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![Adobe Reader warning]

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CHAPTER 6

AIRCRAFT GUNS

Gun systems installed in high-speed aircraft must meet demanding performance requirements and provide firepower. The General Electric M61A1 and M61A2 20-mm automatic gun system, installed in the F/A-18 aircraft, along with the GAU-21, GAU-16, GAU-17 and M240D machine guns, meet these requirements.

LEARNING OBJECTIVES

When you have completed this chapter, you will be able to do the following:

1. Identify the components of the M61A1 and M61A2 automatic gun and recognize the operating principles.
2. Identify the ammunition handling and gun drive systems of the M61A1 and M61A2 automatic gun. Describe the principles of operation of each system and identify the interrelationship of the various systems.
3. Identify M61A1 and M61A2 gun system installations to include those used on the F/A-18 aircraft.
4. Identify maintenance and testing procedures at the organizational and intermediate levels.
5. Identify safety precautions to follow when working with the M61A1 and M61A2 gun.
6. Describe the characteristics and nomenclature of the GAU-21, 16, and 17 machine guns.
7. Describe the characteristics and nomenclature of the M240D machine gun.
M61A1 AND M61A2 AUTOMATIC GUN

The M61A1 and M61A2 (M61A1/2) (Figure 6-1) is a six-barrel, rotary-action, automatic gun based on the machine-gun design of Richard J. Gatling. The gun consists of a revolving cluster of barrels. Each barrel is fired once per revolution. The M61A1/2 automatic gun is hydraulically driven, electrically controlled, and can fire M50 and PGU-series ammunition at 4,000 to 6,000 rounds per minute. As installed in Navy aircraft, the gun has a pilot-selectable firing rate of either 4,000 (GUN LOW) or 6,000 (GUN HIGH) rounds per minute. It is designed for either air-to-ground or air-to-air gunnery missions.

Figure 6-1 — M61A1 and M61A2 automatic gun.

Ammunition is supplied to the M61A1/2 gun by an ammunition handling and storage system that functions within a specific aircraft. The system uses an endless conveyor that transports 20-mm ammunition from the ammunition drum to the gun. The conveyor then returns the expended cases and unfired rounds to the ammunition drum.

Although the physical location of components varies between different aircraft gun installations, the function and description of the components are essentially the same. The primary parts of the gun are the barrels, housing assembly, and rotor assembly.

The following paragraphs contain a description of each gun component and an explanation of how each component works. Figure 6-2 and Figure 6-3 show an exploded view of the gun components. Figure 6-4 and Figure 6-5 show the gun component locations. These figures should be reviewed as each component is discussed.
Figure 6-2 — M61A1 gun components (exploded view).
Figure 6-3 — M61A2 gun components (exploded view).
Figure 6-4 — M61A1 gun component locations.
Figure 6-5 — M61A2 gun component locations.
GUN COMPONENTS

The primary parts of the gun are described in the following paragraphs.

**Muzzle clamp assembly.** The muzzle clamp assembly is positioned at the outer end of the barrels. It restrains individual barrel movement during firing. It is positioned against the flange on the barrels and secured by the pressure of the self-locking nut assembly against the opposite side of the shoulders.

**Mid-barrel clamp assembly.** The mid-barrel clamp assembly is positioned near the center of the barrels. The clamp tabs are engaged in the slots of the stop shoulders on the barrels. This clamp should be secured in this position by rotating the locating disk to the locked position. The direction of rotation of the gun and barrel hue prevents the clamp from unlocking. As an additional safety measure, a cotter pin should be inserted through the locking disk.

**Barrels.** The M61A1/2 automatic gun has six rifled barrels. The stub rotor attached to the rotor body supports them. The three rows of interrupted locking lugs on the barrel engage similar interrupted locking lugs in the rotor to secure the barrel. There are three knurled bands near the center of the barrels. These bands provide a gripping surface for easy installation and removal of the barrels from the rotor.

**Recoil adapters.** The recoil adapters are mounted on the bearing retainer and provide the front mounting for the gun. The adapters reduce the amount of recoil and counter-recoil forces transmitted to the supporting structure when the weapon is fired.

**Firing contact assembly.** The firing contact assembly is mounted to the housing so that the connector is outside the housing, and the spring-loaded cam is inside the assembly. The contact assembly provides the necessary path for the current to enter the housing and reach the breech-bolt assembly. This path goes through the connector to the conductor, to the insulated insert in the contact cam assembly, and then to the breech-bolt assembly.

**Clearing solenoid assembly.** The clearing solenoid assembly is mounted near the back of the gun housing. It is linked to and controls the movement of the clearing sector assembly.

**Clearing sector assembly.** The clearing sector assembly is linked to and controlled by the clearing solenoid assembly. When the solenoid is activated, the sector arm diverts the bolt assemblies into the clearing cam path.

**Guide bar.** The guide bar is located on the gun housing. It guides the rounds into and out of the extractor lip that is located on each of the six breech-bolt assemblies.

**Breech-bolt assembly.** The breech-bolt assembly picks up a round as it enters the gun, transports it to the firing chamber, locks it into the firing position, transmits the firing voltage to the primer of the round, and returns the empty case to the guide bar, where it is cammed out of the gun. An extractor lip on the front of each bolt assembly engages the rim of a round throughout these actions.

There are six breech-bolt assemblies in the gun. Guide slots or grooves on the side of the bolt body permit it to slide on the rotor tracks. The bolt roller shaft determines the position of the bolt as it follows the main cam path or the clearing cam path in the housing.

**Rotor assembly.** The rotor assembly (Figure 6-6) is a major unit of the M61A1/2 gun. The front section or stub rotor supports the six barrels. The main body of the rotor
assembly contains the rotor tracks, rotor drive gear, and the locking lugs to lock the barrels in place.

