CDC 2A673

Aircrew Egress Systems Maintenance Craftsman

Volume 2. F-16, F-15, and F-22 Aircraft

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THIS career development course (CDC) serves to provide the basic maintenance management knowledge you need to upgrade to a craftsman (7-level) while in the Egress 2A673 career field. This is the second and last volume of your 7-level CDC's. It is a self-study course that the Air Force intends for you to complete during your off-duty time and when available, during idle duty hours. Satisfactory completion of this course is a prerequisite for upgrading to the 7-skill level.

You're required to know all the material contained within these two volumes to perform your job. Even though you may not use all the information, you may find it useful at a future assignment.

This volume is broken into three units:

Unit 1—F-16 Egress System.

Unit 2—F-15 Egress System.

Unit 3—F-22 Egress System.

A glossary is included for your use.

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For Guard and Reserve personnel, this volume is valued at 12 hours and 3 points.

NOTE:

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

Please read the menu for Unit 1 and begin. ➔

Unit 1. F-16 Egress System

THE F-16 FIGHTING FALCON is a compact, multirole fighter aircraft. It is highly maneuverable and has proven itself in air-to-air combat and air-to-surface attack. It provides a relatively low-cost, high-performance weapon system for the United States and allied nations.

In an air combat role, the F-16's maneuverability and combat radius (distance it can fly to enter air combat, stay, fight, and return) exceed that of all potential threat fighter aircraft. It can locate targets in all weather conditions and detect low flying aircraft in radar ground clutter. In an air-to-surface role, the F-16 can fly more than 500 miles (860 kilometers), deliver its weapons with superior accuracy, defend itself against enemy aircraft, and return to its starting point. An all-weather capability allows it to accurately deliver ordnance during nonvisual bombing conditions. The first F-16 Block 1 flew on 1978, and since then, more than 4,500 F-16s have rolled off assembly lines in five countries. The F-16, along with the modern F-22 and F-35, will continue to serve as a front-line fighter and sustainment will extend well beyond 2030.

The F-16 and F-22 cockpits are covered by a bubble canopy designed to give the pilot an unobstructed forward and upward vision; it greatly improves vision over the side and to the rear. The canopy uses a type of optical grade polycarbonate plastic with protective coatings to improve abrasion and weathering resistance. In fact, it can withstand bird strikes by four-pound birds at 350 knots. Although a durable canopy is very important to flight safety, it can also present an egress problem. Because of the strength and flexibility of the polycarbonate plastic canopy, the seat (and pilot) can't eject through it like with the A-10 and F-15. For this reason, canopy jettison is a necessity to the ejection sequence. Because of the critical functions of the canopy during flight and ejection, its importance can't be over-emphasized. As an egress journeyman, you play an important role in how well the canopy's critical functions perform during flight and ejection.

To provide the information you need to perform your job as a 7-level in a competent and professional manner, we'll first take an in-depth look at the F-16 escape system. There will be times that you respond to a redball or attend a meeting where your expertise help make important decisions or at the very least, help a pilot decide between a ground abort on a mission or whether to trust your expertise and fly. We'll cover component description, theory of operation, detonation transfer assembly (DTA) lines, and operational checkouts.

In the second section, we'll explore the canopy system. This will include component descriptions, theory of operation, removing and installing the canopy, rigging canopies, and troubleshooting canopies.

1–1. Escape System

We will cover the two-seater F-16s so that you, as an egress journeyman, can learn the more complex system. All unit review exercises, self-test questions, and end-of-course questions concerning the F-16 will be referencing the two-seat version.

201. Component description

The crew's escape and safety system provides an escape system for the aircrew at high or low speeds and at high or low altitudes. The capability is also provided for emergency canopy jettison and ground egress. It consists of the following major subsystems:

- Ejection seats.
- Canopy.
- Survival equipment.

F-16s are equipped with the Advanced Concept Ejection Seat (ACES) II, which provides safe escape at aircraft speeds from zero to 600 knots at sea level (KEAS). The seat assemblies mount on sets of guide rails. The design of the guide rails allows the forward seat to pivot forward, providing access for maintenance to components located behind the forward seat support. Due to the guide rails, both seats disconnect and raise for additional maintenance access. Both seats electrically adjust 5.0 inches along the rails by means of a *seat adjustment actuator*.

The following are aircraft egress components associated with the ejection system:

- Ejection mode selector valve.
- Sequence valves.
- M99 manually actuated instantaneous hot gas initiators.
- M53 instantaneous hot gas initiators.
- Time delay hot gas initiators.
- CKU–5 series rocket catapults.

Ejection mode selector valve

The ejection mode selector valve (fig. 1–1) is located on the right console of the aft cockpit. The selector valve permits the preselection of one of three modes of ejection. The selector valve positions and modes are as follows:

- NORM—The forward crewmember ejects both crewmembers with the aft crewmember exiting the aircraft 0.40 second before the forward crewmember. The aft crewmember can eject only the aft seat by pulling the ejection control handle.
- AFT—Either crewmember ejects both crewmembers with the aft crewmember exiting the aircraft 0.40 second before the forward crewmember.
- SOLO—Crewmembers should only use this when the aft seat is unoccupied. The forward crewmember ejects without delay.

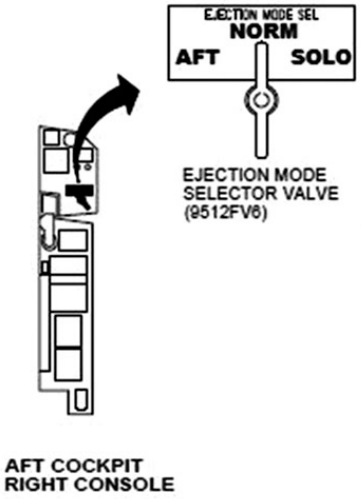


Figure 1–1. Ejection mode selector valve.

Sequence valves

Two sequence valves are located on the back of each seat support, one valve on each side (fig. 1–2). The sequence valve is a gas-operated valve whose principal moving component is a spool positioned centrally in the valve body. When the crewmember pulls the seat-mounted ejection handle, gas from one of the ejection initiators fires an M53 initiator which provides gas to shuttle the valve spool to a position that permits gas from the M99 initiators that are fired later by the departing canopy to flow through the valve and then to the seat rocket catapult. If the canopy jettison handle is pulled, gas from the M99 initiators fired by the departing canopy shuttles the spool to the opposite end of the valve body and prevents any flow of gas to the seat rocket catapult. If the crewmember should subsequently decide to eject, gas will flow immediately through the already shuttled valve and then to the seat rocket catapult.

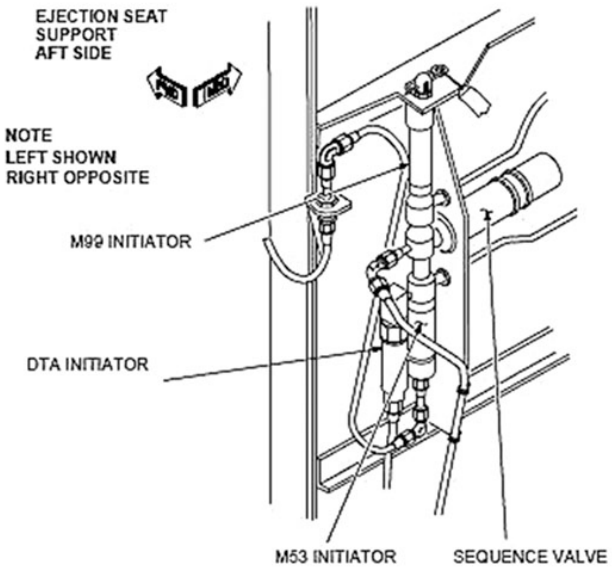


Figure 1–2. Ejection sequencing system components.

M99 initiators

An M99 initiator mounts on each side of the aft seat support (fig. 1–2). They are cartridge-type, manually-actuated initiators. These initiators attach to the canopy by a lanyard interlock mechanism. The M99 initiators provide gas pressure for two-seat aircraft during normal ejection process. If the canopy manually jettisoned before attempting ejection, pressure comes from the M53 initiator. When the canopy is jettisoned during crew ejection, each lanyard fires one of the M99 initiators, which then provides hot gas to flow through the sequence valve and then to the seat rocket catapult. When the canopy jettisons, but the seat is not ejected, gas from the M99 initiator shuttles the sequence valve.

M53 initiators

M53 hot gas initiators are located on the forward and aft seat supports, as shown in figure 1–2, with one on the floor of the aft cockpit. These cartridge-type, gas-actuated initiators function as boosters, providing additional gas to keep the pressure of the gas in the system at an acceptably high level.

Time delay initiators

The time delay initiators are located on the forward and aft seat supports. These are cartridge-type, gas-actuated initiators, each of which contains two delay ignition elements. After incoming gas fires the initiator, each delay element burns for a predetermined time and then ignites the propellant. The burning propellant produces hot gas which, in turn, fires another initiator or one of the seat rocket catapults. Two of these initiators delay the firing of the aft seat rocket catapult long enough for the canopy to clear the path of the aft seat. Three initiators are located in the hot gas system that interconnects the forward and aft seats and provide for a delay between the ejection of the aft seat and the forward seat.

Rocket catapults

The rocket catapult is located behind each seat, the bottom portion attaches to the top portion of the seat actuator and the top portion attached to the seat. The CKU–5 series rocket catapult consists of a solid propellant rocket motor integrated with the catapult. The rocket catapult ejects the seat from the cockpit and propel it away from the aircraft.

202. Theory of system operation

Now let’s look at how all these pieces fit together. The two principal functions of the crew escape system are canopy jettison and seat ejection. Seat ejection initiates only from the ejection control handle located on the center forward portion of the seat between the crewmember’s legs. Pulling the ejection control handle causes two JAU–8/A25 initiators on the seat to fire. Gas from each initiator flows through hoses and the seat-to-aircraft hot gas disconnect to the M53 initiator mounted on a sequence valve attached to the aft face of the seat support assembly. Gas from the right side JAU–8/A25 initiator also provides gas to fire the inertia reel gas generator. Gas from each of the two M53 initiators shuttles the sequence valve and fires the DTA initiator, also mounted on the sequence valve. DTA lines are a small diameter line with an explosive core and an explosive tip on each end. We will go over them in greater detail in the next lesson.

Each DTA initiator fires a DTA which, in turn, fires several other DTAs, which fire one of the two emergency canopy release lines (ECRL), the canopy actuator release bolt (CARB) and one of the two canopy-remover rocket motors. The ECRL expands, breaking a group of frangible bolts, thereby releasing the canopy from its attachment to the fuselage. The CARB breaks in two places, releasing the canopy from its attachment to the canopy actuator. The rocket motor then propels the canopy from the aircraft. As the canopy is departing, each of the two attached lanyards fires M99 initiators that mounted on one of the two sequence valves. There is a 0.33-second delay between the firing of the M99 initiators and the firing of the aft seat rocket catapult. This delay, controlled by three delay initiators, prevents a collision between the aft seat and the canopy during ejections that might occur before aircraft takeoff. Gas from an M53 initiator flows through the previously shuttled sequence valve and then through a hose to the CKU–5 series ejection seat rocket catapult. Bleed off gas from

the catapult fires an initiation device in the thermal batteries power module in the recovery sequencer and propels the seat up the guide rails.

As the seat moves up the rails, a spring-loaded pitot tube located on each side of the headrest and a static port on the back of the seat sense total pressure and static pressure, respectively, and they send inputs to the environmental sensing unit, which then determines aircraft speed and altitude. From that point forward, the ACES II digital recovery sequencer takes over and puts the seat in one of the three modes of ejection discussed in unit 1 of this volume. One difference is that a small rocket motor on each seat causes the forward seat to diverge slightly right and the aft seat to diverge slightly left of a direction upward from the cockpit.

There is a seat-to-seat sequencing system controlled by three delay initiators and the ejection mode selector valve preset in any of the three modes:

1. NORMAL.
2. AFT.
3. SOLO.

Ejection mode selector valve is set in NORMAL mode and forward seat ejection handle is pulled

Gas from the two JAU–8/A25 initiators fires M53 initiators. Gas from the right-hand JAU–8/A25 initiator also fires the front seat's inertia reel gas generator which then provides gas to function the forward seat inertia reel. Gas from the two M53 initiators shuttles the two sequence valves, fires the valve-to-valve interconnect M53 initiator, and fires two DTA initiators, thereby initiating the canopy jettison system. Gas from the valve-to-valve interconnect M53 initiator then fires another M53 initiator, which provides gas to fire yet another M53 initiator on the aft sequence valve and aft seat inertia reel gas generator. Gas from the gas generator functions the inertia reel. Gas from the last M53 initiator in this sequence also shuttles the aft sequence valve and fires the DTA initiator. Time-delay initiators keep the forward seat from firing before the aft seat.

As the canopy leaves the aircraft, two interlock lanyards fire two M99 initiators. Gas from these initiators flows through a sequence valve and through the valve-to-valve interconnect and then fires 0.33-second delay initiators. Gas from the right 0.33-second delay initiator fires a 0.40-second delay initiator, flows through the ejection mode selector valve, and fires an M53 initiator. Gas from that M53 initiator fires the aft seat catapult and backfires a 0.33-second delay initiator. Gas from the first 0.33-second delay initiator fires an M53 initiator. Gas from the M53 flows through the sequence valve and fires a 1.00-second delay initiator.

Gas from the 0.40-second delay initiator fires an M53 initiator. Gas from the M53 flows through the forward sequence valve, firing the forward seat catapult and backfiring the 1.00-second delay initiator.

Ejection mode selector valve is set in NORMAL mode and aft seat ejection handle is pulled

Gas from two aft seat JAU–8/A25 initiators fires two M53 initiators and fills the hot gas line up to another M53 initiator. Gas from the right-hand JAU–8/A25 initiator also fires the aft seat inertia reel gas generator which then provides gas to function the inertia reel. Gas from the first two M53 initiators shuttles sequence valves and fires two DTA initiators, thereby initiating the canopy jettison system. As the canopy leaves the aircraft, two interlock lanyards fire two M99 initiators. Gas from these initiators flows through each aft sequence valve, firing two 0.33-second delay initiators and flows through the valve-to-valve interconnect to fire another 0.33-second delay initiator.

Gas from the right 0.33-second delay initiator fires a 0.40-second delay initiator, flows through the ejection mode selector valve and fires an M53 initiator. Gas from that M53 and also the left 0.33-second delay initiator fires the aft seat rocket catapult. Gas from the valve-to-valve interconnect 0.33-second delay initiator fires another M53 initiator which shuttles a forward seat support sequence valve.

Then gas from the 0.40-second delay initiator fires an M53, which shuttles the other forward seat support sequence valve. At this time, the front crewmember can eject by pulling the ejection handle on the seat without encountering any initiation system delay.

Ejection mode selector valve is set in AFT mode and forward seat ejection handle is pulled

The AFT mode, forward seat initiation ejection theory of operation mirrors the NORMAL mode, forward seat initiation exactly with the exception of one important addition. When the ejection mode selector valve is in the AFT mode, it allows gas pressure to fire an extra M53 that plumbs directly into the right forward sequence valve's M53. In AFT mode, when the forward seat initiates ejection, this M53 does nothing, because its gas pressure is applied to an M53 already fired by the forward seat's right ejection initiator during ejection ignition. The purpose of this extra M53 is to shuttle the forward sequence valves when the AFT seat initiates ejection in AFT mode. Remember, in AFT mode, the aft crew member can eject both seats.

Ejection mode selector valve is set in AFT mode and aft seat ejection handle is pulled

The AFT mode, aft seat initiation theory of operation mirrors the NORMAL mode, aft seat initiation exactly, except for one important addition. As stated previously, when the ejection mode selector valve is in the AFT position, it allows gas pressure to fire a special M53. Remember in the NORMAL mode, aft initiated ejection, the system stops forward seat ejection until the pilot fires the forward seat ejection initiators. The AFT mode specific M53 provides an automatic sequence to eject the forward seat.

The AFT mode unique M53 provides gas pressure to another M53 mounted to the right forward sequence valve. This M53 shuttles the sequence valve, provides gas pressure through the forward valve-to-valve interconnect to fire another M53 initiator and provides gas to the other forward sequence valve. The other sequence valve directs the gas to a 1.0-second time delay, which fires the forward catapult. Neither forward sequence valve DTA initiator fires because they have already been backfired. The forward valve-to-valve M53 fires another M53 that expels its gas into lines already filled from when the right aft ejection initiator fired. Meanwhile, gas from the 0.40-second delay initiator fires an M53 which sends gas pressure through the forward right sequence valve, which fires the forward seat catapult and backfires the 1.00-second delay initiator.

Ejection mode selector valve is set in SOLO mode and forward seat ejection handle is pulled

As you've probably noticed, the *aft seat always fires first except for in SOLO mode*. The reason for this sequence of events is to protect the aft crew member from being hit with the output of the forward seat's rocket catapult and vernier rocket. Since SOLO mode is designed for selection when there is no aft crew member in the cockpit, there's no need to protect the aft crew member, so the aft seat does not eject.

Gas from the two front seat JAU–8/A25 initiators fires the M53 initiators. Gas from the right-hand JAU–8/A25 initiator also fires the front seat's inertia reel gas generator, which then provides gas to function the inertia reel. Gas from the two M53 initiators shuttles the two sequence valves, fires the forward valve-to-valve M53 initiator and fires two DTA initiators, thereby initiating the canopy jettison system. Gas from the M53 initiator then fires another M53 initiator which provides gas to fire yet another M53 initiator mounted on an aft sequence valve and also fires the aft seat inertia reel gas generator. Gas from the gas generator functions the inertia reel. Gas from the last M53 initiator in this sequence also shuttles the sequence valve and fires the DTA initiator.

As the canopy leaves the aircraft, two interlock lanyards fire two M99 initiators. Gas from these initiators flows through sequence valves, firing two 0.33-second delay initiators and flows through the valve-to-valve interconnect to fire another 0.33-second delay initiator.

Gas from the 0.33-second delay initiator flows through the ejection mode selector valve, fires an M53 initiator and backfires a 0.40-second delay initiator. Gas from the aft valve-to-valve 0.33-second delay initiator fires an M53 initiator which sends gas pressure through the forward sequence valve

and fires a 1.00-second delay initiator. Gas from the first M53 initiator in this chain flows through the sequence valve, firing the forward seat catapult and backfires the 1.00-second delay initiator.

203. Removing and installing detonation transfer assembly lines

DTA lines (fig. 1–3) are the energy transfer lines that move detonation around the F-16 egress system. Here are some general procedures on how to remove and install DTA lines. As always, this career development course (CDC) is not tech data! Always consult applicable tech data when performing explosive maintenance.

Figure 1–3. Detonation Transfer Assembly (DTA).

F-16 DTA lines are mostly flexible lines. In years past, more of the DTA lines on the F-16 were rigid but the design changed to flexible to ease maintenance and reduce damage from flexing the rigid lines. There are still some rigid DTA lines today such as the DTA lines that connect to the canopy actuator release bolt on the two-seat model F-16. As such, take care not to bend any rigid lines.

Components

We've already discussed the line itself; it can be either flexible or rigid. Let's talk about how the components connect to connectors or explosives (fig. 1–4).

Components of shock tube (ST) type DTA ends are:

- Seal.
- Ferrule.
- Nut with threads.

Components of standard type DTA ends are:

- Tip.
- Seal.
- Ferrule.
- Nut with threads.

Removing DTA lines

Removing DTA lines is a fairly simple process, unless the DTA line you need to remove is buried beneath boxes of aircraft components. Do not ever attempt to remove a DTA line if another section's component is in the way. It is not worth taking the risk of damaging a DTA line due to the extra down time it would take to submit an emergency requisition for a replacement part. Add to that the fact that DTA lines cost upwards of $800.00 and if a statement of survey is done, you may end up having to pay for the replacement cost out of your own pocket. Instead, contact the respective section and have them remove whatever component is blocking access to the DTA line. Remember to always perform aircraft safe for maintenance prior to performing any task.

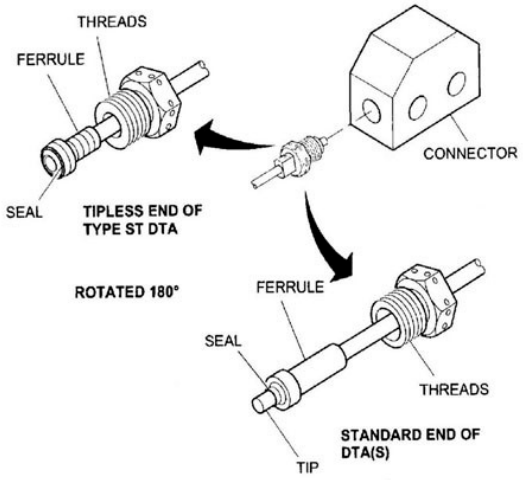


Figure 1–4. DTA end components.

To remove a DTA, carefully cut the safety wire from the DTA with a pair of diagonal cutting pliers. Never remove safety wire with a pair of pliers by snapping it loose as this action may damage the holes in the DTA nut. Unfortunately, supply on some DTA lines is low and you may end up cannibalizing a line if there is a zero balance on your base; save yourself a lot of extra maintenance and remove them with care.

Disconnect the DTA using the appropriate sized wrench. Using the wrong-sized wrench or an adjustable wrench may round out the flats on the DTA nut, making it hard to properly torque during installation. If you can put a protective cap on the DTA tip immediately following removal of the nut, do it. Some maintenance may require that you wait until the DTA line is completely removed so that you can freely route the line before capping it. Regardless, cap the DTA line on both ends as soon as possible to prevent damage to the explosive tips. Also, cap the DTA line if you are only temporarily removing one part of it to avoid damage (e.g., such as during canopy removal when the canopy to aircraft DTA lines are disconnected). In addition, always install plugs in DTA ports as soon as possible. Plugs protect the ports from any foreign objects such as dust, which can interfere with the operation of the DTA. Even though the flexible lines are “flexible,” avoid over-flexing them and immediately place the lines in a container after removal to further protect them from damage.

Installing DTA lines

Once again, take great care to avoid damaging the lines and always follow the applicable tech data. Always perform aircraft safe for maintenance checks prior to any aircraft maintenance.

In the technical order, the first note says that protective devices shall be removed from lines and ports. This does not mean that they should be removed as soon as you start the installation process. Wait until right before you need to install the DTA nuts before you remove the caps and plugs. If you have to route them, it’s easier to route them without the caps installed. Put them back on when done routing so you can protect the tips. Coat the threads of the DTA line with a light coat of solid film lubricant. If the threads are not already coated, slide the DTA nut back from the tip and apply a thin film of grease to the DTA nut threads with a cotton swab. Wipe off any excess with clean cheesecloth. Also, apply a thin film of grease to the DTA ferrule that contacting the DTA nut. Wipe off any excess with clean cheesecloth. Inspect the DTA tip and seal for grease and wipe with clean cheesecloth if grease is present.

When connecting ferrule-type connectors, insert the ferrule freely through the port threads to rest firmly against the bottom of the port and install the nut by hand to firmly seat against the ferrule. Connect the DTA line to the connector by installing the nut. When applying torque to a DTA nut, prevent twisting by using a wrench on flats provided behind the DTA nut (if the DTA nut is a type with flats). Failure to comply may result in damage to equipment. Type standard, standard shielded,

donor, and receptor have flats behind the DTA nut, but donor and receptor have flats at one end only. Types flexible confined, confined, and shock tube do not have flats and cannot be held while turning the DTA nut. Torque the DTA nut to 50–70 inch pounds.

After that, measure the gap between the DTA nut and port. Standard ends of all type DTAs have a 0.064 inch maximum and a 0.010 inch minimum measurement. Tipless ends of type ST DTA have a 0.057 inch maximum and a 0.010 inch minimum measurement. If the gap is not as specified, use the DTA inspection gage detailed in the next lesson. Replace any item found to be defective. If no defects are found or if defects are within the acceptable limits, safety wire the DTA nut to the fitting. Don't forget to document the aircraft forms!

204. Inspecting detonation transfer assembly lines

In an F-16 shop's composite tool kit (CTK) you'll find a DTA and ECRL inspection gage set like the one in Figure 1–5. Following are the procedures for using the set, but first we'll talk about some warnings.

Figure 1–5. DTA/ECRL inspection gage set (go-no-go).

Warnings

Type receptor (R) or shock tube receptor (STR) DTA lines contain a primary explosive that may be detonated by impact, shock, abrasion, or excessive heat, defined as temperatures above 500 degrees Fahrenheit (°F). Use stringent precautions when handling the type R or STR DTA lines. Failure to comply may result in injury to personnel and/or damage to aircraft.

Before handling the type R or STR DTA lines, discharge any possible static electricity from your body. Failure to observe this warning may cause accidental detonation of the DTA line with injury to personnel and/or damage to equipment.

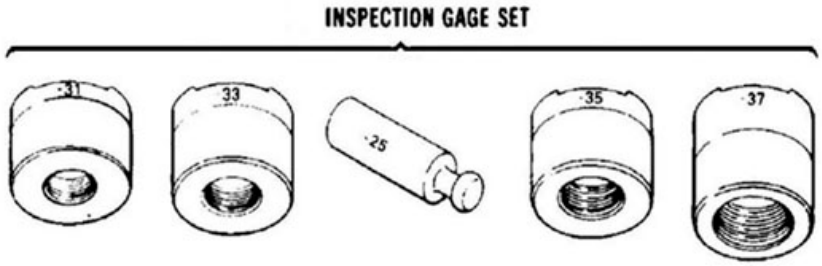
Using the inspection set on DTA lines

Inside your F-16 series –95JG–00–1 job guide, *Organizational Maintenance, Crew Escape, and Safety System*, you'll find a handy cross-reference sheet, as shown in figure 1–6. This sheet will tell you what type of gage you should use for each part number. All inspection gage part numbers contain the prefix 16A97001–XX; therefore, only specific dash number of each inspection gage will be discussed. Using the sheet, select the correct inspection gage which corresponds to the part number of the DTA to be inspected.

1. Check the DTA attaching nut threads by inserting the DTA into the inspection gage with the ferrule resting firmly against the inside flange of the inspection gage and install the nut by hand to firmly seat it against the ferrule, as seen in figure 1–7.
2. Check the DTA tip for *minimum length* by positioning the –25 inspection gage across lower surfaces of the inspection gage containing the DTA (fig. 1–6). Verify that the DTA tip

contacts the –25 inspection gage and the –25 gage does not rest on both shoulders of the inspection gage. If the DTA tip is the correct length, the –25 gage will not rest simultaneously on both shoulders of the –31, –33, or –35 gage.

3. Check the DTA tip for *maximum length* by positioning the –25 inspection gage on the upper surface of the inspection gage containing the DTA and verifying that the DTA tip allows the –25 inspection gage to contact both surfaces of the inspection gage containing the DTA simultaneously (fig. 1–7).
4. Check the DTA tip for straightness by inserting the –25 inspection gage into the top of the inspection gage containing the DTA and verifying the –25 inspection gage rotates completely around the tip without excessive friction (fig. 1–8).
5. Loosen the DTA attaching nut and remove the DTA from the inspection gage.



*–33 GAGE IS USED ON ONE END OF THIS DTA AND -35 GAGE IS USED ON THE OTHER END

▲ CHECK STANDARD END ONLY. NO CHECK REQUIRED FOR TIPLESS END

**CHECK STANDARD END ONLY NO CHECK REQUIRED FOR RECEPTOR END

C

TYPE	PART NO.	GAGE
D	51066-5	-33
* ST	51281-721	-33
* ST	51281-721	-35
▲ ST	51281-723	-33
ST	51281-725	-31
ST	51281-726	-31
ST	51281-727	-31
ST	51281-728	-31
ST	51281-729	-33
ST	51281-730	-31
**STR	51476-731	-31
**STR	51476-732	-31
▲ ST	51281-733	-35
▲ ST	51281-734	-35
▲ ST	51281-735	-35
▲ ST	51281-736	-35

D

TYPE	PART NO.	GAGE
C	51092-3	-31
C	51092-4	-31
C	51092-5	-31
ST	51281-722	-35
ST	51281-724	-33
ST	51281-725	-31
ST	51281-726	-31
ST	51281-737	-33
ST	51281-738	-31
ST	51281-739	-35
ST	51281-740	-33
ST	51281-742	-31
ST	51281-743	-31
▲ ST	51281-744	-33
▲ ST	51281-745	-33
▲ ST	51281-746	-33
ST	51281-747	-35
ST	51281-749	-35
ST	51281-750	-35

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Figure 1–6. Inspection gage cross-reference sheet.

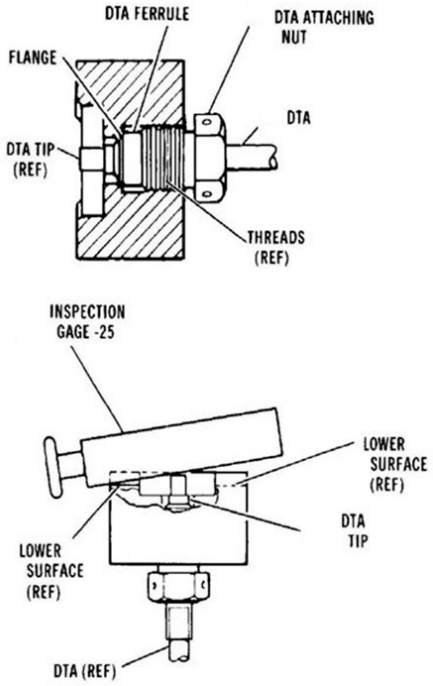


Figure 1–7. DTA tip inspection.

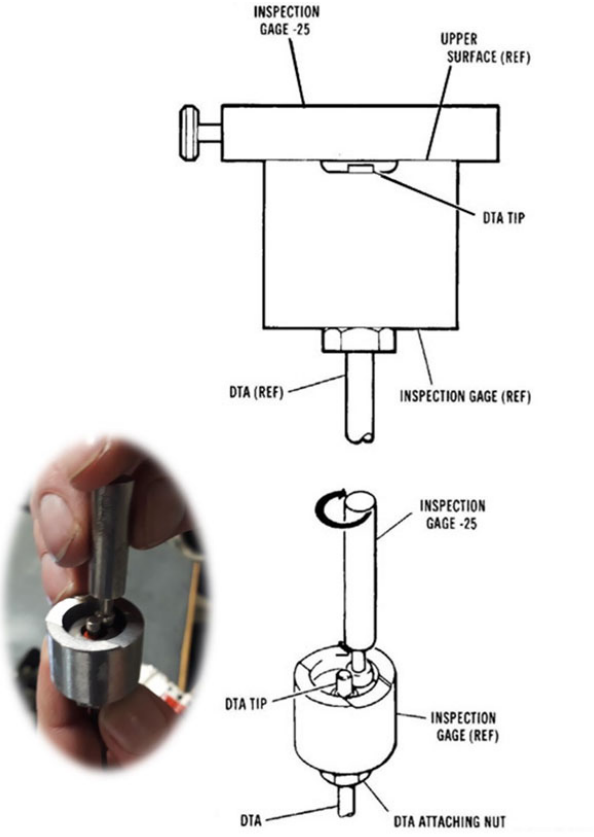


Figure 1–8. Straightness inspection.

Using the inspection set on corresponding port or explosive device

Select the correct inspection gage which corresponds to the size of the port in the connector or the explosive device which you are going to install the DTA line into (fig. 1–9).

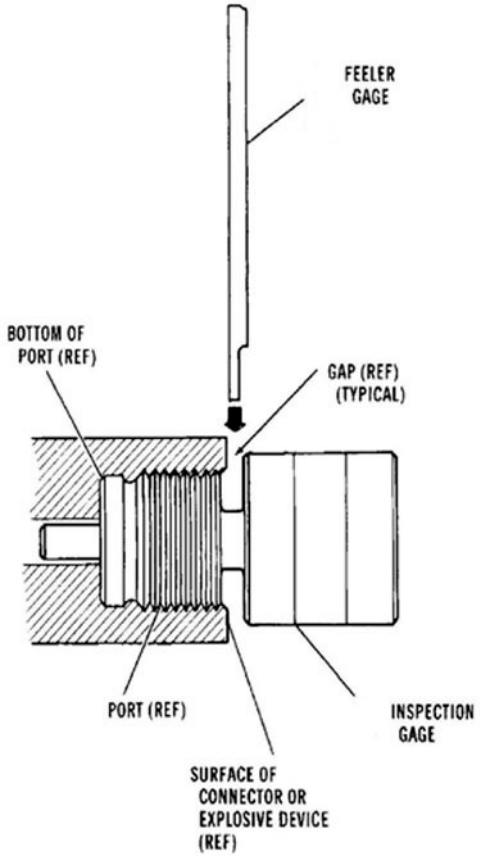


Figure 1–9. Port inspection.

