



MD-88/90 Operations Manual Volume 2

Delta Air Lines, Inc.

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Preface

Chapter P2

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Preface

Model Identification

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Section 1

General

The airplanes listed in the table below are covered in the operations manual. The table information is used to distinguish data peculiar to one or more, but not all of the airplanes. Where data applies to all airplanes listed, no reference is made to individual airplanes.

Note: The procedures and information contained in this manual also apply to aircraft acquired by Delta Air Lines subsequent to the current revision; however, this document may not address all pertinent information for these airplanes. In such instances, specific operating procedures and systems information can be found in appropriate Differences Chapter(s) and/or Flight Crew Bulletin(s) prior to their incorporation in the next scheduled revision.

Airplane number is supplied by the operator. Registry number is supplied by the national regulatory agency. Serial number is supplied by Boeing.

Airplane Number	Registry Number	Serial Number	Model
0904	N904DL	49535	MD-88
0905	N905DL	49536	MD-88
0906	N906DL	49537	MD-88
0907	N907DL	49538	MD-88
0908	N908DL	49539	MD-88
0909	N909DL	49540	MD-88
0910	N910DL	49541	MD-88
0911	N911DL	49542	MD-88
0912	N912DL	49543	MD-88
0913	N913DL	49544	MD-88
0914	N914DL	49545	MD-88
0915	N915DL	49546	MD-88
0916	N916DL	49591	MD-88
0917	N917DL	49573	MD-88

Airplane Number	Registry Number	Serial Number	Model
0918	N918DL	49583	MD-88
0919	N919DL	49584	MD-88
0920	N920DL	49644	MD-88
0921	N921DL	49645	MD-88
0922	N922DL	49646	MD-88
0923	N923DL	49705	MD-88
0924	N924DL	49711	MD-88
0925	N925DL	49712	MD-88
0926	N926DL	49713	MD-88
0927	N927DL	49714	MD-88
0928	N928DL	49715	MD-88
0929	N929DL	49716	MD-88
0930	N930DL	49717	MD-88
0931	N931DL	49718	MD-88
0932	N932DL	49719	MD-88
0933	N933DL	49720	MD-88
0934	N934DL	49721	MD-88
0935	N935DL	49722	MD-88
0936	N936DL	49723	MD-88
0937	N937DL	49810	MD-88
0938	N938DL	49811	MD-88
0939	N939DL	49812	MD-88
0940	N940DL	49813	MD-88
0941	N941DL	49814	MD-88
0942	N942DL	49815	MD-88
0943	N943DL	49816	MD-88
0944	N944DL	49817	MD-88
0945	N945DL	49818	MD-88

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Airplane Number	Registry Number	Serial Number	Model
0946	N946DL	49819	MD-88
0947	N947DL	49878	MD-88
0948	N948DL	49879	MD-88
0949	N949DL	49880	MD-88
0950	N950DL	49881	MD-88
0951	N951DL	49882	MD-88
0952	N952DL	49883	MD-88
0953	N953DL	49884	MD-88
0954	N954DL	49885	MD-88
0955	N955DL	49886	MD-88
0956	N956DL	49887	MD-88
0957	N957DL	49976	MD-88
0958	N958DL	49977	MD-88
0959	N959DL	49978	MD-88
0960	N960DL	49979	MD-88
0961	N961DL	49980	MD-88
0962	N962DL	49981	MD-88
0963	N963DL	49982	MD-88
0964	N964DL	49983	MD-88
0965	N965DL	49984	MD-88
0966	N966DL	53115	MD-88
0967	N967DL	53116	MD-88
0968	N968DL	53161	MD-88
0969	N969DL	53172	MD-88
0970	N970DL	53173	MD-88
0971	N971DL	53214	MD-88
0972	N972DL	53215	MD-88
0973	N973DL	53241	MD-88

Airplane Number	Registry Number	Serial Number	Model
0974	N974DL	53242	MD-88
0975	N975DL	53243	MD-88
0976	N976DL	53257	MD-88
0977	N977DL	53258	MD-88
0978	N978DL	53259	MD-88
0979	N979DL	53266	MD-88
0980	N980DL	53267	MD-88
0981	N981DL	53268	MD-88
0982	N982DL	53273	MD-88
0983	N983DL	53274	MD-88
0984	N984DL	53311	MD-88
0985	N985DL	53312	MD-88
0986	N986DL	53313	MD-88
0987	N987DL	53338	MD-88
0988	N988DL	53339	MD-88
0989	N989DL	53341	MD-88
0990	N990DL	53342	MD-88
0991	N991DL	53343	MD-88
0992	N992DL	53344	MD-88
0993	N993DL	53345	MD-88
0994	N994DL	53346	MD-88
0995	N995DL	53362	MD-88
0996	N996DL	53363	MD-88
0997	N997DL	53364	MD-88
0998	N998DL	53370	MD-88
0999	N999DN	53371	MD-88
9000	N900DE	53372	MD-88
9001	N901DE	53378	MD-88

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Airplane Number	Registry Number	Serial Number	Model
9002	N902DE	53379	MD-88
9003	N903DE	53380	MD-88
9004	N904DE	53409	MD-88
9005	N905DE	53410	MD-88
9006	N906DE	53415	MD-88
9007	N907DE	53416	MD-88
9008	N908DE	53417	MD-88
9009	N909DE	53418	MD-88
9010	N910DE	53419	MD-88
9011	N911DE	49967	MD-88
9012	N912DE	49997	MD-88
9013	N913DE	49956	MD-88
9014	N914DE	49957	MD-88
9015	N915DE	53420	MD-88
9016	N916DE	53421	MD-88
9017	N917DE	49958	MD-88
9018	N918DE	49959	MD-88
9019	N919DE	53422	MD-88
9020	N920DE	53423	MD-88
9201	N901DA	53381	MD-90-30
9202	N902DA	53382	MD-90-30
9203	N903DA	53383	MD-90-30
9204	N904DA	53384	MD-90-30
9205	N905DA	53385	MD-90-30
9206	N906DA	53386	MD-90-30
9207	N907DA	53387	MD-90-30
9208	N908DA	53388	MD-90-30
9209	N909DA	53389	MD-90-30

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Airplane Number	Registry Number	Serial Number	Model
9210	N910DN	53390	MD-90-30
9211	N911DA	53391	MD-90-30
9212	N912DN	53392	MD-90-30
9213	N913DN	53393	MD-90-30
9214	N914DN	53394	MD-90-30
9215	N915DN	53395	MD-90-30
9216	N916DN	53396	MD-90-30

Preface

Introduction

Chapter P2

Section 2

Purpose

The Boeing Company developed normal and non-normal procedures for the MD-88/90 aircraft. Delta Air Lines has modified some of the procedures for simplification and standardization, when appropriate with other Delta aircraft. Finally, the FAA has approved the procedures presented in the Operations Manual, with the exception of flight crew bulletins.

These procedures are company policy for pilots to follow during ground operations and in flight. Deviations from these policies and procedures should be made only with good cause and based on the safest course of action. If an abnormality occurs that is not covered by these procedures, the Captain must use his best judgement.

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Corrections to the Manual

To correct any errors or discrepancies discovered in this manual, or to submit a suggested change to any Aircraft Operating Manual (Volume 1, Volume 2, QRH, Flight Crew Training Manual), Normal Checklist, Airway Manual, Flight Operations Manual (FOM), OE/TOE Guide, Flight Crew Bulletin (FCB), or Flight Operations Bulletin (FOB):

Log on to the Delta Flight Operations Portal; <http://dlnet.delta.com/portal> and submit a Publications Change Request (PCR).

There are links to the PCR form on each fleet page and also on the Flight Ops Manuals/Library Services page.

Once submitted, the PCR is automatically routed to the applicable Fleet Technical Manager and Technical Writer for that manual.

Organization

The operations manual is organized in the following manner.

Volume 1

- Preface – contains general information regarding the manual's purpose, structure, and content. It also contains lists of abbreviations, a record of revisions, a list of effective pages, and bulletins.
- Limitations and Normal Procedures chapters cover operational limitations and normal procedures. All operating procedures are based on a thorough analysis of crew activity required to operate the airplane, and reflect the latest knowledge and experience available.
- Supplementary Procedures chapter covers those procedures accomplished as required rather than routinely on each flight.
- Aircraft Differences chapter notes differences between aircraft types.

Volume 2 - Chapters 1 through 15 contain general airplane and systems information. These chapters are generally subdivided into sections covering controls and indicators and systems descriptions.

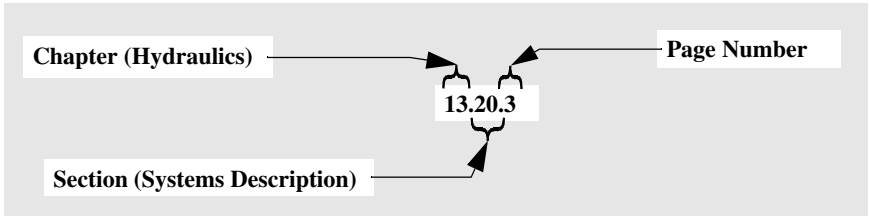
Quick Reference Handbook (QRH) - The QRH covers normal checklists, non-normal checklists, and non-normal maneuvers.

Flight Crew Training Manual (FCTM) - The Flight Crew Training Manual provides information and recommendations on maneuvers and techniques.

Page Numbering

The operations manual uses a decimal page numbering system. The page number is divided into three fields; chapter, section, and page. An example of a page number for the hydraulics chapter follows: chapter 13, section 20, page 3.

Example Page Number



Warnings, Cautions, and Notes

The following levels of written advisories are used throughout the manual.

WARNING: An operating procedure, technique, etc., that may result in personal injury or loss of life if not carefully followed.

CAUTION: An operating procedure, technique, etc., that may result in damage to equipment if not carefully followed.

Note: An operating procedure, technique, etc., considered essential to emphasize. Information contained in notes may also be safety related.

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Abbreviations

Chapter P2

Section 3

General

The following abbreviations may be found throughout the manual. Some abbreviations may also appear in lowercase letters. Abbreviations having very limited use are explained in the chapter where they are used. Since this list is compiled across several fleets, there may be some abbreviations that do not apply to this specific fleet.

A	
ABV	Above
AC	Alternating Current or Aircraft
ACARS	Aircraft Communications Addressing and Reporting System
ACE	Actuator Control Electronics
ACP	Audio Control Panel
ACT	Active
ADC	Air Data Computer
ADF	Automatic Direction Finder
ADI	Attitude Director Indicator
ADIRS	Air Data Inertial Reference System
ADIRU	Air Data Inertial Reference Unit
ADM	Air Data Module
AED	Automatic External Defibrillator
AFDC	Autopilot Flight Director Computer

AFDS	Autopilot Flight Director System
AFE	Above Field Elevation
AFM	Airplane Flight Manual (FAA approved)
AFM - DPI	Airplane Flight Manual - Digital Performance Information
AFS	Automatic Flight System (Autopilot or Autothrottle)
A/G	Air/Ground
AGL	Above Ground Level
AH	Alert Height
AHRS	Attitude Heading Reference System
AI	Anti-Ice
AIL	Aileron
ALFA	Safe Stall Margin Speed
ALT	Altitude
ALT ACQ	Altitude Acquire
ALT HOLD	Altitude Hold
ALTN	Alternate
AM	Amplitude Modulation

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AIMS	Airplane Information Management System
AMI	Airline Modifiable Information
ANP	Actual Navigational Performance
ANT	Antenna
ANU	Aircraft Nose Up
AOA	Angle of Attack
AOC	Airline Operational Communication Data Link
A/P	Autopilot
APL	Airplane
APP	Approach
APU	Auxiliary Power Unit
AR	Authorization Required
ARINC	Aeronautical Radio, Incorporated
ARM	Aircraft Restrictions Manual
ARPT	Airport
ARR	Arrival
ART	Automatic Reserve Thrust
ASA	Autoland Status Annunciator
ASI	Airspeed Indicator
ASR	Airport Surveillance Radar
ASYM	Asymmetry
A/T	Autothrottle
ATA	Actual Time of Arrival

ATC	Air Traffic Control
ATIS	Automated Terminal Information Service
ATM	Assumed Temperature Method
ATT	Attitude
AUTO	Automatic
AUTO–THROT	Autothrottle
AUX	Auxiliary
AVAIL	Available
AWABS	Automated Weight and Balance System
B	
BARO	Barometric
BAT	Battery
B/C or B/CRS or BAC or BCS	Back Course
BFO	Beat Frequency Oscillator
BITE	Built-In Test Equipment
BKR	Breaker
BLD	Bleed
BLW	Below
BRG	Bearing
BRT	Bright
BTL	Bottle
BTL DISCH	Bottle Discharge (fire extinguisher)
BTMS	Brake Temperature Monitoring System



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C	
C	Captain or Celsius or Center or Cool
CAA	Civil Aviation Authority
CADC	Central Air Data Computer
CALSEL	Call Select
CANC/RCL	Cancel/Recall
CANPA	Constant Angle Non-Precision Approach
CAP	Capture
CAPT	Captain
CAWS	Central Aural Warning System
CB	Circuit Breaker
CCD	Cursor Control Device
CDS	Common Display System
CDU	Control Display Unit
CFIT	Controlled Flight Into Terrain
CG	Center of Gravity
CHKL	Checklist
CHR	Chronograph
CKD	Checked
CKT	Circuit
CL	Close
CLB	Climb
CLMP	Computer Lockout Manual Power
CLR	Clear

CMD	Command
CO	Company
COMM	Communication
COMP	Comparator
COMPT	Compartment
CON	Continuous
CONFIG	Configuration
CONT	Control
COOL	Cooling
CRM	Crew Resource Management
CRS	Course
CRT	Cathode Ray Tube
CRZ	Cruise
CTL	Control
CTR	Center
CWS	Control Wheel Steering
D	
DA	Decision Altitude
DA(H)	Decision Altitude (Height)
DC	Direct Current
DCU	Display Concentrator Unit
D/D	Direct Descent
DDA	Derived Decision Altitude (MDA +50 feet)
DDG	Dispatch Deviations Guide
DEL	Delete
DEP	Departure
DEP ARR	Departure Arrival

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DEPR	Depressurize
DES	Descent
DEU	Display Electronic Unit
DFCS	Digital Flight Control System
DFGC	Digital Flight Guidance Computer
DFGS	Digital Flight Guidance System
DH	Decision Height
DIFF	Differential
DIR	Direct
DISC	Disconnect
DISCH	Discharge
DK	Deck
DME	Distance Measuring Equipment
DN	Down
DPC	Display Processing Computer
DSP	Display Select Panel
DSPL	Display
DTG	Distance to Go
DTW	Distance to Waypoint
DU	Display Unit
E	
EADI	Electronic Attitude Director Indicator
ECON	Economy
E/D	End of Descent
E/E	Electrical/Electronic

EEC	Electronic Engine Control
EFI	Electronic Flight Instruments
EFIS	Electronic Flight Instrument System
EGPWS	Enhanced Ground Proximity Warning System
EGT	Exhaust Gas Temperature
EHSI	Electronic Horizontal Situation Indicator
EICAS	Engine Indication and Crew Alerting System
EIS	Electronic Instrument System
ELEC	Electrical
ELEV	Elevator
EMER	Emergency
ENG	Engine
ENG OUT	Engine Out
ENT	Entry
EO or E/O	Engine Out
EOAP	Electronic Overhead Annunciation Panel
EPR	Engine Pressure Ratio
EQPT or EQUIP	Equipment
ETOPS	Extended Range Operation with Twin Engine Airplanes
EVAC	Evacuation
EXEC	Execute
EXT	Extend or External



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F	
F	Fahrenheit
FAC	Final Approach Course
FAA	Federal Aviation Administration
FADEC	Full Authority Digital Engine Control
FAF	Final Approach Fix
FAR	Federal Aviation Regulation
FCB	Flight Crew Bulletin
FCC	Flight Control Computer
FCTL	Flight Control
FCTM	Flight Crew Training Manual
FD, F/D or FLT DIR	Flight Director
FF	Fuel Flow
FFM	Force Fight Monitor
FGCP	Flight Guidance Control Panel
FGS	Flight Guidance System
FILT	Filter
FIR	Flight Information Region
FL CH or FLCH	Flight Level Change
FLT	Flight
FLT CTRL	Flight Control
FLPRN	Flaperon
FMA	Flight Mode Annunciator
FMC	Flight Management Computer

FMS	Flight Management System
F/O or F O	First Officer
FOM	Flight Operations Manual
FPA	Flight Path Angle
FPM	Feet Per Minute
FPV	Flight Path Vector
FREQ	Frequency
F/S	Fast/Slow
FT	Feet
FWD	Forward
FWSOV	Fire Wall Shut Off Valve
FX	Fix
G	
GA	Go-Around
GEN	Generator
GLS	GNSS Landing System
GMT	Greenwich Mean Time
GND	Ground
GNSS	Global Navigation Satellite System
GP or G/P	Glide Path
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GS	Ground Speed
G/S	Glide Slope
GW	Gross Weight
H	
HAA	Height Above Airport

