United States Army Warfighting Center
Fort Rucker, Alabama
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STUDENT HANDOUT

TITLE: CH-47D ENGINE CONTROL SYSTEM

FILE NUMBER: 011-2109-3

PROPONENT FOR THIS STUDENT HANDOUT IS:

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CH-47D ENGINE CONTROL SYSTEM

STUDENT HANDOUT

TERMINAL LEARNING OBJECTIVE (TLO):

Action: Describe components, operational characteristics, functions, and limitations of the CH-47D Engine Controls System.

Conditions: In a classroom, given a CH-47 Engine N_1 Control Trainer, CH-47 Engine Control Trainer, and a student handout.

Standards: Correctly answer in writing, without reference, six of eight questions pertaining to components, operational characteristics, limitations, functions, and malfunctions of the CH-47D T55−L−712 Engine Controls, In Accordance With (IAW) TM 1−1520−240−10 and the student handout.

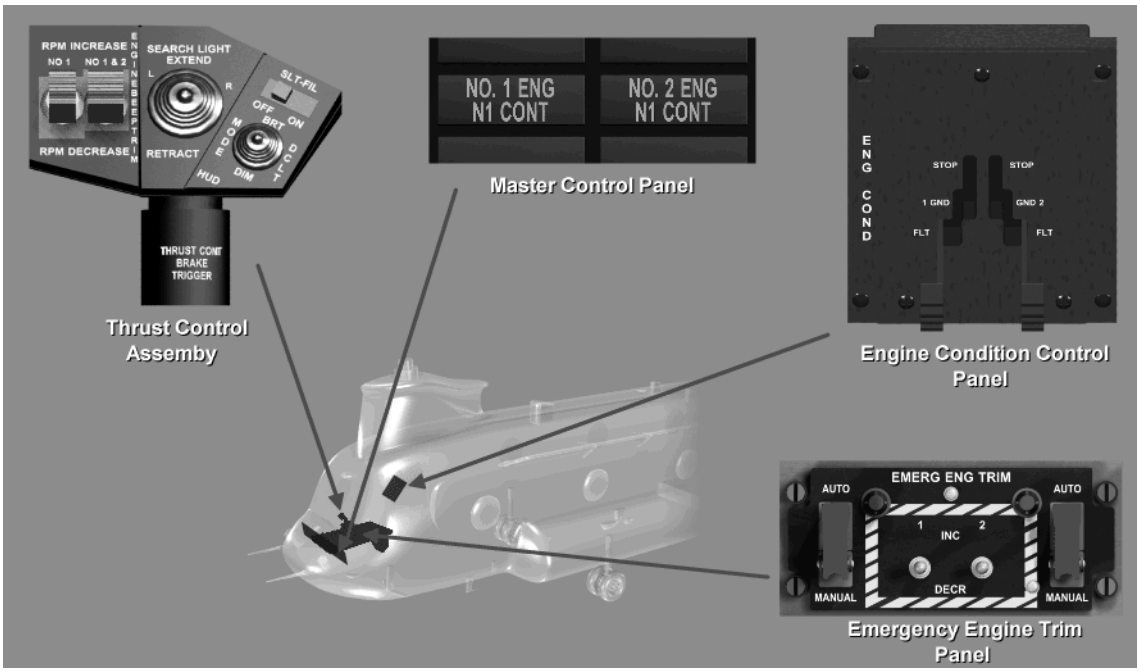
Safety Requirements: None.

Risk Assessment Level: Low.

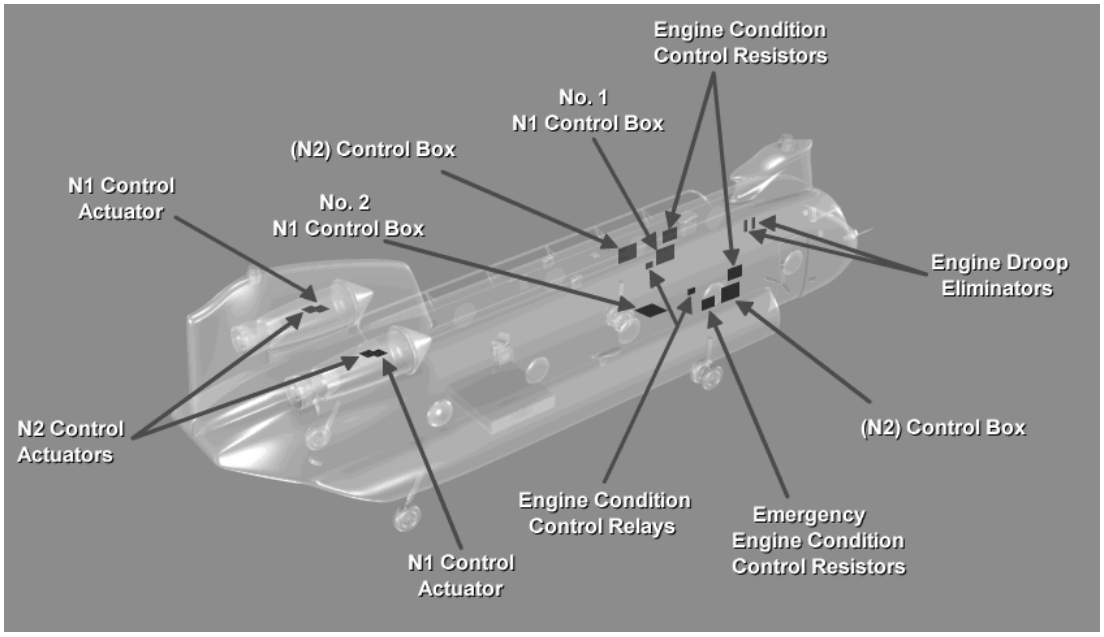
Environmental Considerations: None.

Evaluation: Each student will be evaluated on this block of instruction during the first written examination. This will be a criterion type examination requiring a GO on each scored unit. You will have 90 minutes for the exam.

