2A-78-10: General

1. General Description:

The purpose of the engine exhaust system is to continue the aerodynamic external surface of the engine and to collect hot and cold stream gas flows. The gases are then propelled through an acoustically lined exhaust unit designed to reduce noise.

A Thrust Reverser (TR) unit is incorporated in the exhaust unit to assist aircraft speed reduction on the ground. Two hydraulically actuated pivot doors, which are supplied with hydraulic pressure from the aircraft hydraulic systems, move into and block the combined fan and core airflow when the TR is deployed.

In the forward thrust configuration, the two pivot doors are closed and locked in position by four door locks. Two primary locks are mounted in the side beams. A secondary lock is integral with the hydraulic actuator and a tertiary lock is mounted on the rear face of the front structure torque box.

A manual restow system is incorporated in the TR design and is actuated by the flight crew by use of a manual stow switch. On airplanes Serial Number (SN) 1000 through 1435 hot having Part 2 of Aircraft Service Change (ASC) 418, the manual restow function energizes a solenoid in two dual solenoid TR selector control valves. The valves are then commanded to route stowing hydraulic pressure to both door actuators. On airplanes SN 1436 and subsequent and airplanes SN 1000 through 1435 having Part 2 of Aircraft Service Change (ASC) 418, the manual restow function de-energizes a solenoid in two single solenoid TR selector control valves. With the solenoids de-energized, stowing hydraulic pressure is routed to both door actuators.

2. Thrust Reverser Lockout:

If a TR system malfunction is suspected or if a failure prevents normal function of either or both TRs (including a no deploy condition), the airplane **cannot** be dispatched until the condition is corrected. Gulfstream recommends contacting Gulfstream Technical Operations, the Operator's Area Field Service Representative or the Operator's Home Base of Operations if a TR system malfunction is suspected or a failure is detected.

Thrust reverser lockout procedures for the Gulfstream IV airplane, although available to increase the level of dispatch capability, are a complex procedure. An improperly locked down TR may cause extensive damage to the TR system, spurious UNLOCK or DEPLOY warnings to be displayed to the flight crew or, in the worst case, actual inadvertent deployment of a TR door. Therefore, consideration should be given to allowing TR lockout procedures to be performed only by properly certificated Airframe and Powerplant Technicians in accordance with Chapter 78 of the latest approved version of the Gulfstream Aerospace GIV Aircraft Maintenance Manual.

With one reverser inoperative, the flight crew must be aware of possible asymmetric braking effects if the operative reverser is deployed on landing. If desired, lockdown of a properly operating TR can be accomplished to avoid possible asymmetric braking effects. However, Gulfstream does not recommend this in the event that the operational TR is needed for any reason during period the single malfunctioning TR is locked down.

The following references should be consulted if a TR system malfunction is

suspected or a failure is detected:

- GIV Airplane Flight Manual, Abnormal Procedures, Section 3-24-00, Thrust Reverser System
- GIV Airplane Flight Manual, Emergency Procedures, Section 4-24-00, Thrust Reverser System
- GIV Aircraft Maintenance Manual, Chapter 78, Engine Exhaust
- GIV Master Minimum Equipment List, System 78
- GIV Operating Manual, Limitations, Section 01-78-10, Reverse Thrust
- GIV Operating Manual, Abnormal/Emergency Procedures, Section 05-24-00, Thrust Reverser System

3. Subsystems, Units and Components:

For the purposes of this discussion, the engine exhaust system is divided into the following subsystems:

- 2A-78-20: Thrust Reverser System

2A-78-20: Thrust Reverser System

1. General:

(See Figure 4.)

A. Description:

The engine exhaust (aft cowl) system directs the exhaust gases from the engine turbine section aft and into the atmosphere. The Thrust Reverser (TR) exhaust unit for the Gulfstream IV is an airframe furnished component and is therefore not considered a part of the engine. It is intended for ground use only and provides a means of decelerating the aircraft during landing roll. When the reverser assembly is in the stowed position, it forms the engine exhaust nozzle and the aft most portion of the nacelle fairing.