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HAT	Height Above Touchdown
HDG	Heading or Hydraulic Driven Generator
HDG REF	Heading Reference
HDG SEL	Heading Select
HF	High Frequency
HGS	Head-Up Guidance System (HGS® is a registered trademark of Flight Dynamics)
HI	High
HLD	Hold
HPA	Hectopascals
HPSOV	High Pressure Shut Off Valve
HSI	Horizontal Situation Indicator
HUD	Head-Up Display
HYD	Hydraulic
I	
IAF	Initial Approach Fix
IAN	Integrated Approach Navigation
IAS	Indicated Airspeed
ICAO	International Civil Aviation Organization
IDENT	Identification
IFE	In-Flight Entertainment System
IFR	Instrument Flight Rules
IGN	Ignition

IGS	Instrument Guidance System
ILS	Instrument Landing System
IM	Inner Marker
IMC	Instrument Meteorological Conditions
IN	Inches
INBD	Inboard
IND	Indicator
IND LTS	Indicator Lights
INOP	Inoperative
INIT	Initialization
INSTR	Instrument
INT or INTPH	Interphone
INTC	Intercept
INTC CRS	Intercept Course
IP	Instructor Pilot
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International Standard Atmosphere
ISDU	Inertial System Display Unit
ISFD	Integrated Standby Flight Display
ISLN	Isolation
J	
JAA	Joint Aviation Authority
K	



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K or KTS	Knots
KCAS	Knots Calibrated Airspeed
KGS	Kilograms
KIAS	Knots Indicated Airspeed
L	
L	Left
LAT	Latitude
LBS	Pounds
LD	Load
LDA	Localizer-type Directional Aid
LDG	Landing
LDG ALT	Landing Altitude
LE	Leading Edge
LIM	Limit
LIM SPD	Limit Speed
LKD	Locked
L NAV or LNAV	Lateral Navigation
LOC	Localizer
LOC-BC	Localizer Back Course
LOM	Locator Outer Marker
LON	Longitude
LRC	Long Range Cruise
LRU	Line Replaceable Unit
LSK	Line Select Key
LT	Light
LWR CTR	Lower Center
LWR DSPLY or LWR DSPL	Lower Display

M	
M	Mach
MAG	Magnetic
MAHP	Missed Approach Holding Point
MAN	Manual
MAP	Missed Approach Point
MASI	Mach/Airspeed Indicator
MAX	Maximum
MCC	Maintenance Control Center
MCDU	Multi-purpose Control and Display Unit
MCO	Maintenance Carry Over
MCP	Mode Control Panel
MCT	Maximum Continuous Thrust
MDA	Minimum Descent Altitude
MDA(H)	Minimum Descent Altitude (Height)
MDM	Mechanical Dispatch Manual
MEA	Minimum Enroute Altitude
MEL	Minimum Equipment List
MFD	Multifunction Display
MHZ	Megahertz
MIC	Microphone
MIN	Minimum
MKR	Marker

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MLS	Microwave Landing System
MM	Middle Marker
MMO	Maximum Mach Operating Speed
MNPS	Minimum Navigation Performance Specification
MOCA	Minimum Obstruction Clearance Altitude
MOD	Modify
MORA	Minimum Off Route Altitude
MSA	Minimum Safe Altitude
MSG	Message
MSGS RCVD	Messages Received
MSL	Mean Sea Level
MTRS	Meters
MUH	Minimum Use Height
N	
N	Normal
NADP	Noise Abatement Departure Procedures
NAR	North American Route
NAV	Navigation
NAV RAD	Navigation Radio
ND	Navigation Display
NLT	No Later Than
NM	Nautical Mile(s)
NNC	Non-Normal Checklists
NNM	Non-Normal Maneuvers

NPS	Navigation Performance Scales
NORM	Normal
N1	Low Pressure Rotor Speed
N2	High Pressure Rotor Speed (Pratt & Whitney and GE engines) or Intermediate Pressure Rotor Speed (Rolls Royce Engines)
N3	High Pressure Rotor Speed (Rolls Royce Engines)
O	
OAP	Overhead Annunciator Panel (a.k.a. EOAP)
OAT	Outside Air Temperature
OCC	Operations Control Center
ODM	Operational Data Manual
OFST	Offset
OHU	Overhead Unit
OM	Outer Marker
OP	Open
OUTBD DSPL	Outboard Display
OVHD	Overhead
OVHT	Overheat
OVRD	Override
OVSPD	Overspeed
OXY or O2	Oxygen
P	



MD-88/90 Operations Manual

PA	Passenger Address
PAPI	Precision Approach Path Indicator
PAR	Precision Approach Radar
PASS	Passenger
PBE	Protective Breathing Equipment
PCP	Pilot Call Panel
PDC	Pitch Data Computer or Performance Data Computer or Pre-Departure Clearance
PERF	Performance
PERF INIT	Performance Initialization
PES	Pitch Enhancement System
PF	Pilot Flying
PFC	Primary Flight Computer
PFD	Primary Flight Display
PI	Performance Inflight
PIP	Product Improvement Package
PLI	Pitch Limit Indicator
PM	Pilot Monitoring
PMC	Power Management Control
PNL	Panel
POS	Position
POS INIT	Position Initialization
POS REF	Position Reference

PPI	Planned Position Indicator
PPOS	Present Position
PRES or PRESS	Pressure
PREV	Previous
PRI	Primary
PROG	Progress
PROX	Proximity
P/RST	Push To Reset
PRV	Pressure Regulating Valve
PSI	Pounds Per Square Inch
PTH	Path
PTT	Push To Talk
PTU	Power Transfer Unit
PWR	Power
PWS	Predictive Windshear System
Q	
Q	Quantity
QFE	Local Station Pressure
QNH	Altimeter Setting
QRH	Quick Reference Handbook
QTY	Quantity
R	
R	Right
RA	Radio Altitude or Resolution Advisory
RAD	Radio

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RAT	Ram Air Temperature or Ram Air Turbine
RCL	Request for Clearance
RDMI	Radio Distance Magnetic Indicator
REC	Recorder
RECIR or RECIRC	Recirculation
REF	Reference
RET	Retract
REV	Reverse
RF	Radius-to-Fix (RF) Legs or Refill
RMI	Radio Magnetic Indicator
RNAV or RNV	Area Navigation
RNP	Required Navigational Performance
RPL	Rudder Pressure Limiter
RPM	Revolutions Per Minute
RPR	Rudder Pressure Reducer
RSEP	Rudder System Enhancement Program
RST	Reset
RSVR	Reservoir
R/T	Radio Transmit
RTE	Route
RTO	Rejected Takeoff
RTP	Radio Tuning Panel
RUD	Rudder
RVR	Runway Visual Range

RVSM	Reduced Vertical Separation Minimum
S	
SAAAR	Special Aircraft and Aircrew Authorization Required
SAARU	Secondary Attitude Air Data Reference Unit
SAT	Static Air Temperature or Satellite
SB	Service Bulletin
S/B	Speedbrake
S/C	Step Climb
SDF	Simplified Directional Facility
SEI	Standby Engine Indicator
SEL	Select
SELCAL	Selective Calling
SENS	Sensitivity
SERV	Service
SG	Symbol Generator
SPD	Speed
SPDBRK	Speedbrake
STA	Station
STAB	Stabilizer
STAT	Status
STBY	Standby
STD	Standard
SYS	System
T	
T or TRU	True



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T or TK or TRK	Track (to a Navaid)
TA	Traffic Advisory
TAA	Terminal Arrival Area
TACAN	Tactical Air Navigation
TAC	Thrust Asymmetry Compensation
TAI	Thermal Anti-Ice
TAS	True Airspeed
TAT	Total Air Temperature
T/C	Top of Climb
TCA	Terminal Control Area
TCAS	Traffic Alert and Collision Avoidance System
T/D	Top of Descent
TDZ	Touch Down Zone
TDZE	Touch Down Zone Elevation
TE	Trailing Edge
TEMP	Temperature
TERR	Terrain
TFC	Traffic
TFR	Transfer
THR	Throttle or Thrust
THR HOLD	Throttle Hold
TMC	Thrust Management Computer
TMI	Track Message Identifier
TMSP	Thrust Mode Select Panel
TO or T/O	Takeoff

TOC	Top of Climb
TOD	Top of Descent
TO/GA	Takeoff/Go-Around
TR	Traffic Resolution
TRK	Track
TRP	Thrust Rating Panel
TRU	Transformer Rectifier Unit
TURB	Turbine or Turbulence
U	
UNLKD	Unlocked
UNSCHD or UNSCHED	Unscheduled
UPR DSPL	Upper Display
U.S.	United States
USB	Upper Side Band
UTC	Universal Time Coordinated
UTIL	Utility
V	
VA	Design maneuvering speed
VAL	Valve
VANP	Vertical Actual Navigational Performance
VASI	Visual Approach Slope Indicator
VDP	Visual Descent Point
VEF	Speed at Engine Failure
VERT	Vertical

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VFR	Visual Flight Rules
VG	Vertical Gyro
VHF	Very High Frequency
VIB	Vibration
VLV	Valve
VMC	Visual Meteorological Conditions
VMCA	Minimum Control Speed Air or Single Engine Minimum Control Airspeed
VMCG	Minimum Control Speed Ground
VMO	Maximum Operating Speed
V NAV or VNAV	Vertical Navigation
VOR	VHF Omnidirectional Range
VR	Rotation Speed
VREF	Reference Speed
VRNP	Vertical Required Navigation Performance
V/S	Vertical Speed
VSCF	Variable Speed Constant Frequency
VSD	Vertical Situation Display
VSI	Vertical Speed Indicator
VTK	Vertical Track
V1	Takeoff Decision Speed
V1 (MCG)	Minimum V1 for Control on the Ground
V2	Scheduled Takeoff Target Speed

W	
W	Warm
WATRS	Western Atlantic Route System
WDR	Weight Data Record
WGS-84	World Geodetic System of 1984
WHL	Wheel
WPT	Waypoint
WT	Weight
WXR	Weather Radar
X	
X-FEED	Crossfeed
XPDR or XPNDR	Transponder
XTK	Cross Track

Preface

Revision Record

Chapter P2

Section 4

Revision Transmittal Letter

To: All holders of Delta Air Lines, Inc. MD-88/90 Operations Manual, Volume 2.

Subject: Operations Manual Revision.

This revision reflects the most current information available to Delta Air Lines, Inc. through the subject revision date. The following Revision Highlights explain changes in this revision. General information below explains the use of revision bars to identify new or revised information.

Revision Record

No.	Revision Date	Date Filed
0	April 01, 2004	
2	August 11, 2008	

No.	Revision Date	Date Filed
1	February 28, 2005	

General

Delta Air Lines, Inc. issues operations manual revisions to provide new or revised procedures and information. Formal revisions also incorporate appropriate information from previously issued operations manual bulletins.

The revision date is the approximate date the revision material is distributed and considered current. The revision should be incorporated as soon as it is received, but may be incorporated as much as 21 days after the revision date.

Formal revisions include a Transmittal Letter, a new Revision Record, Revision Highlights, and a current List of Effective Pages. Use the information on the new Revision Record and List of Effective Pages to verify the operations manual content.

The Revision Record should be completed by the person incorporating the revision into the manual.

Filing Instructions

Consult the List of Effective Pages (P2.5). Pages identified with an asterisk (*) are either replacement pages, new (original) issue pages, or deleted pages. Remove corresponding old pages and replace or add new pages. Remove pages marked DELETED; there are no replacement pages for deleted pages.

Be careful when inserting changes not to throw away pages from the manual that are not replaced. The List of Effective Pages determines the correct content of the manual.

Revision Highlights

This section (P2.4) replaces the existing section P2.4 in your manual.

Pages containing revised technical and non-technical material have revision bars associated with the changed text or illustration.

Repaginated material not containing technical revisions are identified only by a new page date.

Note: This revision of the MD-88/90 Volume 2 has new formatting and fonts which have been adopted for use. This will bring the MD-88/90 Volume 2 into standardization with the rest of Delta's fleets Volume 2s. These changes affect the appearance of the information, but not the technical information, and will not be identified by revision bars.

Note: In this revision, for cross-fleet standardization purposes, "cockpit" is now "flight deck." The only exception to this rule is where a switch or selector is labeled using the term cockpit; e.g. "Cockpit Voice Recorder". No revision bars are used to denote these changes.

Title Page

Revised to reflect latest revision information.

Chapter P2 - Preface

Section 2 Introduction

Manual Rights

P2.2.1 - Changed Operating to Operations.

Corrections to the Manual

P2.2.2 - Revised procedure for submitting changes to the manual.

Section 3 Abbreviations

Abbreviations

P2.3.1-12 - Updated abbreviations table to cross-fleet standard.

Section 4 Revision Record

Revision Highlights

P2.4.1-8 - Revised to reflect changes for Revision 2.

Section 5 List of Effective Pages

List of Effective Pages

P2.5.1-4 - Revised to reflect changes for Revision 2.

Chapter 1- Aircraft General, Emergency Equipment, Doors, Windows

Section 0 Table of Contents

Table of Contents

1.TOC.0.1-4 - Revised to reflect content changes.

Section 20 Instrument Panels

Forward Overhead Panel

1.20.1 - Changed the Blue Advisory Lights from "AHRS 1/2 BASIC MODE" to "IRS 1/2 ATT MODE."

Aft Overhead Panel

1.20.2 - Revised location and text of multiple circuit breakers.

Section 30 Controls and Indicators

Emergency Lighting Controls

1.30.8 - Under Emergency Lights Switch (FWD Cabin), revised description of the ARM position, per the Aircraft Maintenance Manual.

Doors

1.30.11 - Under Flight Deck Door, Door Louvers, revised description to close the louvers by raising the sliding panel.

Section 40 Systems Description

1.40.1-22 - Entire section reissued with new formatting and fonts.

Emergency Locator Transmitter (ELT)

1.40.17-18 - New section created. Incorporated FCB 08-01, New Portable ELT Installation.

Emergency and Cabin Equipment Symbols

1.40.19 - Revised symbols for cross-fleet standardization.

Emergency and Cabin Equipment Locations

1.40.20-21 - Revised to distinguish between one and two class configurations. Added overwater configuration to the two class configuration.

Section 90 MD-90 Differences

1.90.1-12 - Entire section reissued with new formatting and fonts.

Systems Description

1.90.11 - Removed emergency equipment symbols table. Revised to update MD-90 Emergency and Cabin Equipment Locations.

Chapter 4 - Automatic Flight

Section 0 Table of Contents

Table of Contents

4.TOC.0.1-2 - Revised to reflect content changes.

Section 20 System Description

4.20.1-18 - Entire section reissued with new formatting and fonts.

Digital Flight Guidance Computer

4.20.1 - Removed AHRS reference.

Speed Control

4.20.14 - Added exception for Takeoff/Go-Around Mode. Added "Autothrottles Engaged" to Gust Integration.

Stability Augmentation

4.20.17 - Under Yaw Damper and Parallel Rudder, revised text for Boeing standardization.

Chapter 5 - Communications

Section 0 Table of Contents

Table of Contents

5.TOC.0.1-4 - Revised to reflect content changes.

Section 22 ACARS 201

5.22.1-36 - Remove entire section as it has been deleted. All aircraft have been retrofitted with ACARS 501.

Chapter 6 - Electrical

Section 50 Circuit Breaker Locations

Circuit Breaker Locations

6.50.2 - Removed AHRS circuit breakers.

6.50.18 - Revised locations of Service Interphone circuit breaker on the MD-88.

Circuit Breaker Location by Panel

6.50.23 - Revised locations of Battery Bus circuit breakers on the MD-88.

Chapter 7 - Engines, APU

Section 0 Table of Contents

Table of Contents

7.TOC.0.1-4 - Revised to reflect content changes.

Section 11 Engine Controls and Indicators (JT8D-219)

Engine Display Panel

7.11.7 - Updated descriptions of panel for Boeing standardization.

Section 21 Engine System Description

7.21.1-6 - Entire section reissued with new formatting and fonts.

Engine Instruments

7.21.1 - Revised note to state that flashing EGT and fuel flow digits may indicate a possible hot start.

Thrust Rating Panel

7.21.4 - Removed methods for setting takeoff power, as they are stated in Vol. 1, NP.20.

Section 90 MD-90 Differences

Controls and Indications - Engine Display Panel

7.90.7-8 - Updated descriptions of panel for Boeing standardization.

Chapter 10 - Flight Instruments, Displays

Section 0 Table of Contents

Table of Contents

10.TOC.0.1-4 - Revised to reflect content changes.

Section 10 Controls and Indicators

Navigation Display (ND) ROSE Mode

10.10.15 - Added definition of dots for course deviation bar.