1. **Learning Step/Activity 1 − Describe components, operational characteristics, functions, and limitations of the Engine Control System.**

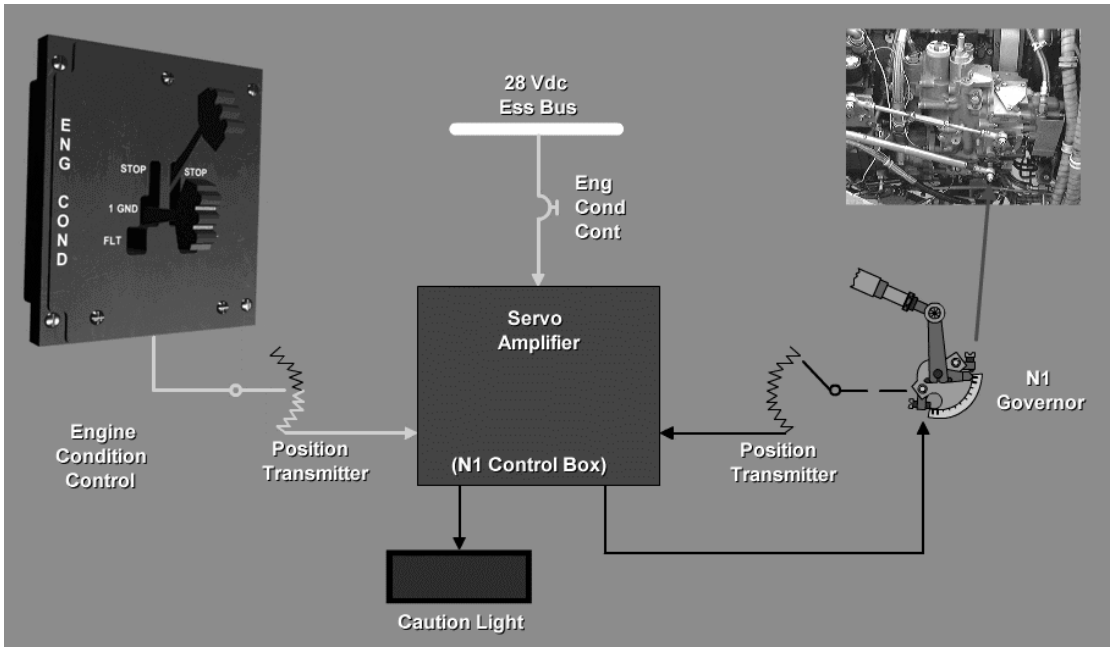


a. A separate control system is provided for each engine.

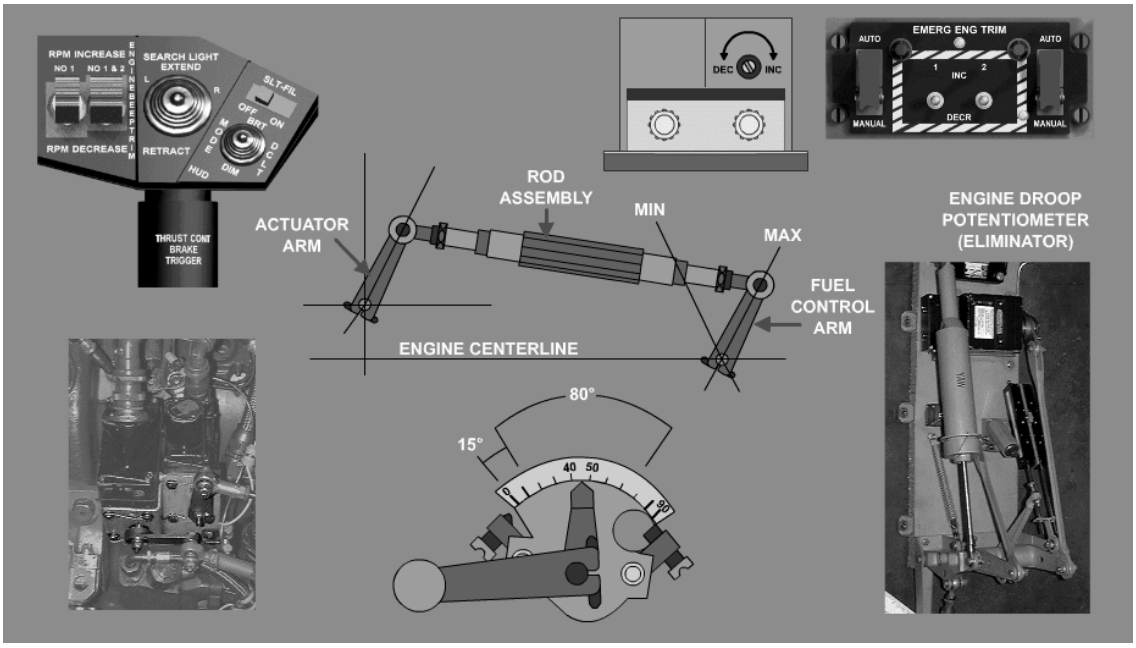


b. It is an electromechanical system consisting of cockpit controls and fuel controls on the engines.

(1) Gas producer (N_1) controls to control the N_1 governor.



(2) Power turbine (N_2) controls to control the N_2 governor.



2. Learning Step/Activity 2 − Describe components, operational characteristics, functions, and limitations of the N_1 Control System.

a. Gas producer (N_1) controls.

(1) Engine Condition Levers (ECL). The ECL's are located on the overhead panel. These levers position the N_1 governor to set the maximum N_1 speed. (The N_1 governor will override the N_2 governor)

Engine Condition Control Panel

(a) A friction brake resists the movement of the ECL (4 to 5 pounds).

(b) Position transmitter (synchronize) mechanically linked to the ECL sends the position to the N_1 control box.

(c) Engine acceleration rate from ground to flight is determined by the rate of movement of the ECL.

(2) ECL Positions.

(a) STOP.

1) Closes the fuel valve in the fuel control unit to shut the engine down.

2) If the engine fails to stop, the engine fuel valve must be closed.

(b) GND (ground).

1) Sets the N_1 governor for the proper ground idle speed, **60** to **63**%.

2) The engine should accelerate to idle speed within **45** seconds.

(c) FLT (Flight).

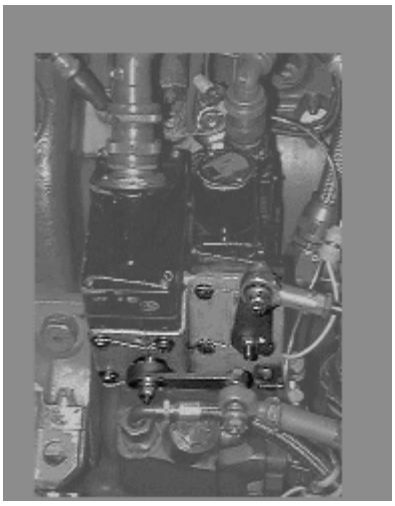
1) Advance the ECL slowly to prevent over-torque.

2) Engine will accelerate to minimum beep rotor rpm.

