of the missile above ground level (AGL). It also provides the INE with a ground-track image during terrain contour-matching (TERCOM) navigation. The radar altimeter electronics is located in the nosecone cavity (below the GMFC). The transmit antenna is located at the bottom of the missile by the underwing fairing. The receive antenna is located on the bottom of the INE bay.

Global positioning system receiver interface unit/precision

The global positioning system receiver interface unit/precision (GRIU/P) is located in the payload bay area of CALCMs. It provides an additional navigation source for the missile computer by monitoring the earth’s satellite constellation and determines the spatial position of the missile. This is a passive system—it *only* receives information and does *not* send any information back to the satellites.

Global positioning system anti-jam antenna system

The global positioning system anti-jam antenna system (GAJAS) enhances the resistance of the CALCM to GPS jamming. The four-element antenna array located on the forward extension cover of the raceway collects GPS signals and provides them to the anti-jam (AJ) module for processing.

Anti-jam module

The AJ module analyzes the signals from the GAJAS four-element antenna array, provides up to three spatial nulls against jamming signal threats, and provides a single radio frequency (RF) output signal to the GRIU/P with a decreased jammer-to-signal ratio. The AJ module is mounted to the underside of the payload bay’s equipment shelf in CALCM models -29 and -30 (fig. 3–35). On CALCM models -25, -27, and -28 it is mounted vertically on a mounting plate located in the payload bay.

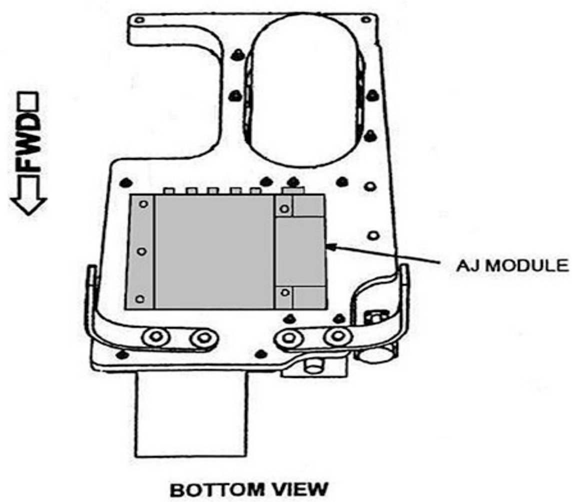


Figure 2–35. Anti-jam module location on AGM-86C 541-21000-29 and -30 missiles.

Self-Test Questions

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

013. Propulsion system

1. Which system provides fuel to the engine?

2. How many tanks does the missile have?

3. What do the pressure bulkheads do?

4. What is the purpose of the fuel pump?

5. What does the bleed air check valve provide?

6. Which valves are used to set ullage?

7. The turbofan cruise engine produces how many pounds of thrust and uses what type of fuel?

8. What is contributed by the oxygen bottle?

9. What does the start cartridge discharge do?

014. Flight control system

1. What are the major components that make up the FCS?

2. Which component processes the flight control information from the INE, adds signals from the FDT, and provides throttle to the fuel controller and elevon signals to the actuator controller?

3. What does the actuator controller monitor?

015. Navigation system

1. Which component is the center of air-vehicle navigation and guidance control?

2. What does the inertial reference unit maintain?

3. Which element provides the INE with electrical analog signals that represent static and differential pressures, and free-stream air total temperature?

4. Which passive system only receives information and does *not* send any additional information back to satellites?

Answers to Self-Test Questions

009

1. 20.
2. Ground checkout, captive carry, transition flight, and free flight.
3. The trapezoidal shape.
4. The wings, fin, and elevons.

010

1. Supply power to missile components during all phases of operation.
2. Power is provided by the IMF.

3. To provide power during the launch sequence from removal of carrier power until missile generator achieves operating speed.
4. Provide all of the missile’s 28-VDC power requirements during free flight.
5. Provides electrical interface to the pylon/launcher (or ESTS during testing), distribution of power and signals to other components, separation of signal categories, and termination for cable shielding.
6. Rotary switch.

011

1. Provide positive control over the warhead, arming and fuzing.
2. WAD.
3. Three in the nose cap panel.
4. Secondary fuzing.

012

1. To cool the INE.
2. Mating the umbilical cable.
3. Turbine and compressor.
4. To cool the generator and engine compartment *only* during free flight.
5. A moisture barrier.
6. A visual humidity indicator.

013

1. FCAT system.
2. Four.
3. Separate the fuel tanks.
4. Transfer fuel from tank 4 to the engine.
5. One-way flow of bleed air to pressurize the fuel tanks.
6. The fill-and-drain valves.
7. 600 pounds of thrust and uses JP-10 fuel.
8. Stabilized combustion during initial acceleration.
9. Turn the engine blades.

014

1. GMFC, FDT, actuator controller, and EMLA.
2. GMFC.
3. Linear actuators.

015

1. INE.
2. A reference coordinate frame.
3. ADE.
4. Global positioning system receiver interface unit/precision.

Complete the unit review exercise 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.

21. (009) During which phase of operation is the missile en route to the missile launch point?
    a. Free flight.
    b. Captive carry.
    c. Transition flight.
    d. Ground checkout.

22. (010) What electrical distribution system component provides power during the missile launch sequence from removal of carrier power until the generator achieves its operating speed?
    a. Engine.
    b. Battery.
    c. Junction box.
    d. Boost pump motor.

23. (011) What electro-mechanical device provides safing control and monitoring functions in the safe, arm, and fuzing (SAF) system?
    a. Rotary switch.
    b. Arm/disarm fuze.
    c. Impact fuze assembly.
    d. Warhead arming device.

24. (012) Which missile environmental control system (ECS) subsystem cools the inertial navigation element (INE)?
    a. Aft ECS.
    b. Mid ECS.
    c. Forward ECS.
    d. Desiccant system.

25. (012) Which missile environmental control system (ECS) subsystem cools the generator and engine compartment?
    a. Aft ECS.
    b. Mid ECS.
    c. Forward ECS.
    d. Desiccant system.

26. (013) What component *reduces* longitudinal fuel slosh in the fuel containment and transfer (FCAT) system?
    a. Pressure bulkhead.
    b. Negative gravity (g) sumps.
    c. Surface tension screen.
    d. Transverse slosh baffles.

27. (013) What engine component is for governing engine speed and keeps it from exceeding operating limits?
    a. Fuel pump.
    b. Fuel controller.
    c. Fuel accumulator.
    d. Fuel pump electronic unit.

28. (013) The engine component that compensates for fuel expansion due to changes in temperature is the fuel
    a. pump.
    b. controller.
    c. accumulator.
    d. pump electronic unit.

29. (014) What flight control system (FCS) component uses sensors to *reduce* the (flight) correction signal as the missile approaches the proper altitude?
    a. Pitot static tube.
    b. Flight data transmitter.
    c. Pressure sensing transducer.
    d. Guided missile flight controller.

30. (014) What flight control system (FCS) component is used to move the elevons?
    a. Flight data transmitter.
    b. Guided missile flight controller.
    c. Rotary switch.
    d. Electro-mechanical linear actuators.

31. (015) What component is the *center* of missile navigation and guidance control?
    a. Inertial navigation element.
    b. Pressure sensing transducer.
    c. Umbilical enclosure assembly.
    d. Guided missile flight controller.

32. (015) Which navigation system component measures absolute clearance of the missile above ground level?
    a. Flight data transmitter.
    b. Electrical temperature transmitter.
    c. Global positioning unit.
    d. Common missile radar altimeter.

Please read the unit menu for Unit 3 and continue ➔

Student Notes

Unit 3. Cruise Missile Processes, Operations, and Checkouts

IN TODAY'S RAPIDLY changing world, the need for aircraft equipped with cruise missiles remains on the leading edge of our nation's ability to project military force. Missile systems have been designed for ease of maintenance. Yet even with all the methods we now have to reduce the maintenance effort, a well-trained technician still must maintain the complex missile systems. This is you! You're a vital contributor to the reliability of the missile. In this unit, you will study missile maintenance operations, general repair, interpreting missile diagrams, and general troubleshooting.

3–1. Missile Maintenance Operations

This section focuses on the missile checkout and fueling operations you perform as a missile maintainer.

016. Missile checkout

Missile checkout is testing operations. We will focus on the Level I and II test programs. These test programs are stored on removable disks that are run by the ESTS. Testing support equipment is also used to interface the missile with the ESTS. The display station, also interfaced with the ESTS, allows the test operator to monitor the test.

Level I test

The primary purpose of the Level I test is to verify the operational capability of the missile. It is usually performed after all missile component replacement and servicing is complete. When a test measurement reading is out of tolerance, creating a test failure, the test performs limited fault isolation. After making repairs, the Level 1 test is ran again to verify the fault has been corrected. You will also use Level 1 test options to perform INE autocalibration, memory declassification, and memory dump. There are additional test options available to fit missile-testing needs.

Level I test options

The Level I test disk contains nine test options. After ESTS initialization, these test options are displayed on the display station monitor for selection. The ninth test option, navigation data reduction, is for depot use only. The following table describes these tests:

Level I Test Options	
Test Name	**Description**
Inertial navigation element autocalibration	This test option establishes new calibration constants for the INE. After the first four modules have been run, then the 7-hour INE autocalibration module is run followed by the remainder of Level I. After successful completion of testing, the missile is verified operational.
End-to-end	The end-to-end option runs the entire Level I test. Usually, this option is initially run on the missile unless a fault is suspected in a particular module. In this test option, the INE ground alignment module is ran in parallel with the CMRA, flight control, and air data

<table>
<tr><th colspan="2">Level I Test Options</th></tr>
<tr><th>Test Name</th><th>Description</th></tr>
<tr><td></td><td>modules. The Level I end-to-end must be run successfully to verify the missile operational.</td></tr>
<tr><td>Restart</td><td>The restart option allows testing to begin at a particular module and continue to the end of Level I testing. It is used because of test equipment failure, operator error, or operator test termination (trap 1 interrupt) before completion of Level I end-to-end testing. After the first four modules have been run, the program jumps to the selected module. Testing then continues to the end of Level I. The restart option is not available for the CMRA module, INE ground alignment and stationary navigation module, flight control module, or air data module.</td></tr>
<tr><td>Selected module</td><td>
<table>
<tr><td colspan="2">This option is used to verify repair directed by Level I. It may be selected before the Level I end-to-end if a fault is suspected in a particular module. The function of the selected module options is explained in the following table:</td></tr>
<tr><th colspan="2">Test Function of Selected Module</th></tr>
<tr><th>Module</th><th>Function</th></tr>
<tr><td>CMRA</td><td>Tests the operation of the CMRA.</td></tr>
<tr><td>Flight control</td><td>Checks out the ALCM/CALCM FCS. Among other things, this module tests the engine throttle and elevon commands, and checks the performance of the accelerometers and rate gyros.</td></tr>
<tr><td>Air data</td><td>Verifies the operation of the missile air data system.</td></tr>
<tr><td>INE ground alignment and stationary navigation</td><td>The ground alignment portion of this module measures drift and other error parameters associated with the INE platform. These parameters are filtered, and then used for stationary navigation. This module determines if the platform can accurately measure the earth’s rotation and orbit using the parameters. At the end of the module, data is analyzed to see if stationary navigation was successful.</td></tr>
<tr><td>Inertial reference unit (IRU) torqueing/telemetry/ FCE sensor</td><td>Verifies the proper operation of the IRU.</td></tr>
<tr><td>Rotary switch</td><td>Checks the rotary switch contacts and verifies the operation of the enable and squib activation relays. Warhead SAF operations are also tested in this module.</td></tr>
<tr><td>Flight control prelaunch</td><td>The elevons are stowed, and then a prelaunch test is ran that includes an operational check of the fuel boost pump if the missile is fueled.</td></tr>
</table>
</td></tr>
<tr><td>Memory declassification</td><td>This test option declassifies the INE if the operational program is loaded.</td></tr>
<tr><td>Air vehicle digital computer (ADCU) unit memory dump</td><td>This test option provides a printout of the selected ADCU memory contents for fault analysis to determine why a missile may have passed a Level I test, but failed on the B–52.</td></tr>
<tr><td>INE autocalibration</td><td>This test option establishes new calibration constants for the INE. The first four modules are ran followed by the 7-hour INE autocalibration module.</td></tr>
<tr><td>MRATA self-test</td><td>This test option provides an internal test of the MRATA. A minimum warm-up time of 15 minutes is required before performing this test.</td></tr>
<tr><td>Navigation data reduction</td><td>For depot use only.</td></tr>
</table>

Typical preliminary modules of the Level 1

At the top of figure 3–1, you can see the first four modules initialized during a Level I test are master control, interrupt test, power test, and ADCU load and fault test. These modules precede nearly all the Level I test options.

They check the status of specific ESTS and missile circuits required for safe operation and monitoring of the missile during checkout.

- The master control module tests the internal patchboard filters.
- The interrupt test module is used to test the ESTS test interrupt and monitoring circuits, including most cable connections.
- The power test module measures the AC and direct current (DC) buses for proper voltage and isolation.
- The ADCU load and fault test module verifies the correct test program has been loaded into the missile computer and performs INE real-time clock and check-sum testing.

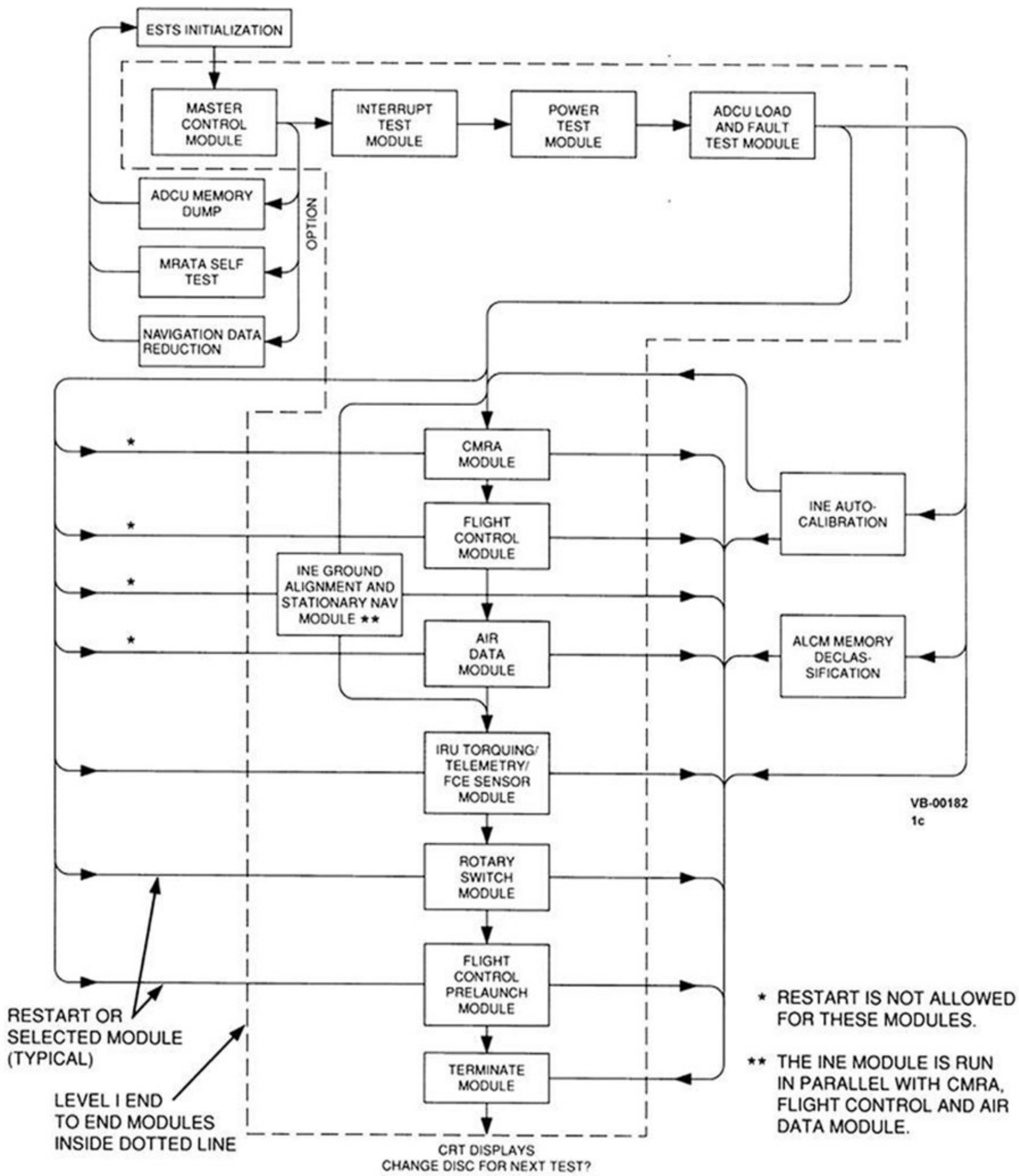


Figure 3–1. ALCM/CALCM Level 1 test modules.

Flight load

After a missile has successfully completed Level I testing, the missile computer must be loaded with the ADCU operational flight load before the missile is returned to service.

Once the ADCU operational flight software (OFS) (classified SECRET) is loaded into the missile, the missile is then classified SECRET. The ESTS station is also classified SECRET because classified operational software may be left on the fixed disk and other memory storage areas. The ESTS station is declassified after the missile flight load is completed using software on the flight load disk

Level II test

Level II testing is performed as a result of Level I test failures that require detailed fault isolation. The Level I and Loaded Pylon/Launcher troubleshooting procedures can also direct this test. A diagnostic pointer number, from the previously mentioned sources, is needed to run a Level II checkout.

017. Fueling operations

The fueling operations you'll perform on the missile are defuel, fueling, and engine prime. You also need to be familiar with emergency actions available should problems arise. We will start with equipment that is associated with these operations.

Support equipment

The fueling operation support equipment consist of the fuel/defuel set, fuel/defuel stand, and air purge and pressurizing unit (APPU).

Fuel/Defuel set

The fuel set consists of a skid, storage tank, trap tank, and hoses (fig. 3–2). The skid is made up of a control panel, bleed down tank, flow meter, pump, vacuum pump, filters, tubing fittings, and a rack to store the hoses. The set has a built in nitrogen gas system (using a facility gas supply) to provide purging and pressurization of the fuel system. The set uses shop air to operate the fuel control valves. The electrical system components are explosion proof and include two pump motors, a vacuum pump motor, a hygrometer, four circuit breakers, and three switches. We will discuss the fuel/defuel set further in the next unit.

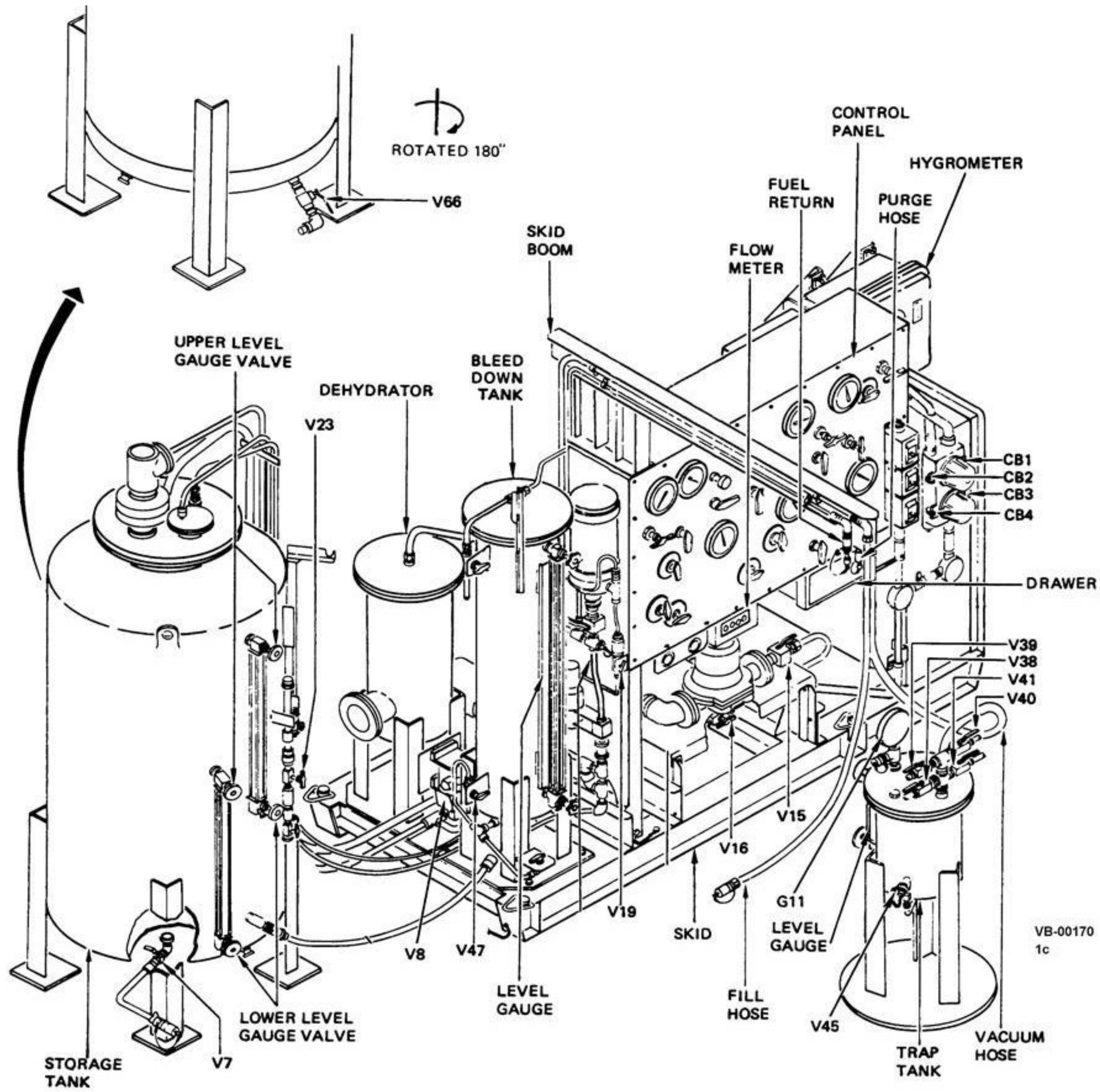


Figure 3–2. Fuel/defuel set.

Fuel/Defuel stands (A/F32R-4)

When performing fueling and defueling operations inside the IMF you will pre-position the missile on a fuel/defuel stand in the fuel room. The A/F32R-4 stands are designed to position the missile within a ½ degree (°) of level for fueling and 4° nose up for defueling. The 4° nose up is accomplished by adding an adapter to the forward stand for defueling. TO 11N-W80.83-2, *Ground Handling Procedures, Missile and Payload, USAF Series AGM-86,* covers the fuel/defuel stand.

Air purge and pressurizing unit

The APPU is a portable cart designed to flush, air purge, and pressurize the engine fuel system (fig. 3–3). The APPU requires shop air to power its internal air motor/fuel pump. Its fuel tank must be filled and waste tank drained sufficiently to perform an engine prime.