Navigation Display (ND) ARC Mode

10.10.18 - Added definition of dots for course deviation bar.

Navigation Display (ND) MAP Mode

10.10.22 - Removed AHRS reference.

Section 20 System Description

10.20.1-6 - Entire section reissued with new formatting and fonts.

Electronic Flight Instrument System

10.20.2 - Removed AHRS references.

Attitude Heading Reference System

10.20.5 - Removed AHRS section.

Section 30 OAP Messages/Lights

Blue Advisory Lights

10.30.1 - Removed AHRS references.

Chapter 11 - Flight Management, Navigation

Section 0 Table of Contents

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11.TOC.0.1-4 - Revised to reflect content changes.

Section 11 Controls and Indicators

Navigation Display (ND) ROSE Mode

11.10.7-8 - Remove pages from manual. Removed AHRS section.

Section 20 System Description

11.20.1-10 - Entire section reissued with new formatting and fonts.

General

11.20.1 - Removed AHRS reference.

Attitude Heading Reference System

11.20.1 - Removed AHRS section.

Radio Distance Magnetic Indicators

11.20.3 - Removed AHRS references.

Weather Radar System

11.20.4 - Removed AHRS reference.

Navigation Display (ND) Symbolology

11.20.7 - Under Wind Speed and Direction, removed AHRS reference.

Section 21 Flight Management System Description

11.21.1-74 - Entire section reissued with new formatting and fonts.

FMS Components

11.21.1 - Removed AHRS reference.

FMS Flight Guidance Modes

11.21.3 - Under NAV Mode and Loss of Radio Position, removed AHRS references.

11.21.4 - Under NAV Engagement, removed AHRS reference.

11.21.8 - Under VNAV Mode, FMS Speed Override, clarified FMS OVRD mode.

Menu Page

11.21.10 - Removed AHRS reference.

Position Reference - IRS Aircraft

11.21.15 - Removed AHRS references.

Cruise

11.21.64 - Removed AHRS references.

Section 30 OAP Messages/Lights

Blue Advisory Lights

11.30.1 - Removed AHRS reference.

Chapter 12 - Fuel

Section 0 Table of Contents

Table of Contents

12.TOC.0.1-2 - Revised to reflect content changes.

Section 10 Controls and Indicators

12.10.1-6 - Entire section reissued with new formatting and fonts.

Fuel Quantity

12.10.2-3 - Updated descriptions of panel for Boeing standardization..

Section 20 System Description

12.20.1-4 - Entire section reissued with new formatting and fonts.

Fuel Feed

12.20.2 - Updated descriptions L/R INLET FUEL PRESS LOW message for Boeing standardization.

Alternate Fuel Burn (AFB) System

12.20.2 - Added information for aircraft modified to change the Low Fuel Warning from 2,500 to 2,000 pounds.

Chapter 14 - Landing Gear

Section 0 Table of Contents

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14.TOC.0.1-2 - Revised to reflect content changes.

Section 10 Controls and Indicators

Anti-Skid Controls and Brake Temperature Indication

14.10.8 - Revised diagram to more accurately show the location of the test band on the First Officer's instrument panel.

Section 20 System Description

14.20.1-6 - Entire section reissued with new formatting and fonts.

Visual/Aural Indicating and Warning System

14.20.4 - Added note under periscope diagram to clarify location of the periscope.

Chapter 15 - Warning Systems

Section 20 System Description

TCAS Data Tags

15.20.26 - Revised description of Traffic Advisory from "Solid Yellow" to "Solid Amber".

TCAS Components

15.20.28 - Removed AHRS reference.

Predictive Windshear System

15.20.50 - Under General, added guidance that right throttle must be advanced for the weather radar to begin automatically scanning.

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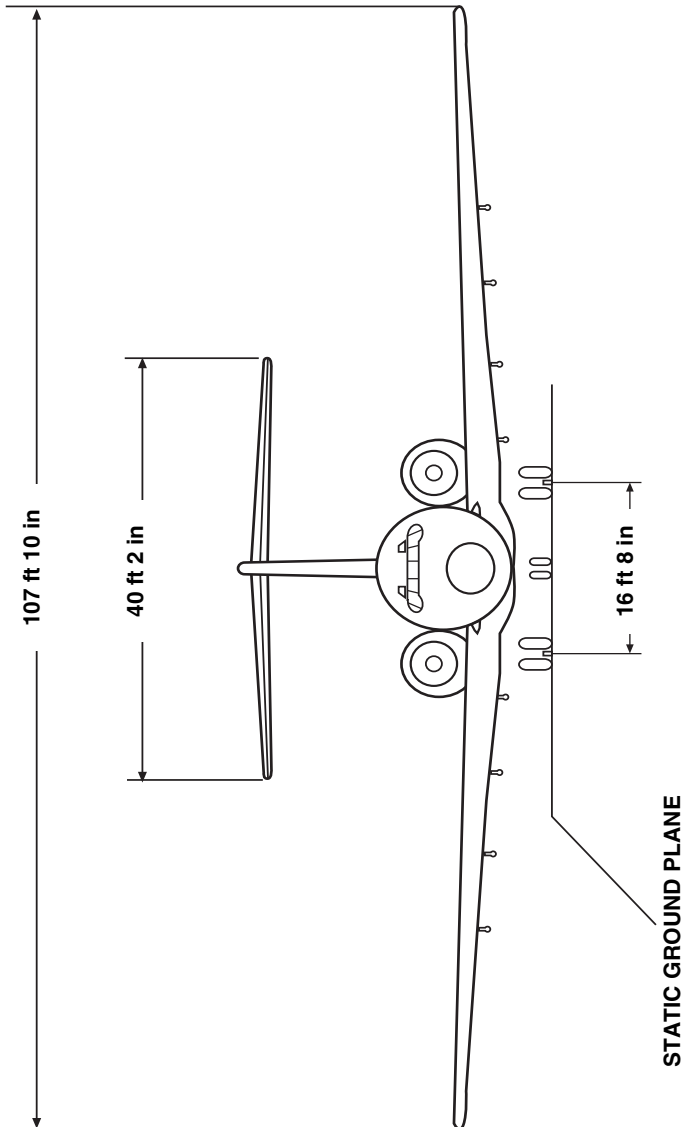
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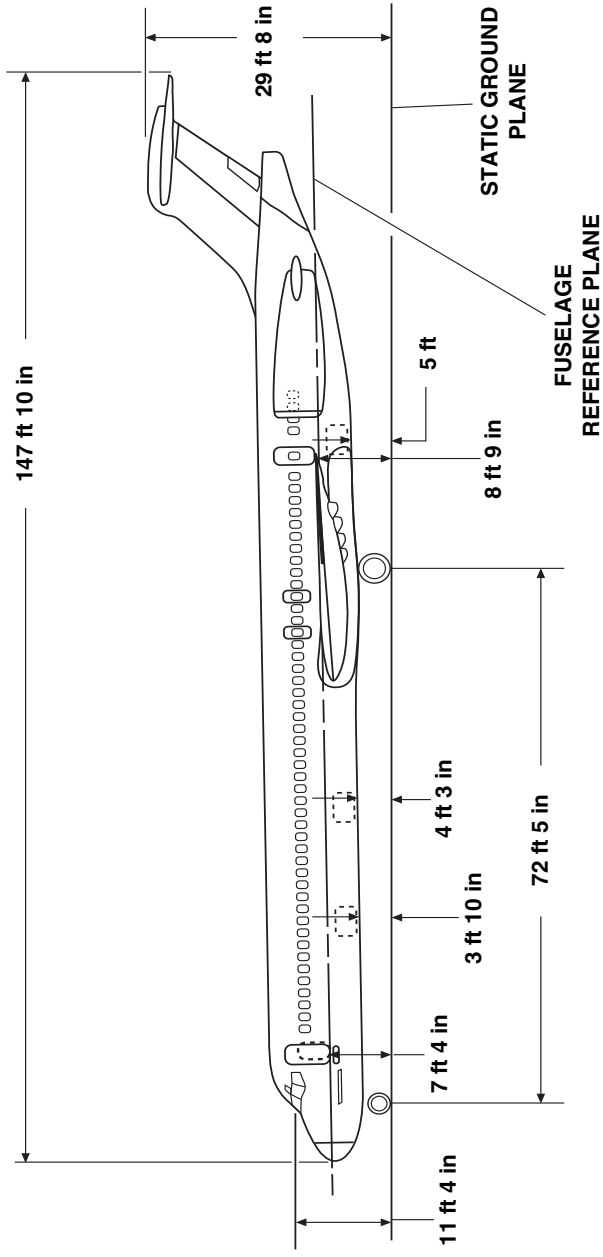
**Airplane General, Emergency
Equipment, Doors, Windows
Principle Dimensions**

Chapter 1

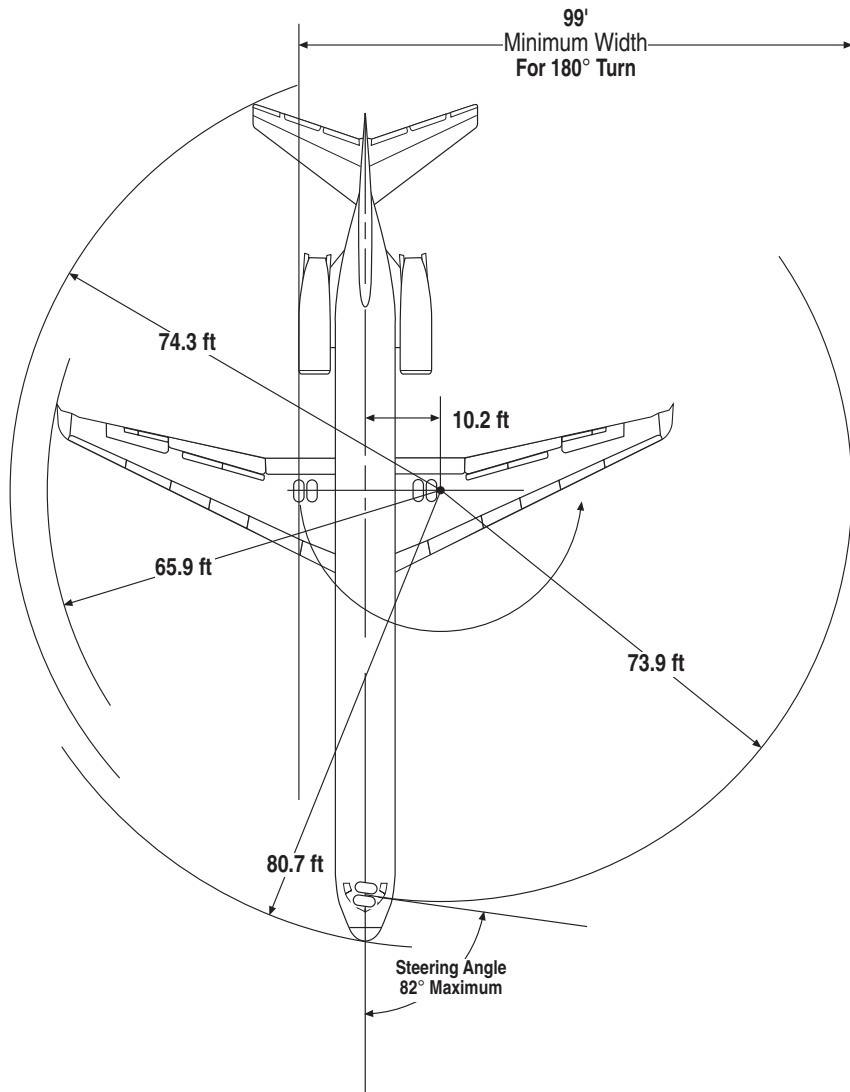
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Principle Dimensions





MD-88 Turning Radius



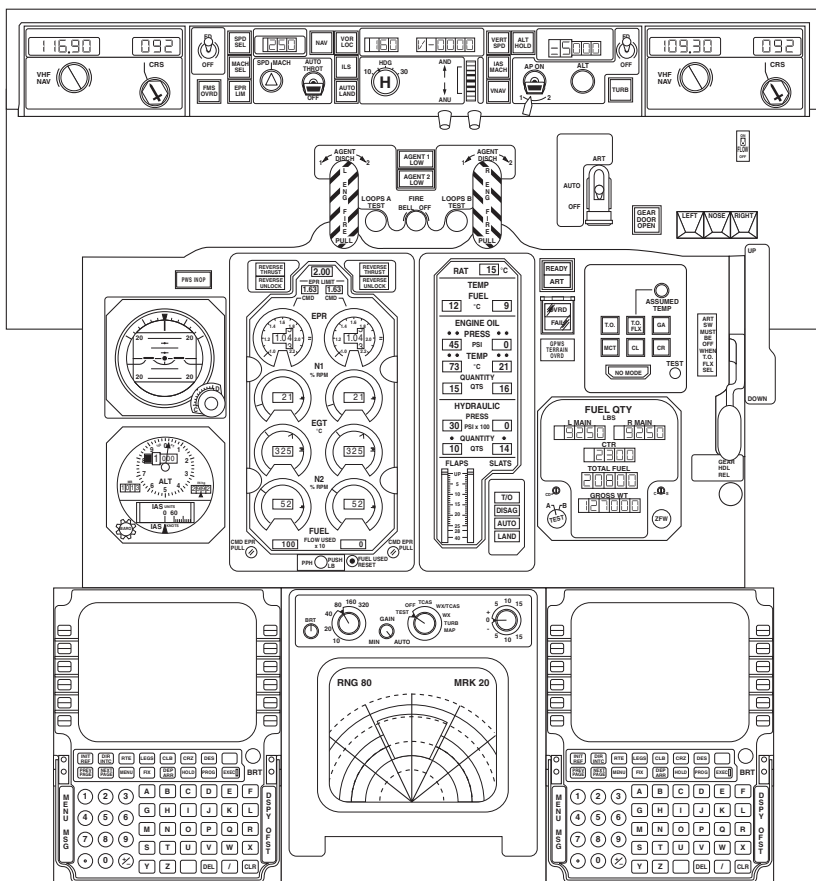
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Section 20

Forward Overhead Panel



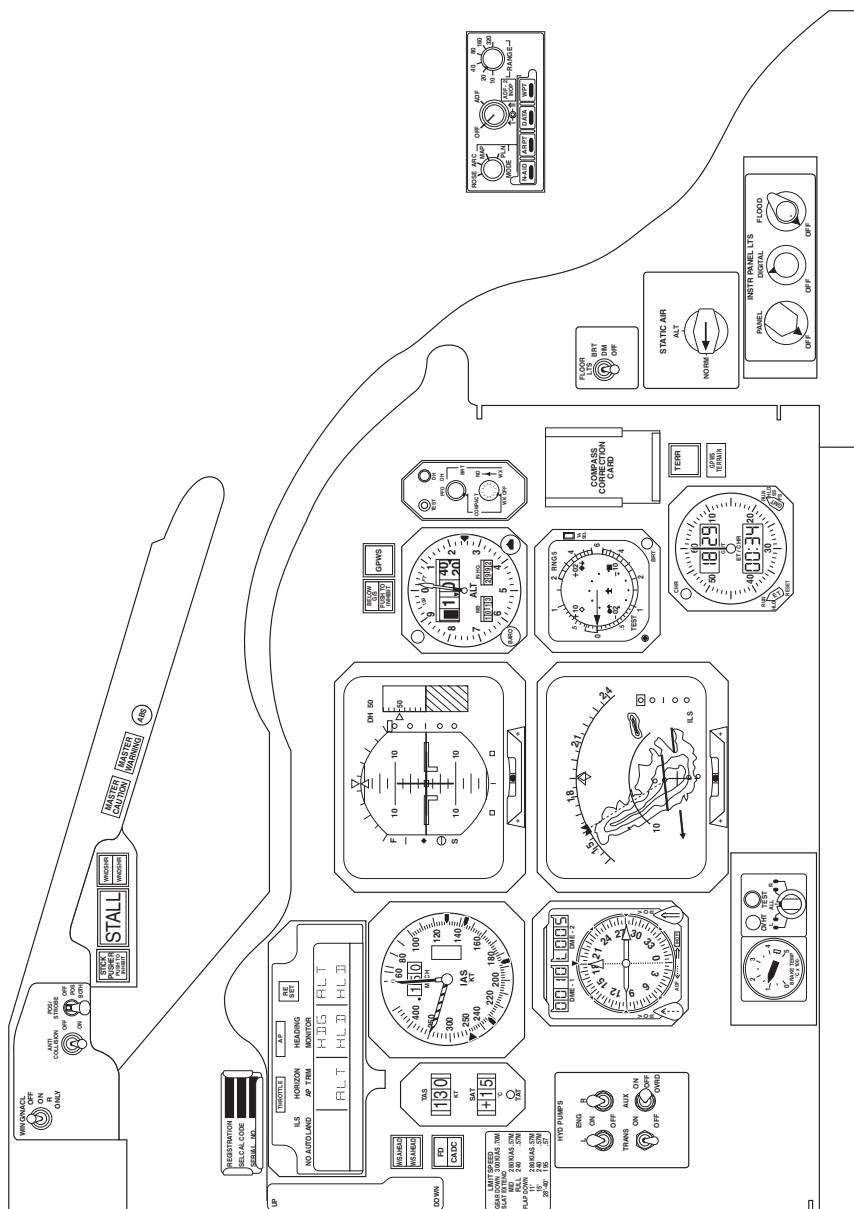
Center Instrument Panel



The diagram illustrates the cockpit instrument panel for a Cessna 440 Conquest II. The central section features several primary instruments: a tachometer at the top left, followed by a fuel gauge with a reserve indicator, an oil pressure gauge, a manifold pressure gauge, and an RPM gauge. Below these are two large airspeed indicators (ASI) flanking a central vertical scale. To the right of the ASI are three altimeters: a main altimeter, a wing leveler altimeter, and a flap altitude indicator. The bottom center contains a turn coordinator and a heading indicator. On the far left, there's a section for engine and system status, including a battery voltage meter, a master battery disconnect switch, and a fuel selector valve. The right side of the panel includes a gear position indicator, a landing gear warning horn, and a flap position indicator. Various control switches and knobs are distributed throughout the panel, such as the master battery disconnect, fuel pump, and cabin heater controls.