3) Watch the rotor rpm, be prepared to move the ECL to ground to prevent rotor rpm exceeding limits.

4) The engine will now respond to the N_2 controls.

OPERATORS MANUAL CAUTION: When the (ECL) Engine Condition Lever is placed to GND during the start sequence, the N_1 actuator could inadvertently go beyond the ground position. The respective Engine N_1 CONT capsule will illuminate. However, ignition will still occur if the start switch is moved to START, thus resulting in a possible engine runaway. **Pg: 2−3−2.**



(3) Gas producer N_1 actuator. Located on each engine. The actuator positions the N_1 lever on the fuel control when the ECL is moved.

(a) Reversible DC motor.

(b) A magnetic brake holds the actuator in position when electrical power is removed.

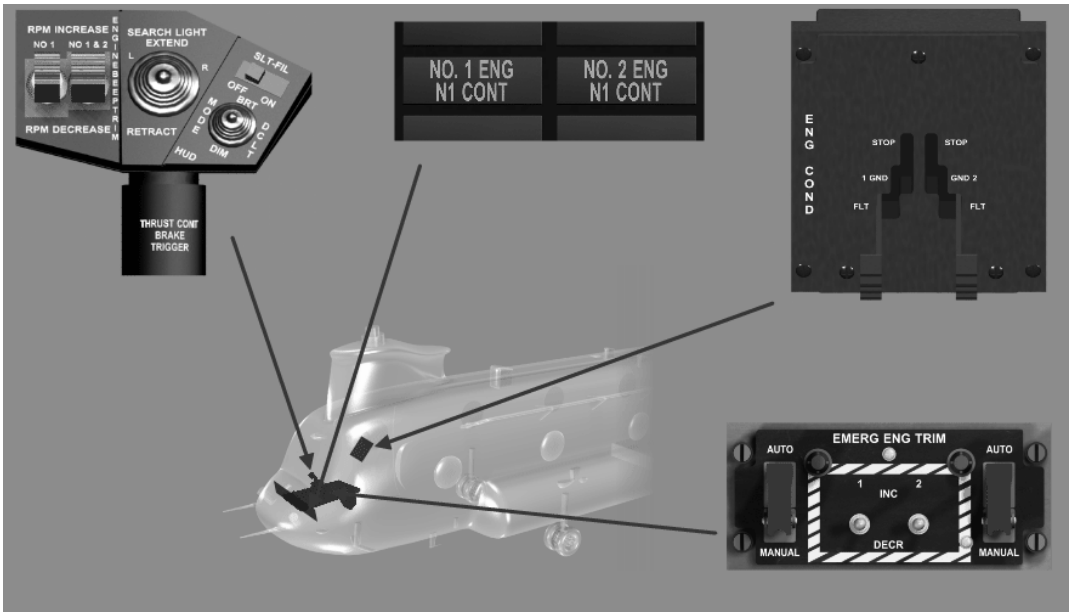
(c) The position transmitter provides the actuator position signal to the N_1 control box.

(4) Gas producer N_1 control box. Located above the seat rails at Sta. 200.

(a) Receives the position signals from the ECL and actuator.

(b) Provides electrical power to the actuator when the ECL and actuator positions are **not** the same.

(c) Controls the ENG N_1 CONT caution light.



(5) ENG N_1 CONT caution lights. These lights will illuminate when:

(a) The ECL and actuator are in transit between detent positions, STOP − GND − FLT.

(b) The ECL is not in full detent position.

(c) Some component failure.

(6) Topping stops. The topping stops allow engine topping checks to be made without entering the emergency power range.

(a) During topping.

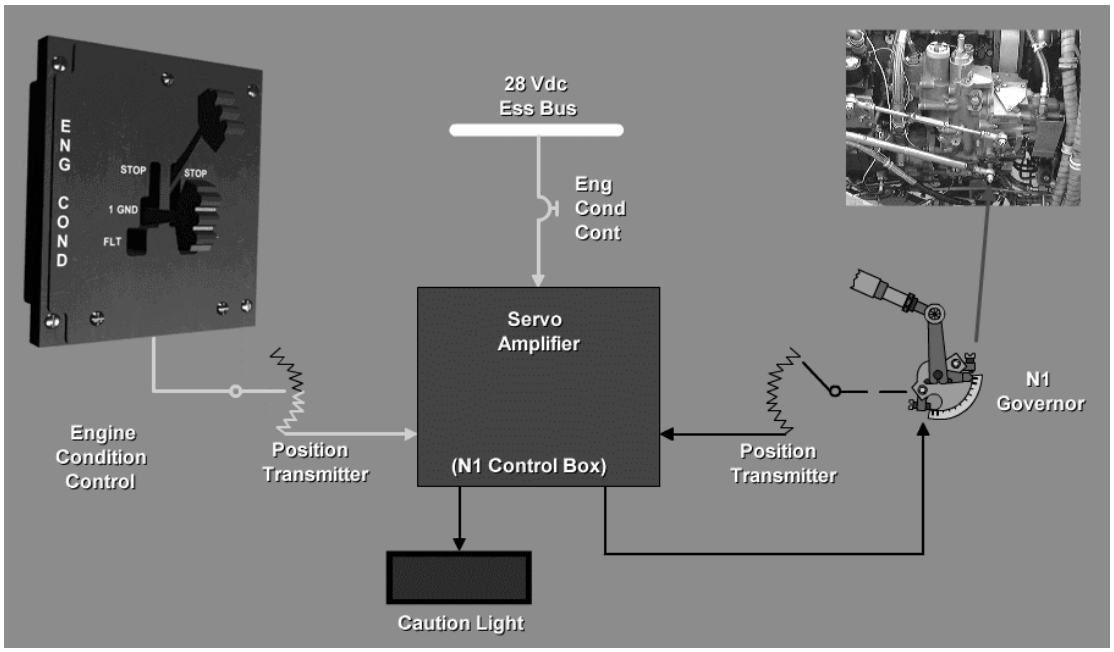
1) The stops are installed on the fuel control N_1 governor quadrant.

2) This limits N_1 speed.

(b) After topping checks are complete.

1) Stops **must be removed** from the fuel control and stowed in the cockpit.

2) If stops are not in the cockpit, ensure that they are not on the engine.



b. Operation of the N_1 controls.

(1) When the ECL is moved from STOP to GND:

(a) This repositions a position transmitter.

(b) The position transmitter sends a signal to the servo amplifier (N_1 control box).

(c) The N_1 control box compares the position transmitter signal to that of the transmitter from the actuator.

(d) The unbalanced circuit:

1) Connects electrical power to the N_1 actuator.

