CHAPTER

78

Engine Exhaust

(LEAP-1B ENGINES)

CHAPTER 78
ENGINE EXHAUST

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A = Added, R = Revised, D = Deleted, O = Overflow, C = Customer Originated Change

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ENGINE EXHAUST

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A = Added, R = Revised, D = Deleted, O = Overflow, C = Customer Originated Change

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ENGINE EXHAUST

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ENGINE EXHAUST SYSTEM - INTRODUCTION

Purpose

The engine exhaust system controls the direction of the engine exhaust gases.

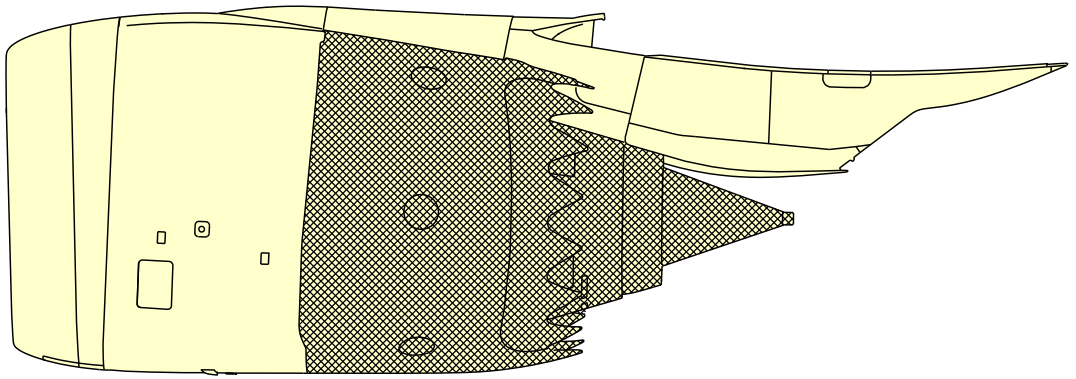
The engine exhaust system has these sub-systems:

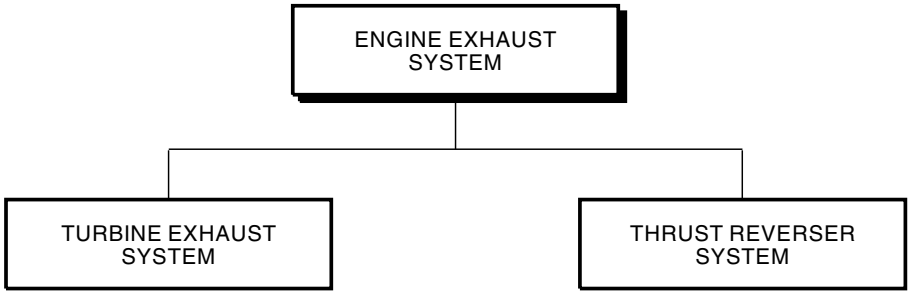
- Turbine exhaust
- Fan air exhaust
- Thrust Reverser

Abbreviations

- A/T - Autothrottle
- MDS - MAX Display System
- CDU - Control Display Unit
- DCV - Directional Control Valve
- DU - Display Unit
- EEC - Electronic Engine Control
- FCC - Flight Control Computer
- HIV - Hydraulic Isolation Valve
- INBD - Inboard
- ISV - Isolation Valve
- LVDT - Linear Variable Differential Transformer
- RTO - Rejected Takeoff
- SL - Sync Lock
- T/R - Thrust Reverser
- TRAS - Thrust Reverser Actuating System

ENGINE EXHAUST SYSTEM - INTRODUCTION





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ENGINE EXHAUST SYSTEM - INTRODUCTION

ENGINE EXHAUST SYSTEM - GENERAL DESCRIPTION

General

The engine exhaust system controls the direction of the turbine exhaust gases and the fan air exhaust.

Turbine Exhaust

The turbine exhaust provides an exit for the engine exhaust gases. This exit increases the velocity of the exhaust gases. This increases engine thrust.

The major components of the turbine exhaust are the exhaust nozzle and the exhaust plug.

Fan Air Exhaust

The fan air exhaust provides a pathway for the secondary air flow. The direction of the secondary air flow can be changed to provide reverse thrust.

Thrust Reverser System

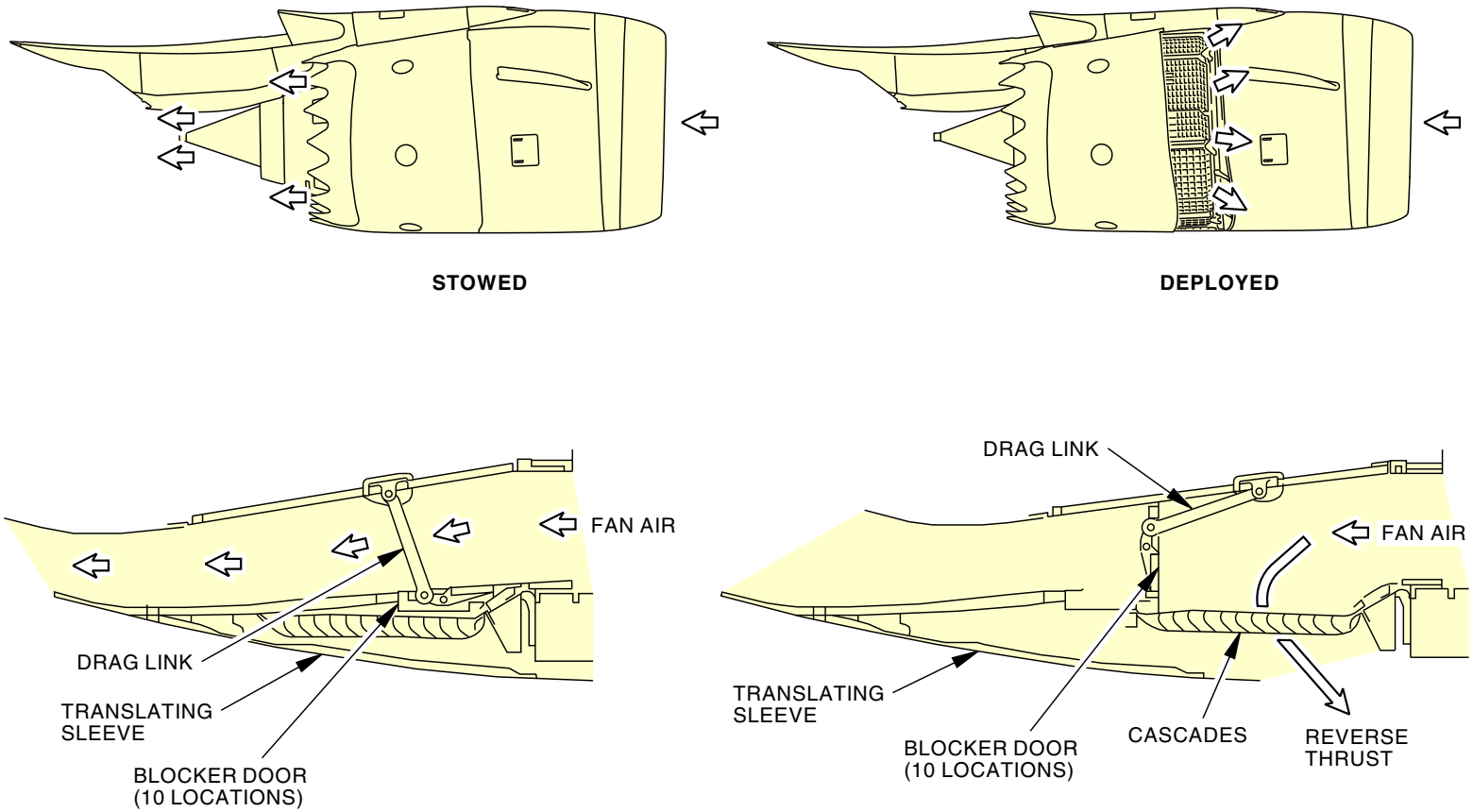
The Thrust Reverser (T/R) system changes the direction of the fan air exhaust to create reverse thrust. The reverse thrust is used to slow the airplane after landing or during a rejected takeoff (RTO). The turbine exhaust direction does not change during reverse thrust. The T/R system has a electro-hydraulic control system and an indicating system.

A thrust reverser is installed on each engine.

Each thrust reverser has a left and right half. Each half has a translating sleeve which moves aft (deploy position) for reverse thrust. The two sleeves work independently but are synchronized to work together. Fan air exhaust goes out radially and forward when the translating sleeves are in the deploy position.

Four hinges attach each T/R half to the strut. The thrust reverser must be deactivated before you open a T/R half. Latches are at the bottom of the two halves. The latches keep the two halves together.

ENGINE EXHAUST SYSTEM - GENERAL DESCRIPTION



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ENGINE EXHAUST SYSTEM GENERAL DESCRIPTION

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TURBINE EXHAUST SYSTEM - INTRODUCTION

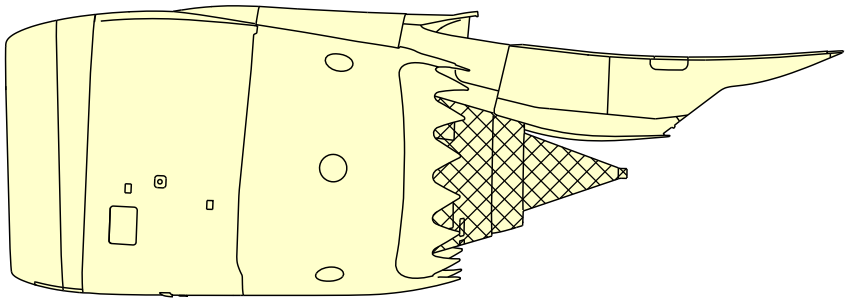
General

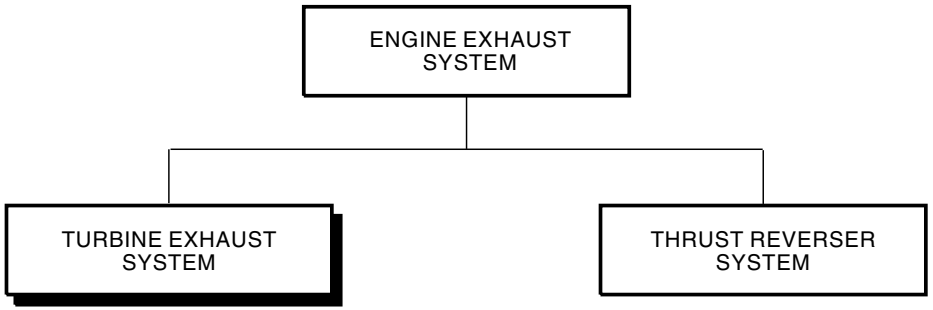
The turbine exhaust system provides an exit for the turbine exhaust gases.

Purpose

The system increases the turbine exhaust gas velocity to increase engine thrust.

TURBINE EXHAUST SYSTEM - INTRODUCTION





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TURBINE EXHAUST SYSTEM - INTRODUCTION

TURBINE EXHAUST SYSTEM - GENERAL DESCRIPTION

General

The turbine exhaust system uses a nozzle and a plug to control the direction of the turbine exhaust gases.

Components

These are the turbine exhaust system components:

- Plug
- Nozzle.

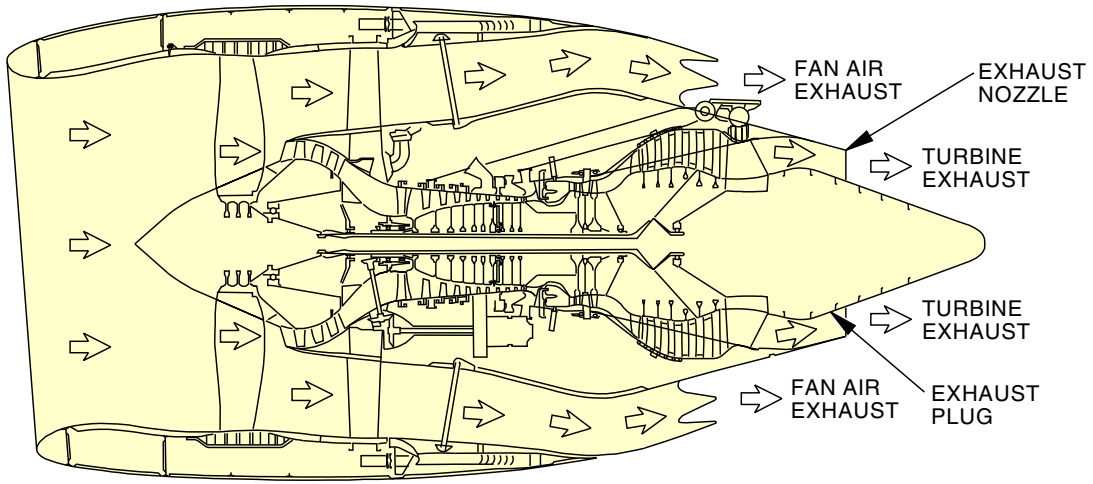
Physical Description

The exhaust nozzle controls the outer edge of the turbine exhaust flow. The nozzle is attached to the engine turbine case.

The exhaust plug controls the inner edge of the turbine exhaust flow. The plug is attached to the engine turbine case.

The plug and the nozzle are made of nickel alloy.

TURBINE EXHAUST SYSTEM - GENERAL DESCRIPTION



ENGINE AIRFLOW

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TURBINE EXHAUST SYSTEM - GENERAL DESCRIPTION

TURBINE EXHAUST SYSTEM - EXHAUST NOZZLE

General

The exhaust nozzle assembly has these components:

- Inner sleeve
- Labyrinth seals
- Fairing
- Fences.

Bolts attach the inner sleeve to the turbine exhaust case.

The exhaust nozzle uses labyrinth seals to contain fire. Bolts attach the seals to the inner sleeve.

The fairing helps smooth the inner edge of the fan air exhaust flow. Rivets attach the fairing to the inner sleeve.

The nozzle fences control the airflow of the fan air exhaust over the nozzle assembly.

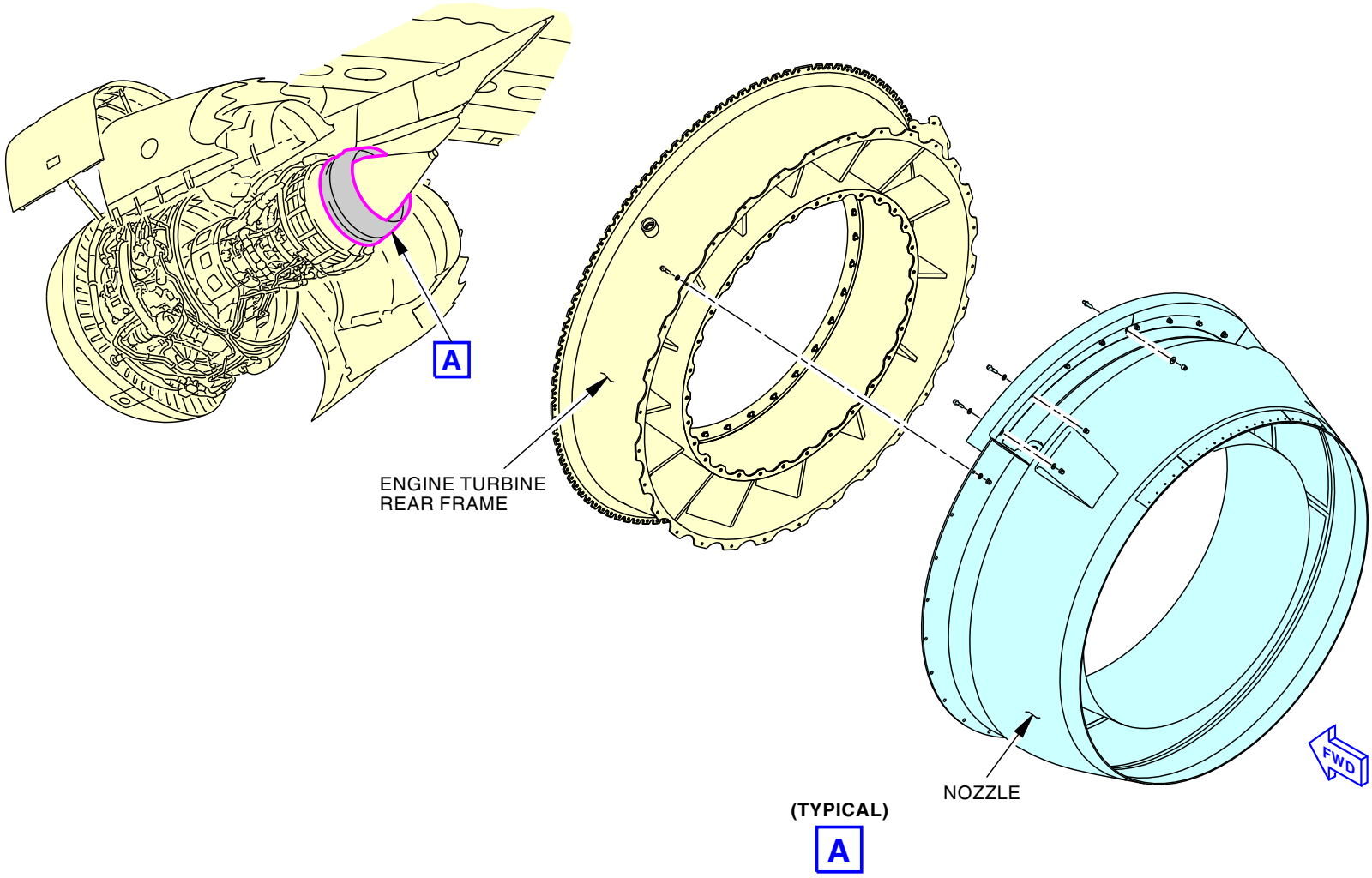
Purpose

The exhaust nozzle assembly controls the outer edge of the turbine exhaust flow. The aft part also controls the inner edge of the fan air exhaust flow.

Location

The exhaust nozzle assembly is on the aft end of the engine. The thrust reverser halves must be open to get access to the exhaust nozzle.

TURBINE EXHAUST SYSTEM - EXHAUST NOZZLE



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TURBINE EXHAUST SYSTEM - EXHAUST NOZZLE

TURBINE EXHAUST SYSTEM - EXHAUST PLUG

General

The exhaust plug assembly has a forward plug and an aft plug.

Bolts attach the aft plug to the forward plug.

Bolts attach the forward plug to the engine turbine exhaust case.

Purpose

The exhaust plug assembly controls the inner edge of the turbine exhaust flow.

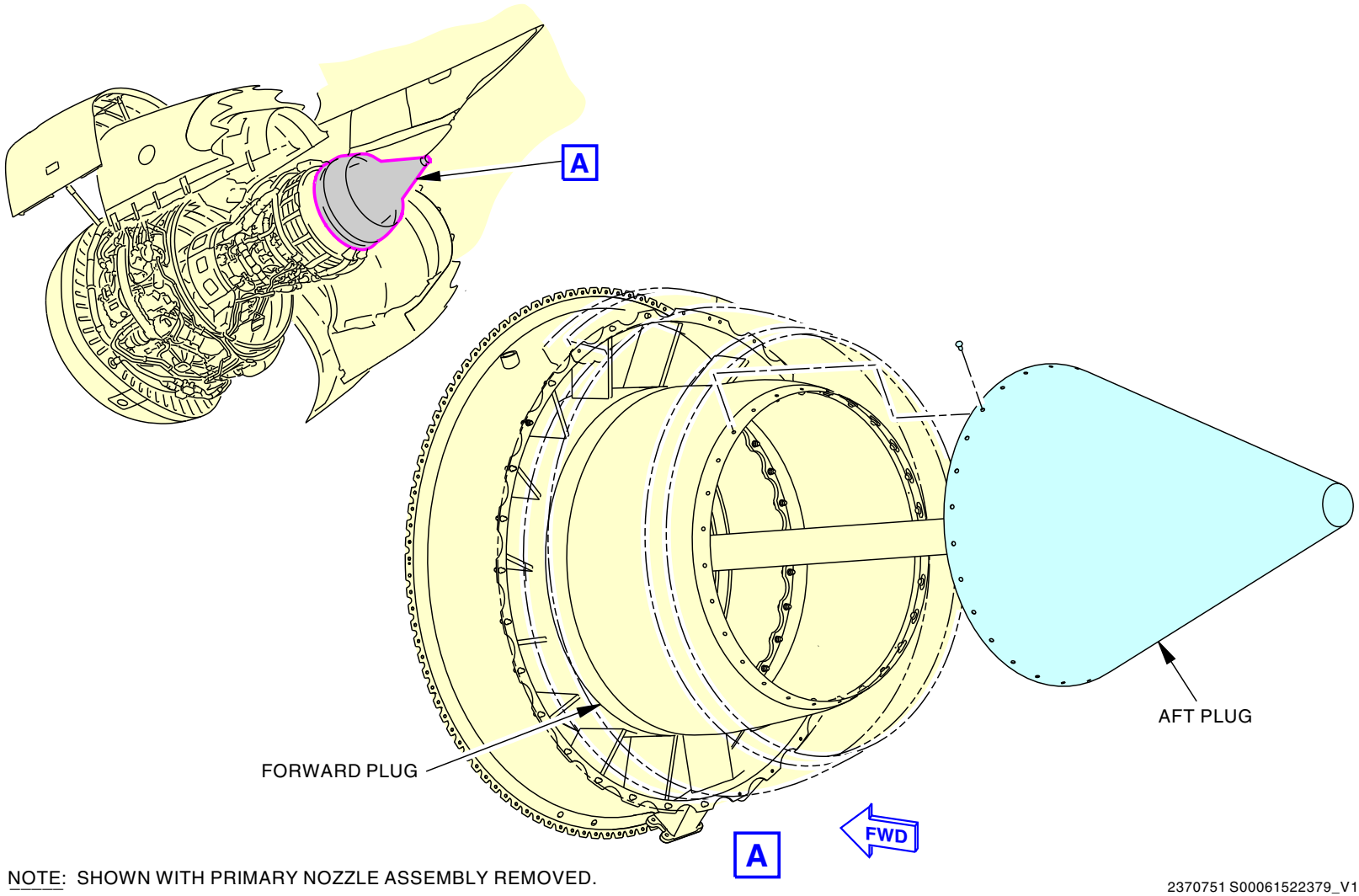
The engine vent system uses a hole at the aft end of the exhaust plug to vent to ambient air.

See the engine oil chapter for more information about the engine vent system. (CHAPTER 79)

Location

The exhaust plug is on the aft end of the engine turbine case.

TURBINE EXHAUST SYSTEM - EXHAUST PLUG



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TURBINE EXHAUST SYSTEM - EXHAUST PLUG

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THRUST REVERSER SYSTEM INTRODUCTION

General

The thrust reverser (T/R) system controls the direction of engine fan air exhaust for forward and reverse thrust. The T/Rs are electrically controlled and hydraulically operated. The T/R components are interchangeable between engines except for the cascades. When the T/Rs deploy, the translating sleeves move aft and the blocker doors close. This will cause the fan air to go out past the cascades radially and forward. Reverse thrust occurs as a result of the change in fan air direction. This helps decrease the airplane speed during landing rollout and during a rejected takeoff (RTO).

Thrust Reverser System Operation

The thrust reversers are not operational in flight. When the translating sleeves extend, these occur:

- The cascade vanes uncover.
- The blocker doors deploy.
- The fan air goes out through the cascade vanes.
- The cascade vanes re-direct the fan air forward.

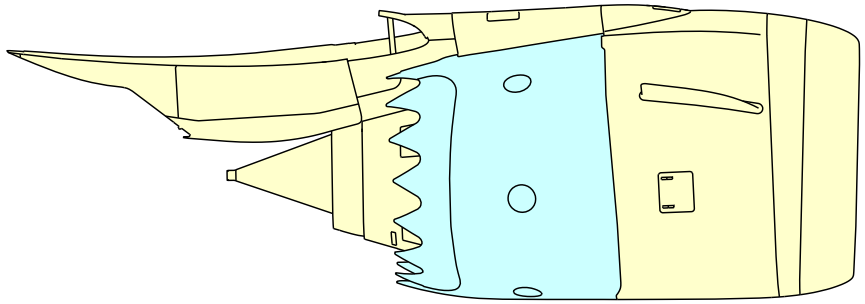
T/R Control System

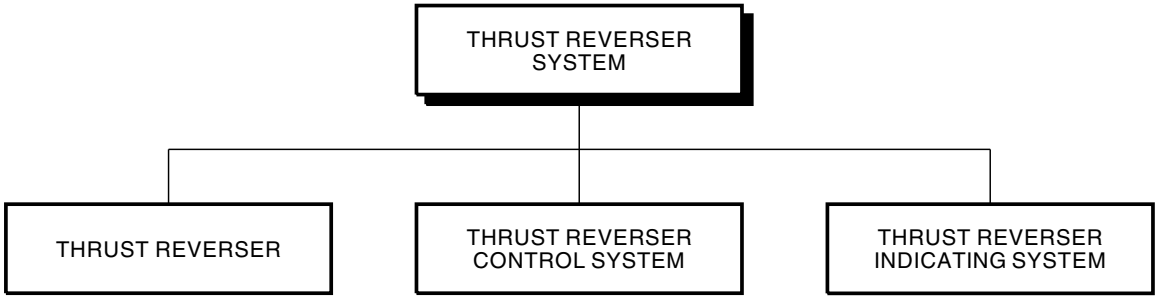
The T/R control system controls electrical and hydraulic power to the T/R system.

T/R Indicating System

The T/R indicating system supplies T/R system and T/R control system indication in the flight compartment.

THRUST REVERSER SYSTEM INTRODUCTION





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THRUST REVERSER SYSTEM INTRODUCTION

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THRUST REVERSER SYSTEM GENERAL DESCRIPTION

General

The thrust reverser (T/R) is a translating sleeve and cascade design. Each T/R has a left and right fan duct half with a translating outer wall (sleeve). The thrust reverser translating and fixed structure is comprised of these components:

- Cascades
- Blocker doors
- Blocker door drag links
- Hinge Beam
- Latch Beam
- Torque box
- Sliders
- Inner Wall
- Aft Cowl
- Acoustic Panel
- Outer Wall
- Tension latches
- Inner and Outer V-Blade

Thrust Reverser Mechanism

The translating sleeves are deployed and stowed by the hydraulic Thrust Reverser Actuation System (TRAS). Aircraft hydraulic fluid enters the TRAS via the Hydraulic Isolation Valve (HIV) and is directed to deploy or stow by the thrust reverser Directional Control Valve (DCV) which ports hydraulic fluid to each translating sleeve. The HIV and DCV are incorporated into one unit called the Thrust Reverser Control Valve Module (CVM). Each translating sleeve is moved by three linear hydraulic actuators that are mechanically interconnected by synchronization (sync) shafts. A synchronization lock is mechanically linked to the hydraulic linear actuators and prevents the uncommanded thrust reverser sleeve movement. Electrical power to all of the lock and valve solenoids is limited to ground operation via air/ground logic that uses a combination of low range radio altimeter (LRRA) signals, weight on wheels proximity switches monitored by the proximity sensor electronics unit (PSEU) and airspeed.