The rotor tracks support the breech-bolt assemblies and provide a guide for the forward and backward movement of the bolt. There are six sets of rotor tracks attached to the ribs along the rotor body. Each set contains a front, center, and rear removable track. The removable track lets you install or remove a bolt assembly for servicing or replacement.

The front support for the rotor assembly consists of a double row of ball bearings. The rear is supported by needle bearings located inside the rotor body. The end plate provides the inner race for the needle bearings, and it also provides for the gun’s rear support.

The rotor assembly is driven by an external hydraulic drive. Drive is applied through a shaft and drive assembly. The drive assembly is bolted to the gun housing but is not a component of the gun.

**Rear housing assembly and associated parts.** The rear housing assembly (Figure 6-7 and Figure 6-8) is a major unit of the gun. It consists of an upper section and a lower section assembled as one unit. The rear housing assembly provides the main cam path that controls the movement of the breech-bolt assemblies. The elliptical (oval) shape of the main cam path causes the forward and backward movement of the bolt assemblies. The clearing-cam path is circular and located at the rear of the housing. It provides a path for the bolt assemblies during the gun’s clearing cycle. The housing cover, when in the closed position, forms a part of the clearing cam path. The housing cover may be removed to install or remove the bolt assembly.

The locking and unlocking cams are part of the housing assembly. The gun-indexing pin (timing pin) is located on the housing. It is used to time the gun when it is mated with the ammunition handling system, or when you perform loading/unloading procedures.
Figure 6-7 — Rear housing assembly and related parts (external view).

Figure 6-8 — Rear housing assembly and related parts (internal view).
**Lubricator assembly.** A lubricator assembly is attached externally to the gun housing assembly. It is used to lubricate the bolt assemblies during gun operation. During gun acceleration/deceleration and when the gun is firing, an inertia-actuated pump located within the lubricator assembly, pumps the lubricant through a metal tube to the gun housing assembly. The lubricator can be refilled when performing normal maintenance procedures.

**M61A1/2 GUN PRINCIPLES OF OPERATION**

The operation of the M61A1/2 gun is divided into two distinct cycles—the firing cycle and the clearing cycle.

**Firing Cycle**

The firing cycle begins when power is applied to the firing contact assembly and the gun drive unit simultaneously.

When the rotor is viewed from the rear, it revolves in a counterclockwise direction. The ammunition is received from an external source. It is guided into the extractor lip on a breech-bolt assembly by the fingers on the transfer assembly and housing (*Figure 6-9*). The bolt roller shaft follows the main cam path and moves the bolt assembly forward along the rotor tracks, chambering the round.

*Figure 6-9 — Round guided into breech-bolt assembly.*
As the breech-bolt assembly enters the front dwell area of the main cam path, the locking cam forces the bolt shaft down, locking the bolt in the front locking well of the rotor (Figure 6-10). The insulated portion of the contact cam in the firing contact assembly depresses the firing pin cam in the breech-bolt assembly. This moves the firing pin forward against the primer of the round. The conductor portion of the contact cam makes contact with the firing pin cam, which allows a firing voltage to pass through the firing pin to fire the round.

As the breech bolt assembly enters the forward dwell, the top of the breech bolt shaft contacts the locking cam which then depresses the locking block into the locking well of the rotor.

![Figure 6-10 — Breech-bolt assembly in firing cycle.](image)

The breech-bolt assembly remains locked throughout the locking cam period until the projectile leaves the barrel. After the projectile leaves the barrel, the barrel pressure is reduced. The unlocking cam lifts the bolt shaft, retracts the bolt-locking block, and unlocks the bolt.

The main cam path guides the breech-bolt assembly rearward. The empty case is removed from the chamber by the extractor lip of the bolt assembly.

Then, the bolt assembly travels back along the rotor tracks until the guide bar removes the empty case from the bolt extractor lip and ejects it from the gun (Figure 6-11). To complete the cycle, the bolt assembly travels along the rear cam dwell area and into position to receive the next round.
Once the breech-bolt assembly has completed a full firing cycle through the elliptical-shaped main cam path. It has performed seven actions or operations in the following sequence:

1. Feeding
2. Chambering
3. Locking
4. Firing
5. Unlocking
6. Extracting
7. Ejecting

All six breech-bolt assemblies repeat this firing cycle (Figure 6-12) until the clearing solenoid is actuated, and the gun starts the clearing cycle.
Figure 6-12 — Firing cycle.
Clearing Cycle

The clearing cycle starts when the clearing solenoid is energized. The clearing solenoid depresses the clearing sector arm to the gun housing. This places the clearing sector arm in a ready position. The first bolt assembly that passes the sector arm triggers the actuating pin that lets the sector arm continue to the clearing mode position. This diverts the succeeding bolt assemblies into the clearing cam path (Figure 6-13).

As the breech-bolt assembly picks up a round at the guide bar, the clearing sector arm depresses the bolt roller shaft. This locks the bolt assembly in the rear locking well of the rotor. While locked in this position, the bolt assembly cannot follow the main cam path, so it follows the clearing cam path. The clearing cam path isn’t as deep as the main cam path, and it keeps the bolt roller shaft depressed. This firmly locks the bolt assembly in the rear of the rotor body.

The M61A1/2 gun continues to receive rounds during the clearing cycle. However, because each bolt assembly remains positioned at the back of the rotor during rotation, the guide bar cam fingers eject all unfired rounds. When the clearing solenoid is deactivated, the clearing sector arm pivots out of the main cam path. This allows the leaf springs in the rear locking well to force the bolt-locking block upward. The bolt roller shaft follows the main cam path that permits the gun to be fired.