First Officer's Instrument Panel



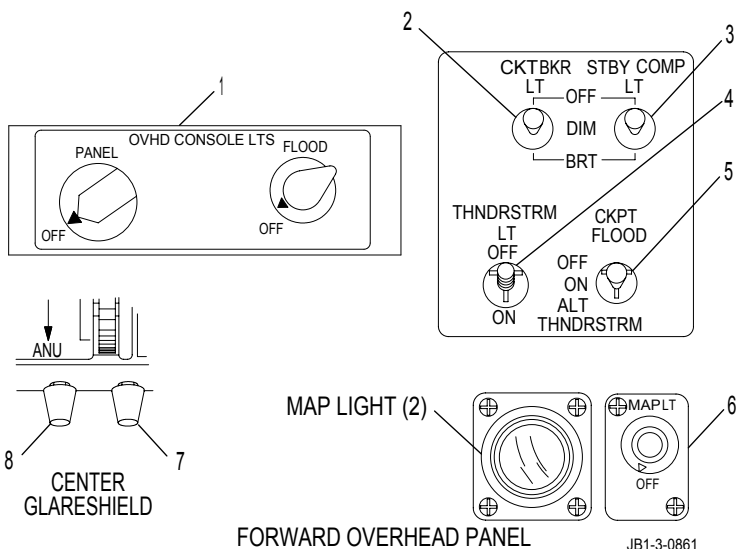
Airplane General, Emergency Equipment, Doors, Windows Controls and Indicators

Chapter 1

Section 30

Lighting

Cockpit Lighting Controls (Sheet 1)



1. OVHD CONSOLE LTS Knobs

PANEL - provides on/off and intensity control for integral lights on overhead panel.

FLOOD - Provides on/off and intensity control for overhead panel flood lights.

2. CKT BKR LT Switch

Provides OFF, DIM, and BRT control for the CB panel floodlights.

3. STBY COMP LT Switch

Provides OFF, DIM, and BRT control for the standby compass light.

4. THNDRSTRM LT Switch

OFF - Returns control of lighting to individual controls

ON - Overrides individual lighting controls and illuminates all cockpit floodlights to full intensity.

5. CKPT FLOOD Lights Switch

OFF - Extinguishes cockpit overhead floodlights.

ON - Illuminates one light in both cockpit overhead floodlights.

ALT THNDRSTRM - Illuminates both lights in both cockpit overhead floodlights.

6. MAP LT knob

OFF - Extinguishes map light.

Clockwise rotation of knob controls intensity of Map light.

Light is located in the ceiling above each pilot.

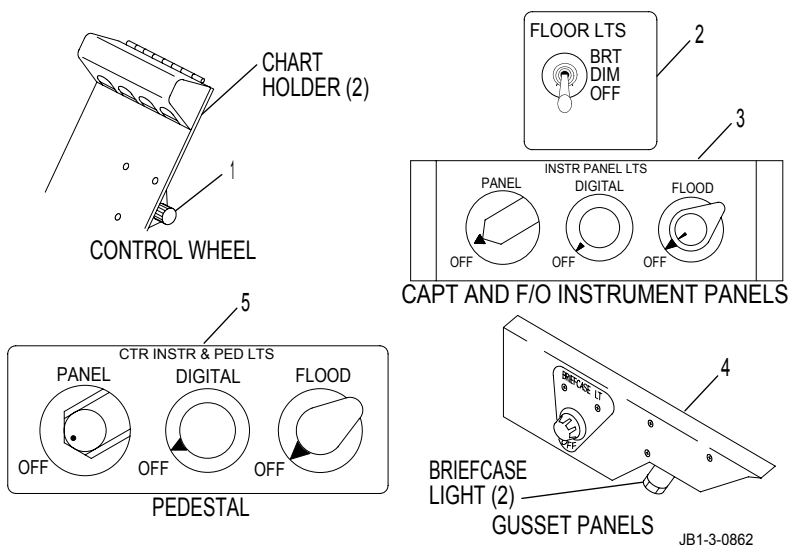
7. FGCP Digital Lights Knob

Controls intensity of FGCP digital readouts.

8. FGCP Modes Buttons and Edge Lighting Knob

Controls intensity of FGCP mode buttons and panel background lighting.

Cockpit Lighting Controls (Sheet 2)



1. Chart Holder Light Knob

On/off switch and intensity control for chart holder light.

2. FLOOR LTS Switch (2)

Provides BRT, DIM, and OFF for cockpit floor lights.

3. INSTR PANEL LTS Knobs (CAPT & F/O)

PANEL - Provides on/off and intensity control for instrument integral lights.

DIGITAL - Provides on/off and intensity control for digital readouts on respective flight mode annunciator.

FLOOD - Dual on/off switch and intensity control for instrument panel fluorescent and flood lights. Small knob controls incandescent instrument floodlight. Large knob controls fluorescent instrument floodlights.

4. BRIEFCASE LT Knob

Provides on/off and intensity control for Flight Kit stowage area.

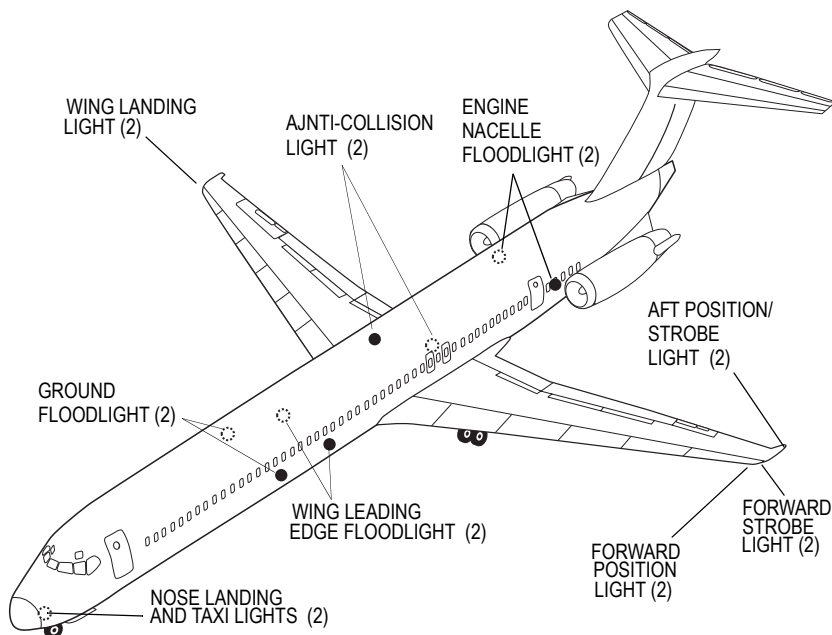
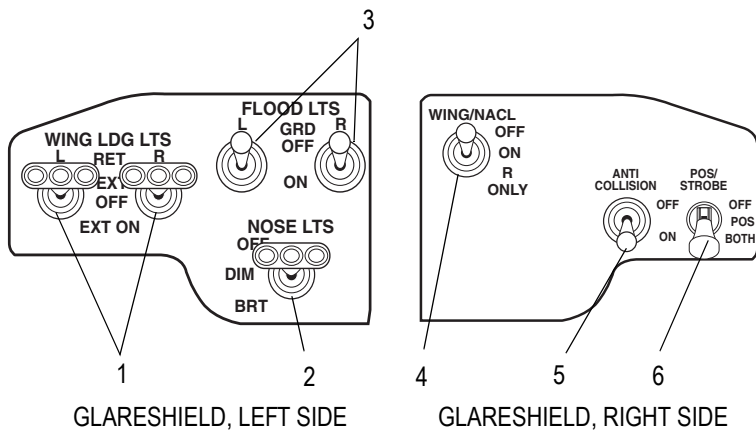
5. CTR INST & PED LTS Knobs

PANEL - Dual on/off switch and intensity control for center instrument panel and pedestal integral lights. Small knob controls the upper and center instrument panel lights. Large knob controls pedestal lights.

DIGITAL - Provides on/off and intensity control for digital readouts on fuel quantity display unit.

FLOOD - Provides on/off and intensity control for center instrument panel and pedestal floodlights.

Exterior Light Controls



1. WING LDG LTS Switch (L/R)

RET - Retracts wing landing lights.

EXT OFF - Extends wing landing lights with lamps off.

EXT ON - Extends wing landing lights with lamps on.

2. NOSE LTS Switch

OFF - Extinguishes nose gear landing and taxi lights.

DIM - Nose gear landing and taxi lights are dim.

BRT - Nose gear landing and taxi lights are bright level.

Nose gear landing and taxi lights automatically extinguish when landing gear handle is moved up.

3. FLOOD LTS GRD Switch (L/R)

OFF - Extinguishes ground flood lights.

ON - Illuminates ground flood lights.

4. WING/NACL Lights Switch

OFF - Extinguishes all wing leading edge and engine nacelle floodlights.

ON - Illuminates both wing leading edge and both engine nacelle floodlights.

R ONLY - Illuminates right wing leading edge and right engine nacelle floodlights.

5. ANTI-COLLISION Lights Switch

OFF - Extinguishes anti-collision lights.

ON - Illuminates upper and lower anti-collision lights.

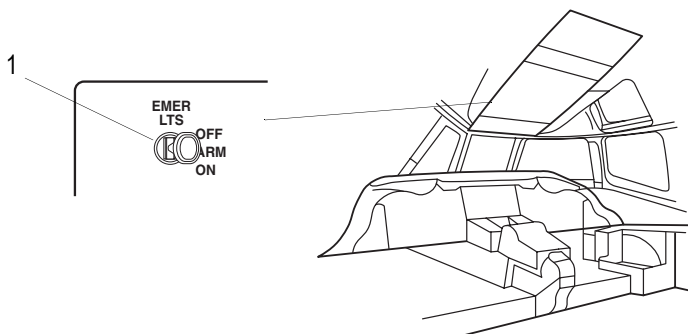
6. POS/STROBE Lights Switch

OFF - Extinguishes forward and aft position and strobe lights.

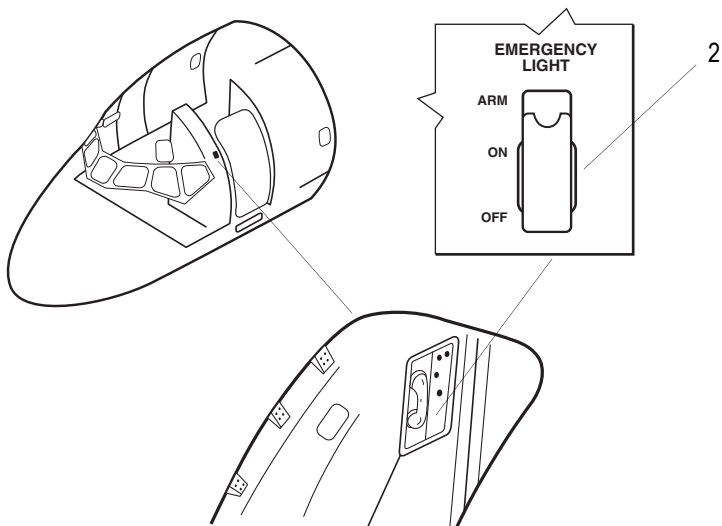
POS - Illuminates forward and aft position lights only.

BOTH - Illuminates the forward and aft position lights, and strobe lights are activated when airborne.

Emergency Lighting Controls



FLIGHT DECK OVERHEAD PANEL



FWD FLIGHT ATTENDANT PANEL

1. EMER LTS Switch (Flight Deck)

OFF - Prevents emergency evacuation lights from illuminating. EMER LIGHT NOT ARMED message is on. This position can be overridden and emergency lights switched ON at the EMERGENCY LIGHTS switch on the forward attendant's panel.

ARM - Normal flight position. Emergency evacuation lights are off. Connects battery packs charging circuits to EMERGENCY DC BUS. Emergency evacuation lights illuminate automatically with loss of power to the EMER DC bus.

ON - Simulates electrical power failure. All emergency evacuation lights and EMER LIGHT NOT ARMED message illuminate.

CAUTION: Emergency evacuation lights cannot be switched off unless DC TRANSFER BUS is powered.

2. EMERGENCY LIGHTS Switch (FWD Cabin)

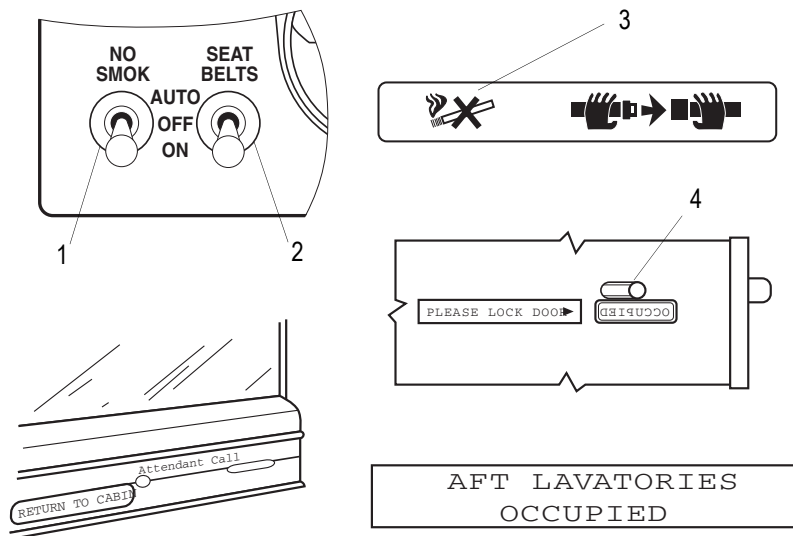
OFF - Normal guarded position. Emergency evacuation lights are controlled by EMER LTS switch on the pilot's overhead panel.

ARM - Momentarily placing this switch to ARM and releasing to ON illuminates the emergency evacuation lights, if the flight compartment EMER LTS switch is in the OFF position.

ON - Illuminates emergency evacuation lights regardless of position of EMER LTS switch on the pilot's overhead panel.

Passenger Cabin Signs

Passenger Information Signs



1. NO SMOK Switch

AUTO - Chime sounds when landing gear is extended.

OFF - Deactivates chime.

ON - Activates chime in cabin attendant stations.

NOTE: NO SMOKING signs illuminate whenever cabin altitude exceeds 10,000 feet, regardless of switch position.

2. SEAT BELTS Switch

AUTO - FASTEN SEAT BELTS and RETURN TO CABIN signs illuminate when slats are extended. Chime sounds.

OFF - FASTEN SEAT BELTS and RETURN TO CABIN signs extinguish.

ON - Illuminates FASTEN SEAT BELTS and RETURN TO CABIN signs.

NOTE: Only FASTEN SEAT BELTS signs illuminate whenever cabin altitude exceeds 10,000 feet regardless of switch position.

