2A-26-10: General

The fire protection system incorporates sensors to detect the excess heat levels associated with fire in areas surrounding the engines and the Auxiliary Power Unit (APU), elevated levels of heat and/or smoke indicative of conditions that may lead to fire in areas of the aircraft interior, and high temperature ranges detrimental to the function of aircraft equipment.

If a fire is detected, the system sensors alert the flight crew to perform procedures to extinguish the fire by manually directing the discharge of the contents of onboard fire extinguishers. After a fire or overheat condition in the aircraft interior has been eliminated, any remaining smoke can be evacuated overboard through the baggage compartment door seals.

The fire protection system is divided into the following subsystems:

- 2A-26-20: Engine and APU Fire and Overheat Detection and Warning
- 2A-26-30: Engine and APU Fire Extinguishers
- 2A-26-40: Aircraft Interior Overheat and Smoke Detection, Smoke Evacuation, Portable and Fixed Fire Extinguishers

2A-26-20: Engine and Auxiliary Power Unit (APU) Fire and Overheat Detection and Warning System

1. **General Description:**

   Each aircraft engine is equipped with dual loop fire detectors placed in critical engine areas to sense heat levels associated with fire. The engine hot bleed air ducting is also monitored for leaks by thermal switches set at predetermined temperatures to signal overheat conditions. The Auxiliary Power Unit (APU) enclosure is monitored by a single element sensor to detect overheat conditions caused by a fire. Any excess temperature in the monitored engine and APU areas is indicated to the flight crew through cockpit visual and/or aural warnings for corrective action.

   All components of the fire and overheat detection system are powered through the essential DC buses, enabling aircraft main battery power to energize the system for protection during APU and/or engine starting. Battery power also provides a means to test the system for integrity prior to APU and engine starts, and ensures that fire and overheat detection is available during failures or malfunctions of AC electrical power. The engine and APU fire test switches are shown in Figure 1.

   The system includes the following subsystems, units and components:

   - Engine Fire Detection and Warning
   - Pylon Overheat Detection and Warning
   - Auxiliary Power Unit (APU) Fire Detection and Warning

2. **Description of Subsystems, Units and Components:**

   A. **Engine Fire Detection and Warning:**

   Each engine has five dual loop sensors that provide indications of high temperatures associated with an engine fire. Sensors are located in the following positions:

   - Around the gearbox accessories

- Between the Integrated Drive Generator (IDG) and fifth and eighth stage bleed ducts
- Near the eighth stage bleed shutoff valve and air starter valve
- Inboard of the engine on the fixed cowling near the front engine mount
- Within the engine around the engine core

The sensors located on the exterior of the engine are termed “rails” since they suspend the loops above the monitored engine region to prevent heat transfer directly from the engine structure. The five sensors are electrically wired together and effectively act as a single dual loop sensor. The sensor loops are designated Loop A and Loop B. Additional redundancy is provided by separating the loop power sources: the left engine Loop A is powered by the left essential DC bus and Loop B powered by the right essential DC bus; right engine Loop A is powered by the right essential DC bus and Loop B by the left essential DC bus. Each of the loops is composed of a sheath of stainless steel surrounding a temperature sensitive glass / oxide material. Centered in the glass / oxide material is a coaxial cable wire. The electrical resistance and capacitance between the steel sheath and the center wire are monitored by a Fire Detector Control Unit located in the tail compartment of the aircraft. As a sensor loop is heated, the glass / oxide material loses insulating qualities and allows a current flow between the center wire and the surrounding sheath, signalling a fire. Both loops are located in parallel and at close proximity, so the control unit must receive a simultaneous fire indication from Loop A and Loop B to send a fire annunciation to the cockpit. If only one loop indicates a fire, the indication could result from a breach of the insulating glass / oxide material or other malfunction, and is reported as a loop fault by the control unit.

If both loops indicate a fire, the control unit sends a signal to input/output (I/O) modules in Modular Avionics Units (MAUs) #1 and #2. The I/O data is formatted by Network Interface Modules (NIMs) for the Monitor and Warning System (MWS) that initiates red CAS messages for engine fire and fire loop alerts that flash on the display unit and an aural warning over cockpit speakers. Control unit hard wire connections illuminate the engine fire handle and release the solenoid holding the fire handle in the stowed position, illuminate the engine fuel control switch, the master warning light on the cockpit glareshield and both loop A and loop B elements of the fire test switch for that engine. Engine fire indications are shown in Figure 2 and Figure 3.

If only a single loop indicates a fire, the control unit will generate a loop fault signal for that loop, illuminating the appropriate fire detection loop fault indicator and prompting CAS messages for fire loop alert and fire detector loop fault. If the flight crew confirms the loop fault through system tests, the erroneous loop may be selected off, and fire detection will be accomplished with the single remaining loop. If a fire is detected when in single loop configuration, all indications and warnings are the same as dual loop detection except there is no loop fault indication for the loop selected off. The loop fault and selector switches as well as the loop test switch are illustrated in Figure 1.

B. Pylon Overheat Detection and Warning:

Engine high temperature bleed air ducts are monitored for leakage and/or rupture by three thermal switches in each engine pylon. The switches are powered by essential DC and will close at a temperature of two-hundred fifty degrees Fahrenheit (250°F) signalling a pylon overheat to I/O modules in MAU #1 and #2 for communication to the MWS that in turn initiates CAS annunciations. The pylon overheat switches are illustrated in Figure 4.

C. APU Fire Detection:

The APU fire detector is a continuous element routed around critical areas within the APU container. The element consists of a tube, approximately seven (7) feet in length, filled with hydrogen gas and a stabilizing chemical. The tube is sealed at both ends, resulting in a container with a constant internal pressure. Two sensors are installed in the end of the tube: one sensing high pressure and the other sensing low pressure. If the gas within the tube is heated, molecular motion within the tube increases, resulting in a rise in pressure. A pressure increase above a preset threshold is indicative of a high temperature level in one or more areas monitored by the detector. The threshold corresponds to a pressure increase caused by a temperature of approximately one thousand degrees Fahrenheit (1,000°F) over a small section of the sensor tube or by a temperature level of four hundred fifty degrees Fahrenheit (450°F) over the length of the sensor. When sensor pressure exceeds the threshold, a fire signal is sent to I/Os in MAUs #1, #2 and #3 for initiation of MWS CAS visual and aural fire warnings. Hard wire signals are generated to illuminate the FIRE legend on the APU overhead panel (shown in Figure 2), the red master warning light on the cockpit glareshield and if the aircraft is on the ground (weight-on-wheels), to the APU fire warning horn in the nose wheel well. The APU Electronic Control Unit (ECU) automatically shuts off fuel to the APU if a fire is detected, bypassing the cool-down mode. (Testing the APU fire warning system while the APU is operating will not result in an automatic shutdown.)