1. Check the port dimensions by screwing the inspection gage into the port by hand until the inspection gage rests firmly against the bottom of the port.
2. Check the *minimum* port depth by verifying that a 0.064-inch feeler gage (provided with the set) *does not fit* between the inspection gage and the surface or connector or explosive device.
3. Check the *maximum* port depth by verifying that a 0.049-inch feeler gage (provided with the set) fits between inspection gage and surface of connector or explosive device. The measurement verified in this step applies to connectors or explosive devices other than the CARB. To check the maximum port depth of the CARB, verify that a 0.014-inch feeler gage (provided with the set) fits between the inspection gage and the surface of the CARB.
4. Remove the inspection gage from the port.

Using the inspection set on type shock tube DTAs

Type shock tube DTAs have their own set of rules. These DTAs are tipless.

1. Prepare the inspection gage set for use by inserting the –57 gage into the top of the –53 gage.
2. Disconnect the opposing DTA line from the DTA connector and install a protective cap on the connector.
3. Check port dimensions by screwing the inspection gage into the port by hand until the inspection gage rests firmly against the bottom of the port.
4. Check the *minimum* port depth by verifying a 0.050-inch feeler gage (provided with the set) *does not fit* between the inspection gage and the surface of the connector or explosive device.

5. Next, check the *maximum* port depth by verifying a 0.032-inch feeler gage (provided with the set) fits between the inspection gage and the surface of the connector or the explosive device.
6. Remove the inspection gage from the port, remove the explosive cap, and reinstall the DTA line into the DTA connector.

Other inspection criteria

There are many types of DTA lines and you'll want to use the tech data while inspecting them because each line has its own section in the job guide. However, we'll go over some general rules.

1. Verify that the identification tag is securely attached and information on it is legible. If it's missing or illegible, and the data is known, then simply replace the tag. If the information is unknown, then reject the DTA line.
2. Verify that bends and indentations on the DTA line do not exceed limits in the tech data and verify that there are no bends that have an inside bend radius smaller than 0.38 inch. Of course, there is an exception to every rule, and type ST and type STR DTA lines should not have an inside bend radius of less than 0.13 inch.
3. Verify that wire braid outer coverings of flexible DTA lines do not exceed more than one broken strand per 12-inch section or more than three broken strands total for the entire line.
4. Verify that cuts or gaps on the black polyethylene outer jacket of rigid DTA lines do not occur at the DTA attachment point and do not occur at points at which the DTA line will be in contact with bare, unpainted metal parts in the aircraft. If the outer jacket is damaged to the extent that the metal sheath is visible, follow criteria in the tech data. Using a lighted magnifier and a feeler gage for comparison, verify that no dents on the upper surface of the DTA tip are deeper than 0.005 inch and total of all dents does not exceed 10 percent of the total upper surface area. Also, verify that no dents on the side of the DTA tip are deeper than 0.005 inch, there is at least 135 degrees of arc between adjacent dents, lateral length of the dent is not greater than 0.03 inch and longitudinal length of the dent is not greater than 0.060 inch. Finally, verify that no dents on the edge of the DTA tip are deeper than 0.005 inch, width of the dent is not greater than 0.020 inch and length of the dent is not greater than 0.040 inch.
6. Verify that DTA edge flattening dimensions do not exceed those prescribed by tech data.
7. Verify that the rubber seal at the base of the DTA tip is not damaged and remove loose foreign material from the DTA tip with a cotton swab.

If the DTA nut shows that the threads are not completely coated with a light coat of solid film lubricant, then slide the DTA nut back from the tip and apply a thin film of grease to the threads with a cotton swab. Do not allow grease to come in contact with the DTA tip. Remove excess grease with clean cheesecloth. Then, inspect the seal and the DTA tip for grease and wipe with clean cheesecloth if grease is present.

205. Operational checkouts

Following F-16 ACES II installation, perform follow-on maintenance operational checkouts. There are three operational checkouts required in the technical order:

1. Ejection seat arm-safe ejection control safety handle and switch checkout.
2. Ejection seat height adjustment switch checkout.
3. Flight control memory checkout.

As an egress journeyman, you will only perform the first two checkouts. Avionics must perform the flight control memory checkout after seat installation, so ensure this checkout is documented in the aircraft forms. However, if only the aft seat was removed, there is no need to do a flight control memory checkout because the flight data recorder is only on the forward seat.

Operational checkout of ejection seat arm-safe ejection control safety handle and switch

The procedures for forward and aft checkout are identical, so the technical order only provides procedures for the forward seat. Figure 1–10 shows the cockpit components you'll be using during this checkout. Some bases may only allow crew chiefs to connect electrical power to the F-16, so find out what your base's policy is before you perform this check. If this is the case, crew chiefs will perform the operational checkout.

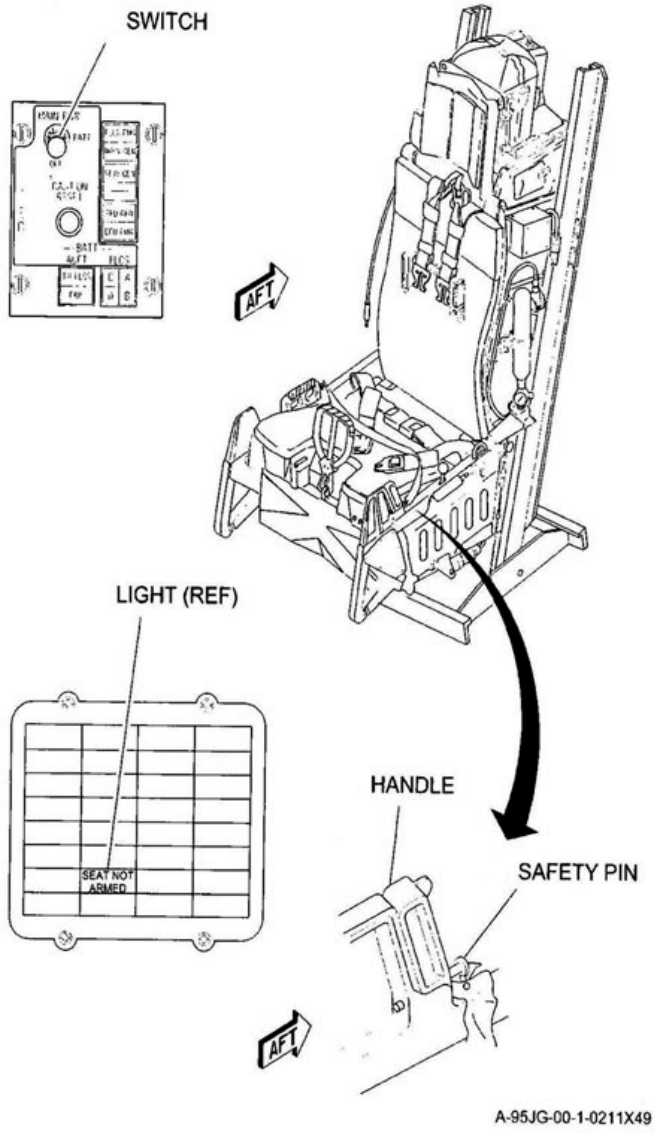


Figure 1–10. Seat arm-safe checkout.

Connect electrical power to the F-16. Don't operate the equipment for more than 30 minutes without cooling air. If power is to be reapplied without cooling air, allow a 15-minute cool-down period. Failure to comply may result in damage to equipment. **ALWAYS** use applicable technical data insuring the aircraft is safe for electrical power, otherwise injury or damage to the aircraft **WILL** occur.

After electrical power is connected, position the main power switch to MAIN PWR. Then remove the safety pin from the ejection control safety handle. Next, place the ejection control safety handle in the armed position (down). The handle should move freely down and the SEAT NOT ARMED light

should go out. Then, place the ejection control safety handle in EJECTION CONTROLS LOCKED (up) position. The handle should move freely and the SEAT NOT ARMED light should come on.

Install the safety pin in the ejection control safety handle. If the checkout was successful, position the main power switch to OFF. Disconnect electrical power from the F–16. If you are doing this checkout in conjunction with the seat height adjustment checkout, you'll want to wait to turn off the power until you've completed both checkouts.

If the checkout was not successful, you'll have to troubleshoot by first making sure that the arm-safe switch electrical disconnect is properly connected. If the connector is loose, connect it properly. If that doesn't correct the problem, then consult the fault isolation (FI) manual.

Operational checkout of seat height adjustment switch

Much like the previous checkout, the procedures for forward and aft seats are the same, so the technical order only lists procedures for the forward seat. Figure 1–11 shows the cockpit components you'll be using during this checkout. You may be doing this checkout in conjunction with the previous checkout. If so, power will already be applied.

If necessary, connect electrical power to the F-16. Don't operate the equipment for more than 30 minutes without cooling air. If power is to be reapplied without cooling air, allow a 15-minute cool-down period. Failure to comply may result in damage to equipment.

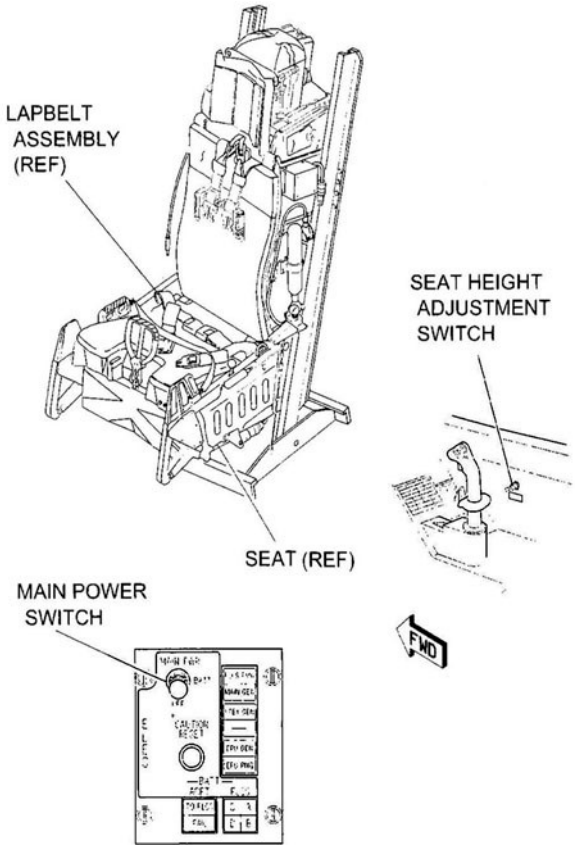


Figure 1–11. Seat height adjustment checkout.

Before you start operating the seat height adjustment switch, ensure that the lap belt is properly stowed. Failure to properly stow the lap belt could result in damage to the equipment. The technical order doesn't spell this out, but you'll also want to look for any other obstructions to seat travel, such as the oxygen and G-suit hoses. Also, don't operate the seat height adjustment motor for more than

15 seconds without a five-minute cool down period. Failure to follow this rule could also result in damage to the equipment and you could find yourself replacing the seat sidecap or actuator.

Position the seat height adjustment switch to the up position and hold. The seat should rise to the full up position and stop.

Next, position the seat height adjustment switch to the down position and hold. The seat should lower to the full down position and stop. Interference with equipment under the seat in the full-down position (with the exception of the pilot relief container) is not acceptable. Anything under the seat can result in damage to the equipment, including the pitch stabilization control assembly (STAPAC). Inspect the hardware and equipment beneath the seat for signs of seat actuator down stop failure.

Finally, position the seat height adjustment switch to the up position and release switch. The seat should start up and stop and the switch should return to the center position.

If the checkout was successful, position the main power switch to OFF and disconnect the electrical power. If the checkout was not successful, consult the FI manual.

Self-Test Questions

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

201. Component description

1. Match the F-16 escape system component listed in column A with its description in column B by writing the correct letter in the blank space provided. Descriptions in column B may be used only once.

Column A	*Column B*
___ (1) Seat adjustment actuator.	a. Contains a spool.
___ (2) Ejection mode selector valve.	b. Functions as a booster.
___ (3) Sequence valve.	c. Allows 5.0 inch seat travel.
___ (4) M99 initiator.	d. Attached to the seat actuator.
___ (5) M53 initiator.	e. Attached to canopy by lanyard interlock mechanism.
___ (6) Time delay hot gas initiator.	f. Allows preselection of three modes of ejection.
___ (7) Rocket catapult.	g. Three of them provide delay between forward and aft seat ejection.

2. How does the sequence valve operate when the crew member decides to eject after the canopy jettison handle has been pulled to jettison the canopy?

202. Theory of system operation

1. What are the two principal functions of the F-16 crew escape system?

2. After the ejection control handles are pulled, what does gas from the first two M53 initiators in the F-16 ejection sequence do?

3. What is the time delay between the firing of the M99 initiators and the firing of the aft seat rocket catapult?

4. What are the three modes of dual-seat F-16 ejection?

5. When the ejection mode selector-valve is set in NORMAL mode and the forward seat ejection handle is pulled, what is the sequence of events from when the canopy leaves the aircraft to the firing of the aft catapult?

6. When the ejection mode selector valve is set in NORMAL and the aft seat ejection handle is pulled, what is the sequence of events from the pulling of the aft ejection control handle to canopy jettison system initiation?

7. When the ejection mode selector valve is set in AFT mode and the forward seat ejection handle is pulled, what is the purpose of the extra M53?

8. When the ejection mode selector valve is set in AFT mode and the aft seat ejection handle is pulled, why won't the forward sequence valve DTA initiators fire?

9. When the ejection mode selector valve is set in SOLO mode and the forward seat ejection handle is pulled, what is the sequence of events from the selector valve to the firing of the forward seat catapult?

203. Removing and installing detonation transfer assembly lines

1. Why should you never try to remove a DTA line if another shop's component is in the way?

2. Why must you always use the appropriate sized wrench when disconnecting DTA lines?

3. What should you do immediately following the removal of a DTA nut?

4. During DTA installation, when should you remove DTA caps and plugs?

5. How do you install ferrule-type connectors?

6. When applying torque to a DTA nut with flats, how can you prevent twisting?

7. When measuring the gap between the DTA nut and port, what measurements should you find on standard and tipless end DTA lines, respectively?

204. Inspecting detonation transfer assembly lines

1. Before handling what type of DTA lines must you ensure you discharge any possible static electricity from your body?

2. When using the DTA and ECRL inspection gage set, where would you find information on the type of gage to use for a particular DTA part number?

3. How do you inspect the DTA attaching nut threads?

4. Using the DTA and ECRL inspection gage set, how do you verify that the DTA tip is the correct length?

5. Using the DTA and ECRL inspection gage set, how do you verify that the DTA tip is straight?

6. Using the DTA and ECRL inspection gage set, how do you check port dimensions?

7. Using the DTA and ECRL inspection gage set, how do you verify *maximum* port depth?

8. Using the DTA and ECRL inspection gage set, how do you verify *maximum* port depth on type shock tube DTA lines?

9. How do you inspect the black polyethylene outer jacket of rigid DTA lines?

10. While inspecting a DTA line, if you discover that the nut threads are not completely coated with a light coat of solid film lubricant, how do you correct this deficiency?

205. Operational checkouts

1. What three operational checkouts are required following an F-16 ACES II installation?

2. If you are connecting electrical power to an F-16, how long should you allow for cool-down in between equipment operation when cooling air is not available?

3. During the operational checkout of the ejection seat arm-safe ejection control safety handle and switch, what should happen when the ejection control safety handle is placed in the armed position?

4. During the operational checkout of the seat height adjustment switch, what are some components you'll want to ensure aren't obstructing seat travel?

5. During the operational checkout of the seat height adjustment switch, what should happen when you position the seat height adjustment switch to the up position and hold?

1–2. Canopy Jettison System

The first step in understanding the canopy system operation is to understand the components themselves. You'll find that the best troubleshooter of a system is the worker who fully understands the basic function of each component in that system. Although the discussions that follow are oriented toward a dual system, the single system functions in a similar manner. Once you understand the components, we'll discuss the canopy system's theory of operation.

Then, we'll discuss removing and installing the canopy, rigging the canopy, and troubleshooting the canopy system.

206. Component description

Canopy jettison on the F-16 can be accomplished automatically during seat ejection, or the canopy can be jettisoned independently of seat ejection. We'll look at each of the components involved in a canopy jettison and how they function. Our discussion focuses on a two-seat aircraft.

As shown in figure 1–12, the canopy jettison system consists of the following seven major components:

- Detonation transfer assemblies.
- Emergency canopy release lines.
- Canopy actuator release bolt.
- Canopy remover rockets.
- Canopy/seat interlock lanyard assembly.
- External canopy jettison handles and initiators.
- Internal canopy jettison handle and initiator.

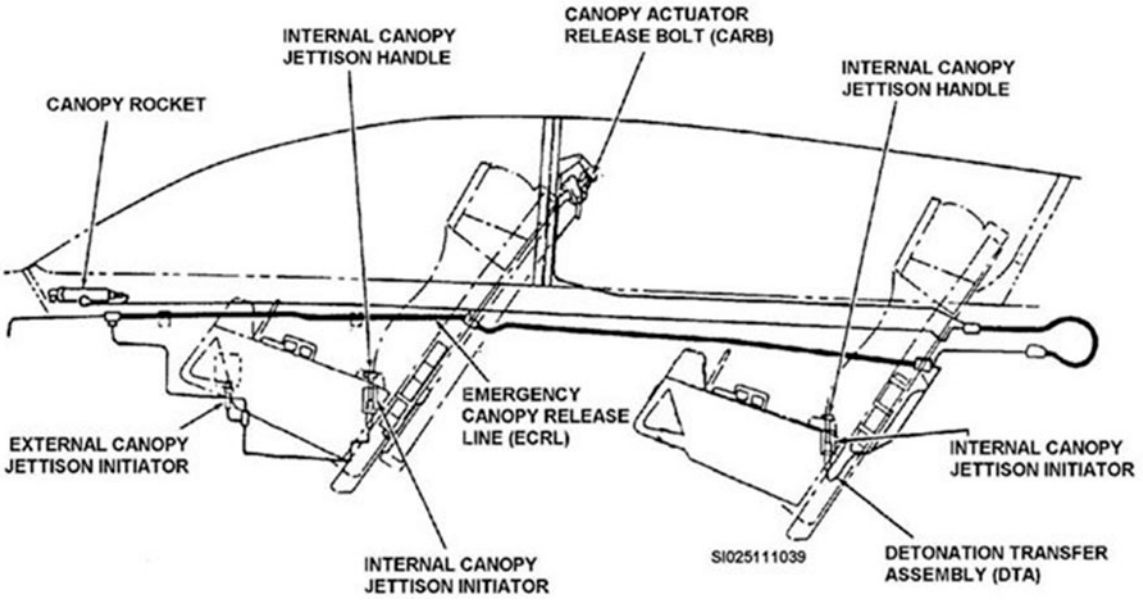


Figure 1–12. Canopy jettison components.

Detonation transfer assembly

The DTAs are located on the canopy assembly and in the cockpit area. As discussed in the previous lesson DTA is a small-diameter line with an explosive tip on each end. The DTAs transfer detonation from the DTA initiators, which are mounted on the sequence valves, to the ECRLs, the CARB, and the canopy remover rocket motors.

Emergency canopy release line

An ECRL is located on each side of the cockpit. Figure 1–13 shows a cutaway of the ECRL. Each ECRL is routed through each of the canopy hook levers, lever retainer, and the lever support fittings. When the ECRL detonates at either end, the explosive-filled cord inside the ECRL detonates throughout its length. This causes the outer housing to expand at the points at which it's in contact with the lever support fitting. The expanding housing breaks two frangible bolts that attach the lever retainer to the lever support fitting and pushes the retainer away from the hook lever. This allows the lever to pivot about its mounting pin and free the canopy hook from its engagement with the lever.

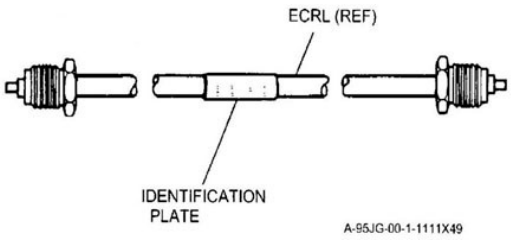


Figure 1–13. Emergency canopy release line.

Canopy actuator release bolt

As shown in figure 1–14, the CARB is located at the upper end of the fuselage-mounted canopy actuator. The CARB, under normal operations, secures the upper end of the canopy actuator to the latching and actuating mechanism in the canopy. The CARB is an explosive bolt that fractures in two places when initiated by a DTA at either end. When the CARB fractures on either side of the attachment point, it releases the canopy from the canopy actuator, freeing it for jettison; hence the name—"canopy actuator release bolt."

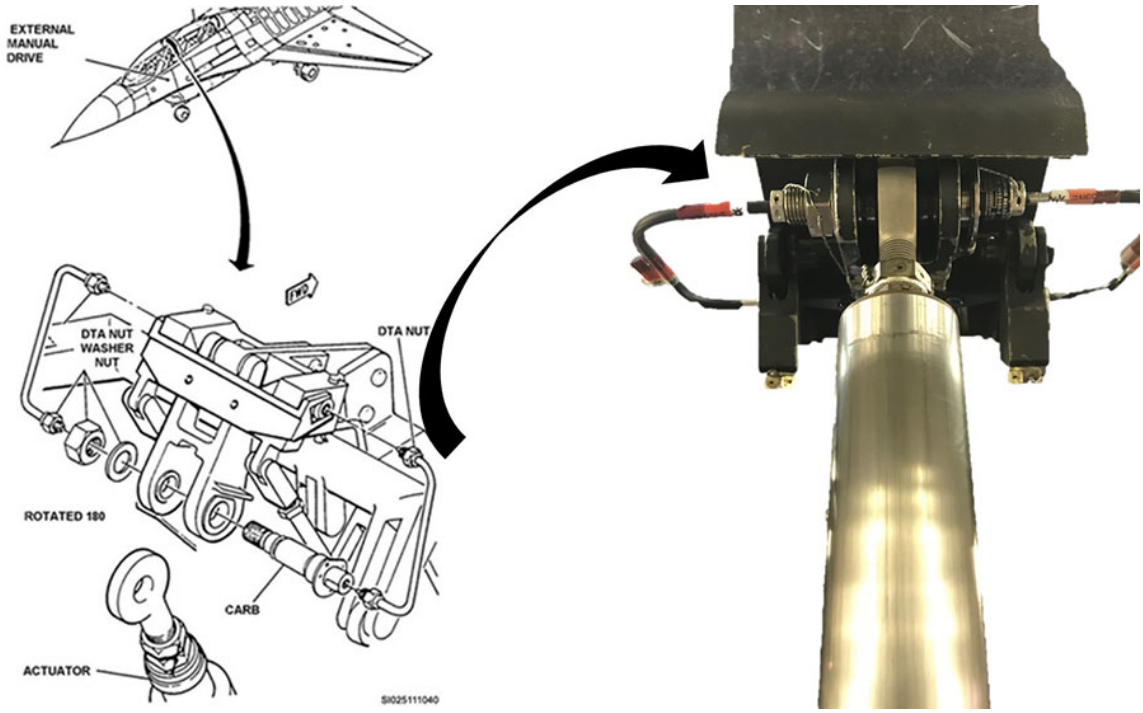


Figure 1–14. Canopy actuator release bolt.

Canopy remover rockets

The canopy remover rockets mount on the forward end of each side of the canopy frame (fig. 1–12). They are solid-fuel, DTA-initiated rockets that propel the canopy clear of the aircraft.

Canopy/seat interlock lanyard assembly

Two interlock lanyard linkages are located at the aft end of the canopy. They're attached to each side of the canopy and routed down along the bulkhead to the M99 initiators mounted on the sequence valve on each side of the seat support. When the canopy ejects from the aircraft, the lanyards fire the M99 initiators. The sequence valve and M99 initiators were discussed earlier in this unit.

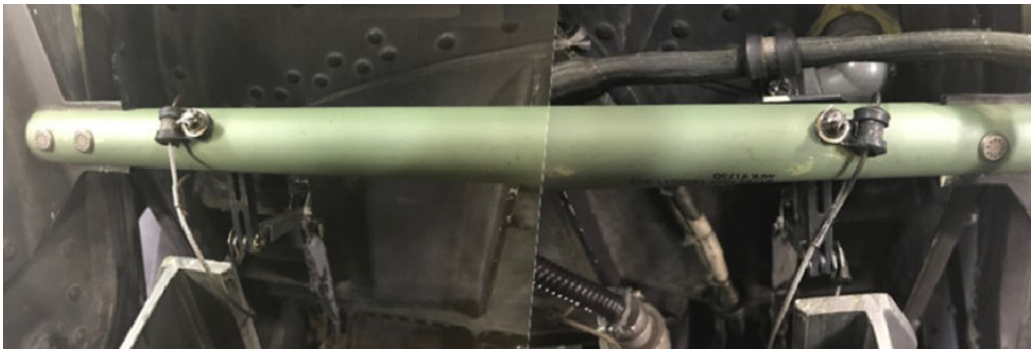


Figure 1–15. Interlock lanyard assembly and linkage.

External canopy jettison handles and initiators

An external canopy jettison handle is located on each side of the aircraft behind access doors 1105 (left side) and 1206 (right side) (fig. 1–16). The handles are D-ring type attached to a lanyard. When pulled, the handle, attached to a six-foot lanyard, fires its respective external canopy jettison initiator. One initiator mounts on each side of the aircraft outside of the forward cockpit. They fire a DTA line attached to the outlet port of the initiators. The DTA line continues a sequence that jettisons the canopy without ejecting the seat.

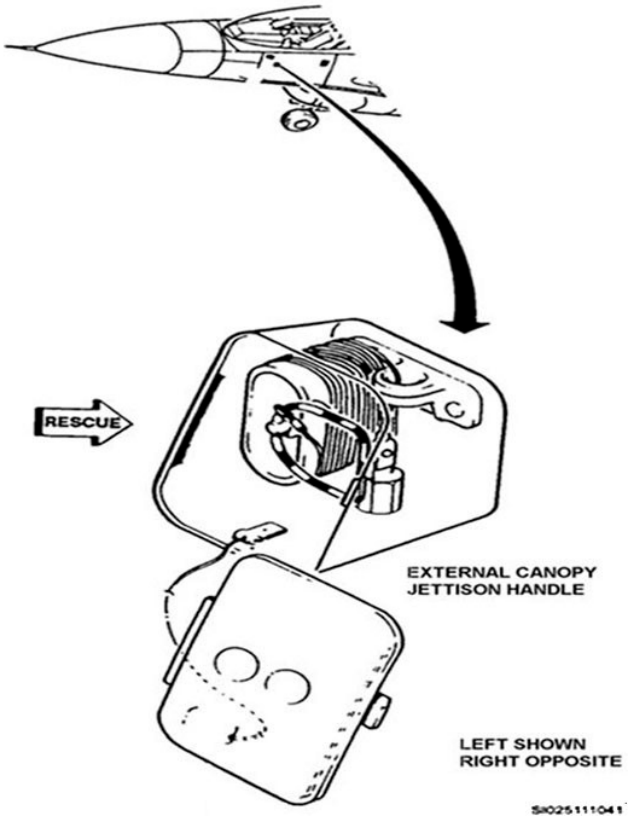


Figure 1–16. External canopy jettison handle.

Internal canopy jettison handle and initiator

The internal canopy jettison handle is tee-shaped. Located on the left console, it attaches to an internal canopy jettison initiator. When the internal canopy jettison tee-handle is pulled, it fires an internal canopy jettison initiator. Just like the external initiator, a DTA line attached to the outlet port of the initiator fires. The DTA line continues the sequence that jettisons the canopy without ejecting the seat.

207. Theory of operation

Now that you know what the canopy jettison system is composed of, let's see how everything fits together (fig 1–17). Dual-seat F-16 canopy jettison is accomplished automatically during seat ejection or the canopy can be jettisoned independently of seat ejection.

Canopy jettison during seat ejection

The ejection control handle, located in the center of the forward edge of the seat bucket, automatically actuates the canopy jettison sequence at the beginning of the escape sequence. When the system is fired by the two ejection initiators, hot gas travels to fire M53 instantaneous hot gas initiators, which in turn, sends hot gas through sequence valves to fire the DTA initiators. The DTA initiators fire the ECRLs, which expand at each canopy latch fittings, breaking the frangible latch lever retainer bolts, thereby detaching the latch retainers and allowing the latch levers to pivot out of the path of the canopy hooks. Simultaneously, the DTAs fire the CARB and then the canopy remover rockets. As the rockets rotate the canopy back past 41 degrees, the canopy hinges are disengaged and the canopy propels away from the aircraft.

Canopy jettison independent of seat ejection

Crewmembers may need to escape from the aircraft without ejecting the seats in cases such as a smoke-filled cockpit. Independent of seat ejection, canopy jettison can be accomplished by pulling either of the two internal canopy jettison handles by the crewmembers or either of the two external

canopy jettison handles by ground crews outside the aircraft. This actuates one of the four manually operated canopy jettison initiators. In this case, when the exiting canopy actuates the canopy interlock system, the hot gas from the M99 will shuttle the sequence valve spools to the opposite end of the valve bodies and prevents any flow of gas to the seat rocket catapults. Seat ejection can be achieved subsequently by pulling the ejection control handle.

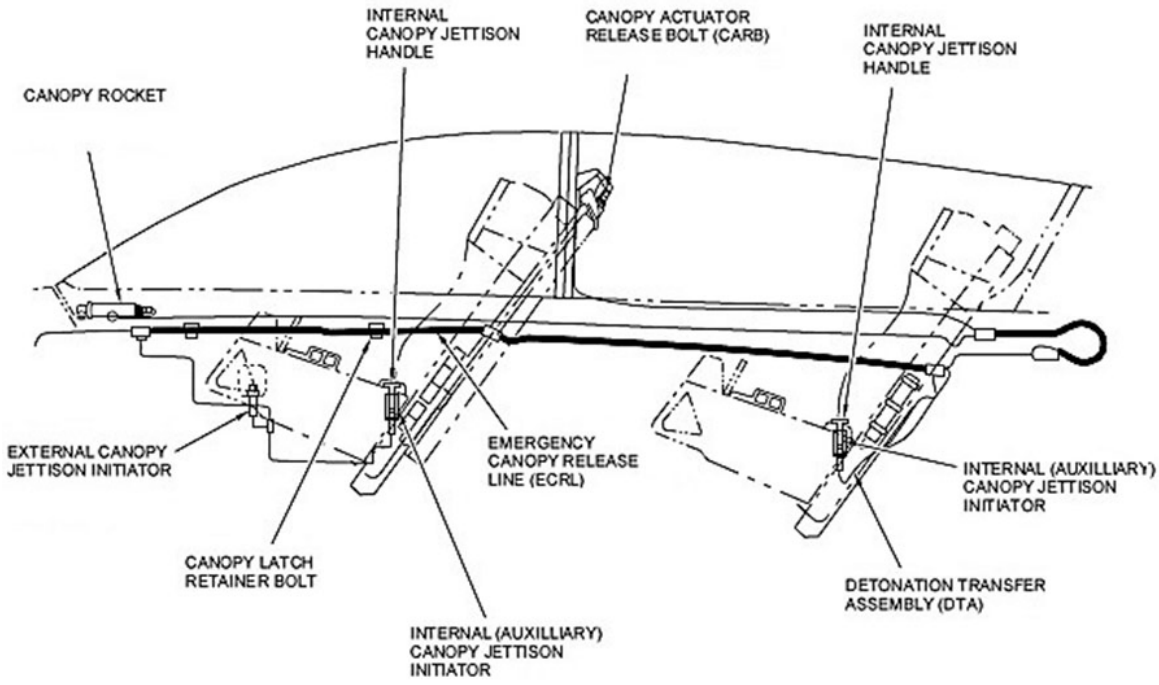


Figure 1–17. F-16D Canopy system components.

208. Removing the canopy

Following are the procedures for removing the dual-seat F-16 canopy. First we'll go over some input conditions and warnings and then some cautions before we get into the procedures. Remember, this CDC is not tech data! Always consult applicable tech data when performing any maintenance.

Input conditions

Remember that you should always do a safe for maintenance check before starting maintenance on any aircraft. You'll need to remove access panels 2415 and 2416 to access DTA lines and also panel 3434 for clearance while removing the canopy before you get started. Three personnel are recommended for this job. Technician A directs removal of the canopy from either side of the aircraft on the maintenance platform. Technician B, located on the opposite side of the aircraft from Technician A, performs removal of the canopy while on the maintenance platform. Technician C assists in removal of the canopy and operates the hoist.

Support equipment

Following are the support equipment items you'll need to perform this task:

- Two canopy maintenance supports.
- Canopy transport/maintenance fixture.
- Crane.

- Maintenance platform.
- Canopy sling assembly.

Perform a prior to use inspection on all support equipment to make sure it is serviceable.