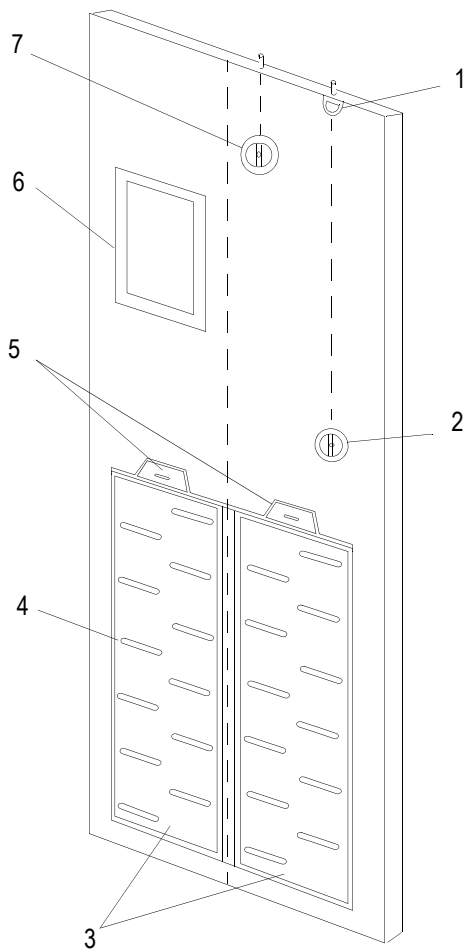
3. NO SMOKING/SEAT BELT Sign (typical)

4. Lavatory Door Lock (Typical)

Lavatory OCCUPIED placard is visible when door is locked. Switch on door jamb is actuated by latching mechanism.

Doors and Windows

Flight Deck Door



1. **D-Ring Latch**
2. **Door Knob/Latch**

A key can be used to lock and unlock the deadbolt from the cabin as required by ground personnel.

3. **Decompression Panels**

4. **Door Louvers**

Used for equalization of pressure between flight deck and cabin. Louvers may be closed during smoke conditions by raising sliding panel on flight deck side of door.

5. **Decompression Latches**

Each of the two decompression panels is held on to the door by a decompression latch just above each panel. If rapid decompression occurs within the flight deck, the latches will release and the door panels will blow open towards the flight deck. Each decompression latch has an indicator that must be aligned with the green band.

6. **View Window**

7. **Deadbolt Latch**

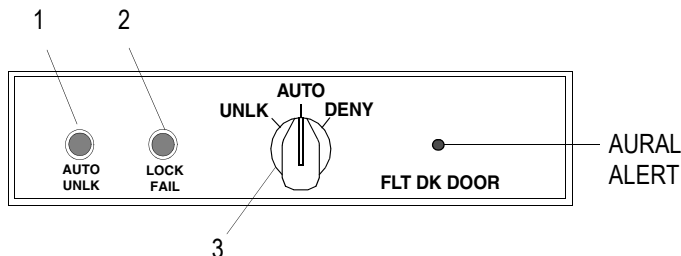
A rotary latch is used to lock and unlock the deadbolt from the flight deck. The rotary latch has three positions:

UNLOCKED

LOCKED - Denies cabin key access

LOCKED - Permits cabin key access (not used by flight crews).

Flight Deck Door Control Panel



1. **AUTO UNLK Light (Amber)**

Indicates access code has been entered, 60 second delay has begun, and automatic flight deck door unlock is pending.

2. **LOCK FAIL Light (Red)**

Flight deck door is unlocked.

3. **Door Control Selector**

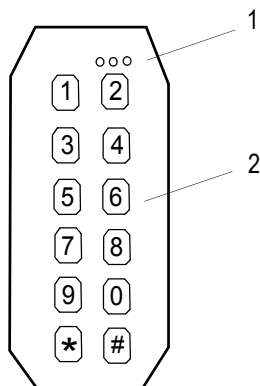
AUTO - Spring-loaded position. Locks the flight deck door and arms the system for a keypad entry request.

UNLK - Push and turn to select. Unlocks flight deck door. Manually overrides DENY lockout period.

DENY - Turn to select. Cancels Keypad entry request.

NOTE: *There will be a five minute lock-out period before the access code can be re-entered, unless UNLK position is selected.*

Remote Access System (RAS) Control Panel



JB1-3-0867

1. Keypad LEDs

YELLOW - 60 second delay in progress.

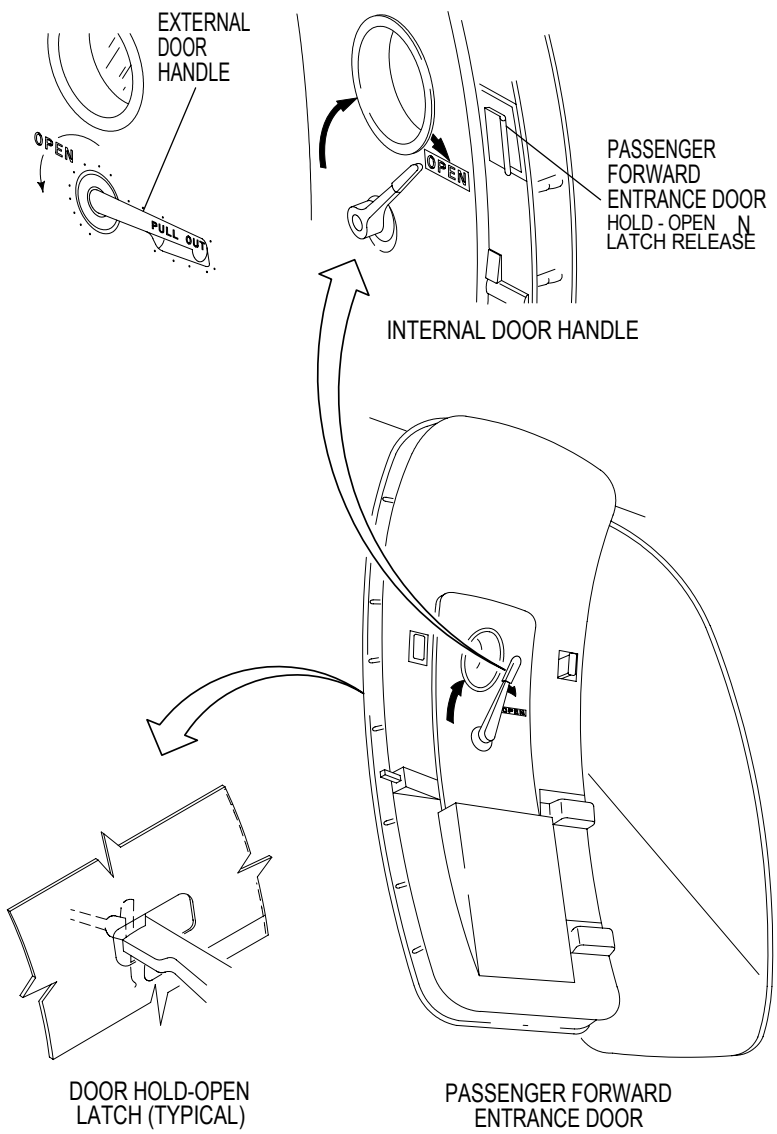
RED - Entry denied or door re-locked.

GREEN - Door unlocked.

2. Keypad Entry Keys

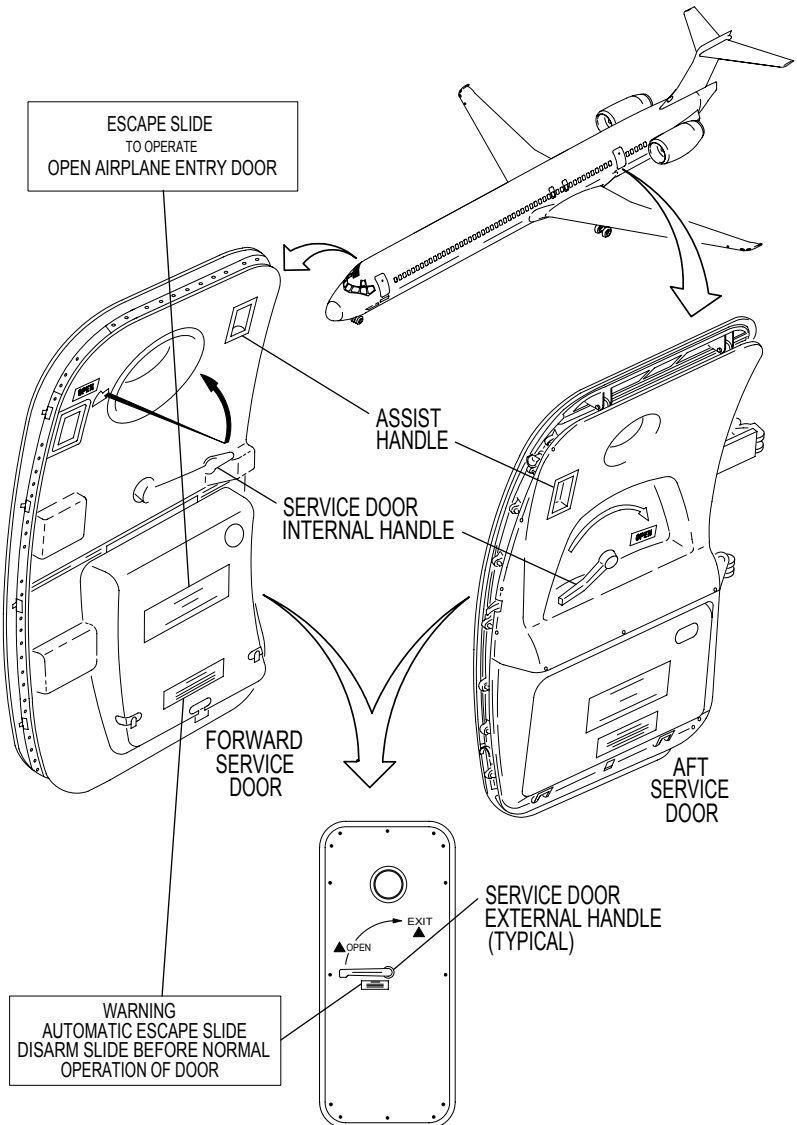
Code Entry Keys - Ten numeric keys (0-9) for access code input and one enter (#) key. The (*) key is not used.

Passenger Forward Entrance Door



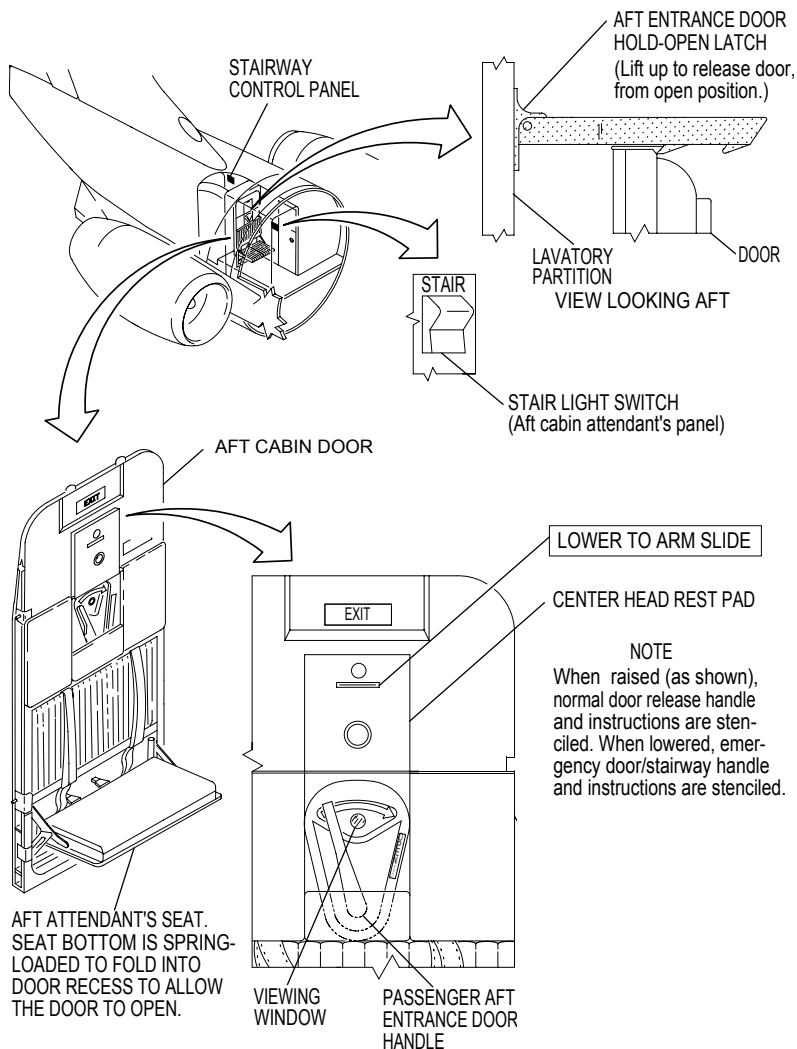
JB1-3-0869

Forward And Aft Service Doors



JB1-3-0871

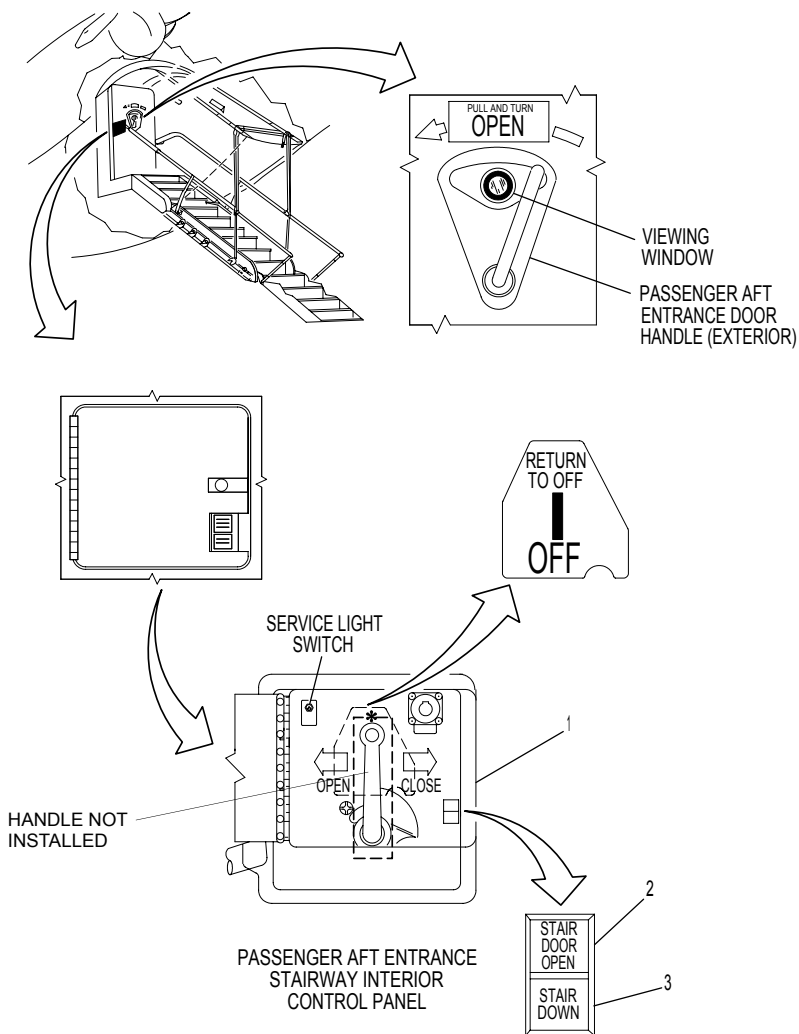
Passenger Aft Cabin Door And Stair (Sheet 1)



JB1-3-0872B

JB1-3-0872B

Passenger Aft Cabin Door And Stair (Sheet 2)



* OPTION

JB1-3-0873A

JB1-3-0873A

1. Stairway Control Handle

Handle not installed.

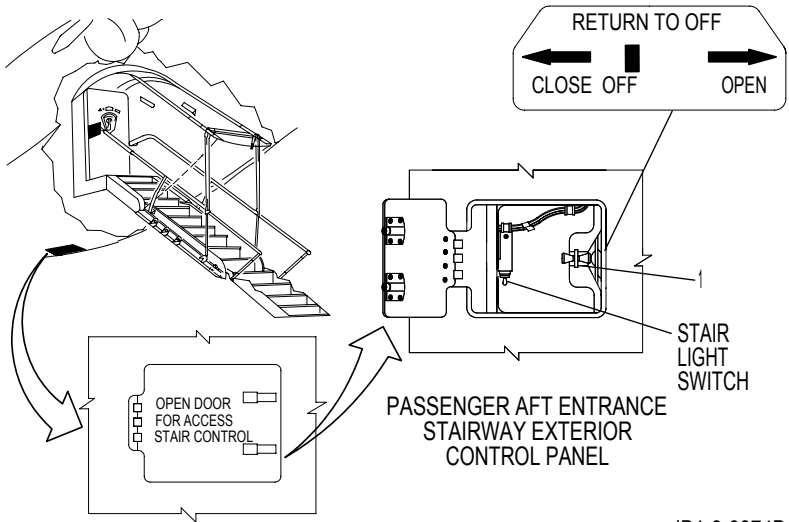
2. STAIR DOOR OPEN Light

Illuminates to indicate stairway door is unlatched.

3. STAIR DOWN Light

Illuminates to indicate stairway is down and locked.