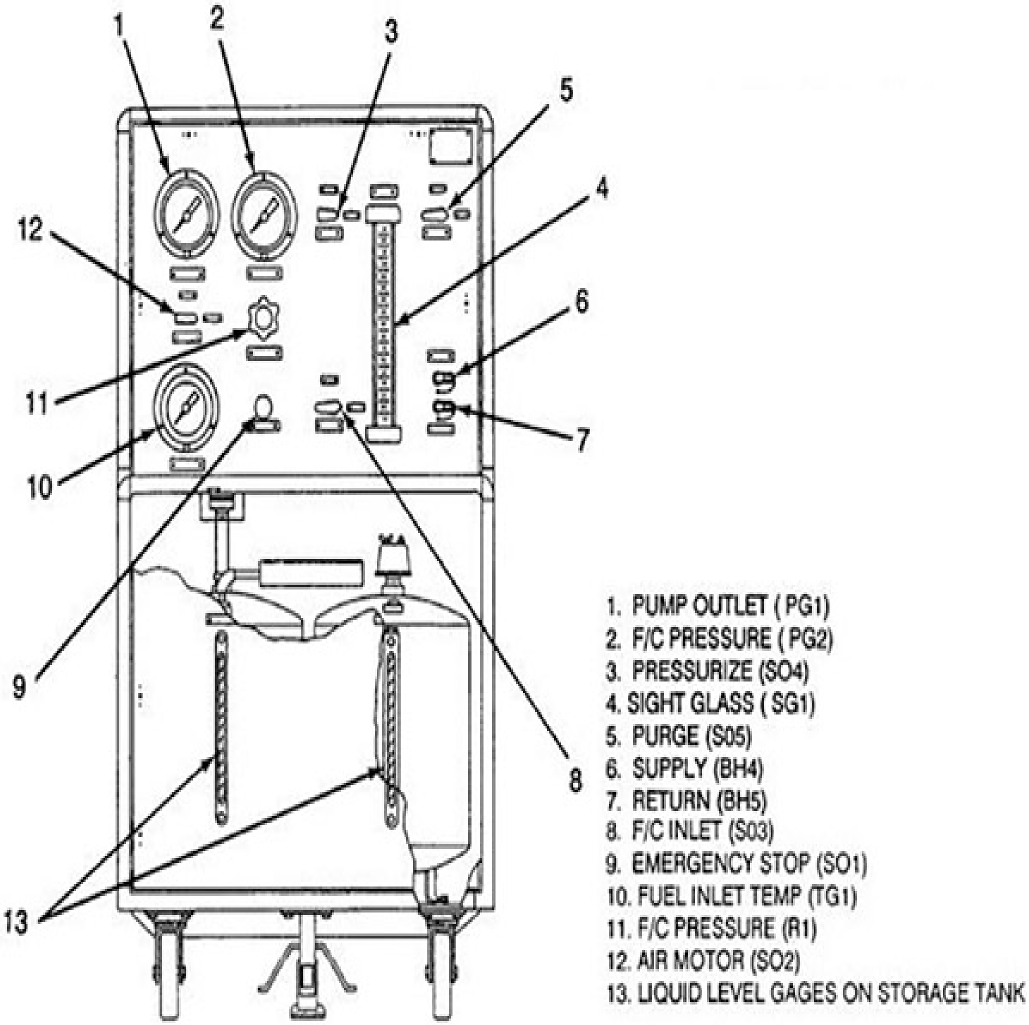


Figure 3–3. Air Purge and Pressurizing Unit.

Defuel

For the defueling operation, the missile is mounted on the fuel/defuel stand in a *nose-up* configuration to aid fuel flow (fig. 3–4). After placing the missile in the nose up configuration, access panels are removed, the nitrogen purge hose from the fuel defuel set is attached, the defueling hose is attached between the missile and the facility fuel return, and the fuel valves are opened. At the fuel/defuel set end, the technicians will first check the nitrogen purge pressure and then open the nitrogen purge valve to begin draining the fuel tanks. When the fuel tanks are empty, the technician will close the nitrogen purge valve and missile fuel valves. Lastly, they will disconnect the hoses.

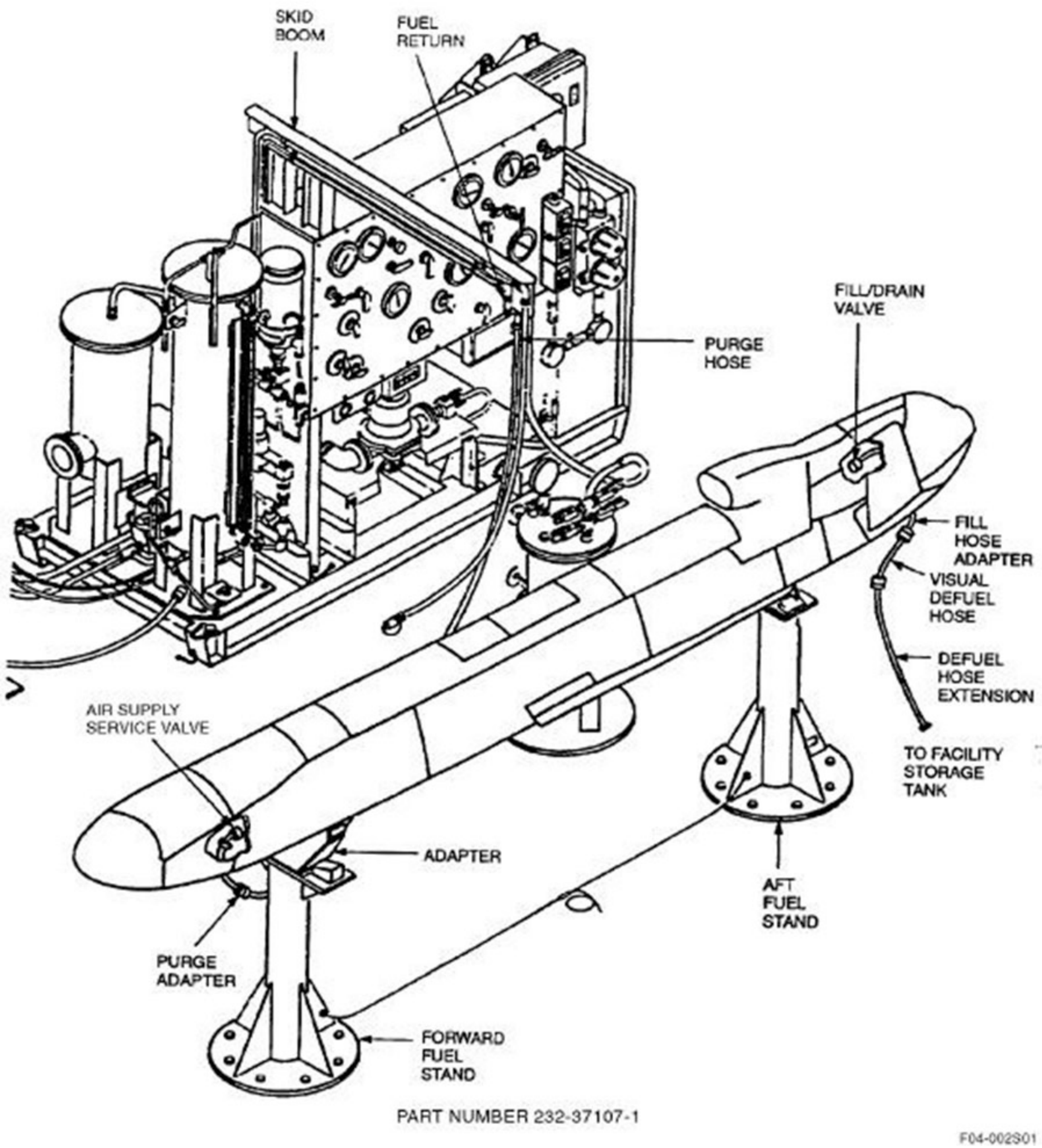


Figure 3–4. Missile defuel operation.

Fueling

The fueling operation is more complex because temperature affects the volume of the fuel. The temperature of the missile must be within plus and minus (±) 20° F of the fuel temperature before fueling begins. After filling the storage tank, checking that the fuel is conditioned (in equilibrium at the loaded pressure), and checking the moisture content for an acceptable degree of dryness, the technicians will prepare the missile for loading. The preparation consists of attaching the fueling hoses and opening the fuel valves (fig. 3–5).

The missile fuel tanks must be evacuated to less than 0.5 pounds per square inch absolute (psia) before filling begins and during the time that the fuel is being loaded. Following the evacuation of the fuel tanks, the technicians fill the missile tanks with jet propellant-10 (JP-10) fuel.
After the tanks are filled, the technicians re-pressurize the tanks to loading pressure and continue filling until the tanks overflow to set ullage.

Ullage is the small portion in the tanks that is not filled with fuel, which compensates for fuel expansion due to temperature changes. The fuel condition is then checked again and the technicians disconnect the hoses from the missile.

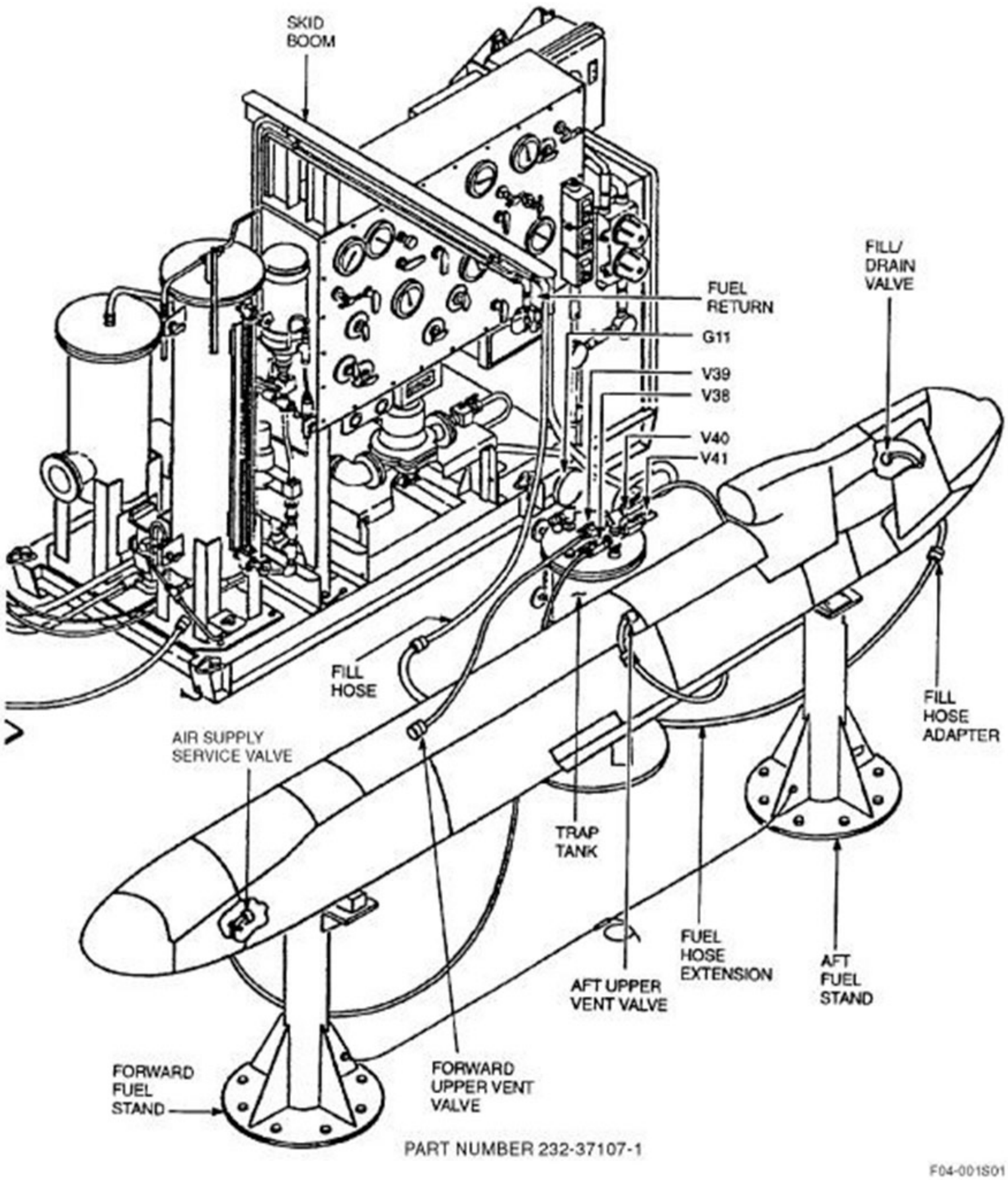


Figure 3–5. Missile fueling operation.

Engine prime

An engine fuel prime is performed to fill the engine fuel system with priming fluid (PF)-1. The technician connects the APPU to the engine fuel system with hoses. PF-1 from the APPU is supplied into the missile's main fuel line and impurities are overflowed out of the other end of two fuel lines – first from the fuel control valve and then the accumulator purge valve. Next, the technician calculates the priming pressure and applies pressurized PF-1 to the accumulator purge valve. This sets the bellows in the accumulator approximately midway.

Finally, the technicians disconnect the hoses from the missile. During this operation, the missile can be seated on either the fuel stand or missile-handling unit. This operation aids engine start.

Emergency actions

In case of an emergency, your technical data provides procedures to stop fueling operations quickly via equipment shutdown. Your technical data also provides missile fuel leak emergency repair and an emergency defueling procedure.

Fuel set emergency shutdown

The fuel set quickly shuts down by closing circuit breakers to turn off electrical power and closing valves on the control panel. These switches and valves are specifically indicated in the TO 21M-AGM86-31, *Operation Instruction–Fuel/Defuel Procedure for AGM-86B Missile.*

Air purge and pressurizing unit shutdown

The APPU has an emergency stop push/pull shut off valve to close off the facility air supply that is used to power it.

Missile fuel leak emergency repair

When a missile fuel leak occurs, the leak must be stopped and a temporary repair must be performed.

There are two methods to stop the leak:

1. Softening dip Oyltite-Stik and applying it to the leak source.
2. Fabricating a bandage, made of absorbent cloth and velostat, to tape it over the leak source.

Temporary repair consists of applying an aluminum patch over the crack and covering it with fiberglass cloth. This patch and cloth is held in place with sealant. These actions are detailed in the TO 21M-AGM86-2-1, *Org Maint Instr—USAF Series AGM-86B Missile (Boeing)*.

Emergency defueling

Low pressure is used to defuel a damaged or leaking missile to minimize leakage. It is conducted on the fuel/defuel test stand for a missile that is upright. In case the missile needs to be inverted, it is installed on a roll collar for defueling. The emergency defuel procedure is located in the TO 21M-AGM86-31.

Self-Test Questions

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

016. Missile checkout

1. What is the primary purpose of Level I testing?

2. Which test option is used for establishing new calibration constants for the INE as well as verifying the missile is operational?

3. Which test option is used to verify repair directed by Level I?

4. What does the missile radar altimeter test assembly self-test option do?

5. What provides you with the diagnostic pointer number required to perform Level II checkout?

017. Fueling operations

1. How does the missile nose-up configuration aid defueling?

2. What type of fuel is used to fill the missile tanks during fueling?

3. What does ullage compensate for?

4. What type of fuel is used for an engine prime?

5. Why is low pressure used during emergency defueling?

3–2. Missile Repair

When performing daily maintenance, some repairs are expected to be repaired when encountered and are considered part of the task assigned. You also need to pay special attention to maintaining hardness. This section consists of structural repair, electrical repair, and hardness critical procedures.

018. Structural repair

Structural repair procedures include repair of composite materials and aluminum castings, threaded insert repair, and captive fastener replacement.

Composite material and aluminum casting repair

Both composite repair and aluminum casting repair consist of "blending out" surface damage on the missile. Blending out consists of sanding the damaged area with sand paper until all raised burrs are flush with the surface around the scratch or abrasion. However, the sand paper grit range used is different for composite material versus aluminum casting. There are different limits for the various missile body areas and surface damage cannot exceed the limit indicated in the TO 21M-AGM86-2-1. Sometimes the damaged area may require fill repair, which is also directed in the same technical order. Composite material repair on the elevons and fin are the most common surface repair you may encounter.

Threaded insert repair

The cruise missile is covered with screw holes in order to safely secure panels. These holes become worn out over time and will require repair. This repair is fairly simple and will normally involve the removal of either a floating or a non-floating insert. To determine if a threaded insert is the floating type, probe the threaded portion of the insert with an awl – a floating type insert will have movement.

The applicable instructions to perform both procedures, floating and non-floating, are in TO 21M-AGM86-2-1.

CAUTION: It is important to remember when doing this work is that the hole depth may *not* be increased when replacing inserts *without* an engineering evaluation.

Captive fastener replacement

Captive fasteners are used to secure the majority of the panels to the missile. Each fastener consists of a stud bolt, a retaining ring, and a plug. This type of repair is quite simple to perform once it is found. The steps performed involve removing the retaining ring, removing the bolt with plug, installing a new bolt and retaining ring, and plugging the new bolt. An important caution to remember is to make certain the inside of holes and countersinks are free of topcoat and contaminants to ensure proper tightening of the fasteners.

019. Electrical repair

Another popular repair that you will experience has to do with electrical wiring. This repair will most likely involve the removal and installation of a shielded heater cable and, afterwards, the installation of cable ties to keep the wires or cables in place.

There are two primary tasks involved in electrical repairs – splice removal and splice installation. Splice removal includes removing heat shrink tubing, a cable jacket, shields, and ferrules. Exercise *extreme* care when removing these items to *prevent* cable damage. Splice installation involves trimming wires, cutting off damaged shielding, stripping wires, replacing heat shrink tubing, and a few other miscellaneous steps in between those listed. These procedures are listed in TO 21M-AGM86-2-1.

Once these repairs are completed, you’ll need to secure the cables with cable ties. Plastic cable ties are used to secure not only single cables but also groups of cables as bundles or attached to support brackets. The ties are self-locking, one-time use items. When the tie is placed around a cable or bundle and pulled tight, it squeezes the cable or bundle and locks it in place. The appropriate cable tie installation tool aids in ensuring the tie is tightly secured.

020. Hardness critical procedures

Hardness critical is a term applied to components that might fail to function properly when exposed to a nuclear environment. A nuclear environment includes nuclear radiation and electro-magnetic pulse (EMP). It is essential to preserve the hardness of these components during maintenance so that the hardened design is not degraded.

Nuclear radiation protection is provided by using parts that have acceptable response or degradation when subjected to a nuclear environment. By preventing unacceptable substitution on hardness critical items, the designed hardness is assured.

Electro-magnetic pulse protection is provided by a combination of the following:

- Ensure all metal enclosures are covered.
- Use filters that attenuate (weaken) EMP induced transients.
- Select components that can survive a nuclear environment.
- Make sure all connectors are electrically bonded to provide shielding against EMP fields.

EMP hardness is highly dependent upon the electrical continuity ground paths between hardness critical components and the missile structure. The inherent hardness of the missile must be maintained by careful attention to certain steps in the procedure for replacement or reassembly.

The following maintenance tasks are of particular hardness concern. Take care not to destroy or alter EMP shielding and electrical continuity by omitting, contaminating or damaging EMP gaskets, and shields. Complete mandatory grounding and bonding and a visual inspection after maintenance.

Use standard torque values for instances where electrical bonding depends on conductive surfaces brought into contact with threaded fasteners unless non-standard torque values are specified. Avoid excess bending and/or pulling of electrical cables and shields during maintenance operations to prevent equipment damage and degradation of system hardness. Retain conductivity of certain metal components that penetrate the missile hull for specific conductive paths between the missile components and the surrounding structure.

Hardness critical procedures (HCP) are identified in the technical orders by the HCP symbol. If the HCP symbol is placed immediately *following* the paragraph number, all of the steps in that paragraph are hardness critical. If *only* some of the steps within the paragraph are hardness critical, only that particular step is marked with the HCP symbol *preceding* it. Warnings, cautions, and notes that pertain to nuclear hardening are marked with the HCP symbol immediately preceding the text of each respectively. Wherever the HCP symbol appears, no deviation of procedures may be made. Failure to comply with this requirement will jeopardize the integrity of the missile.

Self-Test Questions

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

018. Structural repair

1. What is used to perform blending out in both composite material and aluminum casting repair?

2. When performing a threaded insert repair, how can you tell it is a floating type?

3. What part of the captive fastener *must* be removed before the bolt during the captive fastener replacement process?

019. Electrical repair

1. Which two tasks are *primarily* involved when performing electrical repairs?

2. After electrical wiring repairs have been completed, how do you secure the cables in-place?

020. Hardness critical procedures

1. Why must you avoid excess bending and/or pulling of electrical cables and shields during maintenance operations?

2. Where is the HCP symbol placed in a technical order procedure if all the steps in the paragraph are hardness critical?

3–3. Interpreting Missile Diagrams and General Troubleshooting

As a missile maintainer, you will use and rely on various diagrams to perform your job. This is especially critical when troubleshooting the missile. You must be able to read and interpret wiring diagrams to diagnose and correct problems that develop in electrical circuitry. Understanding wiring diagrams is key to learning electrical circuit operations and isolating problems during the troubleshooting process. This section focuses on interpreting missile diagrams and general troubleshooting.

021. Interpreting missile diagrams

Diagrams are used to depict various missile relationships in a visual format. The common types of electrical diagrams you will have to interpret are functional, wiring, and schematic. These diagrams have a threefold purpose and general characteristics, which we will go over first. Then we will go over interpreting each type.

Threefold purpose

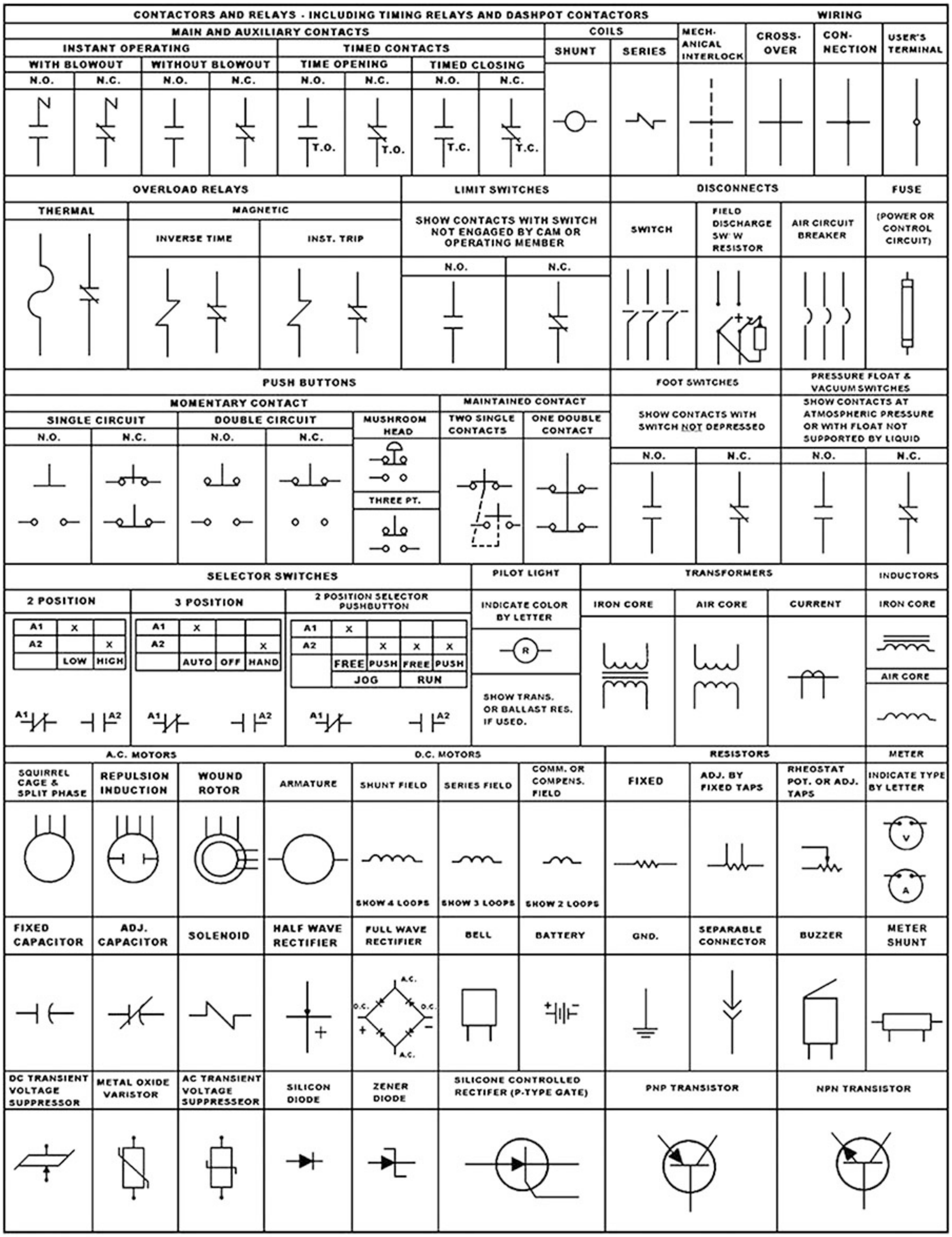
Diagrams have a threefold purpose that provides the benefits noted in the following table:

Purpose and Benefits of Diagrams	
Purpose	**Benefit**
Show system components	Common use of symbols and abbreviations.
Provides a visual picture	This allows you to understand system operation. Shows how components interact with each other. When this is combined with individual component functional and operational descriptive paragraphs in the technical order a technician has the ability to develop a thorough understanding of system operation.
Troubleshooting aid	Provide a quick visual representation of the suspected circuit. This “road map” allows the technician to trace the suspected circuit to the probable cause.