2) The ENG N_1 CONT caution light comes on.

(e) The N_1 actuator positions the N lever on the fuel control and rebalances the circuit.

(f) The balanced circuit:

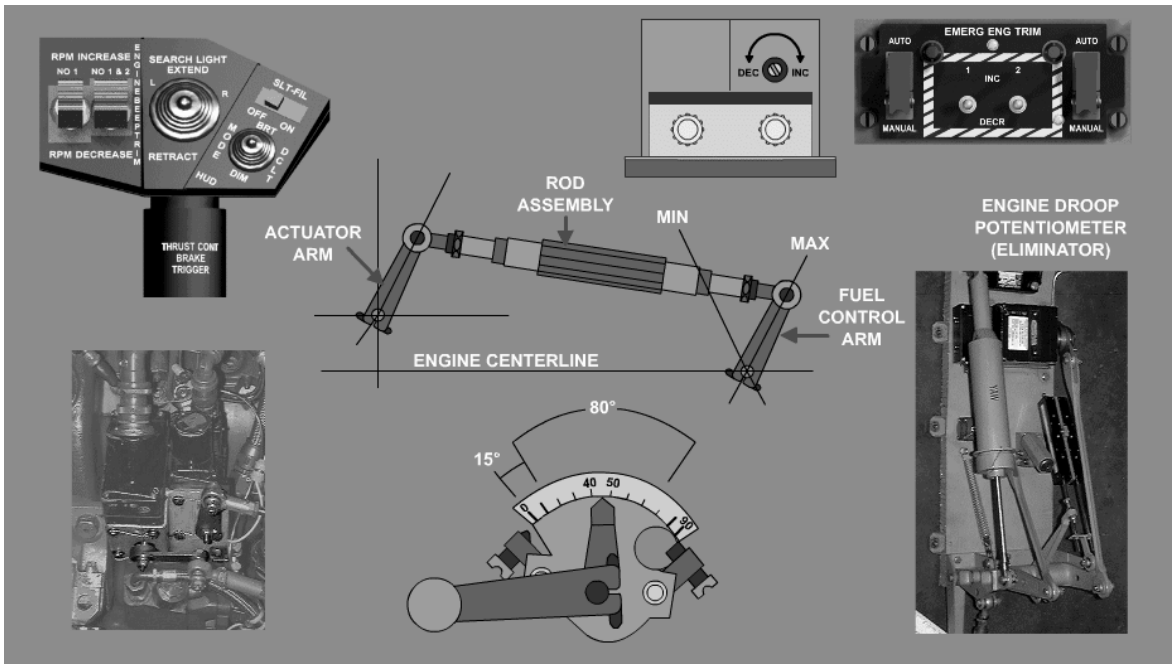
1) Removes power from the N_1 actuator.

2) The ENG N_1 CONT caution light goes out.

(g) A magnetic brake holds the actuator position until the circuit is again unbalanced.

(2) When the ECL is moved from GND to FLIGHT, the same action takes place as previously discussed.

3. Learning Step/Activity 3 − Describe components, operational characteristics, functions, and limitations of the power turbine controls.



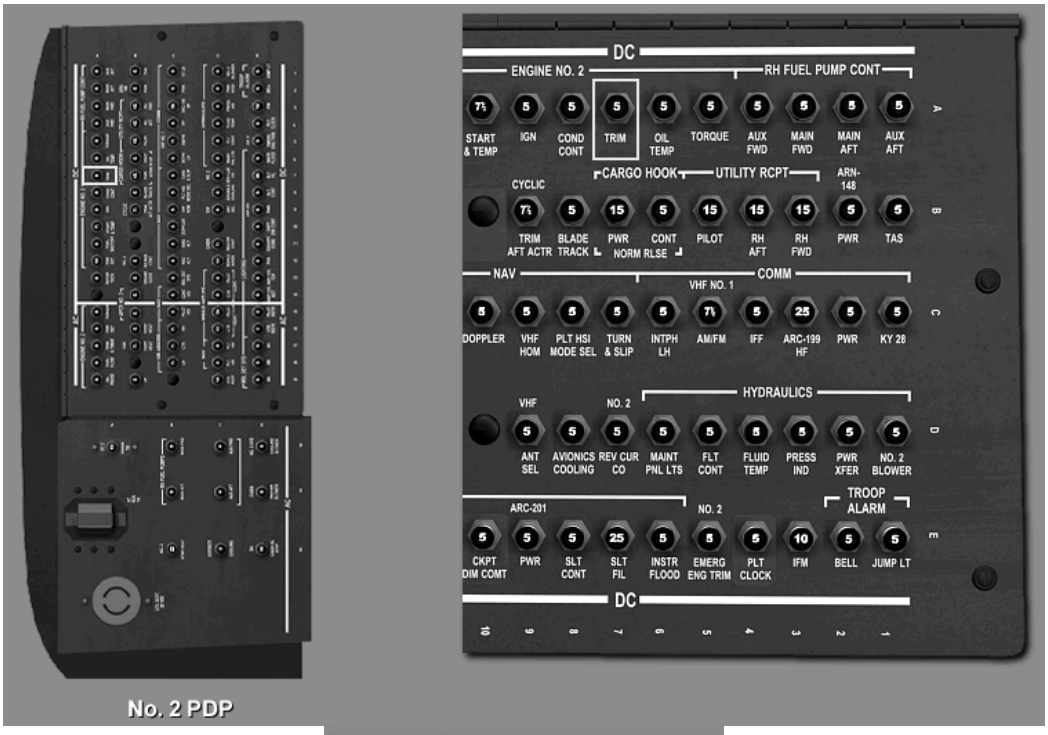
a. The power turbine controls (N_2) consist of two subsystems: Normal engine beep trim and the Emergency engine trim. This system controls the power turbine (N_2) speeds between minimum beep rotor rpm and maximum power.

b. Normal engine beep trim.

(1) Electrical power.

(a) No.1 and No.2 DC buses, circuit breakers are marked ENGINE No.1 and No.2 DC TRIM.

(b) No.1 and No.2 115 VAC buses, circuit breaker are marked ENGINE No.1 and No.2 TRIM & TIMER.



(2) Normal engine beep trim switches. These two switches are located on the thrust rod. This is a three position switch.

(a) Normal is the spring loaded center position.

(b) RPM increase.

(c) RPM decrease.

(d) The No.1 engine switch is used to match the engine torque loads.

(e) The No.1 and No.2 engine switch.