B. Operation:

Between touchdown and 70 KCAS, reverse thrust may be used to shorten landing roll distance. The thrust reverser system is armed upon touchdown (with both nutcrackers in the ground mode or wheel speed sensors detecting acceleration) and the power lever for specific reverser is at IDLE. Only when the indication system on the instrument panel indicates REV ARM can reverse thrust be utilized. Reverse thrust is obtained by pulling up and aft on the reverse thrust levers. When the reverser doors unlock, the REV UNLOCK light will illuminate and when the doors are fully deployed, REV DPLY light will illuminate. Increased reverse thrust is obtained by further aft movement of reverse levers.

(1) Arming System:

When the power lever mounted in the cockpit control pedestal is in the idle position (left power lever electrical switch also in idle position), the reverse thrust lever can be moved in its upward / aft direction for deployment.

Providing that the following conditions are met, 28V DC essential bus power is transmitted via the L TR CONT circuit breaker to the left TR arm indicator, resulting in the REV ARM light on the pilot's instrument panel to illuminate:

- Left power switch in the idle position
- Left fire handle in the normal position
- T/REV EMER STOW switch not depressed (and on airplanes SN 1000 - 1143 excluding SN 1034 not having Aircraft Service Change (ASC) 166 Nutcracker No. 3 relay energized [on ground configuration]) or on airplanes SN 1000 - 1143 excluding 1034 having ASC 166 and airplanes SN 1034, 1144 and subsequent
- Either nutcracker No. 3 relay energized (on ground configuration) or TR wheel speed relay energized (wheel speed above 65 MPH)

(2) Deployment:

When reverse thrust lever is moved in its upward / aft direction, a sector wheel and push-pull rod in the cockpit pedestal is caused to move forward to activate the left TR lever switch into the deploy position. Power from the 28V DC essential bus is also routed to energize the left secondary lock relay. When this relay is energized, a circuit is completed via the L SEC LOCK circuit breaker and the closed contacts of the left secondary lock relay to energize the secondary lock actuator. With the secondary lock actuator energized, the circuit (coming through L T/REV CONT circuit breaker) is also completed to energize solenoid No. 1 of the left TR selector control valve. This routes hydraulic pressure to the deploy side of the TR actuator, resulting in the unlocking of the TR actuator primary lock and deploying the doors.

NOTE:

On airplanes SN 1000 - 1143 excluding SN 1034 having ASC 166 and airplanes SN 1034, 1144 and subsequent, the left secondary lock time delay relay is energized after 5 seconds. Power is no longer routed to left secondary lock relay and to secondary lock actuator, but is routed directly to solenoid No. 1 of the left TR selector control valve to maintain hydraulic pressure to the deploy side of the actuator.

- REV UNLK indication:

  The left thrust reverser REV UNLK light will illuminate when the secondary lock actuator retracts (unlocks), either the upper or lower door limit switch is activated, or the primary lock switch (part of TR actuator) is closed (unlocked position). When any or all of these conditions are present, power is transmitted from the warning lights power system to energize the left TR interlock relay. When activated, this relay completes a circuit through its contacts to the left TR unlock indicator, causing the REV UNLK light to illuminate. In addition, when any of the conditions for the REV UNLK light illumination occurs, the Engine Instrument and Crew Advisory System (EICAS) and standby warning light indications are also activated if either Nutcracker No. 1 relay is not energized

(air configuration) or power lever No. 2 T/O relay is energized.

- REV DPLY indication:

  The left thrust reverser REV DPLY light on the pilot's instrument panel will illuminate when TR doors are fully deployed. In this condition, power is transmitted from the warning lights power system through closed contacts of the deploy limit switch to the left TR deploy indicator which causes the REV DPLY light to illuminate.

(3) Stowing:

When reverse thrust lever in cockpit is moved to the stow position, the left TR lever switch opens. This de-energizes the left secondary lock relay, thereby opening circuits to de-energize solenoid No. 1 of the left TR selector control valve and to shut off hydraulic pressure to the deploy side of TR hydraulic actuator. At the same time, circuits are closed to energize solenoid No. 2 of the left TR selector control valve to allow hydraulic pressure to the stow side of TR hydraulic actuator. The REV DPLY light will extinguish when doors begin to transition towards stow position. When TR doors are stowed and locked, the REV UNLK light will extinguish also.

(4) Emergency Stowing:

(See Figure 1.)