Characteristics of electrical diagrams

The characteristics listed below are fundamental to interpreting basic wiring and schematic diagrams.

1. Unless otherwise indicated, all wiring diagrams show the circuit in a de-energized state, meaning it is shown in the configuration with no power applied. This is especially critical to remember when dealing with circuit components that change a signal route when energized (power applied). Examples of these circuit components are relays and switches that are often shown as graphic symbols.
2. Graphic symbols are used to represent system components and parts. They don’t necessarily represent physical, outward appearance, but rather a component’s or part’s function. They are usually depicted as simple shapes and one shape can be used to represent all versions of a component (fig. 3–6).
3. Many diagrams contain legends (fig. 3–7). Legends are used to convey critical information, which is too large to be incorporated into the picture without detracting from the diagram. Some examples are unique part numbers, voltage tolerances, unique diagram symbol definitions, and so forth.
4. Abbreviations are used to shorten words, phrases, or text. Components, cables, and internal circuit components are commonly abbreviated (fig. 3–7).



VB 00-0004

Figure 3–6. Common electrical symbols.

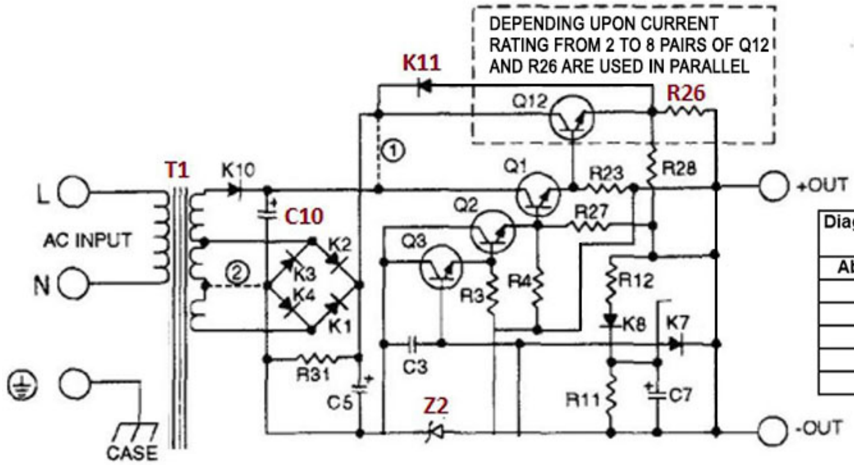


Diagram Abbreviations and Meanings Legend	
Abbreviation	**Meaning**
T1	Transformer 1
C10	Capacitor 10
R26	Resistor 26
K11	Relay 11
Z2	Zener diode 2

Figure 3–7. Typical diagram.

Interpreting diagrams

Just as being able to interpret a road map is important for getting from destination to destination as a driver, you need to know how to read and understand each of the electronic diagram types as a missile maintenance technician.

Interpreting functional or block diagrams

Functional diagrams, also known as block diagrams, are designed to provide the technician with the essential units of the overall system. They are drawn in the form of blocks connected by lines. These lines usually represent the signal path and often have arrows showing direction of flow. These diagrams are very useful because they give a quick general view of an overall system.

Let’s look at the missile FCS functional diagram example below (fig. 3–8). The components are in blocks with the solid lined arrows showing the signal path of each component used to result in elevon movement. The dashed line shows that the elevon position effects the missile altitude, which is a flight data, input for the FDT. It also shows the elevon and FDT are not physically connected.

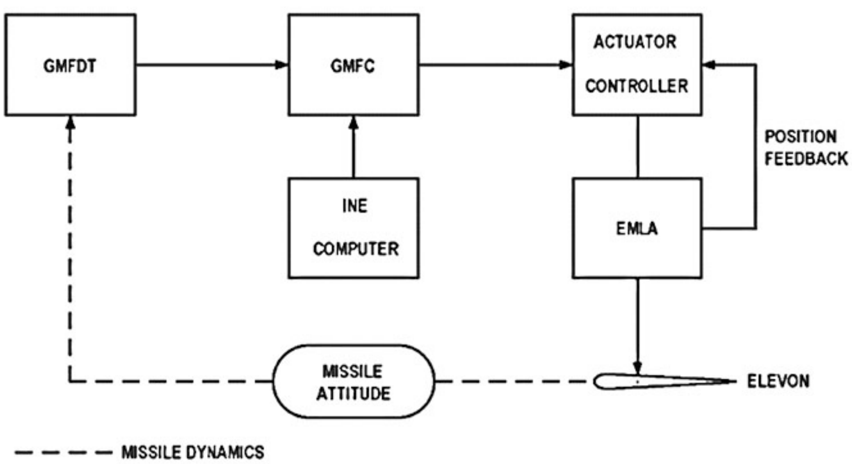


Figure 3–8. Functional (block) diagram example (AGM-86B Flight Control System).

Interpreting wiring diagrams

Wiring diagrams are designed to show the point-to-point connections between components. These diagrams are commonly referred to when troubleshooting test failures or are used to illustrate how to hook up equipment for testing. Wiring diagrams are generally found in two forms—wire bundles (cables) or individual wire runs between connector plugs or jacks.

Let us look at the wiring diagram example of the Level II test hook up (fig. 3–9). You can see that plugs (P) and jacks (J) are used to connect the cable wires (W) to the ESTS patchboard, signal data converter (SDC), and missile assemblies. When W849 is used, you can see it connects at the ESTS patchboard at J13. At the other end of W849 are P2 and J1. P2 connects to the missile INE at 1J6 while J1 connects to W14P2 on the missile.

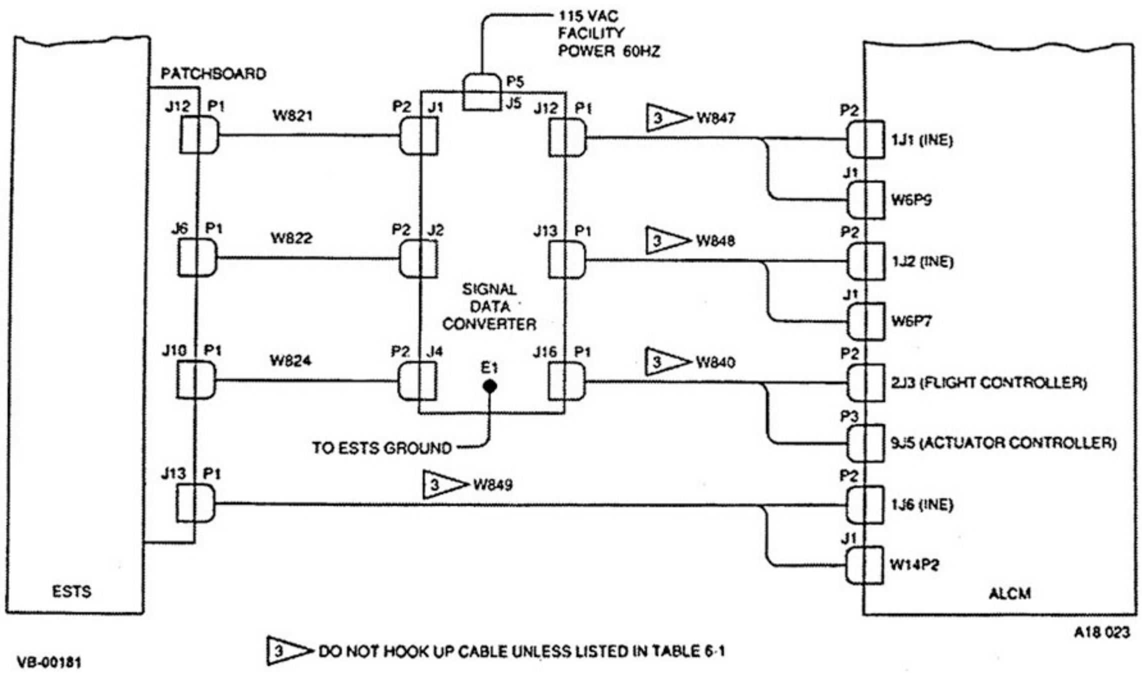


Figure 3–9. Wiring diagram example (Level II test hookup).

Interpreting schematic diagrams

Schematic diagrams provide an even deeper level of detail by showing the interconnections of components in a circuit using straight lines without regard for physical location. Most schematic diagrams use standard symbols and include component values and perhaps tolerances. Schematics are typically used to show you the circuit path for signals through wires and components. To trace a signal connection, you simply follow the black line(s) throughout the circuit. These diagrams are usually depicted in a de-energized state unless otherwise indicated.

Let's take a look at the schematic diagram example for battery signals (fig. 3–10) following the *enable battery activate* signal circuit. It begins with W9P2S connected to the rotary switch at 4J1S, then it energizes relay (K) 2, and is finally routed to the return path. Energizing K2 means the relay switches close (changes to the down position). This allows the *battery activate* signal to travel past K2, out the rotary switch at 4J2E and D, and to the battery at 7J2B and A. This activates the battery. The signal begins its return path leaving the battery at 7J2C.

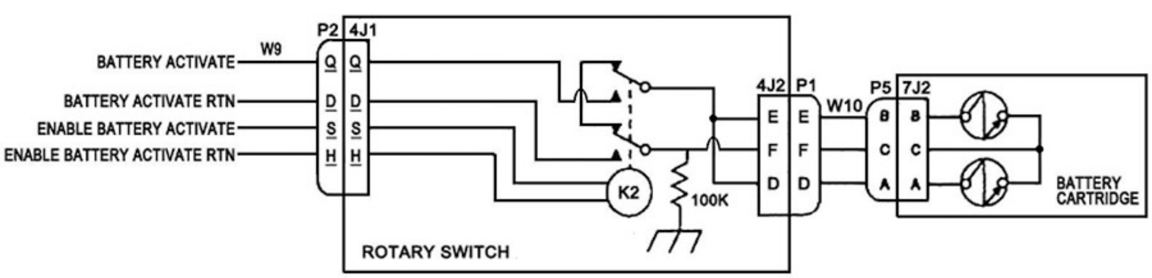


Figure 3–10. Schematic diagram example (AGM-86B battery signals).

022. General troubleshooting

Troubleshooting is performed because of a test failure when you must find and correct the cause of the fault. The cause typically falls under three categories: operator error, test equipment malfunction, or missile malfunction. There are many things you can try to identify the cause. Remember, every time you try to correct the suspected cause you must run the test again to verify your repair fixed the fault. It is also a good idea to document what you tried and what actually fixed the problem. This data helps other test operators continue on going troubleshooting and repair similar faults in the future. Now let's go over some general troubleshooting methods.

Look at the test data

The test failure typically provides you with a starting point. Look at the test that was ran, the measured value, and the expected value. Comparing the measured value to the expected value can show you if the reading was too high, too low, or if no signal was received. Your test number can be correlated against your test diagnostic table (from the test procedure technical order) to *find* the cable and pins used for the test. This data may help you identify the signal path.

Check test hookup

Look over the test hookup to make sure connections/hoses are properly connected and seated. During this check, you must also watch for bent or broken pins. You must use your senses, for example, burning smells or marks and odd noises can signal you to a specific problem area. It is a good practice to look over your entire test hookup to avoid another failure later on in the test operation. Your test equipment must also be checked to make sure the settings are correct. Since tests are usually ran after missile component replacements, you should also check the missile connections. It is also common practice to reseat the patchboard panel because the patchboard provides the majority of cable interfacing between the missile and test equipment to the ESTS.

Check circuit for continuity

Another troubleshooting method is to measure the circuit path for continuity with a multimeter. It's done by setting the multimeter to ohms (Ω) and placing its test leads on the suspected circuit for a resistance reading. However, the cables to be measured are usually very long, so a smaller conductive cable called a *jumper* is typically installed on one end of the cable to be measured. One end of the jumper is placed on the cable backshell (ground) and the other on the cable pin (being tested). This helps close the circuit path for measurement with the multimeter on the other end of the cable. One multimeter test lead is placed on the cable backshell (ground) and the other on the corresponding cable pin. This closes the circuit to get a resistance reading. See the table below for reading meanings.

Continuity Check	
Reading	**Meaning**
0 Ω	Continuity
OL	No continuity

Keep in mind your multimeter may *not* read exactly 0 Ω but something very close. You will look for a reading close to the measurement you get when you touch the multimeter test leads together. No continuity (an open) means you have likely found the cause of your fault; however, there can be more than one cause. Another thing to watch out for is loose pins that can cause an intermittent fault. For this issue you can *gently* bend your cable while checking for continuity, however, take care *not* to exceed the cable's bend radius.

Replace items

Another troubleshooting method is replacement. You can replace many items such as test cables, test equipment, or missile components (as a temporary install). You can even move the missile to a different test station.

Research

A more difficult failure may need to be researched. Look over maintenance history in IMDS and local databases to find more information on the fault and the missile. The history may provide you with trends or how your test failure was repaired on another missile. In addition, look into what maintenance was performed on your missile that may be related to your fault. Your technical order may provide you with other avenues to check and you can always reach out to experienced coworkers for guidance.

Self-Test Questions

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

021. Interpreting missile diagrams

1. What is the benefit of diagrams when used as a troubleshooting aid?

2. Unless otherwise indicated, in which electrical state does a wiring diagram show a circuit?

3. Interpret which component receives the position feedback signal from the EMLA using Figure 3-8, Functional (block) diagram example (AGM-86B Flight Control System).

4. Interpret which three cable wires connect the ESTS patchboard to the SDC using Figure 3-9, Wiring diagram example (Level II hookup).

5. Interpret where the *enable battery activate return* signal goes next after activating K2 using Figure 3-10, Schematic diagram example (AGM-86B battery signals).

022. General troubleshooting

1. What can your test number be correlated against to find cables and pins used for the test?

2. Why is it a good practice to look over your entire test hookup?

3. What does an “OL” reading mean when checking a circuit for continuity?

4. Which general troubleshooting method includes moving the missile to a different test station?

Answers to Self-Test Questions

016

1. To verify the operational capability of the missile.
2. Level I with inertial navigation element autocalibration.
3. Level I selected module.
4. Provides an internal test of the MRATA.
5. Level I and the troubleshooting procedures of the Level I and Loaded Pylon/Launcher.

017

1. Fuel flow.
2. JP-10.
3. Fuel expansion.
4. PF-1.
5. To minimize leakage.

018

1. Sandpaper.
2. Probe the threaded portion of the insert with an awl to detect movement.
3. The retaining ring.

019

1. The splice removal and splice installation.
2. Cable ties.

020

1. To prevent equipment damage and degradation of system hardness.
2. Following the paragraph number.

021

1. They provide a "road map" to trace a suspected circuit.
2. De-energized state.
3. Actuator controller.
4. W821, W822, and W824.
5. 4J1$\underline{\text{H}}$.

022

1. The test diagnostic table.
2. To avoid another failure later on in the test operation.
3. There is no continuity in the circuit.
4. Replace items.

Complete the unit review exercise 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.

33. (016) Which Level I test option allows testing to begin at a particular module and continue to the end of Level I testing?
    a. Level I restart.
    b. Missile radar altimeter test assembly self-test.
    c. Level I selected option.
    d. Level I with inertial navigation element autocalibration.

34. (016) Which Level I module tests the internal patchboard filters?
    a. Power test module.
    b. Interrupt test module.
    c. Master control module.
    d. Air vehicle digital computer unit load and fault test module.

35. (016) Which missile checkout test requires a diagnostic pointer number to be run?
    a. Level I.
    b. Level II.
    c. Flight load.
    d. Empty missile.

36. (017) Which cruise missile fueling operation sets ullage to compensate for fuel expansion?
    a. Fuel.
    b. Defuel.
    c. Engine purge.
    d. Engine pressurization.

37. (017) Which cruise missile fueling operation supplies priming fluid–1 (PF–1) to the main fuel line?
    a. Fuel.
    b. Defuel.
    c. Engine prime.
    d. Emergency prime.

38. (017) What is used during emergency defueling to *minimize* leakage?
    a. Low pressure.
    b. High conditioning.
    c. Circuit breaker shutoff.
    d. Emergency stop valve closure.

39. (018) Which two types of structural repair consist of "blending out" surface damage on the missile?
    a. Threaded insert and captive fastener repair.
    b. Aluminum casting and captive fastener repair.
    c. Composite material and threaded insert repair.
    d. Composite material and aluminum casting repair.

40. (018) When performing threaded insert repair, what part of the hole may *not* be increased when replacing inserts *without* an engineering evaluation?
    a. Cap.
    b. Depth.
    c. Width.
    d. Thread.

41. (019) During which electrical repair, *must* extreme care be taken when removing items to prevent cable damage?
    a. Splice removal.
    b. Threaded insert.
    c. Splice installation.
    d. Threaded removal.

42. (019) What is used to secure recently repaired electrical wires?
    a. Tape.
    b. Cable ties.
    c. Wire wraps.
    d. Velco straps.

43. (020) Where is the hardness critical procedure (HCP) symbol placed on a technical order procedure to indicate all the steps in the paragraph are hardness critical?
    a. Prior to notes.
    b. Preceding every step.
    c. Within corresponding tables.
    d. Following the paragraph number.

44. (020) Where is the hardness critical procedure (HCP) symbol placed on a technical order procedure to indicate *only* some of the steps within the paragraph are hardness critical?
    a. Prior to notes.
    b. Preceding every step.
    c. Within related figures.
    d. Within corresponding tables.

45. (021) Which type of electrical diagram provides a general view of essential units in an overall system using blocks connected by lines?
    a. Zen.
    b. Wiring.
    c. Functional.
    d. Schematic.

46. (021) Which type of electrical diagram shows components in a circuit using straight lines without regard for physical location and are usually depicted a de-energized state?
    a. Zen.
    b. Wiring.
    c. Functional.
    d. Schematic.

47. (022) Which fault test data can be correlated against the technical order test diagnostic table to find the test cable and pins used?
    a. Test option.
    b. Test number.
    c. Test expected valve.
    d. Test measured value.

48. (022) What additional item is installed on one end of a long cable to be measured when checking for continuity to help close the circuit?
    c. Solder.
    b. Gasket.
    c. Jumper.
    d. Amplifier.

Please read the unit menu for Unit 4 and continue ➔

Unit 4. Cruise Missile Support, Test Equipment, and Generation

BEING A MISSILE maintainer requires you to be familiar with more than just the missile. Maintenance requires use of a variety of equipment that supports repair, servicing, and testing operations on a daily basis. You are also responsible for testing and transporting pylon and launcher used to interface the missile with the aircraft at a moment's notice. To maintain rapid missile-to-aircraft integration readiness, you will participate in wing-wide operational exercises to provide an effective weapon system ready for war.

This final unit consists of five sections. It begins with missile support equipment and the fuel/defuel set. Second, the electronics systems test set (ESTS) and the air data test set (ADTS) will be covered. Third, we review the test equipment that supports missile checkout. Fourth, we describe the pylon and launcher systems and their respective checkout. Finally, we explain procedures related to cruise missile generation.

4–1. Missile Support Equipment and Fuel/Defuel Set

Missile support equipment plays a big role in maintaining the ALCM and CALCM weapon systems. This includes handing support equipment and the fuel/defuel set.

023. Handling support equipment

Missile handling support equipment helps you work on the missile system. They are specially designed for missile tasks like transport, assembly/disassembly, testing, and servicing. As a cruise missile technician, you'll use several pieces of handling support equipment on a daily basis.

Guided missile handling unit

The guided missile handling unit (MHU-159/E) (fig. 4–1) is a box-type, steel welded stand used to support missile transfer, transportation, and storage. Various missile maintenance tasks can be performed with the missile on the guided missile handling unit such as touch-up painting, panel and fastener repair, engine fuel-priming and miscellaneous component replacement. The cruise missile is secured to the stand from underneath by locking bolts, which are torqued. Once the missile has been secured to the stand, it *must* be grounded to the facility ground.

As a technician, you will also be directly responsible to maintain the stand itself to include replacing the missile protective pads, inspecting and replacing grounding jumpers, and correcting general wear and tear of the stand. TO 11N-H5054-2, *Org Maint Instr with IPB – Missile*, provides procedures for maintaining the MHU-159/E stand.

Figure 4–1. Guided missile handling unit.

Guided missile hoisting beam

Another popular piece of support equipment you will use is the guided missile hoisting beam (MHU-186/E). This beam is attached to the missile so it can be lifted and moved using a hoist-monorail system within the facility (fig. 4–2). It is used to transfer the missile between test stands, handling units, and fuel/defuel stands, and anywhere in the building to complete work. The MHU-186/E is a rectangular beam with safety locks and a sling link and shackle (assembly). The sling link and shackle can be installed in one of the six different positions on the beam. The position used depends on the missile configuration being handled.

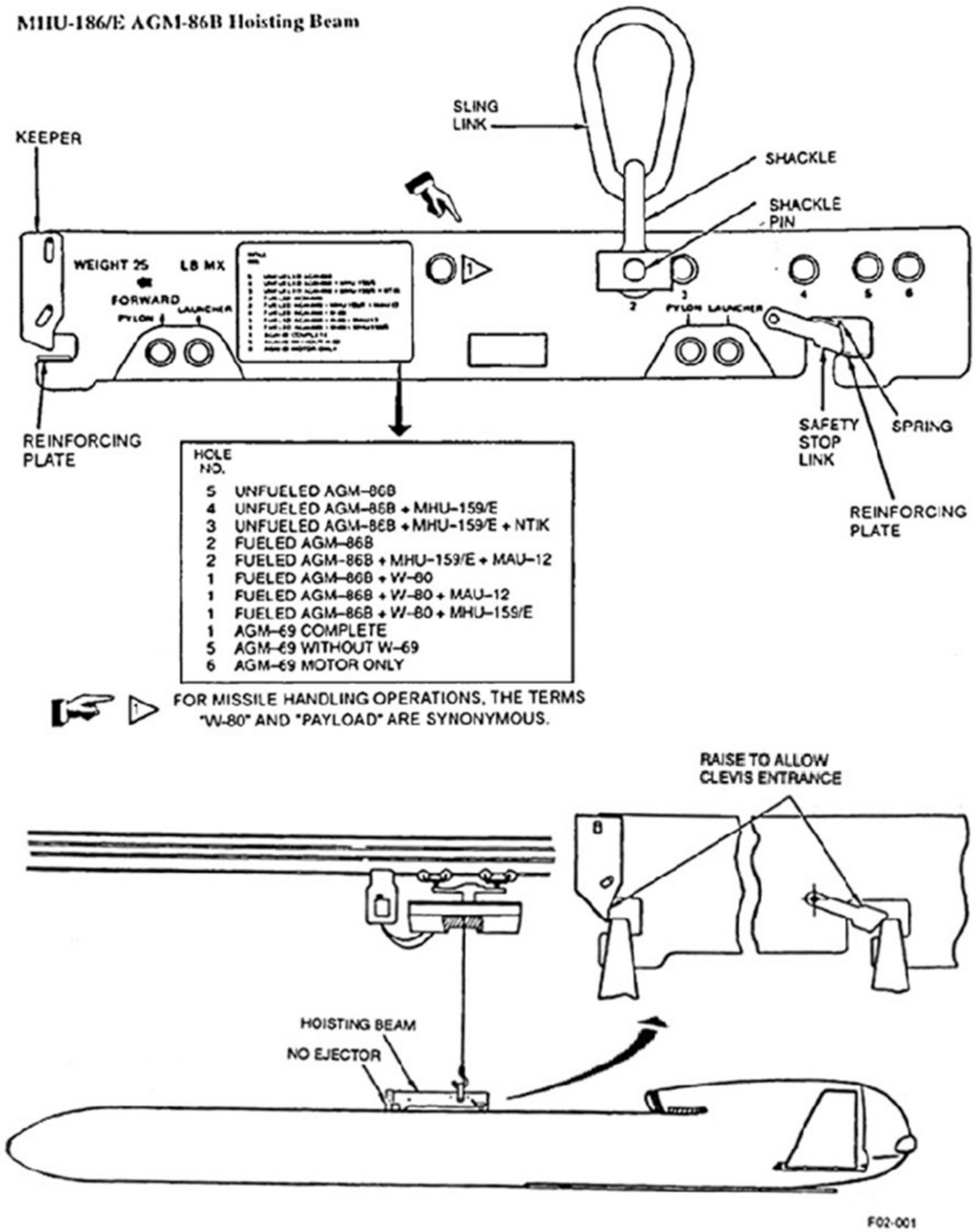


Figure 4–2. Guided missile hoisting beam.

