

# B737 NG



# Engines

## Introduction

The airplane is powered by two CFM56–7 engines. The engine is a dual–rotor, axial–flow turbofan. The N1 rotor consists of a fan, a low–pressure compressor and a low–pressure turbine. The N2 rotor consists of a high–pressure compressor and a high–pressure turbine. The N1 and N2 rotors are mechanically independent. The N2 rotor drives the engine gearboxes. A bleed–air–powered starter motor is connected to the N2 rotor.

A dual–channel electronic engine control (EEC) regulates each engine. The EEC monitors autothrottle and flight crew inputs to automatically set engine thrust.

Each engine has individual flight deck controls. Thrust is set by positioning the thrust levers. The thrust levers are positioned automatically by the autothrottle system or manually by the flight crew. The forward thrust levers control forward thrust from idle to maximum. If the EECs are in the alternate mode, advancing the thrust levers full forward provides some overboost and should be considered only during emergency situations when all other available actions have been taken and terrain contact is imminent. The reverse thrust levers control thrust from reverse idle to maximum reverse

## Engine Indications

### [Option - Side by side display]

Engine indications are displayed on the center instrument panel upper display unit (DU). If a failure is detected on the upper DU, the engine indications automatically shift to the lower DU. The engine indications can also be manually selected to either the Captain's or First Officer's inboard DU, or the lower DU, using the respective display select panel.

N1, EGT, N2, and FF/FU are the primary indications and are displayed as both digital readouts and round dial/moving pointer indications. N1, EGT, and N2 have operating limits indicated by redlines. EGT also displays an amber caution limit. If one of these indications exceeds the red or amber line, the digital readout, box, pointer, and indicator change color to red or amber.

Oil pressure, oil temperature, oil quantity, and engine vibration are the secondary engine indications. Oil pressure and oil temperature indications are displayed with a round dial/moving pointer. Operating and caution ranges are displayed with red and amber lines. If the red or amber line is reached, the pointer changes color to red or amber for that indication. The oil quantity indicator displays a digital readout of quantity as a percent of full.

Engine vibration indications are displayed with a round dial/moving pointer.

The EEC must receive electrical power to supply engine operating data to the flight deck engine indications. When the EEC is not powered, N1, N2, oil quantity and engine vibration are displayed directly from the engine sensors. Positioning the engine start switch to GRD supplies electrical power to the EEC and displays pointers/digits for all engine parameters.

During battery start with no power on the airplane, only N1, N2, and oil quantity are available. The EEC is not powered until the engine accelerates to a speed greater than 15% N2. At 15% N2, the EEC becomes energized and pointers/digits for all engine parameters are displayed.

An engine failure alert indication (ENG FAIL) is displayed in amber on the EGT indicator when the respective engine is operating at a condition below sustainable idle (50% N2) and the engine start lever is in the IDLE position. The alert remains until the engine recovers, the engine start lever is moved to CUTOFF, or the engine fire warning switch is pulled.

## Engine Indications

### [Option - Over/Under display]

Primary and secondary engine indications are provided. Engine indications are displayed on the center forward panel upper display unit (DU), lower DU or the Captain's or First Officer's inboard DU.

## Primary Engine Indications

N1 and EGT are the primary engine indications. The primary engine indications are normally displayed on the center forward panel upper DU. If that unit fails, the display automatically moves to the lower DU. The primary engine indications can also be manually selected to either the Captain's or First Officer's inboard DU, or the lower DU, using the respective display select panel.

## Secondary Engine Indications

### [Option - Fuel flow displayed full time]

N2, fuel flow, oil pressure, oil temperature, oil quantity, and engine vibration are the secondary engine indications. The secondary engine indications, except for fuel flow, are manually selected to either the Captain's or First Officer's inboard DU, or the lower DU, using the respective display select panel and the ENG switch on the engine display control panel. Fuel flow is displayed full time on the upper display unit below the primary engine indications.

The secondary engine indications are automatically displayed when:

- the displays initially receive electrical power
- in flight when an engine start lever is moved to CUTOFF

- in flight when an engine N2 RPM is below idle
- a secondary engine parameter is exceeded.

When the secondary engine indications are automatically displayed, they cannot be cleared until the condition is no longer present.

## Normal Display Format

N1, EGT, and N2 are displayed as both digital readouts and round dial/moving pointer indications. The digital readouts display numerical values while the moving pointers indicate relative value.

Oil pressure, oil temperature, and engine vibration indications are both digital readouts and vertical indication/moving pointers. Fuel flow and oil quantity are digital readouts only. All digital readouts are enclosed by boxes.

The dials and vertical indications display the normal operating range, caution range, and operating limits.

Normal operating range is displayed on a dial or vertical indication in white.

N1, EGT, and N2 have operating limits indicated by redlines. EGT also displays an amber caution limit. If one of these indications exceeds the red or amber line, the digital readout, box, pointer, and indicator change color to red or amber.

The oil temperature and oil pressure vertical indications have a caution range and an operating limit redline. If the oil temperature or pressure reaches the caution range, the digital readout, digital readout box, and pointer all change color to amber. If one of these indications reach the operating limit, the digital readout, digital readout box, and pointer all change color to red.

The EEC must receive electrical power to supply engine operating data to the flight deck engine indications. When the EEC is not powered, N1, N2, oil quantity and engine vibration are displayed directly from the engine sensors. Positioning the engine start switch to GRD supplies electrical power to the EEC and displays pointers/digits for all engine parameters.

During battery start with no power on the airplane, only N1, N2, and oil quantity are available. The EEC is not powered until the engine accelerates to a speed greater than 15% N2. At 15% N2, the EEC becomes energized and pointers/digits for all engine parameters are displayed.

An engine failure alert indication (ENG FAIL) is displayed in amber on the EGT indicator when the respective engine is operating at a condition below sustainable idle (50% N2) and the engine start lever is in the IDLE position. The alert remains until the engine recovers, the engine start lever is moved to CUTOFF, or the engine fire warning switch is pulled.

## Compact Display

In compact format, the primary and secondary engine indications are combined on the same display. The N1 and EGT indications are displayed as they are normally. All other indications change to digital readouts only. N2, oil temperature, and oil pressure digital readouts turn red or amber if an exceedance occurs. The N2 digital display is framed with a red box after engine shutdown on the ground if an inflight exceedance occurred.

Primary and secondary engine indications are displayed in compact format on the upper DU when the secondary engine indications are selected for display (manually or automatically) and the lower DU is unavailable. Alternatively, the compacted indications are displayed on the lower DU if the upper DU is unavailable.

### Selectable Compact Engine Display

#### [Option - Selectable Compact Engine Display]

The compact engine format may also be selected by pushing the MFD ENG key on the Engine Display Control panel.

<b>Initial Formats Displayed on Center DUs (Upper/Lower)</b>	<b>After ENG Key is Pushed</b>	<b>When an Exceedance Occurs</b>	<b>Exceedance is Active &amp; ENG Key is Pushed</b>
Primary Eng/Blank	Primary Eng/ Secondary Eng	Primary Eng/ Secondary Eng	Comp Eng/Blank
Primary Eng/ Secondary Eng	Comp Eng/Blank	Comp Eng/Blank	Primary Eng/ Secondary Eng
Comp Eng/Blank	Primary Eng/Blank	Primary Eng/ Secondary Eng	Comp Eng/Blank
Primary Eng/Sys	Primary Eng/ Secondary Eng	Primary Eng/ Secondary Eng	Comp Eng/Blank
Comp Eng/Sys	Primary Eng/Sys	Comp Eng/Sys	Primary Eng/ Secondary Eng
Primary ENG/ND	Comp Eng/ND	Comp Eng/ND	Comp Eng/ND
Comp Eng/ND	Primary ENG/ND	Comp Eng/ND	Comp Eng/ND

If the compact engine format is displayed, the subsequent exceedance of a secondary engine parameter will cause a rectangular box outline to appear around the secondary engine parameter. For the initial 10 seconds, the box outline is displayed with thick lines and the box blinks. After 10 seconds, thinner lines are used for the box, and the box stops blinking. The color of the box will match the color of the digits of the exceedance: amber box for an amber exceedance, red box for a red exceedance, and white box for an exceedance indicated by reverse video. Once all exceedances are removed, the box outline will be removed. For multiple exceedances, the color of the box color will match the worst case exceedance.

## Electronic Engine Control (EEC)

Each engine has a full authority digital EEC. Each EEC has two independent control channels, with automatic channel transfer if the operating channel fails. With each engine start or start attempt, the EEC alternates between control channels. The EEC uses thrust lever inputs to automatically control forward and reverse thrust. N1 is used by the EEC to set thrust in two control modes: normal and alternate. Manual selection of the control mode can be made with the EEC switches on engine panel.

### EEC Normal Mode

In the normal mode, the EEC uses sensed flight conditions and bleed air demand to calculate N1 thrust ratings. The EEC compares commanded N1 to actual N1 and adjusts fuel flow to achieve the commanded N1.

The full rated takeoff thrust for the installed engine is available at a thrust lever position less than the forward stop. Fixed or assumed temperature derated takeoff thrust ratings are set at thrust lever positions less than full rated takeoff. The maximum rated thrust is available at the forward stop. The EEC limits the maximum thrust according to the airplane model as follows:

- 737-600 – CFM56-7B22 rating
- 737-700 – CFM56-7B24 rating
- 737-800 – CFM56-7B27 rating
- 737-900 – CFM56-7B27 rating

### Takeoff Bump Thrust

#### [Option - Takeoff bump thrust]

Takeoff bump thrust is available when increased thrust is needed for takeoff, above the normal maximum takeoff thrust setting. When selected using the FMC N1 LIMIT page, takeoff thrust is increased by either the flight crew or the autothrottle positioning the thrust levers to set N1 to the reference N1 bug. Bump thrust applies only to the takeoff rating; maximum climb, maximum continuous and go-around thrust ratings are not affected.

Airplanes equipped with a takeoff thrust bump have a reserve thrust capability which is greater than the standard values listed under the EEC Normal Mode listed above. Use of this reserve thrust capability is intended for emergency use only in the event of wind shear or impending ground contact.

FMC selection of takeoff bump thrust can be configured as either “Bump Option” or a “Full-Rate Option.” When configured as a FMC “Bump Option”, the default takeoff rating is lower than takeoff bump, and the takeoff bump must be activated via the FMC-CDU. With this “Bump Option” configuration, assumed temperature engine derates are not available from the bump. When configured as a FMC “Full-Rate Option”, the default takeoff rating is the takeoff bump. With this full-rate option, the assumed temperature engine derate method may always be used. With this “Full-Rate Option” configuration, the ability to select the lowest normally offered takeoff fixed derate is lost.

## **EEC Alternate Mode**

The EEC can operate in either of two alternate modes, soft or hard. If required signals are not available to operate in the normal mode, the EEC automatically changes to the soft alternate mode. When this occurs, the ALTN switch illuminates and the ON indication remains visible. In the soft alternate mode, the EEC uses the last valid flight conditions to define engine parameters which allows the mode change to occur with no immediate change in engine thrust. Thrust rating shortfalls or exceedances may occur as flight conditions change. The soft alternate mode remains until the hard alternate mode is entered by either retarding the thrust lever to idle or manually selecting ALTN with the EEC switch on the aft overhead panel.

**Note:** Loss of either DEU results in a loss of signal to both EECs. The EEC ALTN lights illuminate and each EEC reverts to the alternate mode to prevent the engines from operating on a single source of data.

When the hard alternate mode is entered, the EEC reverts to the alternate mode thrust schedule. Hard alternate mode thrust is always equal to or greater than normal mode thrust for the same lever position. If the hard alternate mode is entered by reducing the thrust lever to idle while in the soft alternate mode, the ALTN switch remains illuminated and the ON indication remains visible. When ALTN is selected manually, the ON indication is blanked.

## **Structural Limit Protection**

The EEC provides N1 and N2 redline overspeed protection in both normal and alternate modes. The EGT limit must be observed by the crew because the EEC does not provide EGT redline exceedance protection.

## Idle Operation

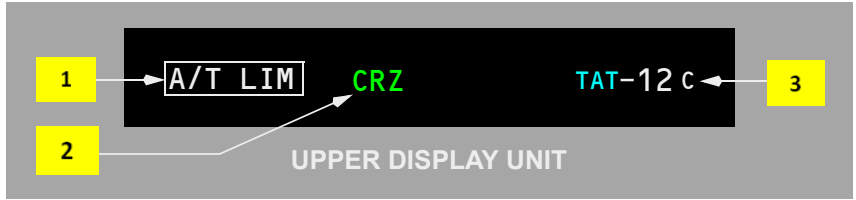
The EEC automatically selects ground minimum idle, flight minimum idle, and approach idle. Ground minimum idle is selected for ground operations and flight minimum idle is selected for most phases of flight. Approach idle is selected in flight if flaps are in landing configuration or engine anti-ice is ON for either engine. At the same airspeed and altitude, N1 and N2% RPM will be higher for approach idle than for flight minimum idle. This higher% RPM improves engine acceleration time in the event of a go-around. Approach idle is maintained until after touchdown, when ground minimum idle is selected. In flight, if a fault prevents the EEC from receiving flap or anti-ice signals, approach idle schedule begins below 15,000 feet MSL.