Consumables

For the removal task, the only consumable you'll need for sure is tape. Masking tape is the easiest type of tape to remove and will not damage equipment. You may also need a few bolts to interchange for the sling adapters.

Warnings

Always look at and read to your team the warnings for a task before performing any maintenance. It could save a life.

Depending on the fuel load, removing one or more of the following systems may cause the aircraft center of gravity to shift, creating a marginal or unsafe condition.

- Ejection seat(s).
- Fire Control Radar System or last remaining line replaceable unit (LRU).
- Gun system.

Refer to Technical Order (TO) 1F–16( )–2–00GV–00–1, *Organizational Maintenance—General Vehicle Description, Aircraft Safety,* and applicable tables for the proper sequence of removal and safety precautions. Failure to comply may result in aircraft rotating aft on the main landing gear and landing on its tail, causing injury or death to personnel and/or damage to equipment. If removal or installation of other components on the aircraft that could cause center of gravity shift is anticipated, then qualified weight and balance personnel will determine if jacks are needed under the aft fuselage. Failure to comply may result in the aircraft rotating aft on the main landing gear, causing injury or death to personnel and/or damage to equipment.

No personnel shall be under the canopy during removal or installation *except* to remove or reinstall the CARB. Failure to comply may result in injury to personnel and/or damage to equipment.

Do not perform canopy maintenance if wind exceeds 20 knots. Failure to comply may result in injury to personnel and/or damage to equipment.

When hoisting the canopy during removal or installation, do not allow the canopy to swing out of control. Failure to comply may result in injury to personnel and/or damage to equipment.

Cautions

We'll go over the cautions for canopy removal first because it's always a good idea to read ahead to see what safety conditions you need to look out for when performing any task.

Use electrical operation of the canopy *except* where specifically instructed to use manual operation. The external canopy switch is shown in figure 1–18. Failure to comply may result in damage to equipment.

The cockpit sill shall be kept free of foreign objects. Failure to comply may result in damage to equipment.

Do not use power tools on the external manual drive to open or close the canopy. Failure to comply may result in damage to equipment.

The aft seat should be in the full-down position. Failure to comply may result in seat and canopy contact causing damage to equipment.

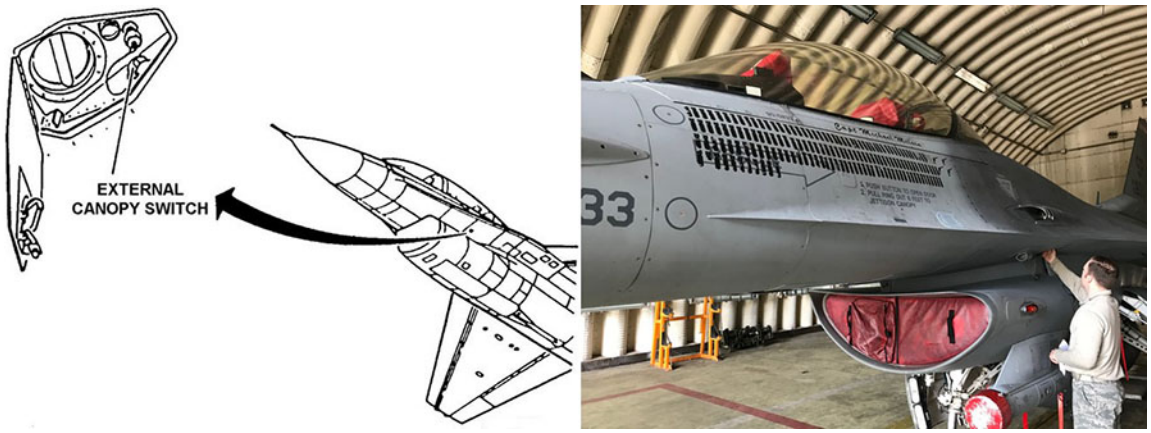


Figure 1–18. External canopy switch.

Interference with the aircraft canopy longeron may occur if the incorrect sling adapter attach bolts are used on the left and right sides. If interference occurs, the bolts shall be replaced as necessary. You may find that you have to use different bolts on different canopies because of canopy warping. Remember the rules on bolts from the first volume? Bolt installations on canopy nutplates should have at least two complete threads protruding from the nut. If you have more or less than this, then it's a good idea to change out the bolts. Keep in mind that you are using them to suspend a very heavy load, and it would not be a good thing to drop the canopy. Failure to comply may result in damage to equipment.

To prevent possible damage to the forward DTA line, hold the DTA connector with a wrench or by hand when disconnecting the DTA nut. Failure to comply may allow the DTA connector bracket to bend slightly and may cause damage to the forward DTA by pressing the DTA against the underside of the DTA cover.

Tape shall be applied to the capped portion of the canopy to aircraft DTA line and secured to the canopy structure. Failure to comply may result in damage to the hinged DTA, surrounding DTA lines and surrounding aircraft and canopy structure.

To prevent damage to the transparency, the hoist shall be adjusted to keep the sling from making contact with the canopy transparency. Failure to comply may result in damage to the transparency.

The canopy shall be removed slowly to prevent contact between the tension tube and the upper seat structure. Failure to comply may result in damage to equipment.

Removal procedures

It's important to retain all serviceable parts for installation, and to install protective devices on all open lines and ports.

Connect electrical power and lower the aft seat to the full down position using the seat height adjustment switch. Once complete, disconnect the electrical power.

Attach forward and aft adapters to each side of the canopy (fig. 1–19). Fully open the canopy with the external canopy switch and install two canopy maintenance supports (fig. 1–20).

Remove the safety wire from the lower end of the canopy to aircraft DTA on each side of the aircraft and disconnect the DTA lines from the fuselage mounted connectors. Install protective caps and plugs. Apply tape to the capped end of the DTA line and secure the line to the canopy structure.

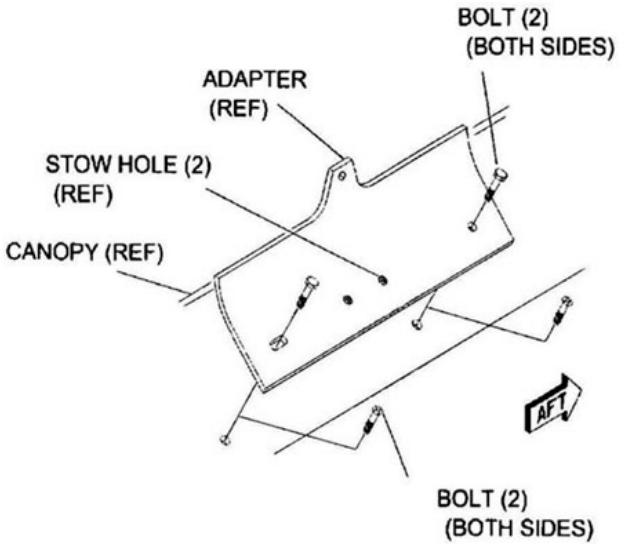


Figure 1–19. F-16 sling adapter.

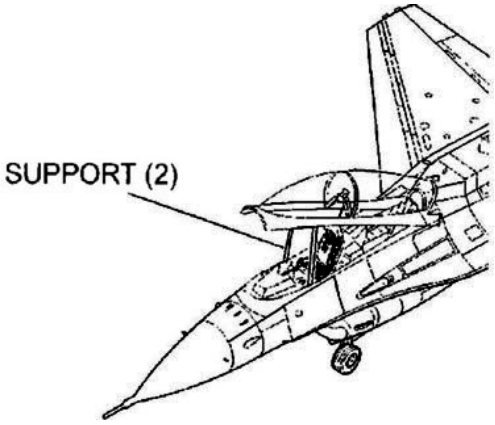


Figure 1–20. F-16 canopy maintenance supports.

Next, disconnect the interlock lanyard and tension tube links by removing the cotter pin, washer, pin, and safety cable from the shear bracket on each side of the aircraft. You can secure interlock links by taping them to the interlock housing in the closed (nonextended) position. Once you have securely taped the tension tube links, remove the CARB.

After connecting the sling to the crane hoist, position the sling over the canopy and attach the sling to the forward adapters with the pins supplied with each sling. Then attach the sling to the aft adapters with the pins supplied with the sling.

Remove the two canopy maintenance supports and slowly remove the canopy from the fuselage. While you're removing the canopy, make sure that the upper and lower roller bearings have freedom of rotation. If they're defective, remove and replace them. Guide the aft end of the canopy until the hinged area clears the aircraft.

Once clear of the aircraft, hoist the canopy down to the canopy transport or maintenance fixture and position the canopy on the transport or fixture. Remove the sling pins, bolts, and adapters. Then reinstall any stowed bolts on each side of the canopy frame.

Document the aircraft forms and make sure you include a canopy seal pressurization operational checkout to be performed by electro-environmental.

209. Installing the canopy

The following are the procedures for installing the dual-seat F-16 canopy. First we'll go over some input conditions and warnings and then some cautions before we get into the procedures. Again, remember, this CDC is not tech data! Always consult applicable tech data when performing any maintenance.

Input conditions

Remember that you should always do a safe for maintenance check before starting maintenance on any aircraft.

You'll need to remove access panels 2415 and 2416 and also panel 3434 before you get started if they were reinstalled after the removal.

Three personnel are recommended for this job. Technician A directs the installation of the canopy from either side of the aircraft on the maintenance platform. Technician B, located on the opposite side of the aircraft from Technician A, performs installation of the canopy while on the maintenance platform. Technician C assists in installation of the canopy and operates the hoist.

Support equipment

Following are the support equipment items you'll need to perform this task:

- Two canopy maintenance supports.
- Canopy rigging protractor.
- Canopy transport/maintenance fixture.
- Crane.
- DTA and ECRL inspection gage set.
- Generator set.
- Maintenance platform.
- Canopy sling assembly.
- Torque wrench.

Perform a prior to use inspection on all support equipment to ensure it is serviceable.

Consumables

Following are the consumables you'll need to perform the canopy installation.

- Cotter pins.
- Cotton swabs.
- General purpose grease.
- Safety wire.

You may also need a few bolts to interchange for the sling adapters.

Warnings

Always look at and read to your team the warnings for a task before performing any maintenance. It could save a life. The installation warnings include all of the removal warnings discussed above, but the installation adds a few more so we'll only cover those.

Properly position the hoist directly over the aircraft centerline to minimize canopy misalignment with the aircraft. Failure to comply may result in injury to personnel and/or damage the aircraft.

When lowering the canopy into the hinge track, both sides of the hinge track should engage. Lowering the canopy without both sides engaging may result in injury to personnel and/or damage to equipment.

Once the canopy is installed, the lower roller bearing shall contact the canopy track. Using finger pressure attempt to move the bearing, the bearing should not rotate. If you do find rotation, then the keeper is improperly torqued. Failure to comply may result in injury to personnel and/or damage to equipment.

Cautions

It's always a good idea to read ahead to see what safety conditions and cautions you need to look out for when performing any task.

Use electrical operation of the canopy *except* where specifically instructed to use manual operation. Failure to comply may result in damage to equipment.

The cockpit sill shall be kept free of foreign objects. Failure to comply may result in damage to equipment.

Power tools shall not be used on the external manual drive to open or close the canopy. Failure to comply may result in damage to equipment.

The aft seat should be in the full-down position. Failure to comply may result in seat and canopy contact causing damage to equipment. Tape securing the tension tube linkage may have been inadvertently removed during in-shop maintenance. Prior to beginning installation of the canopy assembly, the tension tube linkage should be secured. Failure to comply may result in damage to the linkage or other equipment.

Interference with the aircraft canopy longeron may occur if using the incorrect *sling adapter attach bolts* on the left and right sides. If interference occurs, replace the bolts as necessary. You may find that you have to use different bolts on different canopies because of canopy warping. Just like we discussed in the last lesson, bolt installations on canopy nutplates should have at least two complete threads protruding from the nut. If you have more or less than this, then it's a good idea to change out the bolts. Keep in mind that you are using them to suspend a very heavy load and it would not be a good thing to drop the canopy. Failure to comply may result in damage to equipment.

To prevent damage to the transparency, the hoist shall be adjusted to keep the sling from making contact with the canopy transparency. Failure to comply may result in damage to the transparency.

The canopy must be lowered slowly to prevent contact between the tension tube and the upper seat structure. Failure to comply may result in damage to equipment.

The canopy forward and aft frame cover bolts on the left and right sides shall be visually checked for possible chafing of aircraft frame. If chafing occurs, check bolts in the forward and aft covers for correct length and replace if necessary. Failure to comply may result in damage to equipment.

Prior to lowering the canopy, ensure that DTA lines at the hinge area will not be trapped between the canopy frame and longeron. Failure to comply may result in damage to equipment.

With canopy in full up position, tension tube links shall form a V pattern with the lower point of the V pointing forward and the upper connection points of the V pointing aft. Failure to comply may result in damage to equipment.

To prevent possible damage to the forward DTA line, hold the DTA connector with a wrench or by hand when connecting the DTA nut. Failure to comply may allow the DTA connector bracket to bend slightly and may cause damage to the forward DTA by pressing the DTA against the underside of the DTA cover.

Do not operate the aircraft for more than 30 minutes without cooling air. If power is to be reapplied without cooling air, allow a 15 minute cool-down period. Failure to comply may result in damage to equipment.

Installation procedures

Before installation of any DTA lines, inspect for damage and if damage is suspected, verify with the DTA and ECRL inspection gage set. Also look for any mushrooming deformation of the left and right canopy hinge tracks. If mushrooming is discovered, make sure it's within the limits of TO 16W2–6–2, *Intermediate Maintenance Instructions with Illustrated Parts Breakdown-Canopy Assembly.*

First, remove the four bolts from each side of the canopy frame and install the bolts in the bolt stow holes in each sling adapter. Attach the forward and aft adapters with two bolts on each side of the canopy. As discussed in the removal, make sure that the bolts aren't too long or too short. Then position the sling over the canopy and attach the sling to the adapters with four pins supplied to the sling.

Remove the nuts, washers, and bolts securing the keepers to each side of the aircraft and remove the cotter pins, nuts, and the keepers (fig. 1–21). Adjust the lower roller bearing on each side of the aircraft by rotating the splined adjusting bolt to the lowest setting.

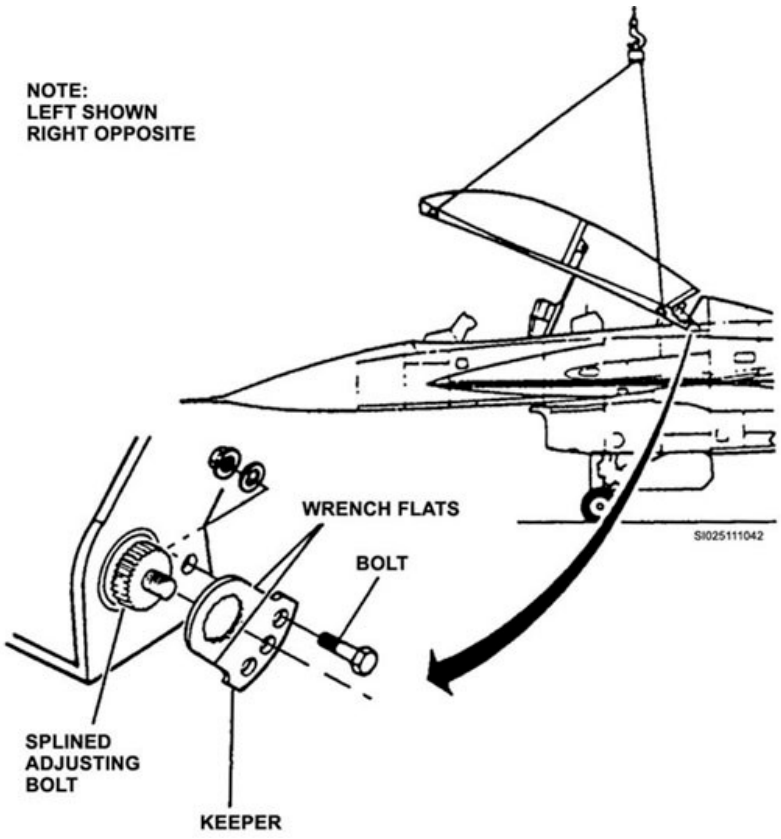


Figure 1–21. Canopy keeper.

Position the canopy over the aircraft, making sure to keep the hoist directly over the aircraft centerline. If the canopy is hanging freely from the sling, the proper angle with the hinge track will occur. Lower the canopy until the upper concave surface of the track on each side engages with the upper roller bearing (fig. 1–22).

Continue to lower the canopy by allowing it to rotate about the upper roller bearing until the lower convex surface of the track contacts the lower roller bearing. Keep lowering the canopy until its angle with the longeron is approximately 27 degrees, using a protractor for measurement. By the "adjust and try" method, install the keeper on the splined adjusting bolt so that the securing bolt can be installed when the keeper has been torqued. Using wrench flats, torque the keeper to 50–150 inch pounds. Secure the keeper by installing the bolt, washer, and nut in one of the three holes in the

keeper. Torque the nut to 60–110 inch pounds and install the cotter pin. You'll duplicate these steps on each side of the aircraft. Check both roller bearings for engagement with the track. No gap should exist. If a gap exists, you'll have to repeat the steps, which is why this is called the "adjust and try" method. Lower the canopy enough to install two canopy maintenance supports. Once the supports are secure, install the CARB and disconnect the sling from the four adapters by removing the four pins. Remove the bolts from each adapter and install them in the bolt stow holes. After that, install all the bolts that were removed from the nutplates of the canopy back into their respective holes. They should be torqued to 25–35 inch pounds.

While Technician A and B are performing maintenance on the canopy, Technician C can move the sling away from the aircraft, lower it, and disconnect the sling from the hoist. You don't want to leave the sling hanging over the aircraft!

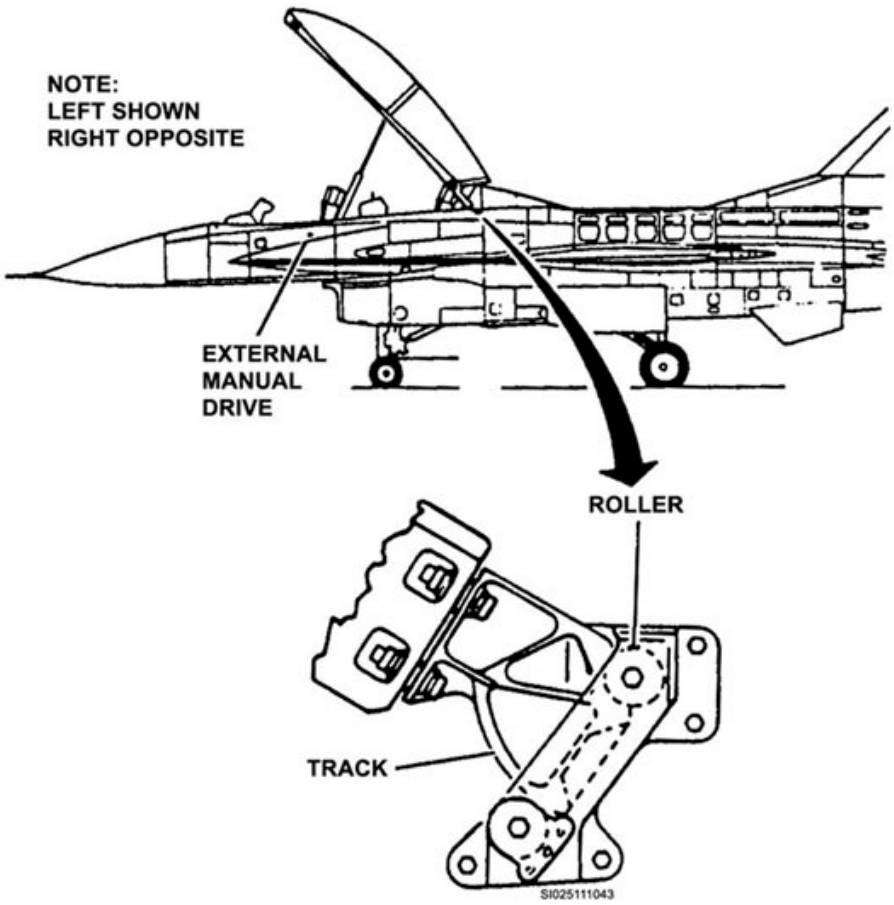


Figure 1–22. Track-roller engagement.

You'll need to remove the maintenance supports before performing this next step; otherwise it can't be performed. After the bolts are installed, lower the canopy slowly to the full down position using the external manual drive. Then raise the canopy to full up position using the external manual drive. You'll do these steps to make sure everything is working properly. Remove the tape from the tension tube links and position the interlock lanyard and lower the tension tube link into the shear bracket by installing the safety cable, pin, washer and cotter pin on each side. Make sure that the links form a V pattern with the lower part of the V pointing forward and not backward. The damage from installing the links improperly is not something you'll want to explain to your maintenance group commander.

Next, remove the securing tape from the canopy to aircraft DTA line on each side of the aircraft. Connect the DTA lines with the procedures outlined in the technical order and discussed previously.

Now, lower the canopy to the desired position using the external manual drive (fig. 1–23). “What is the desired position,” you may ask? The desired position is far enough to do the next operational check which is done by raising the canopy to the full up position using the internal canopy switch. This means that someone is inside the cockpit, so the desired position for you may be far enough to allow air to flow into the cockpit without completely closing the canopy. It is not fun to be stuck inside an F-16 cockpit with no airflow when a canopy hinge or linkage system malfunctions.

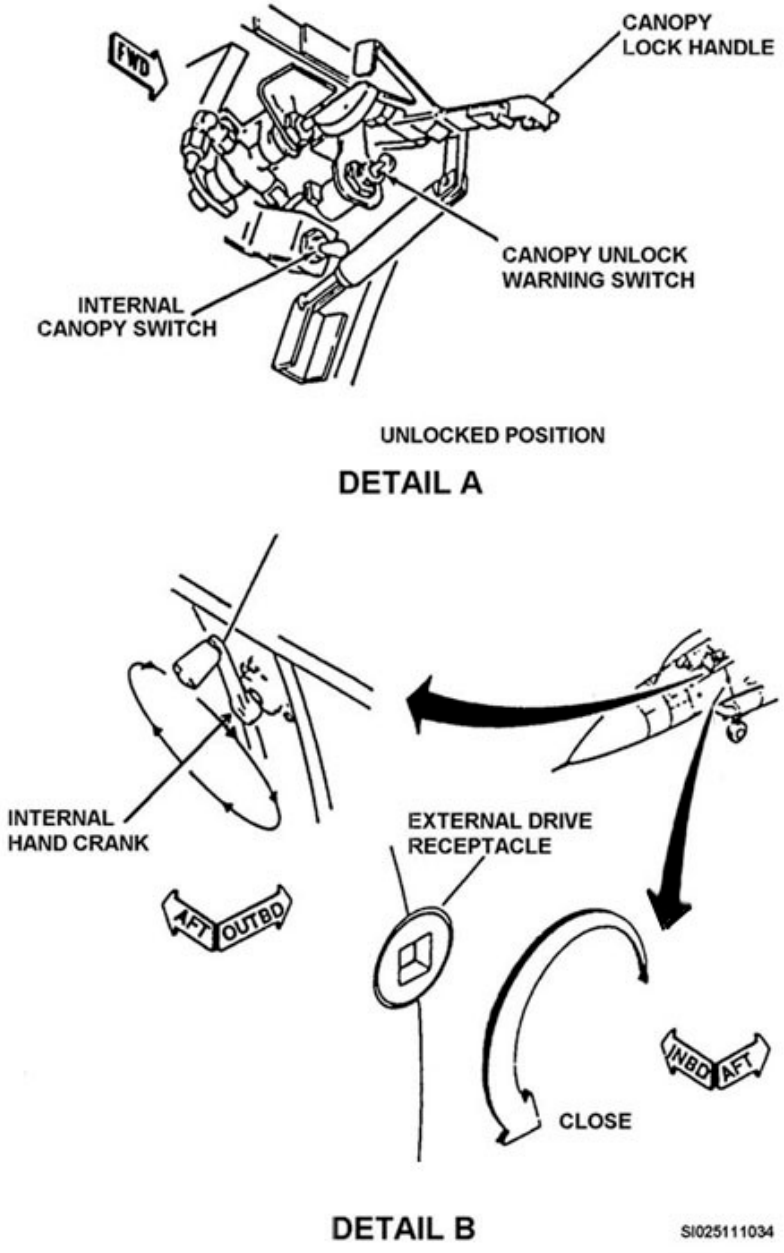


Figure 1–23. Methods of canopy movement.

After you raise the canopy with the internal canopy switch (fig. 1–23), verify that the roller bearings are engaged on each track with no gap. If they’re not or if a gap exists, you’re going to have to remove and reinstall the keepers again.

If everything is operating smoothly, reinstall access panel 2415 and access panel 2416. Lower the canopy slowly using the manual drive and ensure that panels 2415 and 2416 do not bind against the fuselage. The clearances for the panels are shown in figure 1–24. If they do, you'll have to call sheet metal, which will take measurements, take the panels back to their shop, and trim them down.

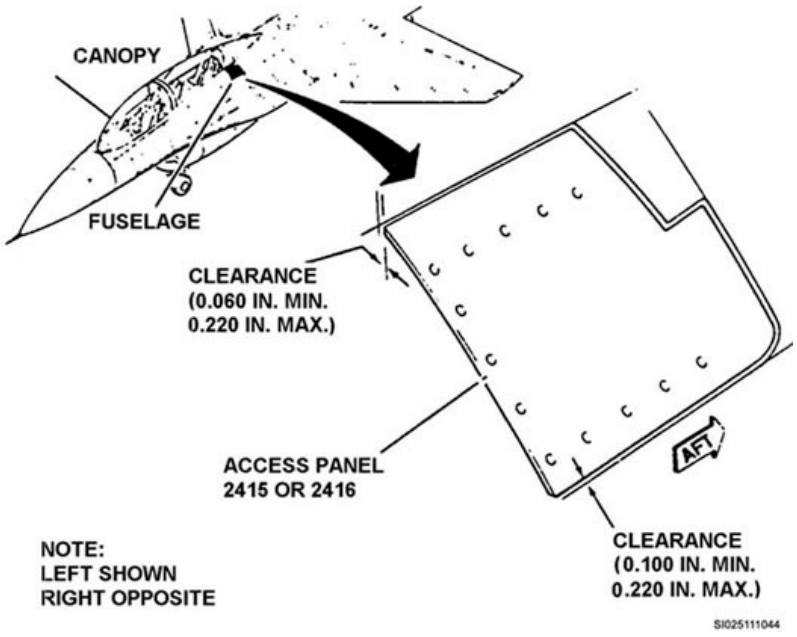


Figure 1–24. Panels 2415 and 2416 clearances.

If the panels don't need to be trimmed, but you're installing a different canopy than the one removed from the aircraft, you'll have to rig the canopy latches. We'll talk about rigging canopy latches in the next lesson. Most likely, you're reinstalling the same canopy, so you won't have to rig the canopy latches.

Operational checkout

Now it's time to perform the operational checkout to make sure that the canopy warning light works.

1. Connect electrical power to the aircraft; remembering that you can't operate the equipment for longer than 30 minutes without cooling air. Position the main power switch to MAIN PWR.
2. Lower the canopy to the full down position using the internal canopy switch.
3. Now, rotate the lock handle to the locked position. The CANOPY warning light should go out. Next, rotate the lock handle to the unlocked position. The CANOPY warning light should come on. If the light does not work properly, you will have to fix the problem using the fault isolation manual.
4. Raise the canopy to the full up position using the internal canopy switch. Position the main power switch to OFF and disconnect the electrical power.

Follow-on maintenance

Install canopy panel 3434 on the backbone of the aircraft and perform an egress final inspection with a qualified egress 7-level inspector.

210. Rigging the canopy

If you are installing a new canopy on an F-16 or if you run into rigging problems with the canopy latches or actuator of a current canopy, you'll need to perform rigging procedures. You may also perform rigging after the install of a new canopy actuator.

Rigging procedures

To begin with, the canopy must be installed. These procedures can't be performed with a removed canopy. Also, perform these procedures inside a hangar, since canopy maintenance can't be performed when winds exceed 20 knots. Open the canopy fully using the external canopy switch. Remove the safety wire, screw, and the keeper from all 10 eccentric bolts (fig. 1–25). Set all 10 eccentric bolts to 60 degrees loose from nominal; install the keepers and screws finger tight. Make sure they're tight enough not to drop out and become foreign object damage (FOD). Last thing any egress personnel ever wants is to have a FOD job that they created.

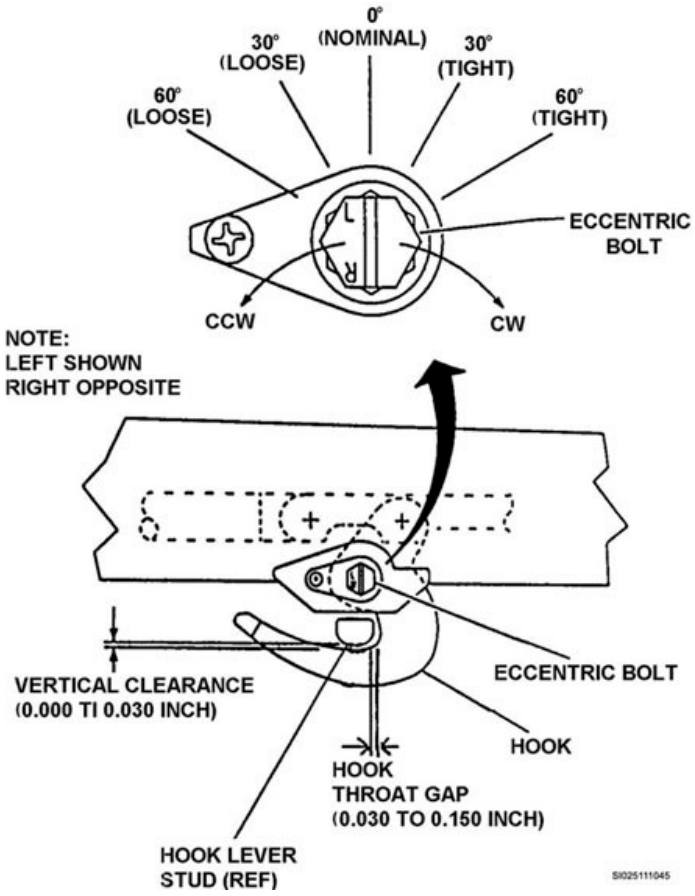


Figure 1–25. Eccentric bolt.

Check all 10 alignment pins and receptacles for wear not to exceed 0.050 inch. If an alignment pin is worn beyond 0.050 inch, it may be rotated 90 degrees to expose an unworn surface area and remain in use. If the pin has been rotated three times or the receptacle is worn beyond 0.050 inch, you'll have to remove and replace. Using the internal or external manual drive, lower the canopy fully and check for interference between alignment pins and receptacles. If the canopy alignment pin interference with the receptacle exceeds 0.050 inch, reshim alignment pin receptacles.

Reshimming alignment pin receptacles

Open the canopy using the internal canopy switch. When shimming, shim the aft four stations first; then shim the remaining six stations as required.

Remove two nuts and receptacle at the applicable location. Install shims as required to relieve the hook interference; install the receptacle and the two nuts. Torque the nuts to 20–40 inch pounds. You'll repeat these steps as required to obtain the measurement of a maximum 0.050 inch interference with the receptacle.

Hooks

Now, let's look at how to rig the hooks (fig. 1–26). To get to the forward hooks, you'll have to remove the right and left kick panels. You may have to remove aircraft components to access the hooks but if so, you need to ask the crew chiefs for assistance.

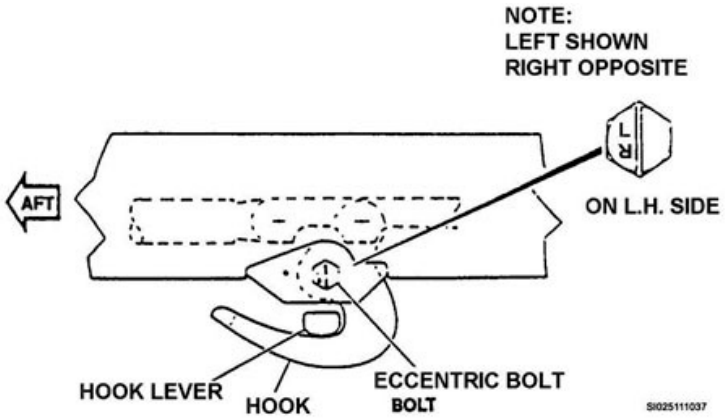


Figure 1–26. Canopy hook.

Close the canopy using the internal canopy switch until automatic shutoff. If the canopy latches make a grinding noise while the hooks are engaging the levers, a thin coat of lubricant shall be applied to contacting surfaces of all hooks.