Guided missile test stand

The guided missile test stand, MSU-179/E, is used to support the AGM-86 cruise missile during maintenance and testing in the IMF. The test stand itself consists of a set of two pedestals bolted to a level floor and aligned to a known heading (fig. 4–3). The stand holds the missile approximately 45 inches above the floor. Each pedestal is composed of a round steel base with triangular reinforcement flange plates welded to the base and the central cylinder.

This particular cylinder acts as a support for a holding fixture and pad. An inspection of these stands is required daily and prior to use much like the majority of the equipment you will work with. The purpose for these inspections are to make sure the equipment is not only ready but also safe to use. TO 35D3-11-45-2, *Org Maint Instr with IPB AGM-86 Missile Support Equip*, is the technical data you will use to maintain this equipment.

Figure 4–3. Guided missile test stand.

Missile engine handling truck assembly

The missile engine handling truck assembly, ETU-102/E, is used to hold the missile engine when it is not installed in the missile (fig. 4–4), such as when an engine is being prepared for installation or shipment. The missile engine handling truck is a welded steel structure that provides the engine with three-point support/suspension. The three attachment points consist of the two arms and a hinged engine attachment rod that hangs from the cross beam. The crossbeam attaches to the vertical support fixtures of the truck with two captive quick release pins. Caster wheels provide easy mobility of the approximately 149-pound engine when installed on the truck, and the wheels can also lock into place for stability. The missile engine handling truck assembly is covered in the same technical data as the guided missile stand.

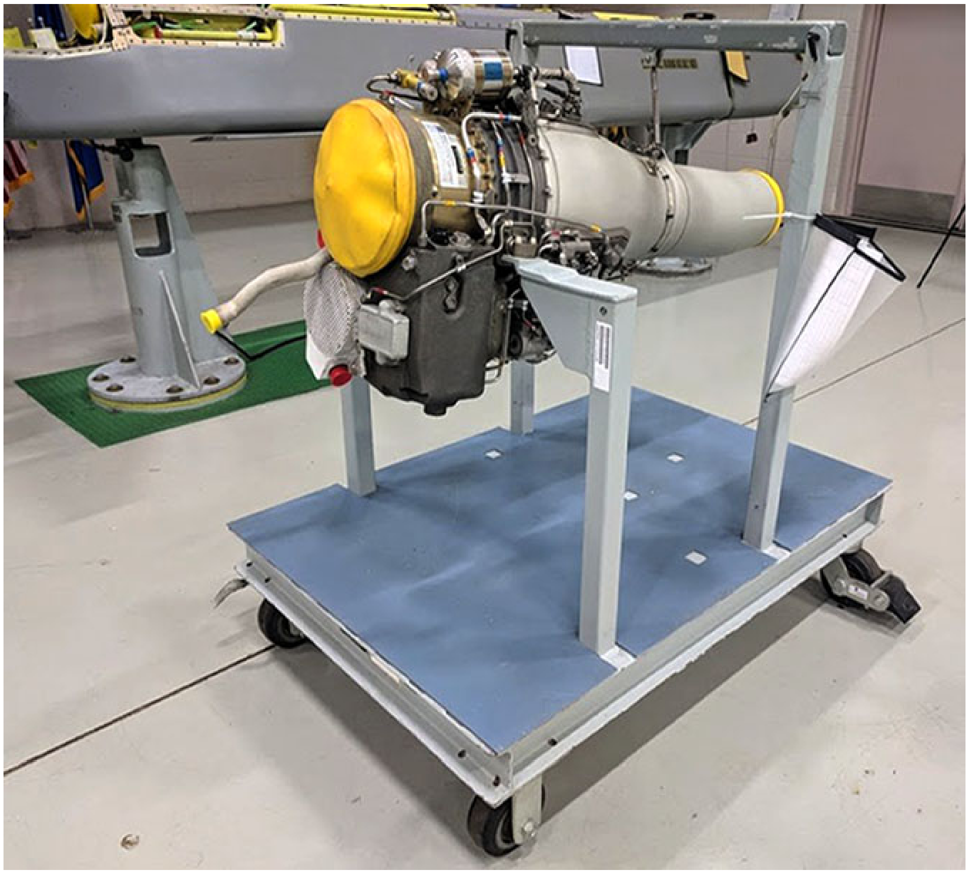


Figure 4–4. Missile engine handling truck assembly.

024. Fuel/defuel set

The fuel/defuel set is used for two main reasons: (1) to supply pressurized filtered fuel for servicing a missile, and (2) to drain and purge fuel from the missile. There are five systems that pertain to the fuel defuel set: shop air, nitrogen, fuel piping, vent, and vacuum systems. The fuel/defuel set and its control panel are illustrated below in figures 4–5 and 4–6 respectively.

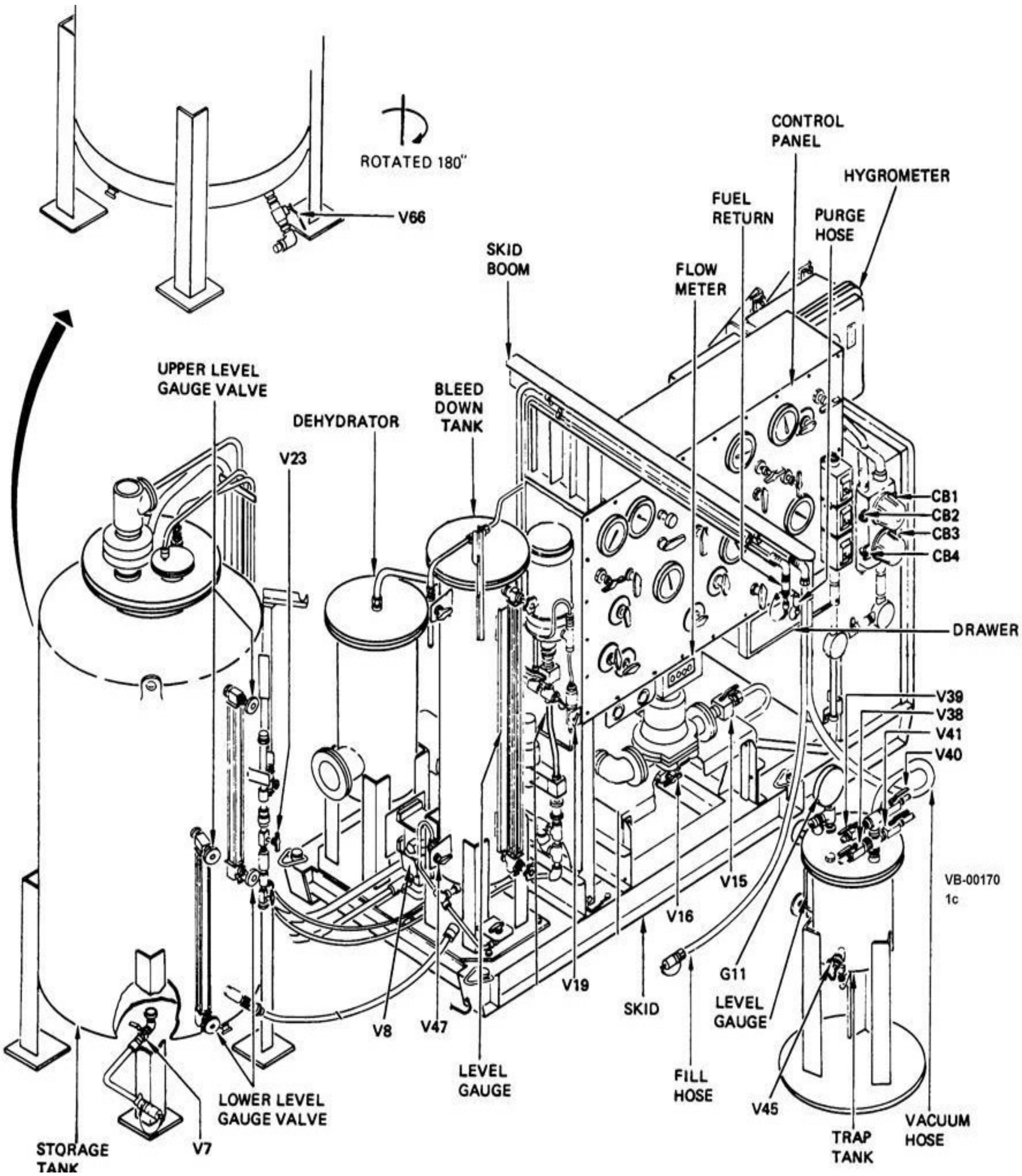


Figure 4–5. Fuel/defuel set.

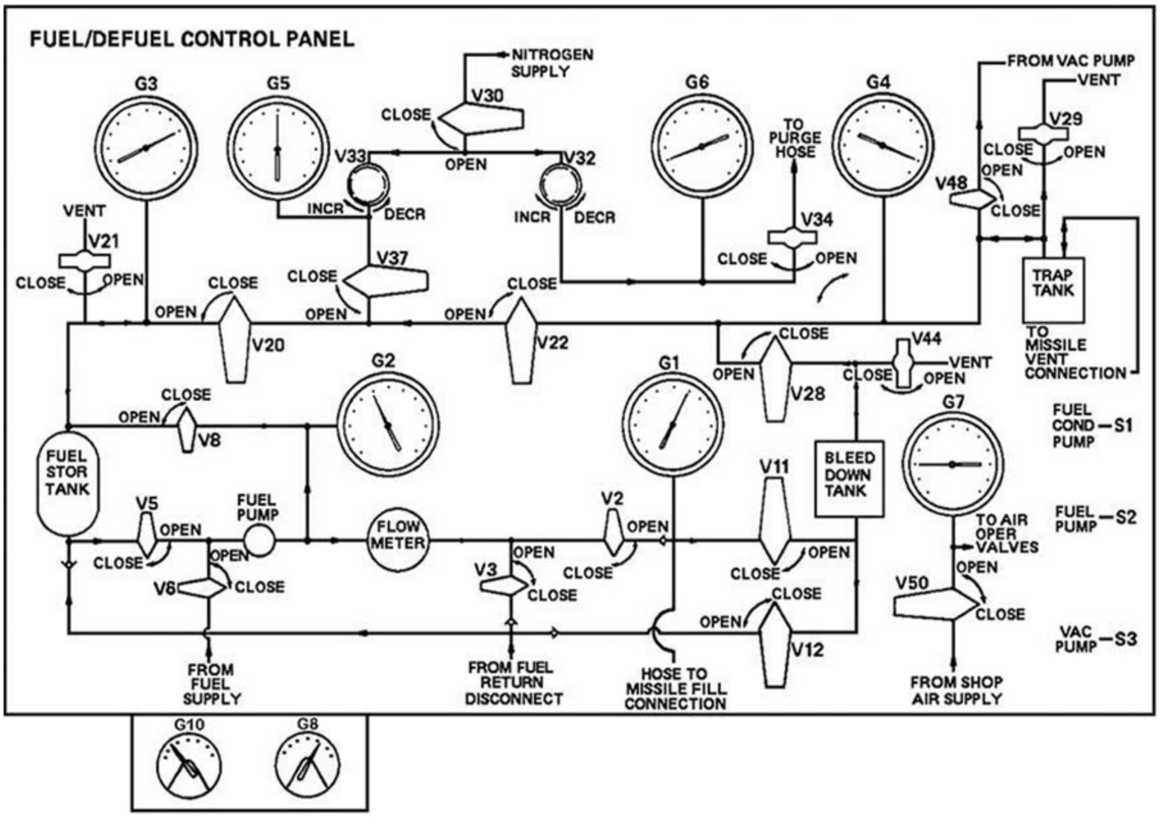


Figure 4–6. Fuel/defuel set control panel.

Shop air system

The fuel/defuel set uses shop air to operate the fuel control valves. Shop air is supplied from facility air at 100 ± 10 pounds per square inch gauge (psig). Control panel V50 supplies air through filter (FLT) 5 to open six air operated valves: V2, V3, V5, V6, V8, and V48. Pressure supplied through V50 is indicated on gauge G7. Air is required to open these particular valves, however, air is not required to close them. A spring return mechanism in the actuator automatically closes the valves when there is a loss of pressure.

Nitrogen system

The nitrogen system provides purging and pressurization for fueling operations. Nitrogen is supplied from facility air at 100 ± 10 psig. Control panel V30 controls nitrogen flow to the fuel/defuel set and supplies nitrogen through FLT 4 to pressurize regulators V32 and V33. The maximum nitrogen pressure is limited to 40 psig by relief valve V31. Valve V32 regulates nitrogen pressure for draining and purging missiles. Purge pressure is indicated on gauge G6 and is limited to 40 psig by V35. Valve V33 regulates nitrogen pressure for fueling the missile, draining the storage tank, bleed down tank, and trap tank, and draining and purging fuel set components for maintenance.

Fuel piping system

The fuel piping system circulates fuel through the system filters and dehydrator prior to fueling a missile. During the fueling procedure, fuel is circulated through system filters V2 and V3 by the fuel pump. During fuel conditioning, fuel is circulated through V8 and system filters by the conditioning pump. Fuel is loaded aboard the missile by the fuel pump at a predetermined loading pressure. Pump pressure is indicated on G2 and is limited to 50 psig by valve V9. Fuel is always routed through the system filters prior to entering the storage tank.

Vent system

The vent system prevents a buildup of fumes or over-pressurization in the fuel/defuel set. Maximum pressure in the storage tank is limited to 25 psig by the rupture disc and can be manually vented through valve V21. Relief valves V31, V35, V36, and V62 prevent the nitrogen system from becoming over-pressurized. The vent system provides an exhaust for the vacuum pump during missile fueling and provides a vent for the trap tank and bleed down tank. The entire system is vented through the facility ventilation system.

Vacuum system

The purpose of the vacuum system is to evacuate the missile fuel tanks during missile fueling operations and aids in draining trap tank hoses after fueling. Trap tank vacuum pressure is indicated on gauge G11 on the trap tank. Vacuum pump pressure is indicated by gauge G4 on the control panel. Check valve V49 prevents airflow into the vacuum system.

Self-Test Questions

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

023. Handling support equipment

1. Which handling unit is used to support a cruise missile for storage, transportation, and handling?

2. What part of the guided missile hoisting beam can be installed in one of six different positions depending on the missile configuration?

3. What piece of equipment is used to hold the missile during testing and consists of two pedestals bolted to the floor and aligned to a heading?

4. What part of the missile engine handling truck provides easy mobility but can also be locked into place for stability?

024. Fuel/defuel set

1. What happens when there is a loss of pressure in the air-operated valves of the shop air system?

2. What happens to fuel prior to entering the storage tank in the fuel piping system?

3. Which system uses relief valves to prevent the nitrogen system from becoming over-pressurized?

4. What is the vacuum system used for during missile fueling operations?

4–2. Electronic Systems Test Set and Air Data Test Set

The Electronics Systems Test Set (ESTS) AN/GSM–263 consists of many pieces of equipment used for testing operations. This section will familiarize you with its make-up and expand on the ADTS.

025. Electronics systems test set

The ESTS is located in the ESTS room of the IMF (fig. 4–7). It is used to check out the following units under test (UUT):

- AGM–86B/C.
- B–52H CSRL:
- Empty missile check.
- Loaded missile check.
- Empty nuclear bomb check.
- B–52H pylon
- Empty pylon check.
- Loaded pylon check.
- B–52H munitions-related line replaceable units (LRU):
- Decoder/receiver (also known as the missile interface unit [MIU]).
- Nuclear station logic unit (NucSLU).

Along with testing missiles and carrier aircraft equipment, the ESTS is capable of testing itself.

The ESTS operates under computer control, which provides power, stimuli, switching, measurement, monitoring, and processing actions during checkout of the UUT. The main units of the ESTS are the main rack, a UUT power rack, an ADTS rack, a display station, and a printer (see the fig. 4–7 below). This lesson will describe each of the units in the ESTS. Before we do that, we must touch on reference designators.

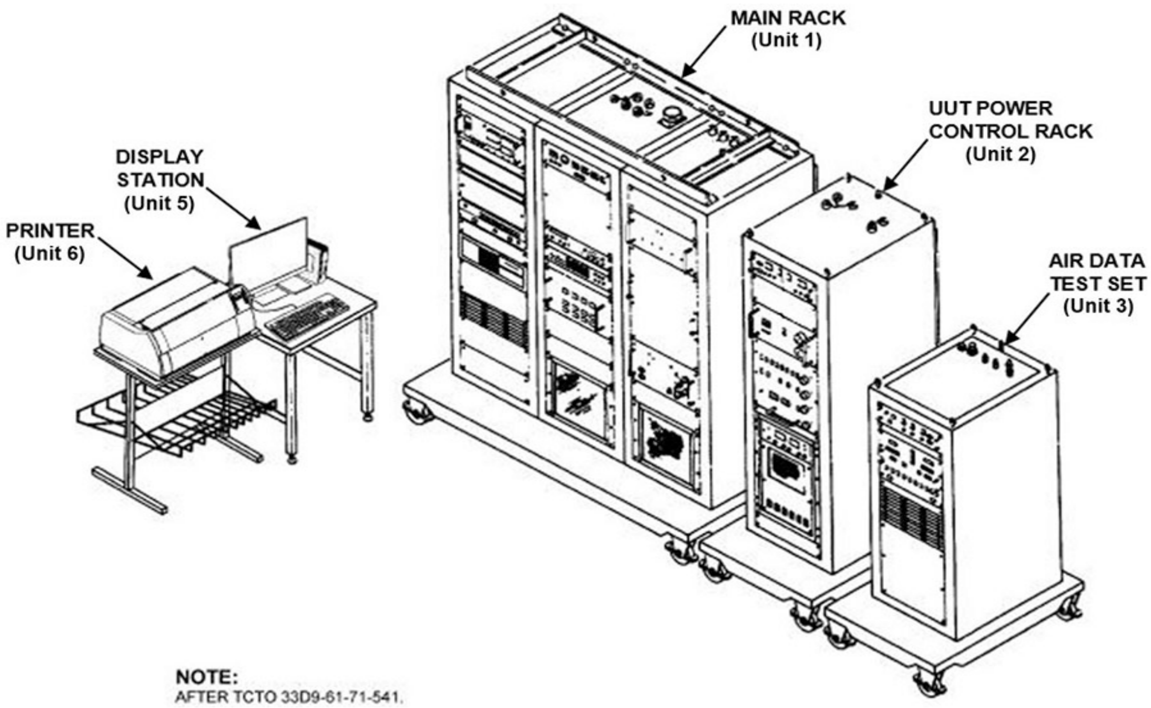


Figure 4–7. ESTS units.

Reference designator

Reference designators are alphanumeric digits assigned to items within the ESTS units to identify them easily. An example of a reference designator is “1A16” that is assigned to the interface electronics. We will focus on the first two parts of the reference designator, which you will typically encounter when performing test operations.

Unit

The first part is a single numerical digit, which identifies the unit of the ESTS. See the table below for the unit number assignment.

ESTS Major Units	
Unit	**Name**
1	Main rack
2	UUT power control rack
3	ADTS.
5	Display station
6	Printer

For 1A16, the first part is a “1” which means the interface electronics is located in the main rack of the ESTS. The first part is always a number.

Assembly

The second part is the letter “A” followed by one or two digits; it represents an assembly within a unit. These assemblies are main components and may be called drawers. For 1A16, the second part is “A16” which means the interface electronics is designated as assembly 16. On figure 4–8, the interface electronics (1A16) within the main rack is circled on the right side.

You will see reference designators located next to its assigned item on the racks of the ESTS. They are also used in technical orders.

Main rack (unit 1)

The main rack is a three-bay rack that contains several electrical components used for system control, interfacing, measuring, and monitoring functions (fig. 4–8). The left side of the main rack is Bay 1, the center is Bay 2 and the right side is Bay 3. We’ll briefly go over them.

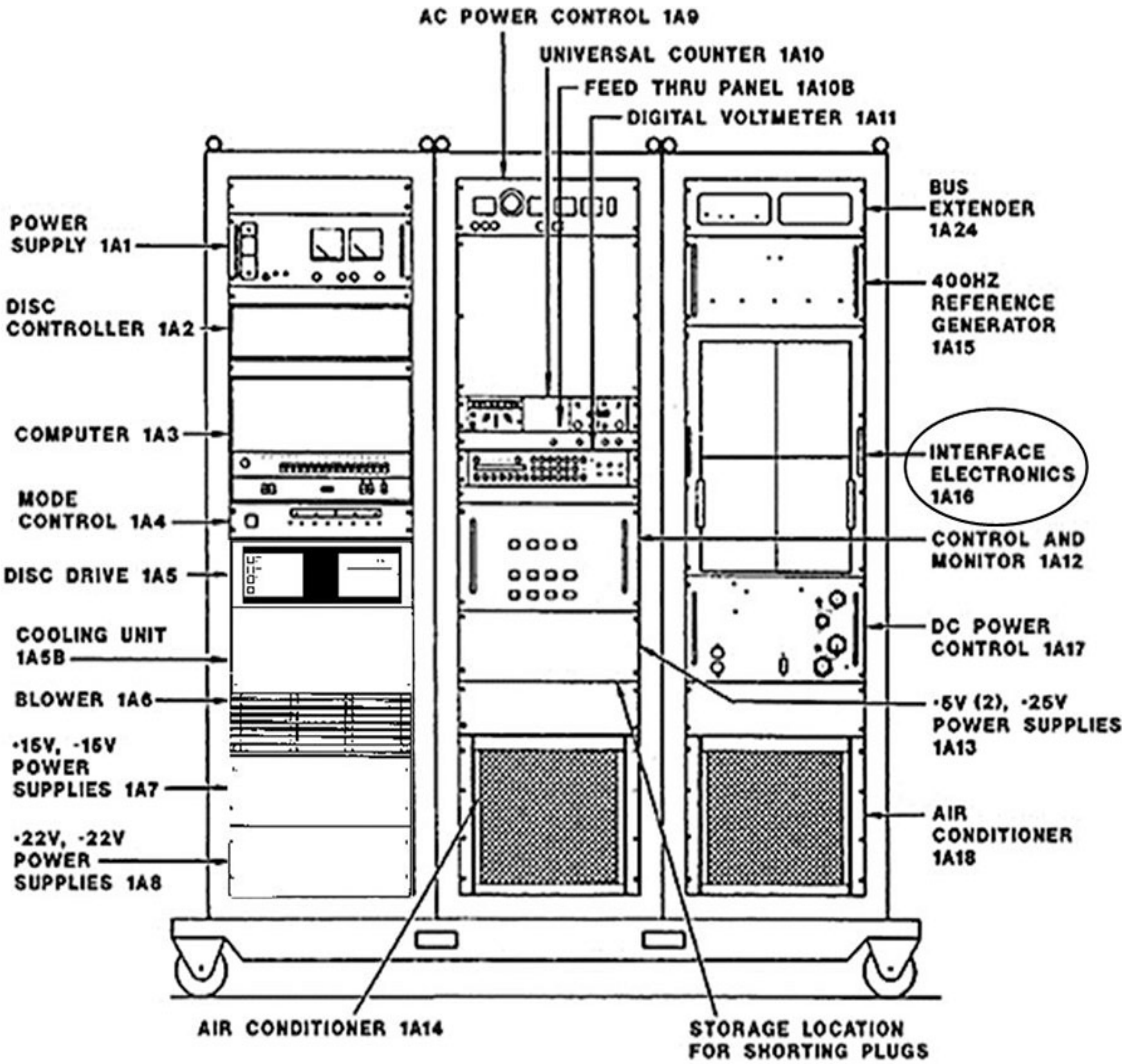


Figure 4–8. ESTS main rack.