T/R Control System

The T/R control system is armed for deployment when the airplane is the ground and the forward thrust lever at idle stop (Throttle Resolver Angle is less than 26°). The thrust reverser for each engine is controlled by a single, dedicated reverse thrust lever which is part of the thrust lever assembly (aisle stand). Reverse thrust lever motion provides the signals to the TRAS to deploy or stow the thrust reverser and to vary the engine power setting from reverse idle up to the maximum allowable reverse thrust level. The Electronic Engine Controller (EEC) is an integral part of the TR control and indication systems.

THRUST REVERSER SYSTEM GENERAL DESCRIPTION

The thrust reverser is stowed by returning the reverse thrust lever back to the full down position. There is no interlock restriction when commanding stow. When returning the T/R lever back to fully stowed, the DCV deploy microswitch opens and the sequencing relay opens ensuring there is no power to the DCV deploy solenoid. The EEC will command the DCV stow solenoid to energize as TRA goes back above 34° TRA. Once the DCV stow solenoid is energized, hydraulic pressure moves the valve back to stow and the sleeve will retract. The EEC also controls the electrical circuit holding the HIV open while the reverser stows. When the reverser is fully stowed, the EEC will remove power from the HIV and DCV (10 seconds after the reverse thrust lever is moved above 34° TRA or one proximity sensors on each sleeve is indicates locked, whichever is longer). A 10 second timer within the Sync Lock relay keeps the sync locks unlocked during stow.

T/R Indicating System

The T/R indicating system supplies these indications in the flight compartment:

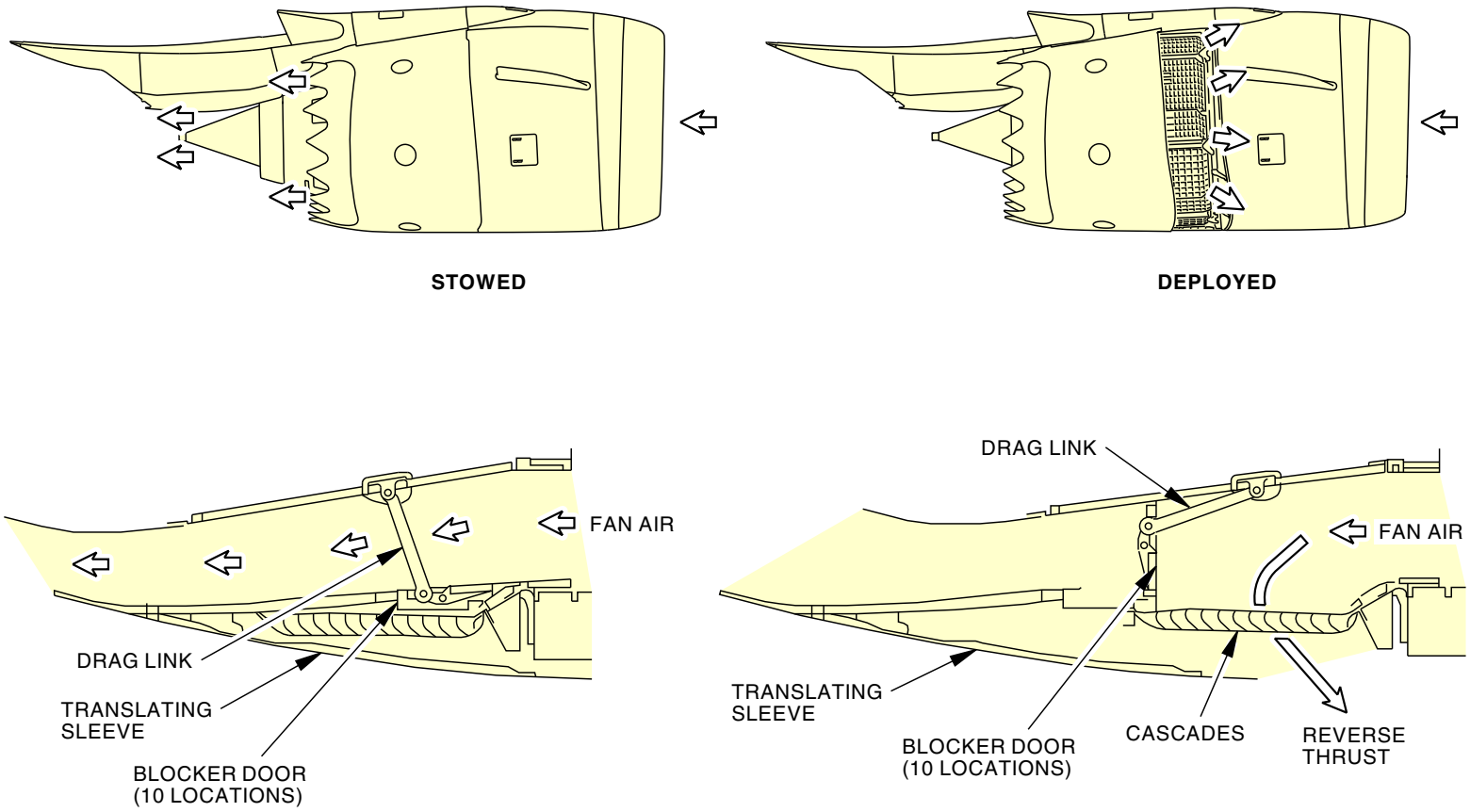
- REV message on MAX display system (MDS)
- REVERSER fault lights on the P5 engine panel
- Linear Variable Differential Transformer (LVDT) data to the EECs

The MAX display system (MDS) shows the REV message above each N1 indications on the engine indication display. This message refers to the positions of the translating sleeves. Each T/R has LVDTs which supply translating sleeve position data to the Electronic Engine Control (EEC).

When on, a REVERSER light indicates these conditions:

- REVERSER COMMAND light comes on if a thrust reverser lever is not in STOW with the airplane in flight.
- REVERSER AIR/GRD light comes on when the air/ground protection for the T/R system in not satisfactory.
- REVERSER LIMITED fault light comes on when the EEC detects a defect in the T/R system.
- A MAINT light triggered by the ENG X REVERSER status message. The ENG X REVERSER INTERLOCK and ENG X REVERSER SENSOR messages will be a scheduled maintenance tasks and thus must be checked at a regularly scheduled interval. These messages provide fault information to assist maintenance crew with troubleshooting.

THRUST REVERSER SYSTEM GENERAL DESCRIPTION



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THRUST REVERSER SYSTEM GENERAL DESCRIPTION

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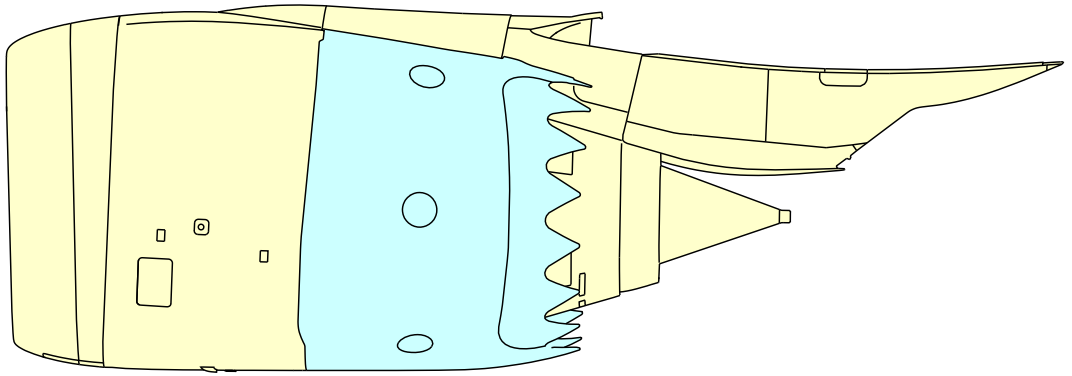
THRUST REVERSER - INTRODUCTION

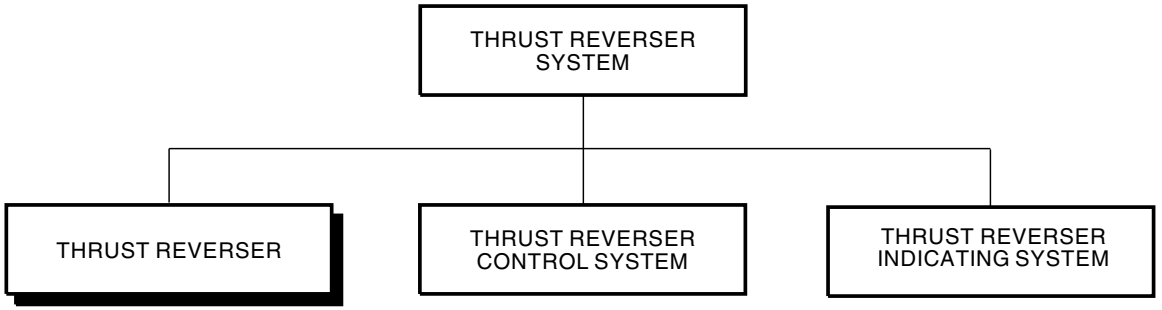
Purpose

The thrust reverser (T/R) system controls the direction of engine fan air exhaust for forward and reverse thrust.

Reverse thrust helps decrease the speed of the airplane after landing or during a rejected take off (RTO).

THRUST REVERSER - INTRODUCTION





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THRUST REVERSER - INTRODUCTION

THRUST REVERSER - GENERAL DESCRIPTION

General

The T/R is a translating sleeve and cascade design. Each T/R has a left and right fan duct half with a translating outer wall (sleeve). The two sleeves on each T/R work at the same time. Each translating sleeve is moved by three linear hydraulic actuators that are mechanically interconnected by synchronization (sync) shafts. A synchronization lock is mechanically linked to the hydraulic linear actuators and prevents the uncommanded thrust reverser sleeve movement.

Each T/R half has these components:

- Translating sleeves
- Hydraulic actuators
- Sync shafts
- Sync locks
- Cascades
- Blocker doors
- Blocker door drag links
- Thrust reverser opening actuator
- Krueger flap deflector
- T/R Control Valve Module (CVM)
- T/R sleeve lock proximity sensor
- T/R control switch

SIA ALL; AIRPLANES WITH COMPOSITE INNER WALL

- Composite Inner Wall

SIA ALL; AIRPLANES WITH TITANIUM INNER WALL

- Titanium Inner Wall

SIA ALL

The sleeves are in the stow position when they are in the full forward position. The sleeves are in the deploy position when they are in the full aft position. The sleeves have sliders which let the sleeves move forward and aft in tracks.

Each blocker door drag link attaches a blocker door to the inner duct.

Functional Description

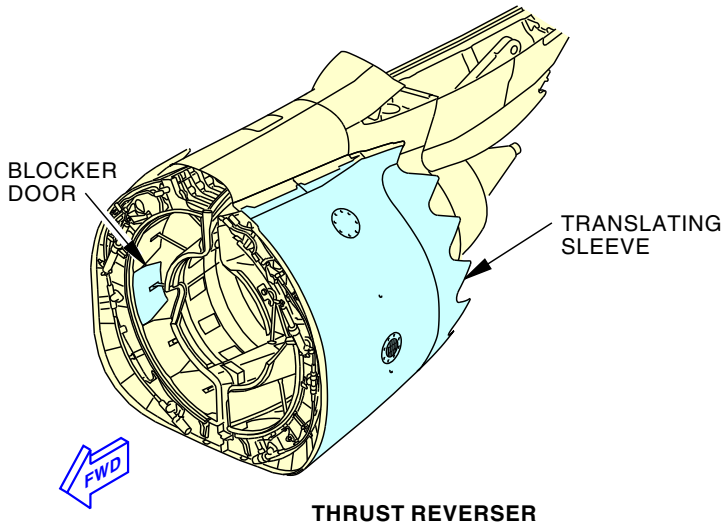
The T/R control system uses the hydraulic actuators to move the translating sleeves. The sleeves move aft of the cascades during a deploy operation.

Each drag link causes its blocker door to move into the fan air exhaust flow as the sleeve moves aft.

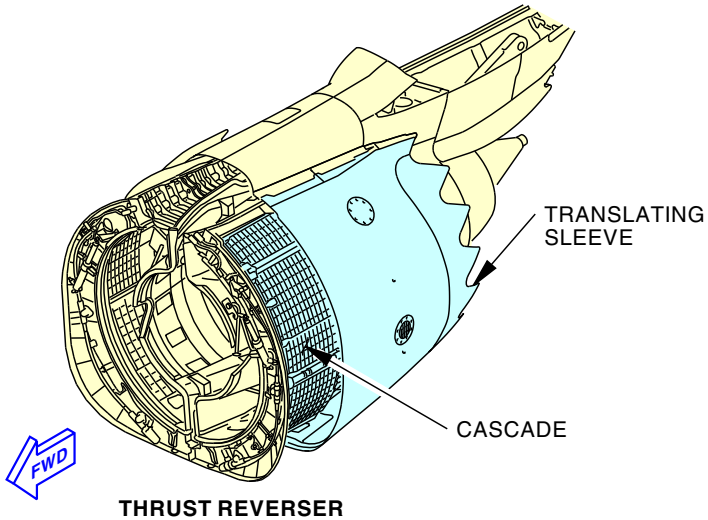
The blocker doors change the direction of the fan air exhaust out through the fixed cascades. This causes reverse thrust.

See the thrust reverser control system section for more information about T/R control. (SECTION 78-36)

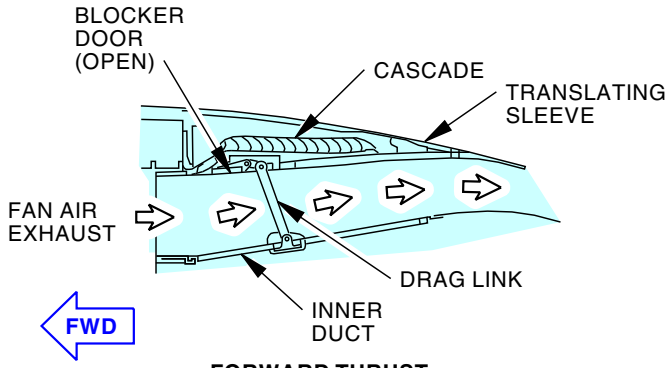
THRUST REVERSER - GENERAL DESCRIPTION



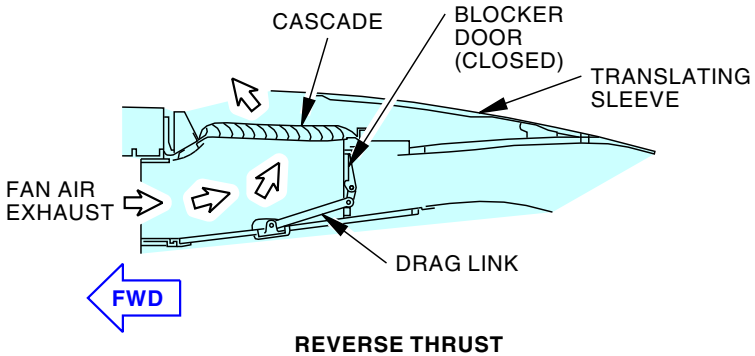
THRUST REVERSER
(STOW POSITION)



THRUST REVERSER
(DEPLOY POSITION)



FORWARD THRUST



REVERSE THRUST

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THRUST REVERSER - COMPONENT LOCATION

General

The thrust reverser is made of three major components; the translating sleeve, the fan duct cowl, and the aft cowl. The inner surface of the translating sleeve and the outer surface of the fan duct cowl forms the fan duct for the fan air exhaust. A cross-section view thru the thrust reverser, aft of the fan, shows a reduction in cross sectional area over the length of the fan duct; this feature is used to create thrust from the fan exhaust air.

Thrust Reverser Fan Duct Cowl

The fan duct cowl is part of the thrust reverser assembly. There is a left and a right fan duct cowl for each engine. The fan duct cowl assembly consists of the following: Inner wall with upper and lower bifurcation and acoustic features, the forward torque box, the cascade aft attachment ring, the cascade segments, the upper hinge and track beam, the lower latch and track beam, the opening actuator attachment fittings and the main and auxiliary tracks and track liners for the translating sleeve.

The cascade segments are made of composite materials. The torque box and upper hinge beam and lower latch beam are made of aluminum.

The inner wall forms part of the fan duct of the thrust reverser. The inner wall is a large structure that forms the upper bifurcation, the cowl that covers the engine core, and the lower bifurcation. On the airflow side, the inner wall has acoustic features. The hinge beam is attached to the upper bifurcation and the latch beam is attached to the lower bifurcation.

The fan duct inner wall is a composite structure with the drag link anchor fittings, lower bifurcation compression pad fittings and upper bifurcation compression receiver fittings. The aluminium hinge beam is attached to the inner wall upper bifurcation. The aluminium latch beam is attached to the inner wall lower bifurcation. The fan duct inner wall is covered with a corrosion resistant steel (CRES) faced thermal insulation blanket and fire barrier. The inner wall also has blocker door drag link fittings, the upper and lower bifurcation fire seals, vertical fire seals and engine core v-blade, the upper bifurcation compression cups and lower bifurcation compression pads. Most of the inner wall is made of honeycomb composite materials.

The torque box is a semi-circular structure that connects the upper hinge beam and the lower latch beam. The torque box also has a v-blade that engages the v-groove in the engine fan case. The hydraulic locking and non-locking actuators are installed through the torque box and the forward actuator gimbals are pinned to fittings on the torque box. The deploy and retract hydraulic tubing are located by tubing clamps mounted on the torque box. Wire bundles for the rotary variable differential transducer (RVDT), the proximity sensors on the locking actuators and the sync lock/manual drive unit are attached to the torque box with wire bundle clamps. The forward attachment points for the cascade segments are on the aft side of the torque box.

Each T/R half has two v-blades. One v-blade is mounted on the front thrust reverser torque box which engages a v-groove on the engine fan case. The second v-blade is mounted to the front of the fan duct inner wall of the thrust reverser that covers the engine core. The second v-blade engages a v-groove on the engine core case. The v-blades transfer the longitudinal thrust forces on the thrust reverser in forward flight and reverse thrust back into the engine and strut structure.

The cascade aft attachment ring is a semi-circular structure that connects the upper hinge beam with the lower latch beam. The ring provides the aft attachment points for the cascade segments.

THRUST REVERSER - COMPONENT LOCATION

Each T/R half has a hinge beam structure at the top of the thrust reverser that has four connection points for two strut hinge fittings and two tie rods. The two center hinge beam connection points attach to the two strut hinge fittings that carry the thrust reverser static weight. The forward and aft hinge beam connection points attach to tie rods that pass through the strut. The strut hinge fittings have spherical ball bushings. The strut tie rods ties the front and aft position of the two thrust reverser halves. The upper hinge beam also has bracket structure for the forward and aft fairing that covers the hinges. The upper bifurcation compression cups engage the ends of three strut-mounted compression rods. The three compression cups are mounted on fittings on the left and right upper bifurcations. The compression rods are the primary load path to transfer the fan duct pressure load between the thrust reverser halves. Continued operation is not permitted with the compression rods damaged or missing. The compression rods are suspended from brackets under the strut. The compression rods are not adjustable at the rod ends. The compression cups are adjustable with shims.

A corrosion resistant steel (CRES) firewall plate is attached at the front of each thrust reverser hinge beam to separate the hinge beam and strut structure from overheat or fire from the engine fan case mounted components. A corrosion resistant steel (CRES) firewall plate is attached at the front of each lower torque box to separate the latch beam structure from overheat or fire from the engine fan case mounted components.

There are three compression wear plates mounted on fittings on the left lower bifurcation.

The latch wearplates and shims are mounted to the side of the tension latches and are adjusted when the strut or the thrust reverser is replaced.

The tracks for the translating sleeve are machined into the hinge beam and the latch beam. Track liners are installed in the tracks. There is a main track and an auxiliary track on each beam. The main track engages the main track sliders on the inner wall of the translating sleeve and carries the weight of the translating sleeve. The auxiliary track engages the auxiliary track sliders on the outer wall of the translating sleeve.

On the lower latch beam, around the latch housings, there are four shear pins on the left thrust reverser and four shear pin bushings on the right thrust reverser. The shear pins fit into the bushings when the thrust reverser is closed and latched. The purpose of the shear pins and bushings is to align the bottom of the thrust reversers together. If a shear pin or bushing is missing, there would be an increase in loads and wear on the remaining shear pins and bushings. The forward shear pin and bushing and the aft shear pin and bushing cannot be missing. Any missing shear pin or bushings must be replaced.

Bulb-type fire seals are mounted in metal retainer tracks on the length of the upper bifurcation and the lower bifurcation to the latch beam. A bulb type fire/aerodynamic seal is mounted around the circumference of the inner wall, aft of the inner wall v-blade. A bulb type fire seal is mounted on the inner wall lower bifurcation of the left thrust reverser half. A bulb type fire seal is mounted on the inner wall upper bifurcation of the left and right thrust reverser half. When the thrust reverser is closed and latched, the bulb type fire seals are compressed against the metal seal depressors on the strut, the engine upper fan case, the structure around the engine core case. The fire seals help to contain a engine core external component fire under the inner wall. Some of the fire seals act also act as aerodynamic seals which close off air gaps that can cause an operational economic penalty.

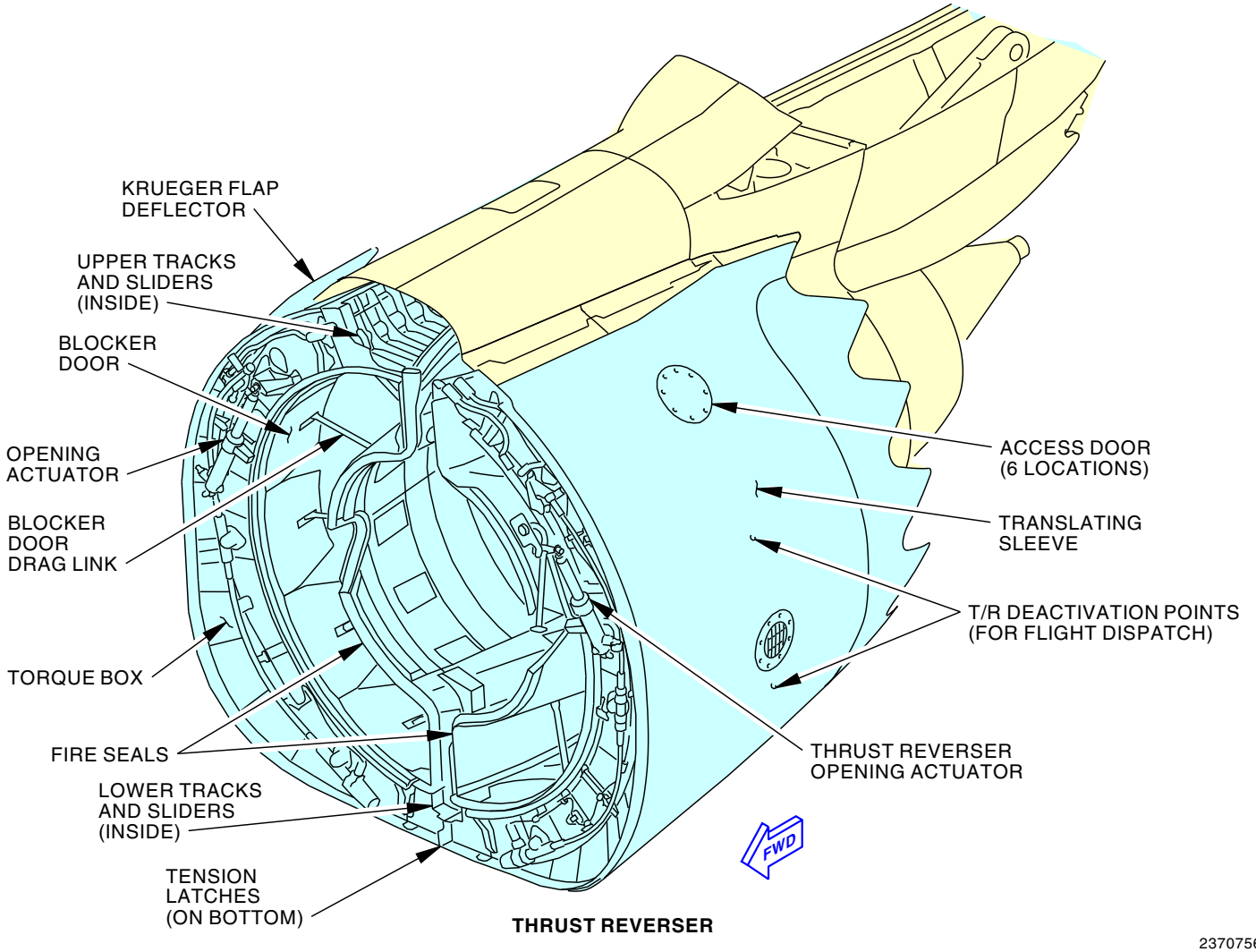
The thermal insulation blankets are installed on brackets that are installed on the inner surface of the inner wall. Thermal insulation blankets are mounted on the inside surface of the fan duct cowl and upper and lower bifurcation. These blankets are a thermal insulation and fire barrier which is necessary to keep the thrust reverser structurally serviceable and can decrease the damage and repair costs from a duct burst or fire. The thermal insulation prevents fire and engine operation heat damage to the composite inner wall of the fan duct cowl.

Rubstrips are mounted on the circumference of the torque box as a wear surface for the fan cowl panels and the translating sleeves.

THRUST REVERSER - COMPONENT LOCATION

A total of six tension latches, at the bottom of the T/R, keep the two halves together. The tension latches are mounted in the latch beam on the left thrust reverser half. The hooks on the tension latches engage latch bolts that are mounted in the latch beam on the right thrust reverser half. There are two tension latches that are mounted together at the forward end of the latch beam. These two tension latches are necessary to keep the v-blades engaged in the v-grooves if a fan blade out or rejected take off event occurs.

THRUST REVERSER - COMPONENT LOCATION



THRUST REVERSER

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THRUST REVERSER - COMPONENT LOCATION

THRUST REVERSER - TRANSLATING SLEEVE

General

The thrust reverser translating structure, or transcowl, consists of an outer wall which is the nacelle external flow surface, the acoustic panel which is the fan duct outer flow surface and contains 10 blocker doors (5 per reverser half). The bullnose seal is connected to the transcowl and provides the seal between the transcowl and the torque box. The acoustic panel and outer wall are connected at the fan nozzle exit to form a translating sleeve housing the fixed stationary cascades. Chevrons are part of the acoustic panel and are treated to provide additional noise abatement of the engine.

Purpose

The translating sleeves have two purposes when the T/Rs are in the stow position:

- Protect the cascades and other internal components
- Control the outer edge of the fan air exhaust flow.

The translating sleeves have two purposes when the T/Rs are in the deploy position:

- Expose the cascades
- Move the blocker doors into the fan air exhaust flow.

Location

The T/R sleeves are aft of the fan cowl. Sliders and tracks attach the sleeve to the structure.