If an in-flight failure causes a REV UNLK light and REV UNLOCKED message to be displayed on the EICAS, the T/REV EMER STOW switch, located on the center pedestal, can be depressed. Although the results of depressing the T/REV EMER STOW switch are the same, the sequence of events varies with airplane effectivity as follows:

Airplanes SN 1000 through 1435 not having Part 2 of ASC 418: Depressing the T/REV EMER STOW switch completes a circuit from the essential 28V DC bus via the T/R EMER STOW circuit breaker (airplanes SN 1000 - 1182 not having ASC 210) or L T/R EMER STOW and R T/R EMER STOW circuit breakers (airplanes SN 1000 - 1182 having ASC 210 and SN 1183 and subsequent) to energize the stow solenoid of both TR selector control valves. This in turn allows hydraulic pressure to the stow side of both TR hydraulic actuators.

Airplanes SN 1436 and subsequent and airplanes SN 1000 through 1435 having Part 2 of ASC 418: These airplanes have the existing dual solenoid TR selector control valves replaced with single solenoid TR selector control valves. The single solenoid TR selector control valve employs a new spool and sleeve assembly that is spring biased and hydraulically powered to the stow position. The new valve spool and sleeve assembly is automatically piloted to the stow position when hydraulic power is available, thus eliminating the need for the stow solenoid. Depressing the T/REV EMER STOW switch removes all electrical power to both TR selector control valves. Spring pressure and hydraulic pressure then move the spool to the stow position, allowing hydraulic pressure to the stow side of both TR hydraulic actuators. The T/R EMER STOW circuit breaker

(airplanes SN 1000 - 1182 not having ASC 210) or L T/R EMER STOW and R T/R EMER STOW circuit breakers (airplanes SN 1000 - 1182 having ASC 210 and SN 1183 and subsequent) are removed on these airplanes.

C. Subsystems, Units and Components:

The thrust reverser system is composed of the following subsystems, units and components:

(1) Safety Devices, Consisting of the Following:

- Primary lock
- Secondary lock
- Mechanical feedback system

(2) Major Components, Consisting of the Following:

- Selector control valve
- Hydraulic actuator
- Secondary lock actuator

2. Description of Subsystems, Units and Components:

A. Thrust Reverser System Safety Devices:

During normal TR system operation, the following safety devices are utilized to protect against inadvertent operation of a TR, a jammed condition and/or improper operation of the system:

(1) Primary Lock:

(See Figure 2.)

The hydraulic actuator includes a built-in locking device which is engaged by a spring force when the actuator is fully extended (TR stowed position). This lock disengages hydraulically when deploy pressure is applied to the actuator.

(2) Secondary Lock:

(See Figure 2.)

A secondary latch located in the outboard stang beam locks both doors in the stowed position. It is spring loaded to the locked position and is unlocked by a solenoid actuator which is energized via a deploy command. On airplanes having ASC 18 (CAA requirements), airplanes SN 1000 - 1143 excluding SN 1034 having ASC 166 and SN 1034, 1144 and subsequent, the solenoid actuator is de-energized when doors deploy with a 5 second time delay relay.

(3) Mechanical Feedback System:

A mechanical feedback system automatically retards the engine power lever from a forward position to a near idle position should a reverser inadvertently deploy. This system also serves as a throttle interlock in that it restricts the reverse thrust lever from moving into reverse power range until the reverser moves from fully stowed to fully deployed position. In addition, the feedback limits reverse power and forward power during reverser transients. This feature protects the system in the event of a jammed reverser during landing or improper reverser operation during an aborted landing (after reverser has been deployed).

B. Thrust Reverser System Major Components:

(1) Selector Control Valve:

(See Figure 3.)

(a) All GIV airplanes:

Two TR selector control valves, located in the tail compartment at FS 682, port hydraulic fluid to the hydraulic actuator for deploying or stowing the TRs. One valve controls left TR door operation and the other valve controls right TR door operation.

(b) Airplanes SN 1000 through 1435 not having Part 2 of ASC 418:

Each TR selector control valve is a four-way, three-position unit that uses two solenoids to deploy and stow the TR. When the deploy solenoid is energized, flow from the pressure port is routed to the deploy port and the stow port is routed to hydraulic return. When the stow solenoid is energized, flow from the pressure port is routed to the stow port and the deploy port is routed to hydraulic return. In the neutral position (both solenoids de-energized), both ports are routed to hydraulic return.

The energized solenoid mechanically controls system pressure to the appropriate end of the spool which then actuates internal routing of the flow-through valve. The center position of spool in sleeve is maintained through opposing springs which position stops at this point. The respective stop-spring is overcome to allow the spool to move to an operating position as commanded.