Figure 6-13 — Breech-bolt assembly in clearing cycle.
If necessary, the gun may be cleared manually. To do this, the clearing sector cam should be manually pivoted into the main cam path while turning the rotor by hand.

For further information on the M61A1/2 automatic gun, you should refer to the *M61A1 and M61A2 Automatic Gun*, NAVAIR 11-95M61-1. NAVAIR 11-95M61-1 provides intermediate-level maintenance procedures and includes associated special support equipment.

**AMMUNITION HANDLING AND GUN DRIVE SYSTEMS**

The ammunition and gun drive systems (*Figure 6-14 and Figure 6-15*) are discussed in the following paragraphs.
Figure 6-15 — M61A2 ammunition and gun drive system.

**DRUM UNIT ASSEMBLY**

Live ammunition and expended cases are stowed in the drum unit assembly. This assembly has four major parts—drum unit, entrance cover, exit cover, and scoop disk. Refer to *Figure 6-16* as you read about these parts.
Drum Unit. The drum unit is a cylindrical structure that consists of an outer drum and an inner drum helix. The live ammunition rounds and expended cases are stored radially around the longitudinal axis of the outer drum with their bases in an outward direction.

Their bases (in partitions) suspend the rounds. These partitions are mounted lengthwise with respect to the inner surface of the outer drum. With the outer drum mounted stationary to the aircraft's structure, the rounds are moved along the length of the partitions by the rotation of the double-lead helix (inner drum). It's easy to understand this movement if the inner drum helix is thought of as the threads on a screw. The projectile end of the casing protrudes into the threads.

As the inner drum helix is rotated, it produces a screwing-type motion, causing the rounds to slide along the partitions from one end to the other end of the outer drum.

Entrance Cover. The entrance cover is stationary mounted to the entrance end of the outer drum. The entrance cover contains a retainer gear and 252 steel ball bearings that support the scoop disks and the inner drum helix. The retainer partitions are mounted to the retainer gear that controls the position of the rounds as they are passed from the entrance cover to the scoop disk. A spring-loaded timing pin on the entrance cover is used to index the drum for installation of the entrance unit.
Exit Cover. The exit cover is stationary-mounted to the exit end of the outer drum. The exit cover is constructed like the entrance cover. It controls the position of the rounds as they pass from the scoop disk to the exit cover. A spring-loaded timing pin on the exit cover is used to index the drum for installation of the exit unit.

Scoop Disk. A scoop disk is mounted on each end of the inner drum helix. Each scoop disk has two sets of sprocket spur gears located 180 degrees apart. These spur gears mesh with the retainer gear in the entrance/exit covers that provide rotating support for the inner drum helix. The sprockets attached to the spur gear transfer rounds from the entrance cover retainer partitions to the drum partitions, and from the drum partitions to the retainer partitions in the exit cover.

EXIT UNIT

The exit unit is attached over an opening in the exit cover and geared to the exit cover retainer gear. The exit unit contains two gear-driven sprocket assemblies. The sprocket assemblies remove live rounds or expended cases from the retainer partitions in the exit cover and place them in the conveyor elements. Before the exit unit is installed to the exit cover, the exit unit timing pin and the exit cover timing pin should be pressed and held to make sure there is proper gear alignment between the two components. Once the exit unit is properly attached to the exit cover, the spring-loaded timing pins must release.

The exit unit also contains a last-round switch that is electrically connected to the gun control firing circuits. The projectiles of the 20-mm rounds actuate the switch. The switch prevents expended rounds (empty cases) from being fed into the gun and jamming it. Before the gun will fire, the ammunition must be cycled through the ammunition drum until the first round actuates the last-round switch. When there is no more ammunition present or when expended rounds are present, the last-round switch is released. This automatically initiates the gun clearing cycle and terminates gun firing. Before the gun can be fired again, the ground loading crew to actuate the last-round switch must manually position live ammunition.

ENTRANCE UNIT

The entrance unit is attached over the opening in the entrance cover and geared to the entrance cover retainer gear. The entrance unit contains three gear-driven sprocket assemblies. The sprocket assemblies remove live rounds or expended cases from the conveyor elements and place them in the entrance cover retainer partitions. Before installation, the spring-loaded timing pin should be pressed and the scoop sprocket stud pin aligned with the entrance unit timing mark. With the entrance unit properly timed and aligned, the entrance cover-timing pin should be pressed and the timing mark aligned on the scoop disk with the timing mark on the entrance cover. To ensure proper gear alignment between the two components, the entrance unit and the entrance cover should be properly timed and aligned.

Once the entrance unit is attached to the entrance cover, the spring-loaded timing pins must release.

TRANSFER UNIT AND ADAPTER ASSEMBLY

The transfer unit and adapter assembly are actually two separate components bolted together to form one unit. They are never separated at the organizational maintenance level. The function of each component is discussed in the following paragraphs.
Transfer Unit
The transfer unit is gear-driven by the gun and attached to the M61A1/2 gun housing by quick-release pins to make maintenance easier. The gear-driven sprocket assemblies and guides maintain positive control of the rounds and conveyor elements passing through the transfer unit. The transfer unit removes the rounds from the conveyor and places them into the extractor lip of the gun breech bolts. The transfer unit also receives expended cases and unfired rounds from the gun breech bolts, and places them in the conveyor elements. When the transfer unit and the adapter assembly are installed as a single unit, the timing pin should be pressed and held on the transfer unit and the gun housing.

Once the transfer unit/adapter assembly is properly attached, the spring-loaded timing pins must release.