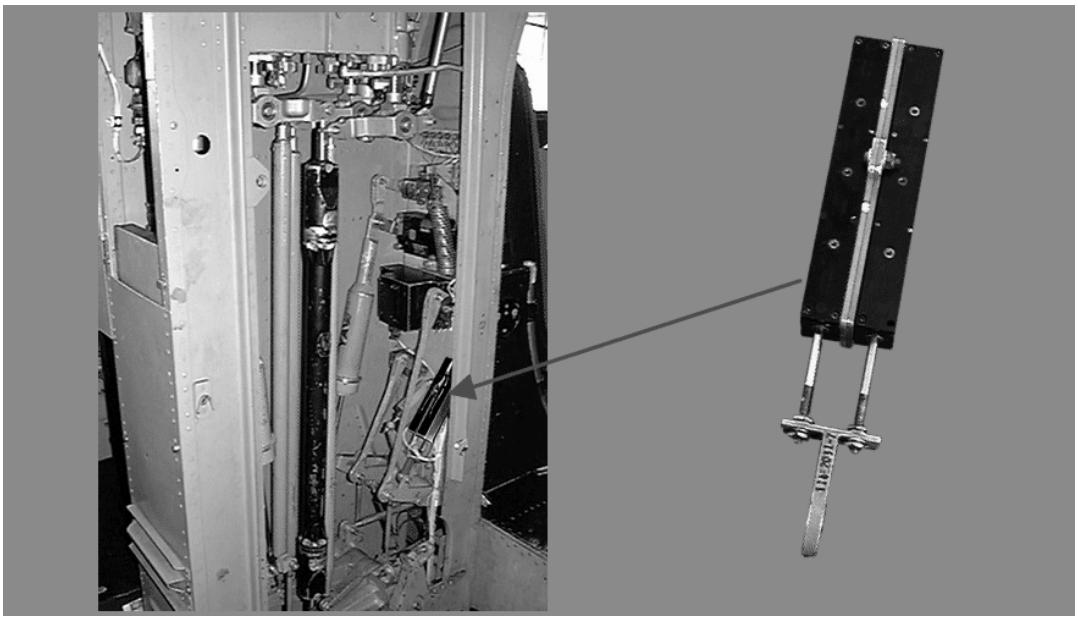
1) Controls the speed of both engines at the same time.

2) Used to control rotor RPM.

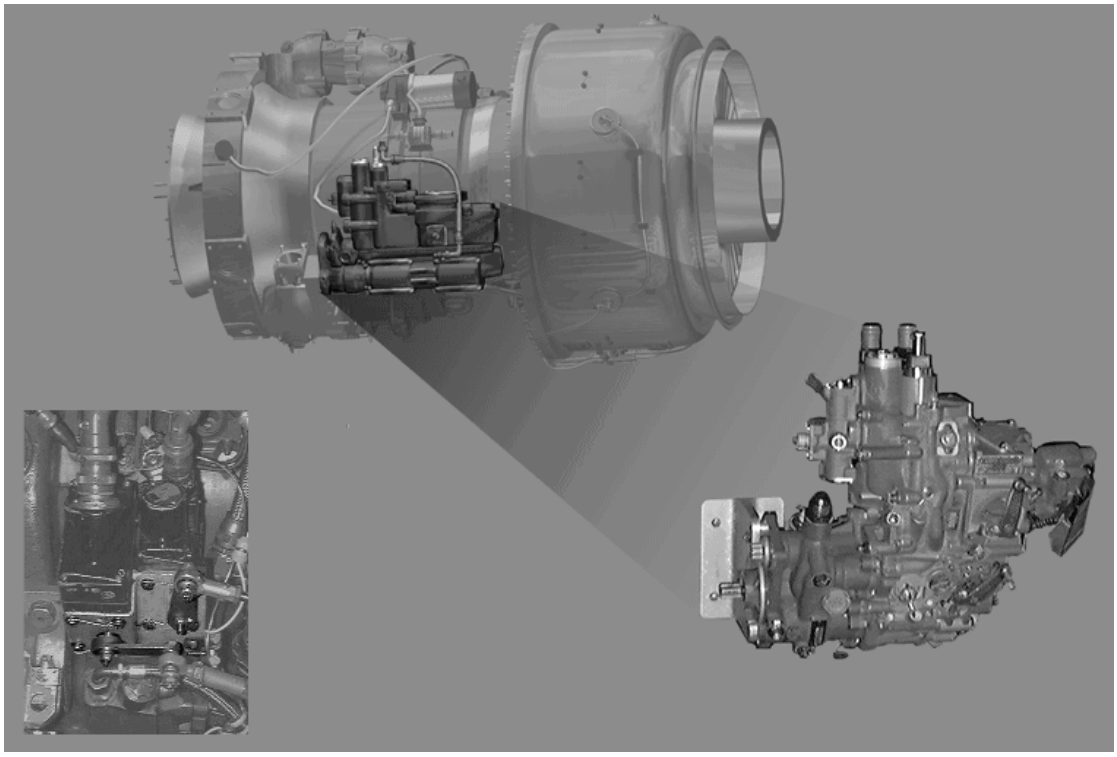
3) The control circuits are independent, failure of one will not affect the other.

(f) **For all single engine operations, use the No.1 and No.2 switch**.

(3) Droop eliminator potentiometer. This component is located inside the flight controls closet and is operated by thrust rod movement. The droop potentiometer controls the engine N_2 speed as thrust (blade pitch) is changed to maintain a constant rotor rpm.



(4) Power turbine (N_2) actuator. The actuator is located on the left side of each engine. The actuator positions the N_2 power lever on the fuel control.



(a) Reversible DC motor.