- 1** Primary Engine Indications
- 2** Fuel Quantity Indications
- 3** Secondary Engine Indications
- 4** Hydraulic Indications

## Autothrottle Limit, Thrust Mode Display and Total Air Temperature



### 1 Autothrottle Limit (A/T LIM) Indication

Illuminated (white) – The FMC is not providing the A/T system with N1 limit values. The A/T is using a degraded N1 thrust limit from the related EEC.

### 2 Thrust Mode Display

Displayed (green) – the active N1 limit reference mode.

With N1 Set Outer Knob (on engine display control panel) in AUTO, active N1 limit is displayed by reference N1 bugs.

With N1 Set Outer Knob (on engine display control panel) in either 1, 2 or BOTH (other than AUTO), the thrust mode display annunciation is MAN.

Active N1 limit is normally calculated by FMC.

#### [Option - Without double derate]

Thrust mode display annunciations are:

- R-TO – reduced takeoff
- R-CLB – reduced climb
- TO – takeoff

#### [Option]

- TO B – takeoff bump thrust
- CLB – climb
- CRZ – cruise
- G/A – go-around
- CON – continuous
- – – – – FMC not computing thrust limit.

**Note:** R-TO does not indicate the type of reduced takeoff. The N1 limit may be reduced due to the entry of an assumed temperature, a takeoff thrust derate or a combination of both assumed temperature and takeoff thrust derate.

**[Option - with Double Derate]**

Thrust mode display annunciations are:

- TO – takeoff
- TO 1 – derated takeoff one
- TO 2 – derated takeoff two
- D-TO – assumed temperature reduced thrust takeoff
- D-TO 1 – derate one and assumed temperature reduced thrust takeoff
- D-TO 2 – derate two and assumed temperature reduced thrust takeoff

**[Option]**

- TO B – takeoff bump thrust
- CLB – climb
- CLB 1 – derated climb one
- CLB 2 – derated climb two
- CRZ – cruise
- G/A – go-around
- CON – continuous

**[Option]**

- Q-CLB – quiet climb
- — – FMC not computing thrust limit.

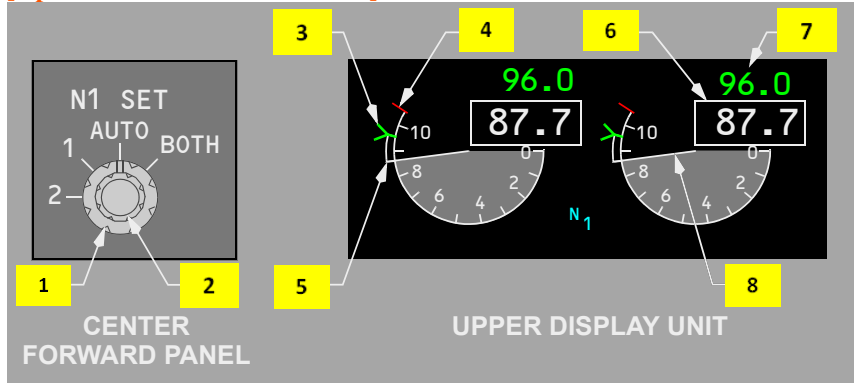
**Note:** In the “bump” configuration, the highest takeoff thrust level is an FMC selectable thrust bump and the use of assumed temperature method (ATM) thrust reduction is not allowed in combination with the bump rating..

**3 Total Air Temperature (TAT) Indication**

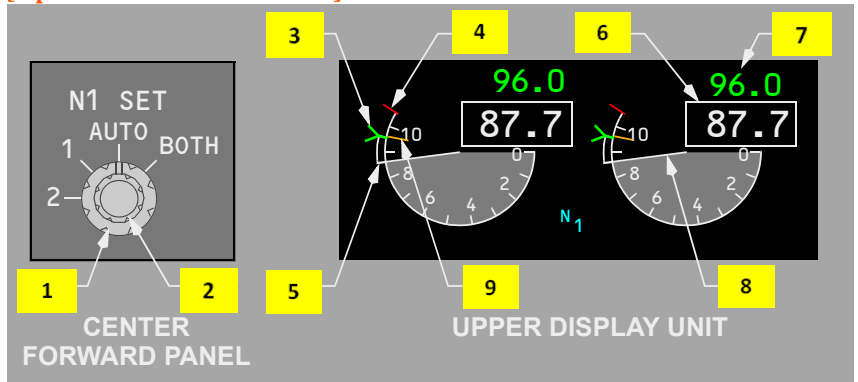
Displayed (label –cyan, temp – white) – total air temperature (degrees C).

## N1 Indications

[Option - without Double Derate]



[Option - with Double Derate]



### 1 N1 SET Outer Knob

AUTO

- both reference N1 bugs set by FMC based on N1 limit page and takeoff reference page
- displays reference N1 bugs at active N1 limit for A/T.

BOTH

- both reference N1 bugs and readouts manually set by turning N1 SET inner knob
- has no effect on A/T operation.

1 or 2 –

- respective N1 reference bug and readout manually set by turning N1 SET inner knob
- has no effect on A/T operation.

## **2 N1 SET Inner Knob (spring-loaded to center)**

Rotate – positions reference N1 bug(s) and readouts when N1 SET outer knob is set to BOTH, 1, or 2.

## **3 Reference N1 Bugs**

Displayed (green) – with N1 SET outer knob in AUTO, 1, 2 or BOTH position.

## **4 N1 Redlines**

Displayed (red) – N1% RPM operating limit

## **5 N1 Command Sectors**

Displayed (white) – momentary difference between actual N1 and value commanded by thrust lever position.

## **6 N1 RPM Readouts (digital)**

Displayed (white) – normal operating range.

Displayed (red) –

- operating limit exceeded
- on ground after engine shutdown, red box indicates an inflight exceedance has occurred.

## **7 Reference N1 Readouts**

Displayed (green) –

- manually set N1% RPM when N1 SET outer knob is in BOTH, 1, or 2 position
- ----- when N1 SET outer knob is in AUTO position and FMC source invalid.

### **[Option - without Double Derate]**

YX800 - YX910

- blank when N1 SET outer knob is in AUTO position

### **[Option - with Double Derate]**

- when N1 SET outer knob is in AUTO position, may indicate fixed derate, assumed temperature derate, or a combination of fixed and assumed temperature derate

Not Displayed when Reverse Thrust is selected.

**8 N1 RPM Indications**

Displays N1% RPM:

- displayed (white) – normal operating range
- displayed (red) – operating limit exceeded.

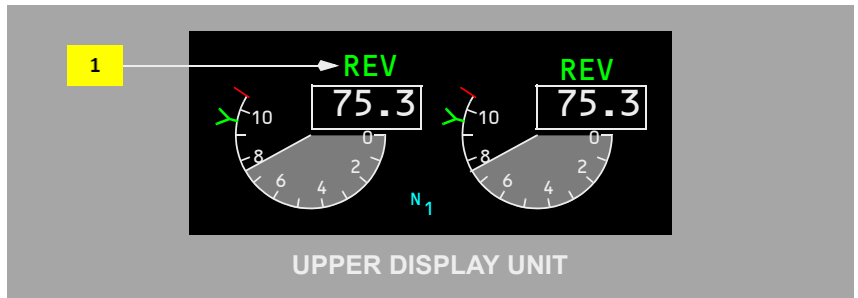
**9 N1 Maximum Bug**

**[Option - Double Derate]**

Displayed (amber) –

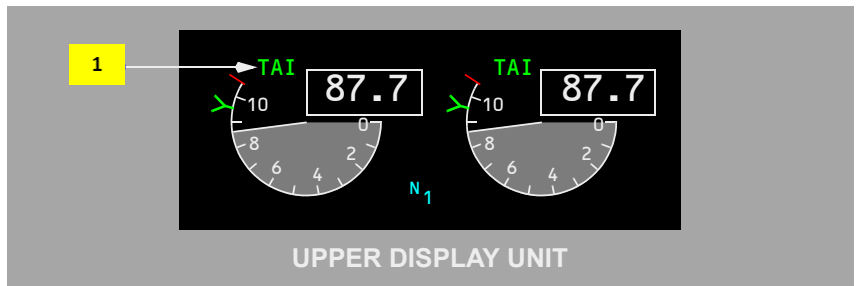
- N1 value for maximum rated thrust
- computed by the EEC through all phases of flight.

Not Displayed when Reverse Thrust is selected.

**Thrust Reverser Indications****1 Thrust Reverser (REV) Indications**

Displayed (amber) – thrust reverser is moved from stowed position.

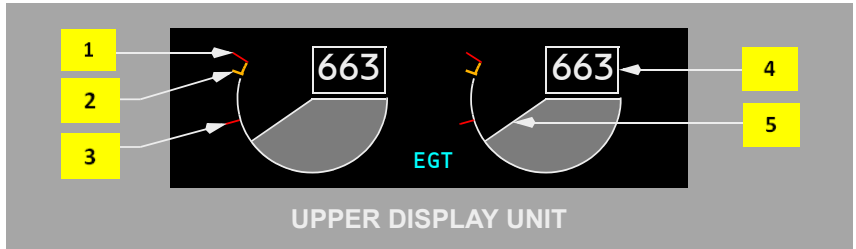
Displayed (green) – thrust reverser is deployed.

**Thermal Anti-Ice Indication****1 Thermal Anti-Ice (TAI) Indications**

Displayed (green) – cowl anti-ice valve(s) open

Displayed (amber) – cowl anti-ice valve is not in position indicated by related engine anti-ice switch..

## EGT Indications



### 1 Exhaust Gas Temperature (EGT) Redlines

Displayed (red) – maximum takeoff EGT limit.

### 2 Exhaust Gas Temperature (EGT) Amber Bands

Displayed (amber) – lower end of band displays maximum continuous EGT limit.

### 3 Exhaust Gas Temperature (EGT) Start Limit Lines

Displayed (red) – until the engine achieves stabilized idle (approximately 59% N<sub>2</sub>).

### 4 Exhaust Gas Temperature (EGT) Readouts (digital)

Displayed (white) – normal operating range (degrees C)

#### [Option - Color change inhibit 5 minutes]

Displayed (amber) – maximum continuous limit exceeded; color change inhibited for up to 5 minutes during takeoff or go-around

#### [Option - Color change inhibit 10 minutes]

Displayed (amber) – maximum continuous limit exceeded

- color change inhibited for up to 5 minutes during takeoff or go-around (normal operation)
- color change inhibited for up to 10 minutes during takeoff or go-around (when an engine out condition occurs within the first 5 minutes of the inhibit)

Displayed (red) – maximum takeoff limit or start limit exceeded

On ground, after both engines are shut down, red box indicates an exceedance has occurred

EEC senses conditions that may lead to hot start during ground starts (blinking white box).

**5 Exhaust Gas Temperature (EGT) Indications**

Displayed (white) – normal operating range.

**[Option - Color change inhibit 5 minutes]**

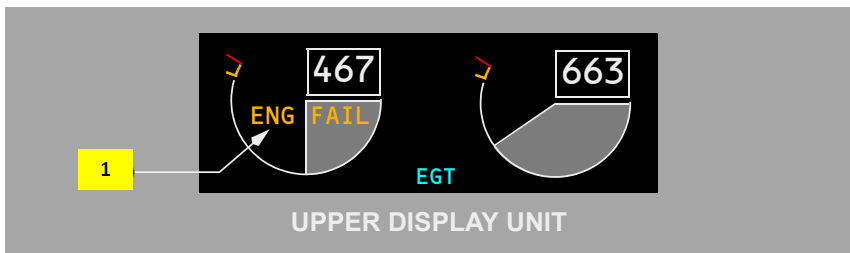
Displayed (amber) – maximum continuous limit exceeded; color change inhibited for up to 5 minutes during takeoff or go-around

**[Option - Color change inhibit 10 minutes]**

Displayed (amber) – maximum continuous limit exceeded

- color change inhibited for up to 5 minutes during takeoff or go-around (normal operation)
- color change inhibited for up to 10 minutes during takeoff or go-around (when an engine out condition occurs within the first 5 minutes of the inhibit)

Displayed (red) – maximum takeoff limit or start limit exceeded.

**Engine Fail Alert****1 Engine Fail (ENG FAIL) Alert**

Displayed (amber) –

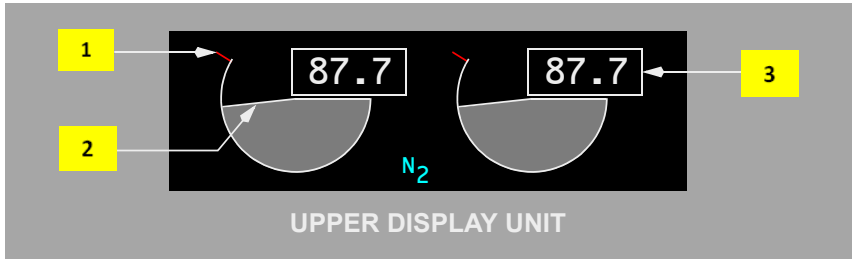
- engine N2 below sustainable idle (less than 50%); and
- engine start lever in IDLE position.

Alert remains until –

- engine N2 above sustainable idle (50% or greater); or
- start lever moved to CUTOFF; or
- engine fire warning switch pulled.