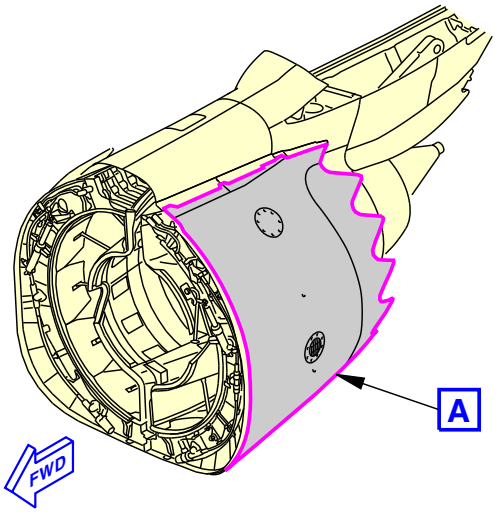
Physical Description

The T/R sleeve is a composite assembly with an inner and outer skin.

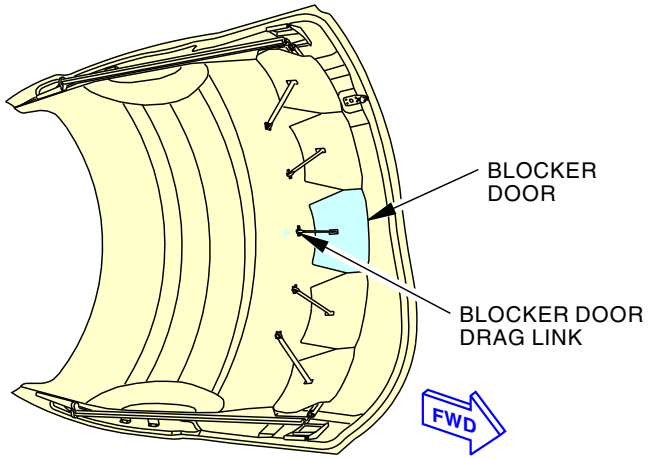
The outer skin completes the aerodynamic contour of the engine cowls and protects internal components.

The inner skin is the outer wall of the fan duct. Blocker doors and acoustic panels make up a large part of the inner skin.

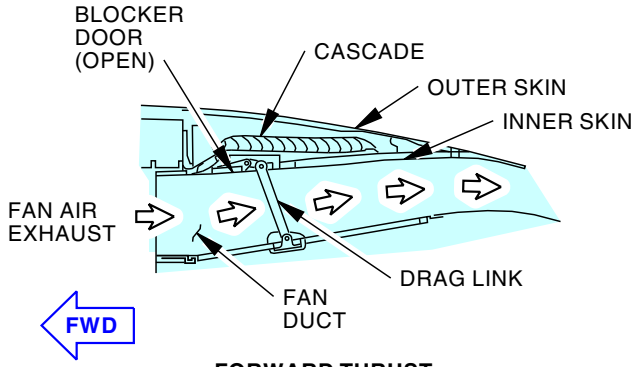
THRUST REVERSER - TRANSLATING SLEEVE



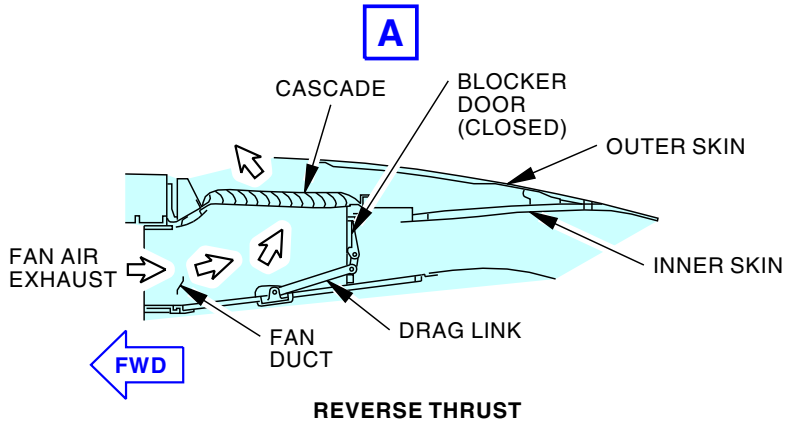
THRUST REVERSER



TRANSLATING SLEEVE
(INNER COWL STRUCTURE IS NOT SHOWN)



FORWARD THRUST
(STOW POSITION)



REVERSE THRUST
(DEPLOY POSITION)

2370757 S00061522395_V2

THRUST REVERSER - TRANSLATING SLEEVE

THRUST REVERSER - HYDRAULIC ACTUATORS AND SYNC SHAFTS - GENERAL DESCRIPTION

General

Each T/R half has three hydraulic actuators. The upper two actuators are locking actuators and the lower one is a non-locking actuator. The locking actuators must unlock for the other hydraulic actuators on that same half to operate.

The locking actuators have a manual unlock lever. The manual unlock lever allows the actuator to unlock for a manual translation of the T/R sleeve.

The upper locking actuator has a position feedback mechanism. The position mechanism operates a Linear Variable Differential Transformer (LVDT).

There are two sync shafts on each T/R half.

Purpose

The hydraulic actuators move the translating sleeves during T/R deploy and stow operations.

The sync shafts make the hydraulic actuators extend and retract at the same speed. The sync shafts also allow the actuators to be manually operated.

Location

The actuators are attached to the torque box and to the translating sleeve.

The fan cowl must be opened and the translating sleeve moved aft to get access to the hydraulic actuators.

The upper sync shaft is inside the deploy hydraulic tube, between the upper and middle actuators. The lower sync shaft is inside the deploy hydraulic tube, between the middle and lower actuators. The deploy tubes are larger than the stow tubes. The fan cowl must be opened to get access to the tubing.

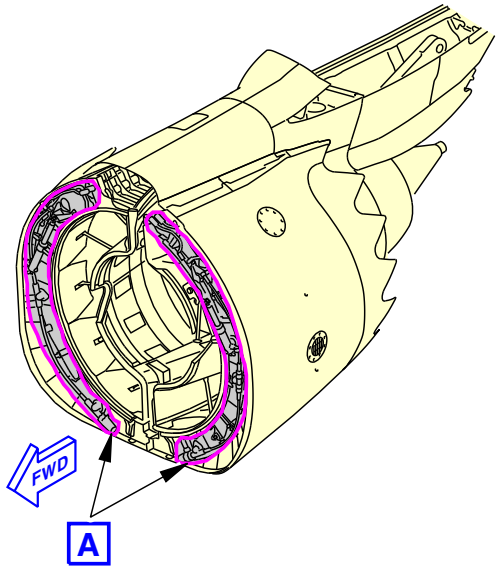
Non-locking Actuators

The non-locking actuator assemblies are located in the lower position on each transcowl. During deployment hydraulic pressure is ported to both the head and rod ends of the actuator. A differential pressure area moves the piston and acme nut towards the deployed position. The nut motion causes rotation of a multi-start acme screw with a worm gear attached to one end. The worm gear drives a worm that is perpendicular to the actuator centerline and attached to a flexible sync shaft cable connecting the actuators. When stowing, the head end pressure drops to return line pressure causing the piston to move towards the stow (head end) position. The actuator is sized to deploy the reverser in a maximum of 3 seconds and stow it in a maximum of 5 seconds. The actuator stroke is 20.55 inches.

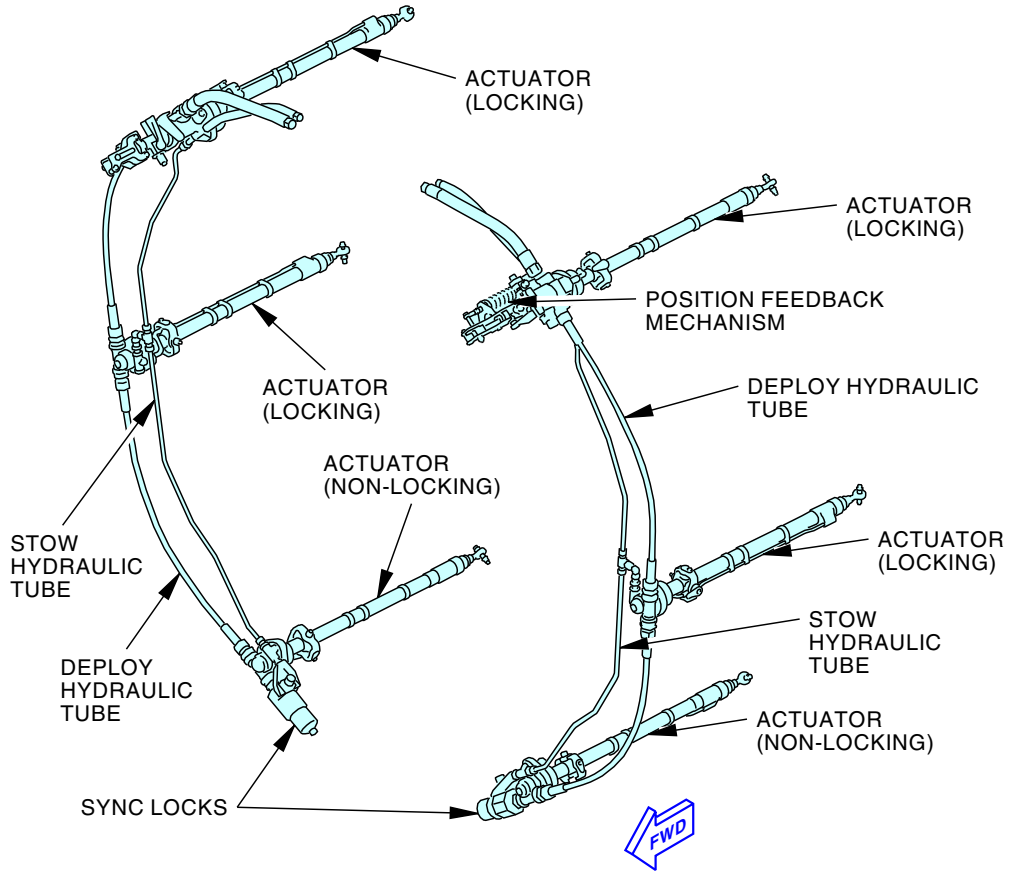
Locking Actuators With and Without Feedback

The locking actuators operate the same as the non-locking type, following lock release. In the upper position are locking actuators with feedback and the center actuators are locking actuators without feedback. The actuators contain a locking mechanism at the head end which prevents piston movement. When the actuators are in the stow position and locked, a spring positions a lock sleeve, holding locking keys radially into a cavity in the piston. When a deploy signal is given, pressure to the head end of the actuator shuttles the lock sleeve allowing the lock keys to be ramped outward into an unlocked position as the actuator starts to deploy. A manual unlock assembly is provided to unlock the actuator to enable manual translation for maintenance purposes. The manual unlock lever also provides the target for the lock position proximity sensor. The proximity sensor provides lock status to the EEC that will set a message if there is a fault. Feedback actuators in the upper position on each transcowl provide sleeve position to the EEC for thrust control during TR cycling. The upper actuator provides a mechanical output proportional to the actuator travel to serve as an input for the thrust reverser position feedback system.

THRUST REVERSER - HYDRAULIC ACTUATORS AND SYNC SHAFTS - GENERAL DESCRIPTION



THRUST REVERSER



HYDRAULIC ACTUATORS TUBING

A

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THRUST REVERSER - HYDRAULIC ACTUATORS AND SYNC SHAFTS - GENERAL DESCRIPTION

THRUST REVERSER - HYDRAULIC ACTUATORS - FUNCTIONAL DESCRIPTION

General

There are two types of T/R hydraulic actuators:

- Locking
- Non-locking

Each T/R half has two locking actuators and one non-locking actuator.

The locking actuators each have a manual unlock lever. The manual unlock lever allows the locking actuator to be manually unlocked. The manual unlock lever is also a target for the T/R sleeve lock sensor.

Only the upper locking actuators have feedback mechanisms. The feedback mechanism operates the Linear Variable Differential Transformer (LVDT). The LVDT supplies translating sleeve position data to the indicating system.

Location

The locking actuators are upper and middle actuators of each T/R half. The non-locking actuators are below the locking actuators. All actuators attach to the torque box at the forward end and to the translating sleeve at the aft end.

The fan cowl must be opened and the translating sleeve moved aft to get access to the hydraulic actuators.

Physical Description

All of the hydraulic actuators have these parts and connections:

- Extend (deploy) pressure port
- Retract (stow) pressure port
- Gimbal assembly
- Sync shaft and tubing connections.

The locking actuators also have these components:

- Manual unlock lever
- Position feedback mechanism
- Internal lock mechanism.

Hydraulic pressure at the extend port unlocks the locking actuator during normal T/R operation.

Pressure Ports

The T/R control valve controls the hydraulic power to the actuators. Hydraulic fluid goes to the extend and retract pressure ports of each actuator during a deploy operation. Hydraulic power unlocks the locking actuators so they can operate. All actuators extend and move the translating sleeve aft.

The T/R control valve sends hydraulic fluid to the retract pressure ports of each actuator during a stow operation. With hydraulic pressure at these ports, the actuators retract and move the translating sleeve forward. The hydraulic fluid at the extend port returns through the hydraulic control valve module to the hydraulic reservoir.

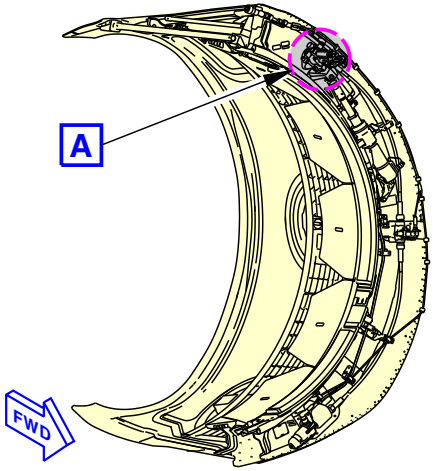
Gimbal Assembly

A gimbal assembly attaches the head end of each hydraulic actuator to the aft side of the torque box. The translating sleeves must be moved aft to get access to the gimbal assembly.

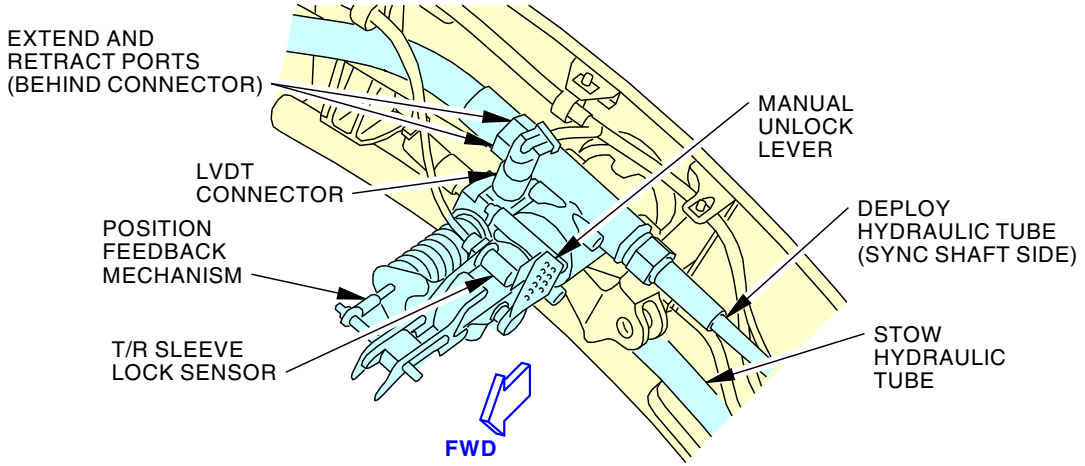
Sync Shaft and Tubing Connections

The sync shafts connect the drive mechanisms of the actuators together. The shafts are inside of the deploy hydraulic tubing which connects to the extend pressure port. The sync shaft connection is at the pressure port.

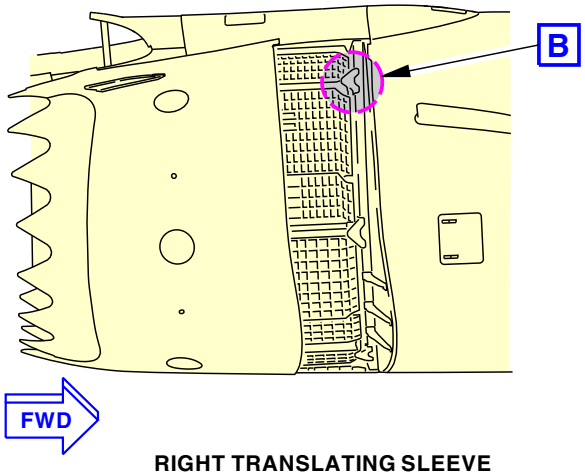
THRUST REVERSER - HYDRAULIC ACTUATORS - FUNCTIONAL DESCRIPTION



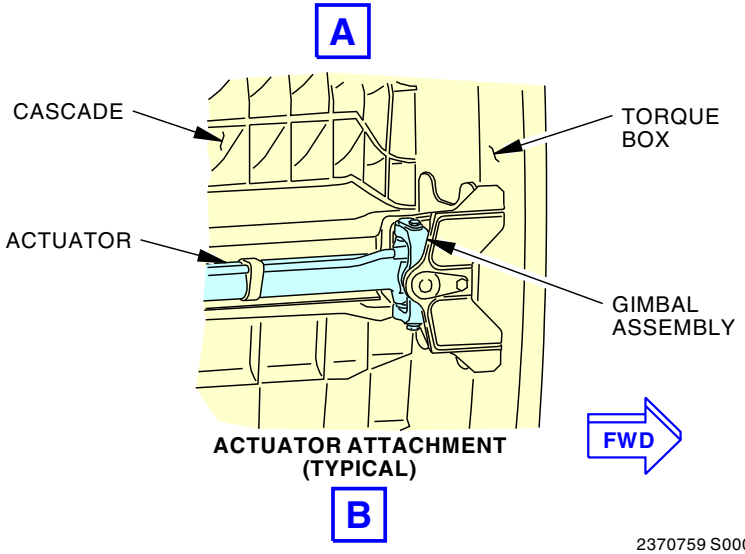
LEFT T/R HALF



LOCKING ACTUATOR INSTALLATION



RIGHT TRANSLATING SLEEVE



ACTUATOR ATTACHMENT
(TYPICAL)

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THRUST REVERSER - HYDRAULIC ACTUATORS - FUNCTIONAL DESCRIPTION

THRUST REVERSER - CASCADE SEGMENTS

Purpose

The cascades are turning vanes that redirect the fan air flow to provide reverse thrust. The cascades are designed to direct air flow away from the fuselage to minimize re-ingesting the airflow back into the engine inlet.

General

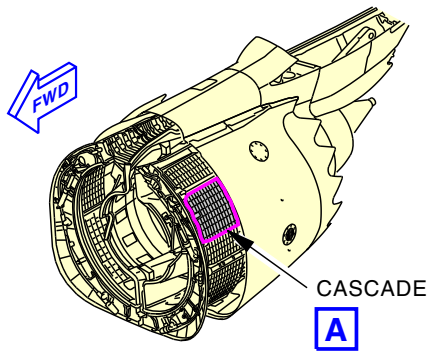
There are 16 different efflux pattern cascades baskets per engine. The outboard half of the engine has 8 cascades and the inboard half has 8 cascades. The left and right hand engine cascade configurations are mirror images of each other. The cascades and structure are physically interchangeable to reconfigure for a different engine.

Location

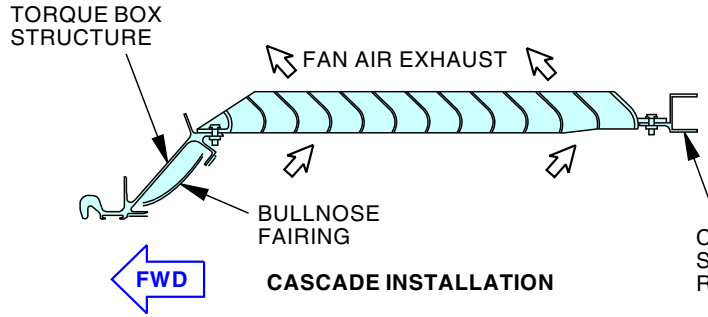
Bolts attach the cascades to the torque box on the forward edge and to the cascade support ring on the aft edge.

Deployment of the T/R is necessary to get access to the cascades.

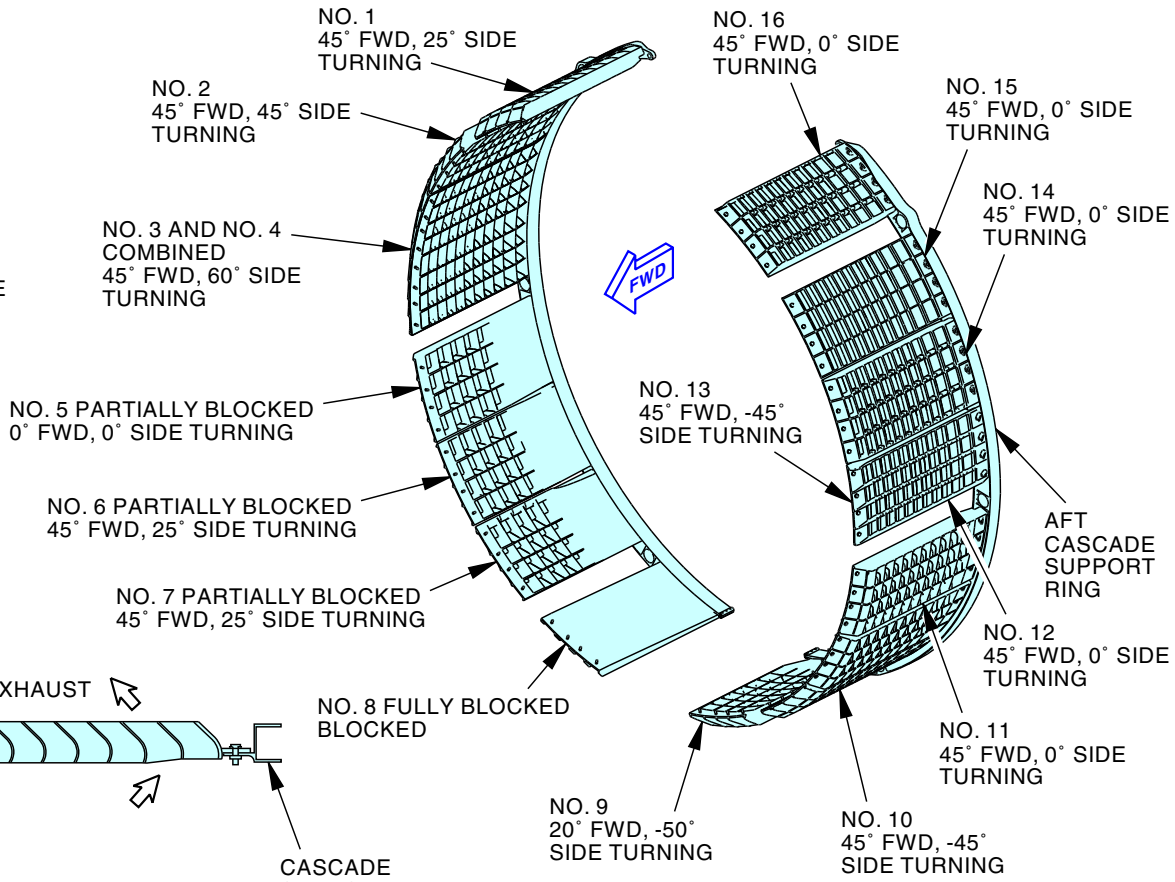
THRUST REVERSER - CASCADE SEGMENTS



THRUST REVERSER (DEPLOY POSITION)



CASCADE INSTALLATION



ENGINE 1 CASCADE STRUCTURE AND EFFLUX PATTERN

NOTE:

ENGINE 1 AND 2 CASCADE CONFIGURATIONS ARE MIRROR IMAGES OF EACH OTHER.

2370760 S00061522401_V2

THRUST REVERSER - CASCADE SEGMENTS

THRUST REVERSER - BLOCKER DOORS AND BLOCKER DOOR DRAG LINKS

General

The blocker door assembly forms part of the fan duct airflow surface when the engine is providing forward thrust. Five aluminum blocker doors are installed on each thrust reverser assembly. A pre-loaded spring internal to the blocker door hinge fitting will provide blocker door vibration damping in forward thrust. The attach fittings on the blocker door and fan duct inner flow surface are attached by a drag link.

Purpose

Upon deployment the blocker doors translate and rotate into the fan duct by means of the drag link to redirect fan air through the cascades.

Location

The blocker doors are part of the translating sleeve. They are smooth to match the inner contour of the translating sleeve.

The blocker door drag links are in the fan duct.

Physical Description

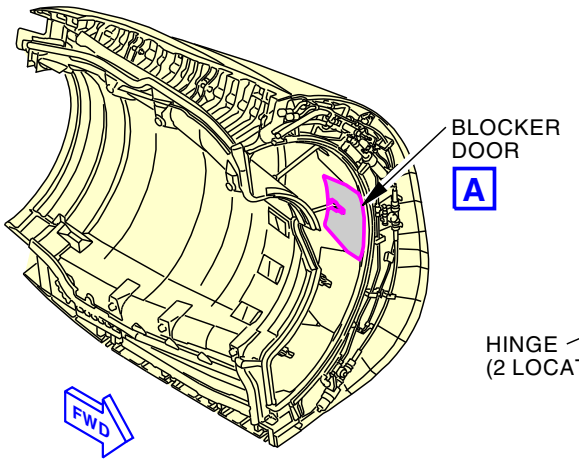
Each translating sleeve has five graphite-epoxy blocker doors. There are two different sizes of blocker doors on each sleeve.

Two hinges connect each blocker door to the forward end of the inner sleeve. The blocker door drag links connect the blocker doors to the fan duct inner wall. Numbers identify blocker door location.

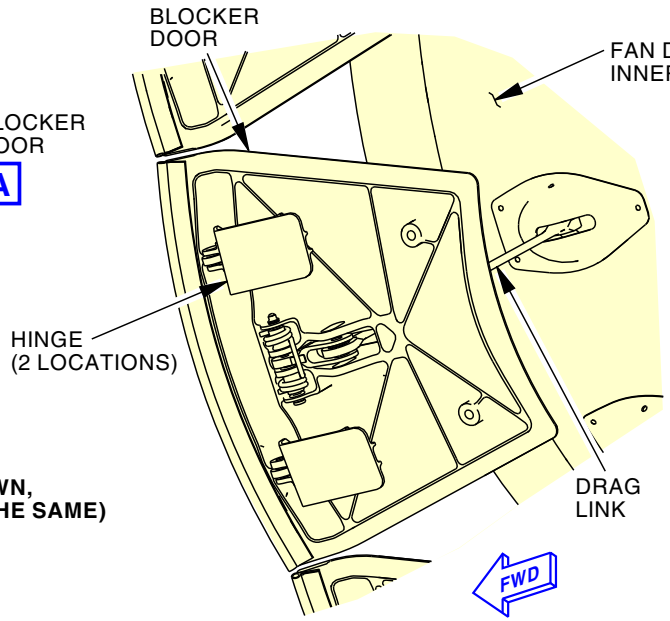
Functional Description

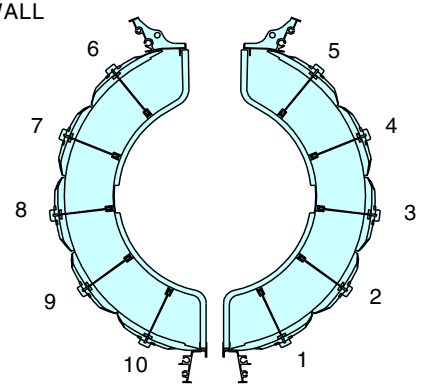
Each translating sleeve moves aft during a T/R deploy operation. This movement causes the blocker doors to move into the fan duct. The fan air exhaust changes direction and exits through the cascades. This creates reverse thrust.