Adapter Assembly
The adapter assembly bolts directly to the transfer unit. During downloading and loading operations, the adapter assembly interfaces with the linkless ammunition loading system (LALS).

CHUTE ASSEMBLIES
The chute assemblies are interlocking segments. They provide a flexible path through which the conveyor elements transport live rounds and expended cases around an aircraft structure. The bypass chute provides a path from the entrance unit to the exit unit, through which the conveyor elements pass. The feed chute provides a path from the exit unit to the adapter assembly, through which the conveyor transports live rounds or unexpended cases. The return chute provides a path from the transfer unit to the entrance unit, through which the conveyor transports expended cases or unfired rounds.

The construction of the chute assemblies lets the conveyor elements pass through in only one direction.

If the system is rotated in the wrong direction, the element tabs will jam in the chute segments and damage the system. The chute ends are color-coded red and green to key the right connection to other components. Additionally, each end is clearly marked with a metal labeling plate. This identifies the component to which a particular chute end must be connected. The ends of the chutes are equipped with quick-release latches for ease of removal and installation.

CONVEYOR ASSEMBLY
The conveyor assembly consists of individual conveyor elements shaped to cradle a 20-mm case. The elements are mated together with shouldered shear bolts and self-locking nuts to form an endless conveyor assembly (Figure 6-17).
During system operation, the conveyor receives rounds of ammunition from the exit unit and delivers them through the feed chute to the transfer unit. The conveyor also receives expended cases and unfired rounds from the transfer unit and transports them through the return chute to the entrance unit. After receipt by the entrance unit, the expended cases and unfired rounds are removed from the conveyor elements and stored in the ammunition drum. The empty conveyor passes from the entrance unit to the exit unit through the bypass chute. Tabs on the conveyor elements, which engage guides in the chutes, exit unit, entrance unit, adapter assembly, and transfer unit, maintain positive control of the conveyor elements. The total number of elements required for a system varies according to aircraft application.

**GUN DRIVE AND DRUM DRIVE SYSTEMS**

A hydraulic drive unit run by the aircraft’s hydraulic system simultaneously drives the M61A1/2 gun and the ammunition handling system. The hydraulic pressure is supplied through a hydraulic fluid manifold electrically controlled by a dual-rate solenoid valve. This solenoid valve is controlled from the cockpit through the gun control unit (GCU), which results in the gun firing at 6,000 (GUN HIGH) or 4,000 (GUN LOW) rounds per minute. Attached to the hydraulic drive unit is a mechanical drive unit that consists of a gear train with one input shaft (from the hydraulic drive unit) and, depending upon the type of aircraft, one or two output shafts.

The F/A-18 aircraft uses a mechanical drive unit with one output shaft. Because the ammunition drum is near the mechanical drive unit, a gear on the output shaft of the mechanical drive unit meshes directly with the drum drive. A two-piece telescoping shaft transmits power from the same output shaft of the mechanical drive unit to the gun drive. This, in turn, drives the gun rotor.

The aircraft has provisions to manually rotate the gun system by using a manual hand crank. During ground maintenance, the gun system may be rotated hydraulically by actuating a manual control on the hydraulic drive unit when the aircraft’s hydraulic system is operating.

**GUN GAS PURGE SYSTEM**

The M61A1/2 gun is internally mounted in the aircraft's fuselage. When the gun is fired, the temperature of the gun barrels increases rapidly, and the gun compartment is filled with gun gas from the fired rounds. If the barrels are not properly cooled, the rounds
may **cook-off** due to excessive barrel temperatures. Gun gas, when confined to an enclosed area such as a gun compartment, is highly explosive. The gun gas purge system cools the barrels and purges gas from the compartment during gun firing operations.

The F/A-18 gun gas purge system uses engine bleed air and has an additional gas control provided by a hydraulically actuated ram-air scavenge door that opens automatically during gun-firing operations. The gun gases are vented through louvers in the lower mold line of the aircraft fuselage.

**M61A1/2 GUN SYSTEM INSTALLATIONS**

M61A1/2 gun and ammunition handling system installations have the same basic components. However, some components are peculiar to specific aircraft.

**F/A-18 GUN SYSTEM INSTALLATION**

The F/A-18 M61A1/2 gun system is internally mounted in the nose of the aircraft on the centerline. The fired projectiles exit the aircraft through the gun blast diffuser assembly, located just forward of the cockpit windscreen. Depending upon the mission objective, the gun can be operated in the air-to-ground (A/G) or air-to-air (A/A) computer mode. There are two A/G modes—continuously computed impact point (CCIP) and manual (MAN). There are three A/A modes—director, disturbed, and cage. The pilot can select any one of the A/G or A/A modes while in flight.

The ammunition handling system holds a maximum of 578 rounds of ammunition. A round limiter, located in the gun compartment, can be preset to limit the total number of rounds the pilot can fire. The round limiter is used during training missions, and permits two or three gunnery missions from one gun load-out.

For example, ground maintenance personnel set the round limiter at 200 rounds. When the pilot has fired 200 rounds, the gun's electrical system automatically initiates the gun clearing cycle. This prevents further firing until ground maintenance personnel manually reset the round limiter.

While in flight, the pilot has the option of selecting unrestricted firing or presetting the number of rounds per burst. If the pilot selects unrestricted firing, the gun fires continuously as long as the trigger is depressed and ammunition is available.

For example, if the pilot presets 50 rounds, the gun fires bursts of 50 rounds each time the trigger is pulled and released. A display panel in the cockpit continuously indicates the number of rounds remaining.