Passenger Aft Cabin Door And Stair (Sheet 3)



JB1-3-0874B

JB1-3-0874A

1. Stairway Control Handle

OFF - Handle is spring-loaded to the OFF (center) position.

OPEN - Extends stairway. Hold in OPEN position until stairway is fully down and locked. If control handle resistance is encountered and no stair operation is observed, move handle to CLOSE and then to OPEN. Handle will return to OFF (center) position when released.

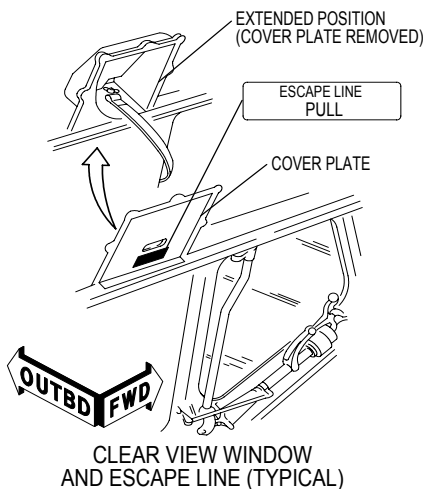
CLOSE - Retracts stairway. Hold in CLOSE position until stairway is fully retracted and locked. If control handle resistance is encountered and no stair operation is observed, move handle to OPEN and then to CLOSE. Handle will return to OFF (center) position when released.

Emergency Exits

Clearview Window

**TO OPEN CLEARVIEW
WINDOW:**

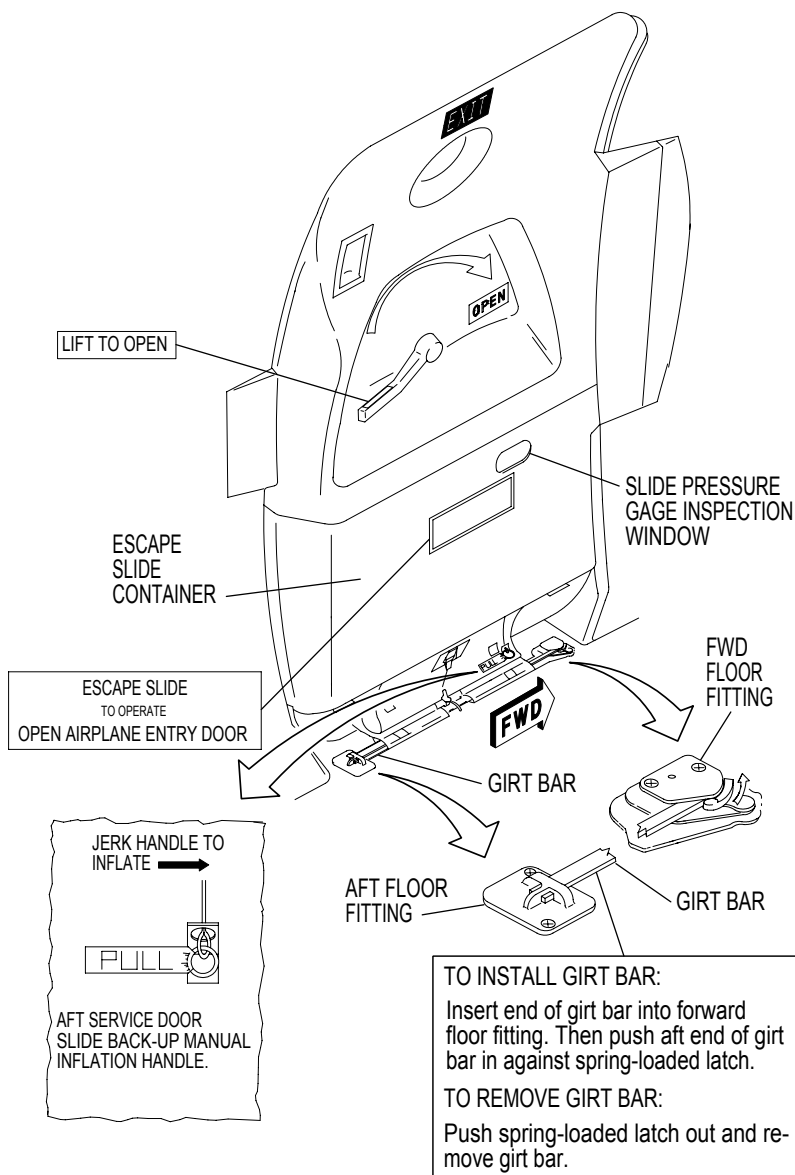
1. Pull handle aft to disengage overcenter lock.
2. Pull handle inboard to move window inboard.
3. Pull handle aft so that window slides aft to an open locked position.



CAG(IGDS)

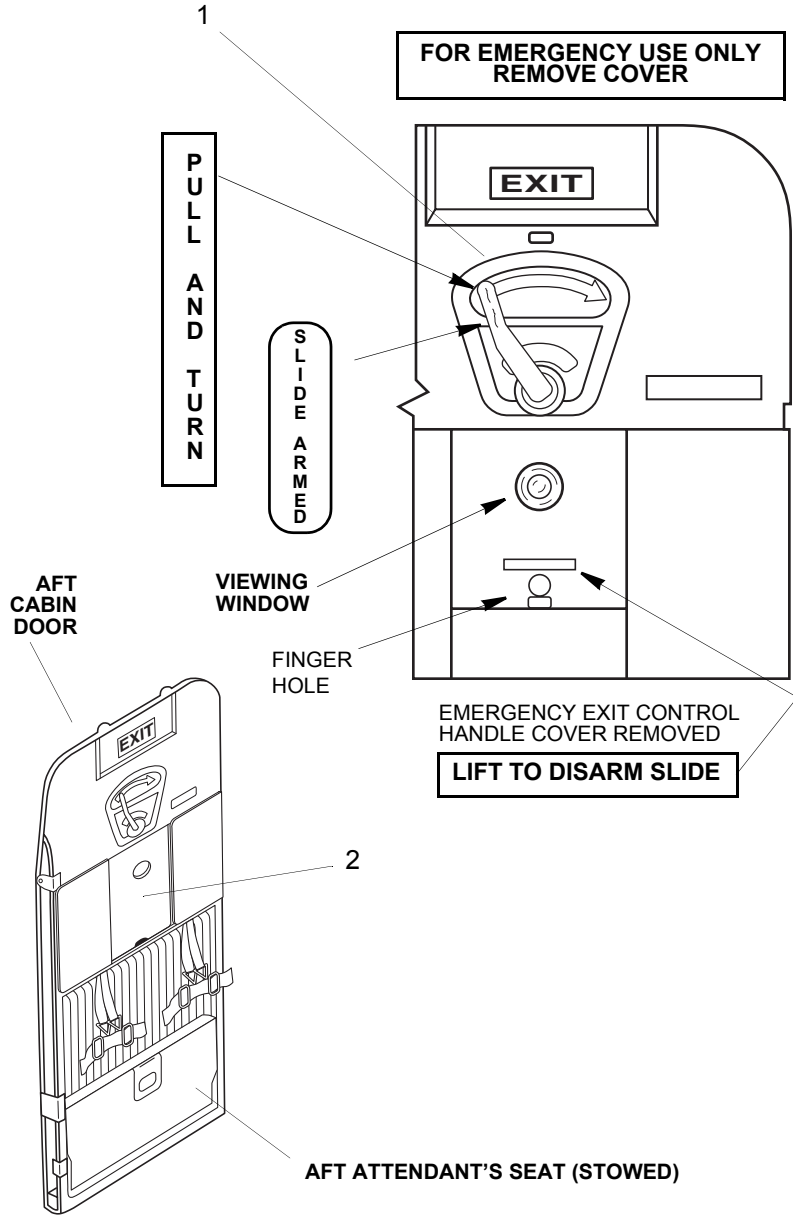
KB1-3-0017

FWD Cabin Door



JB1-3-0788

Aft Cabin Door



1. Emergency Exit Handle (Cover Removed)

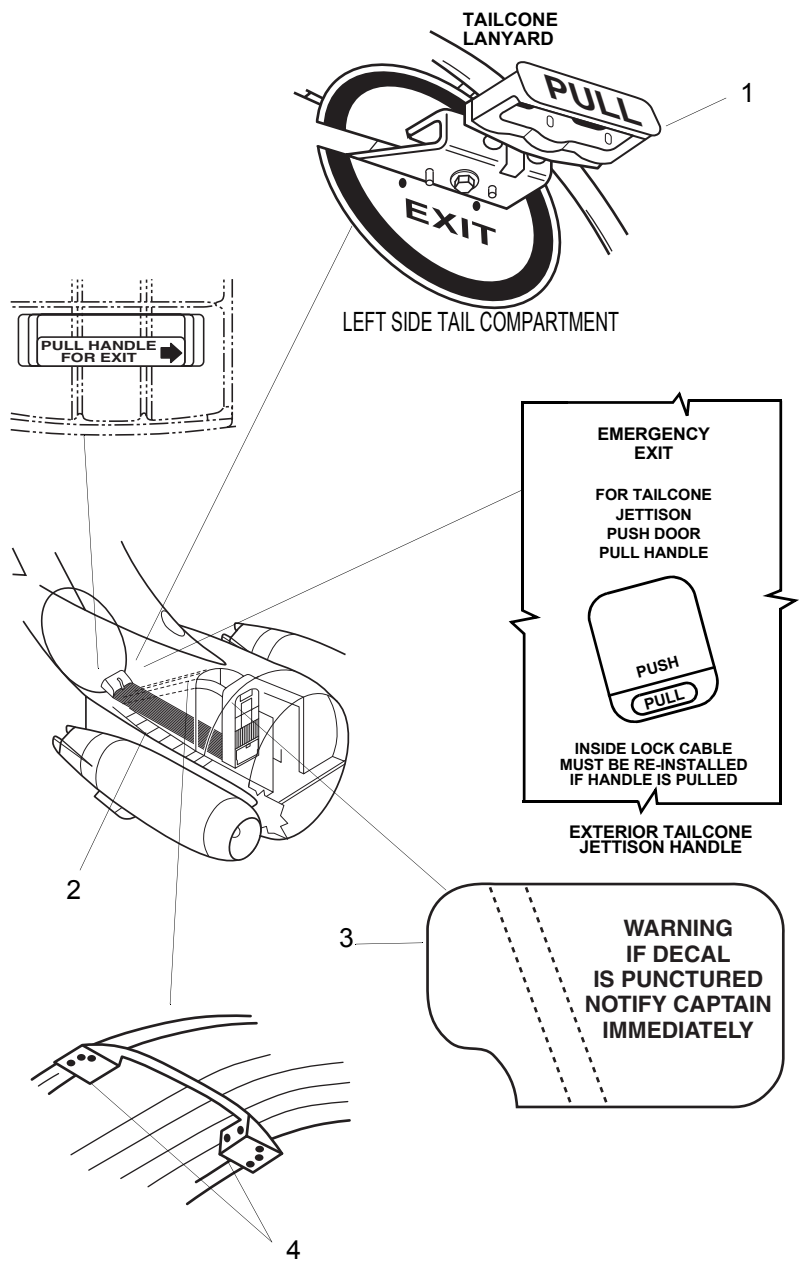
Rotate Clockwise - Unlatches door. Tailcone is jettisoned and evacuation slide is automatically deployed when door is opened.

2. Center Head Rest Pad

Lowered - (Shown) Emergency exit handle with cover exposed.

Raised - Normal door handle exposed to latch and unlatch Aft cabin door.

Tailcone Evacuation Slide (Sheet 1)



1. **Back-Up Tailcone Jettison Handle (Tail Compartment)**

PULL - Jettisons tailcone and deploys slide.

2. **Emergency Walkway**

Folds into ceiling when aft stairway is extended. When stairway is retracted, walkway is in the lowered position.

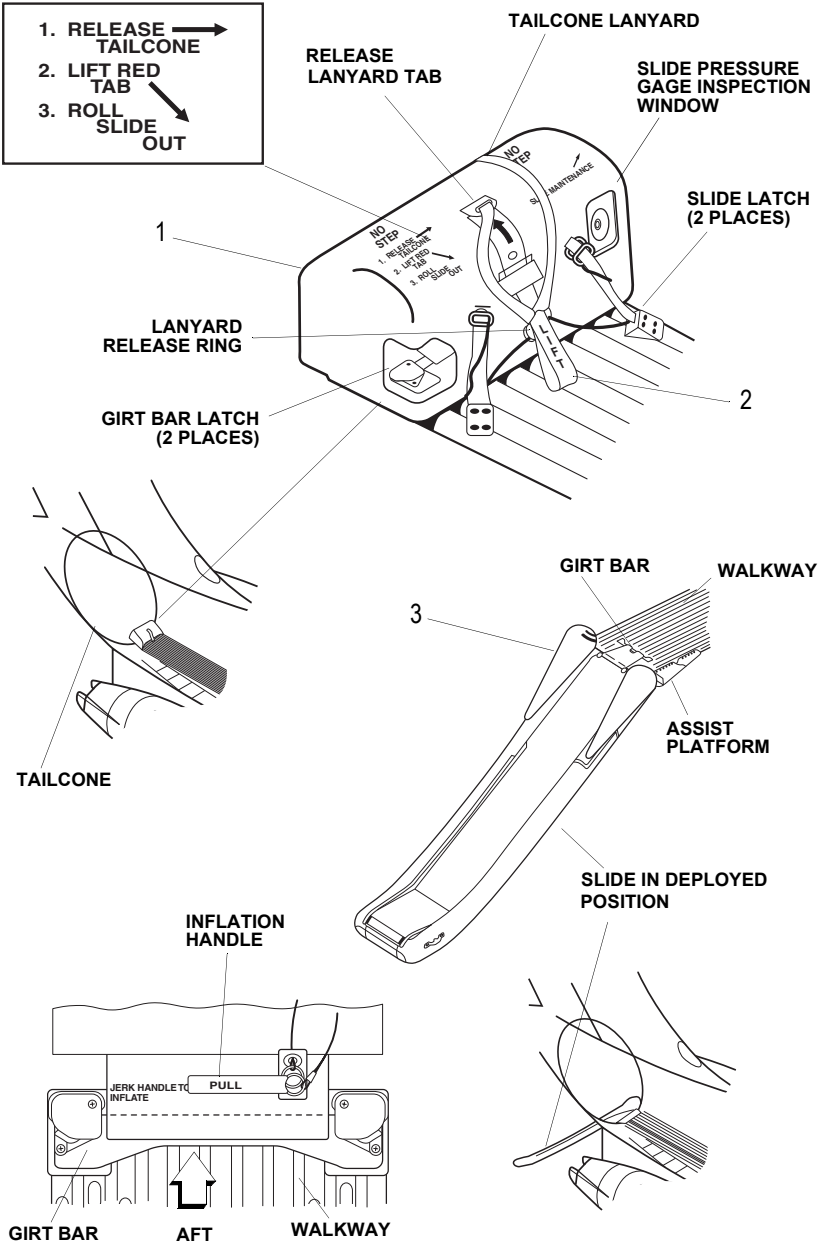
3. **Tailcone Release Mechanism Placard**

NOTE: Punctured decal indicates need for tailcone release mechanism inspection.

4. **Ceiling Stops**

Emergency walkway is spring and cable operated and may be manually overridden by pulling down on the stops in the event of a malfunction.

Tailcone Evacuation Slide (Sheet 2)



1. **Tailcone Evacuation Slide**

Normally the slide is automatically deployed and inflated when tailcone is jettisoned. If malfunction occurs after tailcone has been jettisoned, deploy slide manually per stenciled instructions.

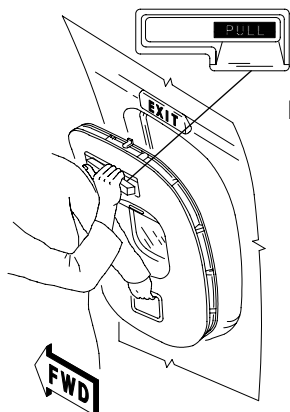
2. **Slide Manual Deployment Handle**

LIFT - Releases slide from latches to deploy slide manually.

3. **Slide Visual Indicator**

Indicator erects showing green stripes indicating slide is usable.

Overwing Emergency Exit (4)



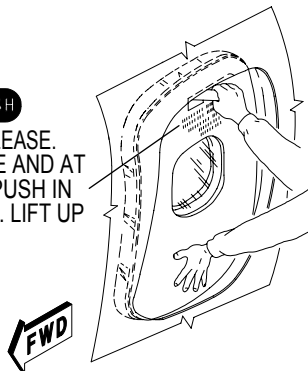
OVERWING
EMERGENCY DOOR REMOVAL
FROM INSIDE AIRPLANE
(R/H DOOR SHOWN)

CAG(IGDS)

EMERGENCY EXIT



PUSH HANDLE RELEASE.
PULL THE HANDLE AND AT
THE SAME TIME PUSH IN
ON TOP OF DOOR. LIFT UP
FORCIBLY.