## N2 Indications



### 1 N2 Redlines

Displayed (red) – N2 % RPM operating limit.

### 2 N2 RPM Indications

Displays N2 % RPM

- displayed (white) – normal operating range
- displayed (red) – operating limit exceeded.

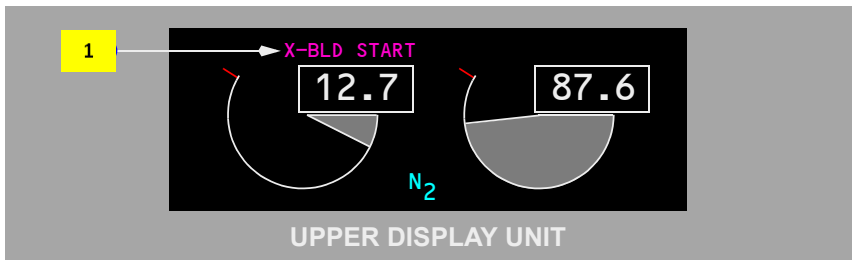
### 3 N2 Readouts (digital)

Displayed (white) – normal operating range.

Displayed (red) –

- operating limit exceeded
- on ground, after engine shutdown, red box indicates an inflight exceedance has occurred.

## Crossbleed Start Indication



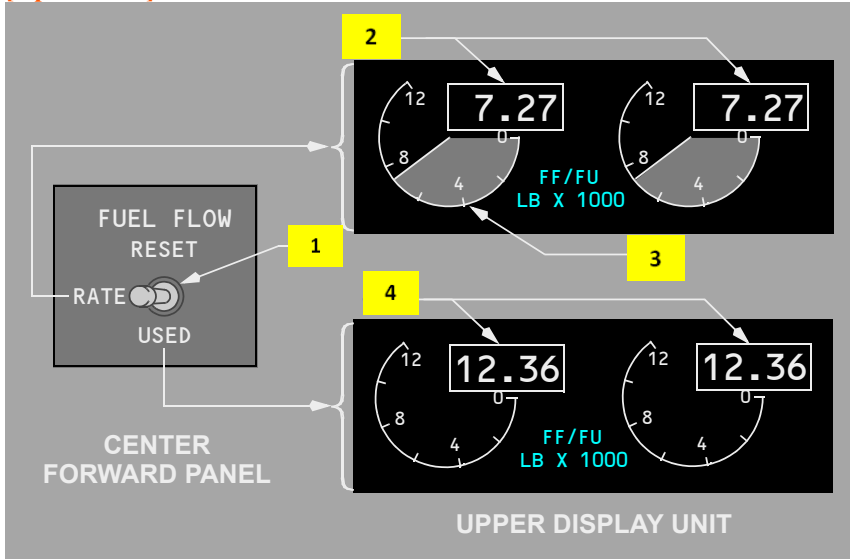
### 1 Crossbleed (X-BLD) START Indication

Displayed (magenta) – crossbled air recommended for inflight start.

Displayed when airspeed is less than required for a windmilling start.

## Fuel Flow/Fuel Used Indications

[Option - lbs]



### 1 FUEL FLOW Switch (spring-loaded to RATE)

**RATE** – displays fuel flow to engine.

**USED** –

- pointer and shading are removed
- displays fuel used since last reset
- after 10 seconds, display automatically reverts to fuel flow.

**RESET** –

- pointer and shading are removed
- resets fuel used to zero
- displays fuel used momentarily, decreases to zero, then displays fuel flow.

### 2 Fuel Flow (FF) Readout (digital)

[Option - lbs]

Displayed (white) – fuel flow to engine with FUEL FLOW switch in RATE position (pounds per hour x 1000).

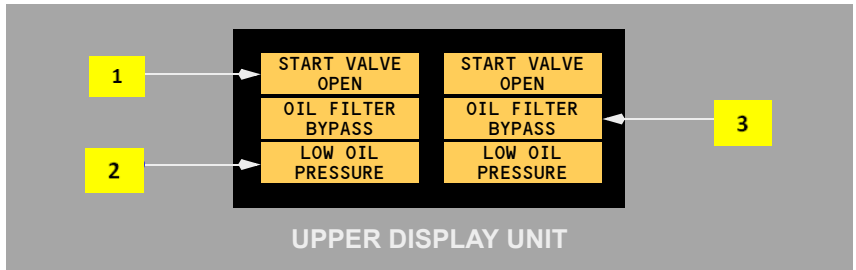
### 3 Fuel Flow (FF) Dial/ Index Markers & Digits (white)

[Option - lbs]

Displayed (white) – fuel flow to engine with FUEL FLOW switch in RATE position (pounds per hour x 1000).

**4 Fuel Used (FU) Readout (digital)**

Displayed (white) – when FUEL FLOW switch moved to USED or RESET.

**Crew Alerts****1 START VALVE OPEN Alert**

Illuminated (amber)

- steady – respective engine start valve open and air is supplied to starter
- blinking – uncommanded opening of start valve. Alert is displayed and solid amber boxes are displayed in unannunciated positions for that engine. All three boxes blink for ten seconds, then alert remains on steady and solid amber boxes are removed (see Note).

**2 LOW OIL PRESSURE Alert**

Illuminated (amber)

- steady – oil pressure at or below red line
- blinking – with a condition of low oil pressure. Alert is displayed and solid amber boxes are displayed in unannunciated positions for that engine. All three boxes blink for ten seconds, then alert remains on steady and solid amber boxes are removed (see note below) .

**3 OIL FILTER BYPASS Alert**

Illuminated (amber) –

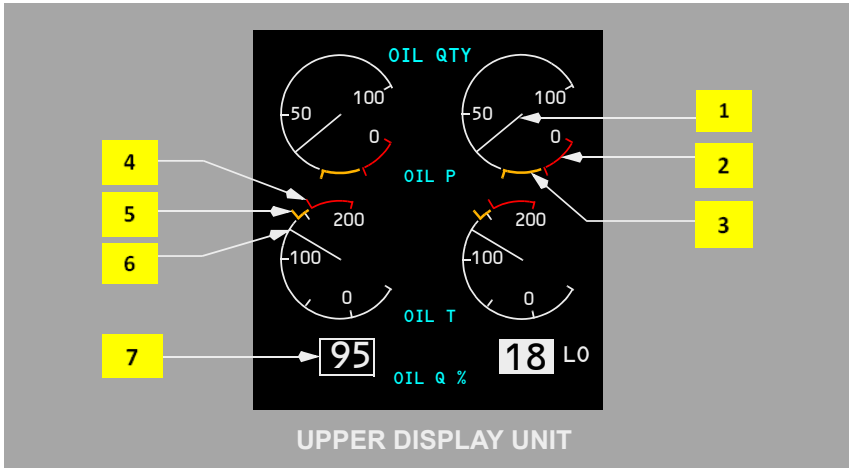
- steady – indicates an impending bypass of scavenge oil filter
- blinking – with an impending bypass. Alert is displayed and solid amber boxes are displayed in unannunciated positions for that engine. All three boxes blink for ten seconds, then alert remains on steady and solid amber boxes are removed (see note below).

**Note:**Blinking is inhibited:

- during takeoff from 80 knots to 400 feet RA, or 30 seconds after reaching 80 knots, whichever occurs first
- during landing below 200 feet RA until 30 seconds after touchdown
- during periods when blinking is inhibited, alerts illuminate steady.

## Engine Oil Indications

[Option - Low oil quantity reverse video]



### 1 Oil Pressure (OIL P) Indication

Displays engine oil pressure (psi)

- displayed (white) – normal operating range
- displayed (amber) – caution range
- displayed (red) – operating limit reached.

### 2 Low Oil Pressure (OIL P) Redline

Displayed (red) – oil pressure operating limit

### 3 Low Oil Pressure (OIL P) Amber Band

Displayed (amber) – low oil pressure caution range beginning at red line:

- variable depending on N2% RPM above 65% N2
- amber band not displayed below 65% N2.

### 4 High Oil Temperature (OIL T) Redline

Displayed (red) – oil temperature operating limit.

**5 High Oil Temperature (OIL T) Amber Band**

Displayed (amber) – oil temperature caution range.

**6 Oil Temperature (OIL T) Indication**

Displays oil temperature (degrees C):

- displayed (white) – normal operating range
- displayed (amber) – caution range reached
- displayed (red) – operating limit reached.

**7 Oil Quantity (OIL Q)% Readout**

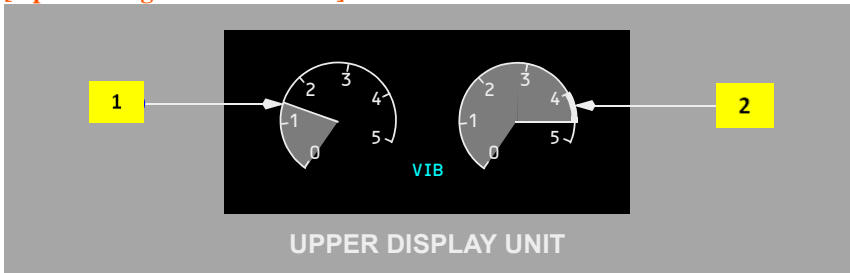
Displays usable oil quantity as a percentage of full quantity.

**[Option - Low oil quantity reverse video]**

Video is reversed and LO (white) displayed for low oil quantity.

**Note:** Indicated oil quantity may decrease significantly during engine start, takeoff and climb out. If this occurs, engine operation is not impacted and the correct oil quantity should be indicated during level flight.

**Note:** An oil quantity indication as low as zero is normal if windmilling N2 RPM is below approximately 8%.

**Engine Vibration Indications****[Option - High vibration alert]****1 Vibration (VIB) Pointer**

Displayed (white) – engine vibration level.

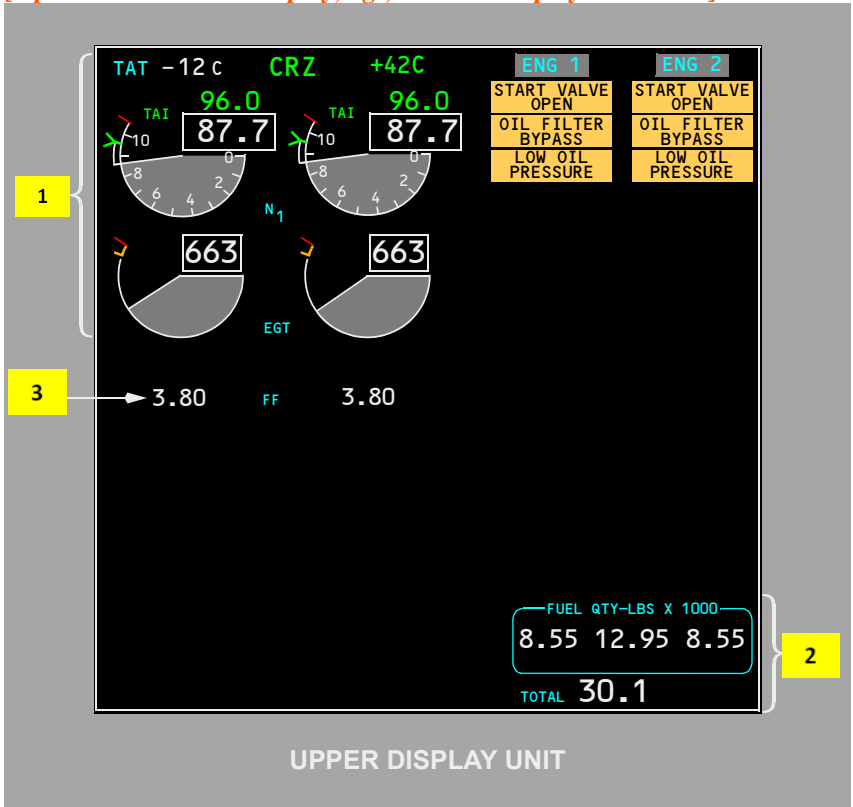
**2 High Engine Vibration Indication****[Option - High vibration alert]**

Displayed (white)

When engine vibration level is greater than four units, the portion of the dial arc between 4 units and the pointer, becomes bold.

## Primary Engine Indications

[Option - Over/Under display, kgs, fuel flow displayed full time]



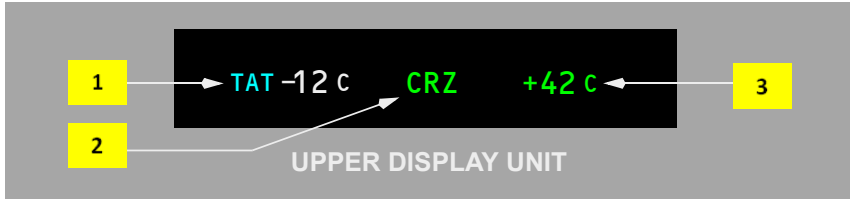
1 Primary Engine Indications

2 Fuel Quantity Indications

3 Fuel Flow Indications

[Option - Fuel flow displayed full time]

## Total Air Temperature, Thrust Mode Display, Selected Temperature and Autothrottle Limit



### 1 Total Air Temperature (TAT) Indication

Displayed (label – cyan, temp – white) – total air temperature (degrees C).

### 2 Thrust Mode Display

Displayed (green) – the active N1 limit reference mode.