The second tube sensor monitors low gas pressure in the fire detector. If an APU malfunction or other failure causes a rupture in the tube structure allowing the escape of the gas within, the sensor will detect the resulting loss of pressure and signal a failure of the APU fire detector to I/O modules in MAUs #1 and #2 for MWS initiation of a CAS annunciation. Failure of the fire warning system will not automatically shut down the APU.

3. Controls and Indications:

(See Figure 1.)

A. Circuit Breakers (CBs):

The following CBs protect the fire detection and warning system:

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
L FIRE DET LOOP A	LEER	B-14	L ESS DC Bus
L FIRE DET LOOP B	REER	B-10	R ESS DC Bus
R FIRE DET LOOP A	REER	B-11	R ESS DC Bus
R FIRE DET LOOP B	LEER	B-13	L ESS DC Bus

NOTE:

There is no dedicated circuit breaker for the APU fire detector. The detector receives essential DC power through the APU CONT #1 or APU CONT #2 circuit breakers on the left or right battery bus.

B. Indications:

(1) The following CAS messages are associated with the engine and APU fire detection and warning system:

Area Monitored:	CAS Message:	Message Color:
L - R Engine	L - R Engine Fire	Red
L - R Engine Fire Detector Loops	Engine Fire Loop Alert	Red
APU Fire Detector	APU Fire	Red
L - R Engine Fire Detector Loops	Fire Detection Loop Fault	Amber
APU Fire Detector	APU Fire Detector Fail	Amber

NOTE:

The red L - R Engine Hot CAS warning message is associated with an engine oil system fire or overheat or Engine Electronic Control (EEC) overheat.

(2) Summary of annunciations present in testing the engine and APU fire detection systems and annunciations for the detection of an actual fire:

(a) Selection of the L (or R) ENG FIRE TEST switch:

- Legends LOOP A and LOOP B illuminate in the L ENG or R ENG FIRE TEST lights
- Both MASTER WARNING glareshield switches illuminate
- L (or R) fire handle illuminates
- L (or R) FUEL CONTROL switch illuminates
- Three-chime aural WARNING tone sounds
- Red L (or R) Engine Fire and red Engine Fire Loop Alert messages on CAS display

(b) Selection of the FIRE DETECTION FAULT TEST switch:

- TEST illuminates in the FAULT TEST switch
- FAULT is displayed on the LEFT / RIGHT LOOP A / LOOP B switches
- Two-chime aural CAUTION tone sounds
- Both MASTER CAUTION switches illuminate on glareshield
- Amber Fire Detector Loop Fault message on CAS

display

(c) Selection of the APU FIRE TEST switch or a valid APU FIRE signal:

- Three-chime aural WARNING tone sounds
- Both MASTER WARNING glareshield switches illuminate
- Exterior fire bell in nose wheel well sounds if the aircraft is on the ground
- FIRE light on the APU control panel illuminates
- Red APU Fire message and an amber APU Fire Detector Fail message annunciated on CAS display

(d) Detection of a valid ENGINE FIRE signal:

- Both MASTER WARNING glareshield switches illuminates
- L (or R) fire handle illuminates
- L (or R) FUEL CONTROL switch illuminates
- Three-chime aural WARNING tone sounds
- Red L (or R) Engine Fire message on CAS display
- Solenoid holding in the L (or R) fire handle releases

(e) Detection of a valid FIRE LOOP FAULT signal:

- LEFT or RIGHT LOOP A or LOOP B switch FAULT legend illuminates (selection to off causes the OFF legend to illuminate)
- Three-chime aural WARNING tone sounds
- Both MASTER WARN glareshield switches illuminates
- Red Engine Fire Loop Alert message on CAS display

4. Limitations:

There are no limitations for the fire detection and warning system established at the time of this writing.

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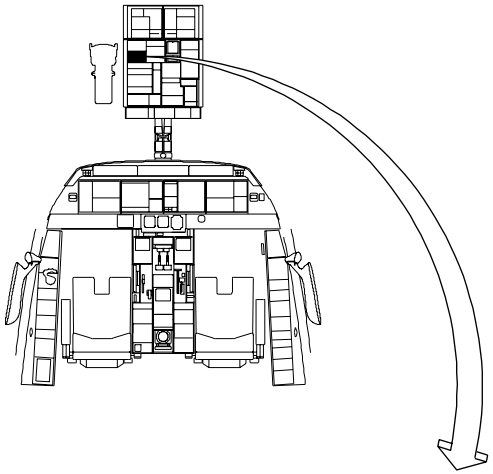

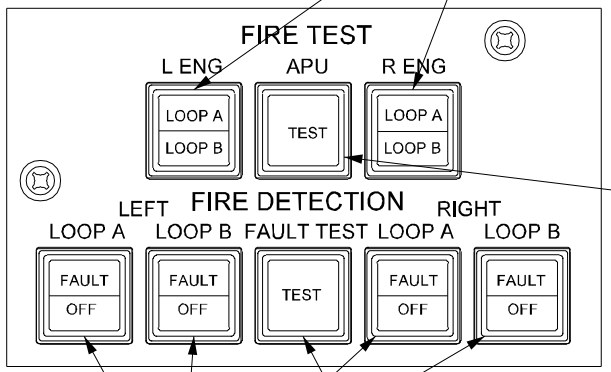

L ENG / R ENG FIRE TEST

When depressed:

- LOOP A and LOOP B lights illuminate red.
- MASTER WARN W reset switch illuminates red.
- Associated fire handle illuminates red.
- Associated FUEL CONTROL switch illuminates red.
- Three-chime aural warning tone sounds.

APU FIRE TEST

When Depressed:

- Three-chime aural warning tone sounds.
- TEST light (APU FIRE TEST) illuminates.
- Exterior fire bell sounds (if aircraft is on ground).
- FIRE light on the APU control panel illuminates red.
- MASTER WARN W reset switch illuminates red.