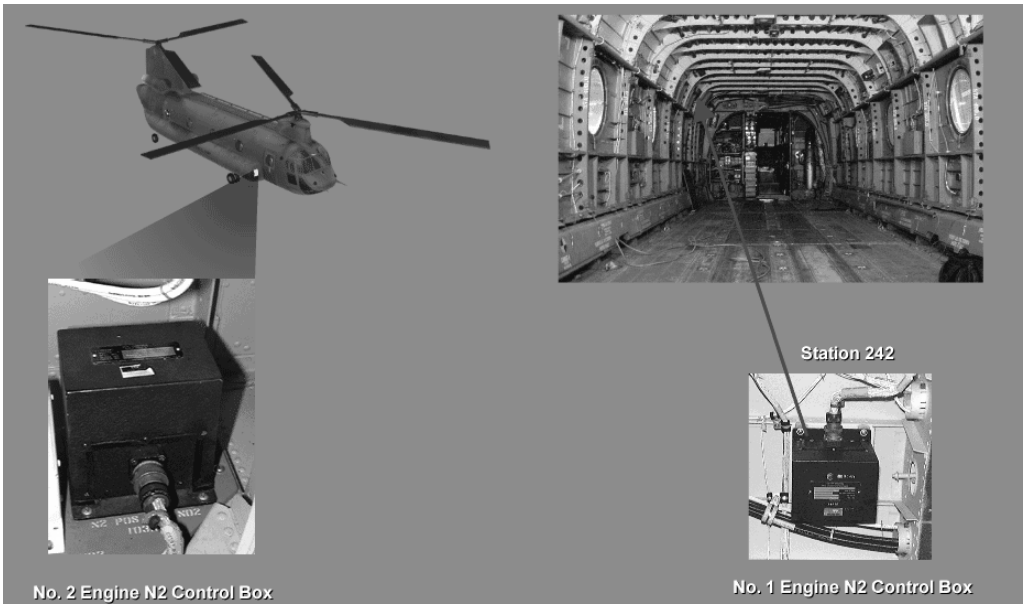
(b) A magnetic brake holds the actuator in position when power is removed.

(c) Connected to the N_2 power lever on the fuel control by a connecting rod.

(d) Variable resistor to stop the actuator.

(5) Power turbine (N_2) control box. There is an N_2 control box for each engine. The No.1 control box is located inside the cargo compartment at Sta.242, above the seat rails. The No.2 box is in the right electrical compartment. The N_2 control box contains:

(6)



(a) Trim motor, operated by the normal engine beep trim switches.

(b) Bridge circuit, controls the electrical power circuit to the N_2 actuator.

(c) Rectifier converts 115 VAC to 10.5 VDC to operate the N_2 actuator.

(6) Normal engine beep trim system disable switches (EMER ENG TRIM AUTO/MANUAL). The switches are located on the emergency engine trim panel on the center console.

(a) The AUTO/MANUAL switches have two positions.

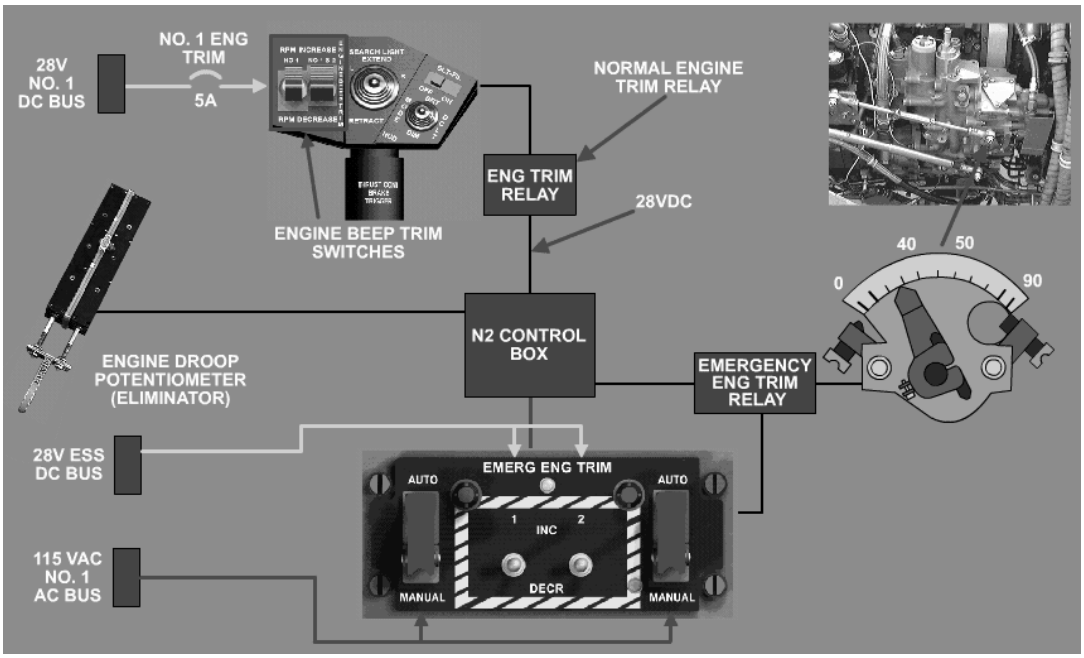
1) AUTO (cover down). The normal beep trim is functional.

2) MANUAL (cover up). The 115 VAC to the power turbine control box is interrupted, disabling the normal engine trim.

(b) Purpose.

1) Allows the pilot to disable either one or both normal engine beep trim systems.

2) To prevent unwanted signal from the normal beep trim system from interfering with the operation of the emergency beep trim.



c. Emergency engine trim. Used to change the power turbine (N_2) speed if the normal engine beep trim malfunctions.

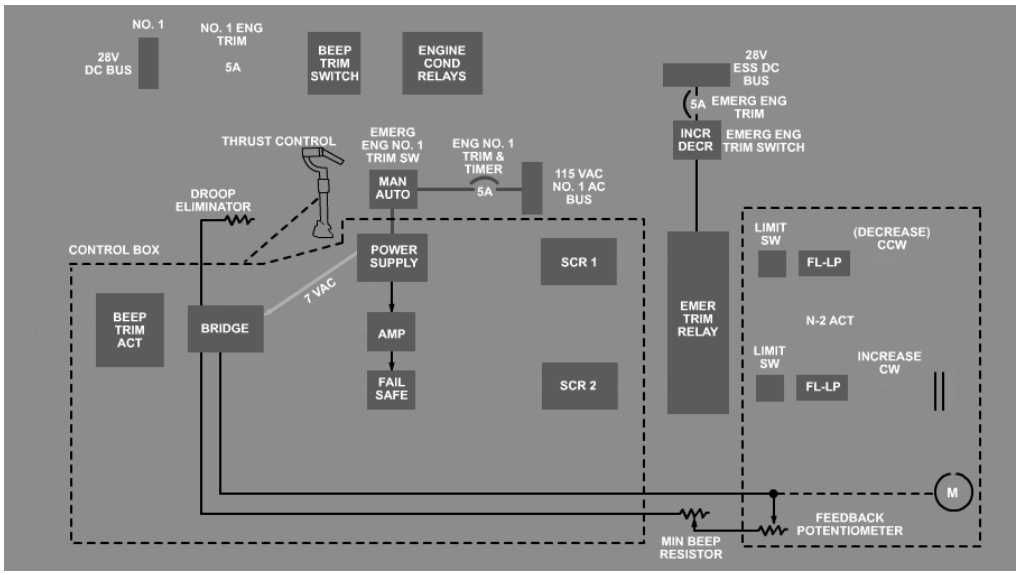
(1) Electrical power is through the 28 VDC essential bus.