THRUST REVERSER - BLOCKER DOORS AND BLOCKER DOOR DRAG LINKS

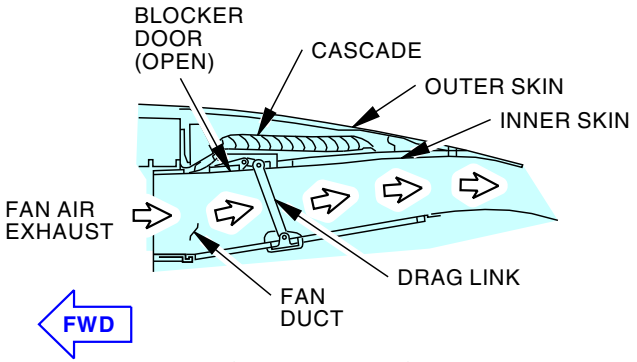


**(LEFT THRUST REVERSER IS SHOWN,
RIGHT THRUST REVERSER IS ALMOST THE SAME)**



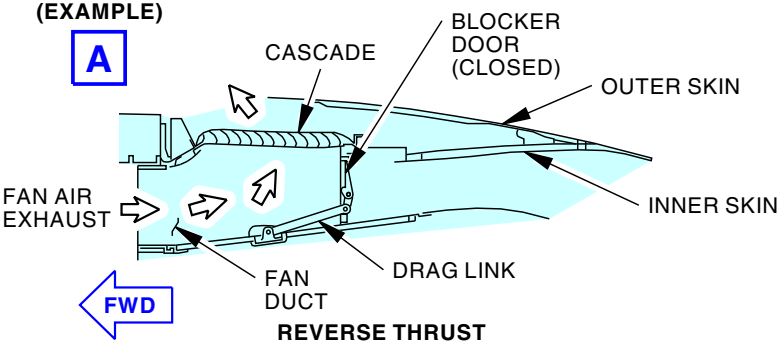


**BLOCKER DOOR NUMBERING
(VIEW IN THE FORWARD DIRECTION)**



**FORWARD THRUST
(STOW POSITION)**

**BLOCKER DOOR
(EXAMPLE)**



**REVERSE THRUST
(DEPLOY POSITION)**

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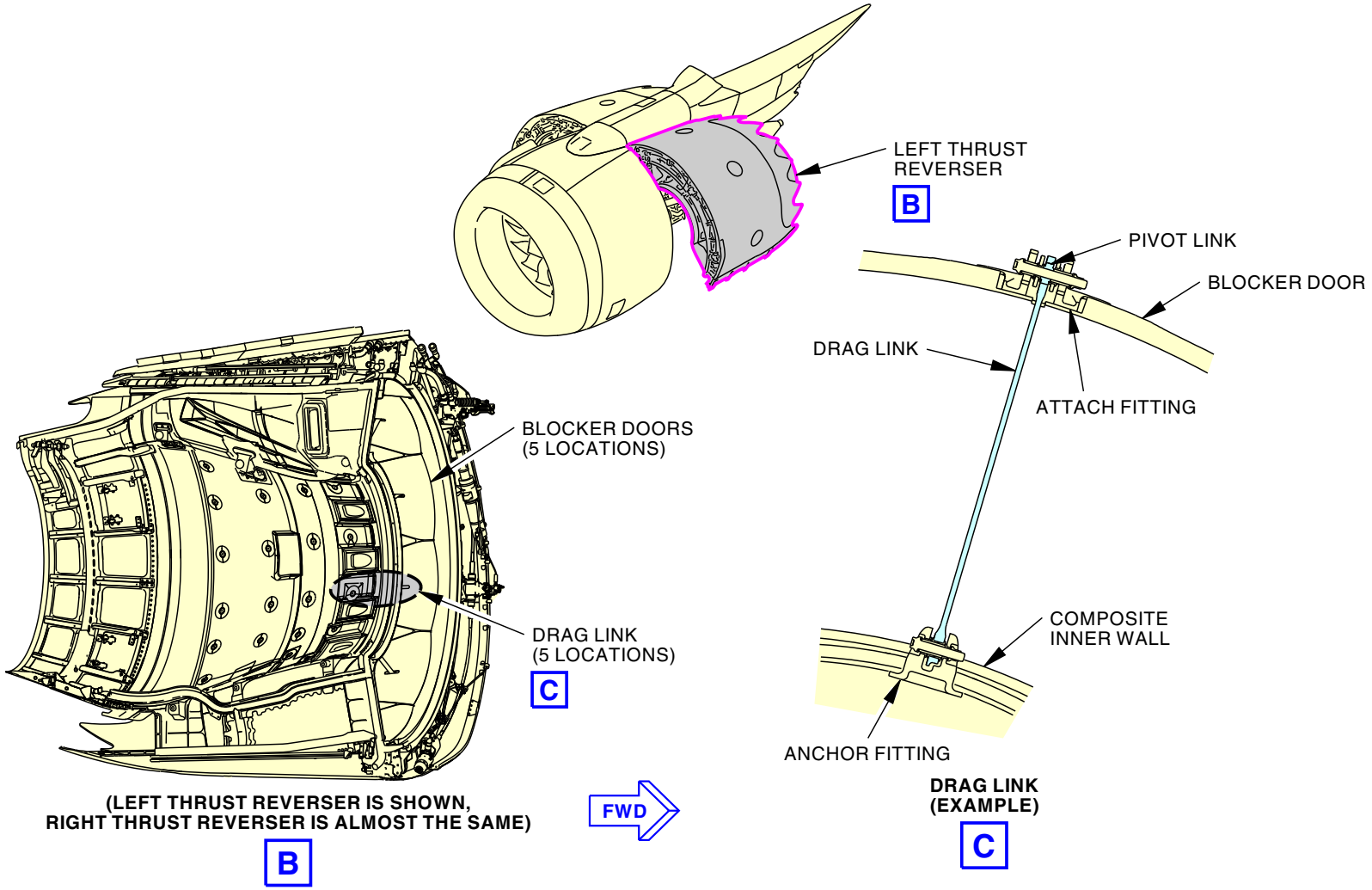
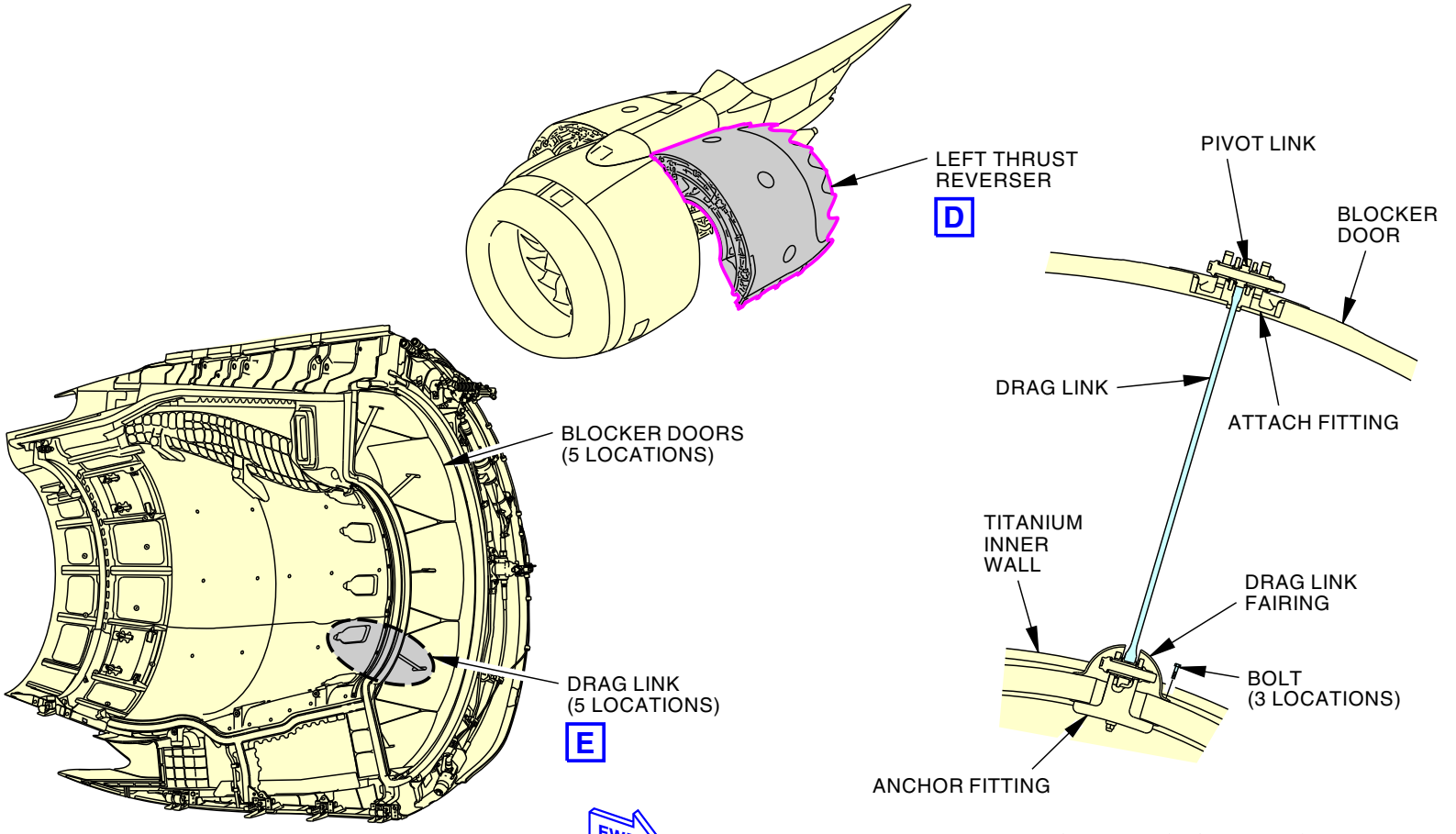
THRUST REVERSER - BLOCKER DOORS AND BLOCKER DOOR DRAG LINKS

THRUST REVERSER - BLOCKER DOORS AND BLOCKER DOOR DRAG LINKS



THRUST REVERSER - BLOCKER DOORS AND BLOCKER DOOR DRAG LINKS

THRUST REVERSER - BLOCKER DOORS AND BLOCKER DOOR DRAG LINKS



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THRUST REVERSER - BLOCKER DOORS AND BLOCKER DOOR DRAG LINKS

THRUST REVERSER - THRUST REVERSER OPENING ACTUATOR

General

Each engine has two T/R opening actuators. A hand-operated GSE hydraulic pump is provided to extend the hydraulic actuators integral to each cowl segment. Once an actuator is fully extended, it automatically locks in the open position.

Purpose

The T/R opening actuator is used to open the T/R cowl (half). The outboard actuator is up-sized to allow the outboard thrust reverser to open to a locked position of 55 degrees, with an initial 56 degree swing. The inboard will open to a locked position of 36 degrees, with an initial 37 degree swing.

Location

Each T/R opening actuator is on the forward face of its T/R cowl. The upper end of the T/R opening actuator attaches to the T/R cowl. The lower end attaches to the engine fan frame extension ring. The fan cowls must be opened to get access to the T/R opening actuators.

Physical Description

The T/R opening actuator has these components:

- Hydraulic piston housing
- Rod
- Lock collar mechanism
- Inlet fitting
- Internal snubber assembly.

The inlet fitting permits you to connect a hand pump necessary to operate the actuator.

The actuator is automatically locked in the extended position by a cylindrical pawl lock mechanism. For operator safety, the lock can not be disengaged while under load. The cowl load must be lifted off the lock with hydraulic pressure prior to unlocking the actuator. The lock can be manually unlocked and will stay unlocked until retraction is selected at the hand pump. A ball-spring detent in the piston head holds the lock in the unlocked position, until the operator opens the pressure release on the hand pump.

An integral auxiliary reservoir is provided in the actuator with sufficient fluid to fill the swept volume of the piston in the event that the thrust reverser cowl doors are forcibly opened (instead of using the hand pump). Suction created by the manual extension of the piston allows free flow through the flow control valve from the reservoir. This provides a controlled closing rate as in normal operation, so there is no sudden drop when the cowl is released.

A flow control/check valve is provided in the actuator to allow free flow from the hand pump or the auxiliary reservoir during extension, and to regulate the flow during retraction. The flow control limits the retract time from 15 to 20 seconds under normal temperature conditions and varying cowl loads. A screen in the valve prevents large particles from entering the actuator. A quick disconnect fitting, protected by a dust cover is connected to the GSE hand pump for extension and retraction.

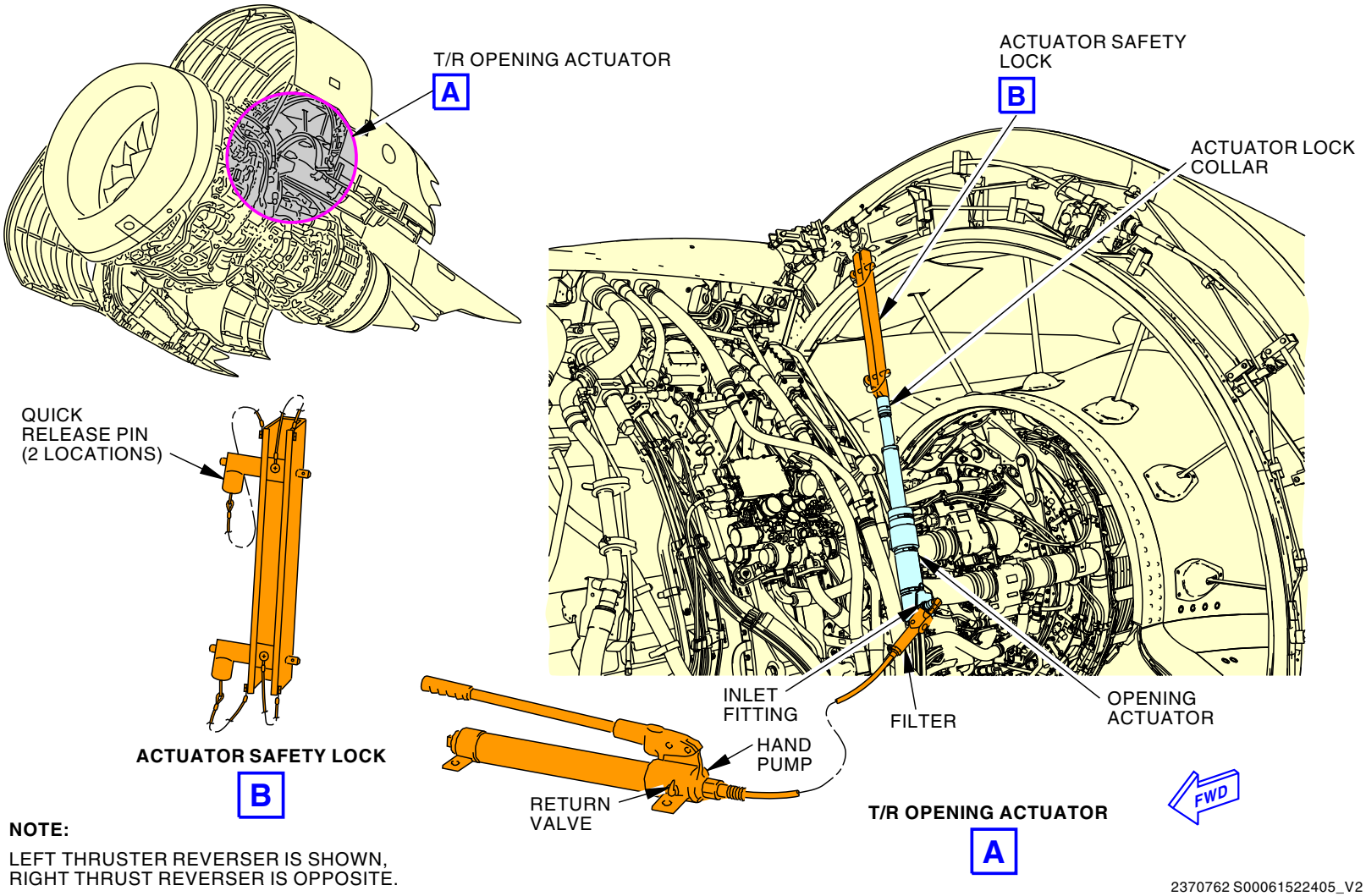
A relief valve in the actuator limits pressure during hand pump operation if the hand pump relief pressure is incorrect or thermal expansion of fluid occurs within the actuator. Fluid flows (external) from the bleed hole in the relief plug when the actuator is over-pressurized.

Functional Description

Fluid from the hand pump causes the T/R opening actuator rod to extend and open the T/R cowl. As the actuator approaches the full extend position, the lock collar goes into the lock position. A band on the rod shows when the collar is in the lock position.

Fluid goes from the opening actuator back to the hand pump when the T/R cowl is closed.

THRUST REVERSER - THRUST REVERSER OPENING ACTUATOR



NOTE:

LEFT THRUSTER REVERSER IS SHOWN, RIGHT THRUST REVERSER IS OPPOSITE.

2370762 S00061522405_V2

THRUST REVERSER - THRUST REVERSER OPENING ACTUATOR

THRUST REVERSER - KRUEGER FLAP DEFLECTOR AND FAIRING

Purpose

The krueger flap deflector keeps separation between the inboard leading edge (krueger) flap and the inboard thrust reverser outer skin during these conditions:

- The inboard leading edge flap in the extend position
- Anytime the T/R is out of the stow position.

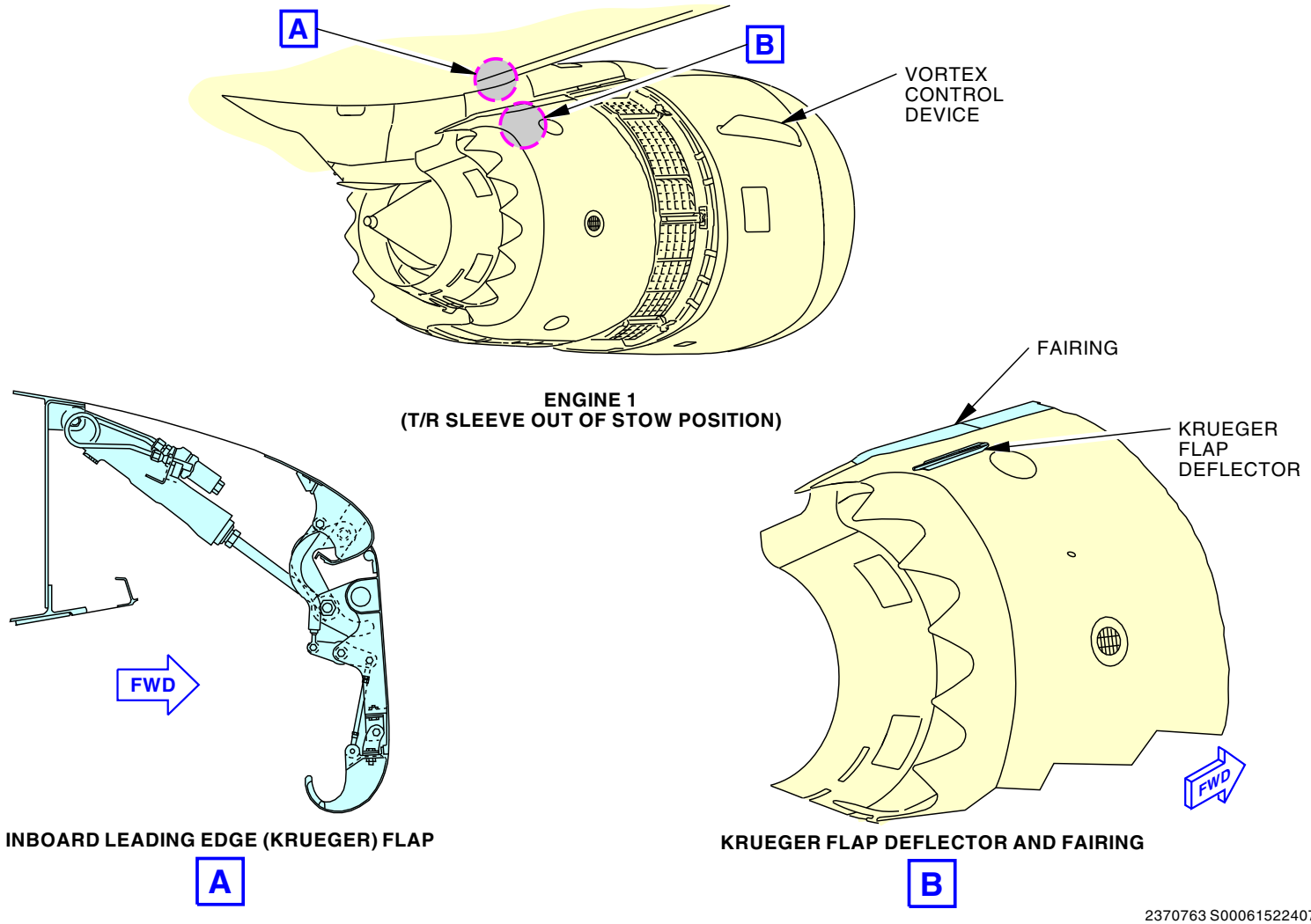
The fairing gives an aerodynamic surface for airflow around the top of the thrust reverser.

Location

The krueger flap deflector is on the inboard T/R half of each engine. The deflector is near the top of the T/R half. Bolts on the inside of the translating sleeve hold the deflector in position. The translating sleeve must be moved aft to get access to these bolts.

The fairing is aft of the deflector. Bolts attach the fairing to the T/R half structure.

THRUST REVERSER - KRUEGER FLAP DEFLECTOR AND FAIRING



THRUST REVERSER - KRUEGER FLAP DEFLECTOR AND FAIRING

THRUST REVERSER - TENSION LATCHES

Purpose

The tension latches hold the T/R halves together.

General

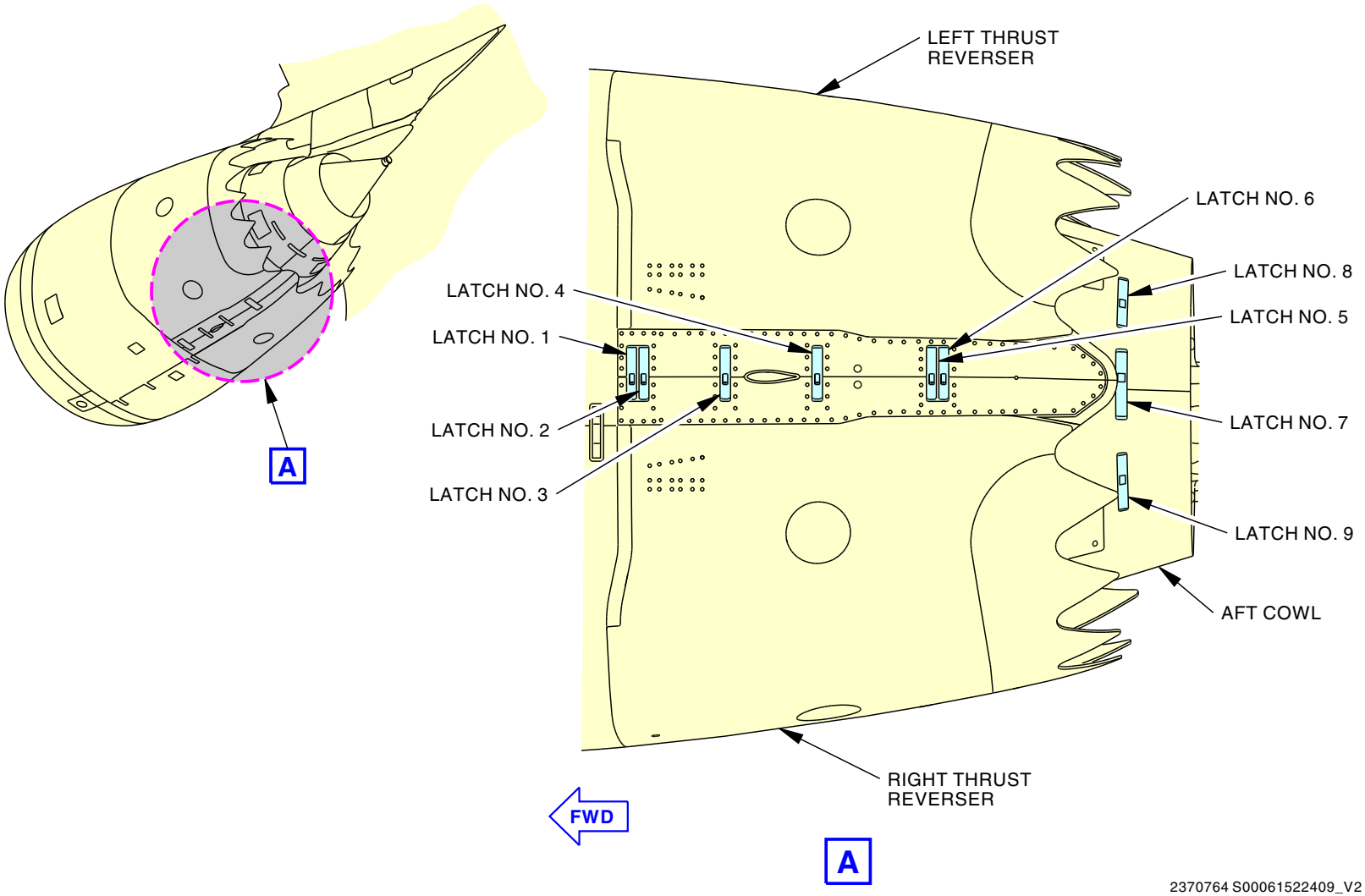
There are six tension latches on the centerline of each T/R outer skin and three more latches on the aft cowl. Numbers identify each latch. Latch number one is the latch most forward.

Latch number three and four have progressive hooks to assist in closing the T/R halves.

Location

All tension latches are at the bottom of the T/R halves. The latch handles and mechanisms are on the left T/R half. The latch keeper pins are on the right T/R half.