FIRE DETECTION LEFT / RIGHT LOOP A / LOOP B

FAULT light in switch illuminates amber when FIRE DETECTION FAULT TEST switch is depressed or when fault occurs. OFF light illuminates amber when faulty fire loop is selected OFF.

FIRE DECTECTION FAULT TEST

TEST light illuminates amber when depressed.
FAULT lights in LEFT / RIGHT LOOP A / LOOP B switches illuminate.

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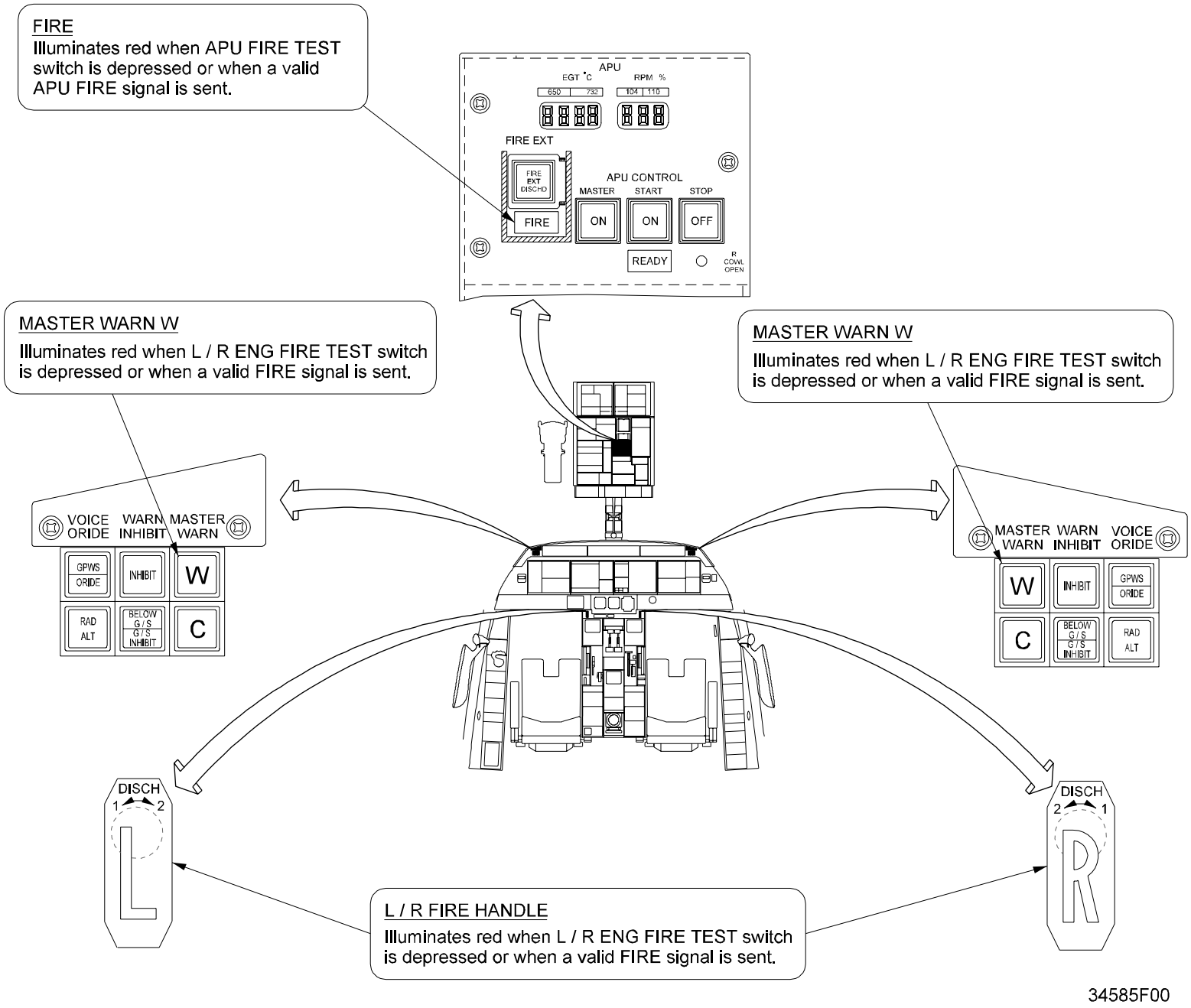
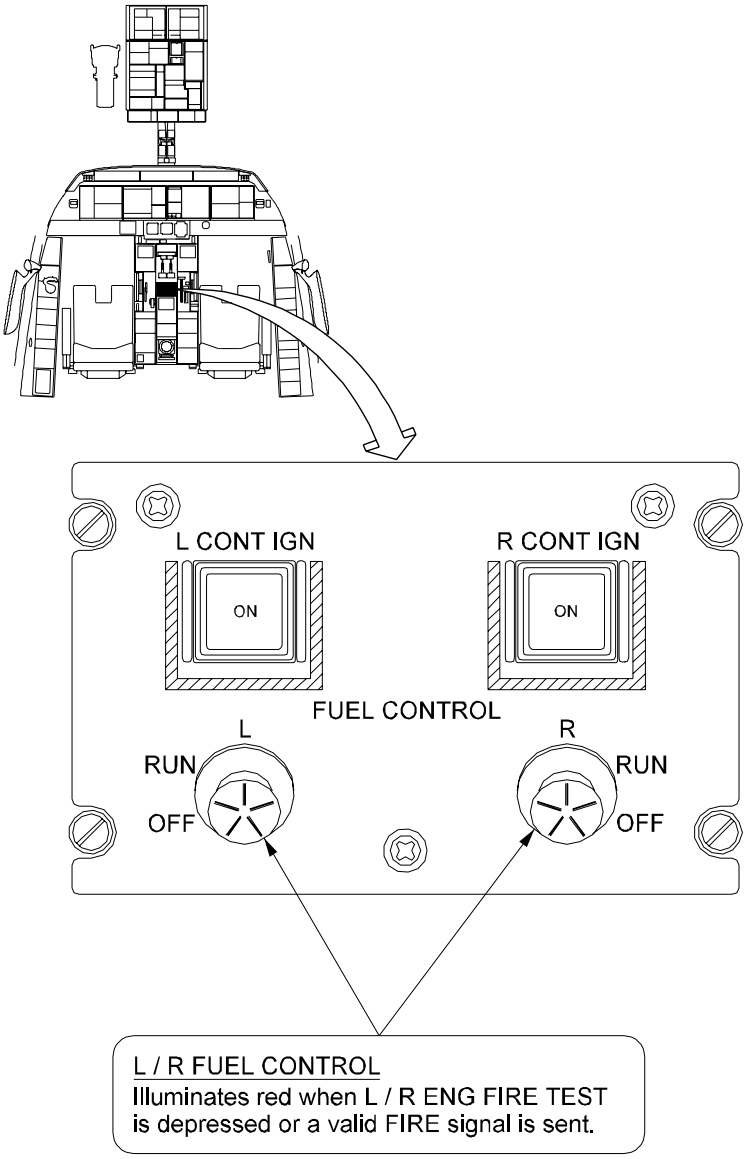
Cockpit Overhead Panel:
FIRE TEST and
DETECTION Section
Figure 1