Verify the vertical clearance of all 10 hooks is 0.000 to 0.030 inch between the hook and the hook lever stud. If clearance is greater than 0.030, perform the following hook rigging steps.

Open the canopy using the internal switch as required to gain access to the keepers and eccentric bolts. The keepers should already be set to 60 degrees loose from nominal. However, eccentric bolts should not be rotated more than 60 degrees in either direction. If the keepers are not installed and secured with a screw after each adjustment, the eccentric bolt will not retain position.

Tighten the hooks by adjusting the eccentric bolt one notch (30 degrees) at a time until the clearance comes to 0.030 or less. You may have to repeat these steps as required.

Close the canopy using the internal switch until automatic shutoff occurs and again check the hook vertical clearance to make sure your adjustments worked.

Hook throat gap

Next, verify the hook throat gap is 0.030 to 0.150 inch at all 10 hooks. To obtain hook throat gaps, adjust as many hooks as possible by increasing or decreasing hook rotation through adjustment of actuator rod end.

Cam and lock lug

Install or remove shims as required to obtain clearance of 0.040 to 0.080 inch between the cam and lock lug (fig. 1–27). A new screw shall be used each time an adjustment is made to the cam shims. If the correct gap cannot be obtained by shim adjustment, linkage travel shall be adjusted with rod end and corresponding levers moved as needed.

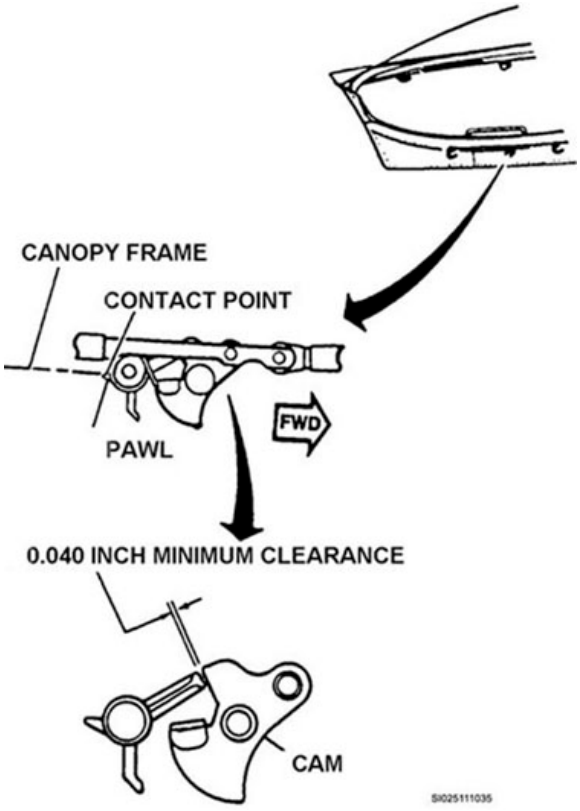


Figure 1–27. Cam.

Canopy actuator

Now we'll check the canopy actuator. Raise the canopy lock handle to up and unlocked position; then open the canopy using the internal canopy switch until the actuator automatically shuts off.

Verify that the canopy stops between 30 and 34 degrees and use the protractor for measurement. If the measurement is correct, you can move on. If not, perform the following steps: Install two canopy maintenance supports and remove the CARB. Using the internal switch, energize the actuator electrically to the fully retracted position (down) and allow the actuator to shut off automatically. If the actuator does not shut off automatically prior to contact with the closed mechanical stop, replace the actuator.

Verify that placing the internal switch in the down position does not reenergize the actuator motor. Remove safety wire from the rod end jam nut as required. Rotate the rod end to obtain a hook throat gap of 0.030 to 0.150 inch and maintain the canopy open angle of 30 to 34 degrees.

After that, manually crank the external manual drive to extend the actuator output ram so the CARB can be installed. During adjustment, the CARB shall be temporarily removed and re-installed. The canopy supports will be removed each time before lowering the canopy. Failure to comply may result in damage to equipment. Temporarily install the CARB, washer, and nut finger tight.

Remove the two maintenance supports and close the canopy using the internal canopy switch until the canopy is latched and the actuator shuts off automatically; lower the canopy lock handle to the down and locked position. Verify that the hook throat gap of 0.030 to 0.150 inch at each of the 10 hooks and that there is a 0.040 to 0.080 inch clearance between the canopy lock handle's cam and lock lug. If out of tolerance, you may have to construct the whole latch system using the aforementioned steps.

Using the internal canopy switch, partially lower the canopy; then raise the canopy until the actuator motor shuts off automatically. Use a protractor to verify that the canopy stops at the 30 to 34 degree

position. If out of tolerance, you'll have to go through all these steps again. If within tolerance, torque the jam nut on the rod end of the actuator 125–150 inch pounds and install safety wire.

Hook levers

If the canopy is not open, open the canopy using the internal canopy switch. Verify that the clearance between washers and each hook lever is 0.004 to 0.025 inch at all 10 hook levers. If the hook lever is out of tolerance, remove two nuts, washers, pin, bushings (if applicable), spring (if applicable) and the hook lever itself. Reposition the washers as required to obtain the correct hook throat gaps and install the hook lever, washers, pin, bushings (if applicable), spring (if applicable) and two nuts. Not all of the hook lever assemblies include bushings and a spring.

Check all 10 hooks for a 0.000 to 0.030 inch vertical clearance. With the canopy open, check all 10 hook levers for free forward and aft movement.

Follow-on maintenance

If the CARB is temp-installed, fully install the CARB. Verify that the lug on the pawl is contacting the underside of the canopy frame with the canopy open.

Tighten the screws on the keeper and install safety wire. Apply adhesive over the curled end of the safety wire. Reinstall any removed avionics components and reinstall the left and right kick panels.

Perform the CANOPY warning light check, and of course, perform an egress final inspection with a qualified 7-level inspector.

211. Troubleshooting canopies

As an egress journeyman assigned to an F-16 base, a good portion of your work will be troubleshooting problems with canopy systems. There are two subsystems where canopies can have problems, the mechanical system and the electrical system.

If you're troubleshooting the canopy mechanical or electrical subsystems, the best place to start is TO 1F-16( )-2-95FI-00-1, *Fault Isolation Organizational Maintenance Crew Escape and Safety System USAF Series F-16( ) and F-16( ) Aircraft*. This technical order will give you everything you need to troubleshoot the F-16 canopy. For the purposes of this CDC, we will only discuss two-seater F-16s.

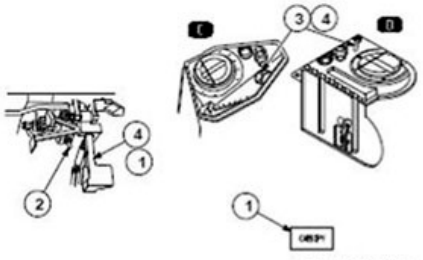
First, we'll look at how to use the technical order for troubleshooting. Then we'll discuss troubleshooting mechanical problems with the technical order and troubleshooting electrical problems with the technical order.

How to read the fault isolation manual

When reading the FI manual, the first place you need to look is the Fault Identification and Description Section (Section I). Find a description in the section that matches the fault discovered on the aircraft. For example, if the canopy warning light is on with the canopy down and the canopy lock handle verified down, you'll look at the description and find that the fault isolation is covered in "95–20–XD" (fig. 1–28).

Next, go to chapter 2, section IV, Fault Isolation Information. Look for the end of the fault code, which in this case is XD. It will appear in a box on the left-hand side of the fault isolation tree (see fig. 1–29). Now you'll follow the FI on the left side to isolate the fault. Then, you'll use the corrective actions on the right side to correct the fault.

SECTION I
FAULT IDENTIFICATION AND DESCRIPTION (95-20-00)



RH STRAKE DC PWR PNL:
1. CANOPY WARNING
2. CANOPY ACTUATOR
3. E PWR IND
4. BATT IND/PWR TEST

BATTERY CONTROL RELAY ASSY;
5. CANOPY CONTROL
6. CANOPY ACTUATOR

FAULT LOCATION	
C Aircraft Cockpit Only	01
Fwd Cockpit Only	02
Aft Cockpit Only	03
Both Fwd and Aft Cockpits	04
Not Applicable	00

PILOT DETECTABLE FAULTS

NOTE

- Canopy open/close malfunctions assume the aircraft battery is operating normally and is charged to operating voltage.
- For the faulty battery indications, refer to (FI24-30-00).
- Under extreme hot or cold weather conditions, expansion or contraction of the canopy transparency will cause a deflection of the canopy frame which may result in a change to the canopy rigging. To prevent functional problems in such conditions, it is recommended that the canopy latches/actuator be set with the aircraft in its operational environment.

1	CANOPY WARNING LIGHT ON WITH CANOPY DOWN AND CANOPY LOCK HANDLE VERIFIED DOWN CB-1	95-20-XD-_ _
2	CANOPY OPEN/CLOSE SWITCH (INTERNAL) POSITIONED EITHER UP OR DOWN AND CANOPY DID NOT MOVE CB-2 → CB-6	95-20-YD-00
3	EXTERNAL CANOPY SWITCH POSITIONED EITHER UP OR DOWN AND CANOPY DID NOT MOVE CB-2 → CB-6	95-20-YE-00
4	EXTERNAL CANOPY SWITCH POSITIONED EITHER UP OR DOWN WITH CANOPY LOCK HANDLE DOWN AND LOCKED AND CANOPY DID MOVE CB-2 → CB-6	95-20-YF-00

Figure 1–28. Fault identification and description.

TO 1F-16C-2-95FI-00-1

SECTION IV
FAULT ISOLATION INFORMATION (95-20-00)

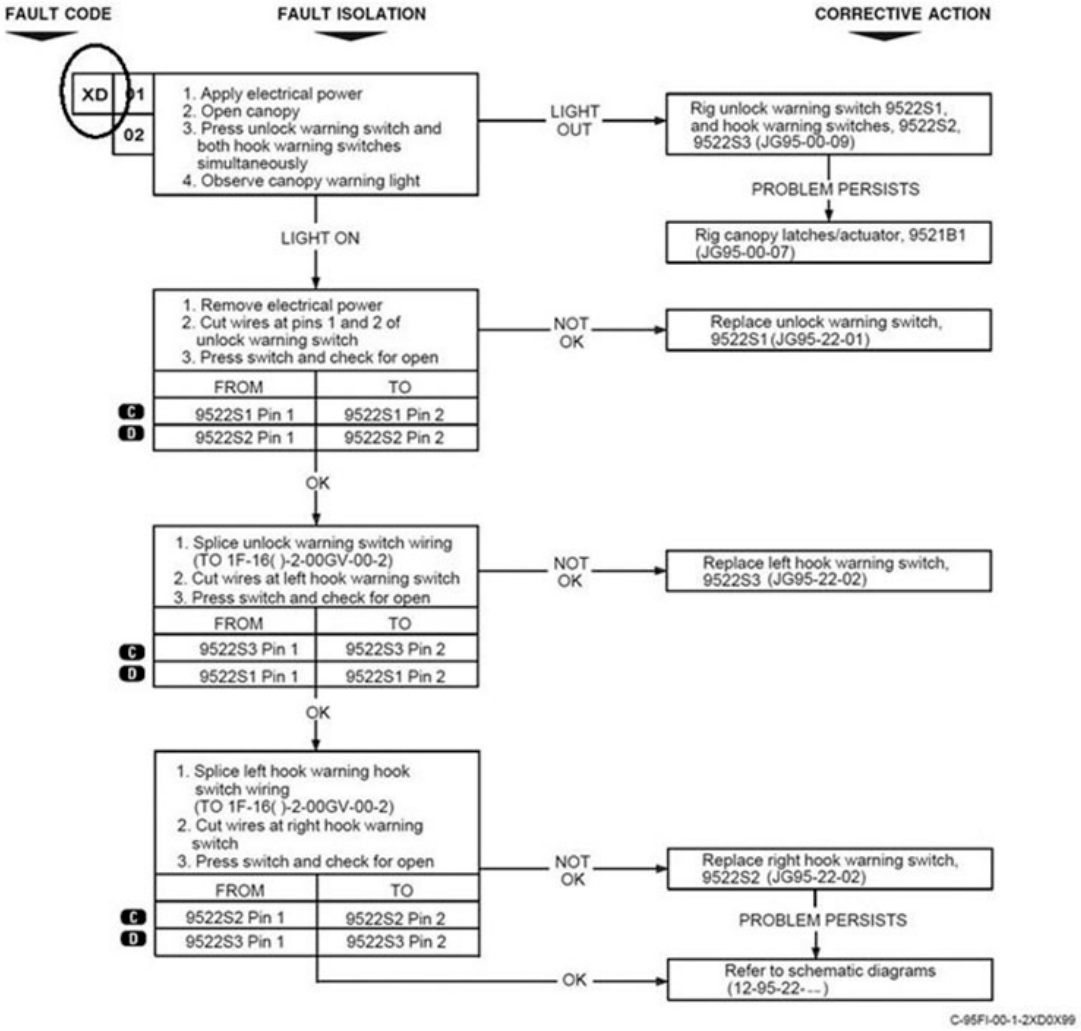


Figure 1–29. Fault isolation information.

Using the FI manual allows you to troubleshoot and fix the mechanical and electrical subsystems quickly and effectively. Just be aware that you'll have to call on electro-environmental when it comes to rewiring or replacing electrical components.

Mechanical subsystem troubleshooting

We discussed much of the mechanical subsystem troubleshooting procedures in the last lesson when we talked about rigging as the job guide for the canopy provides troubleshooting procedures right alongside the rigging procedures. However, the FI manual includes troubleshooting for the following:

- Canopy lock handle will not move to down position with canopy closed.
- Canopy manual drive assembly binds.
- Canopy manual drive handcrank did not engage and operate manual drive assembly.

Canopy lock handle will not move to down position with canopy closed

If the canopy lock handle will not move to the down position with the canopy closed, then the first step is to connect electrical power and position the main power switch to MAIN PWR. Next, lower the canopy to closed using the internal canopy switch. Rotate the canopy lock handle to the down position to verify the fault. Sometimes, pilots or crew chiefs might write up this fault and the only problem is that they did not let the canopy close all the way. If you can't duplicate the fault, document the forms as appropriate and return the aircraft to service.

If you are able to duplicate the fault, then re-rig the canopy latches and the actuator. If the problem persists, you'll have to replace the canopy actuator.

Canopy manual drive assembly binds

To isolate the fault if the canopy manual drive assembly binds, you'll need to first disconnect the flexible shaft from the canopy actuator. Then you'll rotate the manual drive handcrank and check for binding. If there is no binding when the shaft is disconnected, that means the problem is with the canopy actuator and you will need to replace it. If the flexible shaft binds when it is disconnected, then the problem is with the flexible shaft. Pull out the core of the flexible shaft and inspect for kinks, bends, twists or other defects. If you find defects on the flexible shaft, then replace the flexible shaft.

If you find no defects on the flexible shaft, then the problem is with the canopy manual drive assembly. You will need to replace the canopy manual drive assembly.

Canopy manual drive handcrank did not engage and operate manual drive assembly

If the canopy manual drive handcrank did not engage and operate the manual drive assembly, you need to check that this is an actual fault. Depress the manual drive handcrank to engage the manual drive and rotate the manual drive handcrank and check the canopy for movement. If the handcrank operates properly, document the aircraft forms and return the aircraft to service. If the handcrank does not operate properly, you will need to replace the canopy manual drive assembly.

Electrical subsystem troubleshooting

The FI manual contains several fault isolation trees for various faults, but for the purposes of this CDC, we'll look at the following electrical faults:

- Canopy warning light on with canopy down and canopy lock handle verified down.
- Canopy internal open/close switch positioned either up or down and canopy did not move.
- Canopy actuator motor continues to operate with canopy closed, hooks latched and internal or external switch in close position.

Canopy warning light on with canopy down and canopy lock handle verified down

If the canopy warning light comes on with the canopy down and the canopy lock handle verified down, the first thing you need to do is apply electrical power, then open the canopy. Manually press the unlock warning switch and both hook warning switches simultaneously while observing the

canopy warning light (fig. 1–30). If the light goes out, rig the unlock warning switch and the hook warning switches. The switches work; they are just not making contact with the canopy lock handle and canopy hooks properly. If the problem persists, you may need to rig the canopy latches and actuator.

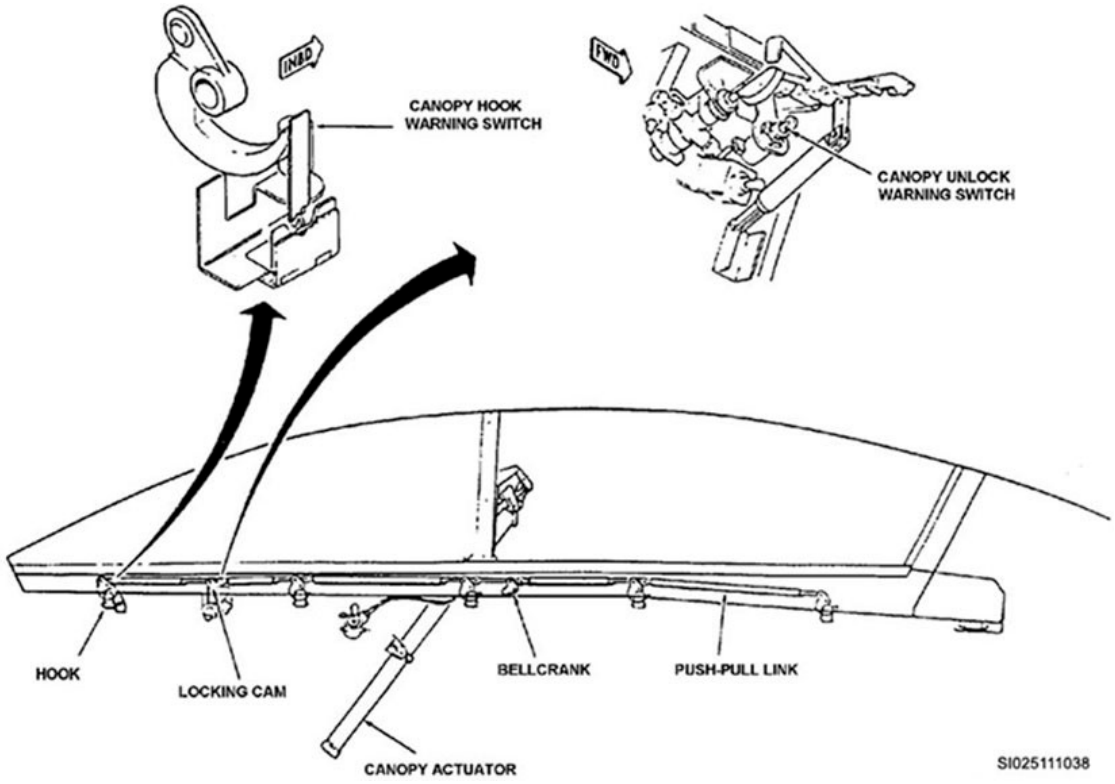


Figure 1–30. Warning switches.

If the light stays on when you press the switches simultaneously, you'll have to get electro-environmental personnel involved for further fault isolation. They will assist by checking and possibly replacing the unlock warning switch and the hook warning switches. If the problem continues to persist after that, you and electro-environmental will have to refer to the schematic diagrams to get deeper into the wiring to fix the problem.

Canopy internal open/close switch positioned either up or down and canopy did not move

The first thing to do if the canopy internal open/close switch is in either the up or down position and the canopy will not open, apply the external electrical power and actuate the external canopy switch to up or down. If the canopy opens or closes, then there is a problem with the internal canopy switch. Your corrective action is to replace it. If the canopy does not open or close by actuating the external canopy switch, remove external electrical power and have electro-environmental troubleshoot the canopy actuator's electrical connector. An electro-environmental technician will troubleshoot the areas in between the external canopy switch and the canopy actuator. If nothing else works and the pins are okay on the canopy actuator that means you will have to replace the canopy actuator.

Canopy actuator motor continues to operate with canopy closed, hooks latched, and internal or external switch in close position

If the canopy actuator motor continues to operate with the canopy closed, hooks latched, and the internal or external switch is in the closed position, connect the electrical power and position the main power switch to MAIN PWR. Using the internal or external canopy switch, lower the canopy to the closed position. With the canopy closed, hooks latched and the switch in the closed position, verify that the actuator motor does not continue to operate. Sometimes, the fault is just operator error, and if

you check it out and you cannot duplicate the problem, simply return the aircraft to service and document in the forms that you could not duplicate. If the motor does continue to operate, re-rig the canopy latches and the actuator. If that still doesn't work, you'll need to replace the actuator.

Self-Test Questions

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

206. Component description

1. Match the F-16 canopy jettison system description listed in column B with its component in column A by writing the correct letter in the blank space provided. Descriptions in column B may be used only once.

Column A	*Column B*
___ (1) Detonation transfer assembly.	a. Fires M99 initiators.
___ (2) Emergency canopy release line.	b. Secures upper end of canopy actuator.
___ (3) Canopy actuator release bolt.	c. Transfers detonation from initiators.
___ (4) Canopy remover rocket.	d. Jettisons canopy without ejecting seats.
___ (5) Canopy/seat interlock lanyard assembly.	e. Propels canopy clear of the aircraft.
___ (6) External canopy jettison handle.	f. Tee shaped.
___ (7) Internal canopy jettison handle.	g. D-ring type.
___ (8) Canopy jettison initiator.	h. Breaks frangible bolts.

2. How do the emergency canopy release lines work during canopy jettison?

207. Theory of operation

1. What is the sequence of events when canopy jettison is initiated by pulling either ejection control handle?

2. What is the sequence of events when canopy jettison is initiated by pulling either the internal or external canopy jettison handles?

208. Removing the canopy

1. What aircraft panels must be removed prior to removing the canopy?

2. What support equipment do you need when removing the canopy?

3. Who will determine if jacks are required under the aft fuselage during a canopy removal?

4. When can you use power tools on the external manual drive to open or close the canopy?

5. During canopy removal, when do you remove the CARB?

6. What should you do with the upper and lower bearings if they don't have freedom of rotation when you're removing the canopy?

209. Installing the canopy

1. How many personnel are *required* to install the F-16 canopy?

2. What support equipment is required for an F-16 canopy installation?

3. Where do you position the hoist when installing the F-16 canopy?

4. Where do you position the aft seat during canopy installation?

5. How many threads should protrude from the canopy nutplate when the sling adapter attach bolts are installed?

6. Explain the "adjust and try" method of installing canopy keepers.

7. After you've removed the maintenance supports, why do you lower the canopy slowly to the full down position then raise the canopy to the full up position using the external manual drive?

8. When you install the canopy tension tube links, which way should the lower part of the "V" pattern point?

9. How much of a gap is allowable between the roller bearings and the canopy hinge track?

10. What are the steps for performing the canopy warning light operational checkout?

210. Rigging the canopy

1. During what wind conditions must you cease canopy maintenance outside?

2. If you discover that a canopy alignment pin's wear exceeds 0.050 inch, how do you correct the deficiency?

3. How do you shim alignment pin receptacles?

4. How do you rig the canopy hooks?

5. Most aircraft canopy hardware can be retained and reused; what about when an adjustment is made to the cam shims?

6. You're using the internal canopy switch to check actuator rigging. How high should it rise before the actuator automatically shuts off?

7. To how many inch pounds is the jam nut on the rod end of the canopy actuator torqued?

8. What is the clearance between the washers and each canopy hook lever?

211. Troubleshooting canopies

1. What is the best place to start when troubleshooting F-16 canopy mechanical or electrical subsystems?

2. In the FI manual, where do you look to find a description that matches the fault discovered on the aircraft?

3. What's the first step when troubleshooting a canopy lock handle that will not move to the down position with the canopy closed?

4. If the canopy manual drive assembly is binding but binding does not occur when you disconnect the flexible shaft from the canopy actuator, what is likely the cause of the binding?

5. If the canopy warning light comes on with the canopy down and the canopy lock handle verified down, and you've already checked that the light stays on when you press the unlock warning switch, and the two hook warning switches simultaneously, what is your next step?

6. If the canopy internal open/close switch does not operate the canopy actuator, but the external canopy switch does operate the canopy actuator, what corrective action should you take?

7. What corrective action should you take when the canopy actuator continues to operate with the canopy closed, hooks latched, and the internal or external switch is in the close position?

Answers to Self-Test Questions

201

1. (1) c.
   (2) f.
   (3) a.
   (4) e.
   (5) b.
   (6) g.
   (7) d.
2. Gas flows immediately through the already shuttled sequence valve and then to the seat rocket catapult.

202

1. Canopy jettison and seat ejection.
2. Gas from each of the two M53 initiators shuttles the sequence valve and fires the DTA initiator that is also mounted on the sequence valve.
3. A 0.33-second delay.
4. NORMAL, AFT, and SOLO.
5. As the canopy leaves the aircraft, two interlock lanyards fire two M99 initiators. Gas from these initiators flows through a sequence valve and through the valve-to-valve interconnect and then fires 0.33-second delay initiators. Gas from a 0.33-second delay initiator fires a 0.40-second delay initiator, flows through the selector valve, and fires an M53 initiator. Gas from that M53 initiator fires the aft seat catapult and backfires a 0.33-second delay initiator.
6. Gas from two aft seat ejection initiators fires two M53 initiators and fills the hot gas line up to another M53 initiator. Gas from the right-hand initiator also fires the aft seat inertia reel gas generator which then provides gas to function the inertia reel. Gas from the first two M53 initiators shuttles sequence valves and fires two DTA initiators, thereby initiating the canopy jettison system.
7. Shuttle the forward sequence valves when the AFT seat initiates ejection in AFT mode.
8. Neither forward sequence valve DTA initiator fires because they have already been backfired.
9. Gas from the 0.33-second delay initiator flows through the selector valve, fires an M53 initiator, and backfires a 0.40-second delay initiator. Gas from a 0.33-second delay initiator fires an M53 initiator which sends gas pressure through the sequence valve and fires a 1.00-second delay initiator. Gas from the first M53 initiator in this chain flows through the sequence valve, firing the forward seat catapult and backfires the 1.00-second delay initiator.

203

1. It is not worth taking the risk of damaging a DTA line due to the extra down time it would take to submit an emergency requisition for a replacement part.
2. Using the wrong-sized wrench or an adjustable wrench may round out the flats on the DTA nut, making it hard to properly torque during installation.
3. Cap DTA tips and plug DTA ports.
4. Wait until right before you need to install the DTA nuts before you remove the caps and plugs, or if you have to route them and it's easier to route them without the caps installed, put them back on when done routing so you can protect the tips.
5. Insert the ferrule freely through the port threads to rest firmly against the bottom of the port and install the nut by hand to firmly seat against the ferrule. Connect the DTA line to the connector by installing the nut.
6. Prevent twisting by using a wrench on flats provided behind the DTA nut.
7. Standard ends of all type DTAs have a 0.064 inch maximum and a 0.010 inch minimum measurement. Tipless ends of type ST DTA have a 0.057 inch maximum and a 0.010 inch minimum measurement.

204

1. R or STR.
2. Cross-reference sheet in the –95JG–00–1 job guide.
3. Check by inserting the DTA into the inspection gage with the ferrule resting firmly against the inside flange of the inspection gage and install the nut by hand to firmly seat it against the ferrule.
4. If the DTA tip is the correct length, the –25 gage will not rest simultaneously on both shoulders of the –31, –33, or –35 gage.
5. Check the DTA tip for straightness by inserting the –25 inspection gage into the top of the inspection gage containing the DTA and verifying the –25 inspection gage rotates completely around the tip without excessive friction.
6. Check the port dimensions by screwing the inspection gage into the port by hand until the inspection gage rests firmly against the bottom of the port.
7. Check the maximum port depth by verifying that a 0.049 inch feeler gage (provided with the set) fits between inspection gage and surface of connector or explosive device. The measurement verified in this step applies to connectors or explosive devices other than the CARB. To check the maximum port depth of the CARB, verify that a 0.014-inch feeler gage (provided with the set) fits between the inspection gage and the surface of the CARB.
8. Check the maximum port depth by verifying a 0.032-inch feeler gage (provided with the set) fits between the inspection gage and the surface of the connector or the explosive device.
9. Verify that cuts or gaps do not occur at the DTA attachment point and do not occur at points at which the DTA line will be in contact with bare, unpainted metal parts in the aircraft. If the outer jacket is damaged to the extent that the metal sheath is visible, follow criteria in the tech data.
10. If the DTA nut shows that the threads are not completely coated with a light coat of solid film lubricant, then slide the DTA nut back from the tip and apply a thin film of grease to the threads with a cotton swab. DO NOT allow grease to come in contact with the DTA tip. Remove excess grease with clean cheesecloth. Then inspect the seal and the DTA tip for grease and wipe with clean cheesecloth if grease is present.

205

1. Ejection seat arm-safe ejection control safety handle and switch checkout; ejection seat height adjustment switch checkout; and flight control memory checkout.
2. A 15-minute cool-down.
3. The handle should move freely down and the SEAT NOT ARMED light should go out.
4. Lap belts and G-suit and oxygen hoses.
5. The seat should rise to the full up position and stop.

206

1. (1) c.
   (2) h.

(3) b.

(4) e.

(5) a.

(6) g.

(7) f.

(8) d.

2. When the ECRL is detonated at either end, the explosive-filled cord inside the ECRL detonates throughout its length. This causes the outer housing to expand at the points at which it's in contact with the lever support fitting. The expanding housing breaks two frangible bolts that attach the lever retainer to the lever support fitting and pushes the retainer away from the hook lever. This allows the lever to pivot about its mounting pin and free the canopy hook from its engagement with the lever.

207

1. The ejection control handle, located in the center of the forward edge of the seat bucket, automatically actuates the canopy jettison sequence at the beginning of the escape sequence. When the system is fired by the two ejection initiators, hot gas travels to fire M53 instantaneous hot gas initiators, which in turn, send hot gas through sequence valves to fire the DTA initiators. The DTA initiators fire the ECRLs which expand at each of the canopy latch fittings, breaking the frangible latch lever retainer bolts, thereby detaching the latch retainers and allowing the latch levers to pivot out of the path of the canopy hooks. Simultaneously, the DTAs fire the CARB and then the canopy remover rockets. As the rockets rotate the canopy back past 41 degrees, the canopy hinges are disengaged and the canopy is propelled away from the aircraft.
2. Independent of seat ejection, canopy jettison can be accomplished by pulling either of the two internal canopy jettison handles by the crewmembers or either of the two external canopy jettison handles by ground crews outside the aircraft. This actuates one of the four manually operated canopy jettison initiators. In this case, when the exiting canopy actuates the canopy interlock system, the hot gas from the M99 will shuttle the sequence valve spools to the opposite end of the valve bodies and prevents any flow of gas to the seat rocket catapults. Seat ejection can be accomplished subsequently by pulling the ejection control handle.

208

1. Panels 2415, 2416, and 3434.
2. Two canopy maintenance supports; canopy transport/maintenance fixture; crane; a maintenance platform; and canopy sling assembly.
3. Qualified weight and balance personnel.
4. Never.
5. Once you have securely taped the tension tube links.
6. Replace them.

209

1. Three.
2. Two canopy maintenance supports; a canopy rigging protractor; a canopy transport or maintenance fixture; a crane; the DTA and ECRL inspection gage set; a generator set; a maintenance platform; and a canopy sling assembly; and a torque wrench.
3. Directly over the aircraft centerline.
4. The full-down position.
5. Two.
6. Install the keeper on the splined adjusting bolt so that the securing bolt can be installed when the keeper has been torque. Using wrench flats, torque the keeper 50–150 inch pounds. Secure the keeper by installing the bolt, washer, and nut in one of the three holes in the keeper. Install the washer and nut, and torque the nut 60–110 inch pounds and install the cotter pin. You'll duplicate these steps on each side of the aircraft. Check both roller bearings for engagement with the track. No gap should exist. If a gap exists, you'll have to repeat the steps.
7. To make sure everything is working properly.
8. Forward and not backward.

9. No gap.
10. (1) Connect electrical power, position main power switch to MAIN PWR. (2) Lower canopy to full down position using internal canopy switch. (3) Rotate lock handle to locked position. Check that the CANOPY warning light went out. Rotate lock handle to unlocked position. Check that the CANOPY warning light came on. (4) Raise canopy to full up position with internal canopy switch. Position the main power switch to OFF and disconnect electrical power.