(2) Emergency engine trim switches.

(a) Located on the emergency trim panel on the center console.

(b) A three position switch − INC, DEC, and the spring loaded Center position.

(3) The emergency trim relay allows the emergency trim to override the normal engine trim.



d. Operation of the N_2 controls.

(1) When the normal beep trim switches are operated:

(a) Controls the DC circuit to the engine trim motor in the N_2 control box.

(b) The engine trim motor unbalances the bridge circuit.

(c) The unbalanced bridge circuit connects electrical power to the N_2 actuator motor.

(d) The N_2 actuator:

1) Positions the N_2 power lever on the fuel control.

2) Rebalances the bridge circuit.

(e) Balanced bridge circuit removes power from the N_2 actuator.

(f) A magnetic brake holds the actuator position until the bridge circuit is again unbalanced.

(2) Movement of the thrust rod:

(a) Operates the droop eliminator potentiometers to unbalance the bridge circuits.

(b) The unbalanced bridge circuit connects power to the N_2 actuator motor.

(c) Repositions the N_2 actuator.

(3) Operation of the emergency engine trim:

(a) Closes the emergency trim relay.

1) Overrides the normal engine trim.

2) Connects 28 VDC to the N_2 actuator.

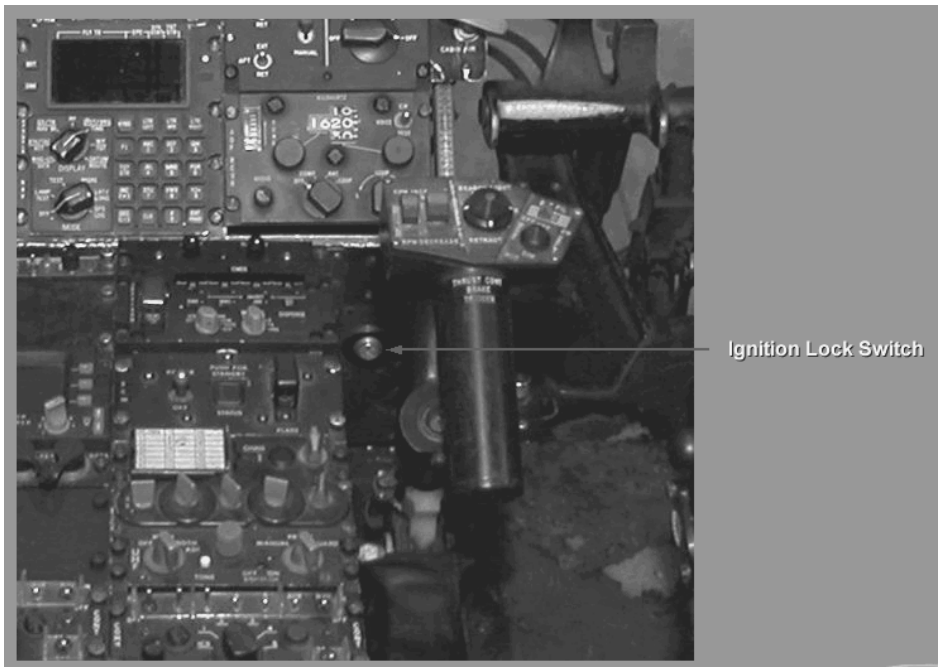
(b) The emergency engine switch is released to the center position.

(4) Place the respective EMER ENG TRIM AUTO/MANUAL switch to MANUAL to deactivate the normal engine trim system.

4. Learning Step/Activity 4 − Describe components, operational characteristics, functions, and limitations of the engine starting system and start procedures.

a. Engine starting systems.

(1) Ignition lock switch and key.

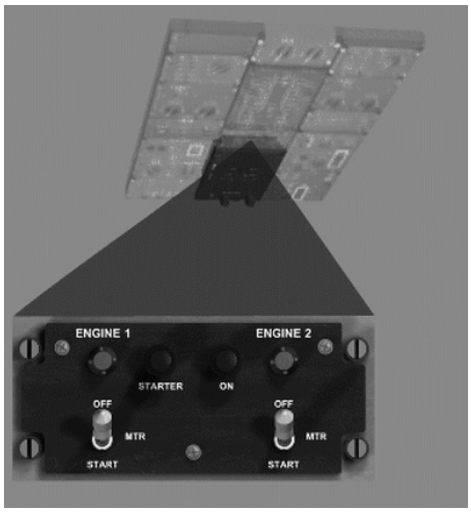


(a) Located on the right side of the center console.

(b) Controls the start fuel and ignition units.

(c) **Be sure that both engine start switches are set at OFF before turning the ignition switch ON or OFF**.

(2) Engine start panel.



(a) Located on the overhead switch panel.

(b) Engine start switch positions.

1) OFF.

a) A locked position.

b) Hydraulic, ignition, and start fuel circuits are de-energized.

2) MOTOR.

a) Detent position.

b) Hydraulic pressure is delivered to the starter.

NOTE: **Both engines cannot be motored or started at the same time**.

3) START.

a) Spring loaded, will return to the MOTOR position when released.

b) Hydraulic, ignition, and start fuel circuits are energized.

(c) Starter ON caution lights.

1) Illuminate when the switch is at MOTOR or START.

2) Alerts the pilots when the switch is inadvertently left at the MOTOR position.

(d) Electrical power.

1) No.1 and No.2 DC buses.

2) Circuit breakers.

a) START & TEMP.

b) IGN.

b. Engine starting and shutdown; procedures and limitations.

NOTE: The instructor will explain the current operator's manual procedures.

(1) Engine start procedures. **Pg: 8−2−9.**

(2) Engine shutdown.

(a) Normal. **Pg: 8−2−16.**

(b) With APU inoperative. **Pg: 9−1−20.**

(3) Limitations.

(a) Main engines **shall not** be started or shutdown in winds (including gusts) in excess of **30** knots from any direction.

(b) If main engine start or shutdown in winds exceeding 30 knots (including gusts) is unavoidable, refer to the checklist.

(c) Main engines **shall not** be started with a tailwind in excess of 10 knots.

c. Adverse environmental conditions.

(1) Cold weather.

(a) Manually check the compressor for freedom of rotation.

(b) Heat must be applied if the compressor is frozen.

(c) Preheating is recommended at temperatures below −18^{O}C.