Cockpit Fire Detection and Warning Indications
Figure 2



Engine Fuel Control Fire Detection and Warning Indications
Figure 3

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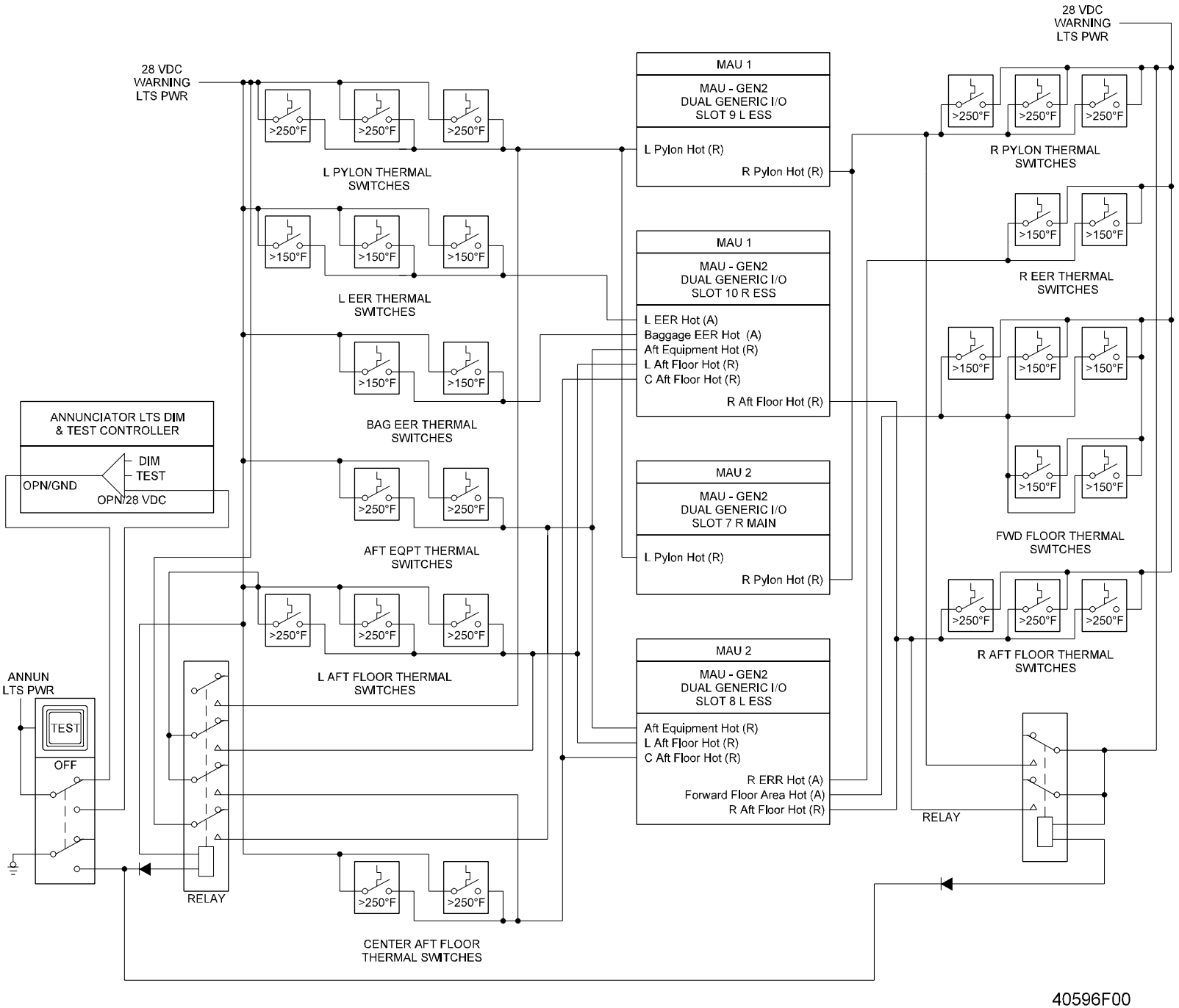

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Overheat Detection Block Diagram
Figure 4

2A-26-30: Engine and APU Fire Extinguishers

1. General Description:

The flight crew extinguishes engine fires by performing two functions: pulling the engine fire handle out and injecting the contents of one or both fire extinguisher bottles into the engine. When an engine fire is indicated by the fire detection loops, an electrical signal is sent to the corresponding engine fire handle, illuminating the fire handle and releasing the locking solenoid that normally latches the handle in the stowed position (preventing inadvertent actuation). Pulling the fire handle out shuts off fuel at the engine fuel control, shuts off hydraulic pressure and de-energizes the engine Integrated Drive Generator (IDG). These actions remove combustible fluids and possible sources of ignition. After the fire handle has been extended, the handle is rotated outboard and, if necessary, inboard to inject a fire extinguishing agent into the engine.

See the illustration of the engine / APU fire bottles and fire handle agent discharge switches in Figure 5

2. Description of Subsystems, Units and Components:

A. Engine Fire Handles:

The left (L) and right (R) engine fire handles are located on the forward section of the cockpit center pedestal (see Figure 6). They are normally locked in the stowed position by an electrical solenoid. When a fire signal is provided by the engine fire detection system, the solenoid opens, allowing the associated fire handle to be pulled out. If the solenoid malfunctions, a manual override button underneath each fire handle allows handle activation.