THRUST REVERSER - TENSION LATCHES



THRUST REVERSER - TENSION LATCHES

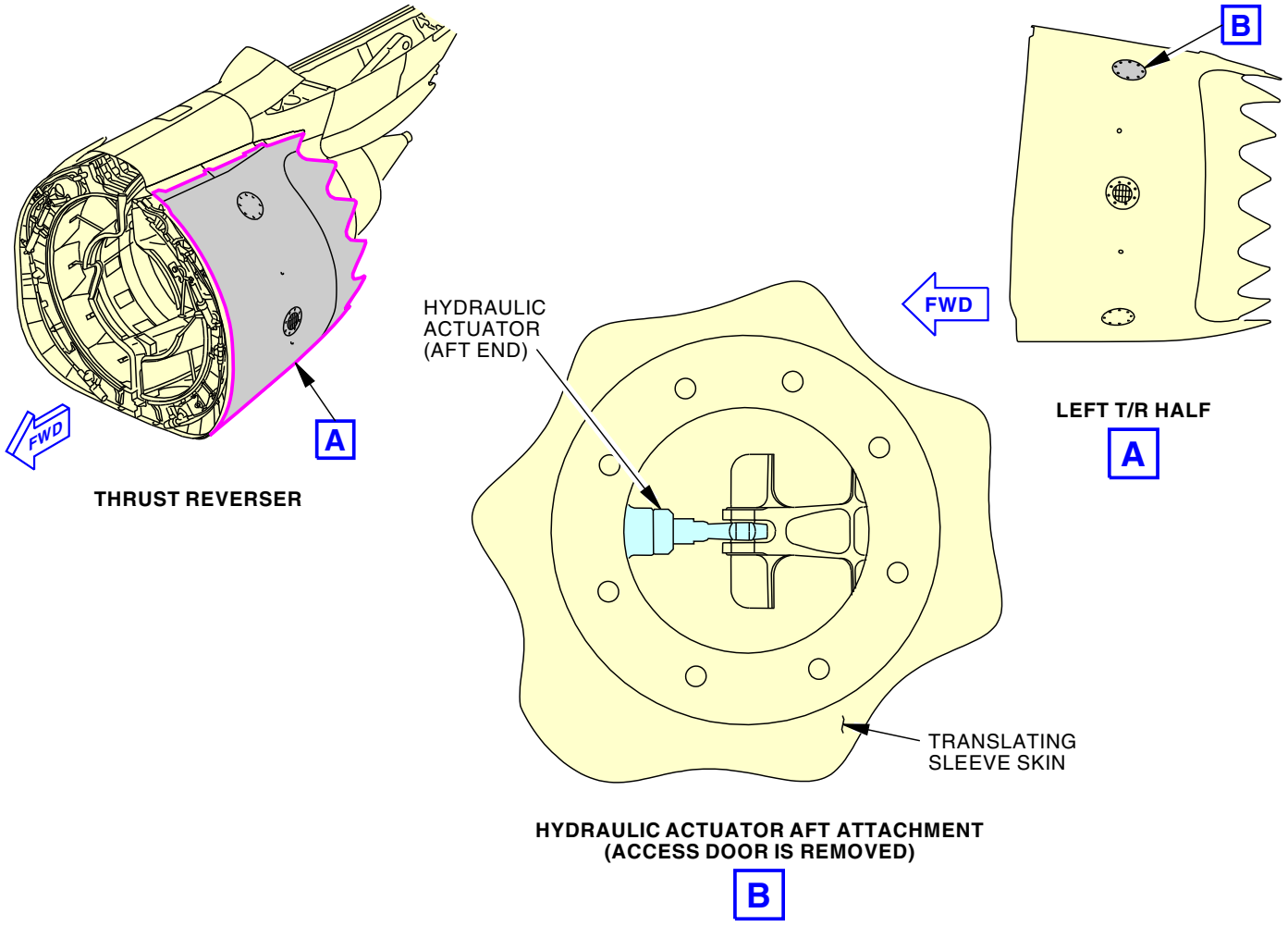
THRUST REVERSER - ACCESS DOORS

General

Each T/R cowl (half) has three access doors to allow access to the T/R hydraulic actuator's aft attach point.

The center access door also supplies an exit for fan air exhaust if it goes by the bullnose seal when the T/R is in the stow position. Refer to the bullnose seal and retainer page in the section for more information.

THRUST REVERSER - ACCESS DOORS



2370765 S00061522411_V2

THRUST REVERSER - ACCESS DOORS

THRUST REVERSER - AUXILIARY AND MAIN TRACK LINER

General

Each T/R sleeve has an upper and lower track liner.

Purpose

The T/R auxiliary and main track liners hold the sliders which let the translating sleeves move forward and aft.

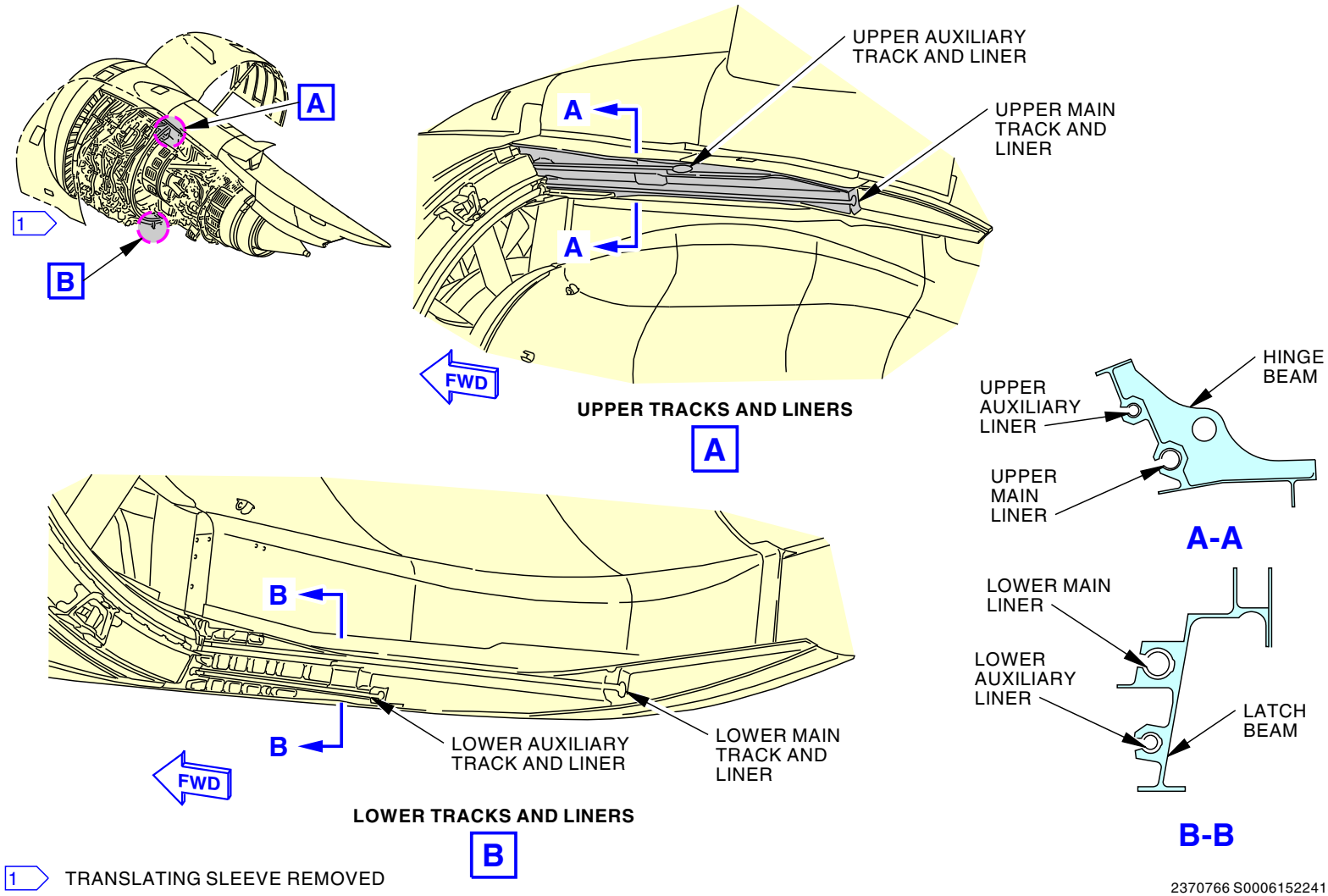
Location

The auxiliary and main tracks are on the upper and lower hinge beams of each T/R half. The liners are inside of the tracks.

Physical Description

Each track has a liner inside. The track liners are stainless steel. The tracks are an aluminum alloy.

THRUST REVERSER - AUXILIARY AND MAIN TRACK LINER



2370766 S00061522413_V1

THRUST REVERSER - AUXILIARY AND MAIN TRACK LINER

THRUST REVERSER - AUXILIARY AND MAIN TRACK SLIDER

General

Each translating sleeve has four sliders. A main track upper and lower sliders and an auxiliary track upper and lower sliders.

Purpose

The auxiliary and main track sliders permit the translating sleeves to move forward and aft in the tracks.

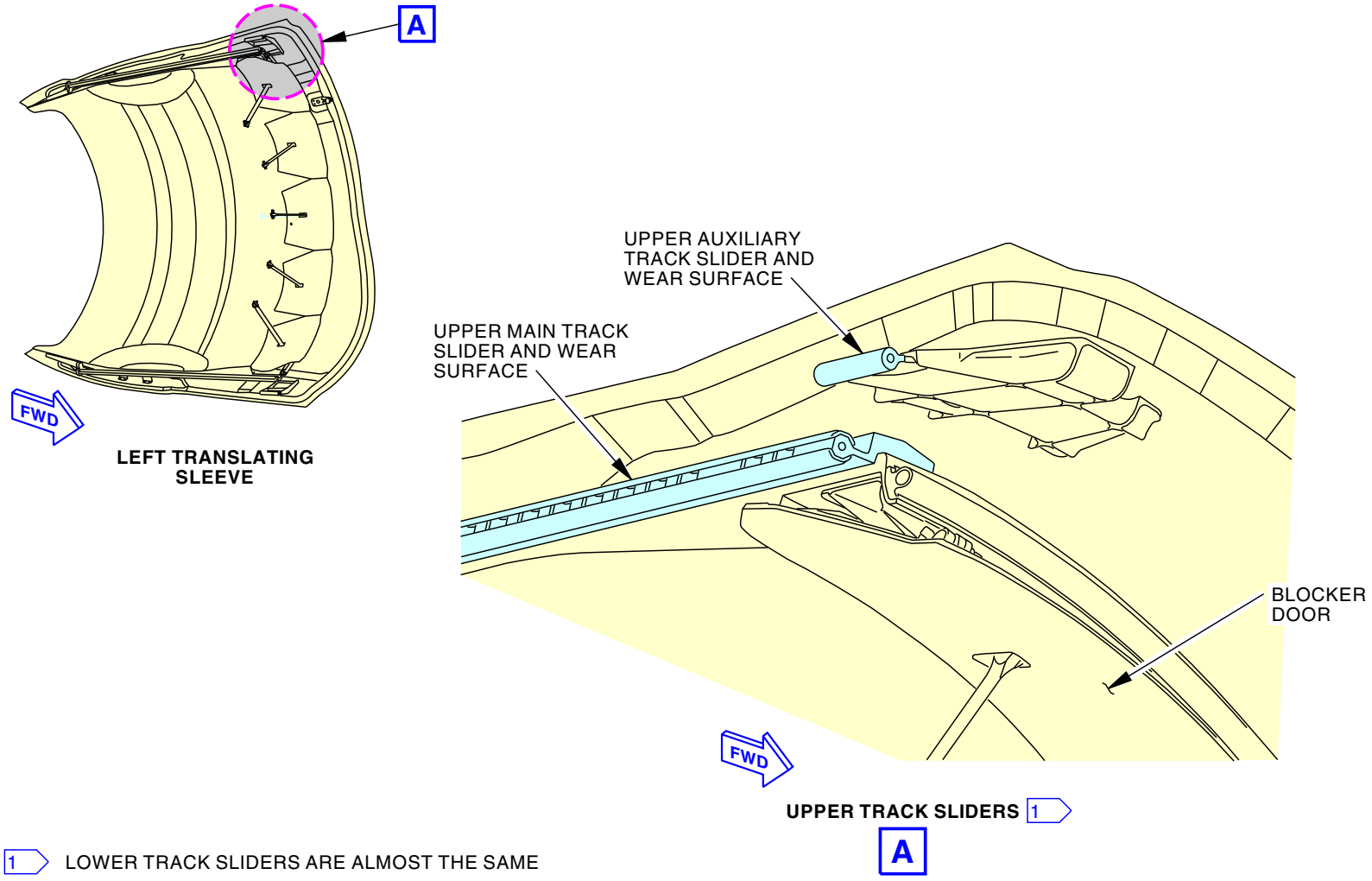
Location

The auxiliary and main track sliders are on the top and the bottom of each translating sleeve.

Physical

The sliders have a wear surface that reduces the friction between the sliders and the track liners.

THRUST REVERSER - AUXILIARY AND MAIN TRACK SLIDER



1 LOWER TRACK SLIDERS ARE ALMOST THE SAME

2370767 S00061522415_V2

THRUST REVERSER - AUXILIARY AND MAIN TRACK SLIDER

THRUST REVERSER - RUBSTRIP

General

The rubstrips are the interface between the translating sleeve and these areas of structure:

- T/R torque box
- Hinge (upper) beam.

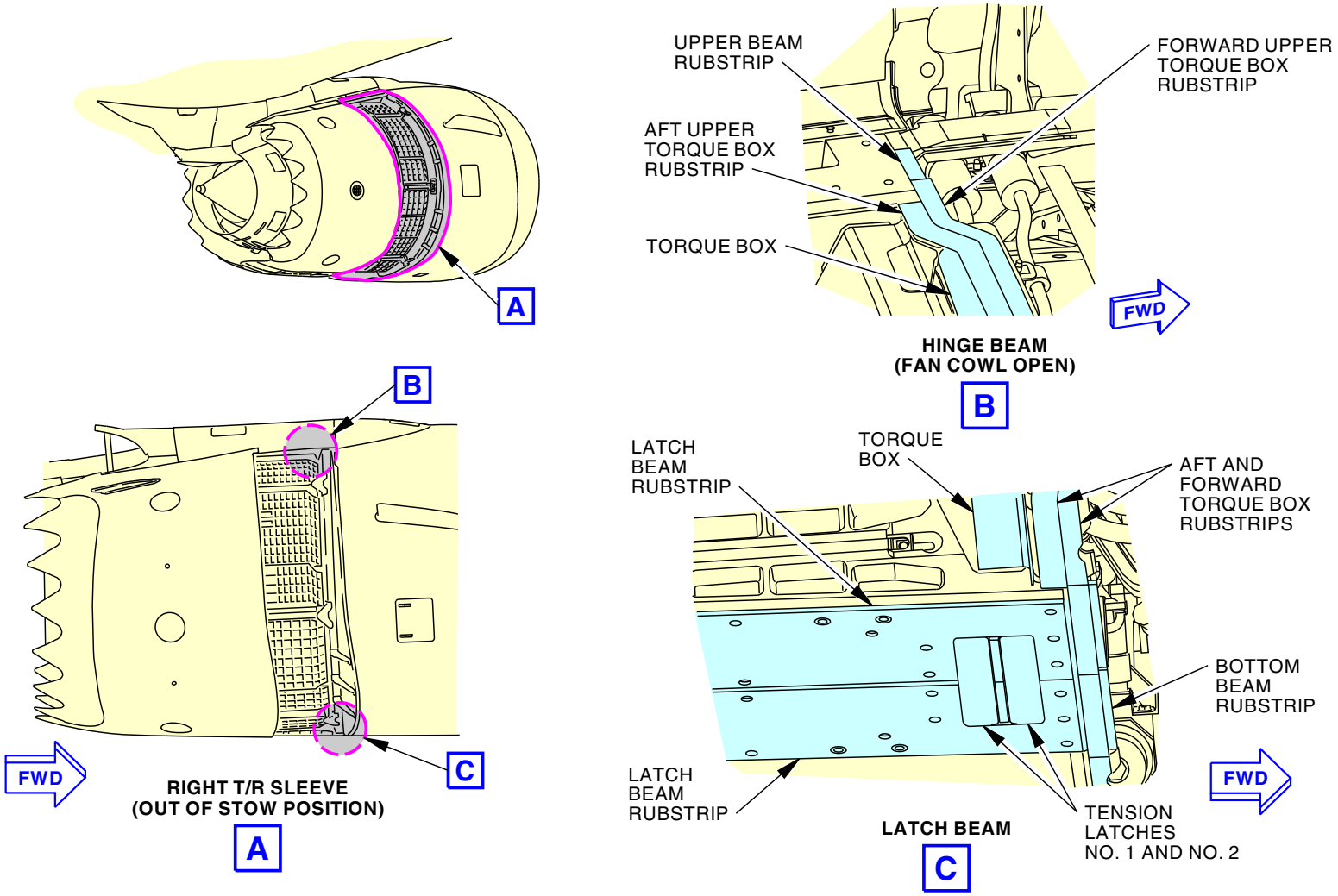
These rubstrips are the interface between the engine fan cowl and these areas of structure:

- T/R torque box
- Hinge (upper) beam
- Latch beam.

Location

All rubstrips are along the forward or aft side of the T/R torque box.

THRUST REVERSER - RUBSTRIP



2370768 S00061522417_V1

THRUST REVERSER - RUBSTRIP

THRUST REVERSER - BULLNOSE SEAL AND RETAINER

General

The bullnose seal is held by a bullnose retainer to the acoustic panel assembly.

Purpose

The bullnose seal prevents fan exhaust airflow into the inner part of the T/R translating sleeve when the T/R is in the stow position.

Location

The bullnose seal and retainer are on forward end of the inner wall structure of the translating sleeve. They are inboard of the blocker doors.

The retainer attaches to the acoustic panel assembly. Grooves in the retainer hold the bullnose seal in position.

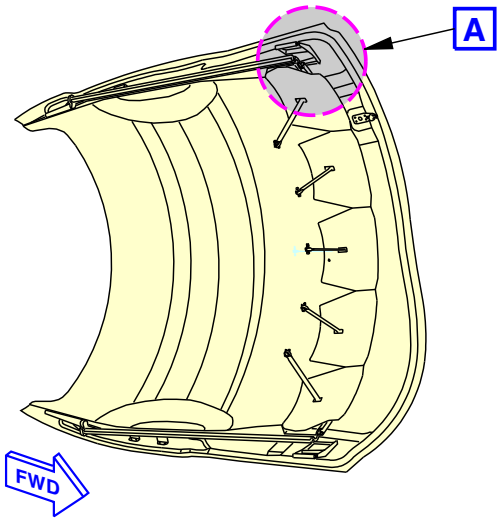
You move the translating sleeves aft to get access to the bullnose seal and retainer.

Functional Description

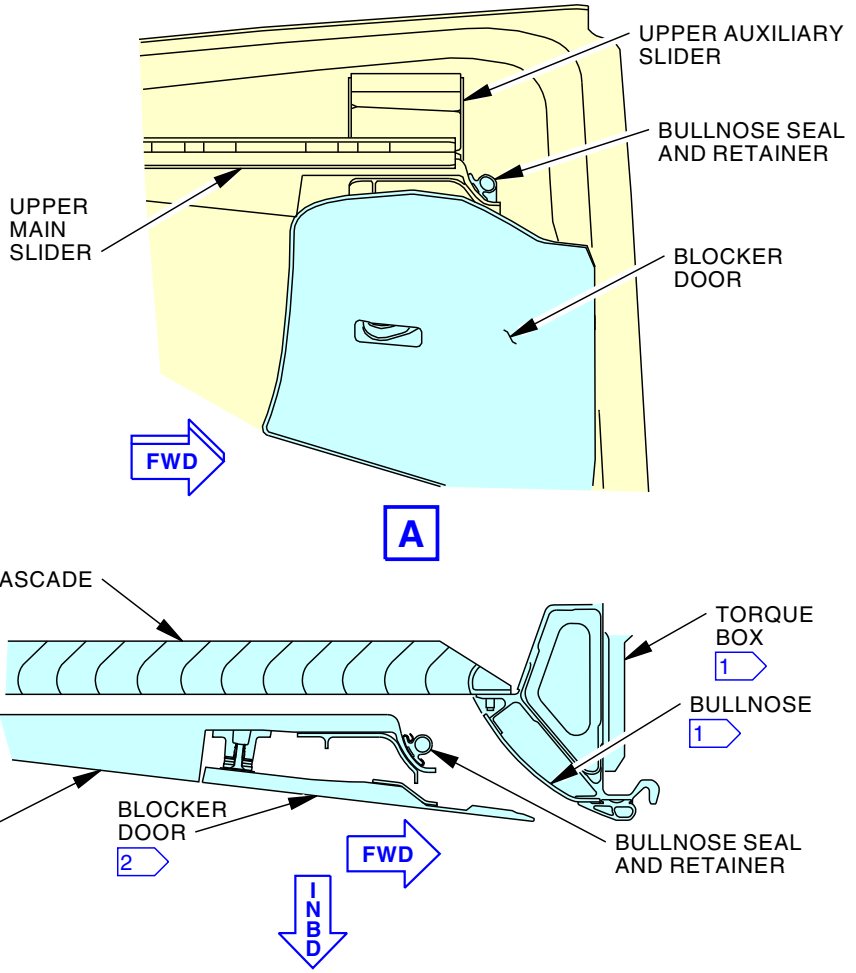
The bullnose seal compresses against the bullnose fairing when the T/R is in the stow position. This prevents fan air exhaust airflow into the inner part of the translating sleeve.

The center access panel supplies an exit for any air that gets past the bullnose seal. This prevents damage to the sleeve components if the seal fails. Refer to the access panel page in this section for more information.

THRUST REVERSER - BULLNOSE SEAL AND RETAINER



LEFT TRANSLATING SLEEVE



BULLNOSE SEAL AND RETAINER INSTALLATION

1 PART OF FIXED T/R STRUCTURE, NOT SHOWN IN OTHER GRAPHICS

2 PART OF TRANSLATING SLEEVE, SHOWN OUT OF STOW POSITION

2370769 S00061522419_V2

THRUST REVERSER - BULLNOSE SEAL AND RETAINER

THRUST REVERSER - FIRE SEALS

General

The left and right thrust reversers have fireseals.

Purpose

The fireseals keeps an engine fire from the turbine case area away from these:

- T/R components
- Engine fan
- Components in the engine fan case area
- Engine strut.

Purpose

The fire seals help contain an undercowl fuel-fed fire.

The upper rubber fire seals close the gap between the strut structure and the upper bifurcation inner walls. The lower rubber fire seal closes the gap between the lower bifurcation inner walls of the left and right thrust reverser halves.

The rubber fire seals also function as an aerodynamic seal and a fluid seal. The fire seals must be able to perform the sealing function even when exposed to fuel, hydraulic fluid, engine oil, alkaline based cleaning solutions, isopropyl alcohol based deicing fluids and ethylene gycol based deicing fluids.

Location

All fire seals are along the upper and forward edges of the T/R cowls (halves).

The upper bulb-seal fire seals are mounted in retainer tracks on the inner surface of the upper bifurcation inner wall on the left and right thrust reverser halves. These fire seals contact metal seal depressors mounted on the strut.

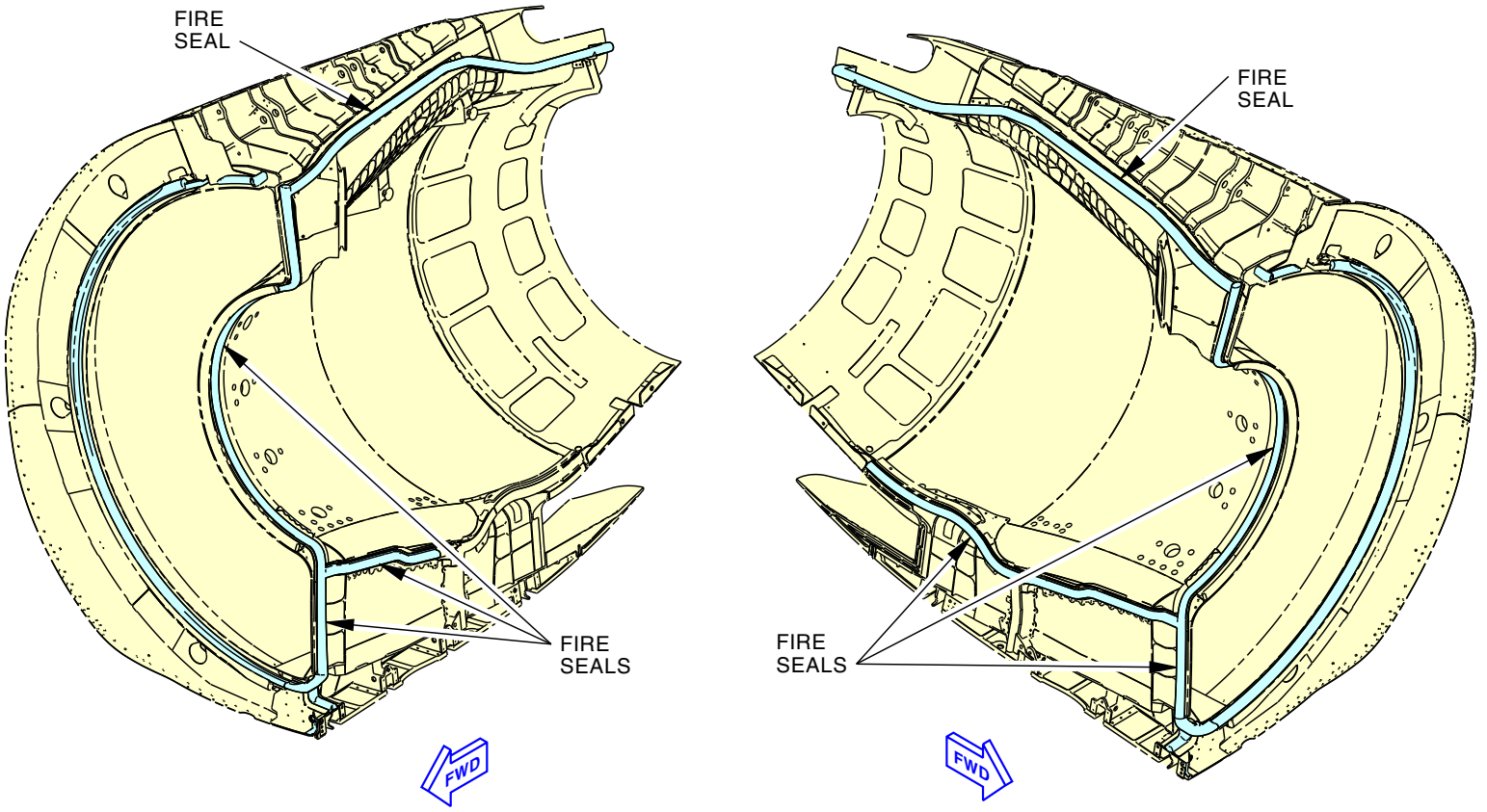
The lower bulb-seal are mounted in retainer tracks on the inner surface of the lower bifurcation wall on the left half. These fire seals contact seal depressors mounted on the right half.

A bulb type fire/aerodynamic seal is mounted around the circumference of the inner wall, aft of the inner wall v-blade. The circumferential bulb-seal fire seals contact the engine case.

Physical Description

The rubber fire seals are constructed from a silicone rubber that is reinforced with fabric layers. The rubber fire seals are bulb-seals that have a circular cross-section and foot that fits in a metal seal retainer track. The bulb-seals can be hollow or can be filled in some segments with a sponge foam to prevent collapse of the seal where the seal fits in small radius curvature turns. The rubber fire seals are also molded into specific shapes for some areas.