With N1 Set Outer Knob (on engine display control panel) in AUTO, active N1 limit is displayed by reference N1 bugs.

With N1 Set Outer Knob (on engine display control panel) in either 1, 2 or BOTH (other than AUTO), the thrust mode display annunciation is MAN.

Active N1 limit is normally calculated by FMC.

#### [Option - without double derate]

Thrust mode display annunciations are:

- R-TO – reduced takeoff
- R-CLB – reduced climb
- TO – takeoff

#### [Option]

- TO B – takeoff bump thrust
- CLB – climb
- CRZ – cruise
- G/A – go-around

- CON – continuous
- ---- FMC not computing thrust limit.

**Note:** R-TO does not indicate the type of reduced takeoff. The N1 limit may be reduced due to the entry of an assumed temperature, a takeoff thrust derate or a combination of both assumed temperature and takeoff thrust derate.

### [Option - with double derate]

Thrust mode display annunciations are:

- TO – takeoff
- TO 1 – derated takeoff one
- TO 2 – derated takeoff two
- D-TO – assumed temperature reduced thrust takeoff
- D-TO 1 – derate one and assumed temperature reduced thrust takeoff
- D-TO 2 – derate two and assumed temperature reduced thrust takeoff

### [Option]

- TO B – takeoff bump thrust
- CLB – climb
- CLB 1 – derated climb one
- CLB 2 – derated climb two
- CRZ – cruise
- G/A – go-around
- CON – continuous

### [Option]

- Q-CLB – quiet climb
- — – FMC not computing thrust limit.

**Note:** In the “bump” configuration, the highest takeoff thrust level is an FMC selectable thrust bump and the use of assumed temperature method (ATM) thrust reduction is not allowed in combination with the bump rating.

## 3 Selected Temperature

Displayed (green) – selected assumed temperature (degrees C) for reduced thrust takeoff N1.

Repeats data selected on TAKEOFF REF page.

## 4 Autothrottle Limit (A/T LIM) Indication

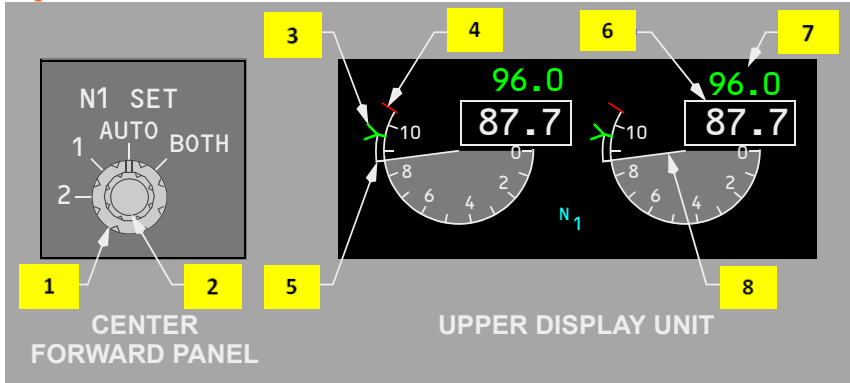
Illuminated (white) – The FMC is not providing the A/T system with N1 limit values. The A/T is using a degraded N1 thrust limit from the related EEC.

Replaces thrust mode display annunciation when illuminated.

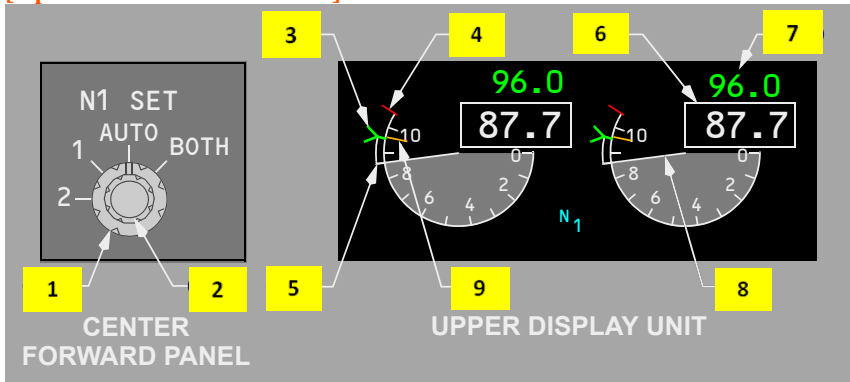


## N1 Indications

### [Option - without Double Derate]



### [Option - with Double Derate]



#### 1 N1 SET Outer Knob

##### AUTO –

- both reference N1 bugs set by FMC based on N1 limit page and takeoff reference page
- displays reference N1 bugs at active N1 limit for A/T.

##### BOTH –

- both reference N1 bugs and readouts manually set by turning N1 SET inner knob
- has no effect on A/T operation.

1 or 2 –

- respective N1 reference bug and readout manually set by turning N1 SET inner knob
- has no effect on A/T operation.

### **2 N1 SET Inner Knob (spring-loaded to center)**

Rotate – positions reference N1 bug(s) and readouts when N1 SET outer knob is set to BOTH, 1, or 2.

### **3 Reference N1 Bugs**

Displayed (green) – with N1 SET outer knob in AUTO, 1, 2 or BOTH position. Position corresponds to digital value on the Reference N1 Readout.

### **4 N1 Redlines**

Displayed (red) – N1% RPM operating limit

### **5 N1 Command Sectors**

Displayed (white) – momentary difference between actual N1 and value commanded by thrust lever position.

### **6 N1 RPM Readouts (digital)**

Displayed (white) – normal operating range.

Displayed (red) –

- operating limit exceeded
- on ground after engine shutdown, red box indicates an inflight exceedance has occurred.

### **7 Reference N1 Readouts**

Displayed (green) –

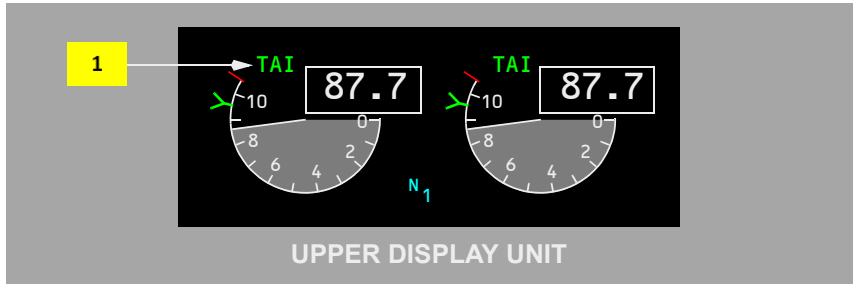
- manually set N1% RPM when N1 SET outer knob is in BOTH, 1, or 2 position
- ---- when N1 SET outer knob is in AUTO position and FMC source invalid.

### **[Option - without Double Derate]**

YX800 - YX910

- blank when N1 SET outer knob is in AUTO position

## Thermal Anti-Ice Indication

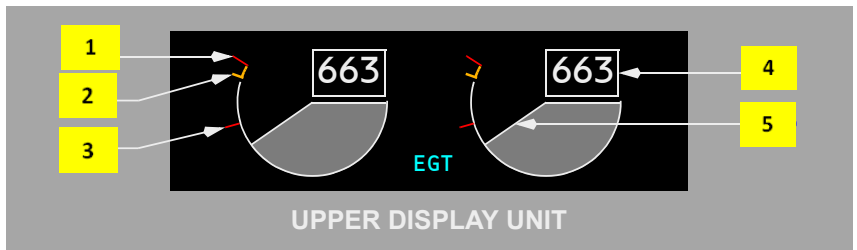


### 1 Thermal Anti-Ice (TAI) Indications

Displayed (green) – cowl anti-ice valve(s) open.

Displayed (amber) – cowl anti-ice valve is not in position indicated by related engine anti-ice switch.

## EGT Indications



### 1 Exhaust Gas Temperature (EGT) Redlines

Displayed (red) – maximum takeoff EGT limit.

### 2 Exhaust Gas Temperature (EGT) Amber Bands

Displayed (amber) – lower end of band displays maximum continuous EGT limit.

### 3 Exhaust Gas Temperature (EGT) Start Limit Lines

Displayed (red) – until the engine achieves stabilized idle (approximately 59% N<sub>2</sub>).

### 4 Exhaust Gas Temperature (EGT) Readouts (digital)

Displayed (white) – normal operating range (degrees C)

**[Option - Color change inhibit 5 minutes]**

Displayed (amber) – maximum continuous limit exceeded; color change inhibited for up to 5 minutes during takeoff or go-around

**[Option - Color change inhibit 10 minutes]**

Displayed (amber) – maximum continuous limit exceeded

- Color change inhibited for up to 5 minutes during takeoff or go-around (normal operation)
- color change inhibited for up to 10 minutes during takeoff or go-around (when an engine out condition occurs within the first 5 minutes of the inhibit)

Displayed (red) – maximum takeoff limit or start limit exceeded

On ground, after both engines are shut down, red box indicates an exceedance has occurred

EEC senses conditions that may lead to hot start during ground starts (blinking white box).

**5 Exhaust Gas Temperature (EGT) Indications**

Displayed (white) – normal operating range.

**[Option - Color change inhibit 5 minutes]**

Displayed (amber) – maximum continuous limit exceeded; color change inhibited for up to 5 minutes during takeoff or go-around

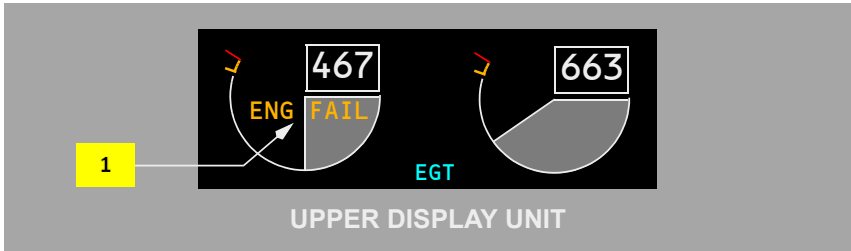
**[Option - Color change inhibit 10 minutes]**

Displayed (amber) – maximum continuous limit exceeded

- color change inhibited for up to 5 minutes during takeoff or go-around (normal operation)
- color change inhibited for up to 10 minutes during takeoff or go-around (when an engine out condition occurs within the first 5 minutes of the inhibit)

Displayed (red) – maximum takeoff limit or start limit exceeded.

## Engine Fail Alert



### 1 Engine Fail (ENG FAIL) Alert

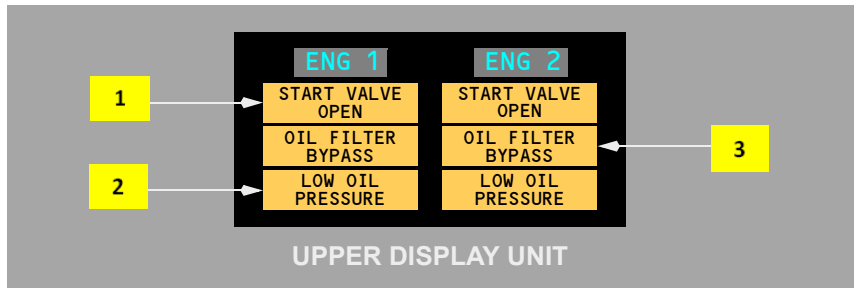
Displayed (amber) –

- engine operating below sustainable idle (less than 50% N2); and
- engine start lever in IDLE position.

Alert remains until –

- engine recovers; or
- start lever moved to CUTOFF; or
- engine fire warning switch pulled.

## Crew Alerts



### 1 START VALVE OPEN Alert

Illuminated (amber) –

- steady – respective engine start valve open and air is supplied to starter
- blinking – uncommanded opening of start valve. Alert is displayed and solid amber boxes are displayed in unannunciated positions for that engine. All three boxes blink for ten seconds, then alert remains on steady and solid amber boxes are removed (see Note).

**2 LOW OIL PRESSURE Alert**

Illuminated (amber) –

- steady – oil pressure at or below red line
- blinking – with a condition of low oil pressure. Alert is displayed and solid amber boxes are displayed in unannunciated positions for that engine. All three boxes blink for ten seconds, then alert remains on steady and solid amber boxes are removed (see Note).