Each fire handle can be rotated to either of two positions after it is pulled out to inject fire extinguishing agent into the engine. Rotating the fire handle outboard to the DISCH 1 position sends an electrical signal to an explosive squib on the right fire bottle, rupturing the seal separating the pressurized bottle contents from the plumbing connected to the engine nacelle. The DISCH 1 position reserves the left fire bottle for use in an APU fire, since only the left fire bottle is plumbed to the APU container. If an engine fire persists, however, the fire handle may be rotated to the inboard DISCH 2 position to inject the agent in the left fire bottle into the engine.

Power for extinguisher activation is from the left essential DC bus for the right extinguisher bottle (DISCH 1) to either engine, from right essential DC for the left extinguisher bottle (DISCH 2) to either engine and left essential DC for the left extinguisher bottle to the APU enclosure. Fire extinguisher activation is therefore available whenever the aircraft main batteries are selected ON and the essential DC buses are powered.

The modes of fire handle operation are shown in the following table:

Fire Handle Pulled:	Rotated To:	Discharges:	Into:
L	DISCH 1	RIGHT Fire Bottle	Left Engine Nacelle
	DISCH 2	LEFT Fire Bottle	
R	DISCH 1	RIGHT Fire Bottle	Right Engine Nacelle
	DISCH 2	LEFT Fire Bottle	

B. Fire Extinguishing Bottles:

Each bottle has an external direct-reading gage that indicates the pressure of the nitrogen / HalonR contents. The bottle is fully pressurized if the gage reads 600 psi at 70°F. A low pressure switch on each bottle will close if the bottle contents are discharged, and an electrical signal sent to Input / Output (I/O) modules in the Modular Avionics Units (MAUs) is formatted for the Monitor and Warning System (MWS) to initiate a Fire Bottle Discharge caution message on the CAS window. Each fire bottle also has a pressure relief disc seal that will rupture if the bottle becomes overpressurized due to excessive temperature, allowing bottle contents to escape into the tail compartment. If the pressure relief disc seal ruptures, the bottle low pressure switch will close, activating the bottle discharge CAS message.

C. APU Fire Extinguishing:

Only the left fire extinguisher bottle is plumbed into the APU compartment. If a fire is detected within the APU enclosure, fuel is automatically shut off at the APU fuel control. The flight crew may discharge the contents of the left bottle into the APU by pushing in the guarded FIRE EXT DISCHD pushbutton above the APU FIRE indicator light. When the left bottle is discharged, the bottle low pressure sensor will signal the activation of the amber L Fire Bottle Discharge CAS message and the illumination of the amber FIRE EXT DISCHD legend in the pushbutton.

NOTE:

After the fire extinguishing agent is discharged into the APU compartment, the left fire bottle is no longer available for engine fire protection.

3. Controls and Indications:

(See Figure 6.)

A. Circuit Breakers (CBs):

The fire extinguishing system is designed so that a single essential DC bus can provide both fire detection and fire extinguishing for the aircraft engines.

The following CBs protect the fire extinguishing system:

Circuit Breaker Name:	CB Panel:	Location:	Power Source:	Provides Power To:
FIRE EXT SHOT #1	LEER	B-12	L ESS DC Bus	Left Fire Handle DISCH 1
				Right Fire Handle DISCH 1
FIRE EXT SHOT #2	REER	B-12	R ESS DC Bus	Left Fire Handle DISCH 2
				Right Fire Handle DISCH 2

B. Indications:

(1) Crew Alerting System (CAS) Messages:

The following CAS message is associated with the fire extinguishing system:

Area Protected:	CAS Message:	Message Color:
Fire Extinguisher Bottles	L - R Fire Bottle Discharge	Amber

4. Limitations:

A. Flight Manual Limitations:

There are no limitations established at the time of this writing.