(c) Airplanes SN 1436 and subsequent and airplanes SN 1000 through 1435 having Part 2 of ASC 418:

Each TR selector control valve is a four-way, three-position unit that uses a single solenoid to deploy and stow the TR. The solenoid is spring biased and hydraulically powered to the stow position. When the solenoid is energized, flow from the pressure port is routed to the deploy port and the stow port is routed to hydraulic return. When the solenoid is de-energized, flow from the pressure port is routed to the stow port and the deploy port is routed to hydraulic return.

The single solenoid TR selector control valve employs a new spool and sleeve assembly. The new spool and sleeve assembly is automatically piloted to the stow position when hydraulic power is available, thus eliminating the need for the stow solenoid.

(2) Hydraulic Actuator:

(See Figure 2.)

The TR hydraulic actuator is used to operate the TR doors. Each actuator is mounted on the outboard side of each engine between the bellcrank and outboard stang beam.

The actuator operates on the aircraft hydraulic system using an

operating pressure of 3000 PSI and a minimum flow of 6 GPM. It uses a mechanical lock that consists of four latches driven by a spring-loaded lock plunger. The normal actuator position is with piston rod extended, TR stowed and mechanical lock engaged.

In the stowed position, the four latches (each riding on a ball bearing) are seated against the lock plunger which retains them in the extended position. When extended, the latches are seated against the end of the piston chamber. Deploy hydraulic pressure (less than 1000 psi) will cause the lock plunger to act against a retaining spring. When the lock plunger moves away from the piston, it allows the latches to retract into the piston. As the piston retracts, residual hydraulic pressure in the STOW side of the actuator is ported to return through the STOW port.

Hydraulic pressure applied through the STOW port forces the piston to the extend position. The residual hydraulic pressure in the deploy side of the actuator is ported to return through the DEPLOY port. At the end of its stroke, the piston bottoms against the plate at the cylinder's end fitting. At the same time, the lock plunger (which is held against the other side of the plate by retaining spring wedges between the latches and piston rod surface) forces the latches to extend from the piston into the locked position. The end circumference of the plunger is sloped, enabling it to wedge between the latches, ball bearings and piston rod surface.

The lock indicator switch is operated by a hydraulic plunger in the switch housing. When the actuator or piston is extended and locked, the plunger is restrained within the housing by one of the latches. A ball bearing between the side of the hydraulic plunger and the spring-loaded switch plunger keeps the switch plunger depressed. When the actuator piston is unlocked, hydraulic pressure moves a hydraulic plunger inward towards the cylinder. The ball bearing seats inside a groove in the plunger, which allows the switch plunger to extend. Extension or retraction of the switch plunger determines which set of contacts in the switch is open or closed.

(3) Secondary Lock Actuator:

(See Figure 2.)

The secondary lock actuator is solenoid operated to provide electro-mechanical control of the secondary lock for the TR. The actuator is mounted at the outboard stang beam.

The solenoid is spring-loaded to the extended position and retracts when 28V DC power is applied to a solenoid coil. A bank of three microswitches is contained within the actuator. Switch A indicates shaft position (unlock), switch B controls current to the TR selector control valve and switch C is not used but can be used to replace switch B (if necessary).

3. Controls and Indications:

A. Circuit Breakers (CBs):

The thrust reverser system is protected by the following CBs:

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
L SEC LOCK	P	G-7	ESS DC Bus
R SEC LOCK	P	H-7	ESS DC Bus
L T/REV CONTROL	P	I-7	ESS DC Bus
R T/REV CONTROL	P	J-7	ESS DC Bus
T/R EMER STOW **(1)**	P	K-7	ESS DC Bus
L T/R EMER STOW **(2)**	P	L-7	ESS DC Bus
R T/R EMER STOW **(2)**	P	K-7	ESS DC Bus

NOTE(S):

(1) Airplanes SN 1000 - 1182 not having ASC 210 or Part 2 of ASC 418.

(2) Airplanes SN 1000 through 1182 having ASC 210 but not having Part 2 of ASC 418; SN 1183 through 1435 not having Part 2 of ASC 418.

B. Crew Alerting System (CAS) Messages:

Warning (Red) Messages and Annunciations:

CAS Message:	SWLP Indication:	Cause or Meaning:
L REV UNLOCK	L REV UNLOCKED	Left thrust reverser has become unlocked.
R REV UNLOCK	R REV UNLOCKED	Right thrust reverser has become unlocked.