**3 OIL FILTER BYPASS Alert**

Illuminated (amber) –

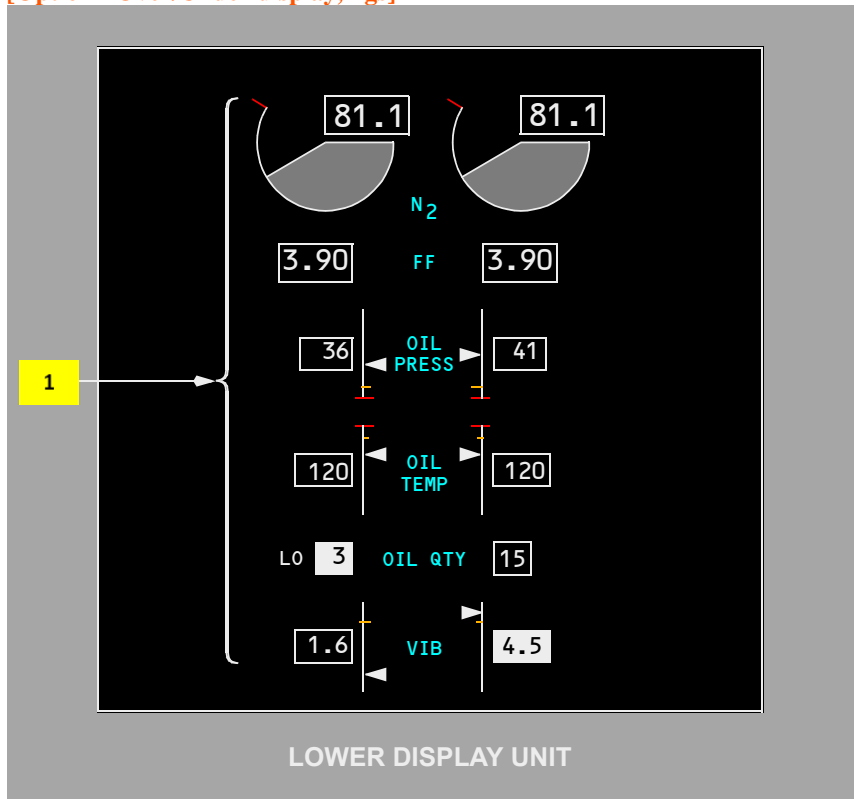
- steady – indicates an impending bypass of scavenge oil filter
- blinking – with an impending bypass. Alert is displayed and solid amber boxes are displayed in unannunciated positions for that engine. All three boxes blink for ten seconds, then alert remains on steady and solid amber boxes are removed (see Note).

**Note:** Blinking is inhibited:

- during takeoff from 80 knots to 400 feet RA, or 30 seconds after reaching 80 knots, whichever occurs first
- during landing below 200 feet RA until 30 seconds after touchdown
- during periods when blinking is inhibited, alerts illuminate steady.

## Secondary Engine Indications

[Option - Over/Under display, kgs]

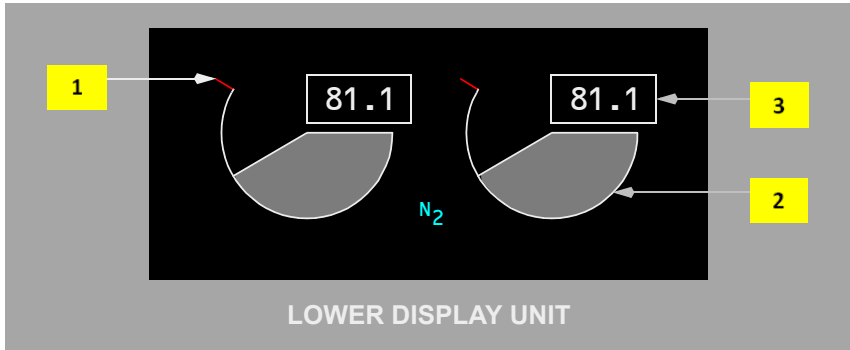


### 1 Secondary Engine Indications

Secondary engine indications are displayed:

- when CDS initially receives power
- when selected by the Multi-Function Display (MFD)
- in flight when an engine start lever moved to CUTOFF
- in flight when an engine fails
- when a secondary engine parameter exceeds normal operating range.

## N2 Indications



### 1 N2 Redlines

Displayed (red) – N2% RPM operating limit.

### 2 N2 RPM Indications

Displays N2% RPM

- displayed (white) – normal operating range
- displayed (red) – operating limit exceeded.

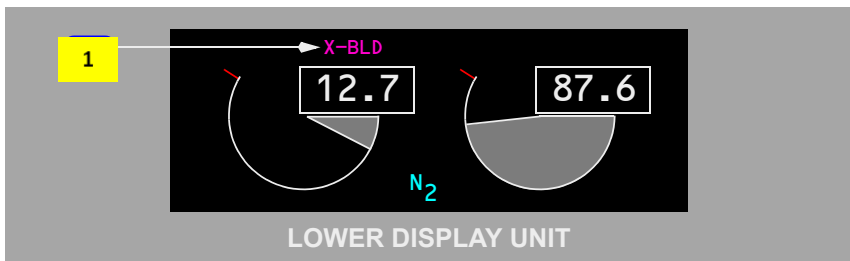
### 3 N2 Readouts (digital)

Displayed (white) – normal operating range.

Displayed (red) –

- operating limit exceeded
- on ground, after engine shutdown, red box indicates an inflight exceedance has occurred.

## Crossbleed Start Indication



### 1 Crossbleed Start (X-BLD) Indication

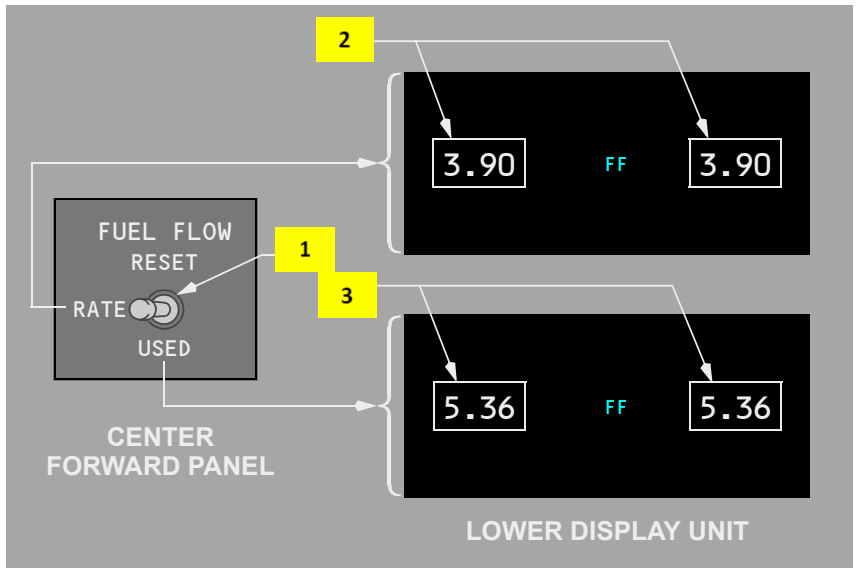
Displayed (magenta) – crossbleed air recommended for inflight start.

Displayed when airspeed is less than required for a windmilling start.



## Fuel Flow/Fuel Used Indications

[Option - Over/Under display, kgs]



### 1 FUEL FLOW Switch (spring-loaded to RATE)

RATE – displays fuel flow to engine.

USED –

- displays fuel used since last reset
- after 10 seconds, display automatically reverts to fuel flow.

RESET –

- resets fuel used to zero
- displays fuel used for 1 second, decreases to zero, then displays fuel flow.

### 2 Fuel Flow (FF) Readout (digital)

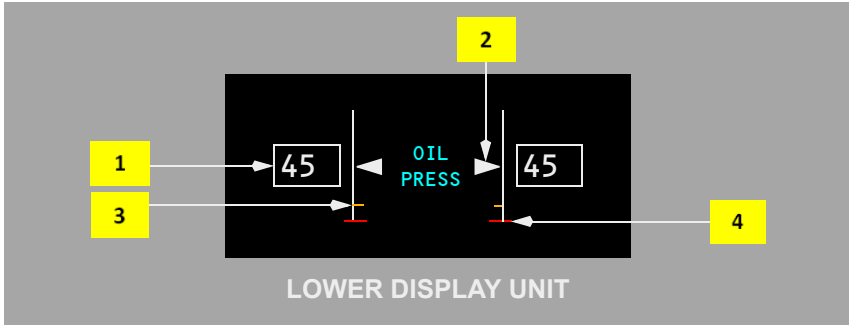
[Option - kgs]

Displayed (white) – fuel flow to engine with FUEL FLOW switch in RATE position (kilograms per hour x 1000).

### 3 Fuel Used Readout (digital)

Displayed (white) – when FUEL FLOW switch moved to USED or RESET.

## Oil Pressure Indications



### 1 Oil Pressure (OIL PRESS) Readout

Displays engine oil pressure (psi)

- displayed (white) – normal operating range
- displayed (amber) – caution range
- displayed (red) – operating limit reached.

### 2 Oil Pressure (OIL PRESS) Pointer

Displays engine oil pressure:

- displayed (white) – normal operating range
- displayed (amber) – caution range reached
- displayed (red) – operating limit reached.

### 3 Low Oil Pressure (OIL PRESS) Amber Band

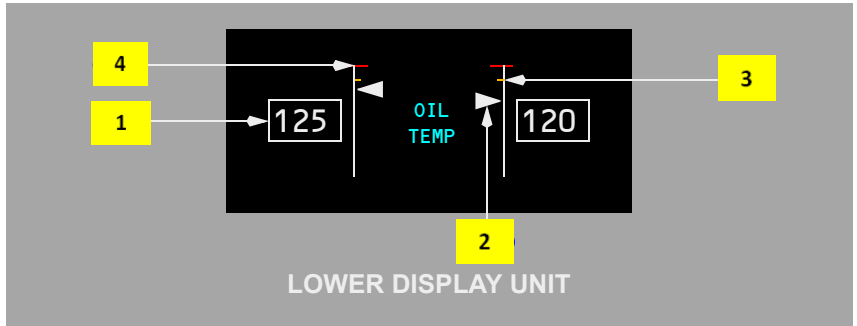
Displayed (amber) – low oil pressure caution range beginning at red line.:

- variable depending on N2% RPM above 65% N2
- amber band not displayed below 65% N2.

### 4 Low Oil Pressure (OIL PRESS) Redline

Displayed (red) – oil pressure operating limit.

## Oil Temperature Indications



### 1 Oil Temperature (OIL TEMP) Readout

Displays oil temperature (degrees C):

- displayed (white) – normal operating range
- displayed (amber) – caution range reached
- displayed (red) – operating limit reached.

### 2 Oil Temperature (OIL TEMP) Pointer

Displays oil temperature (degrees C):

- displayed (white) – normal operating range
- displayed (amber) – caution range reached
- displayed (red) – operating limit reached.

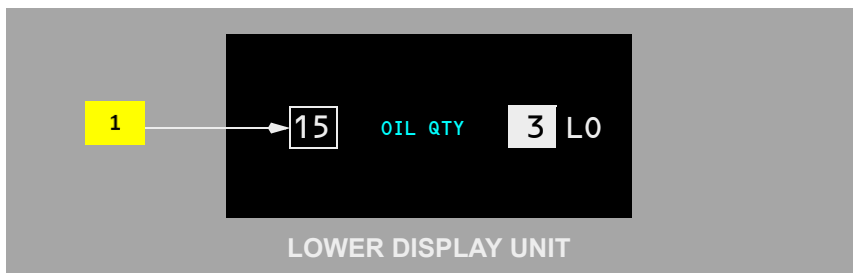
### 3 High Oil Temperature (OIL TEMP) Amber Band

Displayed (amber) – oil temperature caution range.

### 4 High Oil Temperature (OIL TEMP) Redline

Displayed (red) – oil temperature operating limit.

## Oil Quantity Indications



## 1 Oil Quantity (OIL QTY) Readout

### [Option - liters]

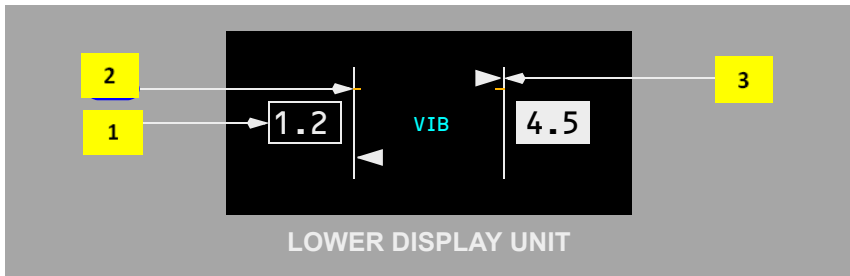
Displays usable oil quantity in liters.

Video is reversed and LO (white) displayed for low oil quantity.

**Note:** Indicated oil quantity may decrease significantly during engine start, takeoff and climb out. If this occurs, engine operation is not impacted and the correct oil quantity should be indicated during level flight.

**Note:** An oil quantity indication as low as zero is normal if windmilling N2 RPM is below approximately 8%.

## Engine Vibration Indications



## 1 Vibration (VIB) Readout

Displayed (white) – engine vibration level.

Video is reversed for high vibration.

## 2 High Limit

Displays tick mark and thick line.