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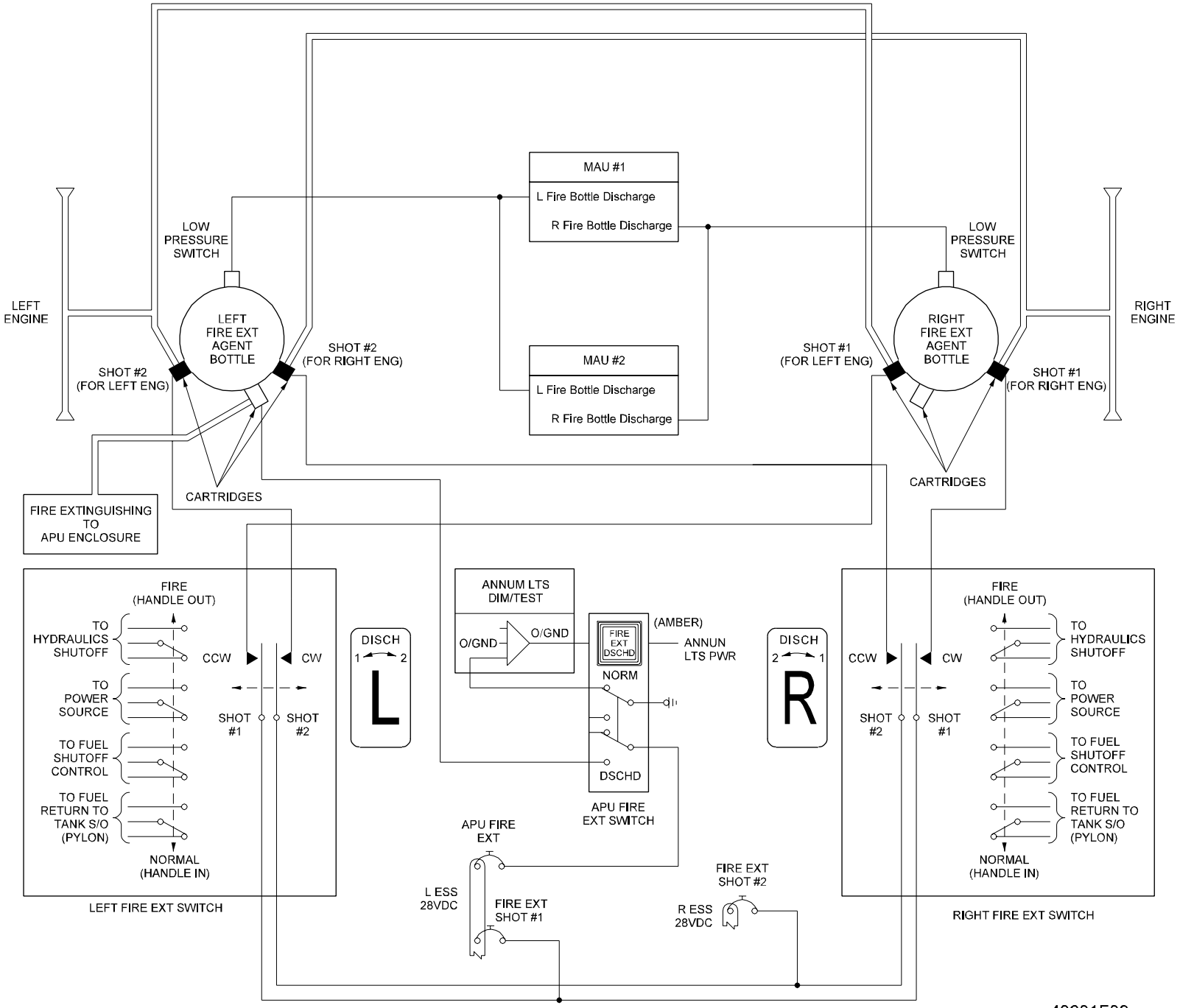
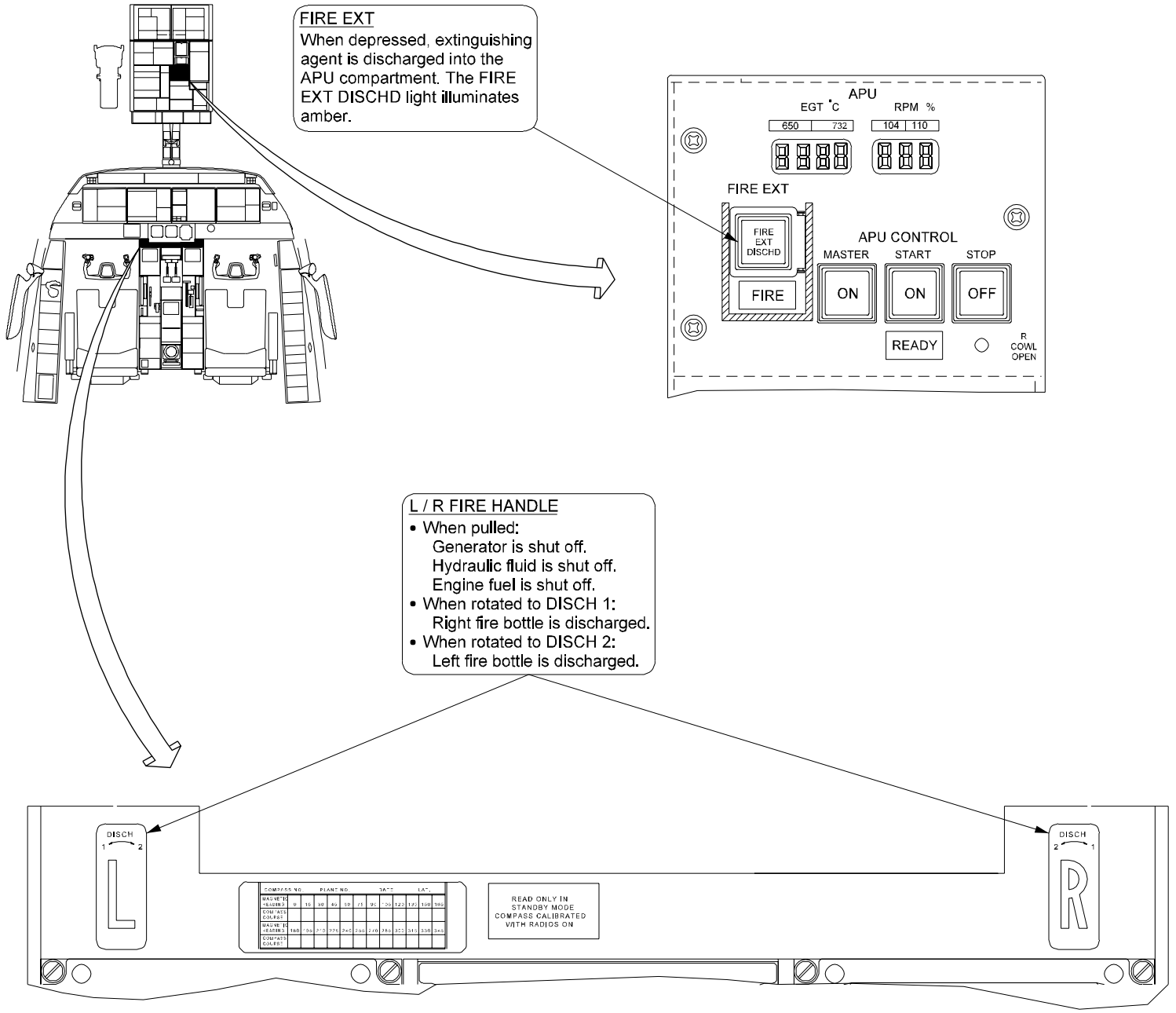


Fire Extinguisher Bottles and Discharge Switches Block Diagram
Figure 5



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Fire Extinguishing System
Controls and Indications
Figure 6

2A-26-40: Aircraft Interior Overheat and Smoke Detection, Smoke Evacuation, and Portable and Fixed Fire Extinguishers

1. General Description:

Areas of the aircraft fuselage not normally accessible to the crew or passengers are monitored by sensors for conditions that indicate possible hazards or degradation of aircraft systems performance. Thermal switches detect undesirable levels of heat in areas containing electronic equipment, in the underfloor areas near hot air manifold ducting of the air conditioning system, and in the tail compartment where the APU and hydraulic reservoirs are located. The baggage compartment is monitored for both overheating in electronic equipment racks and smoke indicating combustion. Smoke in the baggage compartment or anywhere in the cockpit or cabin may be evacuated from the aircraft after the cause of the smoke is eliminated. Portable and fixed fire extinguishers located in aircraft interior can be used to prevent smaller scale combustion from becoming a hazard to the aircraft. This system comprises the following subsystems, units and components:

- Overheat Detection
- Smoke Detection
- Smoke Evacuation
- Portable and Fixed Fire Extinguishers

2. Description of Subsystems, Units and Components:

A. Overheat Detection:

A total of twenty-two (22) heat detector switches are installed in the aircraft interior to monitor temperature levels (see the block diagram in Figure 4). The switches are the same as those installed in the engine pylons for detecting bleed air leakage. The temperature switches are set at two trip points, depending upon location and type of equipment monitored. Ten (10) high temperature switches set at two hundred fifty degrees Fahrenheit (250°F) are placed in the following locations:

- Two (2) switches in the aircraft tail compartment
- Three (3) switches beneath the right aft cabin floor near hot air ducting
- Two (2) switches beneath the center aft cabin floor near the hot air manifold
- Three (3) switches beneath the left aft cabin floor near hot air ducting

Twelve (12) lower temperature switches set at one hundred fifty degrees Fahrenheit (150°F) are placed to monitor electronic equipment temperature levels in the following locations:

- Two (2) switches in the Aft (baggage) Electronic Equipment Rack (AEER)
- Five (5) switches beneath the cabin floor near the main entrance door to monitor electronic equipment installations
- Three (3) switches in the Left Electronics Equipment Rack (LEER)
- Two (2) switches in the Right Electronics Equipment Rack (REER)

If the temperature in the monitored area reaches the trip point of the switch,

the switch closes and sends a signal over wire connections to Input / Output (I/O) modules in the Modular Avionics Units (MAUs) for formatting and transmission to the Monitor and Warning System (MWS). The MWS will generate a Crew Alerting System (CAS) message alerting the crew to the location and nature of the malfunction. Switches set at a trip point of 150°F will generate an amber caution CAS message when that temperature is reached; switches set at 250°F will generate red warning CAS messages.

B. Smoke Detection:

A smoke detector is installed in the ceiling of the baggage compartment to warn the flight crew of possible combustion within the aircraft. The detector is composed of a light emitting source and a photoelectric cell placed on opposite sides of an enclosure with a white interior. Vents in the enclosure allow compartment air to circulate through the interior. In normal conditions the photoelectric cell receives a constant level of illumination from the light source and produces a steady voltage. If the air within the baggage compartment is contaminated with smoke or particles, less illumination is received by the photoelectric cell and voltage output drops, signaling the presence of smoke. The detector communicates with MAU I/O modules to initiate a MWS generated CAS message and aural alerts.

The circuitry of the smoke detector can be tested with the SMOKE DET button on the SYSTEM TEST panel on the cockpit overhead, shown in Figure 7. Actual operation of the detector is not tested with the button, i.e., no simulated smoke is passed between the light source and the photoelectric cell in the detector.

C. Smoke Evacuation:

If smoke is present in the baggage compartment or anywhere in the aircraft interior, it may be evacuated from the aircraft by deflating the seal around the baggage compartment exterior door and allowing cabin differential pressure to eject the smoke. A panel installed in the forward cabin bulkhead above the interior baggage compartment door contains controls for smoke evacuation. The installation is shown in Figure 8. Within the panel is a handle labeled EMERGENCY SMOKE EVACUATION VLV. Rotating the handle to the VENT / SMOKE position deflates the pressurized seal around the exterior door of the baggage compartment. Whenever the compartment becomes depressurized, the baggage compartment shut off valve will close, interrupting conditioned air flow into the baggage compartment.

At the completion of smoke evacuation, normal pressurization of the baggage compartment can be restored. Rotating the handle to the NORMAL OPS position allows the bleed air system to reinflate the baggage door seal. A toggle switch next to the smoke evacuation handle must be held to the reset position for ten (10) seconds to open the baggage compartment shut off valve to restore pressurization to the baggage compartment. For more information see section 2A-21-30 of this manual.

D. Portable and Fixed Fire Extinguishers:

The aircraft is equipped with two types of portable fire extinguishers to control fires in interior areas accessible to the crew. Each extinguisher is used to control fires from different sources:

- A HalonR extinguisher with a capacity of 8.2 pounds is stored on a quick release bracket in the cockpit on the pilot side. This type of extinguisher is most effective against oil or grease fueled fires and electrical fires
- An extinguisher containing approximately seven pounds of a water and antifreeze mixture pressurized with nitrogen is mounted on the right side of the forward cabin bulkhead. This type of extinguisher is most effective against fires originating in paper or cloth materials

Each cabin lavatory is equipped with an integrated fire detector and extinguisher unit mounted over lavatory trash bins. The unit consists of a container holding nine (9) cubic inches of a bromotrifluoromethane extinguishing agent and discharge tubes capped with a fusible alloy. The discharge tubes are positioned over the trash container. If the temperature level below the tube caps exceeds one hundred seventy to one hundred seventy-seven degrees Fahrenheit (170 - 177°F), the discharge tube caps will melt and the contents of the extinguisher will be directed into the trash bin in three to fifteen (3 - 15) seconds. The unit cannot be refilled and is a disposable item. If the unit discharges it must be replaced. The detector / extinguisher is weighed periodically to ensure unit integrity.

3. Controls and Indications:

(See Figure 7 and Figure 8.)

A. Circuit Breakers (CBs):

The following CBs protect the smoke detection and evacuation system:

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
AFT BAGG SMOKE DET	LEER	C-8	L ESS DC Bus
AFT BAGG VENT VLV	LEER	D-6	L ESS DC Bus

B. Indications:

The following Crew Alerting System (CAS) messages are associated with smoke and overheat detection:

Area Monitored:	CAS Message:	Message Color:
Aft Equipment Compartment Temperature ≥250°F	Aft Equipment Hot	Red
Aft Baggage Compartment Smoke Detector	Aft Baggage Smoke	Red
Aft Baggage Compartment Smoke Detector	Aft Baggage Flame	Red
Aft Cabin Underfloor Area Temperature ≥250°F	L - C - R Aft Floor Hot	Red
Baggage Compartment EER Temperature ≥150°F	Baggage EER Hot	Amber
Forward Cabin Underfloor Area Temperature ≥150°F	Forward Floor Area Hot	Amber
Left or Right EER Temperature ≥150°F	L - R EER Hot	Amber
Left or Right PDB Temperature ≥175°F	L - R PDB Overheat	Amber