Annunciation:	Cause or Meaning:
White REV UNLOCK light above DU 2 or 5.	Thrust reverser unlocked.
White REV DPLY light above DU 2 or 5.	Thrust reverser deployed.

Advisory (Blue) Annunciations:

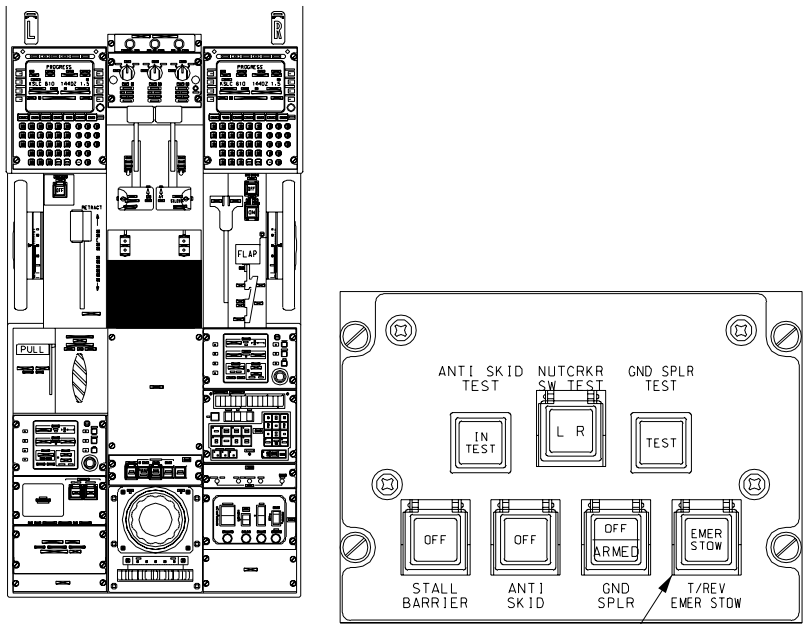
Annunciation:	Cause or Meaning:
REV ARM light (green) illuminated above DU 2 or 5.	Parameters satisfied for thrust reverser deployment.

4. Limitations:

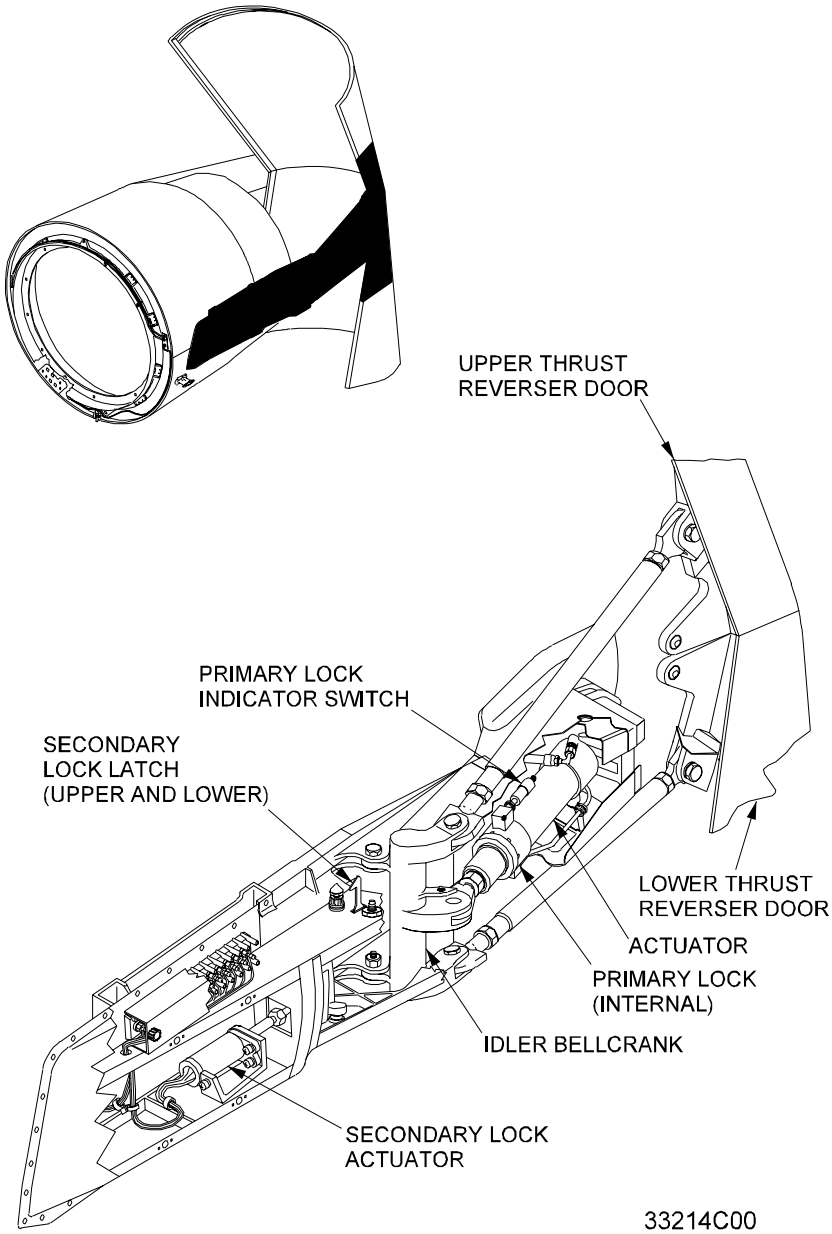
A. Flight Manual Limitations:

Cancellation of reverse thrust should be initiated by 70 KCAS so as to be at reverse idle by normal taxi speed. Thrust reverser door extension at taxi speeds is permitted if ASC 166 is incorporated and thrust reversers are kept low.

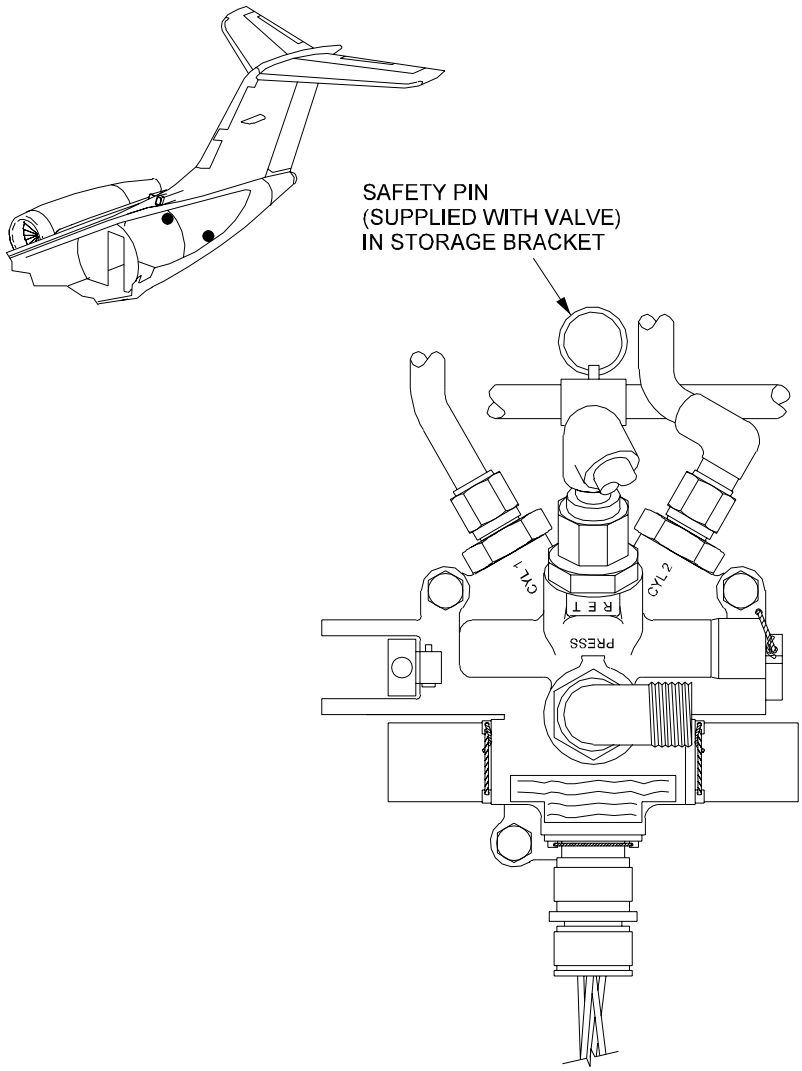
For airplanes SN 1000 through 1143 without ASC 166, use of thrust reversers is limited to one (1) minute every thirty (30) minutes.