THRUST REVERSER - FIRE SEALS



RIGHT T/R HALF

LEFT T/R HALF

2370770 S00061522421_V1

THRUST REVERSER - FIRE SEALS

THRUST REVERSER - THERMAL PROTECTION SYSTEM BLANKETS

SIA ALL; AIRPLANES WITH COMPOSITE INNER WALL

Purpose

The Thermal Protection System (TPS) blankets give protection to the Composite Inner Wall (CIW) of the thrust reverser sleeves.

SIA ALL; AIRPLANES WITH TITANIUM INNER WALL

Purpose

The thermal insulation blankets give protection to the Titanium Inner Wall (TIW) of the thrust reverser sleeves.

SIA ALL; AIRPLANES WITH COMPOSITE INNER WALL

Thermal Protection System

The TPS blankets are made of metal/kapton materials. It is attached to the CIW using a combination of brackets, fasteners, and through studs. The CIW is acoustically treated to achieve noise attenuation. All edges and splices are sealed except at the ventilation and drainage locations. Fan air is introduced under the blankets at the drag link anchor fittings to maintain a positive pressure difference between the panel-TPS cavity and the core compartment for added robustness.

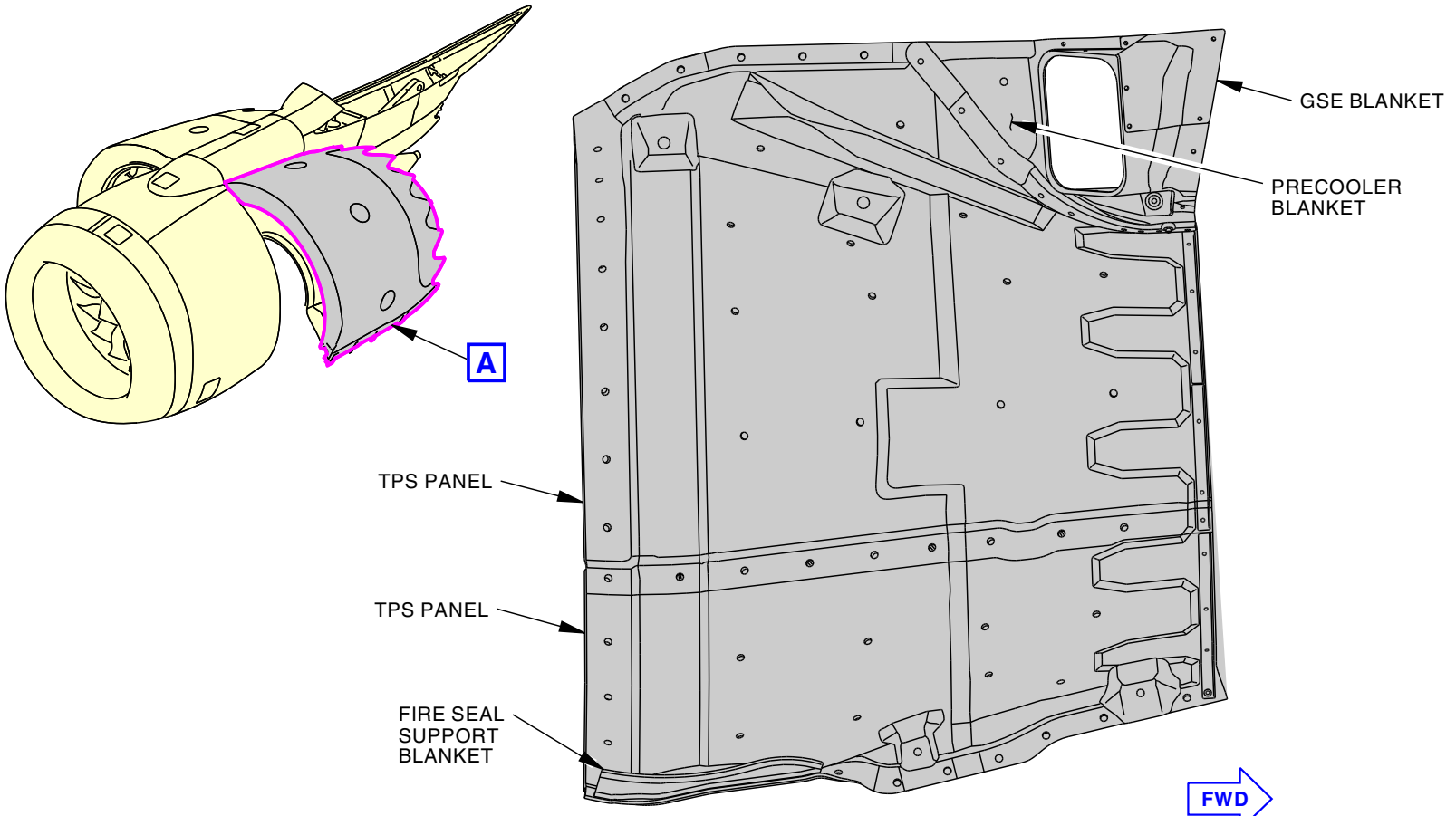
SIA ALL; AIRPLANES WITH TITANIUM INNER WALL

Thermal Insulation Blankets

The thermal insulation blankets are on brackets that are installed on the inner surface of the inner wall. Thermal insulation blankets are mounted on the inside surface of the fan duct cowl and upper and lower bifurcation. These blankets are a thermal insulation and fire barrier which is necessary to keep the thrust reverser structurally serviceable and can decrease the damage and repair costs from a duct burst or fire. The thermal insulation prevents fire and engine operation heat damage to the composite inner wall of the fan duct cowl.

SIA ALL

THRUST REVERSER - THERMAL PROTECTION SYSTEM BLANKETS



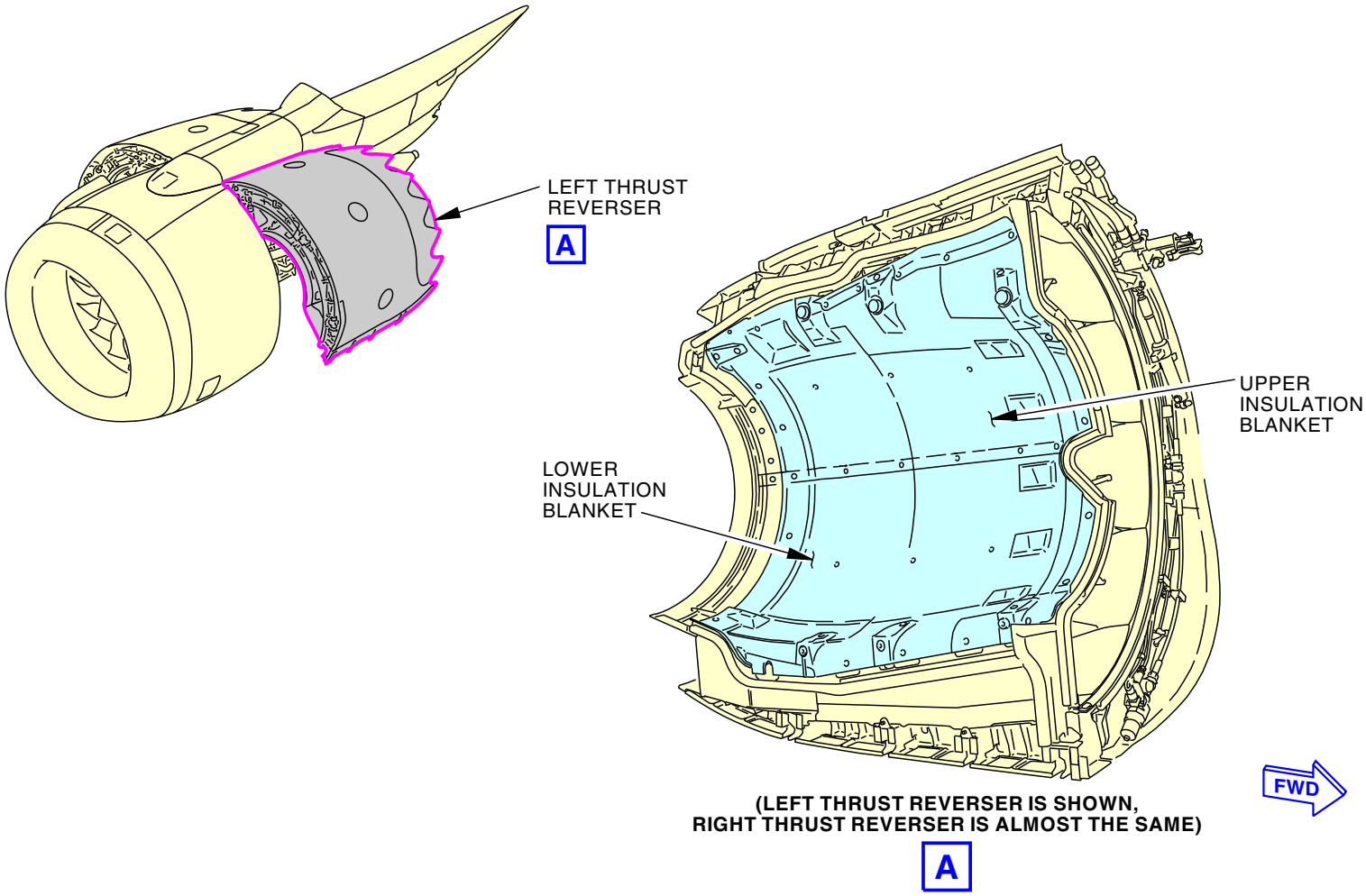
LEFT THRUST REVERSER
(RIGHT THRUST REVERSER IS OPPOSITE)
SIDE VIEW

A

2554717 S0000609168_V2

THRUST REVERSER - THERMAL BLANKETS

THRUST REVERSER - THERMAL PROTECTION SYSTEM BLANKETS



THRUST REVERSER - THERMAL BLANKETS

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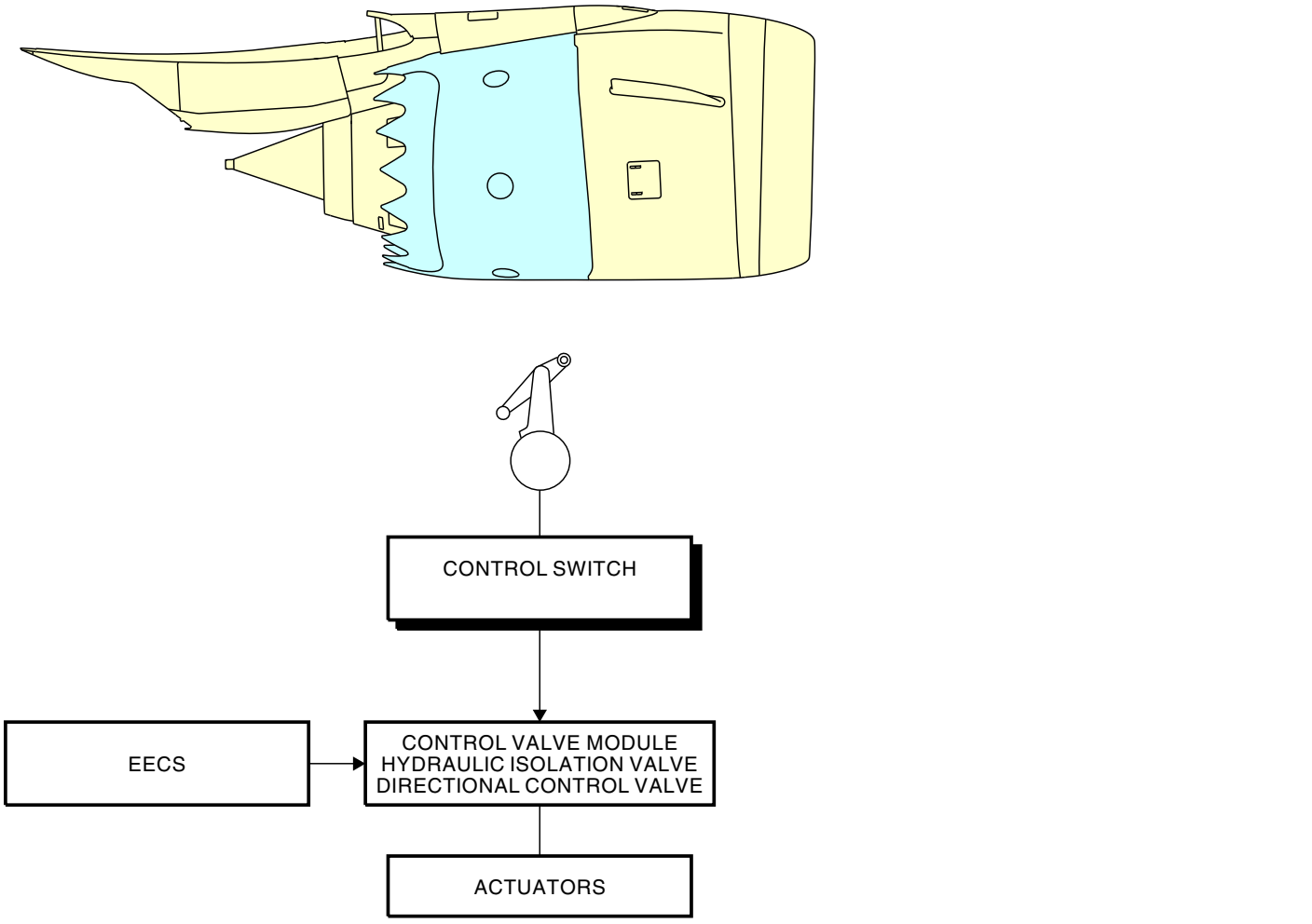
THRUST REVERSER CONTROL SYSTEM - INTRODUCTION

General

The thrust reverser system uses electrical control and hydraulic power to operate. The T/R control system uses 28 VDC to control the hydraulic pressure to the Hydraulic Isolation Valve (HIV) and Directional Control Valve (DCV) that operates the actuators for the thrust reverser.

THRUST REVERSER CONTROL SYSTEM - INTRODUCTION



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THRUST REVERSER CONTROL SYSTEM - INTRODUCTION

THRUST REVERSER CONTROL SYSTEM - GENERAL DESCRIPTION

General

Three electrically operated solenoid valves for the HIV and the DCV control hydraulic pressures to the T/R actuators. Both of these valves are contained in one unit called the Control Valve Module (CVM). The Hydraulic Isolation Valve (HIV) isolates the aircraft hydraulic power from the T/R system until commanded open (energized) by the EEC. The Directional Control Valve (DCV) ports hydraulic fluid to extend or retract the reverser actuators. There are two CVMs on the airplane. One for each T/R.

The EEC will command power to the HIV when the engine is running on the ground and reverse thrust has been commanded via the thrust levers. During an RTO, the EEC will not energize the HIV until N1 is below a specific threshold, defined as a function of altitude and airspeed, in order to prevent the T/R structure from exceeding design loads during T/R translation. The EEC will remove power to the HIV 10 seconds after the T/R is commanded to stow, as long as at least one proximity sensor per T/R sleeve indicates locked. When the engine is not running, there is a T/R special function that can be run to deploy/stow the T/R for maintenance and troubleshooting.

The DCV interfaces with the aircraft hydraulic system and ports hydraulic fluid to hydraulic actuators that deploy/stow the thrust reverser sleeve. The EEC only controls the stow circuit of the DCV. The EEC will command power to the DCV stow solenoid when the engine is running on the ground and the T/R has been commanded to stow from the deploy position. The EEC will remove power to the DCV stow solenoid 10 seconds after the T/R is commanded to stow, as long as at least one proximity sensor per T/R sleeve indicates locked.

Sync shafts on each translating sleeve make sure the sleeve's three actuators operate at the same speed. The actuators can operate only if the shaft is free to turn.

A sync lock connects to the bottom hydraulic actuator on each T/R half. The sync lock must unlock for the sync shafts to turn. During normal T/R operation, the sync locks energize to unlock. The sync lock is also a manual drive mechanism. The sync lock can be used to manually move the T/R translating sleeves for maintenance operations.

Deploy Operation

For the T/R to deploy, the aircraft must be on the ground and the forward throttle at idle position. Then the reverse thrust lever can be moved aft until it contacts an interlock which physically restricts the reverse thrust lever position to idle until both sleeves are at least 60% deployed. The thrust reverser deploys when the HIV arm solenoid and DCV deploy solenoid are energized and the valves shuttle. The EEC will automatically control the maximum allowable N1 level with the throttle in reverse based on TRA and reverser position (LVDT).

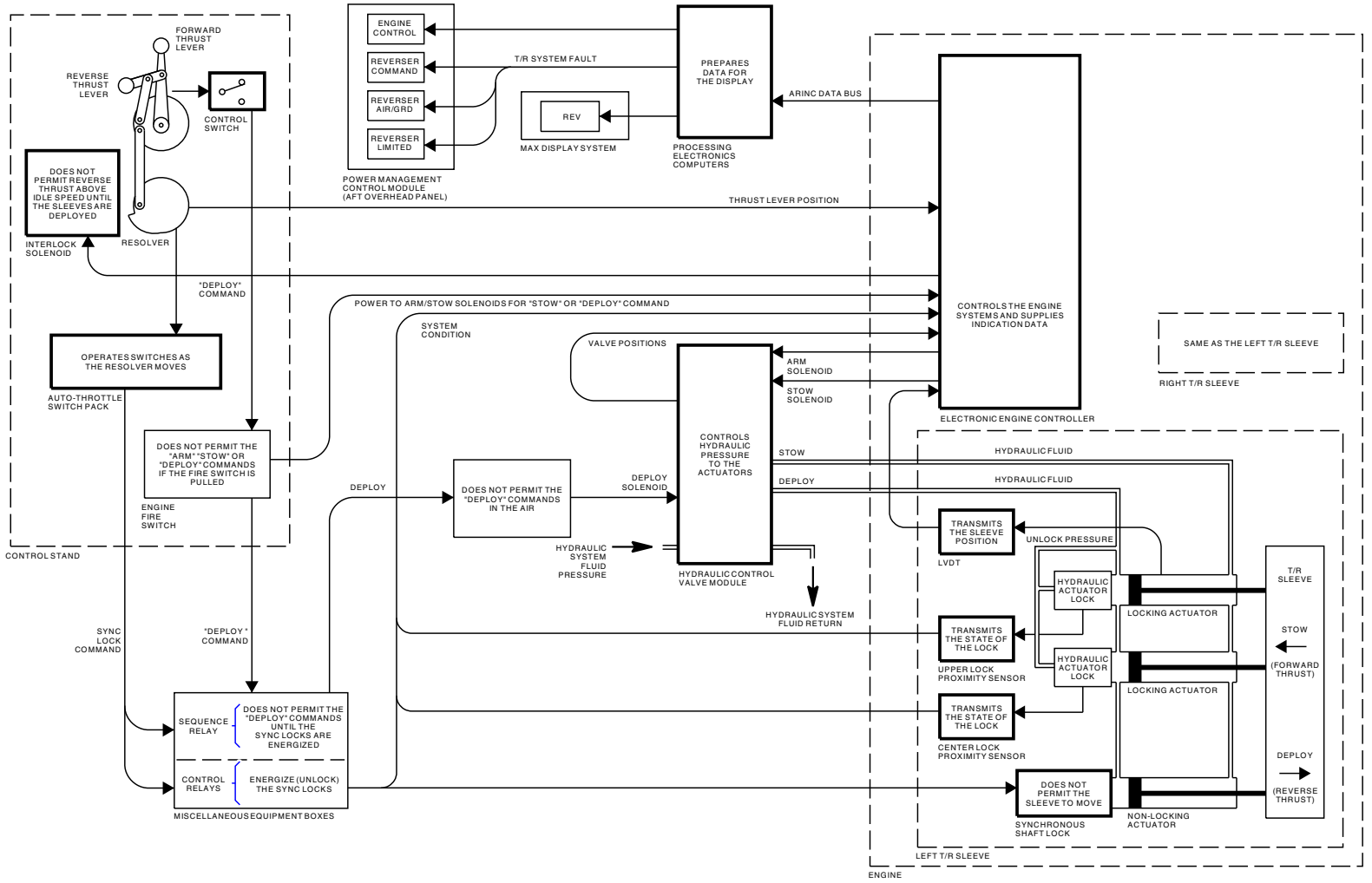
When the T/R deploys the translating sleeves extend and these events occur:

- The cascades uncover
- The blocker doors deploy
- The blocked fan air goes out through the cascades
- The cascades direct the fan air forward.

Stow Operation

To stow the T/R, the reverse thrust lever must be moved all the way down to the fully stowed position. The DCV deploy solenoid is immediately de-energized when the reverse lever is less than 35.3° TRA (nominal). Then the stow solenoid becomes energized by the EEC, commanding the reverser to stow. The sync lock control relay has an internal time delay and will keep the sync locks unlocked for 10 seconds after the reverse lever is commanded to stow to allow the sleeves to fully stow. The EEC also allows the HIV arm solenoid to remain powered for a minimum of 10 seconds after the thrust reverser is commanded to stow, to ensure full closure of the reverser once the TRA transitions above 34° TRA. In addition, if at least one proximity sensor per sleeve does not indicate locked after the sleeves are commanded stowed the HIV arm solenoid and DCV stow solenoid will remain energized.

THRUST REVERSER CONTROL SYSTEM - GENERAL DESCRIPTION



2370773 S00061522429_V2

THRUST REVERSER CONTROL SYSTEM - GENERAL DESCRIPTION

THRUST REVERSER CONTROL SYSTEM - COMPONENT LOCATIONS

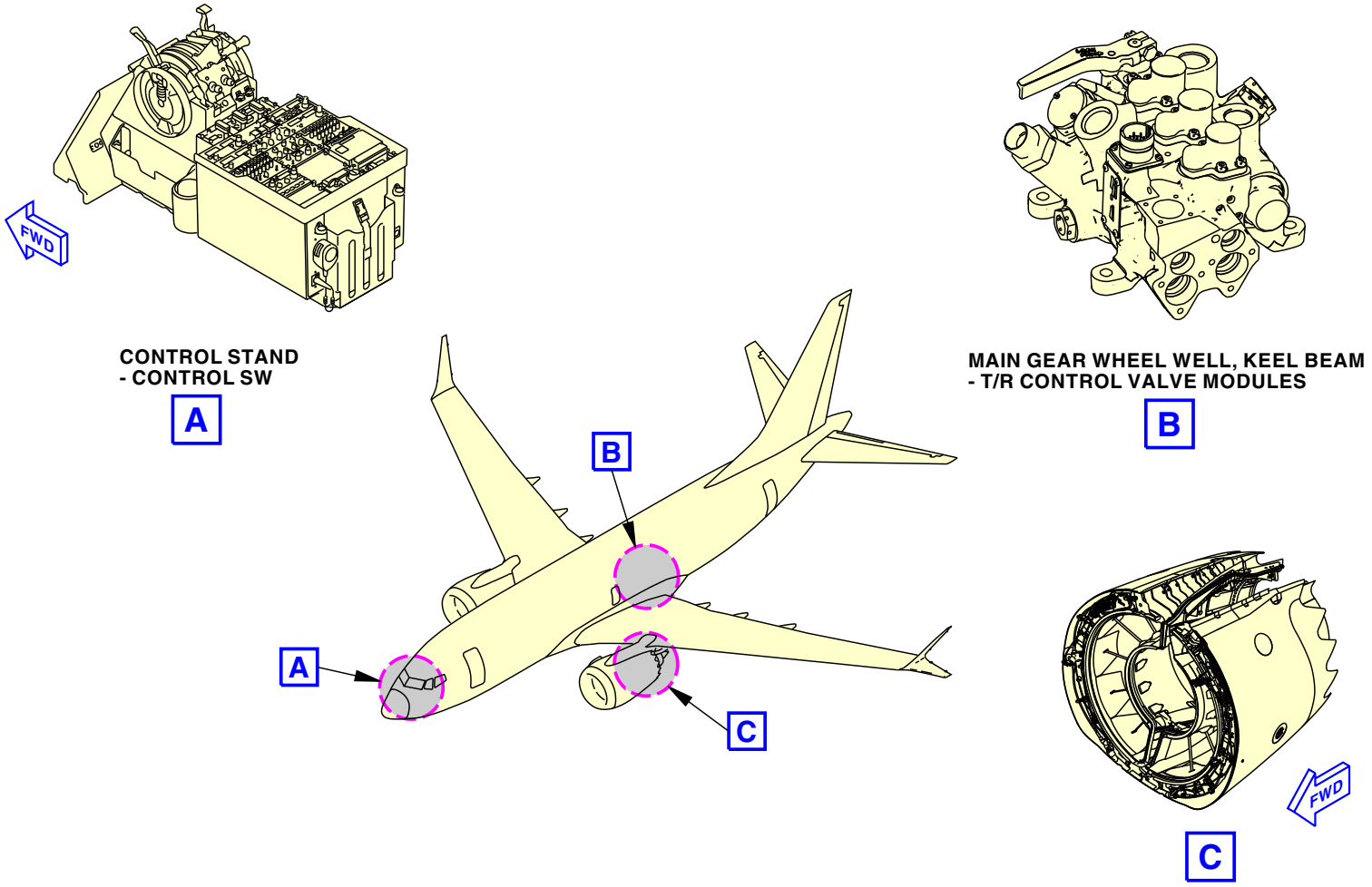
General

The thrust reverser (T/R) control components are at these areas of the airplane:

- Control stand
- T/R halves
- Main gear wheel well.

The graphic shows the general location of the control system components. Refer to the component page to see exact location.

THRUST REVERSER CONTROL SYSTEM - COMPONENT LOCATIONS



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THRUST REVERSER CONTROL SYSTEM - COMPONENT LOCATIONS

THRUST REVERSER CONTROL SYSTEM - ARM/STOW SWITCHES AND SYNC LOCK CONTROL RELAYS

General

The HIV arm and DCV stow switches are contained within the EEC and controlled by logic internal to the EEC. These switches are referred to as EEC Switch Voltage Outputs (SVO). The system uses Reverser Lever Angle (RLA) and Thrust Resolver Angle (TRA) to generate the SVOs that control hydraulic power to the T/R.

A switch in each auto-throttle switch pack closes control relays that energize a solenoid in the sync lock to unlock it. This allows the sync shaft that mechanically connects the three hydraulic actuators on each T/R sleeve to rotate.

Location

The two autothrottle (A/T) switch packs are located below the flight compartment aisle stand.

Access to the A/T switch packs is through the lower nose compartment access door.