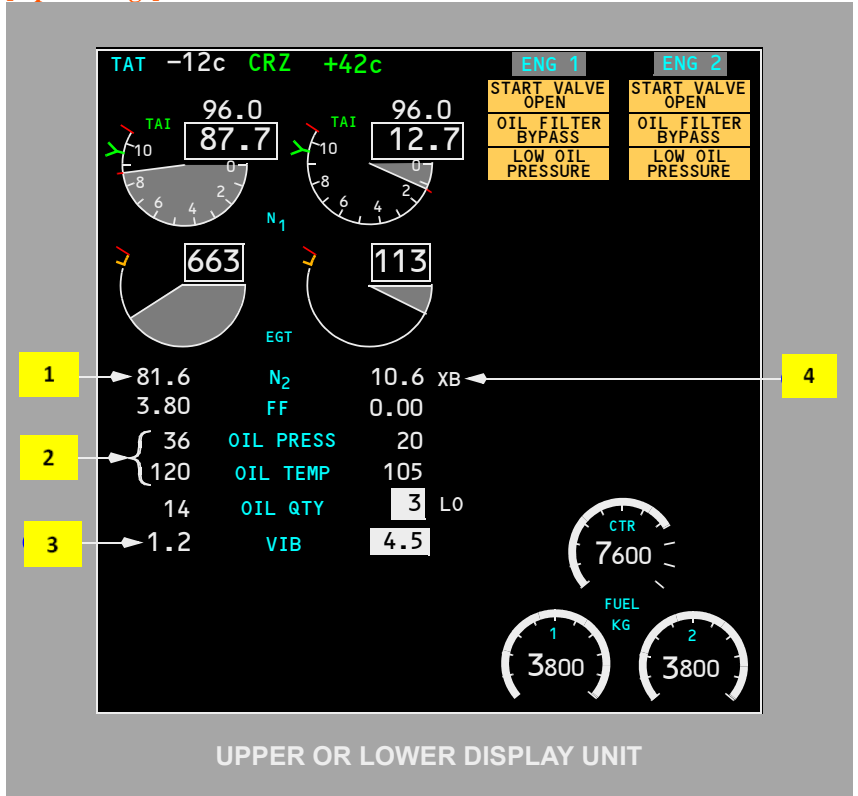
## 3 Vibration (VIB) Pointer

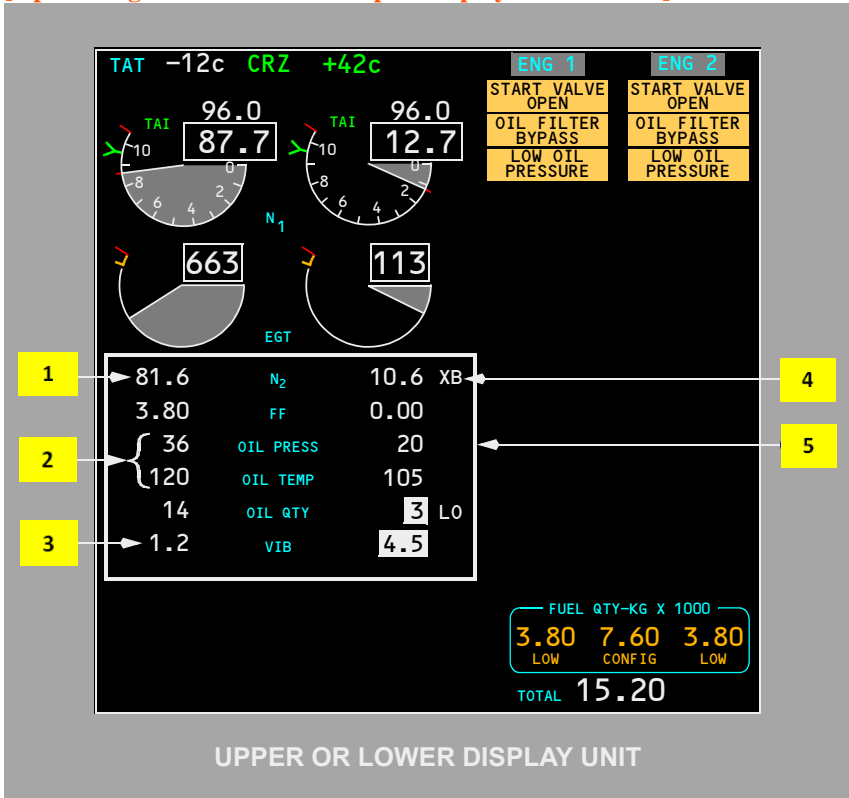
Displayed (white) – engine vibration level.

## Compact Engine Displays

The following changes occur to the secondary engine display in the compact engine displays.

[Option - kgs]



**[Option - kgs with selectable compact display and total fuel]****1 N2 RPM Indications**

N2 changes from round dial display to a digital display.

The digital display is framed by a red box after engine shutdown on the ground if an inflight exceedance occurred.

**2 OIL PRESS, OIL TEMP Indications**

Displayed as digital readouts only

The digital readouts display amber or red if limits are exceeded.

**3 Vibration (VIB) Indications**

Displayed as digital readout only.

#### 4 **Crossbleed Start (XB) Indications**

Displayed on the side of N2

#### 5 **Exceedance Indication**

##### **[Option - Selectable Compact Display]**

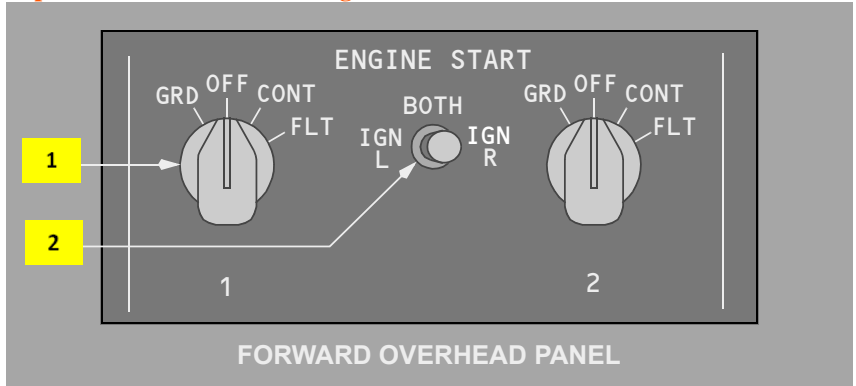
Displayed as rectangular box outline around secondary engine parameters if limits are exceeded when compact display is selected.

The outline has thick lines and blinks for 10 seconds. After 10 seconds, the lines are thinner and do not blink.

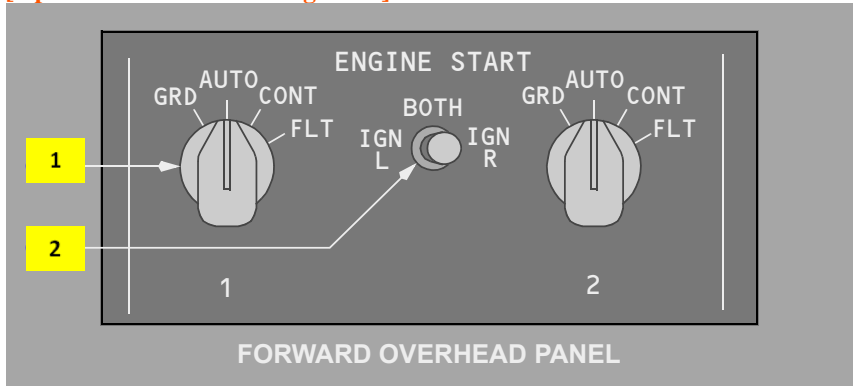
The color of the outline matches the color of the exceedance - amber, red or white.

## Engine Start Switches

### [Option - Without automatic ignition]



### [Option - With automatic ignition]



#### 1 ENGINE START Switches

GRD –

- opens start valve
- closes engine bleed valve
- for ground starts, arms selected igniter(s) to provide ignition when engine start lever is moved to IDLE
- for inflight starts, arms both igniters to provide ignition when engine start lever is moved to IDLE

### [Option - Without automatic ignition]

- releases to OFF at start valve cutout.



**[Option - With automatic ignition]**

- releases to AUTO at start valve cutout.

**[Option - Without automatic ignition]**

OFF –

- ignition normally off
- both igniters are activated when engine start lever is in IDLE and:
  - an uncommanded rapid decrease in N2 occurs or,
  - N2 is between 57% and 50% or,
  - in flight - N2 is between idle and 5%.

**[Option - With automatic ignition]**

AUTO –

- ignition normally off
- both igniters are activated when engine start lever is in IDLE and:
  - an uncommanded rapid decrease in N2 occurs or,
  - N2 is between 57% and 50% or,
  - in flight - N2 is between idle and 5%.
- provides automatic ignition to selected igniters when:
  - engine is running and,
  - flaps are not up below 18000 feet altitude or,
  - engine anti-ice is selected to ON.

CONT –

- provides ignition to selected igniters when engine is operating and engine start lever is in IDLE
- in flight - provides ignition to both igniters when N2 is below idle and engine start lever is in IDLE.

FLT – provides ignition to both igniters when engine start lever is in IDLE.

## **2 Ignition Select Switch**

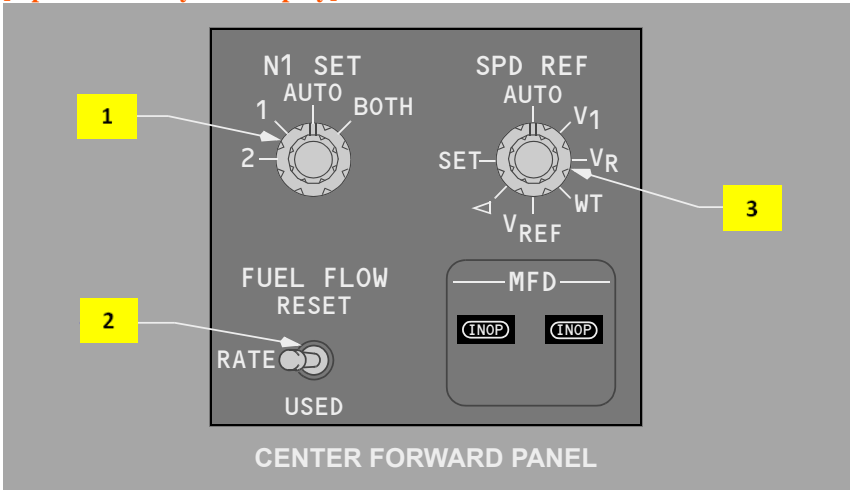
IGN L – selects the left igniter for use on both engines.

BOTH – selects both igniters for use on both engines.

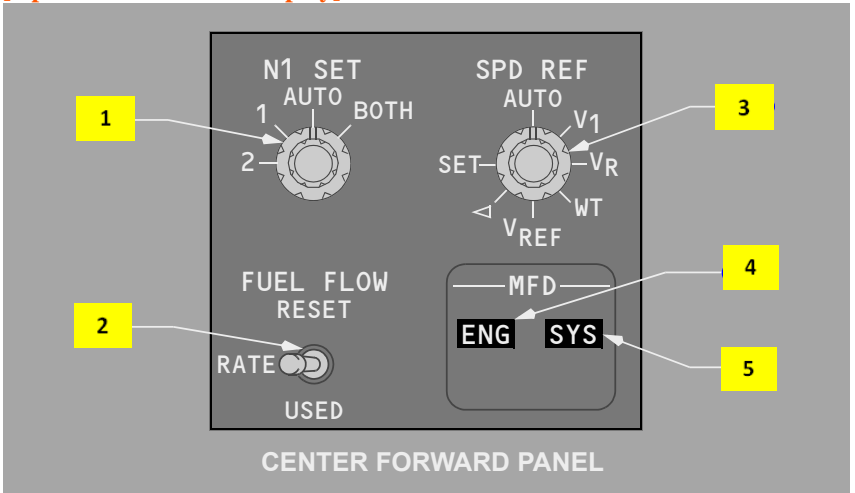
IGN R – selects the right igniter for use on both engines.

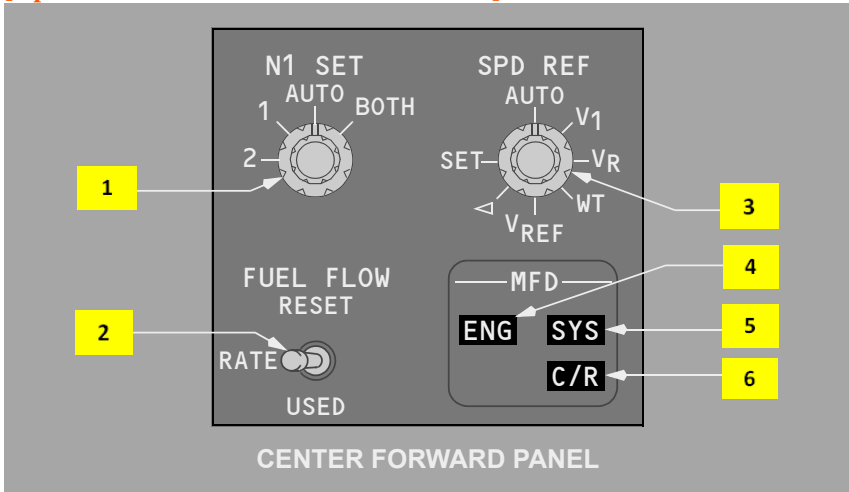
## Engine Display Control Panel

[Option - Side by side display]



[Option - Over/Under display]



**[Option – MFD CANCEL/RECALL Switch]****1 N1 SET Knob****[Option - Side by side display]**

Refer to section 10, Side by Side - Displays

**[Option - Over/Under display]**

Refer to section 11, Over/Under - Displays

**2 FUEL FLOW Switch****[Option - Side by side display]**

Refer to section 10, Side by Side - Displays

**[Option - Over/Under display]**

Refer to section 11, Over/Under - Displays

**3 Speed Reference Selector**

Refer to Chapter 10, Flight Instruments, Displays.

**4 MFD Engine (ENG) Switch****[Option - Over/Under display]**

Push – ENG

- displays secondary engine indications on lower DU; or if the lower DU is unavailable, on upper or inboard DU based on the position of the display select panel selector
- second push blanks lower DU.