(d) Allow the engine and transmission oil pressures and temperatures to stabilize prior to takeoff.

(2) Desert and hot weather operations: Refer to FM 1−202, Environmental Flight. **Pg: 8-4-3**

(3) Engine shutdown.

(a) It may be necessary to motor the engines if temperature does not decrease below **350^{O}C**. It may not be possible to lower the

temperature to **260^{O}C**. If the temperature will not decrease below **260^{O}C**, terminate motoring when the temperature indication stabilizes.

5. **Learning Step/Activity 5 − Describe Emergency Procedures**.

NOTE: The instructor will explain the indications and the current operator's manual emergency procedures.

a. Normal Engine Beep Trim System Failure (High Side) or N2 Governor Failure.

NOTES: Failure of the normal engine beep trim system to the high side may be recognized by increasing torque on the affected engine, decreasing torque on the unaffected engine, an increase in RRPM, and a lack of response of normal engine beep trim. These indications should be confirmed by observing all the engine instruments.

Controlling RRPM with the ECL must be done smoothly and with care. Engine response is much faster and it is possible to cause the RRPM to exceed limitations or decrease to the point that the generators will be disconnected from the buses. If the thrust control is moved, it is necessary to control RRPM with the engine condition lever and the No.1 and 2 ENGINE BEEP TRIM switch. If a malfunction to the high side occurs, perform the following: **Pg: 9−18**

1. **Thrust control − Adjust** as required to maintain RRPM within limits.
2. **ENG COND** lever (affected engine) − **Adjust** to a position between FLT and GND that will control RRPM.
3. **ENGINE BEEP TRIM switch No.1 & 2 − Adjust** as required.
4. Refer to single-engine failure emergency procedures..

b. Normal Engine Beep Trim System Failure (Low Side or Static). **Pg: 9−18.**

NOTE: Failure of the normal engine beep trim system to the low side can be recognized by decreasing torque on the affected engine, increasing torque on the unaffected engine, a loss of RRPM, a lack of response to ENGINE BEEP TRIM and N_1 stabilized at or above ground idle (**60** to **63%** N_1). These indications also accompany an engine failure: therefore, engine instruments must be monitored to determine which event has occurred. A static failure may be recognized by failure of one or both engines

to respond to beep commands or may resemble a high or low side failure when the thrust control is lowered or raised. If the thrust control is moved with either EMERG ENG TRIM AUTO/MANUAL switch in MANUAL, it is necessary to control RRPM and torque by use of the appropriate EMERG ENG TRIM INC or DECR switch. Perform the following:

1. **EMERG ENG TRIM switch (affected engine) − Adjust** as required.

2. **EMERG ENG TRIM AUTO/MANUAL switch (affected engine) − MANUAL.**

3. **EMERG ENG TRIM switch (affected engine) − Adjust** in coordination with the ENGINE BEEP TRIM No.1 & 2 switch to normal operating RRPM and match torque.

c. Engine Shutdown − Complete Electrical Failure. **Pg: 9−19.**

1. **FE**. FUEL VALVE No.1 and No.2 ENGINE − CLOSE.

2. Normal shutdown — Perform.

d. Engine Shutdown − Condition Lever Failure. **Pg: 9−20.**

NOTE: Should the engine condition lever fail to shut down or control an engine, use the following procedure for engine shutdown.

1. FIRE PULL handle (affected engine) − Pull.

2. Normal shutdown − Perform.

Appendix C - Practical Exercises and Solutions

CH-47D ENGINE CONTROLS

PRACTICAL EXERCISE

NOTE: This practical exercise covers the instruction you received in this handout. Completion is optional, but strongly encouraged!

1. Which electrical bus supplies power to operate the gas producer (N_1) controls?

2. Placing the EMG ENG Trim auto/manual switch to manual de-activates what system?

3. During cold weather operation, what must the compressor be checked for?

4. What is the proper engine N_1 ground idle speed?

5. How should the pilot shutdown the engine if the engine condition lever fails?

6. What must the pilot do to disable an engine normal beep trim system if it malfunctions?

7. During dual engine operation, what is indicated when the torque splits, rotor RPM decreases, and one of the engines has a decrease in N_1 speed to above 60%?

8. If an N_2 governor failure occurs, which cockpit engine control must the pilot use to control the engine?

9. If the normal engine trim disable switch for an engine is placed to MANUAL, will the droop eliminator potentiometer for that engine be operational?

10. Main engines should not be started with a tailwind in excess of?

11. What is the mandatory temperature for motoring an engine on shutdown?

12. What are two of the three functions of the N_1 Control Box?

13. What is the maximum time you should delay after starting the first engine before starting the second engine?

14. How long must you operate the engines at ground during shutdown?

15. What is the maximum time for the engines to attain minimum ground idle speed during start?

16. With a split in torque, what is the Primary indication for a HIGH SIDE?

17. What conditions will cause the ENG N_1 CONT caution light to illuminate?

18. What action is required if the N_1 topping stops are not stowed in the cockpit?

19. How will a low side normal engine beep trim failure be indicated to the pilot?

20. The rectifier in the N_2 control box converts what, to operate the actuator?

21. Which normal engine beep trim switch should you use during all single engine operations?

22. How will a high side normal engine beep trim failure be indicated?

23. If the engine transmission clutch fails to engage when the ECL is moved from ground to flight, how will it be indicated?

24. How will you shutdown the engine if a complete electrical failure occurs?

CH-47D ENGINE CONTROLS

PRACTICAL EXERCISE SOLUTIONS

1. Essential bus.
2. Normal engine beep trim
3. Freedom of rotation.
4. 60 to 63%.
5. Pull the fire pull handle.
6. Place the AUTO/MANUAL switch to MANUAL.
7. Low side normal beep trim failure.
8. ECL.
9. No.
10. 10 Knots.
11. Above 350º degrees.
12. Receive the position signal from the N1 Actuator and/or ECL.
    Provide power to the actuator.
    Lights the N_1 Caution light.
13. 3 Minutes.
14. 2 Minutes minimum.
15. 45 Seconds.
16. Increase in RRPM
17. ECL not in detent, component failure, and actuator is in transit.
18. Ensure they are not on the engine.
19. Drop in rotor rpm, torque split, decrease in N_1 speed to above 60% N_1.
20. 115 VAC to 10.5 VDC.
21. No.1 and No.2.
22. Increase in rotor rpm, torque split, increase in N_1 speed.
23. No. increase in torque and N_1 does not increase to above 70%.
24. Close the #1 and #2 Engine main fuel valves.