210

1. When winds exceed 20 knots.
2. Rotate pin 90 degrees to expose unworn surface area. If the pin has been rotated three times or the receptacle is worn beyond 0.050 inch, you'll have to remove and replace it.
3. Remove two nuts and receptacle at the applicable location. Install shims as required to relieve the hook interference; install the receptacle and the two nuts. Torque the nuts 20–40 inch pounds. You'll repeat these steps as required to obtain the measurement of a maximum 0.050 inch interference with the receptacle.
4. Open the canopy using the internal switch as required to gain access to the keepers and eccentric bolts. The keepers should already be set to 60 degrees loose from nominal. However, eccentric bolts should not be rotated more than 60 degrees in either direction. If the keepers are not installed and secured with a screw after each adjustment, the eccentric bolt will not retain position. Tighten the hooks by adjusting the eccentric bolt one notch (30 degrees) at a time until the clearance comes to 0.030 or less. You may have to repeat these steps as required. Close the canopy using the internal switch until automatic shutoff occurs and again check the hook vertical clearance to make sure your adjustments worked.
5. Use a new screw each time.
6. The canopy should stop between 30 and 34 degrees using a protractor for measurement.
7. 125–150 inch pounds.
8. 0.004 to 0.025 inch at all 10 hook levers.

211

1. TO 1F–16( )–2–95FI–00–1.
2. The fault identification and description section, Section I.
3. Verify the fault by connecting electrical power and position the main power switch to MAIN PWR. Lower the canopy to closed using the internal canopy switch. Rotate the canopy lock hand to the down position.
4. The canopy actuator is faulty and you will need to replace it.
5. Get electro-environmental to further fault isolate the unlock warning switch and the hook warning switches. If the problem continues to persist, you and electro-environmental will have to troubleshoot the wiring using the schematic diagrams.
6. Replace the internal canopy switch.
7. If you've verified the fault and the motor does continue to operate, re-rig the canopy latches and the actuator. If that doesn't correct the fault, you'll need to replace the actuator.

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

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

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

1. (201) What are the modes of ejection available for an F-16 dual seat aircraft?
   a. FWD, SOLO, and AFT.
   b. NORM, FWD, and AFT.
   c. NORM, SOLO, and AFT.
   d. NORM, SOLO and FWD.

2. (201) What F-16 escape system component keeps the pressure of the gas in the escape system at an acceptably high level?
   a. M53 initiators.
   b. M99 initiators.
   c. Time delay initiators.
   d. Canopy actuator release bolt (CARB).

3. (202) Which dual seat F-16 explosive component fires each seat's inertia reel initiator?
   a. The left-side JAU–8/A25 ejection control initiator.
   b. The right-side JAU–8/A25 ejection control initiator.
   c. A gas-shielded mild detonating cord (SMDC) initiator.
   d. A shielded mild detonating cord (SMDC)-gas initiator.

4. (202) During a dual seat F-16 ejection when the ejection mode selector valve is set in *aft mode* and the *aft* seat ejection handle is pulled, what explosive component is specifically designed to provide an automatic sequence to eject the forward seat?
   a. A JAU–8/A25 initiator.
   b. A catapult initiator.
   c. An M99 initiator.
   d. An M53 initiator.

5. (203) What type of energy transfer line does the F-16 emergency escape sequencing system use?
   a. Electronic wiring harness.
   b. Flexible linear shaped charge (FLSC).
   c. Shielded mild detonating cord (SMDC).
   d. Detonation transfer assembly (DTA).

6. (203) What tool should you always use to remove the safety wire from a detonation transfer assembly (DTA)?
   a. Slip-joint pliers.
   b. Flat-nosed pliers.
   c. Diagonal cutting pliers.
   d. Lineman's side cutting pliers.

7. (203) If detonation transfer assembly (DTA) line threads are *not coated* with a light coat of solid film lubricant, lubricate them by sliding the nut back from the tip and
   a. spraying a thin film of solid film lubricant on the nut threads.
   b. applying a thin film of grease to the nut threads with a cotton swab.
   c. applying a thin film of torque stripe to the nut threads with a cotton swab.
   d. applying a thin film of anti-seize compound to the nut threads with a cotton swab.

8. (203) To how many inch-pounds should you torque detonation transfer assembly (DTA) nuts?
   a. 15–20.
   b. 30–40.
   c. 50–70.
   d. 110–120.

9. (204) What types of detonation transfer assembly (DTA) lines contain a primary explosive that may be detonated by impact, shock, abrasion or excessive heat?
   a. Standard (S) or confined (C) types.
   b. Donor (D) or standard shielded (SS) types.
   c. Shock tube (STD) or flexible confined (FC) types.
   d. Receptor (R) or shock tube receptor (STR) types.

10. (204) Using the detonation transfer assembly (DTA) and emergency canopy release line (ECRL) inspection gage set, how do you check the DTA *minimum* tip length?
    a. Insert the –25 inspection gage into the top of the inspection gage containing the DTA.
    b. Position the –25 inspection gage on the upper surface of the inspection gage containing the DTA.
    c. Position the –25 inspection gage across lower surfaces of the inspection gage containing the DTA.
    d. Insert the DTA into the inspection gage with the ferrule resting firmly against the inside flange of the inspection gage.

11. (204) How many broken strands are allowable on wire braid outer coverings of flexible detonation transfer assembly (DTA) lines?
    a. No more than one broken strand per 12-inch section or more than three broken strands total.
    b. No more than three broken strands per 12-inch section or more than six broken strands total.
    c. No more than one broken strand per 10-inch section or more than three broken strands total.
    d. No more than three broken strands per 10-inch section or more than six broken strands total.

12. (205) When performing the operational checkout of the ejection seat arm-safe ejection control handle and switch on an F-16, when you place the ejection control safety handle in the EJECTION CONTROLS LOCKED position the handle should move freely and the
    a. SEAT NOT ARMED light should come on.
    b. CANOPY warning light should come on.
    c. SEAT NOT ARMED light should go out.
    d. CANOPY warning light should go out.

13. (205) While performing the operational check of the F-16 seat height adjustment switch, when you position the seat height adjustment switch to the UP position and release the switch, the seat should
    a. start up and stop and the switch should return to the center position.
    b. rise to the full up position and the switch should lock in the up position.
    c. rise to the full up position and the switch should return to the center position.
    d. lower to the full down position and the switch should return to the center position.

14. (206) Where is the F-16’s emergency canopy release line (ECRL) located?
    a. Under the canopy actuator.
    b. On each side of the cockpit.
    c. On each side of the canopy.
    d. Forward of the canopy frame.

15. (206) What F-16 canopy jettison explosive component releases the canopy from the canopy actuator?
    a. Frangible bolt.
    b. Canopy remover rocket.
    c. Canopy actuator release bolt (CARB).
    d. Emergency canopy release line (ECRL).

16. (206) F-16 canopy remover rockets are initiated by
    a. gas-actuated cartridges.
    b. electrically-actuated cartridges.
    c. mechanically-actuated cartridges.
    d. the detonation transfer assembly (DTA).

17. (207) During dual-seat F-16 canopy jettison during seat ejection, the detonation transfer assembly (DTA) initiators are fired by hot gas from the
    a. M53 initiators through the sequence valves.
    b. M99 initiators through the sequence valves.
    c. ejection initiators through the sequence valves.
    d. canopy jettison initiators through the sequence valves.

18. (207) How many canopy jettison initiators are installed on a *dual* seat F-16?
    a. 1.
    b. 2.
    c. 3.
    d. 4.

19. (208) When performing a dual-seat F-16 canopy removal, Technician C's job is to
    a. assist in removal of the canopy and operate the hoist.
    b. perform removal of the canopy from inside the aircraft.
    c. direct removal of the canopy from either side of the aircraft.
    d. perform removal of the canopy from either side of the aircraft.

20. (208) You should cease F-16 canopy maintenance if wind speed exceeds how many knots?
    a. 5.
    b. 10.
    c. 15.
    d. 20.

21. (208) When performing a dual-seat F-16 canopy removal, you should fully open the canopy prior to installing the two canopy maintenance supports using the
    a. internal canopy switch.
    b. external canopy switch.
    c. internal manual drive handcrank.
    d. external manual drive receptacle.

22. (208) *During* F-16 canopy removal, you should check that
    a. access panels 2415 and 2416 do not bind against the fuselage.
    b. the upper and lower roller bearings have freedom of rotation.
    c. both sides of the canopy hinge track engage the roller bearings.
    d. the lower roller bearing contacts the canopy track with no rotation.

23. (209) *After* the F-16 canopy is installed, you should check that
    a. the upper and lower roller bearings have freedom of rotation.
    b. access panels 2415 and 2416 do not bind against the fuselage.
    c. both sides of the canopy hinge track engage the roller bearings.
    d. the lower roller bearing contacts the canopy track with no rotation.

24. (209) When you install the tension tubes on a dual-seat F-16 during canopy installation, what pattern should they form with the canopy in the full up position?
    a. V pattern with the lower point of the V pointing forward and the upper connection points of the V pointing aft.
    b. V pattern with the lower point of the V pointing aft and the upper connection points of the V pointing forward.
    c. W pattern with the lower point of the W pointing forward and the upper connection points of the W pointing aft.
    d. W pattern with the lower point of the W pointing aft and the upper connection points of the W pointing forward.

25. (209) When installing a dual-seat F-16 canopy, you stop lowering the canopy *before* you install the keeper when the protractor reflects the canopy angle with the longeron at approximately how many degrees?
    a. 27.
    b. 35.
    c. 41.
    d. 47.

26. (210) When rigging a dual-seat F-16 canopy actuator, what should the canopy lock handle's cam and lock lug measure?
    a. 0.040 to 0.080 inch.
    b. 0.030 to 0.150 inch.
    c. 0.004 to 0.025 inch.
    d. 0.000 to 0.030 inch.

27. (211) When using the fault isolation (FI) manual to troubleshoot an F-16, which section in Chapter 2 would you find the fault isolation tree?
    a. Section III, Log Book Report.
    b. Section V, Supplemental Data.
    c. Section IV, Fault Isolation Information.
    d. Section I, Fault Identification and Description.

28. (211) When troubleshooting an F-16 canopy system, if you have verified that the canopy manual drive hand crank does not engage and operate the manual drive assembly, your *only* course of action is to replace the
    a. canopy actuator.
    b. canopy unlock handle.
    c. unlock warning switch.
    d. canopy manual drive assembly.

29. (211) When troubleshooting an F-16 canopy system, if the canopy warning light stays on with the canopy down and the canopy lock handle is verified down, but manually pressing the unlock warning switch and both hook warning switches simultaneously causes the light to go out, the *first* step you take to correct the problem is to rig the
    a. actuator.
    b. switches.
    c. warning light.
    d. canopy latches.

Unit 2. F-15 Egress System

THE F-15 EAGLE is an all-weather, extremely maneuverable, tactical fighter designed to permit the Air Force to gain and maintain air supremacy over the battlefield. The Eagle's air superiority is achieved through a mixture of unprecedented maneuverability and acceleration, range, weapons, and avionics. It can penetrate enemy defense and outperform and outfight any current enemy aircraft. The F-15 has electronic systems and weaponry to detect, acquire, track, and attack enemy aircraft while operating in friendly or enemy-controlled airspace. The weapons and flight-control systems are designed so one person can safely and effectively perform air-to-air combat.

The F-15E Strike Eagle is a dual-role fighter designed to perform air-to-air and air-to-ground missions. An array of avionics and electronics systems gives the F-15E the capability to fight at low altitude, day or night, and in all weather. The aircraft uses two crewmembers, a pilot and a weapon systems officer. The F-15E has the capability to fight its way to a target over long ranges, destroy enemy ground positions and fight its way out. Previous models of the F-15 are assigned air-to-air roles only.

In this unit we'll present the F-15 egress system. It's composed of a hydraulically-actuated canopy system, a shielded mild detonating cord (SMDC) jettison system, and the Advanced Concept Ejection Seat (ACES) II which we covered in the first unit. We'll begin our discussion by looking at the escape system.

2–1. Escape System

For the purposes of this course, we will be covering the two-seat F-15E escape system so that we can look at how a more complex aircraft ejection system operates.

212. System description

Emergency escape from the aircraft is provided by a jettisonable canopy, an ACES II ejection seat, and an emergency escape sequencing system. Actuation of either ejection seat or ejection control handle starts the escape sequence.

The emergency escape sequencing system fires the canopy remover to jettison the canopy and then provides correct sequence to allow pilot and rear crewmember to safely escape from the aircraft. There are three modes of operation:

1. NORM.
2. SOLO.
3. AFT INITIATE.

The mode of operation is selected by an EJECT MODE selector in the rear cockpit (fig. 2–1).

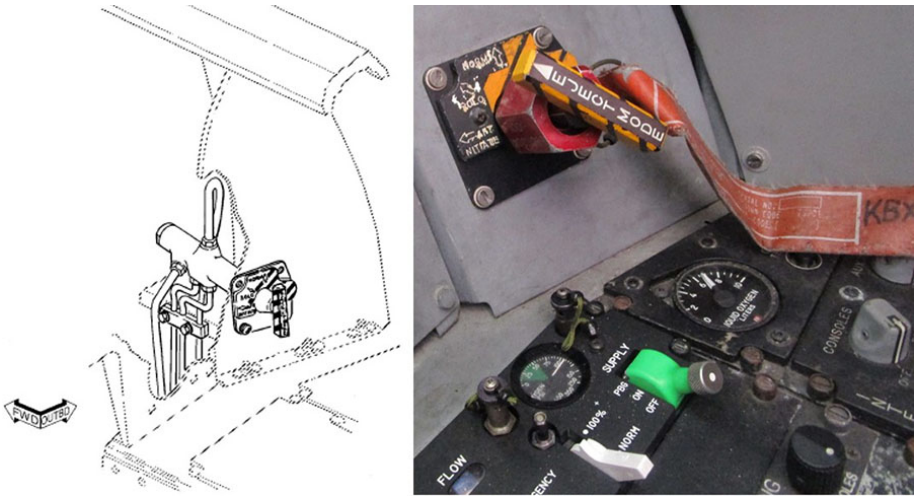


Figure 2–1. F-15E canopy mode selector.

NORM mode

In NORM mode, both seats eject when the escape sequence is started from the front cockpit, but only the rear seat is ejected if the escape sequence is started from the rear cockpit. When the escape sequence has been initiated from the rear cockpit in the NORM mode, the front seat ejects only when the front seat ejection control handle is pulled.

SOLO mode

SOLO mode is for flight with the rear cockpit unoccupied and only the front seat ejects when the escape sequence starts.

AFT INITIATE mode

In AFT INITIATE mode, both seats eject when the escape sequence is started from either cockpit.

Sequence of operation

The sequence of operation, *except* for in the SOLO mode, is:

- Canopy jettison.
- Rear seat ejection.
- Front seat ejection.

A 0.400-second delay between canopy jettison and rear seat ejection allows time for the canopy to clear the ejection seat path. If a dual ejection has been started, the front seat will eject 0.400 after rear seat ejection. If the rear seat has previously ejected in the NORM mode, the 0.400-second delay is automatically bypassed to allow the front seat to eject in minimum time. In SOLO mode, the sequence of operation is the same except that the rear seat will not eject and the 0.400-second delay is bypassed.

Emergency canopy jettison

Emergency canopy jettison without ejection of either seat is also provided for by the emergency escape sequencing system. A CANOPY-EMERG JETT initiator in each cockpit or an external jettison initiator as seen in figure 2–2 will start the emergency canopy jettison sequence when actuated. If the escape sequence is started after the canopy jettisons, the ejection sequence of the seats is the same as previously described for each mode of operation.

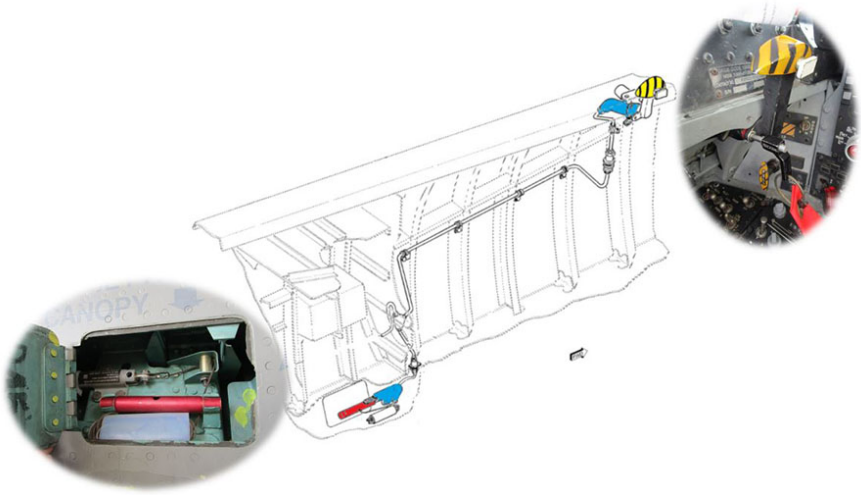


Figure 2–2. F-15E internal and external jettison handles.

Canopy

The canopy is a clamshell type consisting of formed, transparent plastic mounted in a metal frame. On each side of the frame are five latches and a lock roller that lock the canopy in the closed position. A guide pin on each lower corner of the forward canopy arch aligns the canopy with the windshield arch as the canopy moves forward when closing. A jettison mechanism on the cross frame at the center of the canopy provides a contact point and leverage for the canopy remover to jettison the canopy. An inflatable seal installed around the entire frame seals the canopy to fuselage mating surfaces to allow the cockpits to be pressurized. Bulb-type seals installed on the canopy and fuselage prevent entry of water into the cockpits when the inflatable seal deflates.

Refer to figure 2–3 as we cover canopy operation. A hydraulic actuator operates the canopy using hydraulic power from the utility hydraulic system. A nitrogen/hydraulic accumulator, located in door 12, provides power for at least one full cycle of canopy operation if utility hydraulic power is not available. A nitrogen chamber in the canopy actuator supplies pressure to the extend side of the canopy actuator piston to open the canopy if the accumulator is depleted. A hand pump in the nose wheel-well closes the canopy if utility hydraulic power is not available and the accumulator is depleted. A hydraulic filler and pressurization unit may be used to provide hydraulic pressure through a quick disconnect.

Two internal CANOPY CONTROL handles and an external CANOPY CONTROL HANDLE control operation of the canopy. One CANOPY CONTROL handle is located in each cockpit under the right canopy sill. The external CANOPY CONTROL HANDLE is located on the left side of the aircraft just below the canopy sill and is stowed in a cutout in the aircraft skin. A release button on the external CANOPY CONTROL HANDLE when pressed will release the handle and allow it to spring outboard. The control handles can be set in any of four positions:

1. LOCKED.
2. DN.
3. HOLD.
4. UP.

Teleflex cables interconnect the control handles, the canopy locking mechanism, and the canopy control valve.

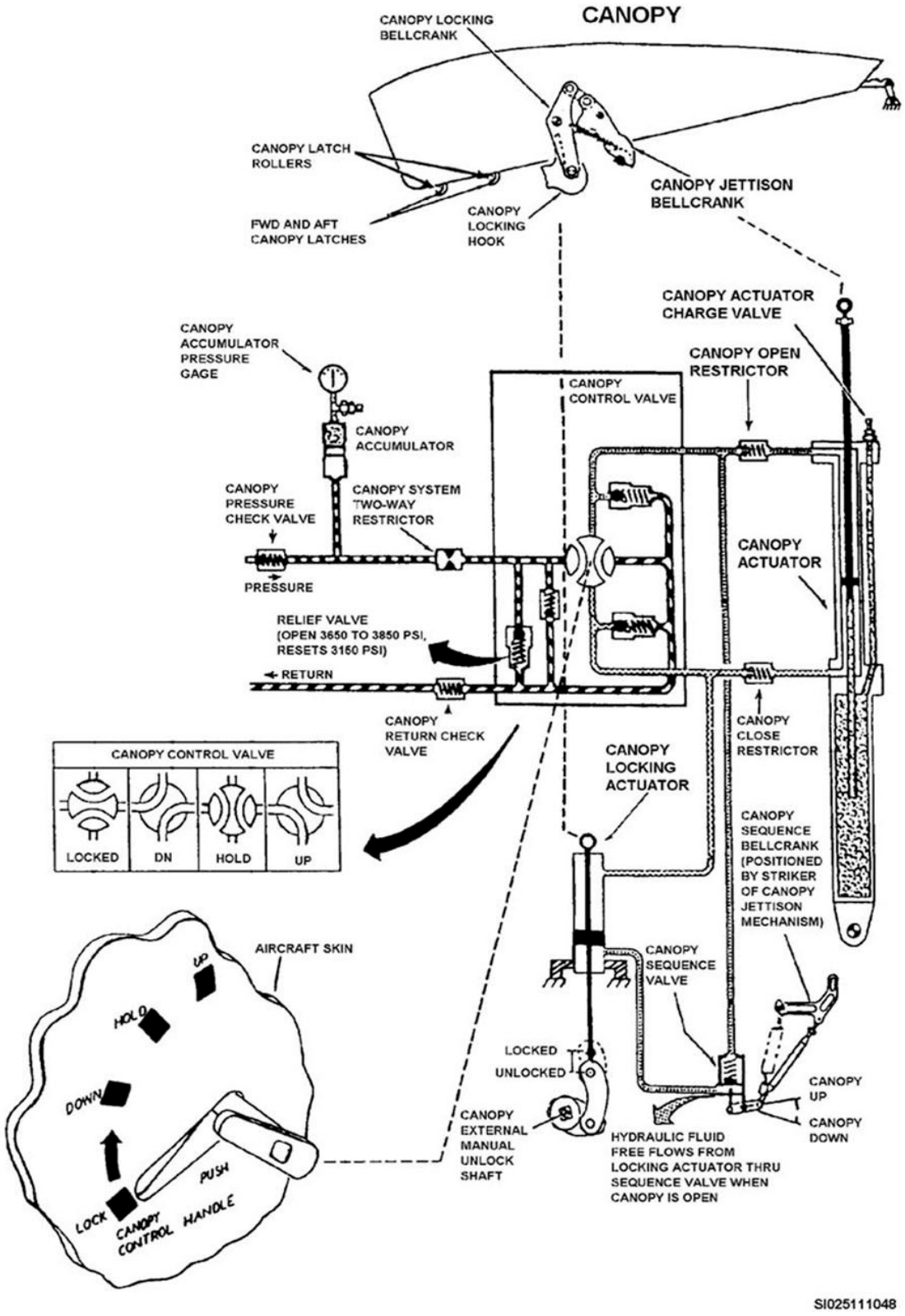


Figure 2–3. F-15 canopy system operation.

A CANOPY UNLOCKED warning light on the main instrument panel in each cockpit warns of an unsafe-for-flight canopy condition. Both lights will remain on if the canopy is not fully closed and locked or if the canopy actuated initiator lanyard is disconnected from the canopy.

213. Theory of operation

This lesson covers the F-15E escape system theory of operation, starting with the principles of operation and discussing all three modes of operation initiated from the front and back seats.

Principles of operation

The emergency escape sequencing system initiators and components are actuated mechanically by gas pressure or by shielded mild detonating cord (SMDC) type energy transfer lines. The initiators, when actuated, produce gas pressure or detonate an SMDC booster tip depending on the type of initiator. Flexible hoses route gas pressure from gas producing initiators to gas pressure actuated components. The SMDC booster tips detonate a compound in the SMDC lines to continue the detonation to the booster tips at the SMDC actuated components. The booster tips then detonate to actuate components.

Front cockpit initiated dual ejection (NORM mode)

The ejection sequence is started from the cockpit by pulling either ejection control handle or both handles on the front ejection seat, firing the JAU–8/A25 initiators. The left JAU–8/A25 initiator then fires the ejection seat SMDC-gas initiator that starts detonation of the SMDC lines.

The SMDC lines fire the inertia reel SMDC-gas initiator, the one-way initiator, and the #2 pyrotechnic module one-way initiator. Detonation of input SMDC booster tip A repositions the No. 1 SMDC sequencer arming pin. With the No. 1 SMDC sequencer arming pin repositioned, the path from the input SMDC booster tip B to output SMDC booster tip B is open. The SMDC lines leading to the #2 pyrotechnic module's one-way initiator will also detonate, but the initiator has already fired and it will not receive input from this direction, so detonation along this path stops at the initiator.

Firing of the inertia reel SMDC-gas initiator fires the inertia reel initiator, which produces pressure to operate the inertia reel and retract the pilot's inertia reel straps. The #2 pyrotechnic module's one-way initiator then detonates the SMDC lines which fire the canopy remover cartridge; the rear inertia reel SMDC-gas initiator and the No. 2 SMDC sequencer arming pin is repositioned by detonation of input SMDC booster tip A. The detonation will also continue up to the rear ejection seat SMDC-gas initiator and stop.

The rear inertia reel SMDC-gas initiator fires the rear inertia reel initiator, which produces pressure to operate the rear inertia reel and retract the rear crewmember's inertia reel straps. Firing of the canopy remover cartridge jettisons the canopy. If the existing escape system fails to fire the front and aft inertia reels, the *redundant escape system* will fire the front and aft inertia reels.

As the canopy leaves the aircraft, the canopy actuated initiator lanyard is pulled, firing the canopy actuated initiator, which then fires the bulkhead-mounted time-delay initiator. After a 0.400-second delay to allow time for the canopy to clear the path of the ejection seats, the bulkhead-mounted time-delay initiator detonates the SMDC lines. The fired warning indicator is actuated and output SMDC booster tip B through the opened path in the No. 2 SMDC sequencer detonates. The SMDC lines fire a pyrotechnic module-mounted time-delay initiator, which detonates through the EJECT MODE selector, which detonates the SMDC line at the NORM port. The rear rocket catapult SMDC-gas initiator is fired, which in turn fires the rear rocket catapult, ejecting the rear seat. After the 0.400-second delay, the pyrotechnic module-mounted time-delay initiator detonates an SMDC line, which detonates through the opened path in the No. 1 SMDC sequencer to detonate the output SMDC booster tip B. The SMDC lines then actuate the identification, friend or foe (IFF) seat switch and fire the rocket catapult SMDC-gas initiator. The rocket catapult SMDC-gas initiator then fires the rocket catapult, ejecting the front seat.

Rear cockpit initiated single ejection (NORM mode)

The ejection sequence is initiated from the rear cockpit by pulling ejection control handle or handles on the rear ejection seat; firing the rear JAU–8/A25 initiators. The left JAU–8/A25 initiator then fires the rear ejection seat SMDC-gas initiator that starts detonation of the SMDC lines.

If the redundant ejection sequence initiates from the rear cockpit, the canopy remover will jettison the canopy and eject the aft seat only. A rear cockpit initiation *does not* result in the redundant escape system firing the front cockpit's rocket catapult. The front crewmember may eject later by pulling the ejection control handle or handles on the forward seat. The SMDC lines fire the rear inertia reel SMDC-gas initiator; the canopy remover cartridge and No. 2 SMDC sequencer arming pin is repositioned by detonation of input SMDC booster tip A. With No. 2 SMDC sequencer arming pin repositioned, the path from the input SMDC booster tip B to output SMDC booster tip B is open. The SMDC lines leading to the #2 pyrotechnic module's one-way initiator will also detonate, but the initiator will not fire because the initiator will not receive input from that direction and detonation along this path will stop at the initiator.

Firing of the rear inertia reel SMDC-gas initiator fires the rear inertia reel initiator, which generates pressure to operate the rear inertia reel and retract the rear crewmember's inertia reel straps. Firing of the canopy remover cartridge jettisons the canopy.

As the canopy leaves the aircraft, the canopy actuated initiator lanyard is pulled, firing the canopy actuated initiator, which then fires the bulkhead-mounted time-delay initiator. After a 0.400-second delay to allow time for the canopy to clear the path of the ejection seats, the bulkhead-mounted time-delay initiator detonates the SMDC lines. The fired warning indicator is actuated and output SMDC booster tip B, through opened path in No. 2 SMDC sequencer detonates. The SMDC lines fire the pyrotechnic module-mounted time-delay initiator and detonate through the EJECT MODE selector to detonate the SMDC line at the NORM port. The rear rocket catapult SMDC-gas initiator is then fired, which in turn fires the rear rocket catapult, ejecting the rear seat. After a 0.400-second delay, the pyrotechnic module-mounted time-delay initiator detonates the SMDC line and the No. 1 SMDC sequencer arming pin is repositioned by detonation of input SMDC booster tip B; with No. 1 SMDC sequencer arming pin repositioned, the patch from input SMDC booster tip A to output SMDC booster tip A is open through which detonation will occur if a front cockpit ejection is later initiated.

Front cockpit initiated single ejection (NORM mode) after ejection initiated by aft cockpit

When a single ejection of the rear seat has occurred, the front seat ejects when the ejection control handle or handles on the front ejection seat are pulled to fire the front JAU–8/A25 initiators. The gas pressure produced by the left JAU–8/A25 initiator fires the ejection seat SMDC-gas initiator that starts detonation of the SMDC lines.

The SMDC lines fire the inertia reel SMDC-gas initiator and the one-way initiator, detonate up to a one-way initiator on #3 pyrotechnic module and detonate through the opened path in the No. 1 SMDC sequencer arming pin which was repositioned during the rear seat ejection sequence, detonating output SMDC booster tip A.

Firing of the inertia reel SMDC-gas initiator fires the inertia reel initiator, which produces pressure to operate the inertia reel and retract the pilot's inertia reel straps. The firing of the #2 pyrotechnic module's one-way initiator has no function for this escape sequence because the SMDC lines on its output side detonated to fire the canopy remover cartridge when the rear seat ejection sequence occurred. From output SMDC booster tip A detonation continues along the SMDC lines to actuate the IFF seat switch and fire the rocket catapult SMDC-gas initiator. The rocket catapult SMDC-gas initiator fires the rocket catapult, ejecting the front seat.

Rear cockpit initiated dual ejection (AFT INITIATE mode)

The ejection sequence is initiated from the rear cockpit when the rear crewmember positions the EJECT MODE selector to AFT INITIATE and pulls the ejection control handle or handles on the rear

ejection seat, firing the rear JAU–8/A25 initiators. The rear left JAU–8/A25 initiator fires the rear ejection seat SMDC-gas initiator that starts detonation of the SMDC lines.

If the existing ejection sequence is in AFT INITIATE mode and a system failure prevents the existing escape system from ejecting the pilot, the only way to eject is for the pilot to initiate the ejection sequence. The SMDC lines fire the rear inertia reel SMDC-gas initiator, the canopy remover cartridge, and No. 2 SMDC sequencer arming pin is repositioned by detonation of input SMDC booster tip A. With No. 2 SMDC sequencer arming pin repositioned, the path from input SMDC booster tip B to output SMDC booster B is open. The SMDC lines leaning to the one-way initiator will not fire and detonation along this path will stop at the initiator.

Firing of the rear inertia reel SMDC-gas initiator fires the rear inertia reel initiator which produces pressure to operate the rear inertia reel and retract the rear crewmember's inertia reel straps. Firing of the canopy remover cartridge jettisons the canopy.

As the canopy leaves the aircraft, the canopy actuated initiator lanyard is pulled firing the canopy actuated initiator, which fires the bulkhead-mounted time-delay initiator. After a 0.400-second delay to allow time for the canopy to clear the path of the ejection seats, the bulkhead-mounted time-delay initiator detonates the SMDC lines. The fired warning indicator is actuated and output SMDC booster tip B, through the opening in No. 2 SMDC sequencer detonates. The SMDC lines fire the pyrotechnic module-mounted time-delay initiator and detonate through the EJECT MODE selector to detonate the SMDC line at the AFT INITIATE port. Two one-way initiators on the #3 pyrotechnic module are then fired by SMDC lines, in turn detonating more SMDC lines. The SMDC lines from one of the pyrotechnic module's one-way initiators fire the rear rocket catapult SMDC-gas initiator and detonate up to the EJECT MODE selector and stop. The rear rocket catapult SMDC-gas initiator fires the rear rocket catapult, ejecting the rear seat. The SMDC lines from the other one-way initiator on the #3 pyrotechnic module fires the inertia reel SMDC-gas initiator, the one-way initiator on the #2 pyrotechnic module detonates up to the ejection seat SMDC-gas initiator and stops, and the No. 1 SMDC sequencer arming pin is repositioned by detonation of the input SMDC booster tip A.

Firing of the inertia reel SMDC-gas initiator fires the inertia reel initiator, which produces pressure to operate the inertia reel and retract the pilot's inertia reel straps. Firing of the one-way initiator on #2 pyrotechnic module has no function since the SMDC lines at its output previously detonated. After a 0.400-second delay, the pyrotechnic module-mounted time-delay initiator detonates the SMDC line, which detonates through the opened path in the previously repositioned No. 1 SMDC sequencer arming pin to detonate the output SMDC booster tip B. The SMDC lines actuate the IFF seat switch and fire the rocket catapult SMDC-gas initiator. The rocket catapult SMDC-gas initiator fires the rocket catapult, ejecting the front seat.