Thrust Reverser Emergency Stow Switch
Figure 1



Thrust Reverser Components
Figure 2



VIEW LOOKING OUTBD LH SIDE

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Thrust Reverser Selector Control Valve
Figure 3

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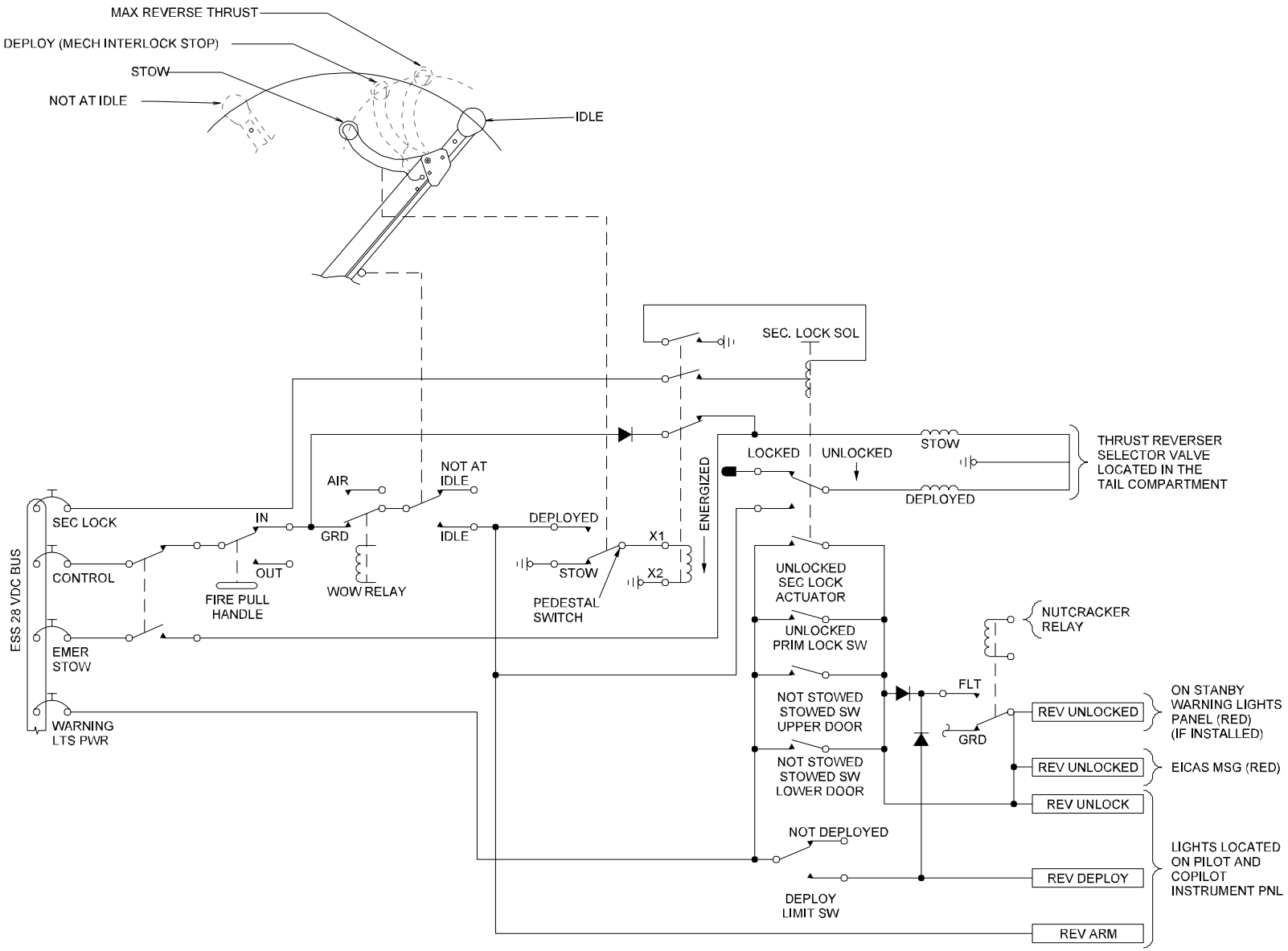