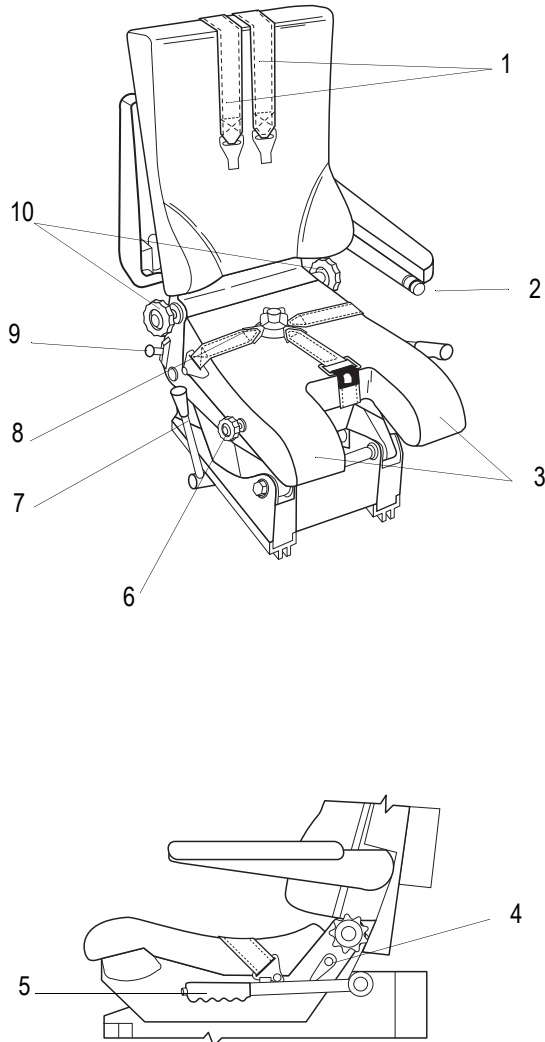


OVERWING
EMERGENCY DOOR REMOVAL
FROM OUTSIDE AIRPLANE
(L/H DOOR SHOWN)

KB1-3-0019

Cockpit Seats

Manual Pilot Seat Controls



LEFT SEAT SHOWN,
RIGHT SEAT SIMILAR

JB1-3-0858

1. Dual Shoulder Harness

2. Arm Rest (2)

Both armrests can be stowed in vertical position parallel to seat back. When armrests are horizontal to seat cushion position, rotation of knob at forward end of armrest moves armrest up or down from horizontal.

3. Thigh Rest

4. Recline Control Lever

Pressing lever permits seat to be reclined.

5. Seat Vertical Adjustment Lever

Seat vertical height is adjusted by pressing button and lifting up on lever arm. Desired seat height is maintained by releasing button and lever.

6. Thigh Pad Adjustment Knob

Rotation of knob adjusts thigh pad up or down.

7. Track Lock Control Handle

When handle is moved aft, seat may be moved forward or aft. When handle is released, seat should be moved until mechanism locks seat in desired position.

8. Lap Buckle

9. Inertial Reel Lock Handle

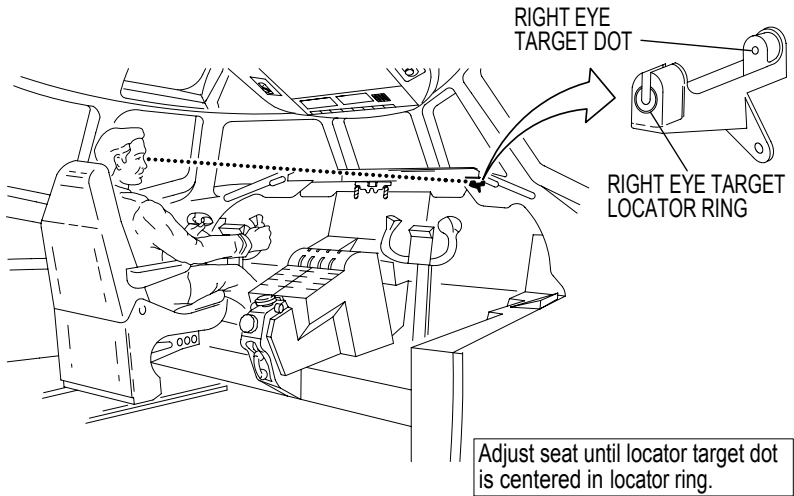
UP - Shoulder harness free to move until automatically locked by forces on inertial reel.

DOWN - Shoulder harness locked in forward extension at time handle is placed in DOWN position. Inertial reel will retract if forward pressure is released

10. Lumbar Adjustment Knob (2)

Rotation of knob adjusts lumbar tension in or out.

Pilot Eye Locator



JB1-3-0857

1. Pilot Eye Locator

Sit normally in seat.

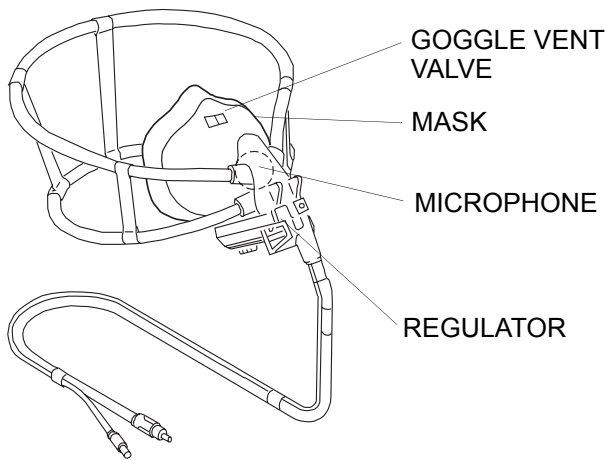
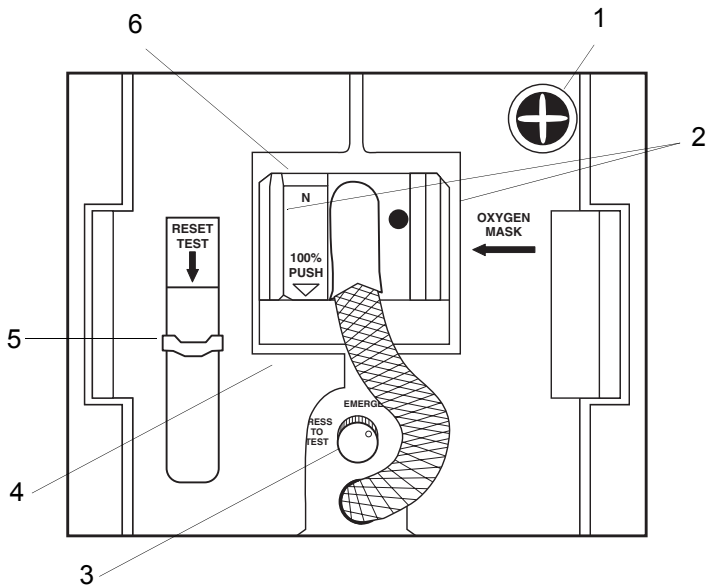
Rotate head about vertical axis to look directly at locator.

Close left eye.

Adjust seat until locator target dot is centered in locator ring.

Oxygen Systems

Crew O₂ Mask (3)



INFLATED HARNESS

1 EACH CREWMEMBER STATION

JB1-3-0876

1. **Flow Indicator**

Shows a yellow cross when oxygen is flowing, black when not flowing.

2. **Release Levers (red)**

SQUEEZE AND PULL - Releases mask from storage box.

Oxygen flow begins when left storage box door is opened.

Flow indicator shows a yellow cross momentarily as harness inflates.

3. **EMERGENCY/TEST Selector**

ROTATE (in direction of arrow) - 100% oxygen is supplied under positive pressure at all cabin altitudes.

PUSH - Tests positive pressure supply to regulator.

4. **Left Door**

CLOSED - Turns oxygen off.

OPEN - Turns oxygen on.

5. **RESET/TEST Slide Lever (spring-loaded)**

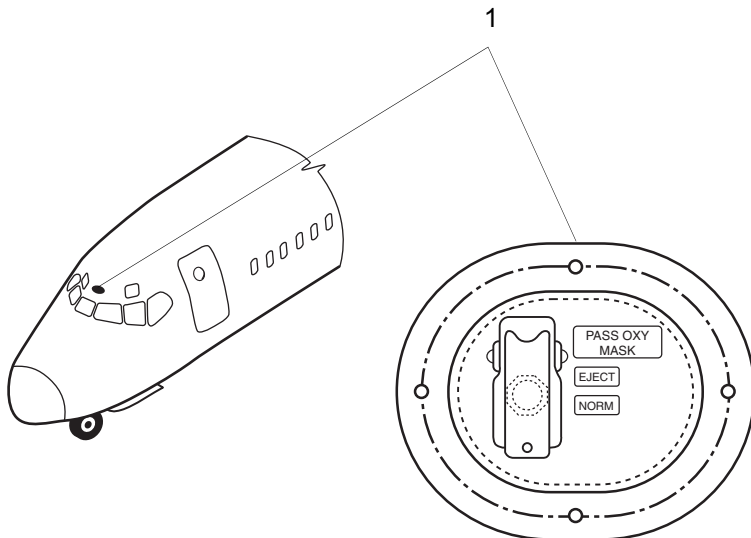
PUSH - Mask stowed, turns oxygen on momentarily to test regulator. Mask not stowed and left stowage box door closed and reset turns oxygen off.

6. **NORMAL/100% Selector**

NORMAL - Air/oxygen mixture on demand. Ratio is dependent on cabin altitude.

100% - Supplies pure oxygen on demand.

Passenger Oxygen Mask Switch



PASS OXY MASK SWITCH
(BEHIND F/O SEAT)

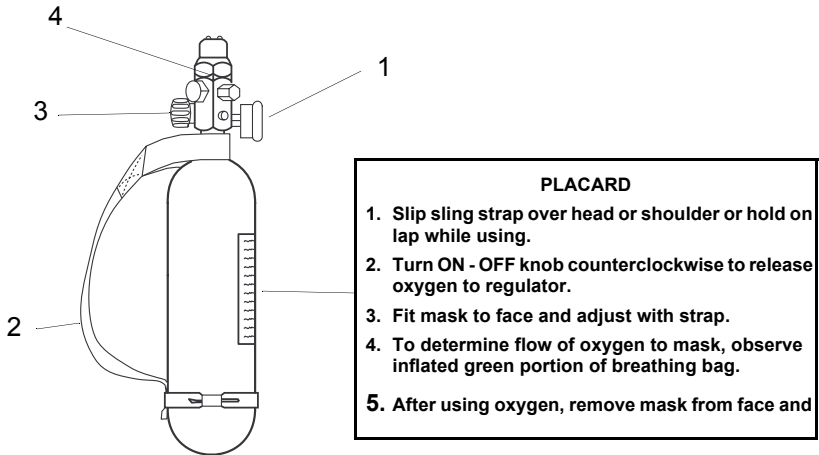
1. PASS OXY MASK Switch

EJECT - (Momentary) Energizes circuit to release door latches and open all oxygen compartment doors at any altitude.

NORM - Door latches on all oxygen compartments will open automatically any time cabin altitude reaches approximately 14,000 feet.

CAUTION: *Holding switch in EJECT position in excess of five seconds may cause damage to the oxygen compartment latches*

Passenger Cabin Portable Oxygen Bottle



1. **Pressure Gauge**

Minimum is 1600 psi.

2. **Sling**

3. **ON - OFF Valve**

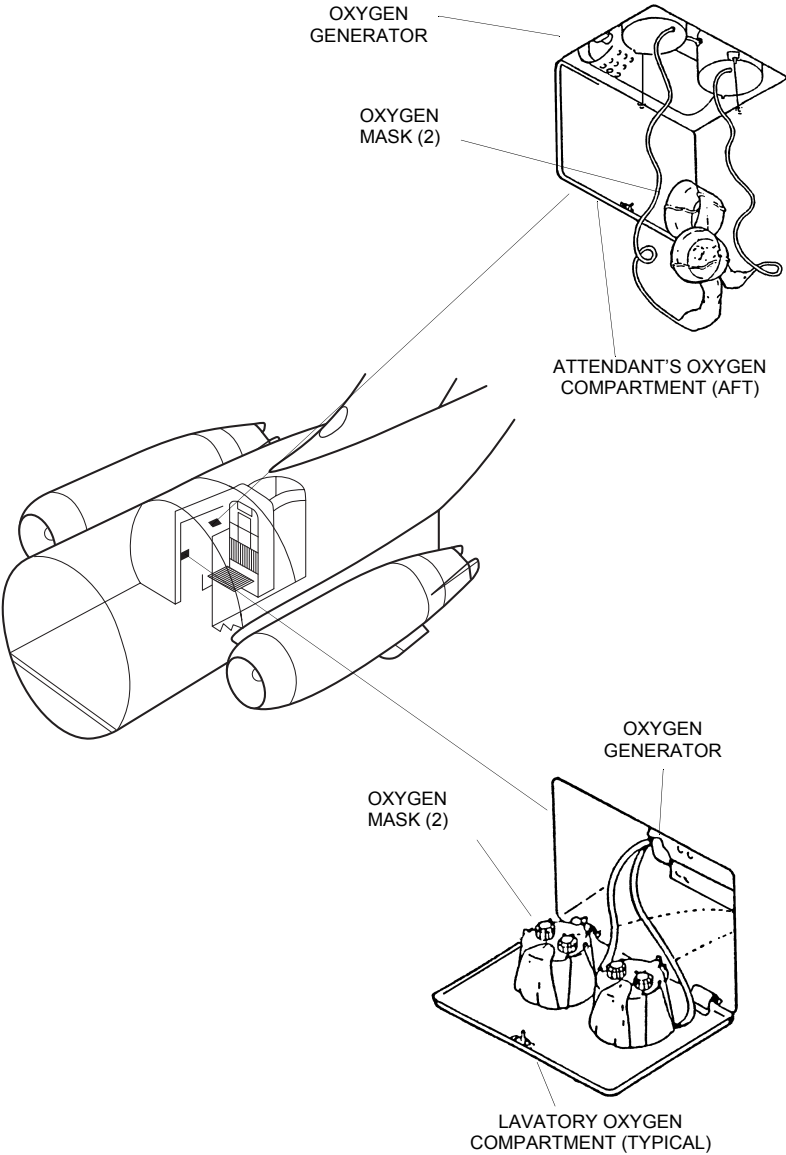
ON - Provides a constant flow of oxygen to the continuous flow mask.

OFF - Shuts off flow of oxygen to the continuous flow mask.

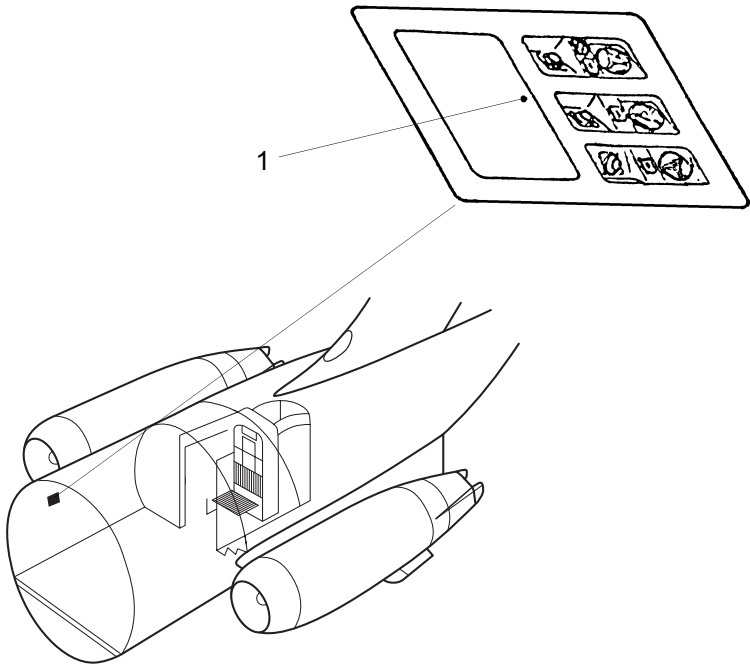
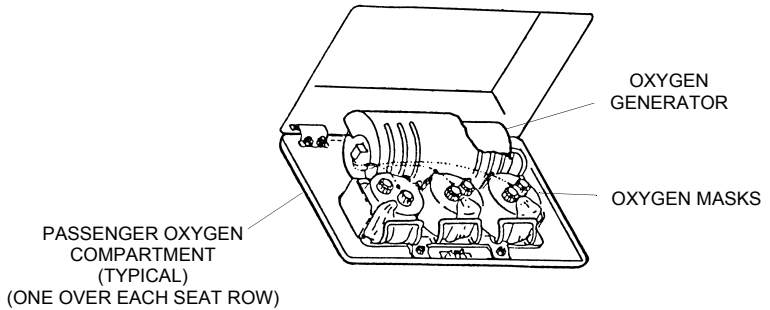
4. **Pressure Regulator**

Regulates pressure of oxygen flow to continuous flow mask.