Bay 1

This bay has a programmable 0-to-60 V power supply (1A1) used to power the UUT. A key component is the digital computer (1A3) that controls the entire ESTS. This computer controls, sequences, and evaluates the ESTS and UUT operations using software programs stored in the disk drive (1A5)(fig. 4–9). The disk drive is a mass storage device for computer program data, known as software, which is transferred to and from the computer. Data are translated and bi-directionally transferred between the computer and disk drive by the disk controller (1A2). The Mode Control panel (1A4) contains switches used to select special ESTS testing and print modes. The Blower (1A6) circulates room ambient air in bay 1 to cool equipment drawers. This bay also contains four power supplies (1A7 and 1A8) for the ESTS and the UUT, which are ± 15 VDC, and ± 22 VDC.

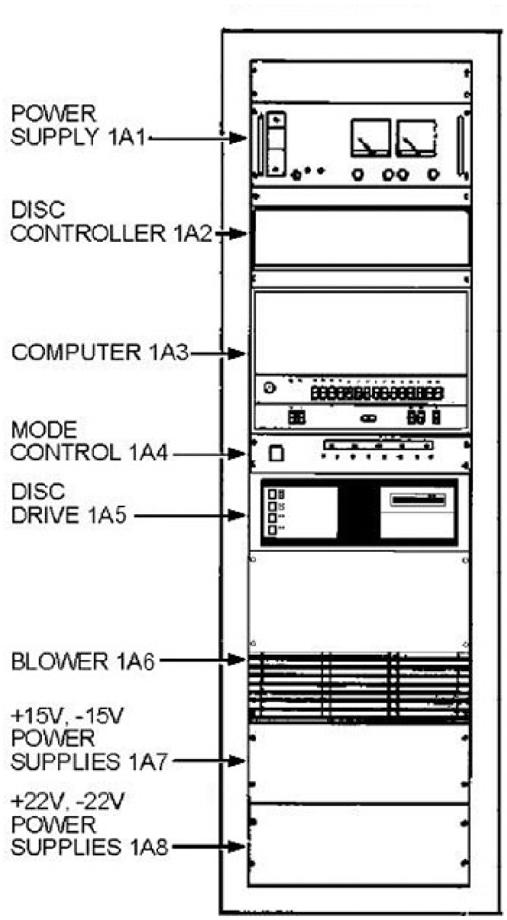


Figure 4–9. ESTS main rack bay 1.

Bay 2

Bay 2 has a power control panel (1A9) that controls 60 Hertz (Hz) power and circuit overload protection to the ESTS. The universal counter (1A10) measures many frequency and time interval signals of the UUT. A feed-through panel (1A10B) connects the universal counter and interface electronics (in bay 3) to send the signals to be measured. The digital voltmeter (1A11) measures DC voltage, AC voltage, and DC resistance levels of the UUT. The control and monitor (1A12) monitors voltages, currents, and critical signals within the ESTS and UUT (fig. 4–10). Any out of tolerance conditions sensed by the control and monitor panel will cause the computer (1A3) to stop testing and remove power from the UUT. This bay also has three power supplies (1A13).

- + 25 VDC power is for ESTS standby and UUT operation.
- + 5 VDC power is for UUT operation only.
- + 5 VDC power is for ESTS circuitry.

All the equipment drawers in bay 2 are provided cool dry air by an air conditioner (1A14).

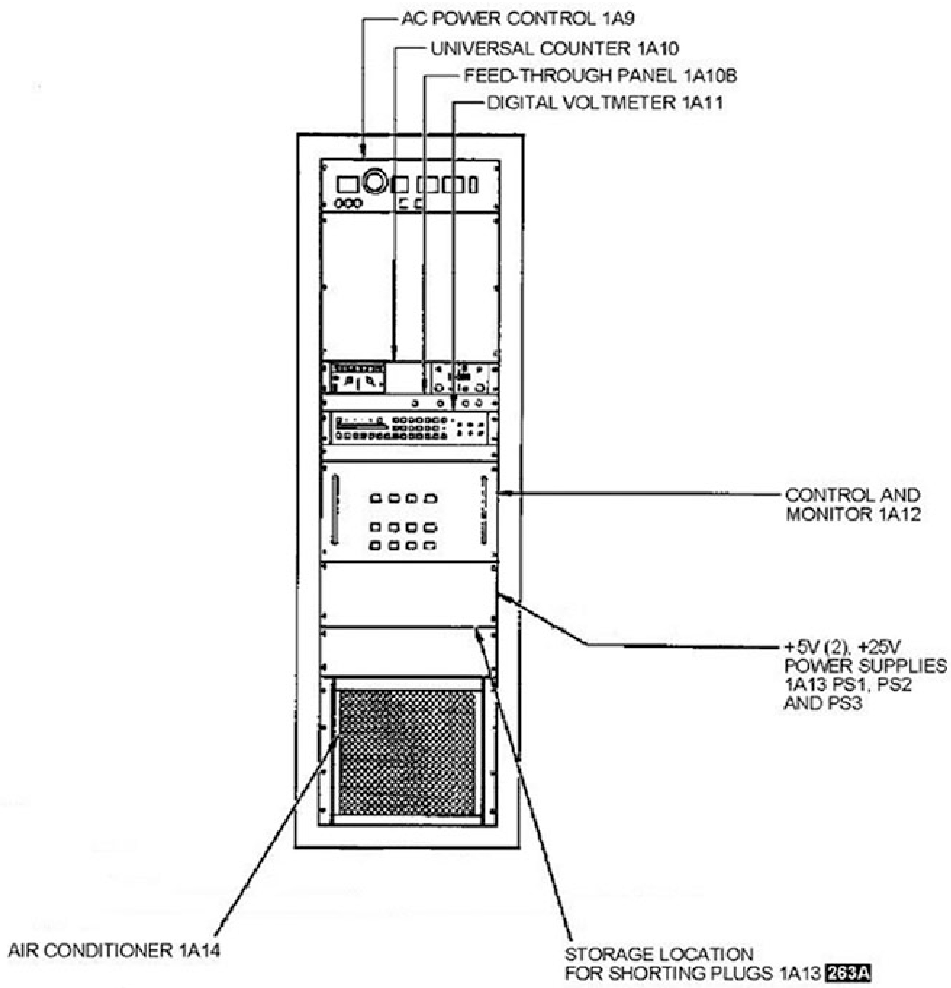


Figure 4–10. ESTS main rack bay 2.

Bay 3

Bay 3 has a 400 Hz reference generator (1A15) that provides a precision 400 Hz reference voltage to the UUT, which is delivered via the interface electronics (1A16). The key purpose of the interface electronics is to provide electronics to control and distribute data between the computer (1A3), patchboard, and measuring equipment (fig. 4–11). The DC power control (1A17) receives all ESTS generated DC power, provides electrical current sensors for monitoring (via the Control and Monitor in bay 2), and distributes power to the UUT. It also prevents UUT circuit overload by a 36-VDC circuit breaker. All the equipment drawers in bay 3 are provided cool dry air by an air conditioner (1A14).

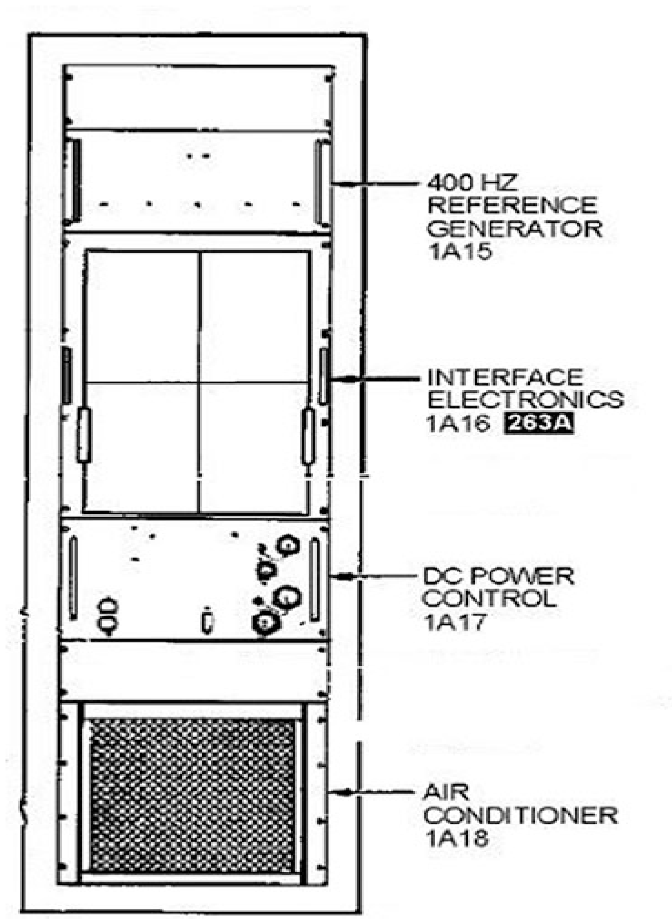


Figure 4–11. ESTS main rack bay 3.

Unit under test power control rack (unit 2)

The UUT is a one bay rack that produces high current test capabilities (fig. 4-12). The 400/60 Hz power control (2A1) provides AC power for the power supply (2A3) and the power and control interface drawer (2A2). The 4-36 VDC, 300 ampere (amp) power supply (2A3) is used to simulate a missile battery during missile testing and to simulate carrier aircraft 28 VDC power during launcher or pylon testing. Its output voltage and current is programmed by computer (in the main rack) utilizing software. External resistance applied to the remote programming terminals (on the back of the power supply) by the power control and interface drawer (2A2) circuitry controls this output. The power and control interface drawer (2A2) circuitry is also used to switch the 115-VAC/230-VAC, 400-Hz facility power and the power supply output (normally 28 VDC) to the UUT. This rack also contains the 230 VAC 400 Hz Power Control Drawer (2A7) which provides initial power control of 230 VAC, 400 Hz input power to the rack. The computer (in the main rack) remotely controls this input power during application and removal of ESTS electrical power.

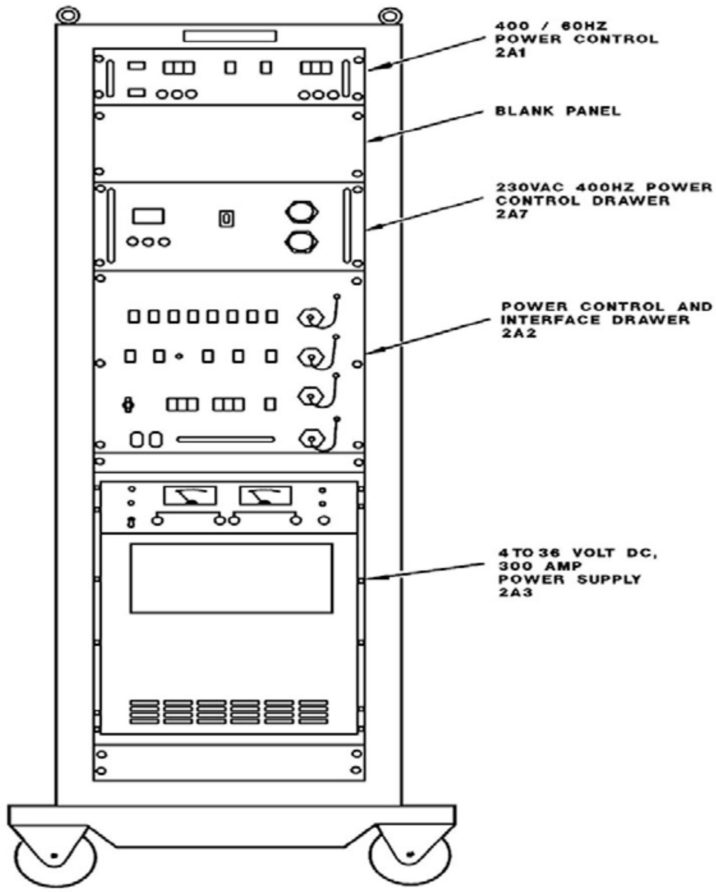


Figure 4–12. UUT power control rack.

Air data test set (unit 3)

Unit 3 is a half-bay cabinet containing equipment, which provides test capabilities for pneumatic avionics instruments. It is used during operational checkout of the missile to simulate flight conditions. This ESTS unit is described in the next lesson.

Display station (unit 5)

The display station is external to the ESTS racks. Operators use it to control and monitor all ESTS operations from a central location. The display station is composed of a flat screen monitor, keyboard, computer tower, and external digital video disk (DVD) read/write drive (fig. 4–13). The monitor provides the operator with a visual display of the ESTS and UUT testing operations. The keyboard allows the operator to program, select, and acknowledges the software programs currently being executed by the ESTS computer (1A3). The computer tower (of the display station) contains the electronics to interface with the ESTS computer (1A3). It also interfaces with the monitor, keyboard, and external DVD drive. The DVD drive is used to record UUT test runs that resulted in successful completion.

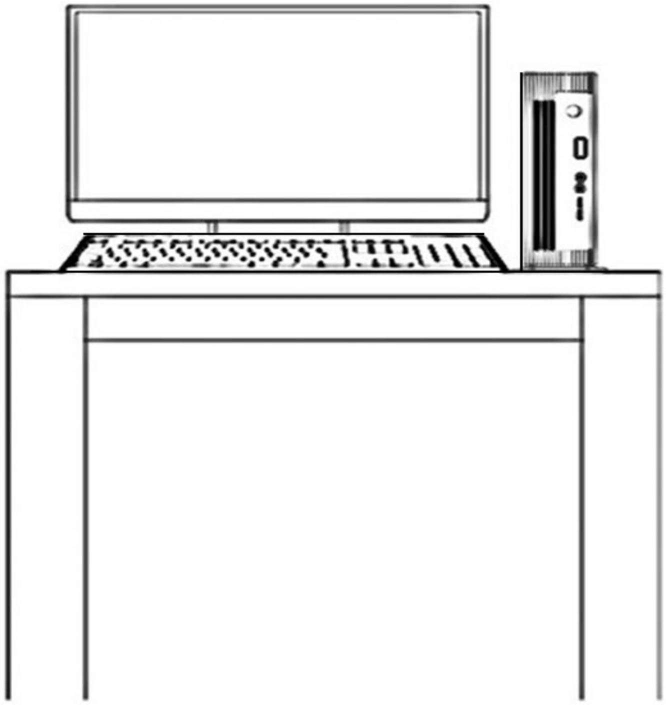


Figure 4–13. Display station.

Printer (unit 6)

The printer used with the ESTS provides the operator with a hard copy of test results, faults, upper and lower test limits, measured values, and suggested repair actions (fig. 4–14).

Figure 4–14. Printer.

Three types of printouts are available.

Printouts	
Type	**Description**
As run	Printed as the program is being run, hence the name. As test data appears on the monitor, it is printed. This printout is optional and can be selected or non-selected by the operator at the beginning of testing.
Logged data	Data are available when the testing has been completed. During software program execution, all test data is logged onto the removable disk located in the disk drive located in the main rack. This data is similar to that of the “as run.” The operator has the option to print this logged data upon completion of the test. The logged data remains on the removable disk and can be retrieved at any time until it has been overwritten. Overwriting occurs when the same program is performed again. Previously stored test data is erased and the new data is logged onto the removable disk.
List source	A listing of the computer software programs contained on the removable disk. This software program information is written in the abbreviated test language for all systems (ATLAS) programming language. In-depth analytical troubleshooting is a possible use for this type of printout.

026. Air data test set

The ADTS (AN/GSM–29) gives the ESTS the capability to check out the ADE in the cruise missile. This self-contained rack contains a vacuum and pressure control system used to simulate pitot (ram) and static pressures associated with a missile in flight (fig. 4–15). An adapter and a pneumatic hose set provide the interface between the missile and the ADTS.

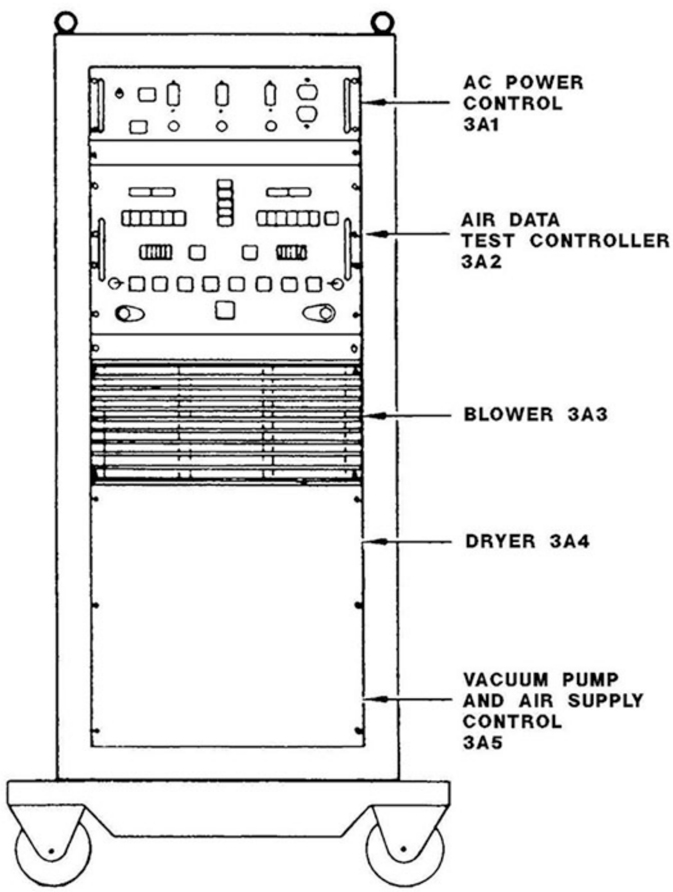


Figure 4–15. Air data test set.

The 1A3 computer controls and programs the operation of the ADTS. During cruise missile checkout, the ADTS generates and applies values of static and pitot pressure (under computer control) to the missile’s ADE. The outputted data from the ADE is compared with limits stored in the ESTS. This data is evaluated by the 1A3 computer and the test is determined GO or NO GO. The purpose of each of the major assemblies within the ADTS is discussed in this lesson.

Alternating current power control (3A1)

The 3A1 AC power control drawer is located at the top of the ADTS. The purpose of this drawer is to control the application or removal of AC input power to the assemblies within the ADTS. The front panel of the 3A1 AC power control contains circuit breakers that provide for rack circuit overload protection (fig. 4–16). Several indicators are also located on this front panel. These indicators provide the operator with a visual means of monitoring the status of the rack.

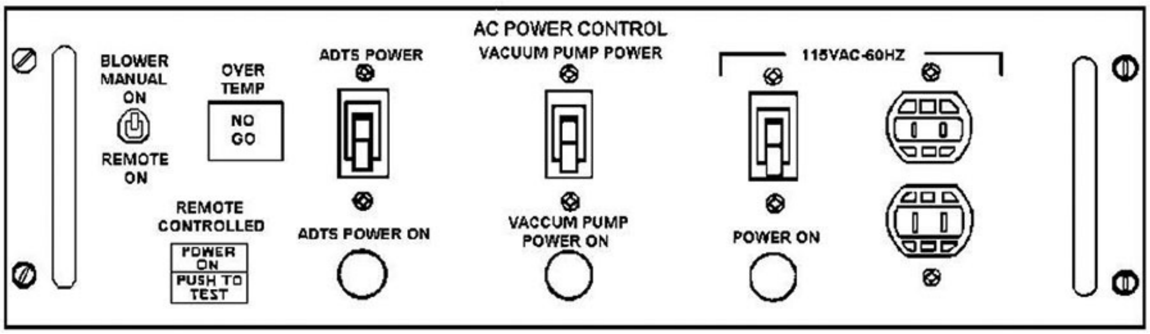


Figure 4–16. 3A1 AC power control.

3A7 electromagnetic interference filter

The 3A7 electromagnetic interference (EMI) filter assembly is located inside the ADTS at the top of the rack. This assembly contains four inductance-capacitance-resistance, pi-type filters connected in series with the 115-VAC, 60-Hz input power to the ADTS. They filter out any 60-Hz input power irregularities and prevent EMI propagation within the ADTS.

Air data test controller (3A2)

The 3A2 air data test controller (ADTC) is located below the 3A1 AC power control drawer. It’s a precise, stable pressure control system designed to accurately simulate and measure pneumatic pressures associated with a cruise missile in flight.

With the use of an external air pressure and vacuum source, the 3A2 ADTC can generate pneumatic pressures that simulate values of pitot and static pressure. These pressures are routed from the controller to the missile.

3A3 blower

The 3A3 blower circulates room ambient air to cool the 3A5 vacuum pump. It’s located beneath the 3A2 ADTC.

Air dryer module (3A4)

The 3A4 dryer module is located inside the ADTS in the lower rear portion of the rack. It dries and removes contaminants from the pressurized air supplied to the pneumatic lines of the 3A2 ADTC. In so doing, the 3A4 air dryer module prevents moisture contamination of the sensitive components within the ADTC. The air dryer module consists of two dryer elements, a fixed bleed, a four-way solenoid valve, and a 30-second timer.

Vacuum pump (3A5)

The 3A5 vacuum pump is located inside the ADTS in the lower front portion of the rack. Its purpose is to *reduce* the volume of air contained in the 30-cubic-inch fixed volume tank located in the pneumatic lines of the ADTC.

Oil trap (3A6)

The 3A6 oil trap is located inside the ADTS, just below the 3A3 blower. It’s installed in the vacuum lines between the vacuum pump and the 3A2 ADTC.

The purpose of this trap is to prevent oil contamination of the pneumatic lines in the 3A2 ADTC. The oil trap consists of a trap tank and a solenoid vent valve.

Self-Test Questions

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

025. Electronics systems test set

1. What is a key component that controls the entire ESTS and is located in bay 1 of the main rack?

2. What causes the computer to stop testing when it senses an out of tolerance condition within the ESTS or UUT?

3. What is the key purpose of the interface electronics (1A16)?

4. What component is located in the UUT power control rack and is used to simulate a missile battery during missile testing?

5. What part of the display station provides the operator with a visual display of the ESTS and UUT testing operations?

6. What provides the operator with a hard copy of test results?

026. Air data test set

1. What controls and programs the operation of the ADTS?

2. What is the purpose of the 3A1 power control drawer?

3. What is the purpose of the 3A7 EMI filter?

4. What is the purpose of the ADTC?

5. What is the purpose of the 3A3 blower?

6. What is the purpose of the 3A4 air dryer module?

4–3. Test Equipment

ESTS requires various pieces of equipment to support its testing operations. In this section, we'll go over the MRATA, SDC, and cooling control unit.

027. Missile radar altimeter test assembly

Measuring the operating performance of a missile radar set is a very important part of a missile operational checkout. The MRATA was developed to make these measurements while at the same time simulating in-flight conditions.

The major assemblies of the MRATA are all contained in a single-bay, roll-around rack (fig. 4–17). These assemblies are the active loop drawer (A1), passive loop drawer (A2), power supply assemblies (A3, A6, and A7), blower (A4); and power control drawer (A5). Two coaxial cables, W21 and W22, are supplied as part of the MRATA.