Cockpit initiated single ejection (SOLO mode)

In SOLO mode, a cockpit initiated ejection follows the same sequence as the NORM mode until the SMDC detonation reaches the EJECT MODE selector. At the EJECT MODE selector, the SMDC line detonates through to detonate the SMDC line at the SOLO port. The SMDC lines trigger the IFF seat switch and fire the rocket catapult SMDC-gas initiator. The rocket catapult SMDC-gas initiator fires the rocket catapult, ejecting the front seat. This eliminates rear seat ejection and bypasses the pyrotechnic module-mounted time-delay initiator to allow the front seat to eject in minimum time. If the emergency escape system fails, the redundant emergency escape system will eject the aft seat first and then 2.0 seconds later, eject the forward seat.

Modes of operation post-ejection

The F-15 and F-16 ACES II use the same three modes of operation previously discussed.

214. Canopy system theory of operation

Now that we've discussed the system theory of operation, let's turn our attention to how the canopy jettisons under nonejection conditions. This can be done from inside or outside the aircraft.

External canopy jettison

For this discussion, refer to figure 2–4. To accomplish *external* canopy jettison, the external canopy jettison initiator must detonate. The handle for this is behind door 9. The canopy jettison handle must be pulled to extend the cable for 8 feet then the handle must be jerked. This fires the external canopy jettison initiator and starts the canopy jettison sequence.

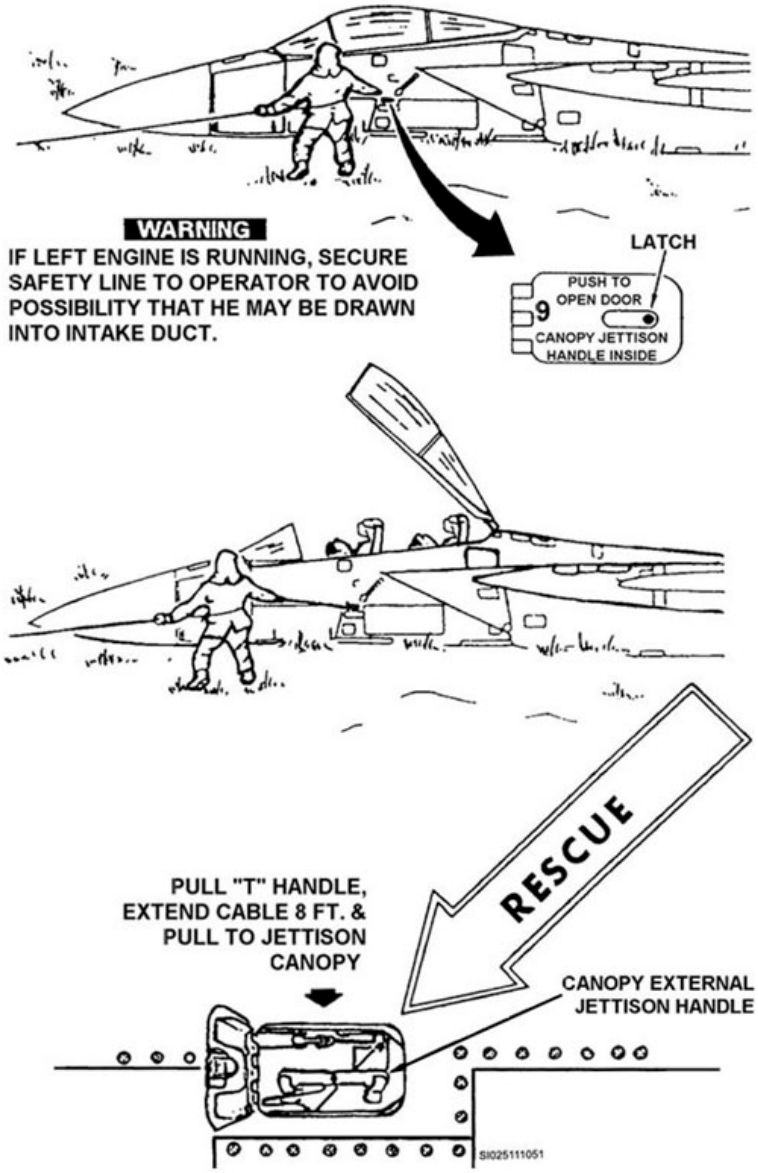


Figure 2–4. F-15 external canopy jettison.

First, the *external* canopy jettison initiator detonates an SMDC, firing the canopy remover cartridge. Gas pressure from the cartridge forcefully extends the canopy remover piston, which engages the jettison bell crank to unlock the canopy. Continued extension of the remover piston shears the pin in the canopy actuator and the pins in the hinge arm to release the canopy from the aircraft. As the

canopy jettisons, a lanyard attached to the canopy pulls taut and fires the canopy-actuated initiator. This initiator fires another SMDC, which in turn fires two more SMDC lines. One of these lines actuates the fired warning indicator, while the other line repositions the SMDC sequencer.

The SMDC sequencer is now ready to allow detonation to flow through to eject the seat from the aircraft. The purpose of the fired warning indicator is to let ground personnel know that the canopy jettison system fired and the seat can be ejected.

Internal canopy jettison

For *internal* canopy jettison, you pull the canopy jettison handle located under either cockpit's left canopy sill. When the canopy is closed, the jettison handle is just a few inches above the seat arming lever. The process is identical to external canopy jettison except the internal canopy jettison initiator starts the jettison sequence.

Self-Test Questions

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

212. System description

1. List the three modes of selection available for the F-15E emergency escape system and describe them.

2. In the escape sequence of operation, except for in the SOLO mode, what is the length of time-delay between the canopy jettison and the rear seat ejection?

3. What F-15E components start the emergency canopy jettison sequence?

4. What F-15E canopy component seals the canopy to fuselage mating surfaces to allow the cockpits to be pressurized?

5. What F-15E canopy component supplies pressure to the extend side of the canopy actuator piston to open the canopy if the accumulator is depleted?

6. What F-15E canopy component warns of an unsafe-for-flight canopy condition?

213. Theory of operation

1. In the F-15E emergency escape sequencing system, what components route gas pressure from gas-producing initiators to gas pressure actuated components?

2. How is the ejection sequence started during a front cockpit initiated dual ejection in NORM mode?

3. When the F-15E dual ejection sequence is initiated from the front cockpit, what happens between the ejection of the rear seat and the firing of the front cockpit's rocket catapult, ejecting the front seat?

4. When an F-15E ejection is initiated from the rear cockpit in NORM mode, when does the forward crewmember eject? Why?

5. What function does the #2 pyrotechnic module's one-way initiator serve during a front cockpit initiated ejection in NORM mode after the ejection initiates from the aft cockpit?

6. If the EJECT MODE selector is in AFT INITIATE and a system failure prevents the existing escape system from ejecting the pilot, how can the pilot eject?

7. In what order do the ejection seats eject when the EJECT MODE selector is in SOLO mode, and the redundant emergency escape system is not needed?

214. Canopy system theory of operation

1. What fires the canopy-actuated initiator when the F-15E canopy jettisons?

2. What is the purpose of the F-15E fired warning indicator?

2–2. System Maintenance

There is a lot more to the F-15 escape system than what we will cover in this volume. However, every few years, the career field will hold a utilization and training workshop (U&TW) to determine what escape system knowledge is important for apprentices, journeymen, and craftsman to learn. The egress U&TWs are composed of experts from around the career field and those experts determined that it's important for you, as an egress journeyman, to know the following aspects of the F-15 escape system:

- SMDC line inspection.
- #3 pyrotechnic module removal.
- #3 pyrotechnic module installation.

Thus, in the following lessons, we'll discuss how to inspect SMDC lines and move into #3 pyrotechnic panel's maintenance.

215. Inspecting shielded mild detonating cord lines

Energy transfer lines transfer a detonating shock wave from initiators to other explosive devices in an egress system. Their rate of detonation is very fast with a detonation rate of up to 25,000 feet per second. To put that into a perspective easy to relate to, if you were to wrap SMDC around the earth at the equator, it would take 88 minutes for the charge to burn end to end. They are used in the same way DTA lines are used in the F-16; however, they just don't have the flexibility. As many egress maintainers have discovered over the years, they are prone to being stripped out if installed incorrectly.

The type of energy transfer line the F-15 uses is SMDCs. SMDCs consist of a protective outer covering, a detonating cord, and booster tips. The outer cover protects the detonating cord and confines the effects of detonation within the cover. The detonating cord is the rapid burning propellant providing the energy needed to sustain the shock wave and cause it to travel the length of the line. The booster tips also contain an explosive and allow the effects of detonation to transfer from line to line or from line to component. They are attached to each end of the line.

As you can imagine, SMDC must be protected from damage. That's why it's so important to regularly inspect these lines to ensure that the ejection systems operate successfully when F-15 crewmembers pull the ejection control handles. Therefore, extreme care should be exercised during installation and removal.

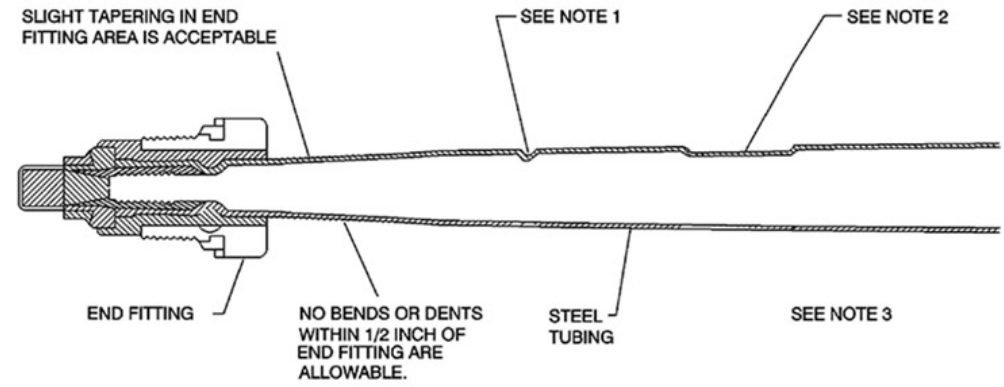
Prior to installation inspection

Prior to operational use or during assembly and buildup, a 100 percent visual inspection for unacceptable defects that preclude use of the item will be accomplished. Make sure you perform this inspection with TO 11P17-3-7, *Specialized Storage and Maintenance Procedures–Shielded Mild Detonating Cord*.

Reject any SMDC that was involved in an ejection or mishap, was fired or expended, or if any part of the line is cracked.

Refer to figure 2–5. Inspect the SMDC line tube for nicks, gouges or dents with a lighted 10X magnifier or equivalent. The line may have a tubing depression less than 0.040 inch deep in which the bottom and edge radius is smooth and presents a rounded appearance under the 10X magnification. However, the surface of the tubing cannot be broken or punctured. Any slight, but smooth depressions existing on the surface of the SMDC tube must be less than or equal to 20 percent, or

equivalent to a depression measuring 0.040 inch in depth, of the SMDC outside diameter and less than one inch in length.



NOTE 1. SHARP DENTS, NICKS OR GOUGES; ANY TUBING DEPRESSION LESS THAN 0.04-INCH DEEP IN WHICH THE BOTTOM AND EDGE RADIUS IS SMOOTH AND PRESENTS A ROUNDED APPEARANCE UNDER A 10X MAGNAFIER IS ACCEPTABLE. THE SURFACE OF THE TUBING CANNOT BE BROKEN OR PUNCTURED.

NOTE 2. ENSURE THAT ANY SLIGHT BUT SMOOTH DEPRESSIONS EXISTING ON THE SURFACE OF THE SMDC TUBE ARE LESS THAN OR EQUAL TO 20 PERCENT (THIS IS EQUIVALENT TO A DEPRESSION MEASURING 0.04-INCH IN DEPTH) OF THE SMDC OUTSIDE DIAMETER AND LESS THAN 1 INCH IN LENGTH.

NOTE 3. USE APPROPRIATE THICKNESS FEELER GAUGE FOR COMPARISON IN DETERMINING SIZE/DEPTH OF DEPRESSIONS. THIS PROCEDURE IS TO BE USED AS AN AID IN DETERMINING THE SERVICEABILITY OF SMDC LINES. WHILE EXACT MEASUREMENTS CANNOT BE OBTAINED BY THIS METHOD, IT CAN BE USED TO DETERMINE SUPERFICIAL IMPERFECTIONS AND MINOR DAMAGE (SCRATCHES/DENTS) WHICH DO NOT EFFECT SMDC PERFORMANCE. IF A DEFECT CANNOT BE DETERMINED UNQUESTIONABLY ACCEPTABLE, THE LINE WILL BE REJECTED.

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Figure 2–5. SMDC inspection criteria.

You'll use a thickness feeler gage like the one in figure 2–6 to compare the size and depth of depressions. This procedure is used as an aid in determining the serviceability of SMDC lines. While exact measurements cannot be obtained by this method, it can help determine superficial imperfections and minor damage such as scratches and dents which do not affect SMDC performance. If a defect cannot be determined as unquestionably acceptable, reject the line.

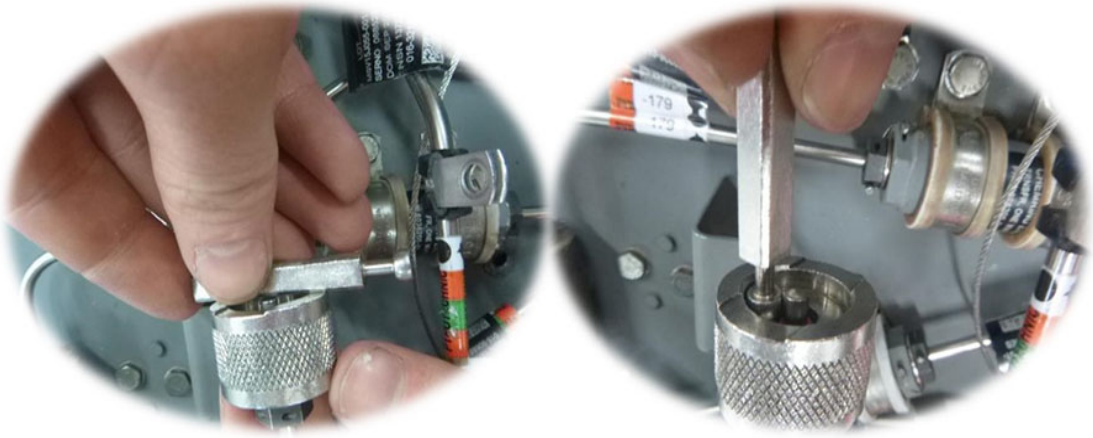

Figure 2–6. SMDC size and depth check (go-no-go gage).

Reject an SMDC line bent beyond allowable limits during installation or maintenance.

Next, inspect the end of the SMDC booster tip for dents or nicks with a lighted 3X magnifier or equivalent. Reject the SMDC if the total area of dents on the edge of the booster tip surface exceeds 10 percent of the outside surface area. Ten percent damage is equivalent to a dent measuring 0.05 by 0.04 inch or 0.02 of a square inch. Dents should not exceed 0.010 inches deep. Dents on the side of the booster tip should not be more than 0.03 inches wide and 0.08 inches long. However, dents of this size are only allowable if they are no deeper than 0.005 inches and there are at least 135-degrees of arc between adjacent dents. Die marks on the surface are allowable. A discontinuity, defined as a ridge or bump, around the tip near the rubber seal is allowable if there are no cracks in the housing. If a defect cannot be determined as unquestionably acceptable, reject the line. Inspect the booster tip for cracks and check to see if it is bent. If the end of the booster tip is cracked or bent, then the SMDC must be rejected. Criteria for inspecting the SMDC booster tip are further outlined in figure 2–7.

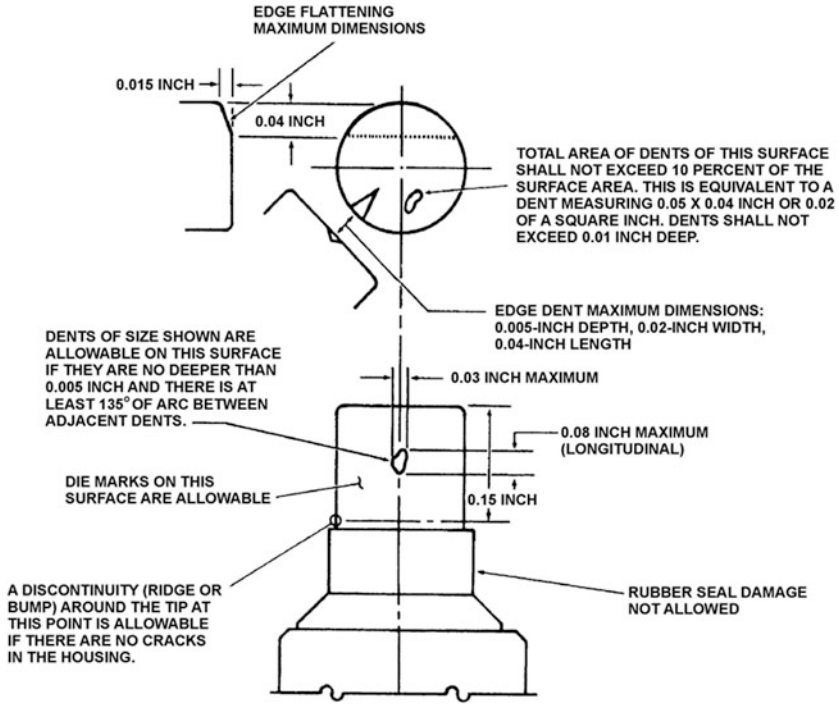

Figure 2–7. SMDC booster tip inspection.

Inspect the SMDC for damaged threads. Reject it if the threads are damaged; it cannot be properly torqued.

Inspect the outer ferrule. If the ferrule rotates on the line assembly a full 360 degrees, reject it.

Inspect the SMDC for rust or corrosion. If the SMDC is rusted or corroded, reject it.

Inspect the label of the SMDC. If the label is missing, but the part number, lot number, and date of manufacture are known, then replace the label. If you can’t obtain the information for the label, reject

the SMDC. If the label is incorrect or illegible, and the information is known, correct the label. If the information is unknown, reject the SMDC, especially if the lot number and date of manufacture are unknown.

Inspect the shelf and service life of the SMDC. If either is expired, reject the SMDC.

Inspect for presence of protective caps. Protective caps should always be present on the SMDC when it is not installed on an aircraft (unless you removed the cap for inspection). Finding a missing protective cap should always automatically make you inspect the booster tip for damage. If you don't find any damage, replace the protective cap.

Inspect for cuts or tears on the rubber seal at the end of the SMDC booster. If they are found, replace the rubber seal.

Correctable defects

Shielded mild detonating cord and explosive cord sets having *correctable defects* will be *temporarily rejected, segregated, marked defective and scheduled for maintenance*.

Noncorrectable defects

Shielded mild detonating cord and explosive cord sets with noncorrectable defects will be *rejected, segregated, identified as defective, and reported for disposition.*

216. Removing the #3 pyrotechnic module

NOTE: This is not a complete description of the requirements and *should never be used in lieu of appropriate technical data.*

Before we begin our discussion, let's look at a few precautionary notes you should observe whenever you are performing maintenance.

Cautions

As stated earlier, handle SMDC lines carefully to prevent damage to the lines and booster tips. To prevent damage to the SMDC lines, rotate the fitting and not the line. Also, the booster tip and ferrule must remain aligned with the port of the mating component until the tip is clear of the port. After removing the line, inspect it for damage. Remove or install components in the sequence prescribed in the TO (this helps prevent damage).

Removal

Refer to figure 2–8 as we discuss the removal procedures. To remove the module, remove the ACES II seat and reposition the seat actuator/rocket catapult (fig. 2–8 detail A, item 1) so access may be gained to the module. Remove the bolts and hoses from the seat actuator and the rocket catapult (item 2), respectively. With the catapult disconnected, reposition it to the right side of the cockpit.

NOTE: Remember, any time hoses or lines are disconnected, install protective caps and plugs immediately. This prevents damage to delicate booster tips and keeps foreign objects (dirt, insects, etc.) from entering openings.

Remove the module cover to gain access to the pyrotechnic module (fig. 2–8 detail B, item 5). To do this; bolts, clamps, spacers, and washers (items 3, 4) must be removed. Anytime you're dealing with small parts such as the nuts and spacers; there's the potential for foreign object damage (FOD). On pyrotechnic modules, especially the #3, there are so many little pieces of hardware, the potential for cockpit FOD is increased. Remember to account for every item you remove—what it is and how many. In this way, you can make sure you haven't dropped anything into the cockpit or onto the flight line, which would instantly turn a standard removal or install into a FOD search. With the attaching hardware removed, the cover can slide (item 5) forward over the hose (item 6) connected to the SMDC-gas initiator, so that the three hoses (item 7) and electrical disconnect (item 8) may be

disconnected. Now, protective covers can be installed and the module cover removed. Finally, the stowage case and console access covers can be removed.

Removing the module is a matter of sequential steps. Remove the blocks and spacers (items 9, 10) that support the SMDC lines leading to the module assembly. Remove the 10 bolts (item 11) attaching the module to the bulkhead. To completely remove the lines, it may be necessary to loosen, or remove, the attaching hardware of the explosive components or clamps to relieve any spring-back from installed SMDC lines.

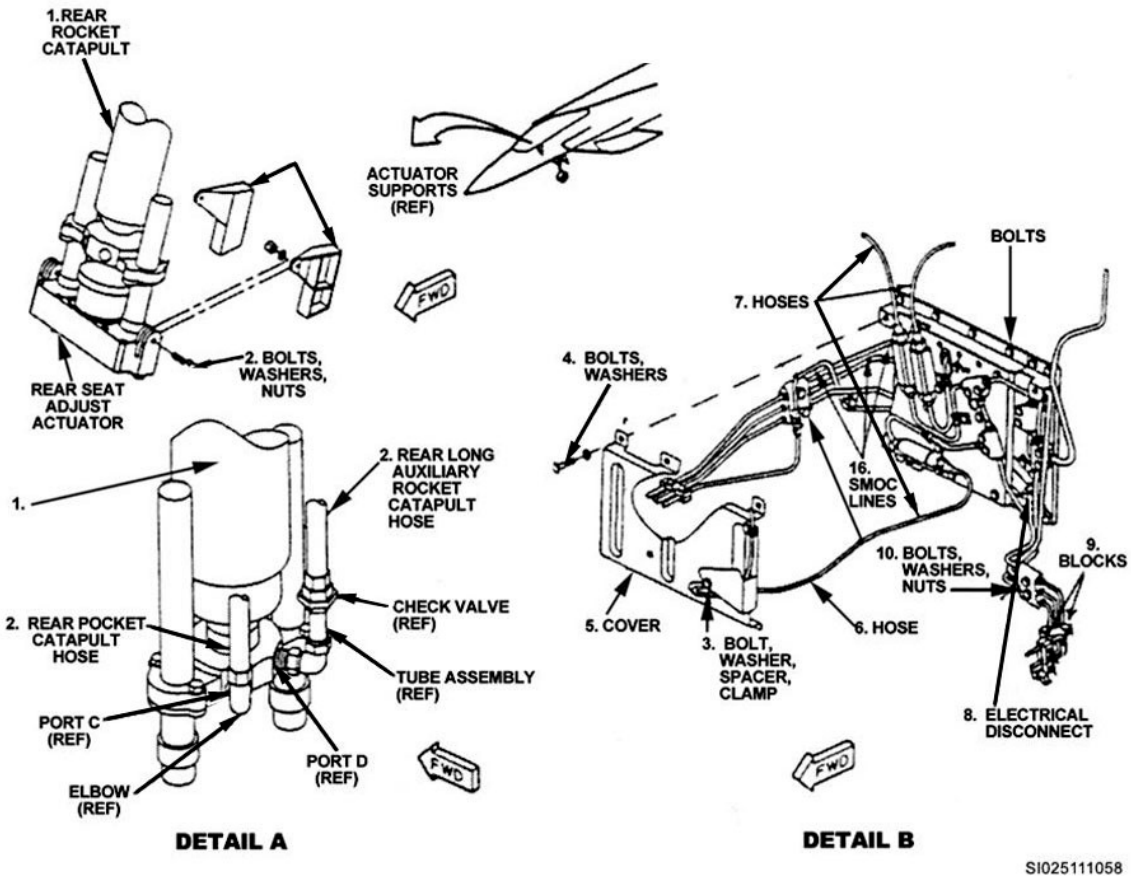

Figure 2–8. F-15 #3 pyrotechnic module.

When damage will not be inflicted to the lines or booster tips; remove the lines and install the protective covers. This will make it possible to remove the module.

Now that the module is free from the aircraft, it can be taken back to the shop for storage and maintenance. Any components may then be replaced, if required. Remember to carefully follow all applicable technical order instructions.

217. Installing the #3 pyrotechnic module

In this lesson, we'll discuss the installation of the #3 pyrotechnic module. Remember, the procedures described do not replace the technical data. *Always follow tech data carefully*. It can save you time and trouble and prevent tragedies involving maintenance personnel or aircrews.

Pre-installation procedures

Before installing the module back into the aircraft, inspect all explosive items to make sure they are serviceable and haven't exceeded their expiration date. Also, it's vital to make sure that any required

modifications have been done before reinstalling the module. If possible, it's advisable to begin by inserting a piece of lockwire for each connection prior to installation and use lockwire long enough to mate with cockpit components after module installation. This procedure is a good practice and can save you a lot of time and frustration. It's easier than trying to insert lockwire through each lockwire hole after installing the module and space is limited. As always, proper eye protection is a must.

Of course, remove the protective covers from the components, but initially only for inspection. Inspect the open ports for damage and foreign objects. To remove any foreign object or contamination, turn the component for the pyrotechnic module upside down and shake it. You must never dig or probe in the ports of explosive devices. You could damage or even actuate the explosive. If the item should actuate, the probe you were using could become a projectile! If you discover contamination you can't dislodge by shaking, just replace the component. Install protective covers when the inspection is complete.

Installation

Refer back to figure 2–8 as we discuss installation procedures. Remove the protective covers from multiport connectors on the aircraft. If foreign objects are present, remove connectors, foreign objects, and reinstall connectors. Then reinstall the protective covers.

The module is carefully positioned in the aircraft. With the module supported, remove the SMDC protective covers as required and connect the SMDC lines to the SMDC connectors. To prevent damage to SMDC lines, use two wrenches when tightening SMDC inline connectors to the proper torque values. One wrench attaches to one fitting to hold the line steady and to prevent it from bending or twisting while the other wrench is used to tighten the connector. Once the connectors are tightened to a reasonable degree, the SMDC fittings should then be tightened to the appropriate torque value and finally safetied with lockwire.

The module's bolts and washers are loosely installed. The multiport connector is positioned and the top bolt and washer installed. The inline connector and the clamp are positioned onto the multiport connector and the bolt and washer are installed. Finally, tighten the bolts attaching the module to the bulkhead. If the fittings on the SMDC lines are inaccessible with a torque wrench, use a feeler gage or a thickness gage to do a gap check. When using the gap check method in place of a torque wrench, tighten the fittings until an appropriate gap (in accordance with tech data) exists between the seal retainer and the component mating surface. The fittings still must be safety-wired.

With SMDC lines connected, install the line blocks and connect the electrical receptacle to the IFF seat switch. Inspect the ballistic hoses for broken or cut metal braiding, flat spots, or any reduction in hose diameter. Disconnect each hose and perform a flow test using dry air or a nitrogen source with a pressure of 5.0–15.0 pounds per square inch (psi). During the flow test, make sure that the dry air or nitrogen flows freely through the hose. Any defective hoses must be replaced. With the flow checks complete, the hoses are reinstalled. Any loose hoses should be secured to the aircraft structure to prevent damage. All hoses must be tightened to the proper torque value.

Route the ejection control hose through the module cover and connect the hose to the initiator. Tighten this hose to the proper torque value. When you're routing the ejection control hose, you have to make sure to route the hose above the SMDC lines located adjacent to the left handrail.

NOTE: Improperly routed hoses can result in injury or death to the aircrew in the event of an ejection.

Now that the module is installed and the hoses are connected, the seat actuator/catapult may be installed. To prevent damage to a hose, use a wrench to hold the elbow while tightening the hose coupling. Tighten the coupling as specified in the applicable tech data. The couplings are safety-wired.

Once you have completed the catapult installation and have installed any other components removed, check the entire area for foreign objects. After accounting for all your tools and removing foreign objects, you can install or lower the ejection seat. Before leaving the area, make sure you properly document the aircraft forms.

Self-Test Questions

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

215. Inspecting shielded mild detonating cord lines

1. What special tool would you use to inspect an SMDC line tube for nicks, gouges, or dents?

2. When inspecting SMDC line tubes, what should you do if a defect cannot be determined as unquestionably acceptable?

3. After inspecting the SMDC line tube for damage, what should be inspected next?

4. What is the maximum allowable size of a dent located on the side of the SMDC booster tip?

5. What are the rejection criteria for SMDC outer ferrules?

216. Removing the #3 pyrotechnic module

1. When removing SMDC lines from the #3 pyrotechnic module, how do you prevent damage to the booster tip and ferrule?

2. During the #3 pyrotechnic module removal, what precaution should you take when disconnecting hoses or lines?

3. How do you gain access to the #3 pyrotechnic module?

4. During the removal, once you have removed the blocks and spaces of the #3 pyrotechnic module, what do you do next?

5. During the #3 pyrotechnic module removal, how do you relieve any spring-back from installed SMDC lines?

217. Installing the #3 pyrotechnic module

1. What must you do before installing the #3 pyrotechnic module back into the aircraft?

2. What's a good practice that will save you a lot of time and frustration during the #3 pyrotechnic module installation?

3. How are the #3 pyrotechnic module's bolts and washers initially installed?

4. When do you tighten the #3 pyrotechnic module's bolts?

5. How do you perform a gap check on the #3 pyrotechnic module's SMDC line fittings if they are inaccessible with a torque wrench?

6. How do you prevent damage to the #3 pyrotechnic module's hoses while tightening the hose coupling?

Answers to Self-Test Questions

212

1. NORM mode, SOLO mode, and AFT INITIATE mode. In NORM mode, both seats eject when the escape sequence is started from the front cockpit, but only the rear seat is ejected if the escape sequence is started from the rear cockpit. When the escape sequence has been initiated from the rear cockpit in the NORM mode, the front seat ejects only when the front seat ejection control handle is pulled. SOLO mode is for flight with the rear cockpit unoccupied and only the front seat is ejected when the escape sequence is started. In AFT INITIATE mode, both seats are ejected when the escape sequence is started from either cockpit.
2. A 0.400-second delay.
3. A CANOPY-EMERG JETT initiator in each cockpit or an external jettison initiator.
4. An inflatable seal.
5. A nitrogen chamber in the canopy actuator.
6. A CANOPY UNLOCKED warning light on the main instrument panel in each cockpit.

213

1. Flexible hoses.
2. It is started from the cockpit by pulling ejection control handle or both handles on the front ejection seat, firing the JAU–8/A25 initiator.
3. After the 0.400-second delay, the pyrotechnic module-mounted time-delay initiator detonates an SMDC line, which detonates through the opened path in the No. 1 SMDC sequencer to detonate the output SMDC booster tip B. The SMDC lines then actuate the IFF seat switch and fire the rocket catapult SMDC-gas initiator. The rocket catapult SMDC-gas initiator then fires the rocket catapult, ejecting the front seat.

4. The front crewmember may eject later by pulling the ejection control handle or handles on the forward seat.
5. No function. The SMDC lines on its output side detonate to fire the canopy remover cartridge when the rear seat ejection sequence occurred.
6. The only way to eject is for the pilot to initiate the ejection sequence.
7. In SOLO mode, only the front ejection seat ejects. Unless the redundant emergency escape system is used during failure of the primary system, then the AFT seat, followed by the forward (FWD) seat.

214

1. A lanyard attached to the canopy pulls taut and fires the canopy-actuated initiator.
2. It is to let ground personnel know that the canopy jettison system has been fired and the seat can be ejected.

215

1. 10X lighted magnifier or equivalent.
2. Reject the line.
3. Inspect the SMDC booster tip.
4. They should not be more than 0.03 inches wide and 0.08 inches long.
5. If the ferrule rotates on the line assembly a full 360 degrees, then it must be rejected.

216

1. The booster tip and ferrule must be aligned with the port of the mating component until the tip is clear of the port.
2. Protective caps and plugs should be installed immediately.
3. The seat must be removed and the seat actuator/rocket catapult must be positioned so access can be gained. Then remove bolts, clamps, spacers, and washers to remove the module cover.
4. Remove the 10 bolts attaching the module to the bulkhead.
5. Loosen or remove the attaching hardware of the explosive components or clamps.

217

1. All explosive items have to be inspected to ensure they’re serviceable and haven’t exceeded their expiration date. Also, it’s vital to ensure that any required modifications have been accomplished prior to reinstalling the module.
2. Pre-install lockwire for each connection prior to installation with lockwire long enough to mate with cockpit components after the module is installed.
3. Loosely.
4. After the in-line connector and the clamp are positioned onto the multiport connector and the bolt and washer installed.
5. When using the gap check method in place of a torque wrench, the fittings must be tightened until an appropriate gap (in accordance with tech data) exists between the seal retainer and the component mating surface.
6. Use a wrench to hold the elbow.