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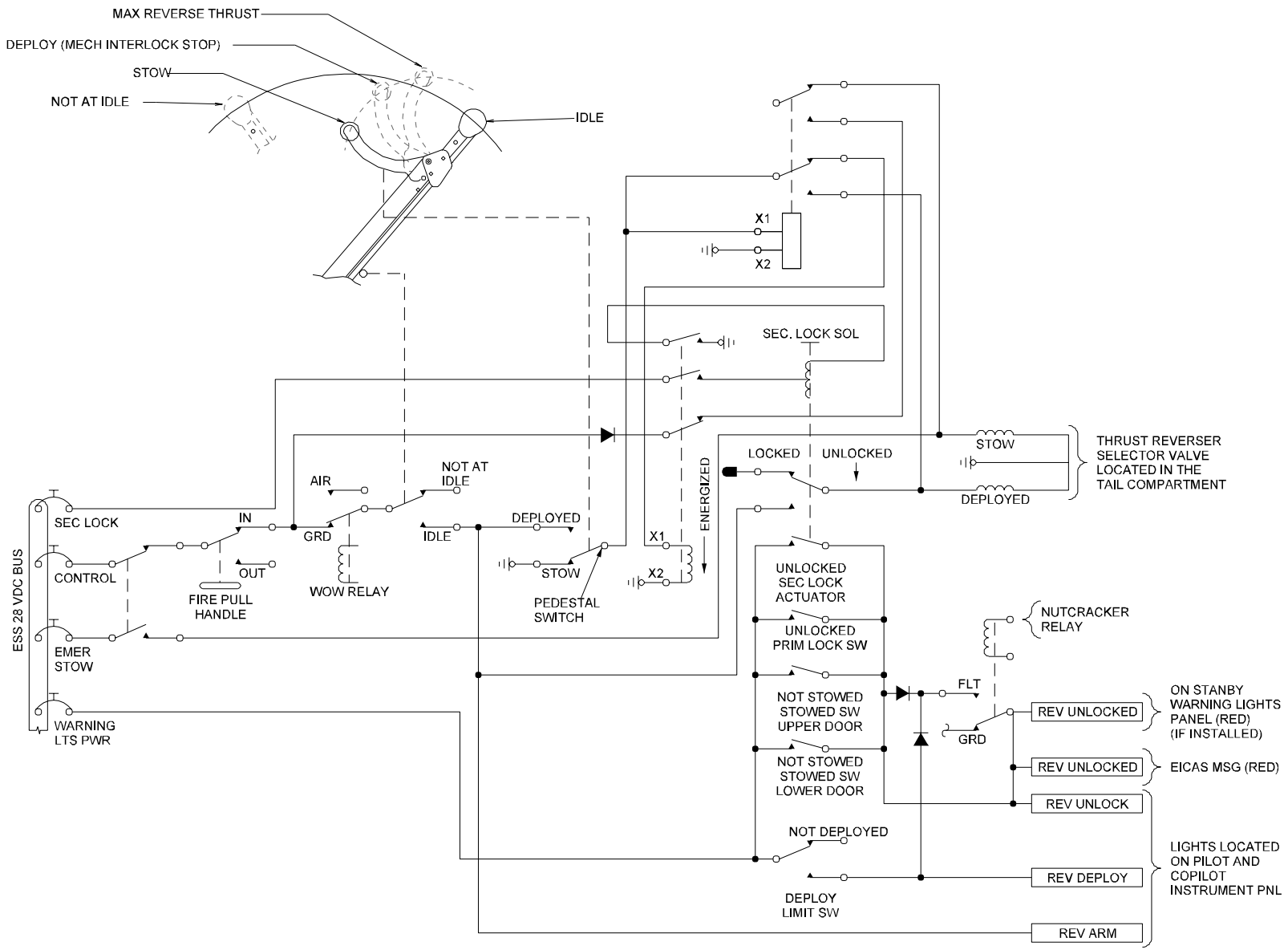
Thrust Reverser Simplified Schematic (Airplanes SN 1000 - 1143 Excluding SN 1034 Not Having ASC 166 / 166A)
Figure 4



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Thrust Reverser Simplified Schematic (Airplanes Having ASC 18, Airplanes SN 1000 - 1143 Excluding SN 1034 Having ASC 166 / 166A and Airplanes SN 1034, 1144 and Subsequent)
Figure 5