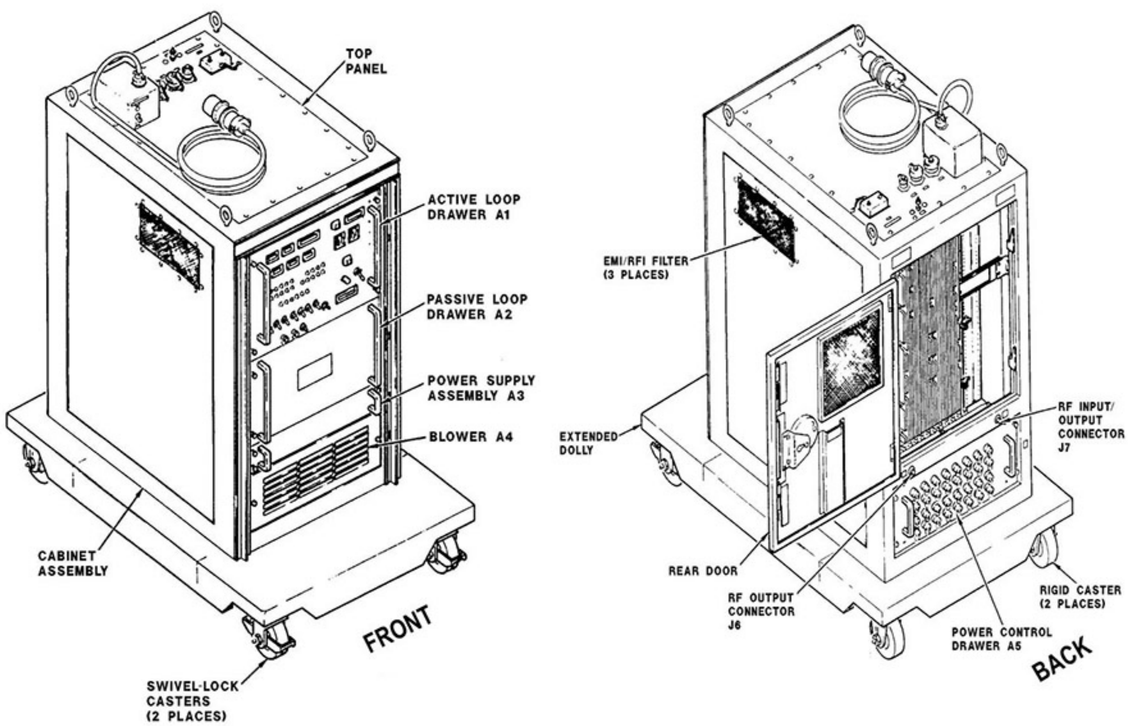


Figure 4–17. Missile radar altimeter test assembly.

Active loop drawer A1

Active loop drawer A1 functions include manual MRATA operation and self-test. Circuits for simulating varying altitude, altitude rate of change (for pulsed-type altimeters), RF signal measuring and monitoring, and electronic countermeasures testing are contained in this drawer.

Passive loop drawer A2

Passive loop drawer A2 provides manual or programmable simulated fixed altitudes, frequency-modulated/continuous-wave type altimeter rate control, and RF signal self-test. There are no controls or indicators on the front panel of the A2 drawer.

Power supply assemblies A3, A6, and A7

Each power supply assembly contains three fixed DC output power supplies. These power supply assemblies provide the MRATA its operating power.

Blower A4

The A4 blower, located at the bottom of the rack, circulates room ambient air within the MRATA. This air circulation provides for the cooling of the rack-mounted assemblies. The MAIN POWER switch, located on the top of the rack, controls the 60 Hz input power to the blower. A filter assembly mounted to the front of the blower provides filtering of the room air circulated by the blower.

Power control drawer A5

The power control drawer A5 provides protection (fusing), control, and distribution of the AC and DC power within the MRATA. The fuses (F1 through F20) are located on the front panel of the drawer. They protect most of the MRATA electrical circuits. Fuses F21 through F32 are available as spares. An elapsed time meter, also located on the front panel, provides an indication of the MRATA total operating hours.

028. Signal data converter

The CV-3643/GSM-263 SDC, also called the signal adapter, is used in conjunction with the ESTS during Level II testing. The signal adapter is used to buffer and condition analog signals coming from the missile, and then transmits these signals to the ESTS. It's located in a single bay, roll-around cabinet and contains a connector panel, buffer drawer, power supply drawer, rack blower, and a storage drawer (fig. 4–18).

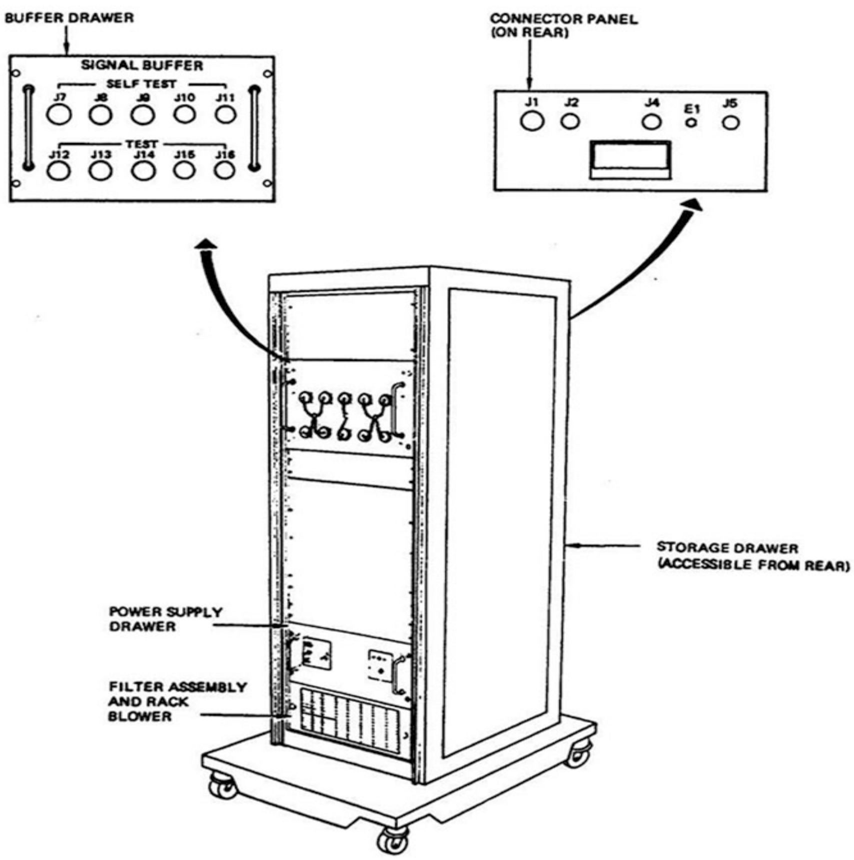


Figure 4–18. Signal data converter.

Connector panel

The connector panel contains connectors for missile and ESTS interface.

Buffer drawer

The buffer drawer provides an interface between analog outputs of the missile and the ESTS during Level II testing. An interface is necessary to prevent damaging currents from reaching the missile circuits and is used to isolate missile ground circuits from the test equipment circuits. The buffer drawer also provides continuity loops for testing cables used during Level II missile tests.

Power supply drawer

The power supply drawer contains a 6 VDC power supply (PS1), +15 VDC power supply (PS2), and a -15 VDC power supply (PS3) which are used to *operate* the buffer drawer. It also includes a power supply monitor card.

Rack blower

The rack blower provides cooling air to the rack mounted equipment.

Storage drawer

The storage drawer, accessible from the rear of the rack, provides storage for the signal adapter’s power and ground cables.

029. Cooling control unit

The MXU–690/E electronic component cooling equipment (fig. 4–19), commonly referred to as the CCU, is used within the IMF to provide UUT cooling. It filters, regulates, and monitors the flow of facility air to the UUT during testing by the ESTS. This lesson will familiarize you with the role of the key cooling air circuits and the purpose of the major components, accessories, and precautions.

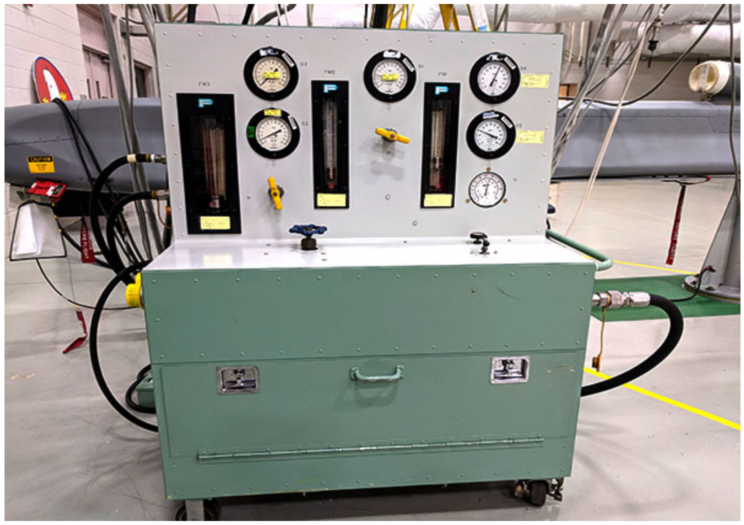


Figure 4–19. MXU–690 electronic components cooling.

Cooling air circuits for the unit under test

Cooling air is distributed to the UUT using the INE, Section 41 and Clip test cooling air circuits (fig. 4–20).

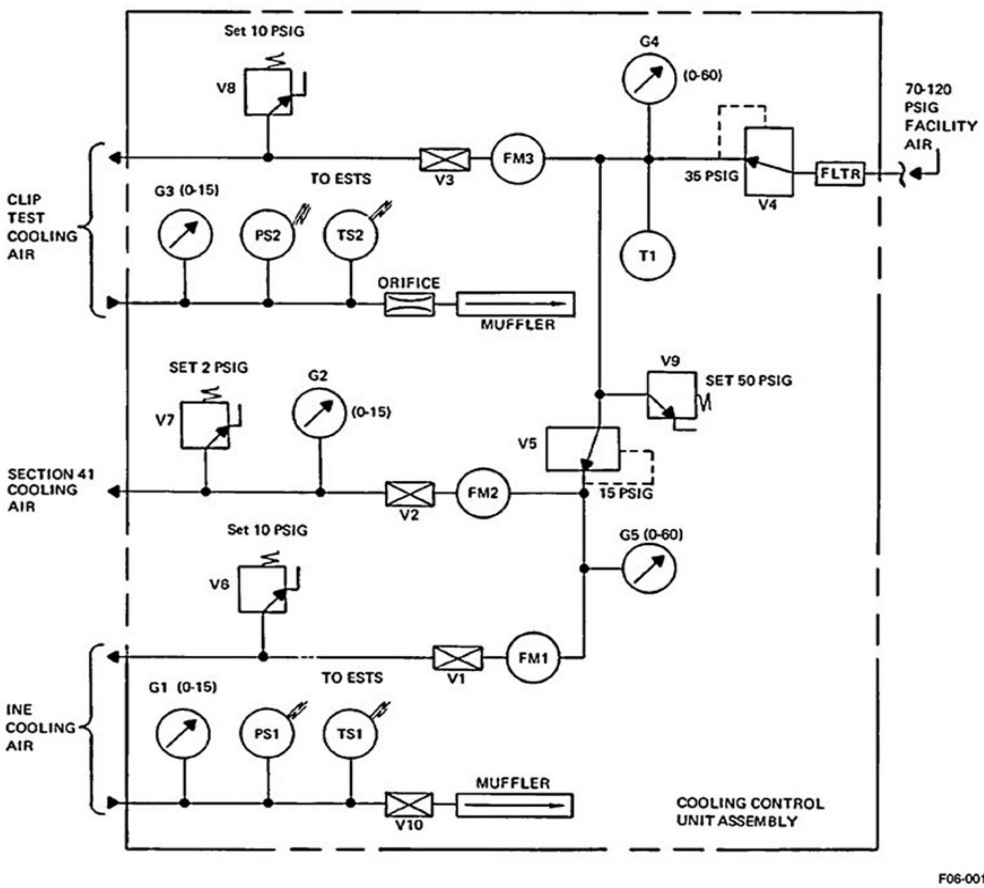


Figure 4–20. CCU pneumatic system.

Inertial navigation element cooling air circuit

The following UUTs are cooled by the INE cooling air circuit:

- Single ALCM/CALCM missiles.
- NucSLU.
- Decoder-receiver (also referred to as the MIU).
- Empty ALCM and CALCM pylons and empty rotary launchers.

Section 41 cooling air circuit

The Section 41 cooling air circuit cools the components located in the nose cap of the ALCM.

Clip test cooling air circuit

The Clip test cooling air circuit provides cooling air to loaded pylons and rotary launchers.

Components

The CCU consists of several types of components with different functions shown on figure 4–21. Your test procedure will provide you with the required settings.

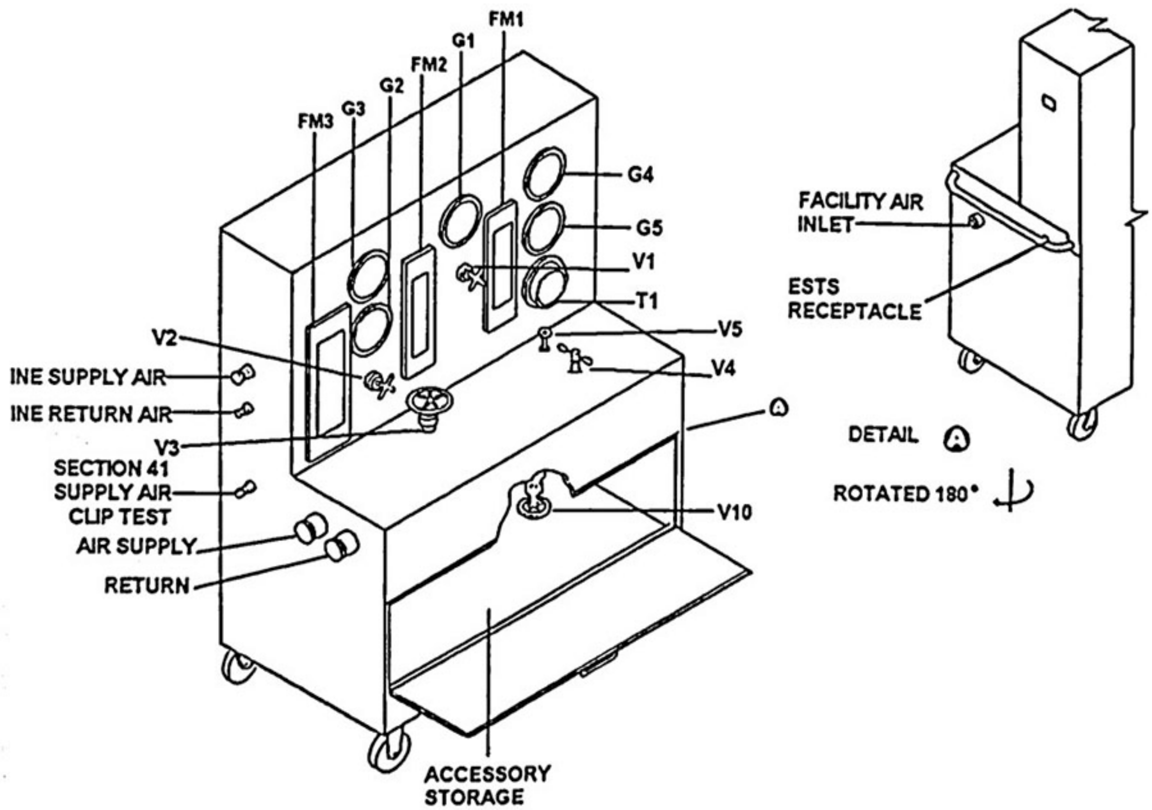


Figure 4–21. MXU–690 electronic components cooling equipment.

Filter

A filter is located behind the accessory storage compartment door. It traps any contaminants and liquids that may be present in the flow of input facility air.

Metering valves

Metering valves are adjustable controls that allow the operator to control airflow. These valves have handholds to facilitate turning to make airflow adjustments.

- V1 controls the INE cooling air circuit airflow.
- V2 controls the Section 41 cooling air circuit airflow.
- V3 controls the Clip test cooling air circuit airflow.
- V4 regulates filtered input air pressure sent to the Clip test cooling air circuit and V5 intermediate pressure circuit.
- V5 further regulates airflow sent to the INE and Section 41 cooling air circuits called intermediate pressure.
- V10 controls return air pressure (called back pressure) from the INE return air.

Pressure release valves

These valves limit the air pressure level in the airflow paths within the CCU. There are four in the CCU, each is designed to relieve excess pressure by opening when pressure levels are exceeded.

- V6 limits the maximum pressure within the INE cooling air circuit to 10 psig.
- V7 limits the maximum pressure within the Section 41 cooling air circuit to 2 psig.
- V8 limits the maximum pressure within the Clip test air circuit to 10 psig.
- V9 limits the maximum pressure at V4 (regulated input air) to 50 psig.

Flowmeters

Flowmeters are used to visually indicate the flow of air in the CCU cooling air circuits. As the airflow through this device increases, the meter float rises up the glass cylinder. (fig. 4–22)

- FM1 shows the flow of air in the INE cooling air circuit.
- FM2 shows the flow of air in the Section 41 cooling air circuit. It is identical to FM1.
- FM3 shows the flow of air in the Clip test cooling air circuit. It is slightly larger than FM1 and FM2.

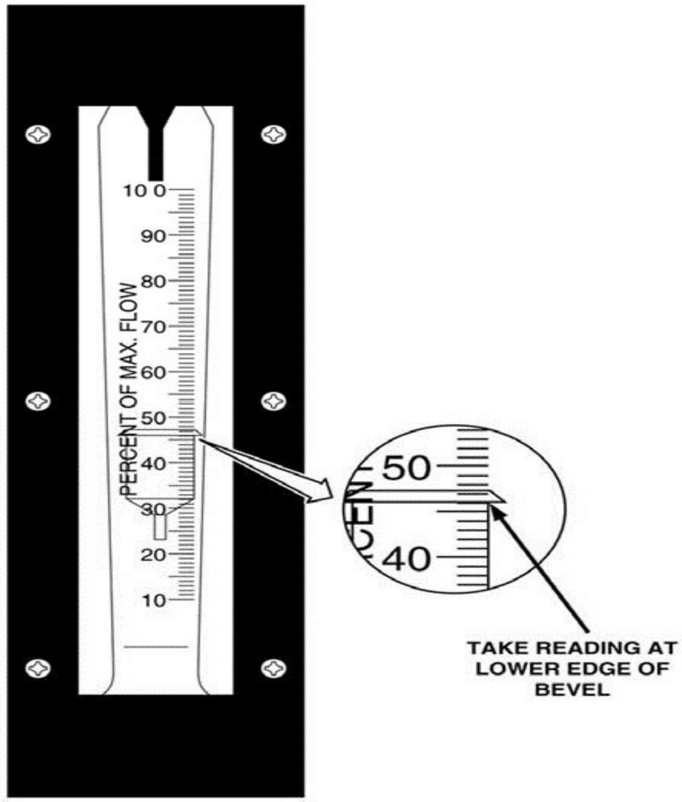


Figure 4–22. CCU flowmeter (typical).

Flow meter readings are taken near the top of meter float, at the lower edge of the bevel.

Pressure gauges

Pressure gauges visually indicate air pressure in the flow paths within the CCU.

- G1 shows the INE return air pressure.
- G2 shows the regulated out pressure of V2 (in the Section 41 cooling air circuit).
- G3 shows the Clip test return air pressure.
- G4 shows regulated (filtered air) output pressure of V4
- G5 shows regulated (intermediate) output pressure of V5.

Temperature gauge

This gauge (T1) shows the temperature of CCU input air (received from facility supply).

Pressure and temperature switches

The pressure switch automatically monitors back pressure and the temperature switch monitors return air temperature from the respective return air (received from the UUT). These switches open due to insufficient cooling and prevent damage to the UUT. When any of these switches open, the ESTS interrupts testing and removes power from the UUT.

- PS1 and TS1 monitors the INE return air back pressure and air temperature. PS1 opens when back pressure drops below 1.8 to 1.5 psig. TS1 opens if return air rises above 148° F to 152° F.
- PS2 and TS2 monitors the Clip test return air back pressure and air temperature. PS2 opens when back pressure drops below 1.8 to 1.5 psig. TS2 opens if return air rises above 145° F to 150° F.

Cooling control unit accessories

The CCU comes with numerous hoses, adapters, and clamps. These accessories are used to interface with the CCU cooling air circuits to the various UUT. They're also used by maintenance personnel during the operational and leak tests of the CCU. When not in use, they're stored in the accessory storage compartment located in the lower front of the cabinet.

Cooling control unit operating precautions

You must be aware of the proper operation of the CCU and adhere to specific operating precautions. Failure to do so could result in personnel injury or equipment damage. Observe the following when operating the CCU:

- Wear eye protection when purging CCU hoses of contaminants.
- Store all hoses, adapters, and clamps in the accessory storage compartment.
- To prevent contamination of the CCU and UUT, dust cap all hoses and CCU fittings and couplings when not in use.
- Before connecting or disconnecting CCU hoses and adapters, make sure the system has been bled and is free of trapped air.
- When adjusting cooling air circuit flow, open and close valves V1, V2, and V3 slowly. This prevents the flowmeter float from oscillating or striking the top or bottom of the cylinder.

Self-Test Questions

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

027. Missile radar altimeter test assembly

1. What are the major assemblies of the MRATA?

2. Which major MRATA assembly can simulate an altitude rate of change for pulsed-type altimeters?

3. What does the passive loop drawer (A2) provide?

4. What do the power supply assemblies provide the MRATA?

5. What does the power control drawer A5 provide?

028. Signal data converter

1. What is the purpose of the SDC?

2. Why is the interface provided by the buffer drawer necessary?

3. What is the purpose of the three power supplies in the power supply drawer?

029. Cooling control unit

1. What are the three cooling air circuits that distribute cooling air to the UUT?

2. Match the CCU components in column A with the function description listed in column B. Function descriptions in column B may be used only once or not at all.

Column A	*Column B*
____ (1) Filter.	a. Limits air pressure level in the in the flow paths within the CCU.
____ (2) Metering valve.	b. Shows the temperature of CCU input air.
____ (3) Pressure release valve.	c. Visually indicate air pressure in the flow paths within the CCU.
____ (4) Flow meter.	d. Adjustable controls that allow the operator to control airflow.
____ (5) Pressure gauge.	e. Traps any contaminants and liquids that may be present in the flow of input facility air.
____ (6) Temperature gauge.	f. Visually indicate the flow of air in the CCU cooling air circuits.

3. What CCU switches will open due to insufficient cooling and cause the ESTS to interrupt testing?

4. Where are CCU hoses, adapters, and clamps stored?

5. Which valves must be opened slowly to prevent the flowmeter float from striking the top or bottom of the cylinder?

4–4. Aircraft Pylon and Rotary Launcher Systems Checkout

In this section, we'll discuss the aircraft pylon and rotary launcher systems and follow up with pylon and launcher checkout.

030. Aircraft pylon and rotary launcher systems

Pylons and rotary launchers are B-52H aircraft loading adapters which provide an interface between the missile and aircraft during captive carry. They are also used to support missile storage. This lesson will provide a description of each loading adapter and its respective systems.

Pylon

The SUU–67/A pylon is an aerodynamic interface between the B–52H aircraft and the AGM-86B/C cruise missiles. The B–52H can carry two pylons, one under each wing, between the fuselage and the inboard engines (fig. 4-23). Each pylon can support up to six missiles in two clusters of three. The missiles can be loaded, launched, or jettisoned individually in any configuration. The pylon itself can be jettisoned from the aircraft either loaded or empty.

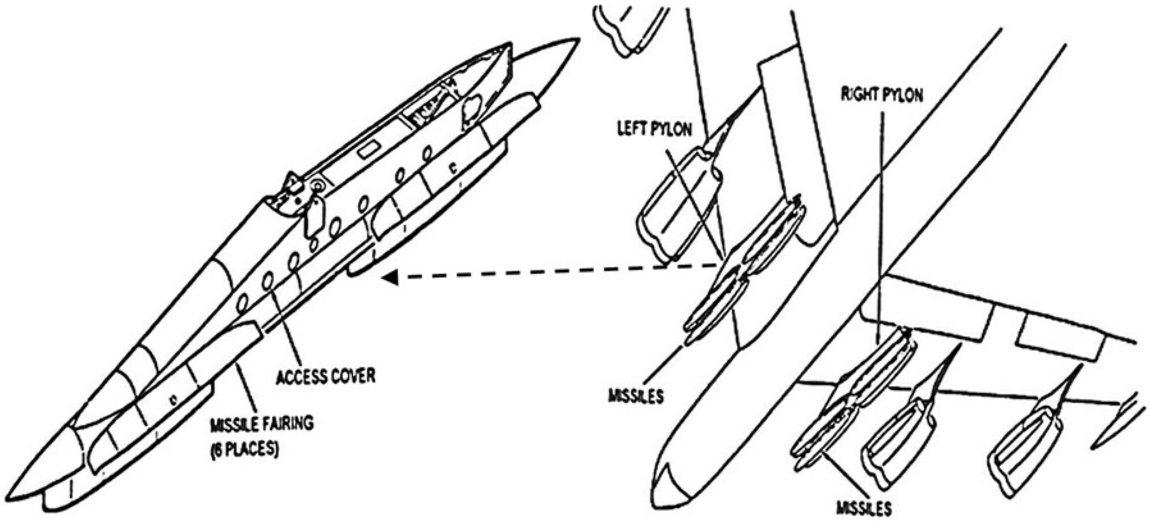


Figure 4–23. SUU-67/A pylon and location.