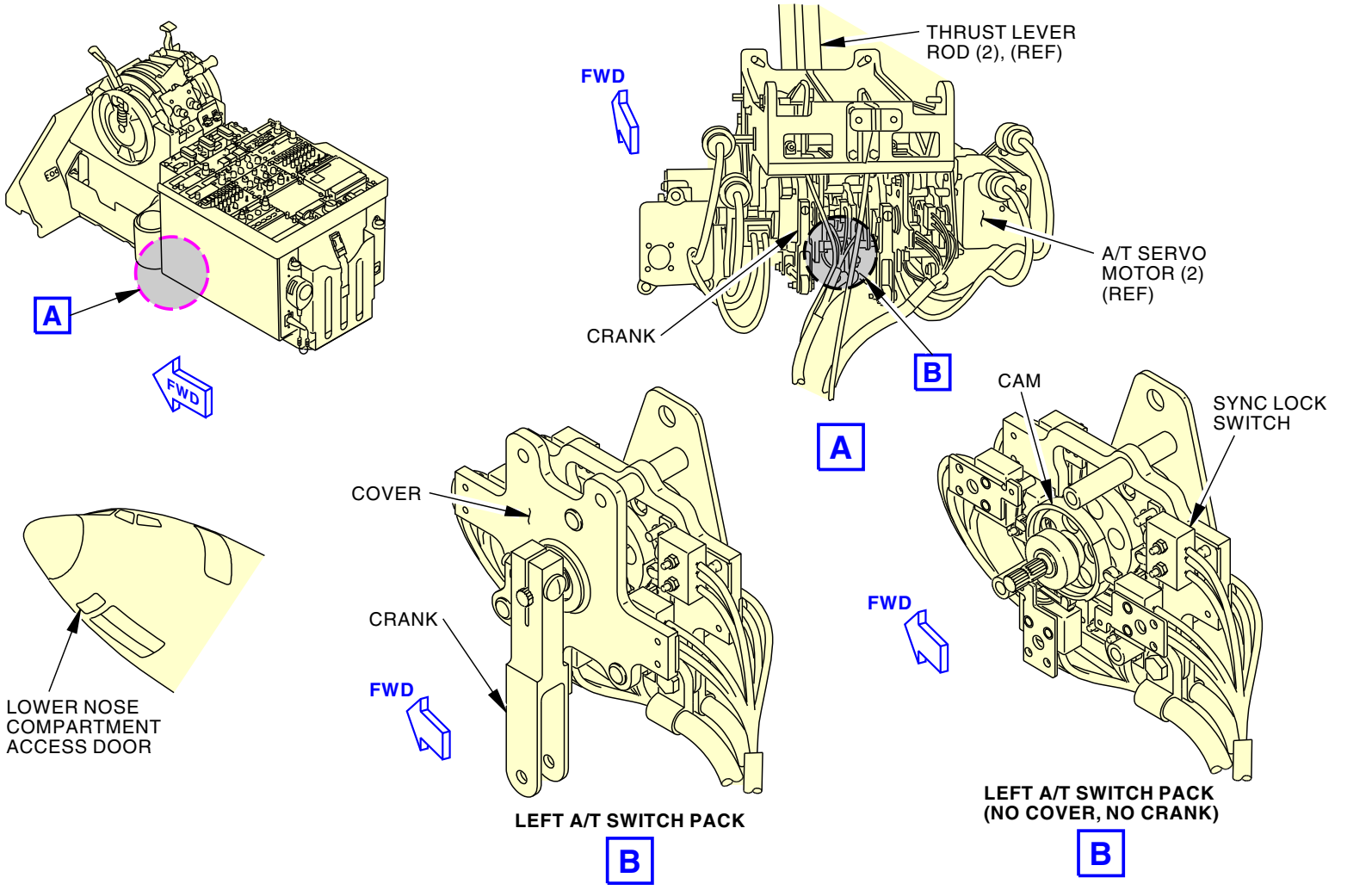
Functional Description

The control switch supplies electrical signal to the EEC that energizes the arm solenoid in each thrust reverser (T/R) control valve module.

When returning the T/R lever back to fully stowed, the DCV control switch opens and the sequencing relay opens ensuring there is no power to the DCV deploy solenoid. The EEC will command the DCV stow solenoid to energize as TRA goes back above 34°. Once the DCV stow solenoid is energized, hydraulic pressure moves the valve back to stow and the sleeve will retract.

The reverse thrust lever link connects the lever subassembly to the lever crank. When the reverse thrust lever is in the full down (stowed) position the reverse thrust lever link connection is "over center" which prevents any motion of the crank from back driving the reverse thrust lever out of the stowed position. When the forward thrust lever is moved to the idle stop, the reverse thrust lever can be lifted out of the stowed position. This motion, transmitted via the lever link causes the crank to continue its rotation, even though the forward thrust lever remains in a fixed position.

THRUST REVERSER CONTROL SYSTEM - ARM/STOW SWITCHES AND SYNC LOCK CONTROL RELAYS



2370775 S00061522433_V1

THRUST REVERSER CONTROL SYSTEM - ARM/STOW SWITCHES AND SYNC LOCK CONTROL RELAYS

THRUST REVERSER CONTROL SYSTEM - CONTROL SWITCH

General

The control switch enables the circuit for the directional control valve deploy solenoid. There are two control switches, one for each T/R.

See the functional description part of this section for more information about how the T/R control system uses the control switches.

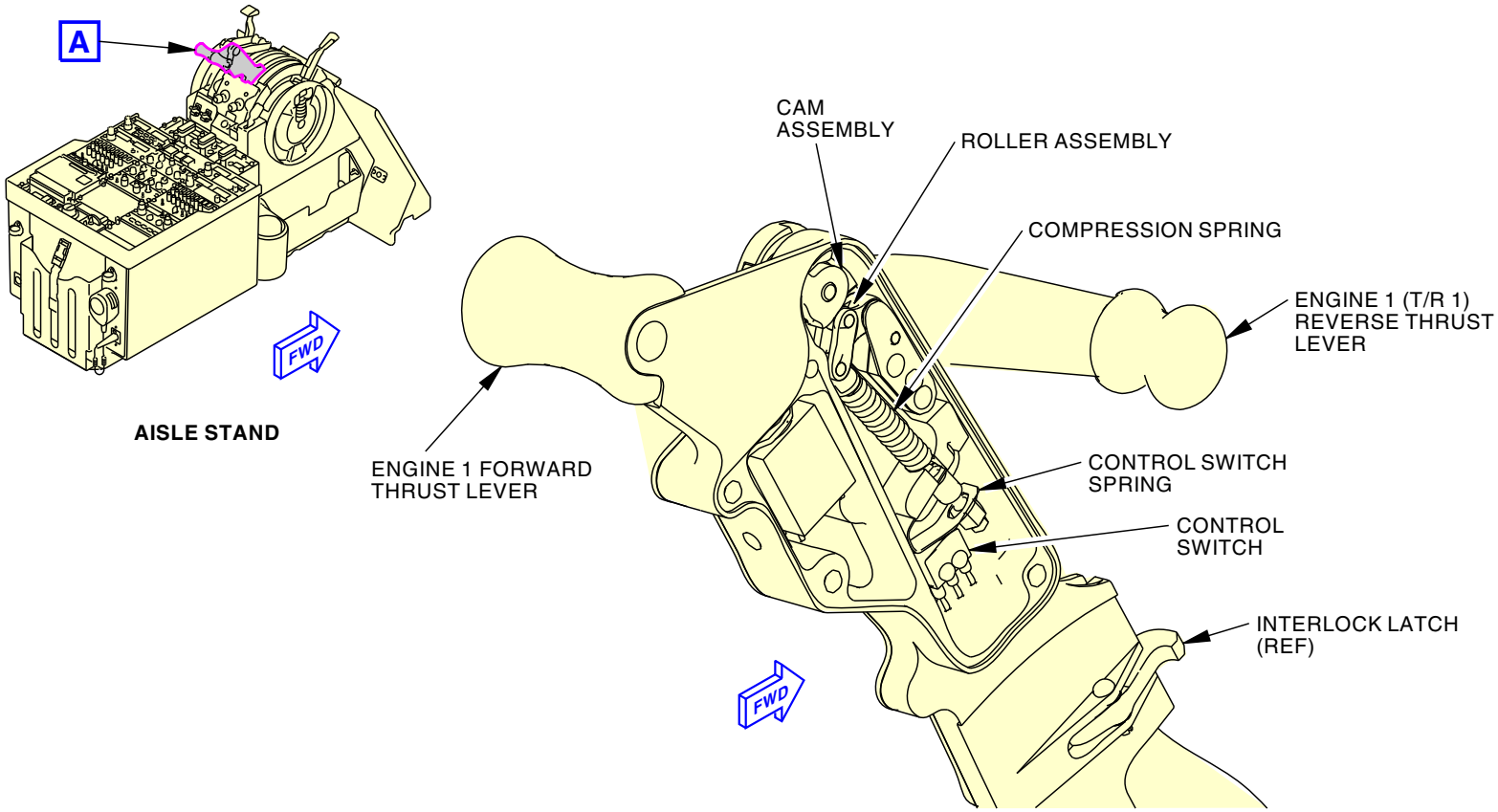
Location

The reverser control switch is mounted on the forward thrust lever below the detent mechanism. Access to the switch is behind the cover on the side of the thrust lever.

Functional Description

The reverser control switch is mounted on the forward thrust lever below the detent mechanism. When the reverse thrust lever is lifted out of the stowed position, rotation of the detent cam causes the detent lever to pivot. The detent lever motion is transmitted via a link to a flat spring which activates the switch between 16° and 19° of reverse lever motion. Actuation of this switch enables the circuit for the directional control valve deploy solenoid. The detent cam is contoured such that the switch is held in the depressed position for reverse thrust lever positions greater than approximately 20° out of the stowed position. The switch is released when the reverse thrust lever is returned to the full down (stowed position).

THRUST REVERSER CONTROL SYSTEM - CONTROL SWITCH



NOTE:

1 SIDE COVER REMOVED
(ENGINE 2 LEVER ALMOST THE SAME)

2370776 S00061522435_V1

THRUST REVERSER CONTROL SYSTEM - CONTROL SWITCH

THRUST REVERSER CONTROL SYSTEM - THRUST REVERSER ACTUATOR LOCK PROXIMITY SENSORS

General

The thrust reverser sleeve lock proximity sensor supplies state of the actuator lock signals to the Electronic Engine Control (EEC).

Location

Two proximity sensors are installed on each thrust reverser half, one in the upper locking actuator and one in the center locking actuator.

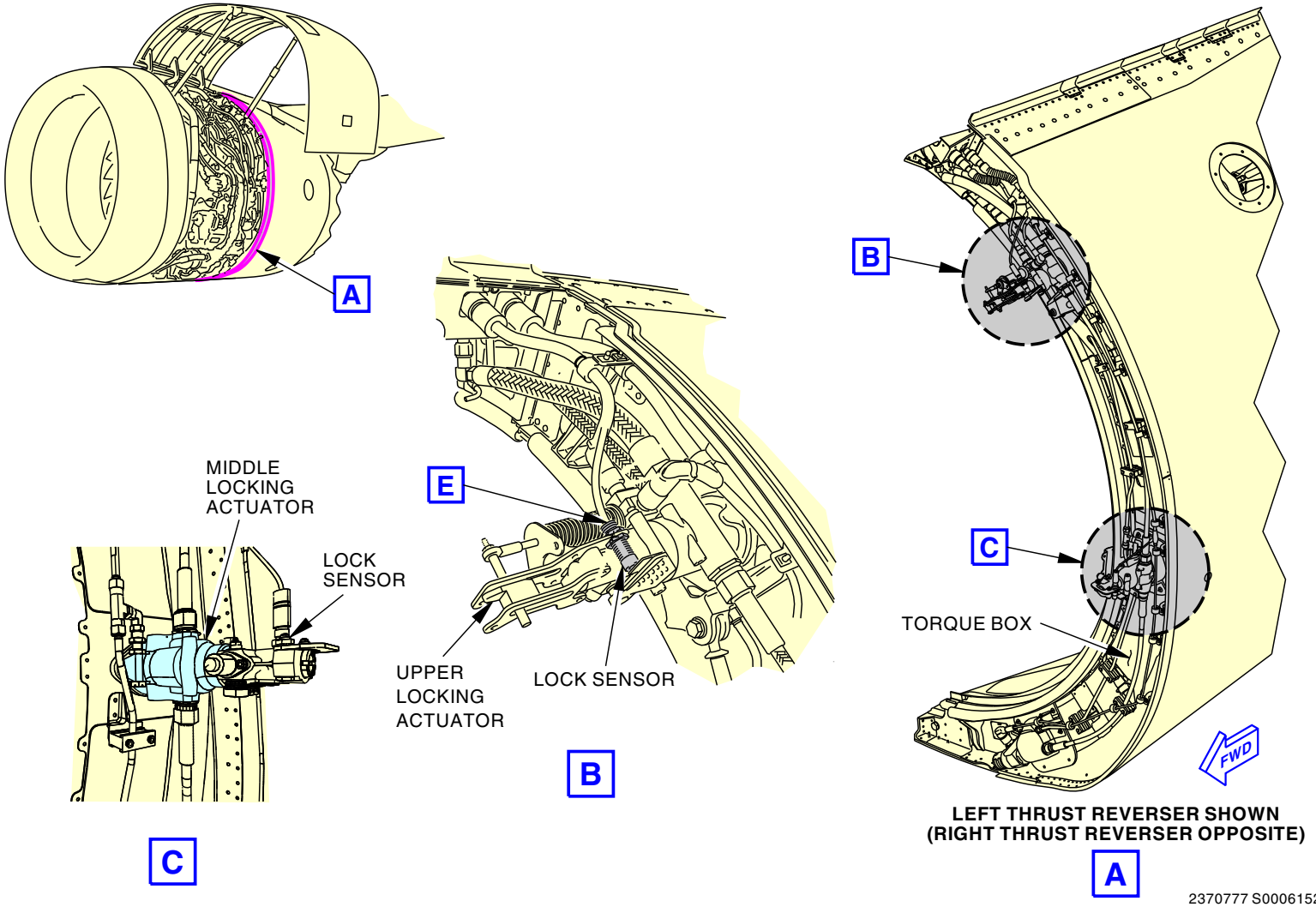
Functional Description

Each sensor has two output levels. One level for the lock position, the other level for the unlock position.

The sensor is a proximity type sensor. The actuator's manual unlock lever is the target for the sensor. The sensor's output changes when target is close (near).

Each sensor contains its own internal processor and bite capability. Each sensor is installed in a bracket on each of the locking actuators, with its associated target installed on the manual unlock lever. When the actuator is locked, the target is away from the sensor in a "target far" condition. When the actuator unlocks the lever rotates causing the target to move across the face of the sensor to a "target near" position.

THRUST REVERSER CONTROL SYSTEM - THRUST REVERSER ACTUATOR LOCK PROXIMITY SENSORS



LEFT THRUST REVERSER SHOWN
(RIGHT THRUST REVERSER OPPOSITE)

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THRUST REVERSER CONTROL SYSTEM - THRUST REVERSER ACTUATOR LOCK PROXIMITY SENSOR

THRUST REVERSER CONTROL SYSTEM - SYNC LOCK

General

The sync lock has two purposes:

- Locks the sync shafts to prevent operation of the hydraulic actuators when there is no T/R deploy signal
- A manual drive for the hydraulic actuators.

Location

A sync lock attaches to the head end of the lower hydraulic actuator on each T/R half.

Physical Description

The sync locks are electric solenoid operated and are spring loaded to the locked position during normal T/R operation. The manual drive is on the bottom. The manual drive is used to disengage the lock mechanism. Electrical power is not necessary when the manual drive is used.

Functional Description

Without electrical power, the sync lock is in the lock position, and the sync shafts cannot turn. The T/R hydraulic actuators cannot operate.

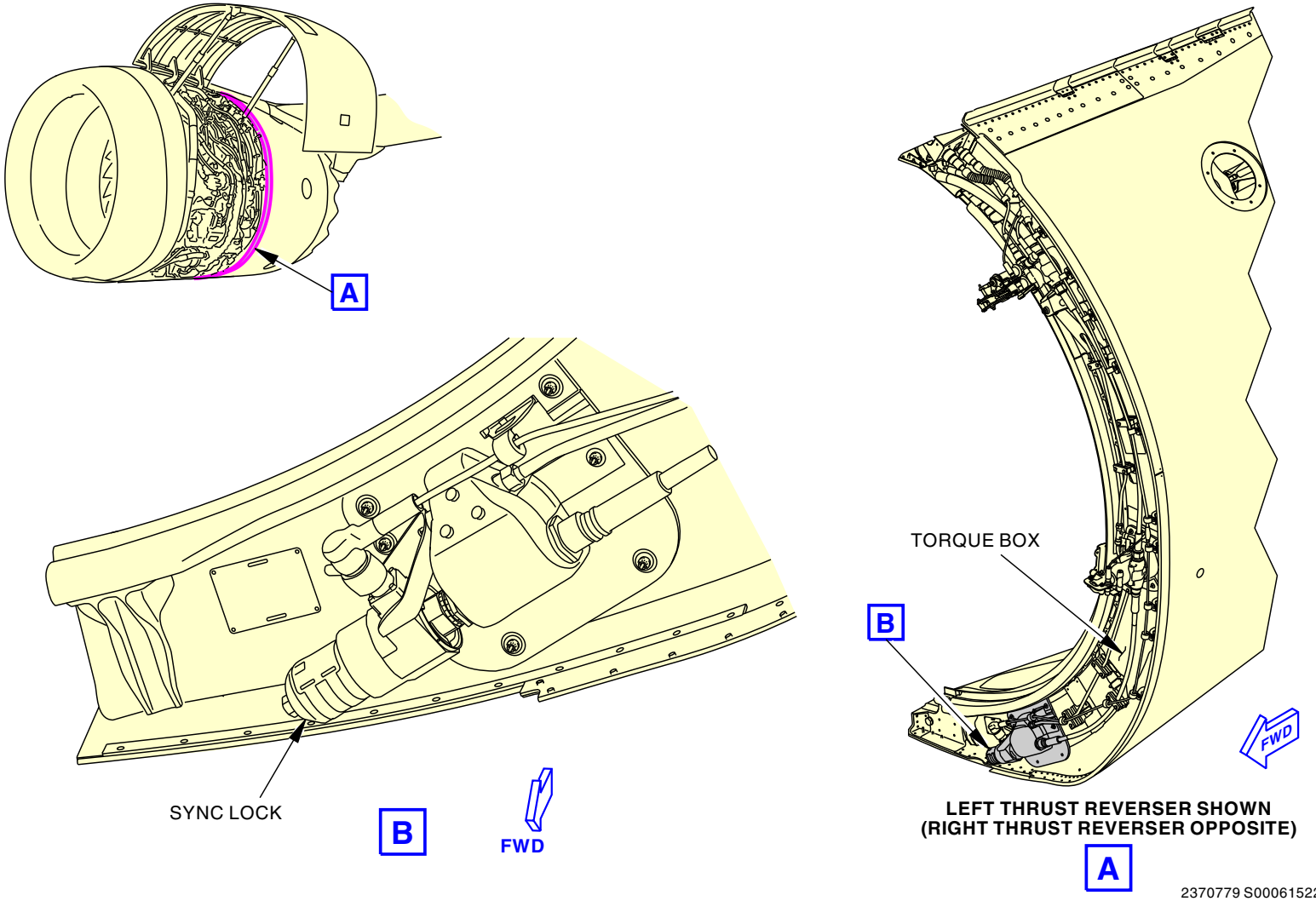
During a T/R deploy operation, the internal solenoid energizes and the sync lock clutch disengages (unlocks). The sync shafts are free to turn and the hydraulic actuators can operate.

If there is an electrical power interrupt during translation to the thrust reverser sleeve, a crash engagement of the locking pins and disk will occur inside the sync lock. The sync lock shaft is designed to shear during such a crash engagement to prevent damage to the thrust reverser actuation system.

Refer to the T/R control system functional description pages of this section for more information about the electrical operation of the sync locks.

A manual drive unit is incorporated into the sync lock assembly. It allows manual deployment and stowing of the thrust reverser actuators for ground maintenance. The drive has a torque limiter which allows a maximum of 45-60 in-lbs. A normal operation torque of around 30 in-lbs is required to translate the sleeve.

THRUST REVERSER CONTROL SYSTEM - SYNC LOCK



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THRUST REVERSER CONTROL SYSTEM - SYNC LOCK

THRUST REVERSER CONTROL SYSTEM - CONTROL VALVE MODULE

General

The T/R control valve modules control hydraulic power to the T/R hydraulic actuators. Each module also has a handle that allows the T/R to be deactivated for maintenance.

Physical Description

Each T/R control valve module has these internal components:

- Isolation valve
- Directional control valve
- Arm solenoid
- Stow solenoid
- Deploy solenoid
- Manual isolation (shutoff) valve.

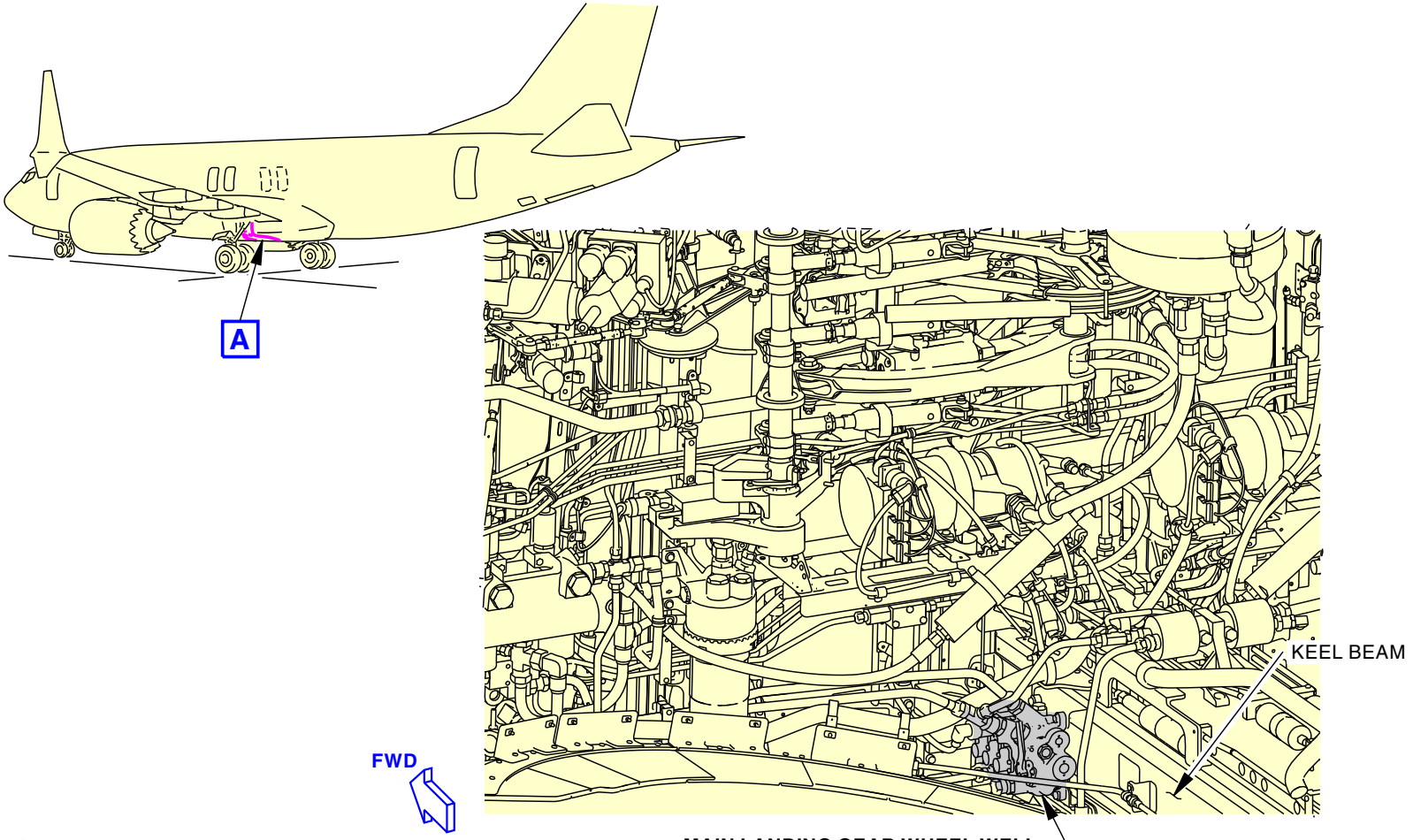
The control valve module houses the electrical and hydraulic components that provide primary hydraulic isolation, reverser directional control and manual isolation functions.

The manual isolation valve handle has a hole for the T/R maintenance deactivation pin.

Location

The T/R control valve modules are in the main gear wheel on the keel beam. The T/R 1 control valve module is on the left side. The T/R 2 control valve module is on the right side.

THRUST REVERSER CONTROL SYSTEM - CONTROL VALVE MODULE



NOTE:

1 ENGINE 1 CONTROL VALVE MODULE IS SHOWN, ENGINE 2 CONTROL VALVE IS ON THE RIGHT SIDE OF THE KEEL BEAM.

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THRUST REVERSER CONTROL SYSTEM - CONTROL VALVE MODULE

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THRUST REVERSER CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - DEPLOY HYDRAULIC FLOW

General

The thrust reverser for each engine is controlled by a single, dedicated reverse thrust lever which is part of the thrust lever assembly (aisle stand) in the flight deck. Reverse thrust lever motion provides the signals to the Thrust Reverser Actuating System (TRAS) to deploy or stow the thrust reverser and to vary the engine power setting from reverse idle up to the maximum allowable reverse thrust level. The Electronic Engine Controller (EEC) is an integral part of the TR control and indication.

Sync Locks

The sync locks must unlock for the T/R hydraulic actuators to operate. The sync locks are energized to unlock. They receive 28 vdc standby bus power through the T/R SL latch relay (RLY) after it energizes to the deploy position.

T/R Control Valve Module

Each T/R control valve module has a deploy solenoid and arm solenoid. Both solenoids must energize to send hydraulic power to deploy its T/R. See T/R CONTROL - FUNCTIONAL DESCRIPTION - HYDRAULIC FLOW for more information.

The deploy solenoid receives power from the 28 vdc standby bus power through the engine fire switch, and the control switch. Power to the deploy solenoid when at least one of these conditions occurs and the sequence relay closes:

- The radio altimeter (R/A) signals the FCCs less than 10 feet or,
- The air sensing relay (R584) senses the airplane is on the ground.

The arm solenoid receives power from the 28 vdc standby bus through the normal position of the fire switch and the T/R deploy/ re-stow logic in the EEC A.

T/R Sequence Relay and T/R Time Delay Module

The T/R sequence relay (SEQ RLY) is energized through the T/R time delay module, 0.1 seconds after the sync locks energize and unlock. This time delay gives the sync locks time to unlock before the arm solenoid and deploy solenoid energize and sends hydraulic power to the T/R. The T/R sequence relay finds an electrical ground through the T/R time delay module.

Flight Control Computer (FCC)

The FCC's A and B supply electrical ground to the deploy solenoid when the altitude of the airplane is ten feet (3 meters) or less. Either FCC A or B ground signal is sufficient.

Deploy

The arm and deploy solenoids energize when the reverse thrust lever is raised.

The following happens when the arm solenoid energizes and hydraulic power is available to the T/R control valve module:

- The hydraulic control valve adjacent to the arm solenoid moves against its spring and hydraulic fluid flows through the valve to the Hydraulic Isolation Valve (HIV)
- The HIV moves to the open position
- Hydraulic power is made available at the Directional Control Valve (DCV)
- Hydraulic fluid goes through the open manual shutoff valve to the rod side of the T/R actuators.

The deploy solenoid energizes after the sync lock receives a signal to unlock.