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

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

30. (212) What are the three modes of operation on the F-15E emergency escape sequencing system?
    a. FWD, SOLO, and AFT INITIATE.
    b. NORM, FWD, and AFT INITIATE.
    c. NORM, SOLO, and AFT INITIATE.
    d. NORM, SOLO and FWD INITIATE.

31. (212) Except for SOLO mode, what is the sequence of operation for two-seat F-15Es during an AFT INITIATE ejection?
    a. Canopy jettison, then only the rear seat ejects.
    b. Canopy jettison, rear seat ejection, then front seat ejection.
    c. Canopy jettison, front seat ejection, then rear seat ejection.
    d. Canopy jettison, then simultaneous front and rear seat ejection.

32. (212) The best description of the F-15E canopy is that it's a
    a. bubble type that's jettisoned from the aircraft frame by a canopy rocket motor.
    b. clamshell type that's jettisoned from the aircraft frame by an M4 canopy remover.
    c. clamshell type consisting of formed, transparent plastic mounted in a metal frame.
    d. bubble type that's designed to give the pilot unobstructed forward and upward vision.

33. (212) What are the four positions for setting the F-15 canopy control handles?
    a. LOCKED, DN, HOLD, and UP.
    b. LOCKED, DN, OPEN, and UP.
    c. UNLOCKED, DN, OPEN and UP.
    d. UNLOCKED, DN, HOLD and UP.

34. (213) What type of energy transfer line does the F-15E emergency escape sequencing system use?
    a. Electronic wiring harness.
    b. Flexible linear shaped charge (FLSC).
    c. Shielded mild detonating cord (SMDC).
    d. Detonation transfer assembly (DTA).

35. (213) When F-15E ejection is initiated in NORM mode by the *front* crewmember, what component fires the rear seat's inertia reel initiator?
    a. The left-hand JAU–8/A25 ejection control initiator.
    b. The right-hand JAU–8/A25 ejection control initiator.
    c. A gas-shielded mild detonating cord (SMDC) initiator.
    d. A SMDC-gas initiator.

36. (214) The F-15E external canopy jettison initiator is fired by
    a. breaking the frangible panel, grasping the handle, and pulling the lanyard approximately 6 feet.
    b. breaking the frangible panel, grasping the handle, and pulling the lanyard approximately 8 feet.
    c. pulling the canopy jettison handle to extend the cable for 6 feet then jerking the handle.
    d. pulling the canopy jettison handle to extend the cable for 8 feet then jerking the handle.

37. (214) Which component extends the canopy remover piston when the F-15E canopy jettison system is initiated externally?
    a. Canopy remover cartridge.
    b. Canopy actuated initiator.
    c. 1.5-second time delay initiator.
    d. External canopy jettison initiator.

38. (214) When the F-15E canopy jettison system is initiated externally, what actuates the fired warning indicator?
    a. Canopy actuated initiator.
    b. The canopy remover cartridge.
    c. The 1.5-second time delay initiator.
    d. The 0.400-second time delay initiator.

39. (214) Where are the F-15E's *internal* canopy jettison handles located?
    a. Mounted on the right interior side of the canopy.
    b. Mounted on the left interior side of the canopy.
    c. Under the right canopy sill in either cockpit.
    d. Under the left canopy sill in either cockpit.

40. (215) Before operational use or during assembly and buildup involving shielded mild detonating cord (SMDC), what is the *first thing* you should do?
    a. Reject lines with visible wear and tear.
    b. Perform 100 percent visual inspection.
    c. Ensure the shipping container is not damaged in any way.
    d. Make sure all fittings are properly torqued to technical order (TO) specifications.

41. (215) When inspecting shielded mild detonating cords (SMDC), what tool do you use to compare the size and depth of depressions?
    a. A thickness feeler gage.
    b. A 10X magnifier.
    c. A 3X magnifier.
    d. A steel rule.

42. (215) The total surface area of dents on a shielded mild detonating cord's (SMDC) booster tip surface *cannot* exceed what percent of the outside surface area?
    a. 5.
    b. 10.
    c. 15.
    d. 20.

43. (215) At least how many degrees of arc should be allowed between adjacent dents on a shielded mild detonating cord's (SMDC) booster tip?
    a. 110 degrees.
    b. 128 degrees.
    c. 135 degrees.
    d. 360 degrees.

44. (215) What action should you take if you find a cut on the rubber seal at the end of a shielded mild detonating cord's (SMDC) booster?
    a. Reject the SMDC.
    b. Fill the cut with sealant.
    c. Replace the rubber seal.
    d. Replace the seal with sealant.

45. (216) When removing the F-15 #3 pyrotechnic module on an aircraft, you prevent damage to shielded mild detonating cord (SMDC) lines by
    a. rotating the lines only, not the fittings.
    b. rotating the fittings only, not the lines.
    c. rotating the ferrule assembly a full 360 degrees.
    d. only installing protective caps when the lines are back at the shop.

46. (216) The first thing you must remove *before* removing an F-15 #3 pyrotechnic module is
    a. the Advanced Concept Ejection Seat (ACES) II.
    b. any shielded mild detonating cord (SMDC) lines.
    c. all hoses and electrical disconnects from the pyrotechnic module.
    d. mounting bolts attaching the pyrotechnic module to the bulkhead.

47. (216) To gain access to the F-15 #3 pyrotechnic module when removing it on the aircraft, you must reposition the
    a. seat actuator/rocket catapult.
    b. external canopy initiator.
    c. fired warning indicator.
    d. pyro panel #5.

48. (216) When removing the F-15 #3 pyrotechnic module on the aircraft, what is a concern that sets this job apart from other egress jobs?
    a. Increased hazards of working with pyrotechnic modules.
    b. Tool accountability with increased socket and wrench usage.
    c. The increased potential for cockpit foreign object damage (FOD) from pyrotechnic hardware.
    d. Unexpected aircraft movement, landing gear compressing or expanding.

49. (217) When installing the F-15 #3 pyrotechnic module, remove foreign objects from an explosive device port by
    a. removing the foreign object with a scribe.
    b. removing the foreign object with a soft cloth.
    c. turning the component upside down and shaking it.
    d. removing the foreign object with 45 pounds per square inch air pressure.

50. (217) When installing the F-15 #3 pyrotechnic module on the aircraft, what is a good way to prevent damage to shielded mild detonating cord (SMDC) lines?
    a. Safety wire connectors before applying torque.
    b. Use two wrenches while tightening connectors.
    c. Rotate SMDC lines, not the fittings when tightening.
    d. Use a wrench and a pair of pliers while tightening connectors.

51. (217) When installing an F-15 #3 pyrotechnic module, what do you do *after* the shielded mild detonating cord (SMDC) lines are installed?
    a. Inspect open ports for damage or foreign objects.
    b. Tighten the mounting bolts for the pyrotechnic module.
    c. Connect the electrical receptacle to the identification, friend, or foe (IFF) seat switch.
    d. Inspect all explosive items to make sure serviceability and expiration dates haven’t expired.

52. (217) When installing the F-15 #3 pyrotechnic module, apply a dry air or nitrogen source to flow check ballistic hoses between
    a. 5.0–15.0 pounds per square inch (psi).
    b. 15.0–20.0 psi.
    c. 15.0–30.0 psi.
    d. 30.0–45.0 psi.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. F-22 Egress System

THE F-22 RAPTOR is one of the Air Force's most advanced fighter aircraft, and is the definition of air dominance. The 5th generation Raptor sports a combination of stealth, speed agility, and situational awareness. The Lockheed Martin F-22 Raptor with its single ACES II seat and twin engines provide a lethal dose of both air-to-air and air-to-ground dominance.

The two F119 engines are currently the world's most advanced combat aircraft engines. These engines, with their unique thrust-vectoring nozzle and integrated stealth characteristics, give the F-22 the capability to super-cruise, reaching speeds greater than Mach 1.5! Unfortunately, due to high costs and budget constraints, with the wars in Iraq and Afghanistan and after the 187th Raptor rolled off the assembly line in 2012, production of the F-22 ended. Therefore, the Air Force could direct funds to the F-35 which will be discussed in this CDC volume either as a supplement or with the next re-write.

The major components of the crew escape and safety system consists of the escape system and the canopy jettisons system. In this unit, we'll discuss the F-22 escape system starting with the major components and theory of operation of the system, and then moving on to the major components and theory of operation of the canopy jettison system.

3–1. Escape System

The emergency escape system on this aircraft enables the pilot to safely eject from a disabled aircraft or from an unsafe environment over a wide range of aircraft airspeeds and altitudes. We'll first look at the components and characteristics of the system. Then, we'll cover its theory of operation.

218. Component description

The escape system provides egress during an emergency and returns crewmembers to earth. It provides seat armed/not armed status, disables mission computers using zeroize guillotine upon ejection and provides a mechanism for raising and lowering the seat.

In this lesson, we'll discuss the ejection seat, the emergency escape sequencer, the emergency escape system wire harnesses, and the guillotine assembly.

Ejection seat

The F-22 ejection seat (fig. 3–1) is basically an F-16 Advanced Concept Ejection Seat (ACES) II that's integrated with the seat back of an F-15 ACES II. In addition, there are several other modifications and improvements. Each enhances escape system capability and improves maintainability. These modifications and improvements include the addition of an arm restraint system to prevent the pilot's arms from flailing. Other improvements include:

- A larger (50 cubic inches), regulated emergency oxygen cylinder.
- A fast-acting, centerline-mounted, mortar-deployed drogue parachute for improved seat stabilization.

- Arm/leg restraints.
- An initiation system.

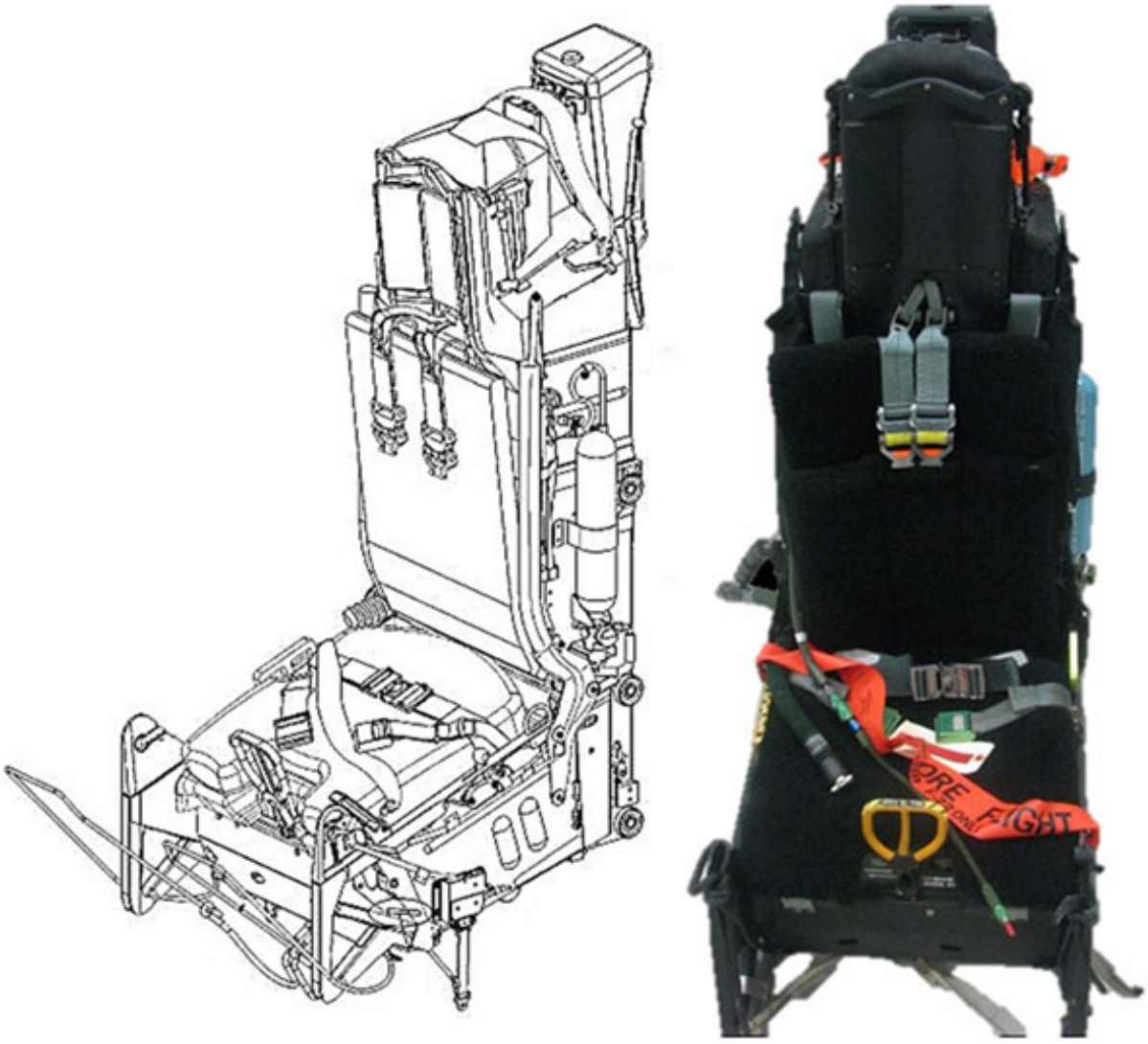

Figure 3–1. F-22 ACES II ejection seat.

Emergency oxygen system

The entire assembly for the emergency oxygen system consists of a 50 cubic inch cylinder and reducer pressurized to 1,800 psi. The pressure reducer includes the pressure gage, relief valve and rupture fitting, along with the manual activation pull (green) ring, cable, and release. It is important to note that if you suspect the cylinder is low on oxygen, you will have to purge and refill the cylinder. Topping off the oxygen bottle is not allowed.

Drogue parachute mortar assembly

The mortar assembly (fig. 3–2) consists of inner and outer mortar tubes. The outer tube attaches to the drogue parachute canister. The inner tube locks to the seat by spring clips on the drogue mounting bracket assembly. The inner tube contains the drogue parachute mortar cartridge. The cartridge fires by a signal from the sequencer provided at a time determined by mode 2, or mode 3 operations. The cartridge develops ballistic pressure to propel the outer tube upward pushing the drogue canister from the seat, deploying the drogue parachute.

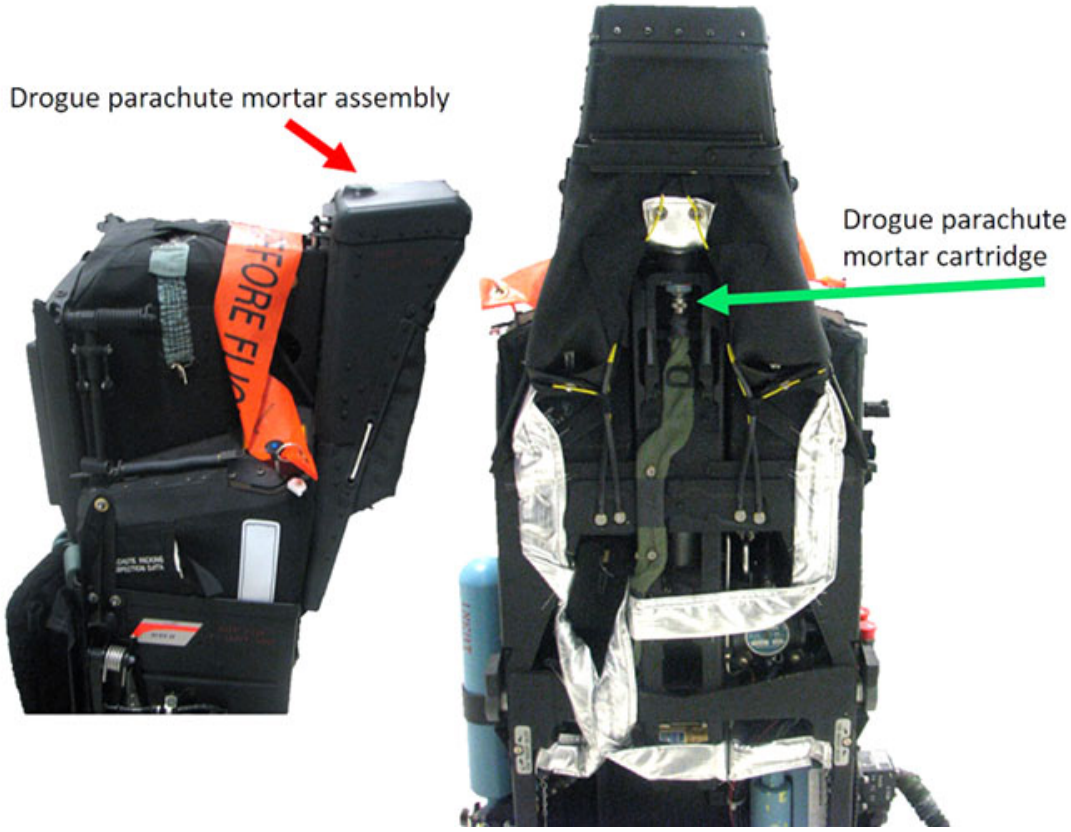

Figure 3–2. Drogue parachute mortar assembly.

Arm and leg restraint system

You are already familiar with the restraint system in the F-16 and F-15; the seat for the F-22 is the same except that it includes a restraint system for the arms and legs as well.

The arm and leg restraints activate during ejection only and help prevent the crewmember's arms and legs from flailing during ejection. The arm restraints consist of nets, stowed along the sides of the seat, and deployment lanyards that route through snubber boxes and attach to the aircraft floor. The leg restraints consist of lanyards that route along the aircraft leg wells, through seat mounted snubber boxes and attach to the aircraft floor.

Initiation system

Similar to how the F-16 D-ring handle pulls the pins on the JAU/8 initiators, the F-22 D-ring fires thermal batteries much like the emergency power supply. The thermal battery ejection initiators (2 each) contains a thermal battery which generates an electrical voltage after a firing pin strikes the thermal battery primer. The voltage starts the seat and canopy sequencing system when the single firing control handle is pulled.

The thermal batteries have a heat-sensitive paint stripe to indicate if the battery has been fired. Depending on the thermal battery manufacturer, the heat sensitive paint stripe is pink/light purple prior to firing the battery. The heat sensitive paint stripe is colored black/dark purple after firing the battery.

Emergency escape sequencer

The emergency escape sequencer, also known as the Emergency Escape Sequencing System (EESS) is an electronic assembly that uses redundant electronic microcontrollers to provide sequenced firing signals for the electronic explosive devices (EED) in the emergency escape system. The EESS is located in an aluminum box under the left console (fig. 3–3).

The EESS receives power from the thermal batteries on the seat, or the internal or external canopy jettison handle assemblies. The microcontrollers sequence the power to generate redundant fire signals to each independent circuit that initiates the canopy thruster, inertia reel gas generator EED, canopy rocket, seat catapult, and the central integrated processor (CIP) guillotine.

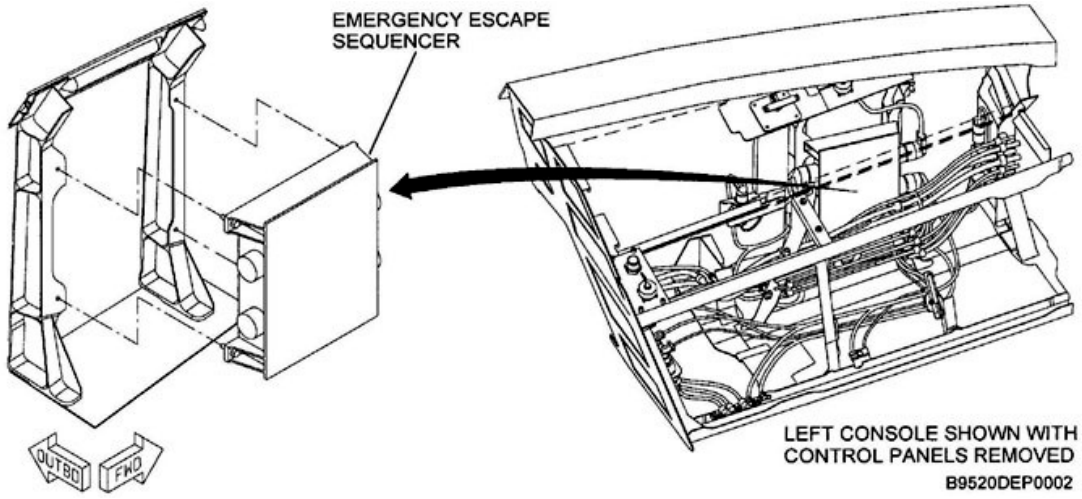

Figure 3–3. Emergency escape sequencer.

EESS wire harness

The EESS wire harnesses provide interface between the emergency escape sequencer, electrically actuated explosive devices, and system connectors with the EESS. The EESS wire harnesses fire the canopy thruster, the canopy rocket motor, and the guillotine assembly. The EESS wire harnesses are located and routed throughout the cockpit. The EESS wire harnesses are constructed of .22-gage twisted and shielded wire of various lengths and terminated with connectors.

Guillotine assembly

The guillotine assembly or cable cutter severs the input power lines to the CIP during the ejection sequence (fig. 3–4).This action will cause the CIPs' internally stored data to zeroize. The firing mechanism for the guillotine assembly uses redundant circuitry from the emergency escape sequencing system with independent EEDs.

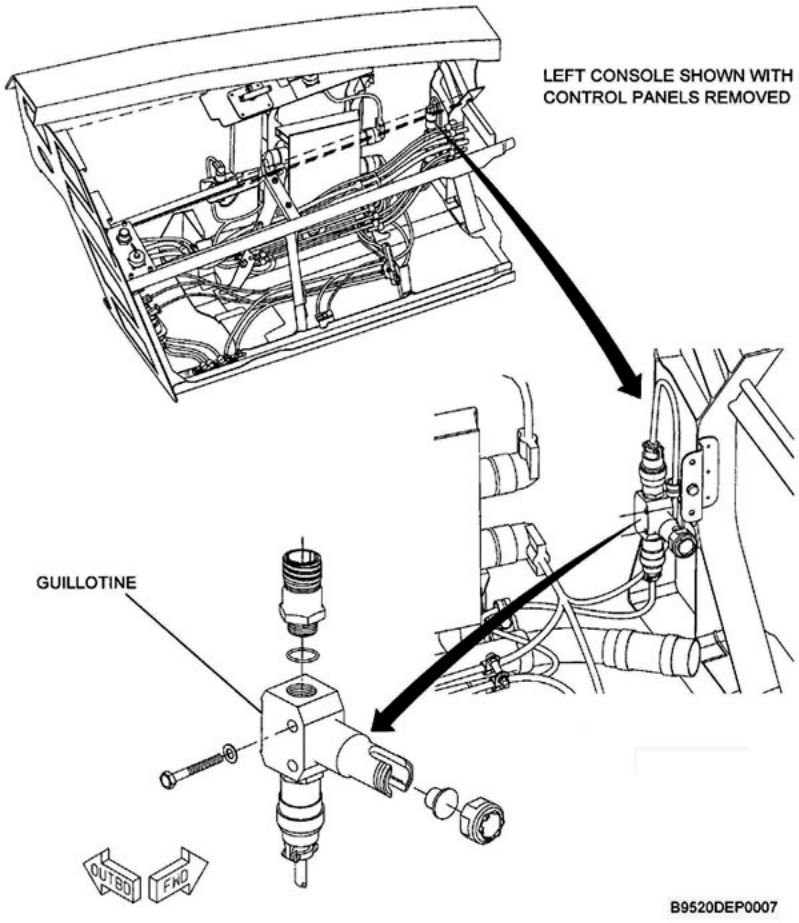

Figure 3–4. Guillotine assembly.

219. Theory of operation

The two principle crew escape system functions, canopy jettison and seat ejection are initiated and sequenced by an electronic sequencing system that is mechanically initiated by the action of pulling the ejection control handle. The sequencing system is fully redundant and completely self-contained. The sequencing system includes seat/canopy interlocks, emergency escape sequencer, and signal transmission lines. In the event of a ground emergency, the canopy can be jettisoned and the seat ejected. The danger area for ground canopy jettison is directly aft and right of the aircraft centerline about 60 feet away from the cockpit. Wind conditions affect the impact area and should be avoided if possible. Seat impact area will be forward of the aircraft up to 160 feet away depending on wind conditions.

Follow along with figure 3–5 to fully understand the sequence of events during an ejection. Actuation of the seat ejection control fires dual seat-mounted batteries that supply electrical energy to power the aircraft escape system. Pulling the firing control handle fires two thermal battery ejection initiators mounted on the forward surface of the seat and pulls the arm restraint release pins, which activate the arm restraints. The aircraft system initiates canopy removal and provides electrical energy to initiate the inertia reel and the rocket catapult.

When the catapult cartridge ignites, high-pressure gas is ported from the catapult chamber to the recovery sequencer, which initiates the thermal battery power supply. As the seat moves up the guide rails, the pitot's on both sides of the parachute assembly are deployed and exposed to the airstream. Pitot and base pressure input to the sequencer unit act on speed and pressure altitude transducers. The recovery sequencer interrogates the transducers and selects the appropriate recovery mode.

Movement of the seat up the guide rails activates the emergency oxygen supply, leg restraints, and severs the two initiation system electrical connections and aircrew connections through the guillotine assembly. As the seat approaches the top of the guide rails, the recovery sequencer start switch closes by impacting a striker on the guide rails, initiating the recovery sequencer microcontroller. The recovery sequencer performs time delay calculations based upon the base and total pressure readings from the speed and pressure transducers to determine the appropriate deployment mode.

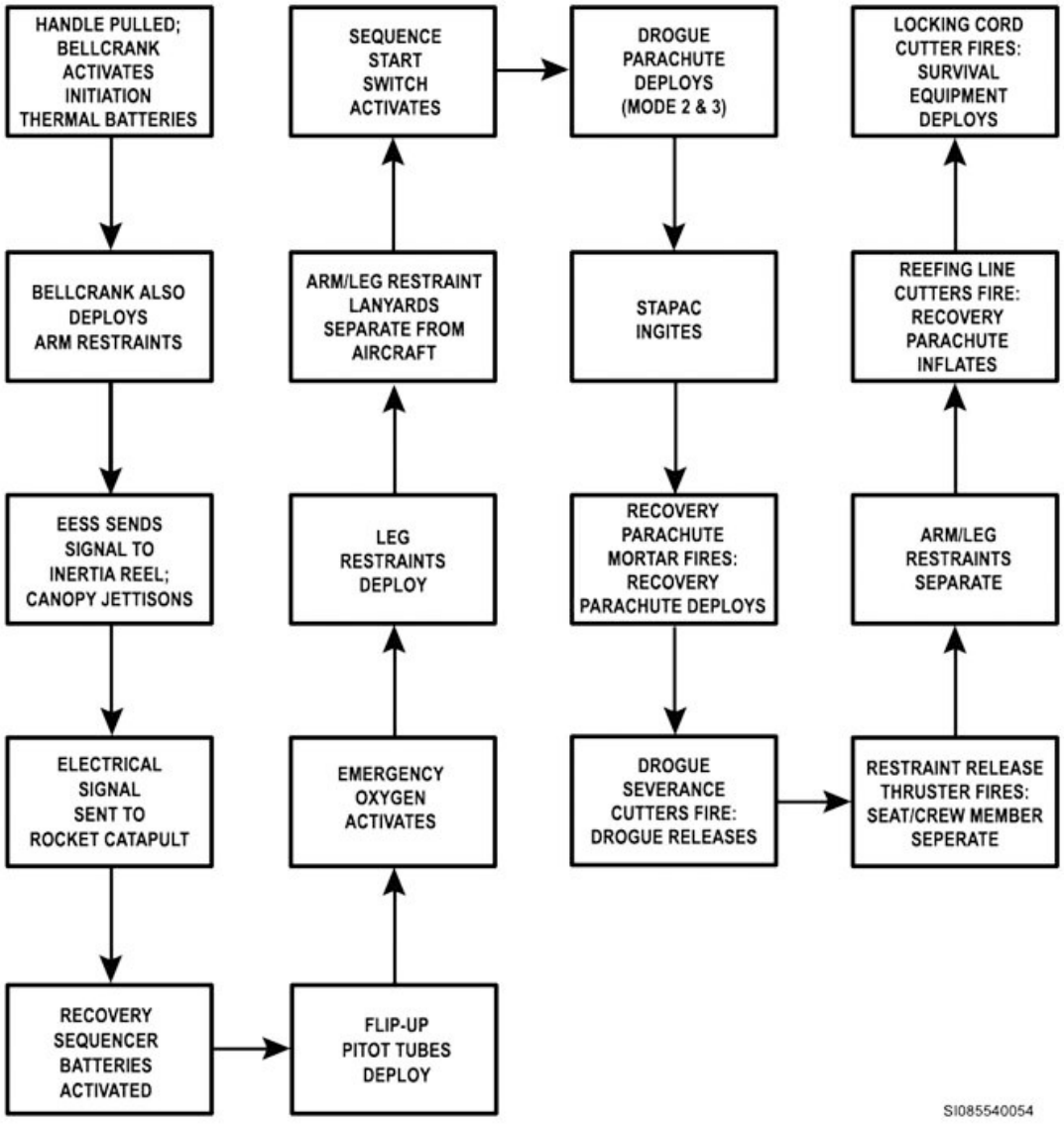

Figure 3–5. Ejection sequence of events.

The pitch stabilization control assembly (STAPAC) initiates as the seat clears the guide rails. The STAPAC keeps the seat in a proper pitch for a safe ejection. The fast-acting drogue parachute deploys, providing seat stabilization and deceleration during high-altitude/high-speed ejection conditions. The drogue parachute is located on the top aft portion of the seat, unlike where it is located on other ACES II seats.

The personnel parachute automatically deploys during the escape sequence. The manual system is mechanically safed while the seat is in the guide rails. In case the primary automatic system

malfunctions, the emergency manual parachute release handle on the right side of the seat can be pulled to manually activate the recovery parachute mortar to deploy the personnel parachute.

Modes of operation

There are some major differences between the modes of operation for the F-22 ACES II and the ACES II for the F-15, and F-16. Here are the three modes of operation for the F-22 ACES II and the backup system. In figure 3–6, you can see the differences between the modes.

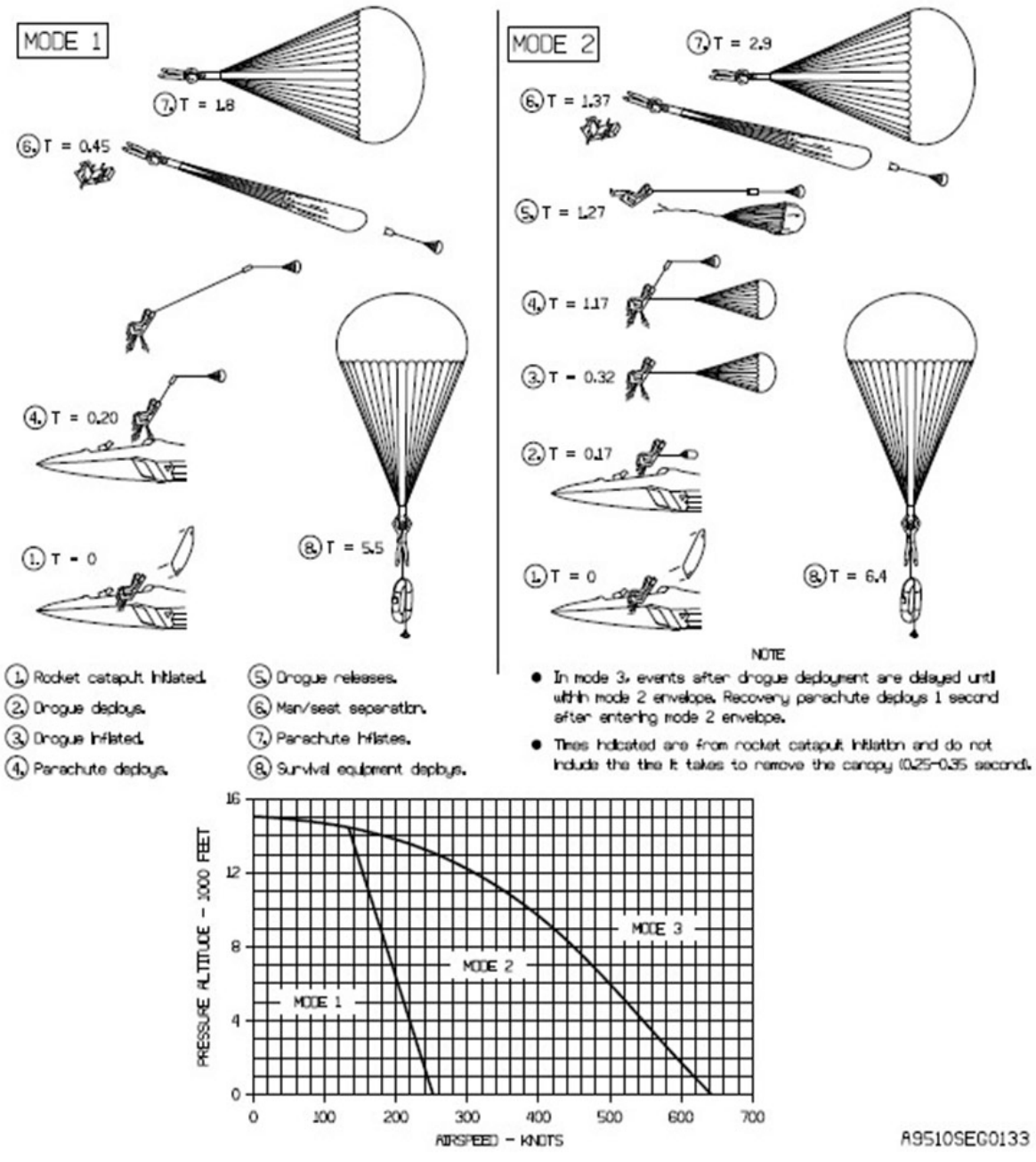

Figure 3–6. Time sequence and Mode envelopes.