The clearing sector retainer assembly (Figure 6-15) is used to manually clear the gun. When the manual clearing handle is in the cleared position, a wire rope assembly depresses the gun clearing sector assembly against the gun housing. This directs the breech-bolt assemblies into the clearing cam path when the gun is manually rotated. The manual clearing handle is held in the clearing position by a locking tab. **For safety reasons, the manual clearing handle should remain in the cleared position until gun-arming procedures are actually performed.** When the gun access door is closed, the position of the manual clearing handle can be determined by the position of the indicator located on the door. If the indicator is flush with the door surface, the manual clearing handle is in the **firing** position. If the indicator protrudes from the door surface, the manual clearing handle is in the **cleared** position.
The entire gun system is handled as a single palletized unit. This includes the M61A1/2 gun, drum unit assembly, ammunition chutes, element chutes, and hydraulic motor. The system bolts directly to the aircraft structure with four bolts, and does not require any other bore sighting or alignment. Other than minor adjustments in the aircraft, all maintenance is performed at the intermediate-maintenance level. The system is removed from the aircraft as a unit by using gun-handling adapters, a weapon skid or trailer, and a bomb-hoisting unit. The bomb-hoisting unit is used to raise or lower the gun system as it is being removed or installed. A gun system hoist adapter, designed to support the hoist boom, is attached to the aircraft during the raising or lowering operation. A gun-handling adapter attached to a weapon’s skid or trailer, supports the gun system after it is removed from the aircraft.


MAINTENANCE AND TESTING

The maintenance and testing responsibilities of M61A1/2 gun installations are distributed evenly between the organizational and intermediate levels of maintenance. The basic responsibilities of these two levels of maintenance are discussed in the following paragraphs.

ORGANIZATIONAL MAINTENANCE

Organizational maintenance includes servicing (loading and unloading), preflight, post flight, minor periodic maintenance, malfunction troubleshooting, and removal and installation of components on the aircraft. Also, maintenance of the aircraft system and controls must be included in the AO's organizational responsibilities.

The gun firing record or log is kept at this level. The cumulative total of rounds fired is the basis for most of the maintenance. The number of rounds fired per firing flight is obtained from a counter located within the aircraft. For record accuracy, each time the gun installation is loaded, the counter must be reset (usually to zero) according to the instructions applicable to the aircraft. The two primary tasks that depend upon the round interval (rounds fired) are (1) torquing the two forward front track bolts (30,000 rounds), and (2) changing the breech-bolt assemblies (15,000 rounds).

Organizational responsibilities are not included in NAVAIR 11-95M61A1-1 or the NAVAIR 11-95M61A1-2. Organizational responsibilities are outlined in maintenance requirements cards (MRCs), aircraft maintenance instruction manuals (MIMs), and aircraft loading manuals.

If a component is being removed for sudden stoppage (jam) maintenance, care and extra precautions should be taken. Loose propellant powder from ruptured cartridge cases may be scattered about the gun compartment. This creates an extremely hazardous situation. The loose powder must be removed in a radiation hazard (RADHAZ)-free environment before removing a component.

INTERMEDIATE MAINTENANCE

Intermediate maintenance responsibilities are tasks associated with repair or replacement of unserviceable or damaged assemblies, components, or parts of the gun installation that do not require the special maintenance facilities of an overhaul depot.
When a gun reaches a round interval of 120,000 rounds fired or requires major repair or alteration, it is sent to a depot-level maintenance activity. The ammunition handling and gun drive system maintenance procedures are identical at both the intermediate- and depot-maintenance levels (with one exception—the depot level removes bearings); therefore, such maintenance is generally performed at the intermediate level. Intermediate maintenance may be divided into two categories—scheduled and unscheduled.

Scheduled maintenance includes inspecting, disassembling, replacing parts, lubricating, assembling, and functionally checking components based on the round interval specified in technical manuals. Scheduled gun maintenance begins at 7,500 rounds and proceeds through various interval states for different parts replacement up to the 120,000-round overhaul interval. Scheduled maintenance for the handling and drive system is set at an interval of 30,000 rounds.

**GAU-21 .50-CALIBER AIRCRAFT GUN SYSTEM**

The GAU-21, .50–caliber aircraft machine gun (*Figure 6-18*) is an air cooled, recoil-operated, alternate-feed weapon. It is capable of firing at a rapid rate of 950 to 1100 rounds per minute and provides medium-range suppressive fire. See *Table 6-1* for additional GAU-21 characteristics.

*Figure 6-18 — GAU-21 .50-Caliber aircraft machine gun.*
### Table 6-1 GAU-21 .50-Caliber Aircraft Machine Gun Characteristics

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
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<tbody>
<tr>
<td>GAU-21 (empty weight of complete gun)</td>
<td>80 lb</td>
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<tr>
<td>Weight of barrel</td>
<td>11.0 lb</td>
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<tr>
<td>Weapon Length</td>
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#### Rifling

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<tbody>
<tr>
<td>Length of barrel</td>
<td>36 inches</td>
</tr>
<tr>
<td>Number of grooves</td>
<td>8</td>
</tr>
<tr>
<td>Twist and direction</td>
<td>Right-Handed</td>
</tr>
<tr>
<td>Twist (one turn in)</td>
<td>15 inches</td>
</tr>
<tr>
<td>Imposed feed belt load</td>
<td></td>
</tr>
<tr>
<td>Barrel life</td>
<td>10,000 rounds</td>
</tr>
<tr>
<td>Depot maintenance cycle</td>
<td>40,000 rounds</td>
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<tr>
<td>Ammunition* (.50 Caliber) 12.7 mm</td>
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</tr>
<tr>
<td>(*Includes cartridge case, projectile, powder, and link)</td>
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</tr>
</tbody>
</table>