The following happens when the deploy solenoid energizes and hydraulic power is available to the T/R control valve module:

- The hydraulic control valve adjacent to the deploy solenoid moves against its spring and hydraulic fluid flows through the valve to the DCV

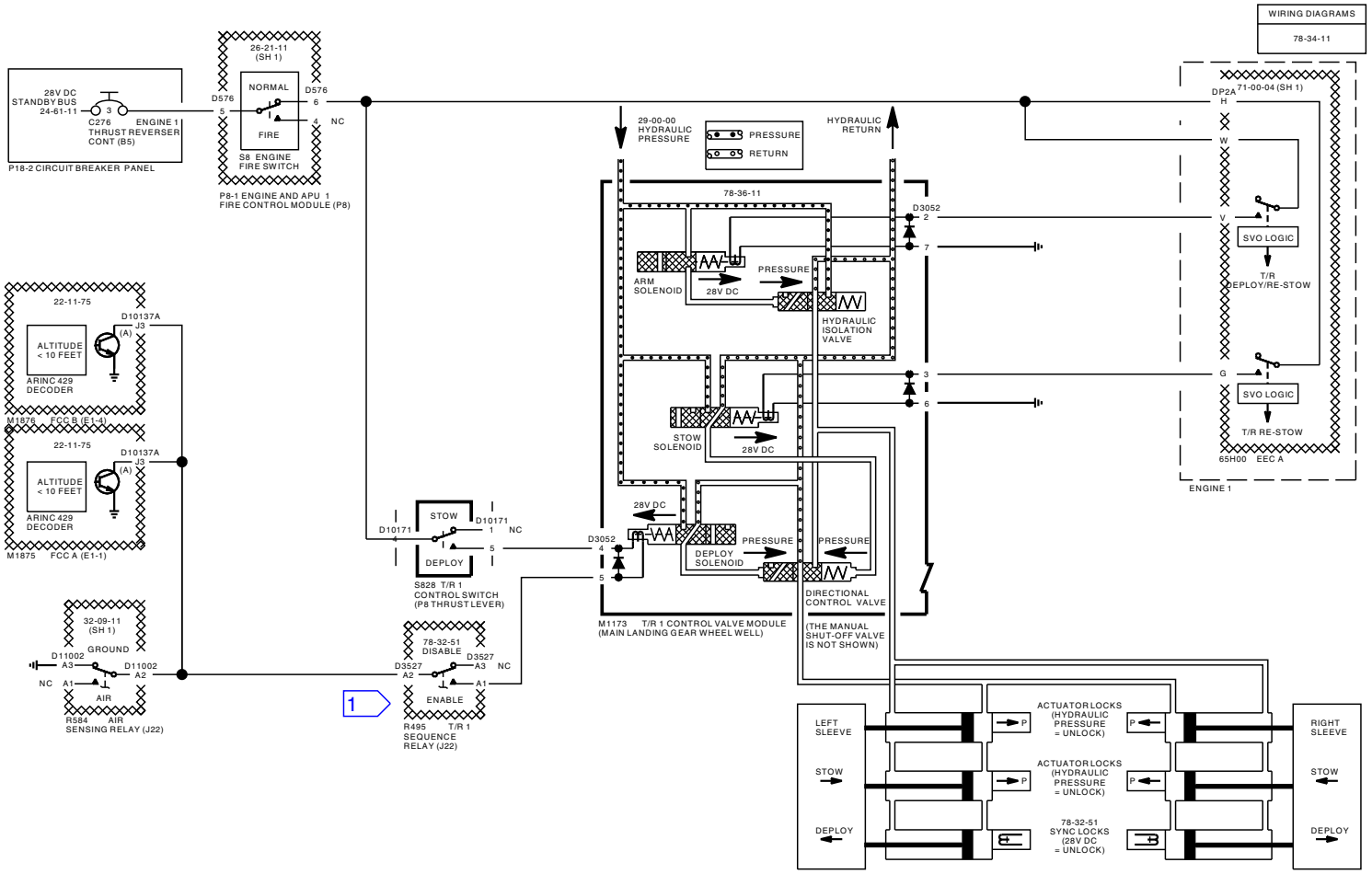
THRUST REVERSER CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - DEPLOY HYDRAULIC FLOW

- The DCV moves to the deploy position (up)
- Hydraulic fluid flows through the DCV to the head side and the rod side of the T/R actuator pistons
- Each locking actuator's mechanism disengages.

The hydraulic pressure on both sides of each actuator piston are equal but the surface area of the head side is larger than the rod side. The larger force on the head side causes the actuator pistons to extend.

As the actuators extend, the fluid on the rod side of the actuators goes to the manual shutoff valve and mixes with the fluid which goes to the head side.

THRUST REVERSER CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - DEPLOY HYDRAULIC FLOW



NOTE:

1 THE SEQUENCE RELAY CLOSES 100 MS AFTER THE SYNC LOCK IS ENERGIZED.

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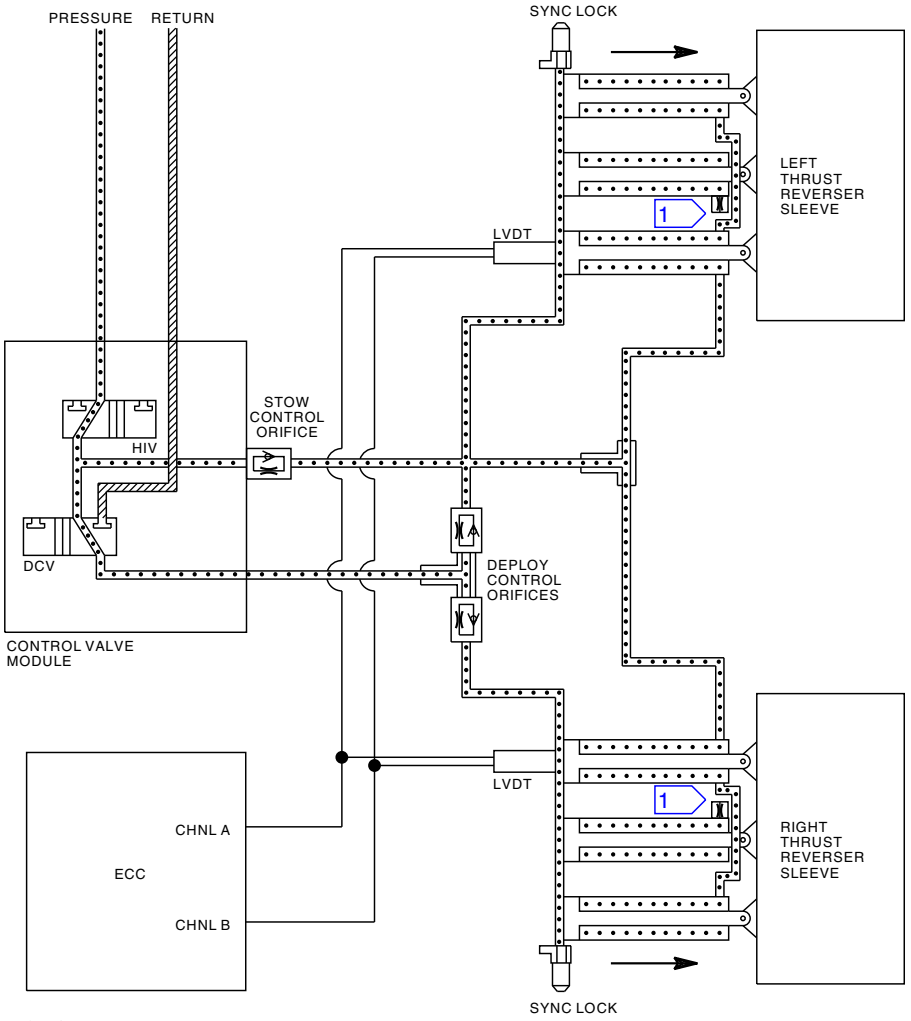
THRUST REVERSER CONTROL SYSTEM - FUNCTIONAL DESCRIPTION

THRUST REVERSER CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - DEPLOY HYDRAULIC FLOW



NOTE:

1 LOAD BALANCING ORIFICES

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THRUST REVERSER CONTROL SYSTEM - DEPLOY HYDRAULIC FLOW

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THRUST REVERSER CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - STOW CONTROL

General

The thrust reverser is stowed by returning the reverse thrust lever back to the full down position. There is no interlock restriction when commanding stow. When returning the T/R lever back to fully stowed, the DCV deploy microswitch opens and the sequencing relay opens ensuring there is no power to the DCV deploy solenoid.

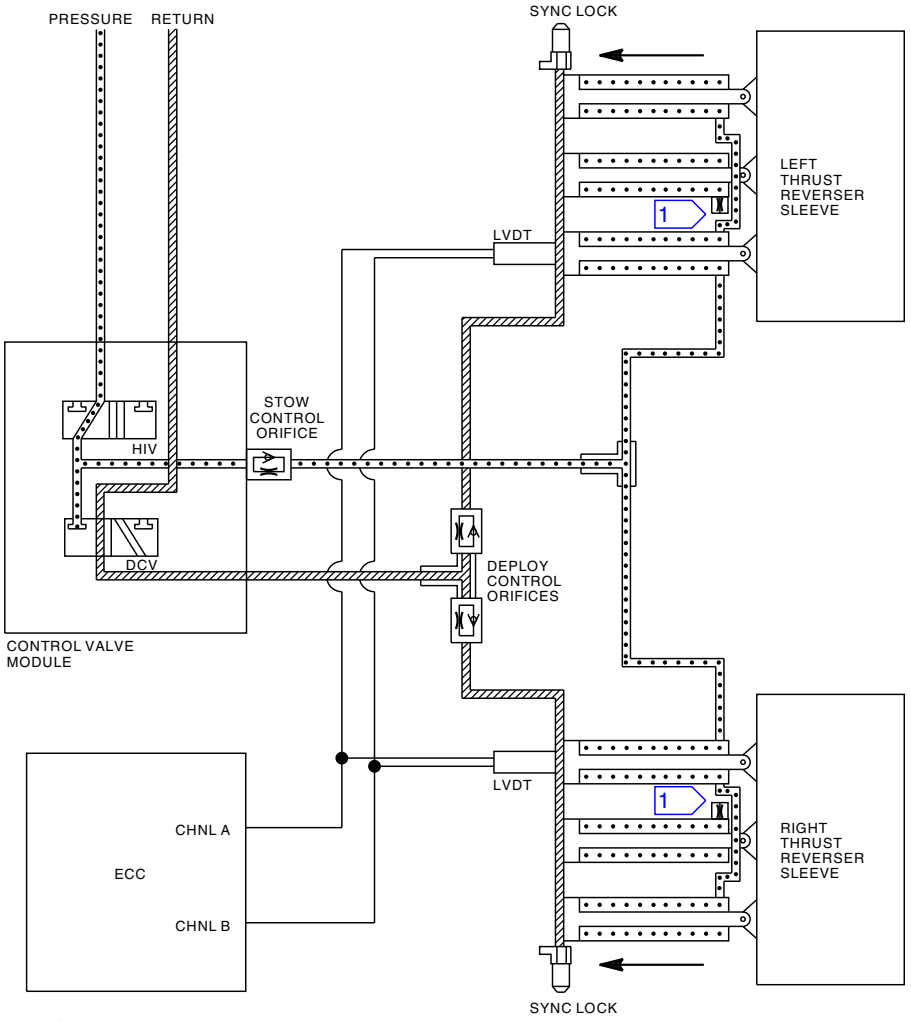
The following happens when the reverse thrust lever is moved to the stow position after a T/R deploy operation:

- The EEC commands the DCV stow solenoid to energize as TRA goes back above 34° TRA.
- The stow solenoid energizes.
- The T/R control valve module sends hydraulic fluid to the actuators to stow the translating sleeves
- The EEC controls the electrical circuit holding the HIV open while the reverser stows.
- When the reverser is fully stowed, the EEC will remove power from the HIV and DCV (10 seconds after the reverse thrust lever is moved above 34° TRA or one proximity sensors on each sleeve is indicates locked, whichever is longer).
- A 10 second timer within the Sync Lock relay keeps the sync locks unlocked during stow.

T/R Control Valve Module

Each T/R control valve module has a stow solenoid and an arm solenoid. Both solenoids must energize for the hydraulic power to stow the T/R.

THRUST REVERSER CONTROL SYSTEM - FUNCTIONAL DESCRIPTION - STOW CONTROL



NOTE:

1 LOAD BALANCING ORIFICES

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THRUST REVERSER CONTROL SYSTEM - STOW HYDRAULIC FLOW

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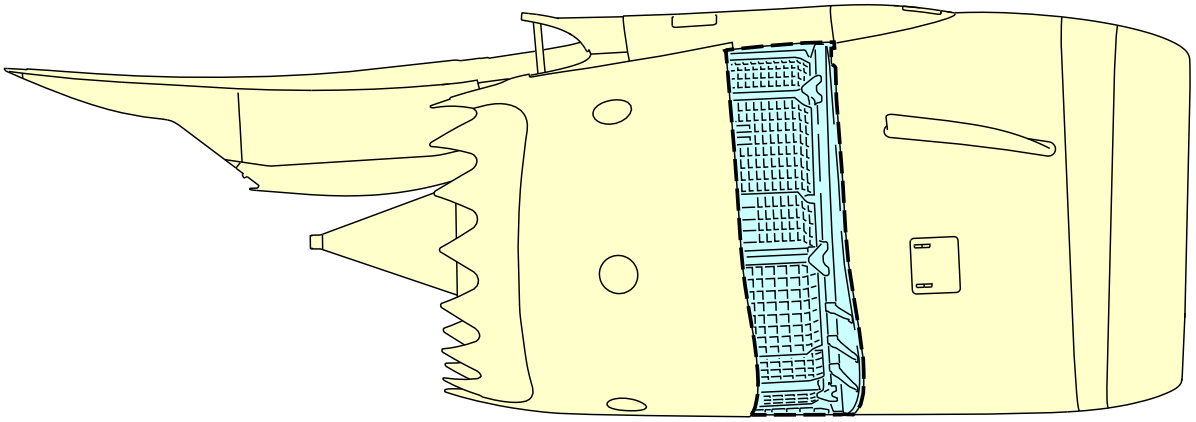
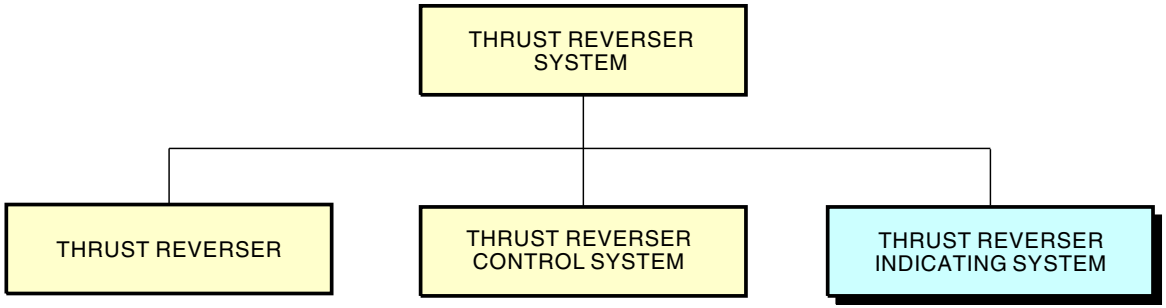
THRUST REVERSER INDICATING SYSTEM - INTRODUCTION

General

The thrust reverser (T/R) indicating system supplies T/R translating sleeve position data to the Max display system (MDS).

THRUST REVERSER INDICATING SYSTEM - INTRODUCTION





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THRUST REVERSER INDICATING SYSTEM - INTRODUCTION

THRUST REVERSER INDICATING SYSTEM - GENERAL DESCRIPTION

General

The Electronic Engine Controls (EECs) control the flight deck indication. The EECs sense the T/R sleeve position and send it to Digital Processing Computers (DPCs). The DPCs send the data to the Max System Display (MDS) for indication. The EECs control the fault lights on the engine panel on the P5 overhead panel.

REV Messages

The REV messages show above the engine N1 indicators on the MDS engine display. During operation, the message shows in amber when the T/R is in transit and the sleeves deploy 10 percent of the travel. The message will turn green when the T/R is in full deploy position. Each T/R translating sleeve has one Linear Variable Differential Transformer (LVDT). The LVDT provides sleeve position data to the EEC. The EECs and the DPCs contain the logic necessary to operate the REV message. The EECs supply the signal on an ARINC 429 bus to each DPC. The DPCs then show the REV message on the MDS engine display.

REVERSER Lights

In flight, the amber REVERSER COMMAND light on the engine panel illuminates if a thrust lever is not in the STOW position.

A REVERSER AIR/GRD light on the engine panel illuminates when the air/ground protection for the T/R system is unsatisfactory.

Each T/R has a REVERSER LIMITED fault light. It will illuminate when the EEC detects a fault in the T/R system.

ENGINE CONTROL Light

Each engine has an amber ENGINE CONTROL light on the engine panel. This light illuminates for a major engine fault. This includes T/R system faults.

The DPCs will not allow the ENGINE CONTROL light to illuminate when the airplane is in air mode. This is true even with faults related to the thrust reverser translating sleeve position. The EEC will send a fault signal to the DPC when the translating sleeve position signals occur. There are no conditions that will cause the ENGINE CONTROL light to illuminate when the airplane is in air mode.

MAX Display System (MDS)

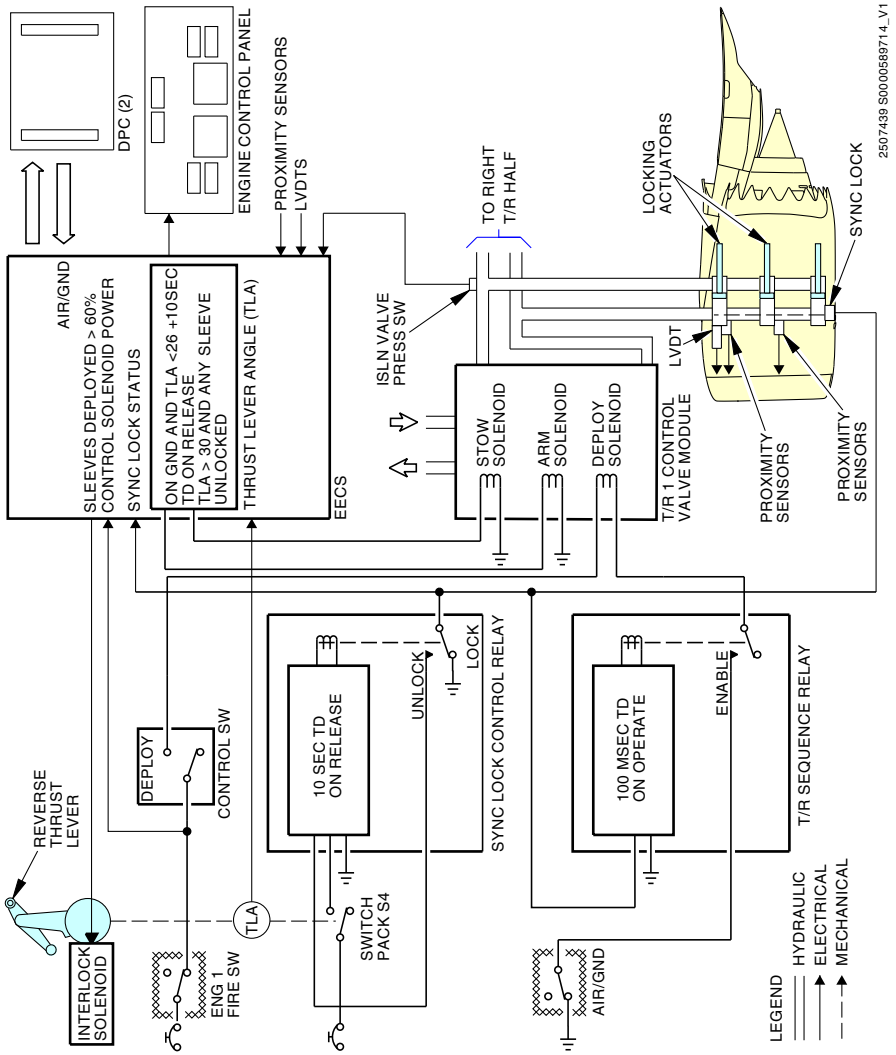
T/R fault data is available on the MDS. The data is on the EPCS maintenance page that is accessed through the multi-function panel buttons and selectors. There are four maintenance data pages that can show engine sensor data. The ENGINE CONTROL light tells the mechanic to check the Onboard Maintenance Function (OMF) for the specific data such as T/R faults. A fault message will have a number that is in the Fault Isolation Manual (FIM). Access to past and present leg fault data is also available.

Status Level Message

When the EEC detects a non-dispatchable fault in the thrust reverser system, it sends a signal to the DPCs. The DPCs will then cause these lights to illuminate and this message to be displayed:

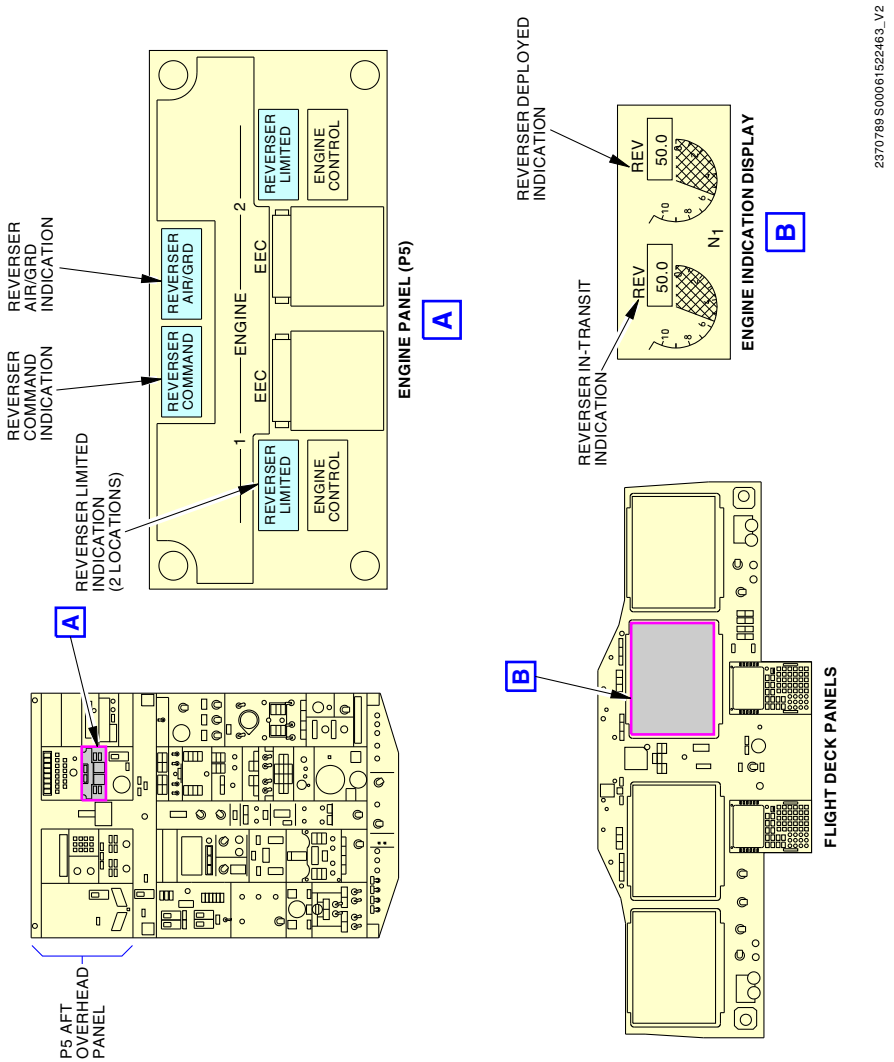
- MAINT light
- MASTER CAUTION lights
- ENG (1/2) REVERSER message on the MDS system status display page.

THRUST REVERSER INDICATING SYSTEM - GENERAL DESCRIPTION



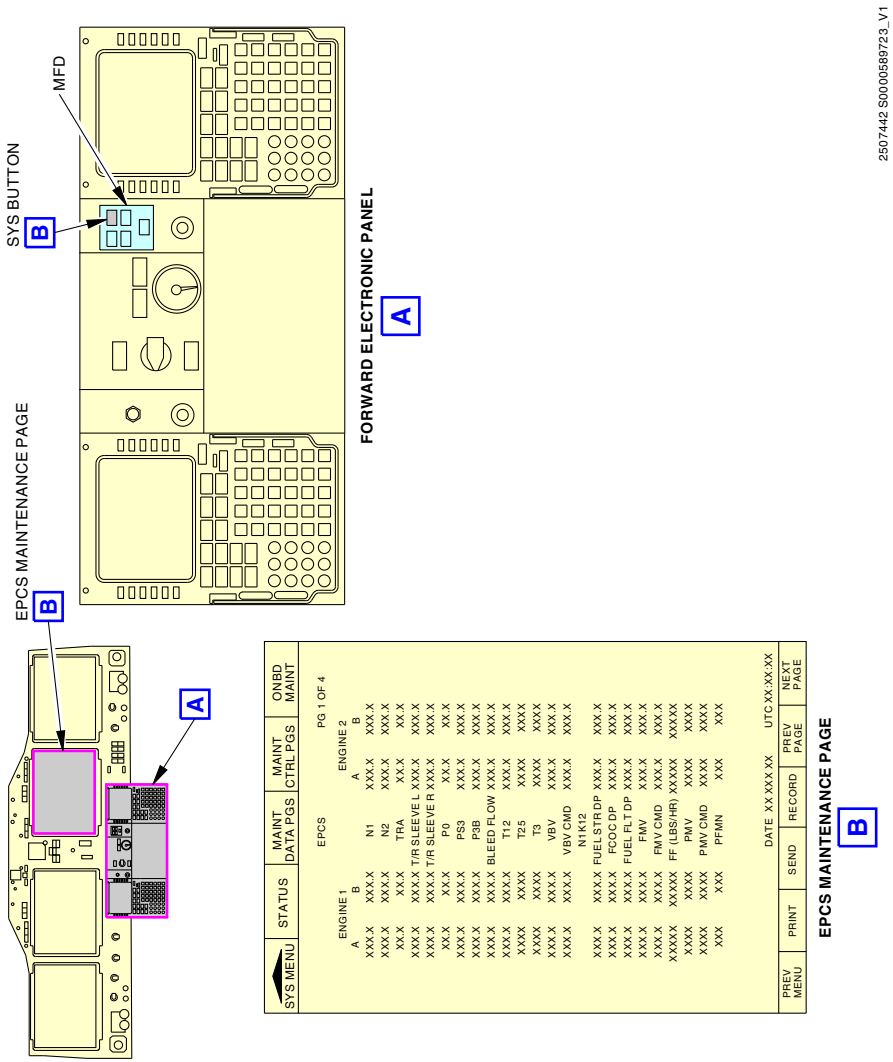
THRUST REVERSER OPERATION

THRUST REVERSER INDICATING SYSTEM - GENERAL DESCRIPTION



THRUST REVERSER INDICATION SYSTEM

THRUST REVERSER INDICATING SYSTEM - GENERAL DESCRIPTION



THRUST REVERSER SYSTEM FAULT INDICATION