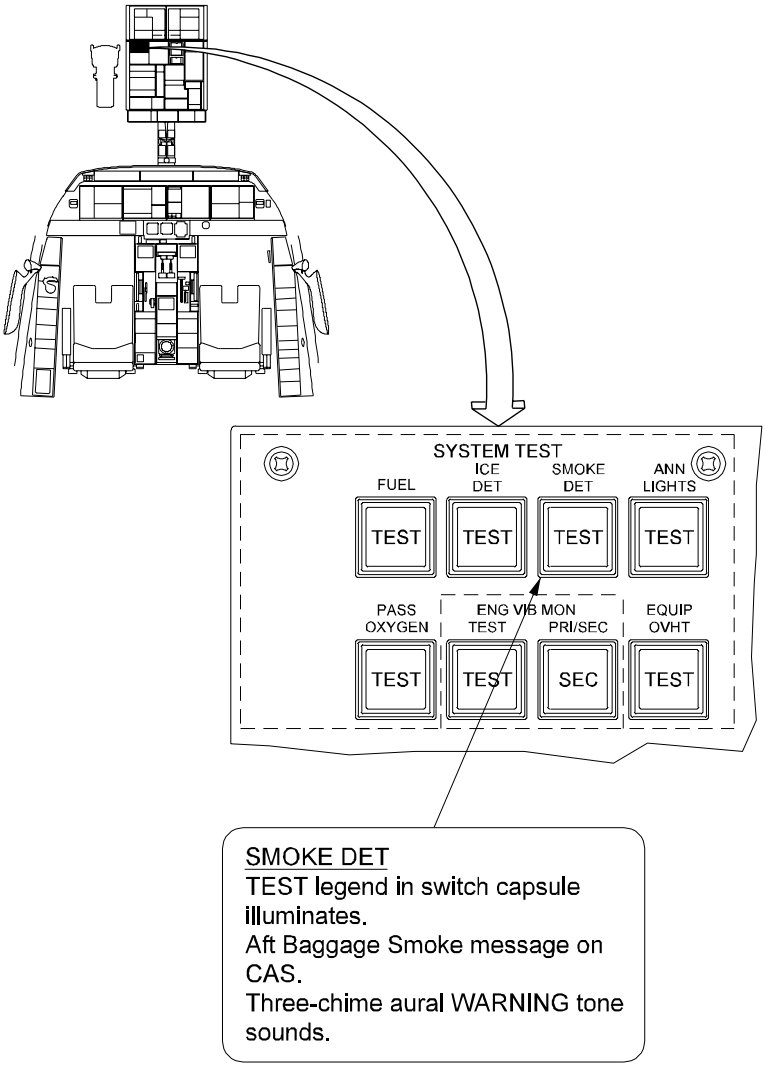
4. Limitations:

A. Flight Manual Limitations:

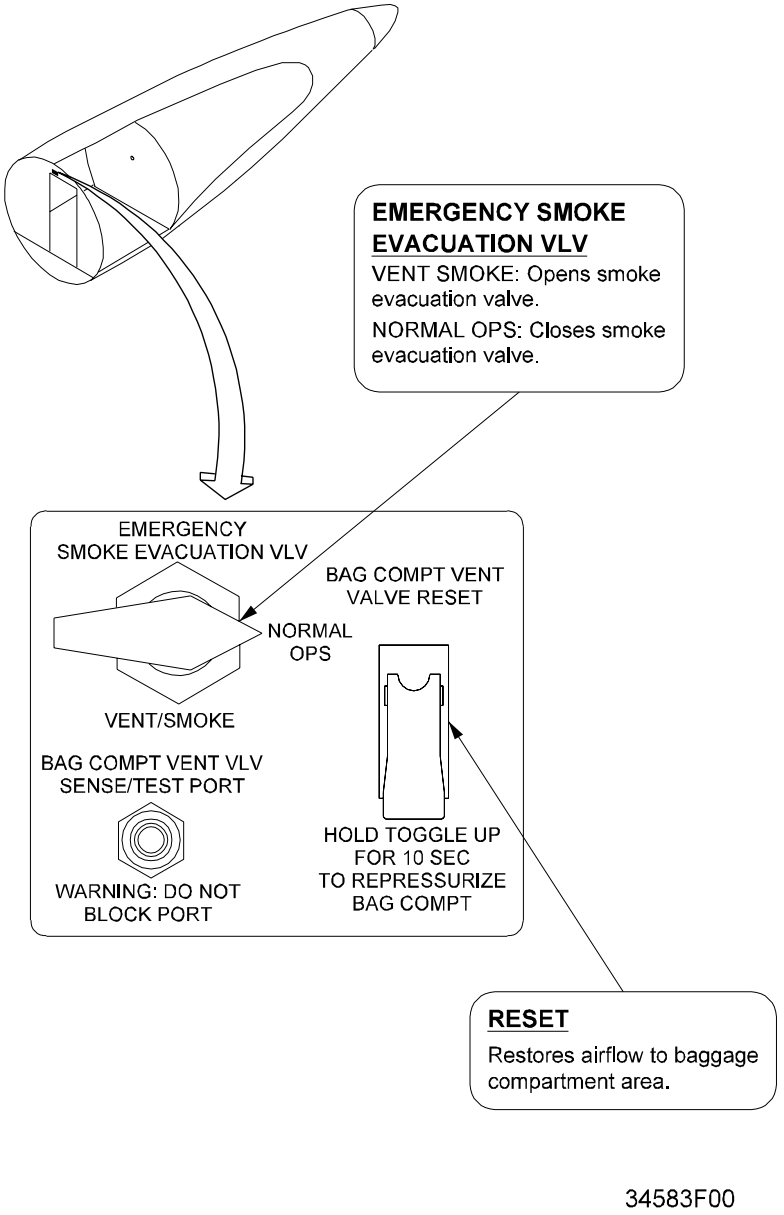
There are no limitations established for this system as of this writing.

B. System Notes:

(1) If the baggage compartment has been depressurized, the internal baggage compartment door cannot be opened until the baggage compartment has been repressurized.



Cockpit Overhead Panel: SYSTEM TEST Section
Figure 7



Emergency Smoke Evacuation Panel
Figure 8