#### Characteristics

<table>
<thead>
<tr>
<th>Item</th>
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</tr>
</thead>
<tbody>
<tr>
<td>RANGE: (air to ground)</td>
<td></td>
</tr>
<tr>
<td>Maximum (M-33 Ball)</td>
<td>6,500 meters</td>
</tr>
<tr>
<td>Maximum effective</td>
<td>1,850 meters</td>
</tr>
<tr>
<td>FIRING RATE: (Rounds/Min)</td>
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</tr>
<tr>
<td>Sustained</td>
<td>1,025 ± 75 rounds</td>
</tr>
<tr>
<td>Rapid</td>
<td>200 rounds per minute for 3 minutes</td>
</tr>
<tr>
<td>Burst Limit</td>
<td>600 rounds</td>
</tr>
<tr>
<td>MUZZLE VELOCITY</td>
<td>Approx. 2,887 feet per second</td>
</tr>
</tbody>
</table>

#### Description

The eight major assemblies of the GAU-21 machine gun (Figure 6-19) consist of the barrel assembly, receiver assembly, bolt assembly, barrel buffer assembly, feed cover assembly, back plate assembly, auxiliary return spring assembly, and trigger assembly.
The GAU-21 weapon system is capable of being mounted on the MH-60 aircraft. The weapon system includes compatibility with Night Vision Device-capable targeting, pointing, and illuminating laser systems. The operation of the weapon, along with the ammunition handling, feed and storage system, does not require electrical power from the aircraft or any other source. The MH-60 aircraft can be configured with one or two GAU-21 machine guns.

Refer to Organizational Maintenance with Illustrated Parts Breakdown, GAU-21 .50-Caliber Aircraft Gun System, NAVAIR 11-95GAU21-1 for detailed operation and maintenance.

**GAU-16 .50-CALIBER AIRCRAFT MACHINE GUN**

The GAU-16 .50-caliber machine gun is an automatic, recoil-operated, belt-fed, air-cooled machine gun designed for installation in aircraft. The gun uses a disintegrating metallic link belt for all firing applications. By repositioning bolt and cover assembly components within the receiver, ammunition can be fed into the gun from either the right or left side. The GAU-16 consists of the following major assemblies (*Figure 6-20*): barrel and barrel extension assembly, rod assembly, breech bolt assembly, recoil buffer assembly, cover assembly, retracting slide assembly, receiver assembly and barrel jacket assembly, back plate assembly and front sight assembly.
Figure 6-20 — GAU-16 Major assemblies.
The weapon is used in the MH-60 aircraft. Gun characteristics are listed in Table 6-2.

### Table 6-2 GAU-16 Characteristics

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gun</td>
<td>65 lb</td>
</tr>
<tr>
<td>Weight of equipment:</td>
<td></td>
</tr>
<tr>
<td>Retracting slide assembly</td>
<td>3.13 lb</td>
</tr>
<tr>
<td>Back plate with spade grips</td>
<td>3.88 lb</td>
</tr>
<tr>
<td>Weight of barrel</td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>15.02 lb</td>
</tr>
<tr>
<td>Old</td>
<td>11.12 lb</td>
</tr>
<tr>
<td>Length of barrel</td>
<td>36.00 in</td>
</tr>
<tr>
<td>Length overall</td>
<td>56.25 in</td>
</tr>
<tr>
<td>With flash suppressor</td>
<td>71.00 in</td>
</tr>
<tr>
<td><strong>Rifling</strong></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>31.92 in</td>
</tr>
<tr>
<td>Number of grooves</td>
<td>8</td>
</tr>
<tr>
<td>Twist (direction)</td>
<td>Right-hand</td>
</tr>
<tr>
<td>Twist (one turn in)</td>
<td>15.00 in</td>
</tr>
<tr>
<td>Operation</td>
<td>Short recoil</td>
</tr>
<tr>
<td>Feed</td>
<td>Disintegrating link belt</td>
</tr>
<tr>
<td>Imposed feed belt load</td>
<td>15 lb max</td>
</tr>
<tr>
<td>Firing pin release:</td>
<td></td>
</tr>
<tr>
<td>Pressure applied to sear</td>
<td>23 lb max</td>
</tr>
<tr>
<td>Pressure applied to sear slide</td>
<td>35 lb max</td>
</tr>
<tr>
<td>Barrel life</td>
<td>5000 rounds(New)</td>
</tr>
<tr>
<td></td>
<td>3000 rounds(Old)</td>
</tr>
<tr>
<td>Depot maintenance cycle</td>
<td>50,000 rounds</td>
</tr>
<tr>
<td>Cooling</td>
<td>Air</td>
</tr>
<tr>
<td>PERFORMANCE Rate of fire</td>
<td>750 to 850 rounds per min</td>
</tr>
</tbody>
</table>

**GAU-17/A 7.62MM AIRCRAFT MACHINE GUN**

The GAU-17/A 7.62MM Aircraft Machine Gun (*Figure 6-21*), is an externally-powered, six-barrel, air-cooled, multi-purpose weapon capable of firing at a rate of 3,000 rounds per minute. The major gun assemblies are the barrels and barrel clamp assembly, housing assembly, rotor assembly, and clutch assembly. The weapon is used in the MH-60 aircraft. Gun characteristics are listed in *Table 6-3.*
Figure 6-21 — GAU-17 7.62MM aircraft machine gun.