Power system

The pylon power system is simply a power distribution system using the relay assembly. The different types of power provided are electronic, instrumentation, heater, and hydraulic. This power is routed to the missiles from either the aircraft or the ESTS through the relay assembly.

Environmental control system

The pylon ECS is a closed-loop system that distributes cooling air from either the aircraft during captive carry or the CCU during ground testing. A manifold within the pylon ECS routes the supplied air to each missile and MIU via a network of insulated ducting.

Monitor and control system

The monitor and control system consists of the MIU electrical interface with the missiles and ejectors for a variety of functions. The MIU is used to distribute commands from the aircraft avionics control unit (ACU) to the missiles and transmits missile status to the ACU. The prearm and unlock enable commands for the ejector racks are routed through the MIU. The MIU also sends signals to the relay assembly to control the missile power application.

Mechanical system

The mechanical system allows the attachment of the pylon to the aircraft. There are two attach points in the middle of the pylon and one in the back. These attach points interface with the aircraft's pylon jettison release system to allow for emergency jettisoning. There is also an electrical and ECS interface (breakaway assembly) located on top of the pylon (fig. 4–24). The breakaway assembly allows electrical and ECS connection without interfering with jettisoning of the pylon.

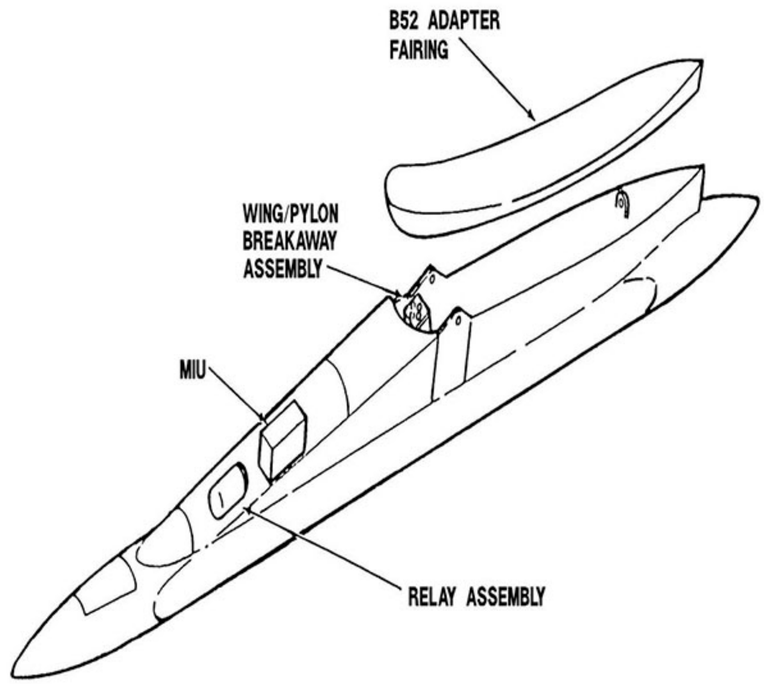


Figure 4–24. Pylon component locations.

Common strategic rotary launcher

The CSRL is an electrically controlled, hydraulically driven launch platform (fig. 4–25). It can be loaded in the bomb bay of the B–52H aircraft and is capable of carrying up to eight ALCMs or CALCMs or eight B83 or B61 gravity bombs. Since the CSRL is loaded into the aircraft bomb bay, the launcher can only release one missile or bomb at a time.

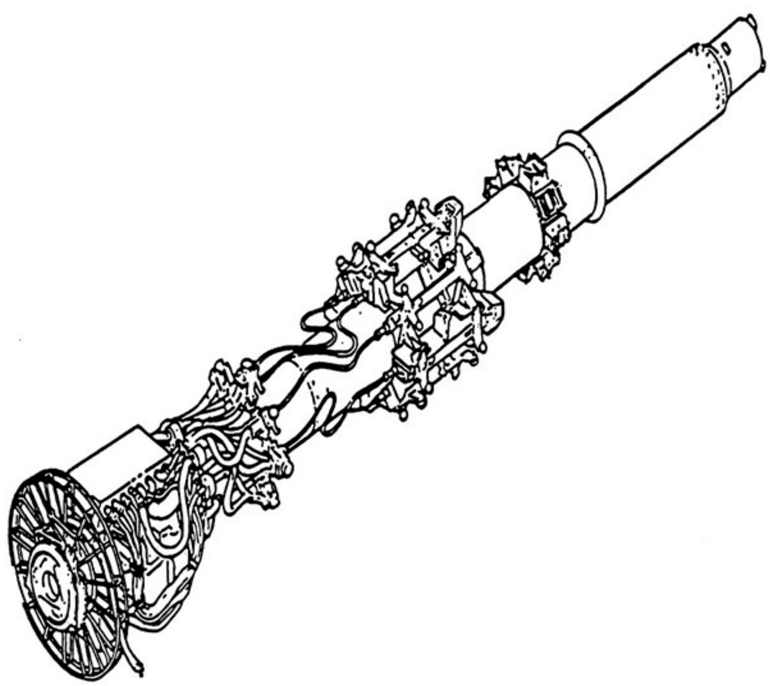


Figure 4–25. Aircraft guided missile and bomb rotary launcher.

The CSRL consists of a central shaft that contains power and pneumatic subsystems. It interfaces with the aircraft through forward and aft end bearing mounted fittings. Brackets on the forward section support the avionics, which include the MIU, relay assembly, associated nuclear hardened wiring, and a NucSLU (fig. 4–26). The systems that make up the CSRL are power, environmental control, monitor and control, and mechanical.

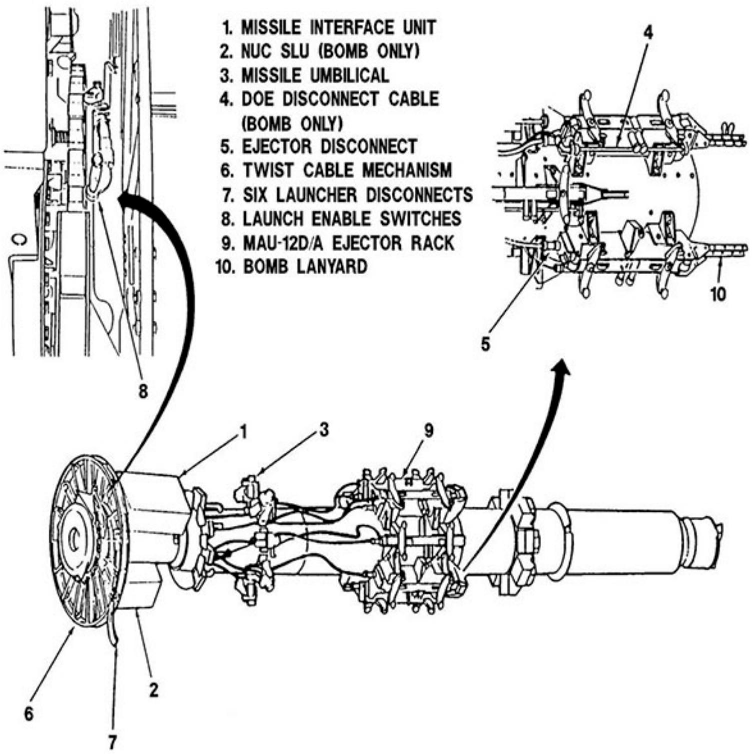


Figure 4–26. Common strategic rotary launcher components.

Power system

The CSRL power system is very similar to the pylon's power system in that it's simply a power distribution system. Electronic, instrumentation, heater, and hydraulic power are routed to the missiles from either the aircraft or the ESTS *through* the relay assembly.

Environmental control system

The ECS of the CSRL, also known as the pneumatic system, is also very similar to that of the pylon. Cooling air is provided to the MIU and NucSLU, as well as the missiles, through ducting, manifolds, and pneumatic valves.

Monitor and control system

The monitor and control system of the CSRL is also very similar to that of the pylon. The MIU provides the electrical interface for the missiles. The MIU receives commands and transmits missile status to the aircraft's ACU. Prearm and unlock enable commands for the ejector racks are routed through the MIU.

If the CSRL is loaded with gravity weapons instead of missiles, the electrical interface is provided by the NucSLU. The NucSLU transmits commands from the ACU to the weapons and sends status updates from the weapons to the ACU. Ejector rack status is also routed through the NucSLU.

Mechanical system

The mechanical system of the CSRL allows the rotation of the launcher shaft to place the selected weapon at the *six* o'clock position for release.

Eight launch enable switches (LES) prevent the weapons from being released at any position other than six o’clock. The mechanical interface consists of a forward drive fitting and an aft end fitting assembly. The forward drive fitting interfaces the front of the launcher to the aircraft, load frame power drive unit, or launcher loader adapter. The aft end fitting assembly interfaces the launcher with the aircraft aft yoke assembly, load frame, or launcher loader adapter.

031. Pylon/launcher checkout and diagrams

Pylon and launcher checkout are testing operations conducted to ensure they work properly. They are tested in both the empty and loaded configurations. Like missile testing, pylon and launcher testing is conducted with ESTS operated software. The ESTS is interfaced to the pylon/launcher via cables. During testing operations, pylon/launcher cooling is provided by the CCU. Testing is also provided for some critical pylon/launcher components. To help you with work on pylons and launchers, your technical data provides several types of diagrams. We’ll go over each pylon and launcher test and then system related diagrams.

Empty pylon test

Before missiles can be uploaded to a pylon in the high bay, the pylon must be certified as operationally ready. The empty pylon test software has two testing modes – the end-to-end-mode and the maintenance mode. The end-to-end mode checks all six-missile positions and must be run completely without a test failure for the pylon to be certified for missile upload. The maintenance mode allows a single missile position to be tested and is ran for repair verification. Empty pylon testing procedures are found in TO 16W6-33-8-1, *Test Procedures Manual -- Aircraft Pylon Type SUU-67A, Type SUU-72A Not Loaded With Missiles.* You’ll quickly find your “seasoned co-workers” referring to this technical order as the “8-1”.

Empty rotary launcher test

Much like the empty pylon test, the empty CSRL test is performed for the same reasons. Before loading the launcher with eight missiles, it must be certified for missile upload. A successful end-to-end test must be completed in order for the launcher to be certified. The option to run partial tests is also available to save time when troubleshooting problems. Additionally, you’ll be required to configure a TAG to your UUT. The empty CSRL test procedures are in TO 11N-L5005-8, *Empty Rotary Launcher, Guided Missile and Bomb*.

Loaded pylon/common strategic rotary launcher test

After a pylon is certified for missile upload, typically the 2W2 weapons personnel will load the six missiles on the pylon. Once complete, you’ll run a *loaded* pylon test. This test certifies the pylon is ready to communicate with the aircraft once it has been loaded onto the B-52; it also allows, targeting information to be loaded by the aircraft. It is imperative for you to know this solid communication exists prior to storage, aircraft upload, and ultimately a wartime situation. A comparable test is run for the loaded launcher. Once the launcher has passed the empty launcher test, it is then loaded with eight missiles and the loaded CSRL test is ran. After successful testing, the launcher is normally transported to the structures (storage) or out to the flightline aircraft for exercise (generation) purposes.

Pylon/launcher line replaceable unit Level III checkout

A step further in the testing process takes us to pylon or launcher Level III checkout. Although not a common task, these tests do come in handy in terms of isolating faults with the pylon and launcher. One of the components tested under the Level III test is the decoder-receiver (D-R), also known as the MIU. The D-R receives command and data words from the ACU through the military standard (MIL-STD)-1553A data bus. The D-R then processes the command and data words for missile control and supplies those same commands to the missiles, ejectors, and relay assembly, under the control of the D-R. You’ll find this particular component on both the pylon and launcher. Checkout procedures involve the ESTS, CCU, and TAG (ESTS patchboards, interconnecting cables, and D-R buffer box).

The TAG provides the functional interface between the ESTS and the D-R and buffer box to accomplish unit testing. This test program is structured to help you accomplish the following basic functions:

- Verifies fault-free operation of the D-R.
- Verifies fault-free operation of the D-R buffer box.
- Isolates malfunctions to a SRU.
- Provides a functional test to demonstrate that the D-R has been repaired and is ready to be returned to service.

Another component involved in Level III testing is the CSRL NucSLU. The NucSLU provides the electrical interface between the nuclear weapon (bomb) and the aircraft ACU. It also provides the electrical interface between the weapons suspension/release equipment and the aircraft ACU. The CSRL NucSLU receives commands from and transmits status of both the weapon and weapon suspension/release equipment to the aircraft ACU. Testing of the NucSLU accomplishes three major functions:

1. Isolates malfunctions to one or more SRU.
2. Provides a functional test to demonstrate that the NucSLU has been repaired.
3. Verifies fault-free operation of the CSRL NucSLU. Successful completion of end-to-end test part 1 and part 2 is required to certify the NucSLU.

Pylon and launcher diagrams

Your technical data provides several diagrams that visually relay information to help you work on pylons and launchers.

Pictorial diagrams

Pictorial diagrams are used to point out components or parts to help you locate pylon/launcher items (fig. 4–27).

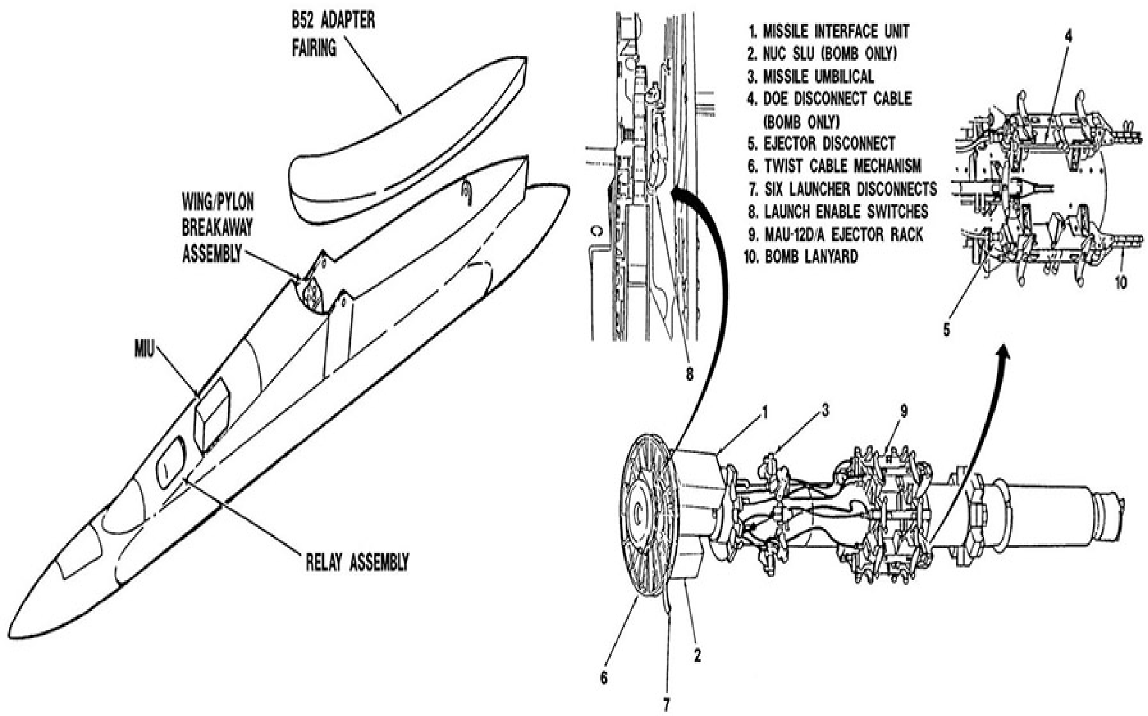
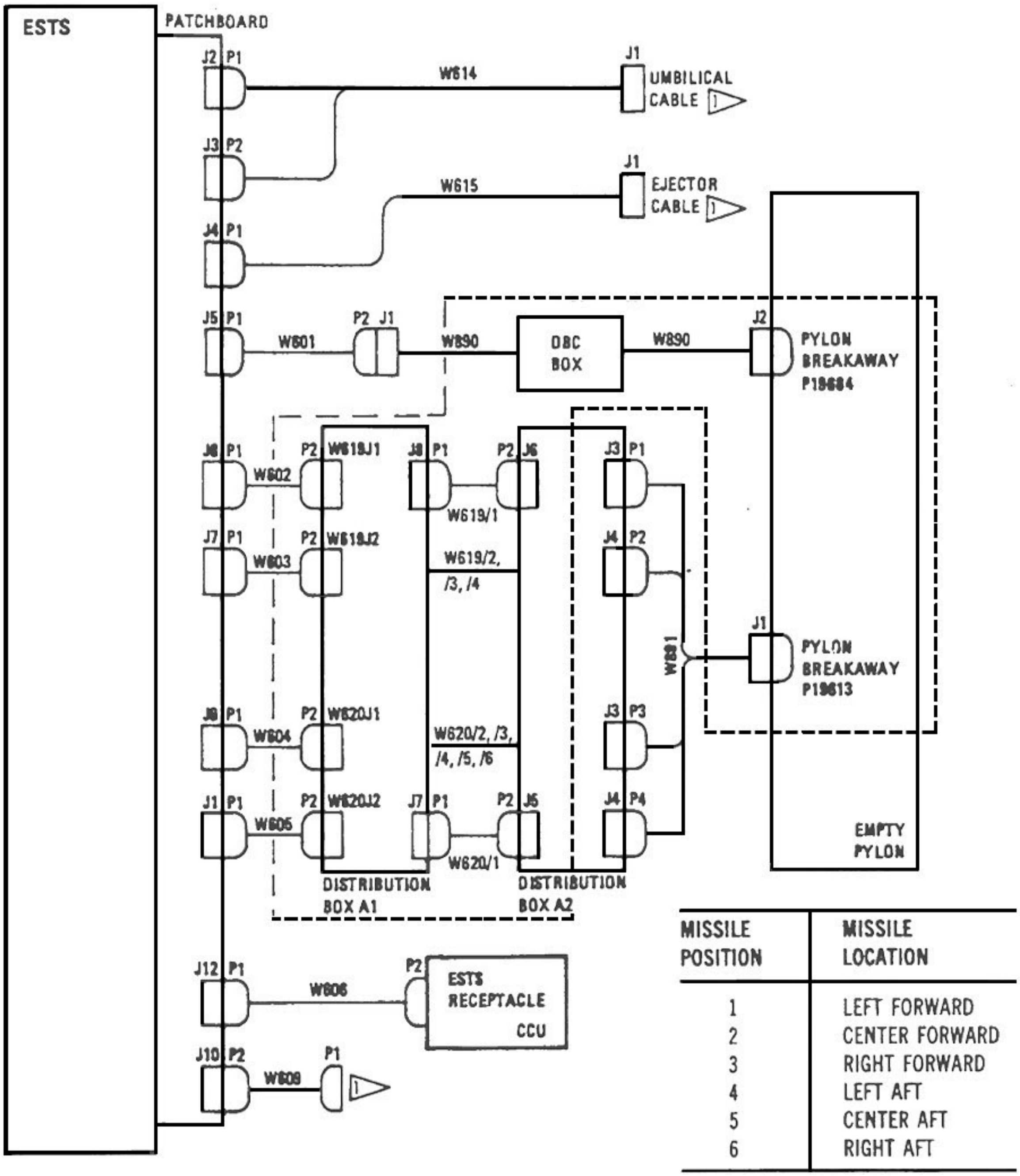


Figure 4–27. Pylon and launcher pictorial diagram example.

Hookup diagrams

These diagrams show pylon and launcher test connections and are provided for each test configuration. Hookup diagrams (fig. 4–28) are a form of wiring diagram that depicts individual wire runs between test components. Component connector jacks (J) and their associated cables (W) and plugs (P) are also identified.



MISSILE POSITION	MISSILE LOCATION
1	LEFT FORWARD
2	CENTER FORWARD
3	RIGHT FORWARD
4	LEFT AFT
5	CENTER AFT
6	RIGHT AFT

Figure 4–28. Empty pylon test hookup.

Test sequence flowchart

Test sequence flowcharts (fig. 4–29) show the major events in the test process for the different pylon and launcher tests. Events are identified in blocks and test options in diamonds that are linked together by lines. The flowchart begins with ESTS initialization and takes a different path to TEST END depending on the decision response to each test option.

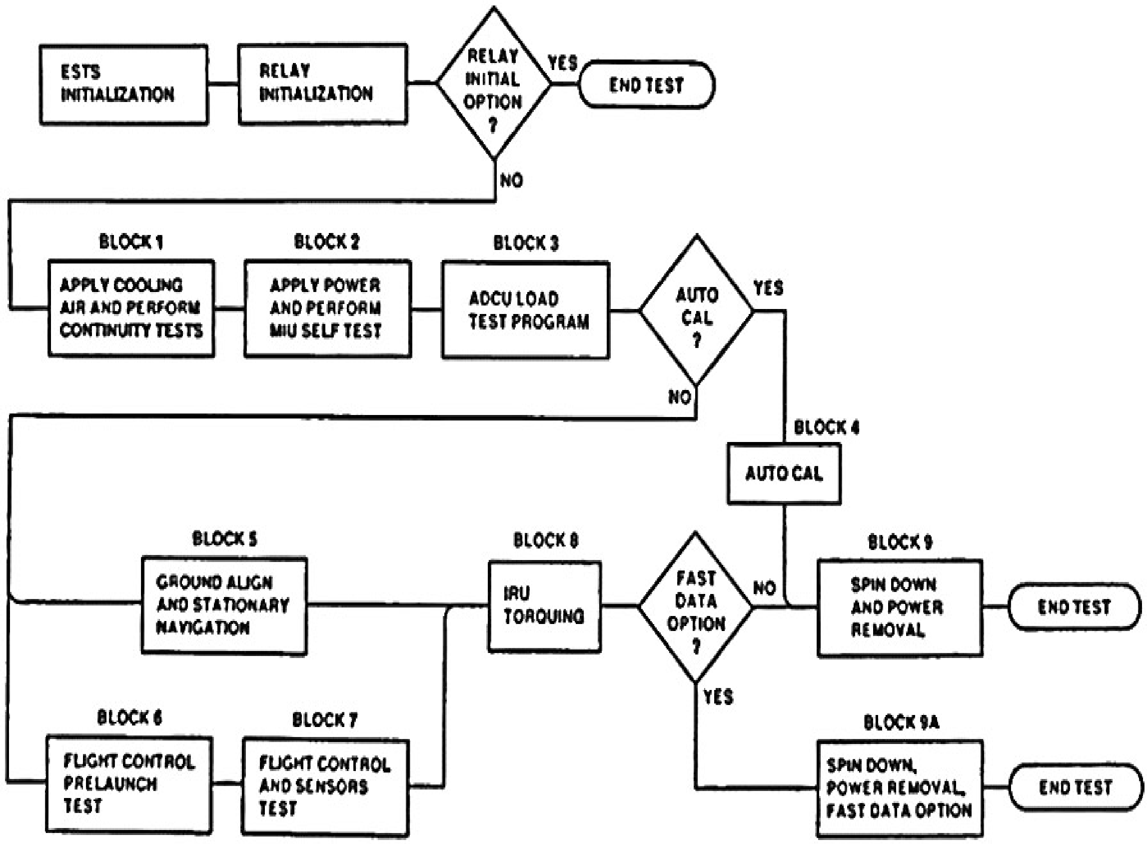


Figure 4–29. Test sequence flow chart.

Troubleshooting flowcharts

Troubleshooting flowcharts guide the fault analysis by providing an appropriate course of action depending on the state of the suspect faulty component. Figure 4–30 shows a typical troubleshooting procedural flowchart.