Mode 1 operation

Mode 1 operation is selected for speeds of less than 250 knots at sea level (KEAS) and for altitudes of 0 to 15,000 feet. Mode 1 operates minus deployment of the drogue parachute. During Mode 1 operation, the mortar fires 0.037 seconds after sequence start detection. As the mortar propels the pilot chute and recovery parachute from the seat, the pilot chute deploys. As the pilot chute deploys, a 1.15-second time delay in each parachute reefing line cutter starts. Even though the drogue parachute does not deploy, the primary and secondary drogue severance cutters fire 0.182 seconds and 0.192 seconds, respectively, after sequence start switch detection. After a time interval of 0.282 seconds from sequence start switch detection, the restraint release thruster fires. The thruster fires to turn the bellcrank assembly. The bellcrank pulls locking pins that secure the lap belts, inertia reel straps, and leg restraints. As the recovery parachute deploys, the crewmember and survival kit are separated from the seat. At seat and person separation, the radio beacon remote switch activates. In Mode 1 deployment, the parachute reefing line cutters fire 1.15-seconds after the mortar, inflating the recovery parachute fully. If automatic survival kit deployment has been selected, the kit will open 4.0 seconds after seat and person separation. The survival kit opening, allows the life raft and rucksack to deploy.

Mode 2 operation

Mode 2 operation is selected for speeds in excess of 250 KEAS and for altitudes of 0 to 15,000 feet. During Mode 2 operation, extraction chute and drogue parachute deployment begins at the same time the sequence start switch is detected. Figure 3–7 shows the components for the drogue assembly. A signal from the sequencer fires the drogue mortar, propelling the drogue canister and deploying the drogue parachute. A signal from the sequencer fires the recovery parachute mortar 1.00 seconds after detecting the sequence start switch. The primary and secondary drogue severance cutters fire 0.182 seconds and 0.192 seconds, respectively, after sequence start switch detection. Recovery parachute deployment and seat and person separation then occurs as described for Mode 1.

Mode 3 operation

Mode 3 operation depends on speeds and altitude in excess of Mode 2. The sequence of events during Mode 3 operation occurs as described for Mode 2 with the following *exceptions*: deployment of the pilot chute and recovery parachute, firing of the drogue severance cutters, and seat and person separation is delayed until Mode 2 speed and altitude conditions are met.

Parachute deployment/seat and person separation backup system

In the event an automatic recovery sequence is not completed and/or started, a backup mortar cartridge initiates the parachute mortar via manual mode in the following manner. The crewmember initiates the manual mode by pulling up on the EMERGENCY MANUAL CHUTE handle, activating a thermal battery via a cable assembly that releases a firing pin that strikes a primer in the emergency power supply battery, resulting in an electrical pulse that ignites the backup mortar cartridge, ballistically deploying the parachute.

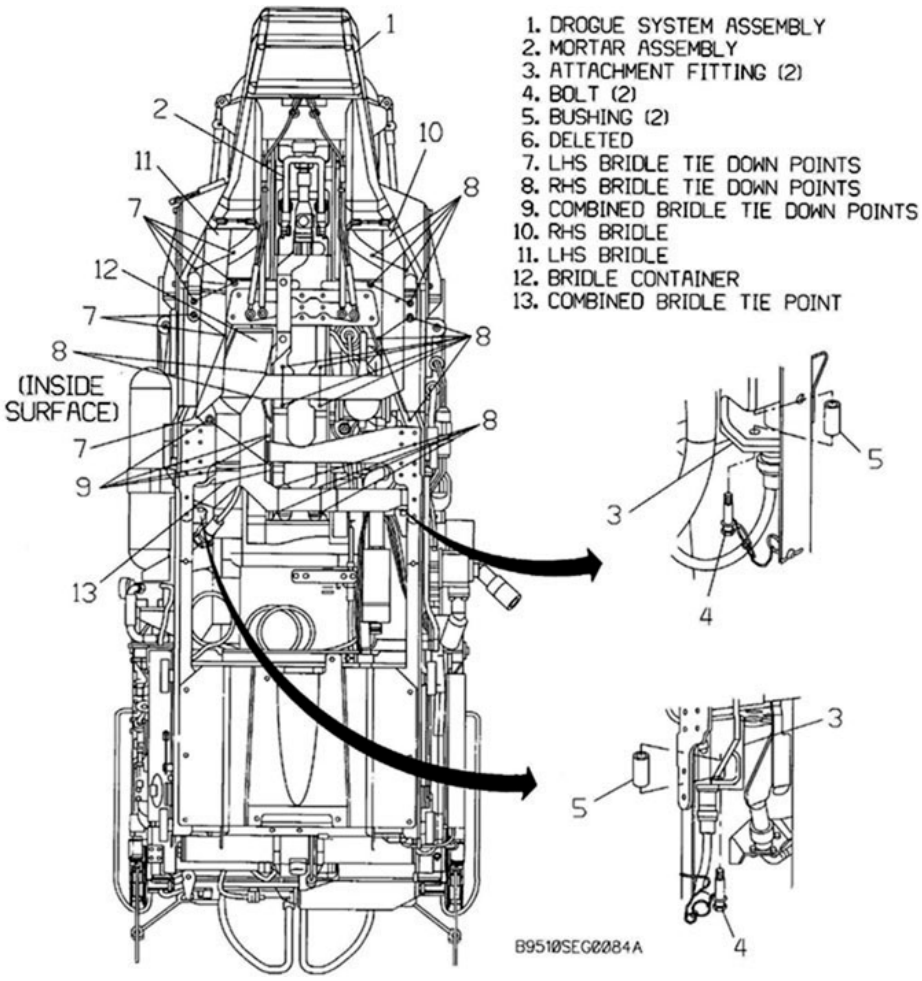

Figure 3–7. Drogue assembly.

Self-Test Questions

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

218. Component description

1. Match the F-22 escape system description listed in column B with its component in column A by writing the correct letter in the blank space provided. Descriptions in column B may be used once, more than once, or not at all.

Column A	*Column B*
____ (1) Ejection seat.	a. Centerline-mounted.
____ (2) Emergency oxygen cylinder.	b. Shares F-16 and F-15 designs.
____ (3) Fast-acting drogue parachute.	c. Interfaces egress components.
____ (4) Emergency escape sequencer.	d. 50 cubic inches.
____ (5) EESS wire harness.	e. Receives power from thermal batteries.
____ (6) Guillotine assembly.	f. Severs input power lines.

2. What EESS internal components sequence the power to generate redundant fire signals to each independent circuit that initiates the canopy thruster, inertia reel gas generator electronic explosive device, canopy rocket, seat catapult and the central integrated processor guillotine?

3. How are the EESS wire harnesses constructed?

219. Theory of operation

1. What powers the recovery sequencer's thermal battery power supply?

2. What components activate when the seat moves up the guide rails during ejection?

3. During a Mode 1 ejection, when does the fast-acting drogue parachute and the drogue severance cutters fire?

4. During Mode 1 ejection and if automatic survival kit deployment has been selected, how long after seat and person separation will the survival kit open?

5. During a Mode 2 ejection, when does the fast-acting drogue parachute and the drogue severance cutters fire?

6. What conditions must be present for the recovery sequencer to select Mode 3 operation during an ejection?

7. How can the parachute mortar fire in the event an automatic recovery sequence is not completed and/or started during freefall of the ejection seat?

3–2. Canopy System

The F-22 Canopy is similar to the F-16 in many ways. For example; it uses a rocket during jettison and it is constructed of high-temperature polycarbonate and provides the pilot with a high degree of visibility and optical clarity allowing compatibility with the HUD, helmet-mounted display, and night vision goggles. The canopy system contains the transparency and required supporting structure, actuator, mechanisms and latches allowing opening and closing; the latches keep the canopy secured and pressurized under all operating and design loading conditions. The canopy can be jettisoned clear

of the cockpit and the path of the ejection seat without delay when actuated in all flight attitudes and speeds within the escape system envelope and at zero speed and altitude.

The canopy assembly has three modes of operation.

- Normal: the canopy is electrically operated and controlled by either an internal or external switch.
- Manual drive backup: consisting of a crank and flex shaft unit in the nose wheel well that enables the ground crew to operate the actuator when aircraft power is not available or if the canopy control system fails.
- Emergency canopy jettison: activated by an internal or external canopy jettison handle.

The F-22 canopy jettison subsystem provides the ability to get rid of the canopy in an emergency situation during flight or on the ground. Emergency canopy jettison may be accomplished by means of the internal canopy jettison handle (located in the cockpit on top of the left console) or using the external canopy jettison handle (located under a frangible panel on the left side weapons bay) as seen in figure 3–8. As you hopefully know by now, the canopy jettison system will also activate automatically as part of pilot seat ejection by pulling the ejection control handle.

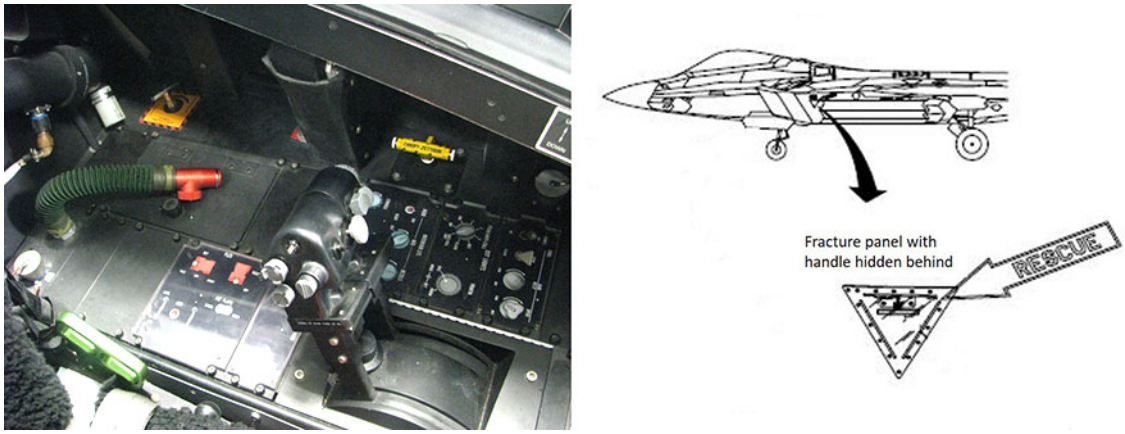

Figure 3–8. Canopy jettison handles.

220. Component description

Canopy assembly

The canopy is a polycarbonate transparency in a titanium frame that weighs approximately 360 pounds. The transparency consist of two sheets of polycarbonate that is sandwiched in between two layers of optical glass and designed to flex in the event of bird strike.

If you work the F-22 system at your base, you should know by now that when the indium tin oxide (ITO) wears off over time, this increases the radar signature of the F-22 and the canopy is usually the first thing to replace that would improve the stealth ability of the aircraft. The canopy is also resistant to chemical/biological and environmental agents and has been successfully tested to withstand the impact of a four-pound bird at 350 knots. Its design also protects the pilot from lightning strikes.

The 3/4" polycarbonate transparency is actually made of two 3/8" thick sheets that are heated and fusion bonded (the sheets actually meld to become a single-piece article) and then drape forged. Like the F-16 canopy, for comparison, is made of laminated sheets. A laminated canopy generally offers better bird strike protection and when flying at lower altitudes this is a must have feature.

The transparency happens to be the largest single piece of monolithic polycarbonate material formed in any industry because of its incredible strength and light weight, it is usually used in high end eye

glasses and bullet proof car windows. Because of its strength, there is zero chance a pilot can eject without the canopy jettison subsystem activating first.

The canopy jettison subsystem contains the following:

- Canopy thruster.
- Canopy rocket motor.
- Internal canopy jettison-handle assembly.
- External canopy jettison-handle assembly.

Canopy thruster

The canopy thruster is a pyrotechnic device which, during normal operation, acts as a fixed structural element between the canopy actuator and the canopy frame (fig. 3–9). During canopy jettison the thruster fires, which forces the canopy aft to disengage the latches from their receptacles. After 2.0 inches of thruster extension, the thruster separates into two segments and disconnects the canopy from the actuator. To prevent canopy rebound and latch reengagement, an energy-absorbing feature has been designed into the aircraft hinge assembly.

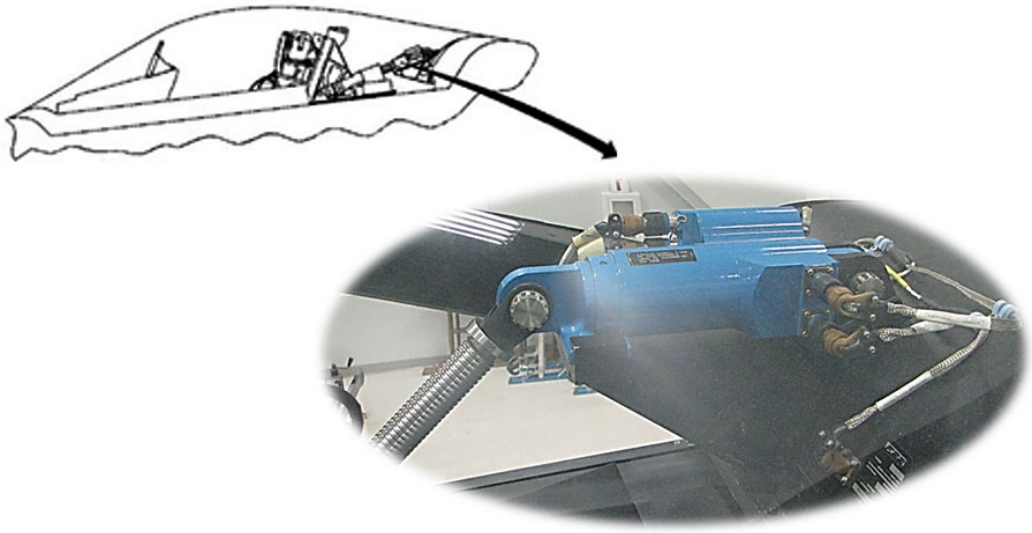

Figure 3–9. Canopy thruster.

Canopy rocket motor

The canopy rocket is located at the forward end of the canopy, which allows easy access and inspection (fig. 3–10). The rocket motor is a two-chamber design that uses propellant grain. A common manifold joins the two chambers. The rocket provides the rotational force to lift the canopy off the aircraft. Rocket ignition is keyed to thruster position and initiates after 1.2 inches of thruster extension. This feature ensures that the latches have fully released prior to rocket ignition. High-pressure gases, produced by one or both of the EEDs, activate the igniter. Hot ignition particles and gases (produced by the igniter) fill the propellant grain, which effects prompt and uniform ignition. The pressure within the rocket rises and produces the required thrust to jettison the canopy.

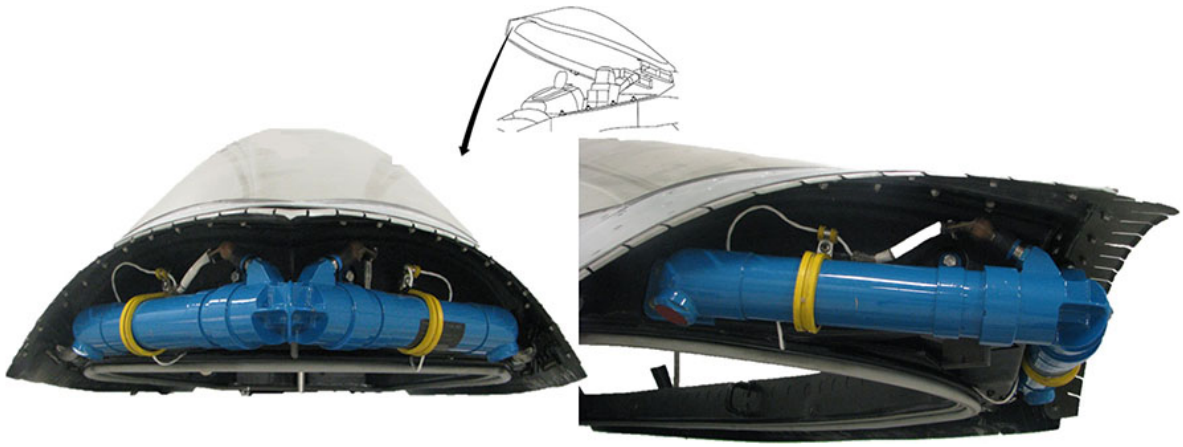

Figure 3–10. Canopy rocket motor.

Internal canopy jettison handle assembly

The internal canopy jettison handle provides a means for the crewmember to jettison only the canopy assembly during emergency situations. The internal canopy jettison handle is located on top of the left console in the cockpit (fig. 3–11).

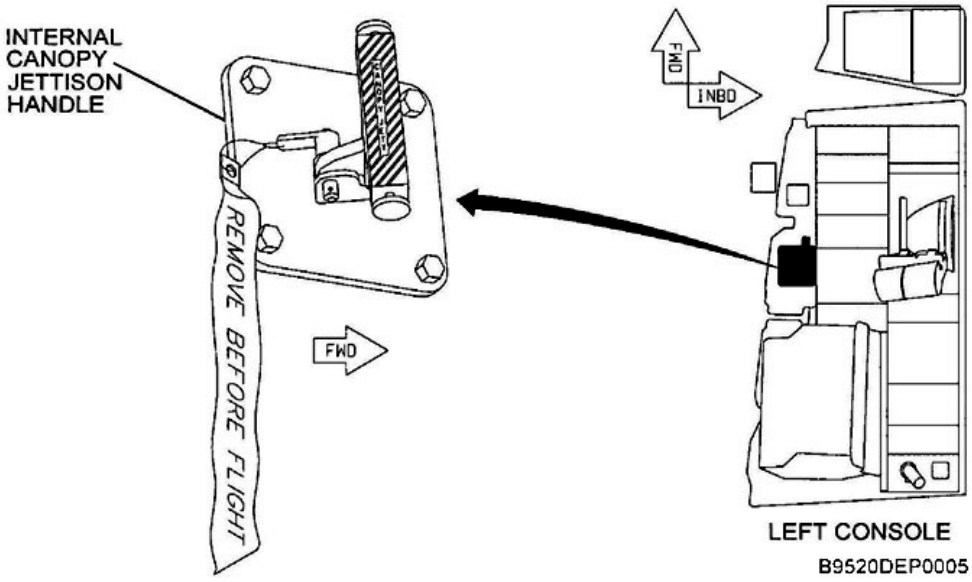

Figure 3–11. Internal canopy jettison handle.

External canopy jettison handle assembly

The external canopy jettison handle assembly allows ground crews to jettison the canopy assembly during ground emergency situations. External canopy jettison is initiated by breaking the frangible panel, grasping the handle and pulling the lanyard approximately six inches. The external canopy jettison handle is located on the left intake, forward of the side weapons bay door (fig. 3–12). The external canopy jettison handle assembly consists of a handle, interconnect cable, thermal battery, and a thermal battery mount assembly.

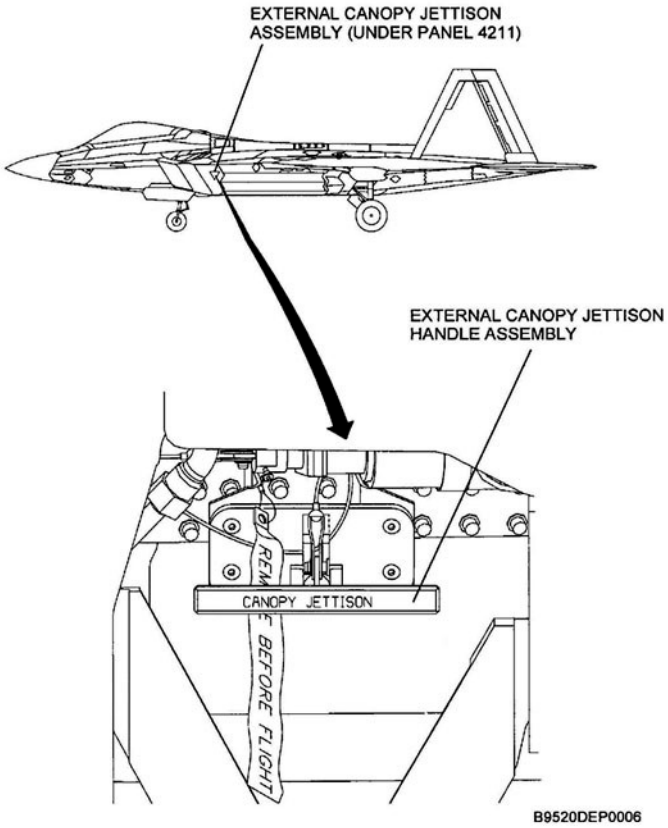

Figure 3–12. External canopy jettison handle.

221. Canopy theory of operation

Refer back to the flow chart illustrated in figure 3–5 for this discussion. The F-22 canopy can be jettisoned automatically as part of the pilot ejection sequence. It can also be jettisoned manually (upon the command of the pilot) by using the internal canopy jettison T-handle or by ground personnel using the external canopy jettison handle mounted under a frangible panel outboard of the left intake. Think of the frangible panel as a very fragile cover that can be shattered with a gentle punch, revealing the jettison handle.

Pulling either of the handles will activate that handle's initiation thermal battery. The battery sends an electrical signal to the EESS, and the EESS generates an electrical pulse to the canopy thruster, which mounts between the canopy actuator and canopy frame. The thruster pushes the canopy aft to the overtravel position and shears through over travel brackets. This is the initial movement of the canopy during jettison. After 1.5 inches of thruster extension, energy-absorbing blocks work with thruster damping to prevent latch reengagement during canopy jettison. After 2.0 inches of thruster extension, the thruster separates into two segments, which disconnects the canopy from the actuator. Canopy jettison occurs in two distinct motions. From the down-and-locked position, initial canopy movement is aft (approximately 2.5 inches) followed by a rotation around the aft hinge line of the canopy until canopy separation (after approximately 40 degrees of rotation). The canopy jettison system is fully self-contained and requires no aircraft power for operation. Crew chiefs and other career fields often have the misunderstanding that aircraft power is required for all systems. This is why the egress system uses thermal batteries, to supply an independent power source, available on demand for emergencies. During the 1.5 inch travel of the thruster, the canopy rocket motor fires to rotate the canopy upward. As the canopy passes the cam release position, the canopy is free to disengage from the hinge. The rocket motor provides the force to rotate the canopy up and off the aircraft. The rocket motor is located at the forward end of the canopy in such a way that rocket blast and debris are not

directed into the cockpit enclosure. Rocket motor ignition is keyed to thruster position and initiates after 1.2 inches of thruster extension. This feature ensures that the canopy latches have fully released prior to rocket ignition. The two rocket motors normally fire by electrical impulses. If only one fires, the burn will immediately detonate the other through the open manifold, and both will provide sufficient force to jettison the canopy in all conditions. When jettisoned under static conditions on the ground, the canopy travels approximately 60 feet behind the aircraft just to the right of the aircraft centerline.

Self-Test Questions

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

220. Component description

1. Match the F-22 canopy jettison system component listed in column A with its description in column B by writing the correct letter in the blank space provided. Descriptions in column B may be used only once.

Column A	*Column B*
____ (1) Canopy thruster.	a. Two chamber design.
____ (2) Canopy rocket motor.	b. Fixed structural element between canopy actuator & canopy frame.
____ (3) Internal canopy jettison handle.	c. Ground crew method of canopy jettison.
____ (4) External canopy jettison handle.	d. Under frangible panel.
	e. Separates into two segments.
	f. Common manifold.
	g. Crewmember method of canopy jettison.
	h. Produces required thrust to jettison canopy.
	i. Forces canopy aft to disengage latches.

2. After how many inches of thruster extension does the thruster separate into two segments and disconnect the canopy from the actuator?

3. How is the canopy rocket motor initiated?

4. What makes up the external canopy jettison handle assembly?

221. Canopy theory of operation

1. Explain the sequence of events between pulling either canopy jettison handle assembly and the initial movement of the canopy.

2. How much aircraft power is required for canopy jettison system operation?

3. What canopy jettison system feature ensures the canopy latches fully released prior to rocket ignition?

4. Under static conditions, when either canopy jettison handle is pulled, where does the canopy travel?

Answers to Self-Test Questions

218

1. (1) b.
   (2) d.
   (3) a.
   (4) e.
   (5) c.
   (6) f.
2. Microcontrollers.
3. .22-gage twisted and shielded wire of various lengths and terminal connectors.

219

1. High-pressure gas from the catapult chamber.
2. The emergency oxygen supply, leg restraints, the guillotine assembly, and the recovery sequencer start switch which, in turn, activates the recovery sequencer.
3. The drogue parachute does not deploy, but the primary and secondary drogue severance cutters are fired 0.182 seconds and 0.192 seconds, respectively, after sequence start switch detection.
4. 4.0 seconds.
5. The drogue parachute is fired immediately after sequence start switch detection and the primary and secondary drogue severance cutters are fired 0.182 seconds and 0.192 seconds, respectively, after sequence start switch detection.
6. Speeds in excess of 250 KEAS and altitudes over 15,000 feet.
7. The crewmember initiates the manual mode by pulling up on the EMERGENCY MANUAL CHUTE handle, activating a thermal battery via a cable assembly that releases a firing pin that strikes a primer in the emergency power supply battery, resulting in an electrical pulse that ignites the backup mortar cartridge, ballistically deploying the parachute.

220

1. (1) b, e, i.
   (2) a, f, h.
   (3) g.
   (4) c, d.
2. 2.0 inches.
3. By high-pressure gases produced by one or both of the EEDs.
4. It consists of a handle; interconnect cable, thermal battery and a thermal battery mount assembly.

221

1. Pulling either handle activates that handle's initiation thermal battery. The battery sends an electrical signal to the EESS, and the EESS generates an electrical pulse to the canopy thruster, which is mounted between the canopy actuator and canopy frame. The thruster pushes the canopy aft to the overtravel position and shears through overtravel brackets.
2. The canopy jettison system is fully self-contained and requires no aircraft power for operation.
3. Rocket motor ignition is keyed to thruster position and is initiated after 1.2 inches of thruster extension.
4. Approximately 60 feet behind the aircraft.

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

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

53. (218) What should be done if the F-22 oxygen system pressure gage reads below limits?
    a. Completely purge and refill the cylinder.
    b. Replace the cylinder and purge the old one to turn into supply.
    c. Top off the cylinder to proper pressure for the applicable climate temperature.
    d. Place the cylinder in a warm area and allow pressure to expand to an acceptable level.

54. (218) How is the F–22 drogue parachute deployed?
    a. Ballistic pressure from the drogue gun cartridge propels a slug that pulls out the extraction and drogue chutes.
    b. Ballistic pressure from the drogue gun cartridge propels a slug, ejecting the chute from a canister.
    c. Ballistic pressure from a mortar cartridge that propels the outer tube, pushing the chute out of a canister.
    d. As the seat travels upwards, a lanyard connected to the aircraft is pulled, releasing the extraction and drogue chutes.

55. (218) What begins the ejection sequence on an F-22?
    a. Gas pressure from the ejection initiator.
    b. Gas pressure from the ballistic pressure initiator.
    c. Bleed off of electrical voltage from the recover sequencer.
    d. Electrical voltage produced from the thermal battery initiators.

56. (218) Which F-22 escape system component provides sequenced firing signals for the electronic explosive devices (EED)?
    a. Emergency Escape Sequencing System (EESS).
    b. Central integrated processor (CIP) guillotine.
    c. Analog recovery sequencer.
    d. Digital recovery sequencer (DRS).

57. (218) The F-22’s rocket motor fires during canopy jettison through
    a. hot gas pressure sent from the canopy jettison hose system.
    b. a detonation transfer wave sent by the shielded mild detonating cord (SMDC).
    c. a detonation transfer wave sent by the detonation transfer assembly (DTA).
    d. impulses sent through the Emergency Escape Sequencing System (EESS) wire harness.

58. (219) What is the danger area if the canopy is jettisoned on the F-22 during a ground emergency?
    a. 60 feet away, aft and to the right of the aircraft centerline.
    b. 200 feet away aft and to the right of the aircraft centerline.
    c. 60 feet away aft and to the left of the aircraft centerline.
    d. 200 feet away aft and to the left of the aircraft centerline.

59. (219) During an F-22 ejection, at what speed and altitude is Mode 1 selected?
    a. Less than 250 knots, less than 15,000 feet.
    b. Greater than 250 knots, less than 15,000 feet.
    c. Less than 250 knots, greater than 15,000 feet.
    d. Greater than 250 knots, greater than 15,000 feet.

60. (219) During a Mode 2 ejection on the F-22, what begins the same time the sequence start switch is detected?
    a. Primary drogue severance cutter fires.
    b. Recovery parachute mortar fires.
    c. Drogue parachute deploys.
    d. Vernier rocket activates.

61. (219) During an F-22 Advanced Concept Ejection Seat (ACES) II Mode 3 ejection, when does the pilot's chute and recovery parachute deploy?
    a. When the speed and altitude conditions of Mode 1 are met.
    b. When the speed and altitude conditions of Mode 2 are met.
    c. 0.037 seconds after sequence start switch detection.
    d. 1.00 seconds after sequence start switch detection.

62. (220) During normal operation, which F–22 canopy jettison component acts as a fixed structural element between the canopy actuator and the canopy frame?
    a. Canopy thruster.
    b. Guillotine assembly.
    c. Canopy rocket motor.
    d. Canopy actuator release bolt.

63. (220) Which F-22 canopy jettison feature ensures full latch release prior to the rocket motor's ignition?
    a. The pressure within the rocket rises and produces the required thrust to jettison the canopy.
    b. High-pressure gases, produced by one or both of the electro-explosive devices (EED), activate the igniter.
    c. The rocket motor is keyed to thruster ignition and is initiated after 1.2 inches of thruster extension.
    d. The canopy disconnects once 2.0 inches of thruster extension separates the thruster into two segments.

64. (220) Where inside the F-22 cockpit is the internal canopy jettison handle located?
    a. Under the left canopy sill.
    b. On top of the left console.
    c. Under the right canopy sill.
    d. On top of the right console.

65. (220) Approximately how far is the lanyard pulled when externally initiating an F-22 canopy jettison?
    a. 6 feet.
    b. 8 feet.
    c. 6 inches.
    d. 8 inches.

66. (221) Which F-22 components are actuated by the internal or external canopy jettison handles to initiate the canopy jettison system?
    a. Ejection cartridges.
    b. Thermal batteries.
    c. M99 initiators.
    d. M53 initiators.

67. (221) During F-22 canopy jettison, how many inches does the canopy travel aft before the canopy rotates around the aft hinge line of the canopy?
    a. 2.5.
    b. 2.0.
    c. 1.5.
    d. 1.2.

Glossary of Abbreviations and Acronyms

°F	degree Fahrenheit
ACES	Advanced Concept Ejection Seat
CARB	canopy actuator release bolt
CDC	career development course
CIP	central integrated processor
CTK	composite tool kit
DTA	detonation transfer assembly
ECRL	emergency canopy release line
EED	electronic explosive device
EESS	Emergency Escape Sequencing System
FI	fault isolation
FOD	foreign object damage
FWD	forward
IFF	identification, friend or foe
ITO	indium tin oxide
KEAS	knots at sea level
LRU	line replaceable unit
psi	pounds per square inch
R	receptor
SMDC	shielded mild detonating cord
ST	shock tube
STAPAC	pitch stabilization control assembly
STR	shock tube receptor
TO	technical order
U&TW	utilization and training workshop

Student Notes

Student Notes

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