Table 6-3 — 7.62MM GAU-17 characteristics

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gun</td>
<td>41 pounds</td>
</tr>
<tr>
<td>Gun, overall length</td>
<td>33 inches</td>
</tr>
<tr>
<td><strong>Barrel</strong></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>22.0 inches</td>
</tr>
<tr>
<td>Weight</td>
<td>1 lb 10 oz</td>
</tr>
<tr>
<td>Rotation of cluster</td>
<td>Counterclockwise viewed from breech end</td>
</tr>
<tr>
<td><strong>Burst Limit</strong></td>
<td></td>
</tr>
<tr>
<td>A. In-Flight</td>
<td>12 – 15 seconds, 1 minute cooling</td>
</tr>
<tr>
<td>B. Aviation Trainer</td>
<td>6 seconds, 1 minute cooling</td>
</tr>
<tr>
<td><strong>Barrel Rifling</strong></td>
<td></td>
</tr>
<tr>
<td>Grooves</td>
<td>4</td>
</tr>
<tr>
<td>Twist</td>
<td>Right hand</td>
</tr>
<tr>
<td>Length</td>
<td>20.0 inches</td>
</tr>
<tr>
<td>One turn in</td>
<td>10 inches</td>
</tr>
<tr>
<td>Muzzle Velocity</td>
<td>2,850 fps</td>
</tr>
<tr>
<td>Cooling</td>
<td>Air</td>
</tr>
<tr>
<td>Rate of fire</td>
<td>3,000 rounds per minute</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>-65 to +165 F</td>
</tr>
<tr>
<td>Burst rate</td>
<td>2 - 3 per second (min) no max</td>
</tr>
</tbody>
</table>

Refer to *Organizational Maintenance with Illustrated Parts Breakdown, Aircraft Machine Gun 7.62MM, GAU-17/A, NAVAIR 11-95GAU17-1* for detailed operation and maintenance.
M240D 7.62MM AIRCRAFT MACHINE GUN

The M240D (Figure 6-22) is an air-cooled, gas-operated, automatic machine gun. It fires the standard 7.62 mm North Atlantic Treaty Organization (NATO) cartridge from the open bolt position at firing rates of 650 to 950 rounds per minute. The weapon barrel head-space and timing are fixed, allowing quick barrel changes during cooling and maintenance. The M240D incorporates a rear sight leaf and a barrel-mounted sighting system.

The weapon can be mounted in the MH-60 aircraft on a pintle and is held by a quick release pin. The weapon mounts are attached to rotating arm assemblies, which allow the weapons to be locked outboard in the firing position or stowed inside the aircraft when locked in the inboard position. The weapon can be removed easily from the helicopter, and if needed, used for ground defense. Refer to Organizational Maintenance with Illustrated Parts Breakdown 7.62mm Aircraft Machine Gun, NAVAIR 11-95M240D1-1 for a detailed discussion of the weapon system. Table 6-4 shows the M240D characteristics.

Figure 6-22 — M240D 7.62mm machine gun.
### Table 6-4 — M240D Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Air Configuration</th>
<th>Ground Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gun Weight</td>
<td>25.6 lbs</td>
<td>26.2 lbs</td>
</tr>
<tr>
<td>Barrel Weight</td>
<td>6.6 lbs (approx.)</td>
<td></td>
</tr>
<tr>
<td>Gun Length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Configuration</td>
<td>42.3 in</td>
<td>49 in</td>
</tr>
<tr>
<td>Gun Width</td>
<td>6.0 in</td>
<td></td>
</tr>
<tr>
<td>Gun Height</td>
<td>6.5 in</td>
<td></td>
</tr>
<tr>
<td>Rate of Fire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyclic</td>
<td>650 to 950 rounds per minute - Change barrel every minute (Gas plug position dependent).</td>
<td></td>
</tr>
<tr>
<td>Sustained</td>
<td>100 rounds per minute (4-5 sec between bursts) - Change barrel every 10 minutes.</td>
<td></td>
</tr>
<tr>
<td>Rapid</td>
<td>200 rounds per minute (2-3 sec between bursts) - Change barrel every 2 two minutes.</td>
<td></td>
</tr>
<tr>
<td>Range:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>3,725 meters</td>
<td></td>
</tr>
<tr>
<td>Maximum effective range</td>
<td>1,200 meters</td>
<td></td>
</tr>
</tbody>
</table>

### SAFETY PRECAUTIONS

The weapons systems described in this chapter are safe systems. Live rounds in the M61A1 and M61A2 are isolated from the firing circuits except when the gun system is deliberately being fired. The M61A1 and M61A2 gun systems are RADHAZ-safe and completely shielded from radiation fields. The M61A1 and M61A2 guns are charged and cleared in flight, so the aircraft can take off and land without live rounds in the firing position.

Although the sole purpose of all ordnance is to destroy an enemy, the equipment cannot identify friend from foe. Therefore, all safety precautions must be followed at all times.

The following general safety precautions are not related to any specific equipment or procedure. These precautions are recommended safety precautions that all personnel should follow when operating and maintaining equipment.

- All persons who supervise or perform work in connection with ammunition handling should be familiar with the United States Ordnance Safety Precautions, NAVSEA OP 3347.
• When firing is conducted using live ammunition, observe all existing range regulations.

• Before undertaking any operation for which a checkoff list exists, the checkoff list is read so all personnel know what to do.

• When provided, always use safety devices to prevent accidents. Keep safety devices in good operating order at all times.

• Do not make changes, modifications, or additions to a weapons system without prior approval and authorization from the appropriate authority.

• A hazardous condition exists if a gun malfunction occurs and there is anything in line with the gun muzzle. Observe area clearance requirements during maintenance periods.

• Percussion can fire electrically-primed ammunition. NEVER cycle live ammunition through a gun for testing purposes.

• The explosive elements in electric primers are highly sensitive to static electricity. Make sure the primer button does not come into contact with the human body.

• Observe fire regulations and maintain good ventilation when using cleaning solvents and other volatile maintenance materials.