**4 MFD Engine (ENG) Switch****[Option - Selectable Compact Engine Display]**

Refer to section 20, Engines, APU - Engine System Description

**5 MFD System (SYS) Switch**

Refer to:

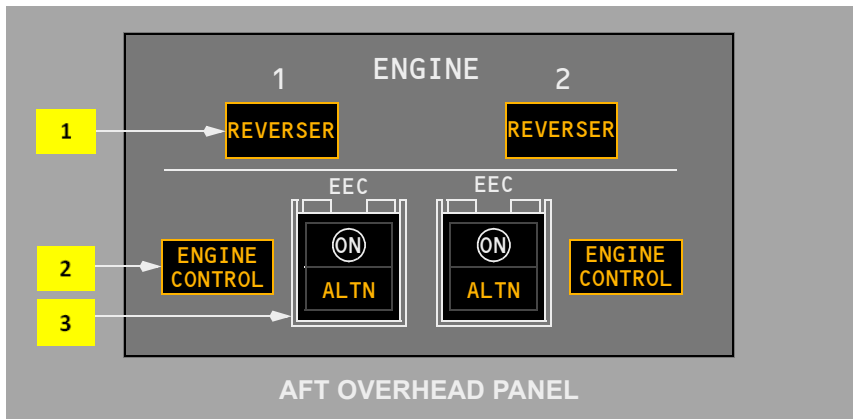
- Chapter 13, Hydraulics

**[Option - Over/Under display with flight control surface position indicator]**

- Chapter 9, Flight Controls

**6 MFD Cancel/Recall (C/R) Switch**

Refer to Chapter 15, Warning Systems.

**Engine Panel****1 REVERSER Lights**

Illuminated (amber) – one or more of following has occurred:

- isolation valve or thrust reverser control valve is not in commanded position
- one or more thrust reverser sleeves are not in commanded state
- auto–restow circuit has been activated
- a failure has been detected in synchronization shaft lock circuitry.

## 2 ENGINE CONTROL Lights

Illuminated (amber) – engine control system is not dispatchable due to faults in system.

Light operates when:

- engine is operating and,
- airplane on ground and:
  - below 80 kt prior to takeoff or,
  - approximately 30 seconds after touchdown.

## 3 Electronic Engine Control (EEC) Switches

ON – in view (white)

- indicates normal control mode is selected
- engine ratings calculated by EEC from sensed atmospheric conditions and bleed air demand
- when ON is not in view, the EEC has been manually selected to the alternate mode.

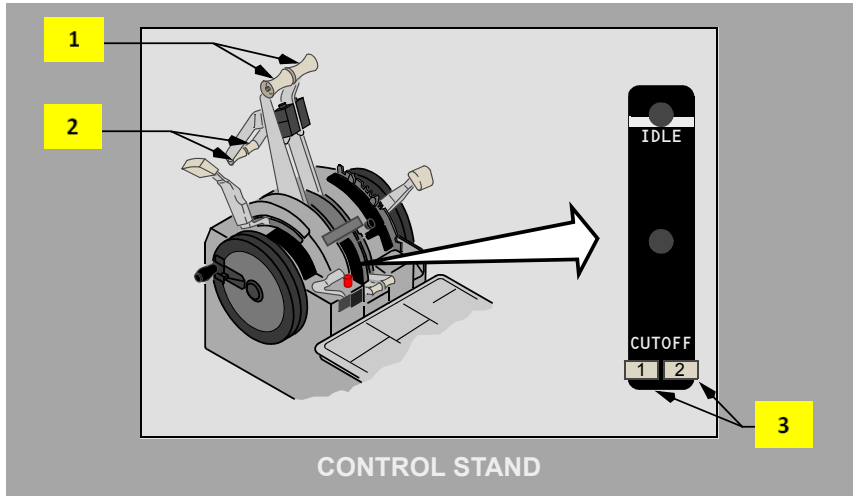
ALTN – in view (amber)

- indicated EEC has automatically switched to alternate control mode or it has been selected manually
- EEC provides rated thrust or higher.

**Note:** Both ON and ALTN may be in view if EEC has automatically switched to soft alternate mode.

**Note:** EGT limits must be observed in both normal and alternate control modes.

## Engine Controls



### 1 Forward Thrust Levers –

- controls engine thrust
- cannot be advanced if the reverse thrust lever is in the deployed position.

### 2 Reverse Thrust Levers –

- controls engine reverse thrust
- cannot select reverse thrust unless related forward thrust lever is at IDLE.

**Note:** Reverse thrust lever is blocked at reverse idle position until related thrust reverser is more than 60% deployed.

**Note:** Movement of reverse thrust lever into reverse thrust engages locking pawl preventing forward thrust lever from moving. Terminating reverse thrust removes locking pawl and restores forward thrust lever movement ability.

### 3 Engine Start Levers

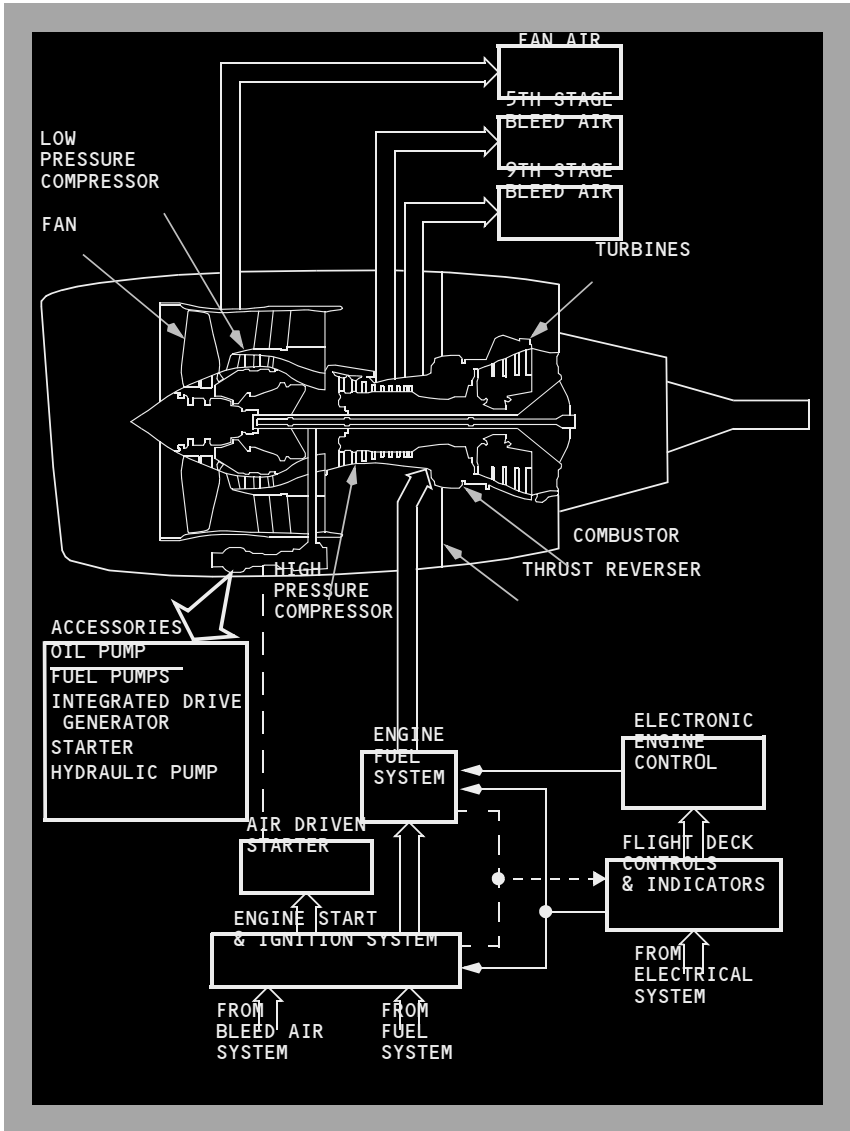
IDLE –

- energizes ignition system through EEC
- electrically opens spar fuel shutoff valve in the wing leading edge outboard of the pylon
- electrically opens engine-mounted fuel shutoff valve via the EEC.

CUTOFF –

- closes both spar and engine fuel shutoff valves
- de-energizes ignition system.

## Power Plant Schematic



## Engine Fuel System

Fuel is delivered under pressure from fuel pumps located in the fuel tanks. The fuel flows through a fuel spar shutoff valve located at the engine mounting wing stations. The fuel passes through the first stage engine fuel pump where pressure is increased. It then passes through two fuel/oil heat exchangers where IDG oil and main engine oil heat the fuel. A fuel filter then removes contaminants. Fuel automatically bypasses the filter if the filter becomes saturated. Before the fuel bypass occurs, the fuel FILTER BYPASS alert illuminates on the fuel control panel. The second stage engine fuel pump adds more pressure before the fuel reaches the hydro mechanical unit (HMU). To meet thrust requirements, the EEC meters fuel through the HMU.

The spar fuel shutoff valve and engine fuel shutoff valve allow fuel flow to the engine when both valves are open. The valves are open when the engine fire warning switch is in and the start lever is in IDLE. Both valves close when either the start lever is in CUTOFF or the engine fire warning switch is out. SPAR VALVE CLOSED and ENG VALVE CLOSED lights located on the overhead panel indicate valve position.

Fuel flow is measured after passing through the engine fuel shutoff valve and is displayed on the display unit. Fuel flow information is also provided to the FMS.

## Engine Oil System

Oil from the individual engine tank is circulated under pressure, through the engine to lubricate the engine bearings and accessory gearbox. The oil quantity indicator, oil temperature indicator, oil pressure indicator and LOW OIL PRESSURE alert are all located on the display unit.

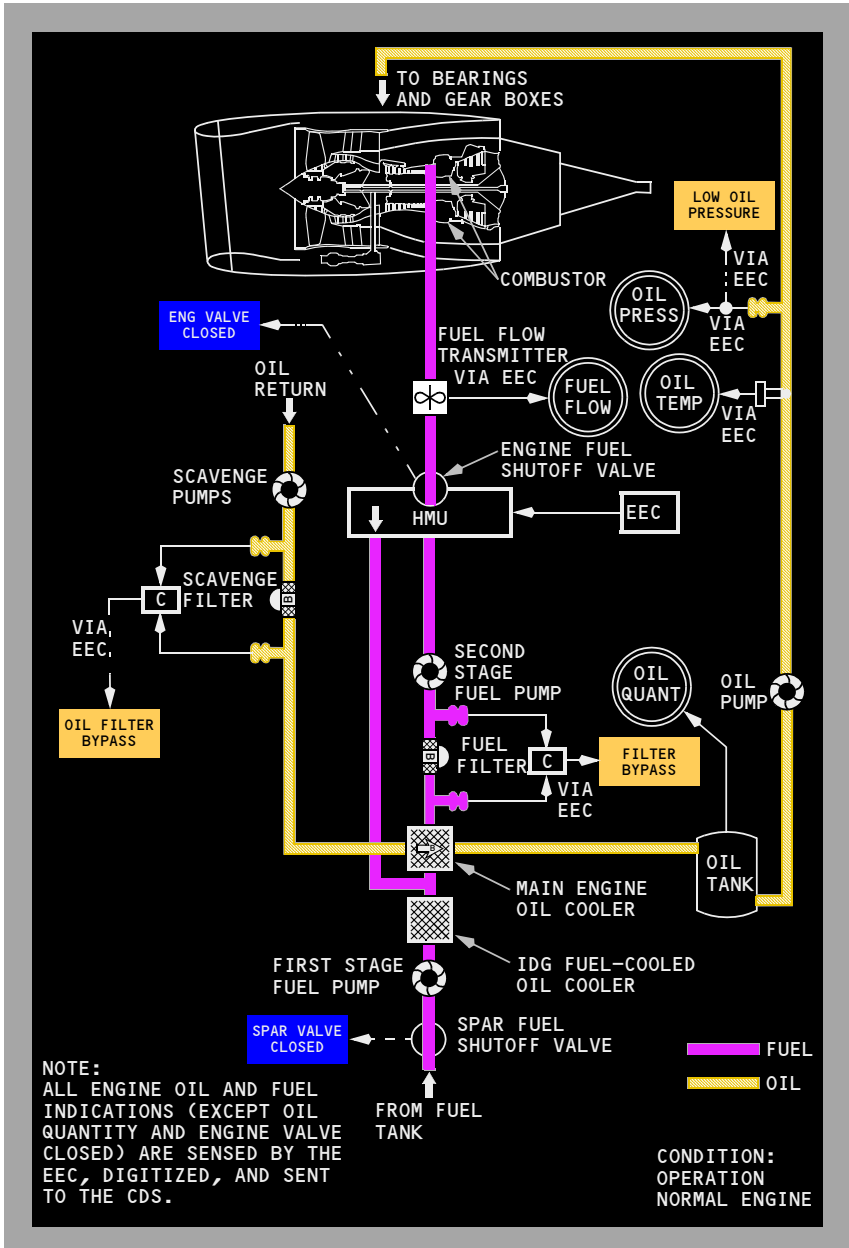
The oil system is pressurized by the engine driven oil pump. Oil from the pump, goes to the engine bearings and gearbox. Sensors for the oil temperature indicator, oil pressure indicator and LOW OIL PRESSURE alert are located downstream of the oil pump prior to engine lubrication.