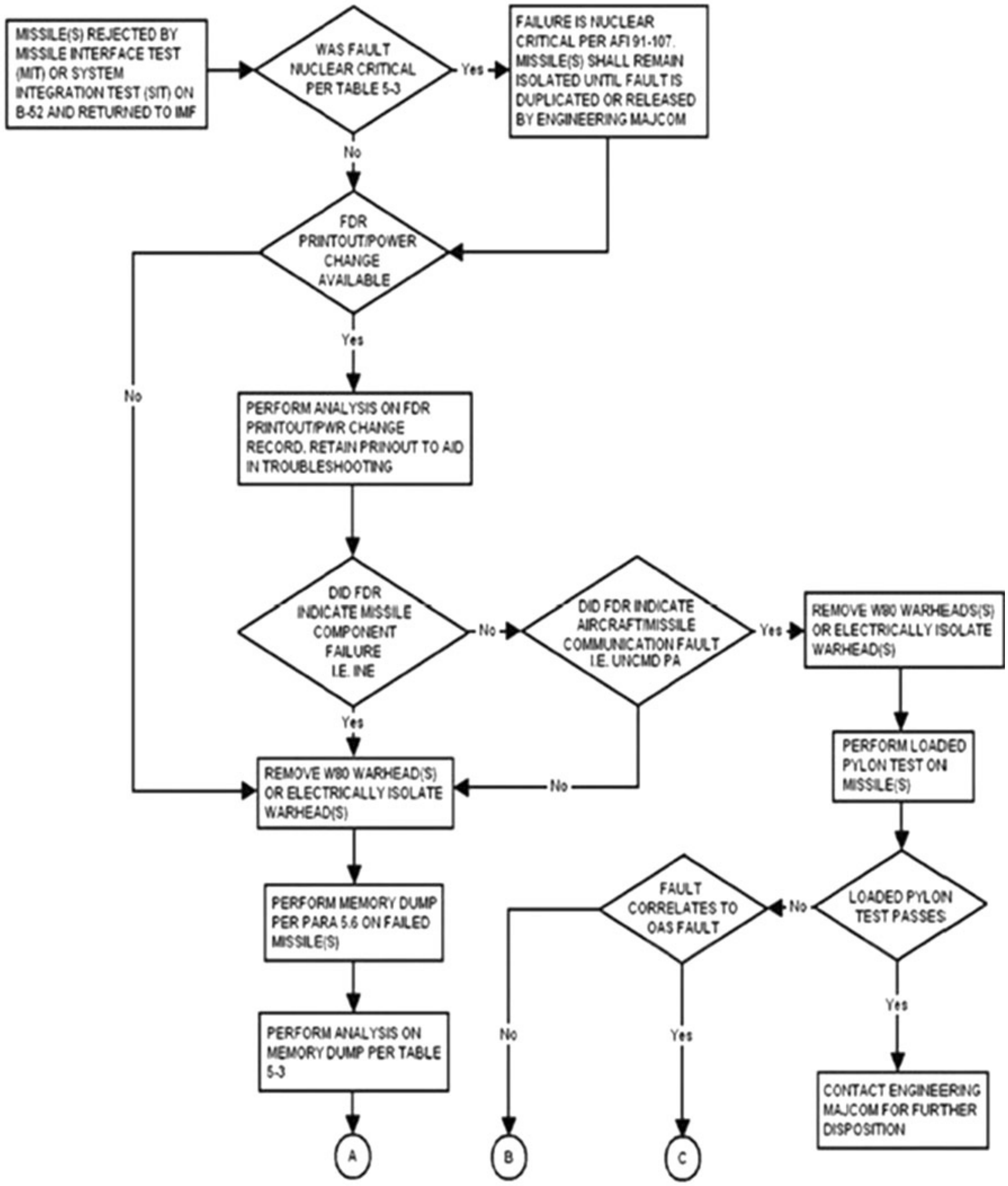


Figure 4–30. Pylon troubleshooting flowchart example.

Self-Test Questions

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

030. Aircraft pylon and rotary launcher systems

1. What types of power are distributed by the pylon power system?

2. During ground testing of a pylon, what provides cooling air for the ECS closed-loop system?

3. What purpose do the pylon attach points serve that interface with the aircraft?

4. Which component receives commands and transmits missile status to the aircraft's ACU in the CSRL monitor and control system?

5. What prevents the weapons from being released at any position other than six o'clock in the CSRL mechanical system?

031. Pylon/launcher checkout and diagrams

1. Pylon testing is performed in which two modes?

2. Which empty launcher test mode must be successfully ran to certify it for missile upload?

3. During pylon/launcher Level III testing, what are malfunctions isolated down to?

4. What type of flowchart diagram shows the major events in the test process for the different pylon and CSRL tests?

5. What type of flowcharts guide fault analysis by providing an appropriate course of action?

4–5. Cruise Missile Generation

An aircraft generation can include a real-world emergency war order (EWO) generation or an exercise generation. In either case, a cruise missile is integrated with an aircraft – the only difference being that aircraft will never leave the ground with a weapon during an exercise. A generation exercise is a measured performance of a wing's ability to generate our aircraft in a wartime environment and is used to determine mission readiness. To a cruise missile maintainer, it typically refers to a wing wide effort to involving expediently transporting weapons to the aircraft, achieving successful integration, and returning the weapons back to the WSA for secure storage. This section will begin with weapons handling, transportation, and storage, then we will go over the aircraft to weapon integration and finish up with fault analysis.

032. Weapons handling, transportation, and storage

Certified personnel that are trained on handling the weapon perform transport. They conduct weapons transport within the WSA as well as outside the restricted area. These transports are called and categorized as movements. A key part of weapons movement involves contact with the munitions control section. Weapons storage is also critical to safeguarding the weapons.

Movement certification and description

Transporting weapons (or packages) inside or outside of the WSA can *only* be performed by a team that is certified on the task. Certification is accomplished using a fully loaded, transportable package (e.g., CSRL or pylon) the operator is qualified to operate within the assigned work center. The certification is conducted by a job qualification standard (JQS) qualified QA evaluator, bay chief, section or element supervisor, or flight chief that evaluates the proficiency checks. This certification allows a technician to perform pre- and post-tow procedures, visually verify and perform safety checks, and operate a tow vehicle or forklift transporting nuclear weapons within the limits of JQS qualifications. Those being certified must have a valid operator's permit and be JQS qualified on all checkout inspections and pre-/post-tow procedures for all lift vehicles, tow vehicles, and trailers operated. During transport certification, the operator (you) must demonstrate an understanding of and ability to operate all levers, switches, and gauges. The operator must demonstrate proficiency in vehicle operation while towing a trailer. Your unit will develop a course to test the operator's ability to turn (right and left), stop in an emergency, and back a loaded trailer into position.

Inner area movement

Inner area movements are the transportation of weapons within the WSA. These movements consist of weapons transports to and from buildings and storage structures that are contained inside the WSA. Security is high and extreme caution measures are taken by the entire team involved, including security force personnel. The only difference you may see depends on which WSA and base you are assigned to. Based on the assets assigned to the units, security measures at Minot AFB will be much higher than at Barksdale AFB.

Outer area movement

Outer area movements involve the transportation of weapons outside the WSA. This particular type of movement normally involves a route that runs to and from the flight line for exercise purposes, though can be used for EWO generation. Movements outside of the area are even more critical due to the simple fact that the security normally provided by the fences and storage facilities within the WSA does *not* exist. To counter this absence, security forces personnel accompany the tow team as part of a weapons convoy from igloo to aircraft.

Conventional outer area movement

Another weapon movement type you may be involved in is associated with Barksdale AFB – a conventional outer area movement. Essentially, this type of transport is comparable to any other nuclear movement except your package is conventional (non-nuclear). Before a conventional movement takes place outside of the WSA, you must make sure your tow vehicle and trailer have the appropriate placards in place (e.g., 1.1 mass-explosion). Placards visually identify the presence of hazardous materials to emergency responders should they be needed. If you have more than one vehicle towing conventional assets, you'll placard the lead vehicle on the front and the last vehicle on the rear. Any vehicles in-between will have placards placed on the sides. However, when towing a conventional package within the WSA, placarding is not required.

Munitions control

Munitions control is the *hub* of the squadron. All operations involving munitions go through munitions control for tracking. *Prior* to making any munition movements, you *must* contact munitions control to receive proper clearance to proceed. Once you've contacted munitions control and received the green light, proceed with the transport until your final destination is reached. Once you've arrived at your destination, you'll immediately contact munitions control again to let them know your status. Should you run into any problems along your route, you must notify munitions control who can then coordinate support services. Solid radio communication between you, your team, and munitions control during all transport operations is a must!

Storage

Safety and security are critical aspects of storing weapons. When backing weapons into storage structures, a spotter must check for clearance during the operation and preposition chocks. Once backing is complete, the trailer holding the weapons is chocked at the wheel and grounded. Once the tow vehicle is disconnected and transport is complete, the structure team inventories the weapons in the structure and reports the inventory to munitions control for verification to ensure there are no inconsistencies prior to closing the structure. Part of closing the structure involves contacting security forces for the required security checks and sealing of the doors. Afterward, massive modular blocks (MMB) may be placed in front of structure doors as a means of deterring or slowing access by unauthorized personnel or hostile forces.

033. Aircraft weapon integration system

In the event of a war or national emergency, the AGM-86B/C cruise missiles must be configured for rapid integration with an aircraft. This is done by first installing an ejector rack on each missile so the missile can be installed on either a pylon or launcher. The pylon or launcher is then stored inside a hardened structure. As we mentioned earlier, if war should develop or the possibility of it exists, the pylons and launchers can be uploaded onto the aircraft in a very short period. Once the missiles are aboard the aircraft, the flight crew is responsible for their delivery to the predetermined launch point. Prior to take-off and before a “mission-ready” status has been confirmed, testing must take place between the aircraft and the missile pylons and launcher. In this lesson, we’ll discuss this testing.

Figure 4-31. B-52H and missile package.

In order to verify the successful integration of the weapons with the aircraft, the missile interface tests (MIT) and/or system interface tests (SIT) are performed. These tests are ran by flightline load crews, however, as a missile maintainer you may be assigned to the "red ball" team on the flight line to provide on-the-spot missile support if needed.

Missile interface test

The MIT is used to verify communication between the weapon and the aircraft. It powers up selected missile(s), initiates built-in tests (BIT) of missile components, and monitors the release and arming circuits to ensure the weapon is safe (unarmed).

System interface test

The SIT, in addition to performing missile BIT, performs missile alignment, targeting (if mission data is available), and checkout of weapon interface equipment and weapon control equipment.

034. Fault analysis

Comparable to Level I empty and loaded pylon and empty and loaded launcher testing, you'll encounter MIT and SIT failures from time-to-time. As a technician, you'll need to troubleshoot failures that occur on the flight line during generation exercises as well.

One of the key positions or teams during an exercise is referred to as "red ball." The red ball maintenance team spends the majority of their time on the flight line addressing MIT and SIT failures.

When a failure occurs during a MIT or SIT, fault analysis is performed to categorize, isolate, and unmistakably identify aircraft, CSRL and pylon, and missile faults. Analysis of MIT and SIT faults *include* the following:

- Examining power change (on missile) record printouts.
- Analyzing fault data retrieval (FDR).
- Following troubleshooting flowcharts from technical order.
- Examining resulting offensive avionics system (OAS) fault messages.
- Interpreting ADCU memory dump printouts.

Self-Test Questions

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

032. Weapons handling, transportation, and storage

1. What is an inner area movement?

2. What is an outer area movement?

3. What is placed on the tow vehicle and trailer for a conventional outer area movement?

4. What section must you stay in contact with before, during, and after a munitions movement?

5. What does the structure team report to munitions control prior to closing the structure?

033. Aircraft weapon integration system

1. Which test is used to verify communication between the weapon and the aircraft?

2. Which test performs missile alignment, targeting, and checkout of weapon interface equipment and weapon control equipment?

034. Fault analysis

1. What is performed in the event of a failure during a MIT or SIT?

2. Why is fault analysis performed?

Answers to Self-Test Questions

023

1. Guided missile handling unit.
2. The sling link and shackle.
3. Guided missile test stand.
4. Wheels.

024

1. A spring return mechanism automatically closes the valve.
2. It is routed through the system filters.
3. The vent system.
4. To evacuate the missile fuel tanks.

025

1. The digital computer (1A3).
2. The control and monitor (1A12).
3. To provide electronics to control and distribute data between the computer (1A3), patchboard, and measuring equipment.
4. The 4-36 VDC, 300 ampere (amp) power supply (2A3).
5. The monitor.
6. The printer.

026

1. 1A3 computer.
2. To control the application or removal of AC input power to the assemblies within the ADTS.
3. To filter out any 60-Hz input power irregularities and prevent EMI propagation within the ADTS.
4. To accurately simulate and measure pneumatic pressures associated with a cruise missile in flight.
5. To circulate room ambient air to provide for 3A5 vacuum pump cooling.
6. To dry and remove contaminants from the pressurized air supplied to the pneumatic paths of the 3A2 ADTC.

027

1. The active loop drawer A1; passive loop drawer A2; power supply assemblies A3, A6, and A7; blower A4; and power control drawer A5.
2. Active loop drawer A1.
3. Manual or programmable simulated fixed altitudes, frequency-modulated/continuous-wave type altimeter rate control, and RF signal self-test.
4. Operating power.
5. Fusing, control, and distribution of the AC and DC power within the MRATA.

028

1. To buffer and condition analog signals coming from the missile and to transmit these signals to the ESTS.
2. To prevent loading of the missile circuits and to isolate missile ground circuits from test equipment circuits during Level II testing.
3. To operate the buffer drawer.

029

1. INE, Section 41 and Clip test cooling air circuits.
2. (1) e.
   (2) d.
   (3) a.
   (4) f.
   (5) c.
   (6) b.
3. Pressure and temperature switches.
4. The storage compartment.
5. V1, V2, and V3.

030

1. Electronic, instrumentation, heater and hydraulic.
2. Cooling control unit.
3. Allow for emergency jettison.
4. The MIU.
5. Launch enable switches.

031

1. The end-to-end-mode and the maintenance mode.
2. End-to-end mode.
3. SRU.
4. Test sequence flow chart.
5. Troubleshooting flowchart.

032

1. Transportation of weapons within the WSA.
2. Transportation of weapons outside of the WSA.
3. Placards.
4. Munitions control.
5. The inventory.

033

1. Missile interface test.
2. System interface test.

034

1. Fault analysis.
2. To categorize, isolate, and identify aircraft, CSRL and pylon, and missile faults.

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.

49. (023) What piece of handling support equipment is used to hold the engine when it is *not* installed in the missile and has wheels to facilitate movement?
    a. Engine test unit.
    b. Engine pedestal.
    c. Engine handling beam.
    d. Engine handing truck assembly.

50. (024) Which fuel/defuel set system provides purging and pressurization for fueling operations?
    a. Nitrogen.
    b. Pneumatic.
    c. Ambient air.
    d. Carbon dioxide.

51. (025) What component stores software programs used by the computer (1A3) in the electronic systems test set (ESTS) main rack?
    a. Disk drive.
    b. Display station.
    c. Disk controller.
    d. Universal counter.

52. (025) What component monitors voltages, currents, and critical signals within the electronic systems test set (ESTS) and unit under test (UUT)?
    a. Digital voltmeter.
    b. Universal counter.
    c. Interface electronics.
    d. Control and monitor.

53. (025) What electronic systems test set (ESTS) unit is used by an operator to control and monitor all ESTS operations from a central location?
    a. Air data test set.
    b. Printer.
    c. Display station.
    d. Unit under test power control rack.

54. (026) Which self-contained rack contains a vacuum and pressure control system that is used to simulate pitot (ram) and static pressures associated with a missile in flight?
    a. Air data test set.
    b. Electronic systems air test set.
    c. Remote switching, control and air assembly.
    d. Missile radar altimeter and air test assembly.

55. (026) What component does the blower cool by circulating ambient air in the air data test set (ADTS)?
    a. Servo valve.
    b. Vacuum pump.
    c. Power control drawer.
    d. Air data test controller.

56. (026) What is the purpose of the vacuum pump in the air data test set (ADTS)?
    a. Purge the air data test controller (ADTC) pneumatic lines.
    b. Depressurize the ADTC fixed volume tanks.
    c. Remove moisture from the air dryers located in the ADTS.
    d. Reduce the volume of air contained in the ADTC fixed volume tanks.

57. (027) Which missile radar altimeter test assembly (MRATA) contains circuits for simulating the altitude rate of change for pulsed-type altimeters?
    a. Active loop drawer A1.
    b. Passive loop drawer A2.
    c. Power control drawer A5.
    d. Power supply assembly A3.

58. (027) Which missile radar altimeter test assembly (MRATA) provides protection, control, and distribution of alternating current (AC) and direct current (DC) power within the MRATA?
    a. Active loop drawer A1.
    b. Passive loop drawer A2.
    c. Power control drawer A5.
    d. Power supply assembly A3.

59. (028) What signal data converter component provides continuity loops for testing cables used during missile Level II testing?
    a. Power rack.
    b. Buffer drawer.
    c. Connector panel.
    d. Power supply drawer.

60. (029) Which cooling air circuit of the cooling control unit (CCU) is used to cool components located in the nose cap of the air launched cruise missile (ALCM)?
    a. Inertial navigation element cooling air circuit.
    b. Clip test cooling air circuit.
    c. Section 41 cooling air circuit.
    d. Forward environmental cooling air circuit.

61. (029) Which type of cooling control unit (CCU) component is adjustable with handholds to allow the operator to control airflow?
    a. Flowmeters.
    b. Pressure gauges.
    c. Metering valves.
    d. Pressure switches.

62. (029) Which type of cooling control unit (CCU) component automatically monitors back pressure and opens to prevent damage to the unit under test (UUT)?
    a. Flowmeter.
    b. Pressure gauge.
    c. Metering valve.
    d. Pressure switch.

63. (030) A manifold within the pylon environmental control system (ECS) routes the supplied air to
    a. the avionics control unit.
    b. each missile and the missile interface unit.
    c. each missile and the nuclear station logic unit.
    d. the weapons control system processor.

64. (030) What component provides electrical interface with the missiles and ejectors for a variety of functions in the pylon monitor and control system?
    a. Relay control unit.
    b. Avionics control unit.
    c. Missile interface unit.
    d. Nuclear station logic unit.

65. (030) What routes power to the missiles from either the aircraft or electronic systems test set (ESTS) in the common strategic rotary launcher (CSRL) power system?
    a. Relay assembly.
    b. Missile interface unit.
    c. Nuclear station logic unit.
    d. Interconnect cable assembly.

66. (031) What test *must* be performed on a pylon before it is considered certified for missile upload?
    a. Level III test.
    b. Empty pylon test.
    c. Empty launcher test.
    d. Auto-calibration test.

67. (032) What type of movement is a weapons transportation from the weapon storage area (WSA) to the flightline?
    a. Inner area.
    b. Outer area.
    c. Certification.
    d. Commission.

68. (032) What section provides clearance to proceed with a munitions outer area movement?
    a. Support.
    b. Mobility.
    c. Analysis.
    d. Munitions control.

69. (033) Which tests are performed to verify successful aircraft weapon integration?
    c. Empty and loaded.
    b. Level III and flightload.
    c. Missile and system interface.
    d. Memory load and calibration.

70. (033) Which test performs missile alignment, targeting, and checkout of weapon interface= equipment and weapon control equipment?
    a. Level III.
    b. Fightload.
    c. System interface test.
    d. Missile interface test.

71. (034) What is performed to categorize, isolate, and unmistakably identify aircraft, common strategic rotary launcher (CSRL) and pylon, and missile faults as a result of a missile interface test (MIT) or system interface test (SIT) failure?
   a. Redball.
   b. Calibration.
   c. Built-in test.
   d. Fault analysis.

72. (034) What is *not* included in analysis of missile interface test (MIT) and system interface test (SIT) faults?
   a. Analyzing fault data retrieval.
   b. Interpreting memory dump printouts.
   c. Troubleshooting on nuclear weapons.
   d. Following troubleshooting flowcharts.

Student Notes

Glossary

Abbreviations and Acronyms

°	degree
° F	degree Fahrenheit
±	plus or minus
+	plus
Ω	ohms
AC	alternating current
ACU	avionics control unit
ADCU	air vehicle digital computer unit
ADE	air data element
ADTC	air data test controller
ADTS	air data test set
AF	Air Force
AFB	Air Force base
AFGSC	Air Force Global Strike Command
AFSC	Air Force specialty code
AFTO	Air Force technical order
AGL	above ground level
AGM	air-to-ground missile
AJ	anti-jam
ALCM	air launched cruise missile
amp	ampere
AMS	Assignment Management System
APPU	air purge and pressurizing unit
ATLAS	abbreviated test language for all systems
BIT	built-in test
BMT	basic military training
CALCM	conventional air launched cruise missile
CCU	cooling control unit
CDC	career development course
CL	constant load
CMRA	common missile radar altimeter
CPIN	Computer Program Identification Number
CSRL	common strategic rotary launcher
DC	direct current

DOD	Department of Defense
D-R	decoder-receiver
DVD	digital video disk
ECS	environmental control system
EED	electro-explosive device
EMI	electromagnetic interference
EMLA	electro-mechanical linear actuator
EMP	electro-magnetic pulse
EPA	Environmental Protection Agency
ERTT	electrical resistance temperature transmitter
ESTS	electronic systems test set
ETRS	expanding tube release system
EWO	emergency war order
FCAT	fuel containment and transfer
FCE	flight control element
FCS	flight control system
FDR	fault data retrieval
FDT	flight data transmitter
FLT	filter
g	gravity
G	gravitational force
GAJAS	global positioning system anti-jam antenna system
GMFC	guided missile flight controller
GPS	global positioning system
GRIU/P	global positioning system receiver interface unit/precision
HCP	hardness critical procedure
Hz	Hertz
ICBM	Intercontinental Ballistic Missile
IMDS	Integrated Maintenance Data System
IMF	integrated maintenance facility
INE	inertial navigation element
IRU	inertial reference unit
J	jack
J-box	junction box
JP	jet propellant
JQS	job qualification standard
K	relay

LES	launch enable switch
LH	left hand
LRU	line replaceable unit
MAJCOM	major command
MIL-STD	military standard
MIT	missile interface test
MIU	missile interface unit
MMB	massive modular block
MNCL	master nuclear certified list
MRATA	missile radar altimeter test assembly
MXW	maintenance supervision
MXWC	materiel flight
MXWK	systems flight
MXWM	air launched cruise missile flight
MXWS	special weapons maintenance flight
NAF	numbered air forces
NARS	nuclear accountability and reporting section
NCE	nuclear certified equipment
NIIN	National Item Identification Number
NucSLU	nuclear station logic unit
NWSSG	Nuclear Weapons Systems Safety Group
O&M	operations and maintenance
OAS	offensive avionics system
OFS	operational flight software
P	plug
PAL	permissive action link
PCU	power-conditioning unit
PF	priming fluid
PL	pulse load
PMEL	precision measurement equipment laboratory
PRP	personnel reliability program
psia	per square inch absolute
psig	pounds per square inch gauge
PST	pressure sensing transducer
QA	quality assurance
QAE	quality assurance evaluator
RF	radio frequency

RH	right-hand
rpm	revolutions per minute
RS/RV	reentry systems/reentry vehicles
SAF	safe, arm, and fuze
SDC	signal data converter
SECAF	Secretary of the Air Force
SIT	system interface test
SRU	shop replaceable unit
TAG	test adapter group
TCM	technical content manager
TCTO	time compliance technical order
TERCOM	terrain contour-matching
TM	technical manual
TMDE	test measurement and diagnostic equipment
TO	technical order
UCMJ	Uniform Code of Military Justice
UEA	umbilical enclosure assembly
UUT	unit under test
UWSF	unarmed weapons storage facility
VAC	volts alternating current
VACE	verification and checkout equipment
VDC	volts direct current
W	wire
WAD	warhead arming device
WIU	warhead interface unit
WSA	weapon storage area
WSSR	weapon system safety rules

Student Notes

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