• Before performing maintenance actions involving pneumatic or hydraulic pressurized components, ensure that all pressure is removed and the component is in the safest possible condition.
End of Chapter 6

Aircraft Guns

Review Questions

6-1. How is an M61A1/A2 automatic gun driven and controlled?

A. (1) Electrically (2) pneumatically
B. (1) Hydraulically (2) electrically
C. (1) Electrically (2) electrically
D. (1) Hydraulically (2) pneumatically

6-2. At what prescribed rate can an M61A1/A2 gun fire M50 series ammunition?

A. 4,000 to 7,200 rpm
B. 4,000 to 6,000 rpm
C. 2,000 to 6,000 rpm
D. 2,000 to 4,000 rpm

6-3. What components are the primary parts of an M61A1/A2 automatic gun?

A. Barrels, housing assembly, and muzzle clamp assembly
B. Housing assembly, muzzle clamp assembly, and clearing sector assembly
C. Barrels, rotor assembly, and housing assembly
D. Muzzle clamp assembly, rotor assembly, and barrels

6-4. What means are used to secure the gun barrels to the stub rotor of an M61A1/A2 automatic gun?

A. Pipe threads
B. Standard threads
C. Interrupted locking lugs
D. Barrel retaining safety pins

6-5. On an M61A1/A2 gun, what component picks up a round as it enters the gun?

A. Clearing sector assembly
B. Guide bar
C. Breech-bolt assembly
D. Firing contact assembly

6-6. On an M61A1/A2 gun, a full firing cycle requires what prescribed number of actions?

A. Four
B. Five
C. Six
D. Seven
6-7. What are the two distinct cycles of an M61A1/A2 automatic gun operation?

A. Firing and clearing
B. Loading and unloading
C. Feeding and extracting
D. Clearing and loading

6-8. What component of an M61A1/A2 automatic gun ejects the empty case from the gun?

A. The ejector
B. The guide bar
C. The extractor lip
D. The ejection cam

6-9. On an M61A1/A2 automatic gun, what sequence of actions is performed by the breech-bolt assembly during one full firing cycle?

A. Feed, chamber, ram and lock, fire, unlock, extract, and eject
B. Feed, chamber, lock and fire, unlock, extract, and eject
C. Ram and chamber, lock and fire, unlock, extract, and eject
D. Load and lock, fire, unlock, extract, and eject

6-10. A drum unit assembly consists of the drum unit and what other major parts?

A. Entrance unit, scoop disk, and exit cover
B. Entrance cover, transfer unit, and exit cover
C. Entrance unit, scoop disk, and exit unit
D. Entrance cover, scoop disk, and exit cover

6-11. The mechanical drive unit in an F/A-18 aircraft has what total number of output shafts?

A. One
B. Two
C. Three
D. Four

6-12. A gun gas purge system is used for what purpose?

A. Provide gas to operate the gun
B. Cool the gun barrels only
C. Purge gas from the gun compartment only
D. Cool the gun barrels and purge gas from the gun compartment
6-13. The air required to operate the gun gas purge system in an F/A-18 aircraft is provided by what air source?

A. Engine bleed air only  
B. Ram air scavenge door only  
C. Engine bleed air and the ram air scavenge door  
D. Environmental cooling system

6-14. In an F/A-18 aircraft, the M61A1/A2 automatic gun system can be operated in what computer mode?

A. A/A or A/B only  
B. A/G only  
C. CCIP only  
D. A/A, A/G, or CCIP

6-15. In an F/A-18 aircraft, what component is used to manually clear the M61A1/A2 automatic gun?

A. Clearing section clamp  
B. Clearing sector holdback  
C. Clearing sector retainer  
D. Clearing solenoid

6-16. An M61A1/A2 automatic gun must be sent to a depot-level maintenance activity under which of the following conditions?

A. When major repair is required  
B. When an alteration is authorized  
C. When 120,000 rounds have been expended  
D. All the answers are correct

6-17. Which of the following gun maintenance procedures should be accomplished during scheduled maintenance?

A. Lubrication  
B. Normal disassembly and parts replacement  
C. A functional check of the components based on the round interval  
D. All the answers are correct

6-18. Scheduled maintenance for an M61A1/A2 automatic gun handling and drive system should be performed after what maximum number of rounds has been fired?

A. 15,000 rounds  
B. 20,000 rounds  
C. 30,000 rounds  
D. 100,000 rounds
6-19. What is the rapid rate of fire for the GAU-21?
   A. 950 to 1100 rounds per minute
   B. 1000 to 1200 rounds per minute
   C. 1000 to 1400 rounds per minute
   D. 1400 to 1500 rounds per minute

6-20. What is the maximum air-to-ground range of the GAU-21?
   A. 5,000 meters
   B. 5,500 meters
   C. 6,000 meters
   D. 6,500 meters

6-21. How is the GAU-16 cooled after firing?
   A. By water
   B. By air
   C. By refrigerant
   D. All the answers are correct

6-22. What is the performance firing rate of the GAU-16?
   A. 200 to 250 rounds per minute
   B. 500 to 600 rounds per minute
   C. 750 to 850 rounds per minute
   D. 850 to 950 rounds per minute

6-23. The GAU-17 major gun assemblies include the barrels and barrel clamp, housing, rotor, and what assembly
   A. Primer
   B. Clutch
   C. Timer
   D. Feeder

6-24. What is the sustained firing rate of the M240D?
   A. 100 rounds per minute
   B. 200 rounds per minute
   C. 600 rounds per minute
   D. 800 rounds per minute

6-25. What weapon can be easily removed from the helicopter and used for ground defense if needed?
   A. GAU-21
   B. MG-17
   C. M240D
   D. M61A1