Oil is returned to the oil tank by engine driven scavenge pumps. From the scavenge pumps oil passes through a scavenge filter. If the filter becomes saturated with contaminants, oil automatically bypasses the filter. Prior to the oil bypassing the scavenge filter, the OIL FILTER BYPASS alert illuminates on the upper display unit.

Prior to returning to the oil tank, the oil passes through the main engine oil cooler where it is cooled by engine fuel to maintain proper oil temperature.



## Engine Fuel and Oil System Schematic



## Engine Start System

Starter operation requires pressurized air and electrical power. Air from the bleed air system powers the starter motor. The APU, an external ground cart, or the other operating engine provides the bleed air source.

In the GRD position, the engine start switch uses battery power to close the engine bleed air valve and open the start valve to allow pressure to rotate the starter. When the start valve opens, an amber START VALVE OPEN alert is provided on the upper display unit. The starter rotates the N2 compressor through the accessory drive gear system. When the engine accelerates to the recommended value (25% N2 or max motoring), moving the engine start lever to the IDLE position opens the fuel valves on the wing spar and engine, and causes the EEC to supply fuel and ignition to the combustor where the fuel ignites. Initial fuel flow indications lag actual fuel flow by approximately two seconds, therefore, during engine start, an EGT rise may occur before fuel flow indication.

### [Option - Without automatic ignition]

At starter cutout speed (approximately 56% N2), power is removed from the start switch holding solenoid. The engine start switch returns to OFF, the engine bleed air valve returns to the selected position, and the start valve closes.

### [Option - With automatic ignition]

At starter cutout speed (approximately 56% N2), power is removed from the start switch holding solenoid. The engine start switch returns to AUTO, the engine bleed air valve returns to the selected position, and the start valve closes.

## Abnormal Start Protection (Ground Starts Only)

During ground starts, the EEC monitors engine parameters to detect impending hot starts, EGT start limit exceedances, and wet starts. These protection features do not function during inflight starts.

If an impending hot start is detected by a rapid rise in EGT or EGT approaching the start limit, the white box surrounding the EGT digital readout flashes. The flashing white box resets when the start lever is moved to CUTOFF or the engine reaches idle N2.

If the EGT exceeds the starting limit, the EGT display, both box and dial, turn red. The EEC automatically turns off the ignition and shuts off fuel to the engine. The alert terminates and the display returns to white when EGT drops below the start limit. Following shutdown of both engines, the EGT box turns red to remind the crew of the exceedance.

A wet start occurs if the EGT does not rise after the start lever is moved to IDLE. If a wet start is detected, the EEC turns off the ignition and shuts off fuel to the engine 15 seconds after the start lever is moved to IDLE.

## Engine Ignition System

Each engine has two igniter plugs. The EEC arms the igniter plug(s) selected by the ignition select switch. The left igniter plug receives power from the associated AC transfer bus. The right igniter plug receives power from the AC standby bus.

### Auto-Relight

An auto-relight capability is provided for flameout protection. Whenever the EEC detects an engine flameout, both igniters are activated. A flameout is detected when an uncommanded rapid decrease in N2 occurs, or N2 is below idle RPM.

### Inflight Starting

Two methods of starting an engine inflight are available, windmill and crossbleed. None of the ground start protection features are functional during inflight start.

**Note:** At low N2 values, the oil scavenge pump may not provide enough pressure to return oil to the tank, causing a low oil quantity indication. Normal oil quantity should be indicated after start.

#### [Option - Side by side display]

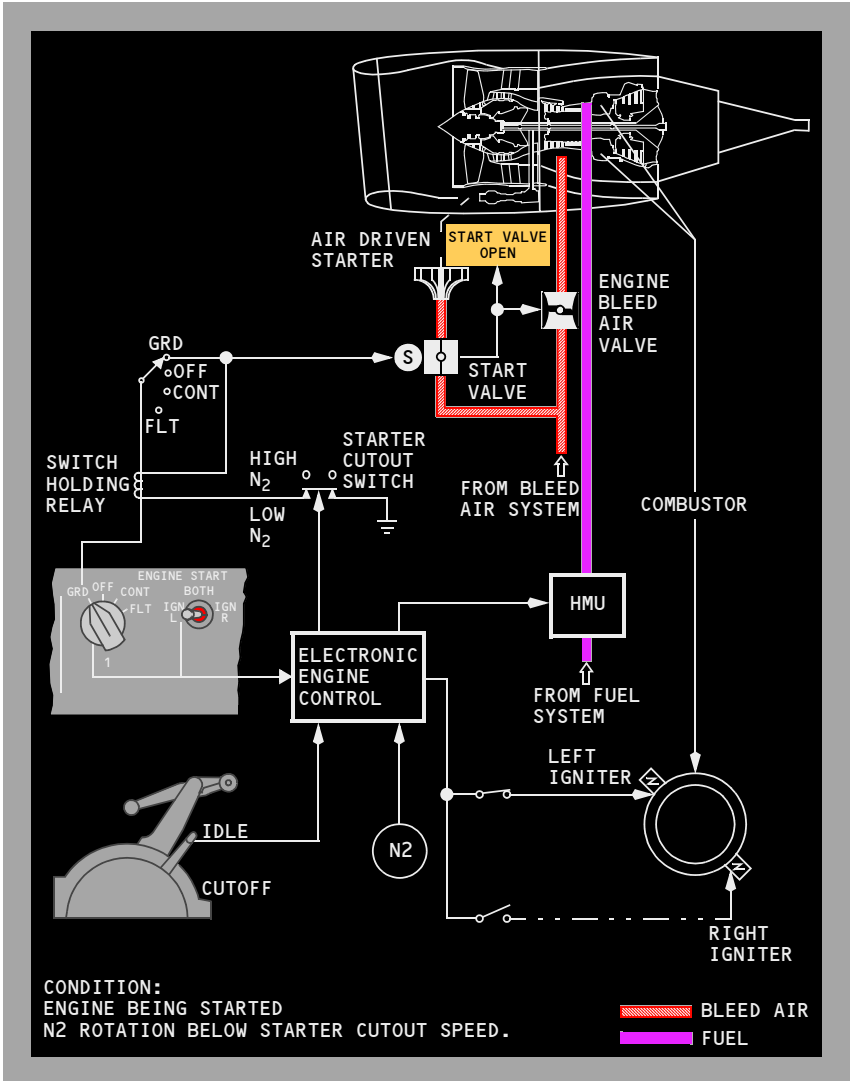
If crossbleed starting is required, the X-BLD START indication is displayed above the N2 dial. This indication is based on airplane altitude, airspeed and N2.

#### [Option - Over/Under display]

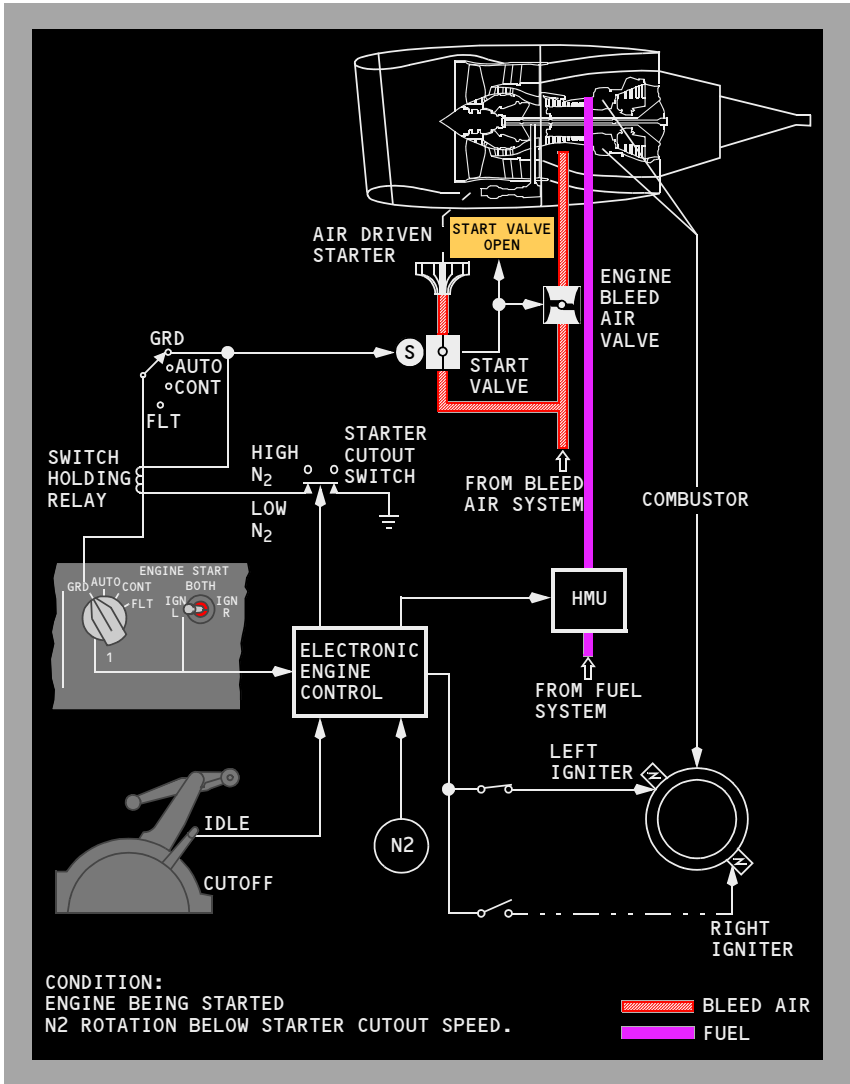
If crossbleed starting is required, the X-BLD indication (XB for the compact engine display) is displayed above the N2 dial. This indication is based on airplane altitude, airspeed and N2.

## Engine Start and Ignition System Schematic

[Option - Without automatic ignition]



[Option - With automatic ignition]



## Thrust Reverser

Each engine is equipped with a hydraulically operated thrust reverser, consisting of left and right translating sleeves. Aft movement of the reverser sleeves causes blocker doors to deflect fan discharge air forward, through fixed cascade vanes, producing reverse thrust. The thrust reverser is for ground operations only and is used after touchdown to slow the airplane, reducing stopping distance and brake wear.

Hydraulic pressure for the operation of engine No. 1 and engine No. 2 thrust reversers comes from hydraulic systems A and B, respectively. If hydraulic system A and/or B fails, alternate operation for the affected thrust reverser is available through the standby hydraulic system. When the standby system is used, the affected thrust reverser deploys and retracts at a slower rate and some thrust asymmetry can be anticipated.

The thrust reverser can be deployed when either radio altimeter senses less than 10 feet altitude, or when the air/ground safety sensor is in the ground mode. Movement of the reverse thrust levers is mechanically restricted until the forward thrust levers are in the idle position.

When reverse thrust is selected, an electro-mechanical lock releases, the isolation valve opens and the thrust reverser control valve moves to the deploy position, allowing hydraulic pressure to unlock and deploy the reverser system. An interlock mechanism restricts movement of the reverse thrust lever until the reverser sleeves have approached the deployed position. When either reverser sleeve moves from the stowed position, the amber REV indication, located on the upper display unit, illuminates. As the thrust reverser reaches the deployed position, the REV indication illuminates green and the reverse thrust lever can be raised to detent No. 2. This position provides adequate reverse thrust for normal operations. When necessary, the reverse thrust lever can be pulled beyond detent No. 2, providing maximum reverse thrust.

Downward motion of the reverse thrust lever past detent No. 1 (reverse idle thrust) initiates the command to stow the reverser. When the lever reaches the full down position, the control valve moves to the stow position allowing hydraulic pressure to stow and lock the reverser sleeves. After the thrust reverser is stowed, the isolation valve closes and the electro-mechanical lock engages.

The REVERSER light, located on the aft overhead panel, illuminates when the thrust reverser is commanded to stow and extinguishes 10 seconds later when the isolation valve closes. Any time the REVERSER light illuminates for more than approximately 12 seconds, a malfunction has occurred and the MASTER CAUTION and ENG system annunciator lights illuminate.

**Note:** A pause in movement of the reverse thrust levers past detent No. 1 toward the stow position may cause MASTER CAUTION and ENG system annunciator lights to illuminate. A pause of approximately 16 seconds engages the electro-mechanical lock and prevents the thrust reverser sleeves from further movement. Cycling the thrust reversers may clear the fault and restore normal operation.

When the reverser sleeves are in the stow position, an electro-mechanical lock and a hydraulically operated locking actuator inhibit motion to each reverser sleeve until reverser extension is selected. Additionally, an auto-restow circuit compares the actual reverser sleeve position and the commanded reverser position. In the event of incomplete stowage or uncommanded movement of the reverser sleeves toward the deployed position, the auto-restow circuit opens the isolation valve and commands the control valve to the stow position directing hydraulic pressure to stow the reverser sleeves. Once the auto-restow circuit is activated, the isolation valve remains open and the control valve is held in the stowed position until the thrust reverser is commanded to deploy or until corrective maintenance action is taken.

**WARNING: Actuation of the thrust reversers on the ground without suitable precautions is dangerous to ground personnel.**

# Thrust Reverser Schematic