Cabin Oxygen (Sheet 1)



Cabin Oxygen (Sheet 2)



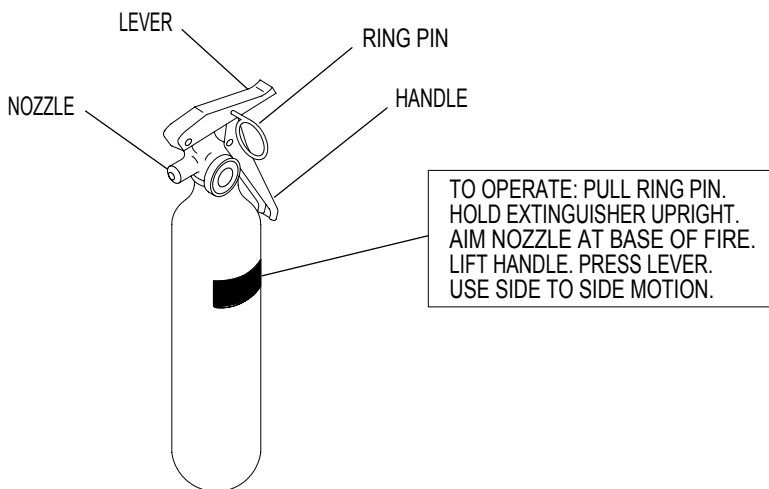
1. Manual Door Release (typical for all oxygen compartment doors)

Insert small rod to open door.

Permits manual operation of door.

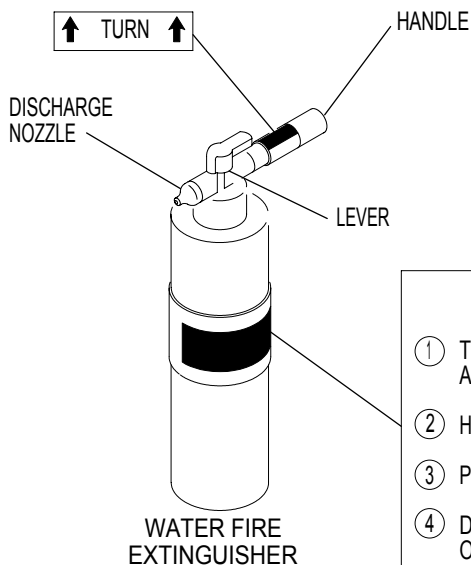
Emergency Equipment

Fire Extinguishers



HALON BCF FIRE EXTINGUISHER

NOTE:
FIRE EXTINGUISHERS
ARE INSTALLED IN
QUICK-DISCONNECT
SUPPORT BRACKETS



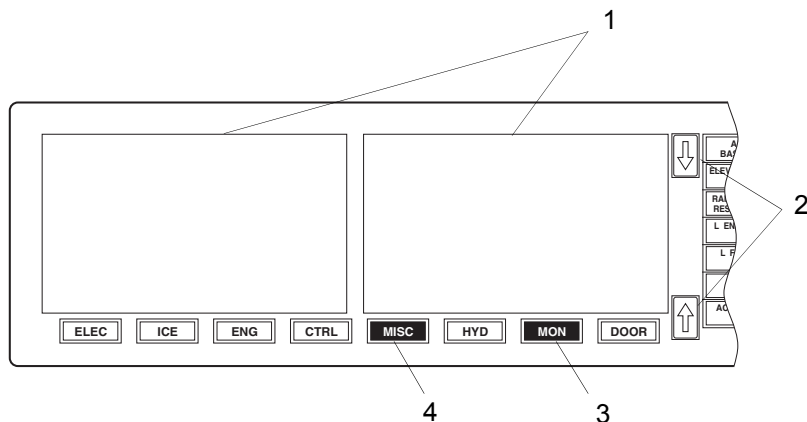
**WATER FIRE
EXTINGUISHER**

CAG(IGDS)

KB1-3-0025

Overhead Annunciator Panel

OAP (Sheet 1))



1. OAP Display Screens

Left display screen is filled from top with messages. After 6 messages, additional messages will appear at top right display screen. If both screens are full, latest message will appear at bottom of right screen.

2. Scroll Buttons

Appropriate scroll button will be illuminated to indicate messages stored off screen. Push to scroll messages up or down when messages are stored above or below those displayed on screens.

3. MON (Monitor) CUE Light

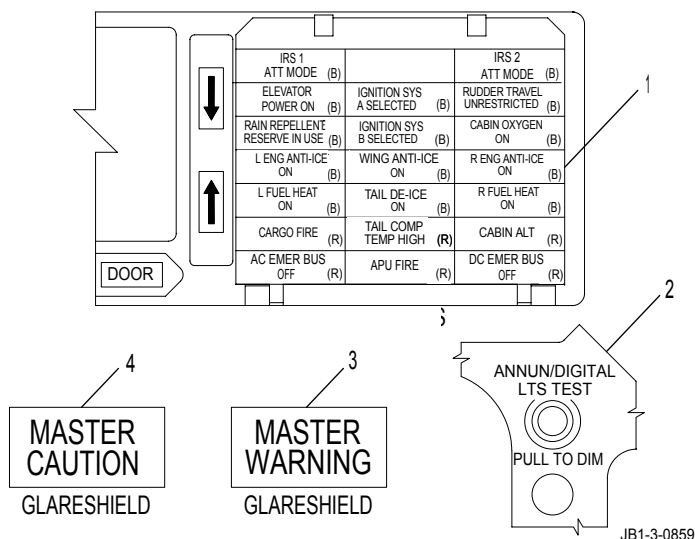
Illuminates to indicate fault exists in annunciator panel.

PUSH - Displays suspect annunciations on right screen.

4. Cue Light (7) (amber)

Associated system cue light flashes 4 times on detection of a caution and a new message is displayed on screen. Pushing cue light displays messages associated with that system. If cue light is pushed and held, messages will be displayed for 10 seconds. If cue light is pushed and released, messages will be displayed for 5 seconds. Messages will remain in message system until emergency or malfunction is corrected.

OAP (Sheet 2))



1. Advisory Lights

R - Red light - Brings on MASTER WARNING.

B - Blue light - Indicates an advisory. This is a normal condition.

Warning lights will stay illuminated until emergency or malfunction is corrected. Blue lights stay illuminated until corresponding system is off or condition no longer exists.

2. ANNUN/DIGITAL LTS Switch

TEST - Momentary. Push to test all OAP display elements (LED displays, annunciators, etc.) and the digital lights of the Captain's and First Officer's FMA and VHF/NAV control panel, Flight Guidance Control Panel, Fuel Quantity Panel, Engine Display Panel, and Systems Display Panel, Captain's and First Officer's Master Warning and Master Caution lights.

PULL TO DIM - Dims all messages except DOOR Cue light and all dimmable warning, caution, and advisory lights on the instrument panel that do not have individual controls.

3. MASTER WARNING Light (2) (red)

Both lights will illuminate when red lights on annunciator panel illuminate. Pushing either light will extinguish both MASTER WARNING lights and reset the system for subsequent indications.

4. MASTER CAUTION Light (2) (amber)

Both lights will illuminate when caution messages are displayed on the OAP. Pushing either light will extinguish both MASTER CAUTION lights and reset the system for subsequent indications.

Intentionally
Blank

Airplane General, Emergency Equipment, Doors, Windows Systems Description

Chapter 1

Section 40

Introduction

This chapter provides the flight crew with general airplane information and specific descriptive information for the following systems:

- Lavatories and galleys
- Passenger forward entrance door and stairway, forward service door
- Passenger aft entrance door and stairway, aft service door
- Oxygen systems
- Lighting systems
- Emergency exits and equipment
- Water and Waste Systems

Aircraft Dimensions/Turning Radius

Clearance for a turning aircraft is governed by the nose, wing tip, and tail of the aircraft. Nose clearance guarantees the tail or wing tip will clear, however, if the wing tip alone clears, the tail may not clear. When an aircraft attempts a turn, the nose tire slips throughout the turn. A conservative estimate of this slip is considered to be 3°. A perfect 180° turn, including this slip, requires 99 feet. Therefore, a taxiway should be at least 125 feet in width to attempt a 180° turn.

Flight Deck

The flight deck is designed for operation by a flight crew of two with accommodations for an observer. The two man capability is made possible by locating all essential controls where they are accessible, and locating all visible indicators and legends where they may be viewed by either pilot.

Pilot Seats

This compartment provides flight stations for the Captain and First Officer. The seats are track mounted and are adjustable in fore and aft, up and down, and reclining planes. A folding seat is provided for an observer. All flight deck seats have safety belts and shoulder harnesses.

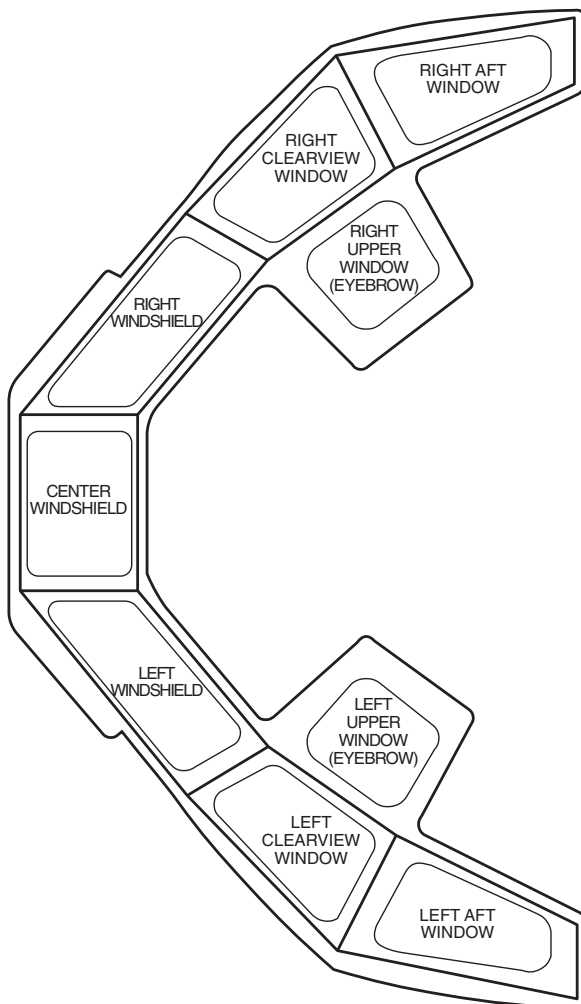
To aid each pilot in attaining a precise seat adjustment, an alignment device is provided under the glareshield on each side of the instrument panel. To properly adjust the seat, each pilot must look across the flight deck at the alignment target. When the seat is properly adjusted, the pilot should see a white dot centered in the eye target locator

Windows

There are four different types of windows in the flight deck.

- A center, left and right windshield.
- A clearview window on either side.
- An aft window on either side.
- Two upper (eyebrow) windows immediately above the clearview windows.

Flight Deck Windows



Lighting Systems

Exterior Lighting

The exterior lights consist of wing and nose landing and taxi lights, ground floodlights, wing/nacelle lights, anti-collision lights, and position and strobe lights

Landing And Taxi Lights

The landing and taxi lights consist of the nose gear landing and taxi lights, and the wing landing lights. Two sealed beam, fixed position, combination landing and taxi lights are installed on the nose gear assembly. The light circuit is interlocked so that the nose lights illuminate only when the landing gear handle is in the DOWN position. One sealed beam retractable landing light is installed on the lower surface of each wing tip. Each light assembly is enclosed in a housing and contains a motor to retract and extend the lights. Each light is controlled by a three position switch located on the Captain's side of the glare shield panel.

With a single engine failure, when landing gear is retracted after takeoff or go-around, the wing landing lights will extinguish and retract automatically.

Ground Floodlights

The ground floodlights aid side and forward visibility when taxiing. These lights are controlled by a pair of two position switches located on the Captain's side of the glareshield panel.

Wing/Nacelle Lights

The wing and nacelle floodlights are installed in each side of the fuselage to visually check the wing leading edge and engine nacelle for icing conditions. These lights may also be used to facilitate ground servicing. These lights are controlled by a three position switch on the First Officer's side of the glareshield panel.

Anti-collision Lights

Anti-collision lights are installed on the upper and lower fuselage surfaces. Both lights are controlled by a single switch located on the First Officer's side of the glareshield panel.

Position And Strobe Lights

The wing tip position and strobe lights include forward position lights consisting of a red light on the left wing tip and a green light on the right wing tip. A white strobe light assembly is also installed in each wing tip adjacent to the forward position lights. A clear wing tip lens fairing covers each forward position/strobe light. A combination aft white position light and white strobe light assembly is installed in the trailing edge of each wing tip.

Wing tip strobes operate only when POS/STROBE switch is in BOTH and the nose wheel is off the ground.

Interior Lighting

Flight Deck Lighting

Flight compartment lighting provides general and local lighting of the flight deck area, panels, instruments, and controls. Separate lighting control panels provide individual selection of intensity and the area to be lighted.

White incandescent floodlights are provided for the overhead panel and pedestal and the Captain's, First Officer's, and center instrument panels. White fluorescent floodlights are provided for the Captain's and First Officer's instrument panels. Lighted digital readouts are provided at the digital flight guidance control panel, Captain's and First Officer's flight mode annunciators, and the FUEL QTY (quantity) indicator. Integral panel and instrument lighting is also provided.

The THNDRSTRM LT switch overrides individual lighting controls and selects all floodlights and digital lighting to maximum intensity.

A CKPT FLOOD (cockpit floodlight) switch operates two floodlight units in the ceiling to provide general flight deck floodlighting below the level of the thunderstorm lights. In the ON position, one light is illuminated in each unit. In the ALT THNDRSTRM position, one additional light illuminates in each unit.

Additional flight compartment lighting consists of floor, map, briefcase, circuit breaker, standby compass, and chart holder lights.

In the event of complete loss of normal electrical power with the BATT (battery) switch ON, minimal lighting is provided by the white pedestal floodlights (incandescent) at the Captain's overhead and center instrument panels. These lights receive power from the DC transfer bus. These lights can be adjusted using the CTR INSTR & PED LTS FLOOD knob (FLOOD knob just left and forward of rudder trim knob).

When the EMER PWR (emergency power) switch is moved to ON with normal electrical power off and BATT switch ON, standby lighting will continue to be provided by the Captain's and First Officer's instrument panel floodlights. These lights receive power from the emergency DC bus and the DC transfer bus. All floodlights can be individually controlled from minimum to maximum intensity using their respective floodlights knob. Immediate bright floodlighting can be obtained by moving the THDRSTRM LT switch to ON.

Passenger Cabin Lighting

Passenger cabin lighting is provided by white incandescent and fluorescent lights. General cabin illumination is provided by sidewall lights, ceiling lights, and entry lights. These are supplemented by reading lights, lavatory lights, and separately controlled galley lights. Controls are located on the forward and aft attendant's panels.

The upper and lower sidewall fluorescent lights illuminate to full bright automatically whenever cabin altitude exceeds 14,000 feet to aid passengers with supplemental oxygen.

Cabin attendant's lights are provided at the forward and aft cabin attendant's stations and are controlled by light switches at the respective attendant's panel.

Standby Lighting

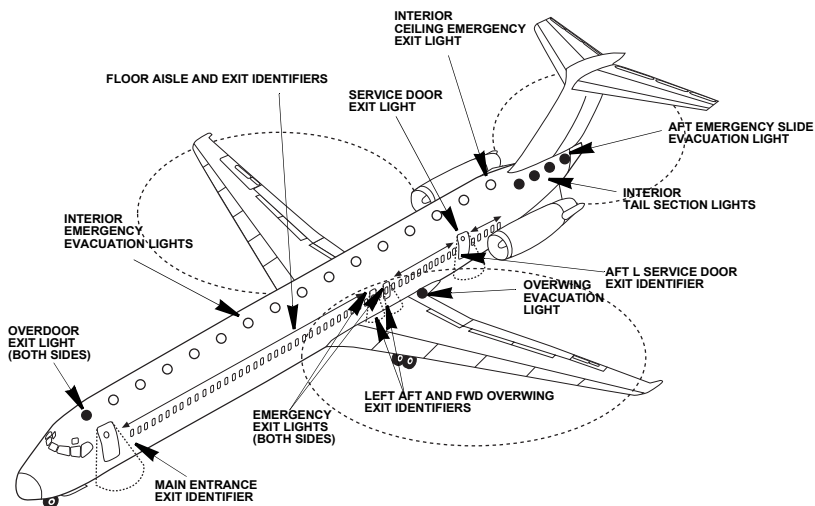
A standby lighting system provides lighting in the main cabin whenever normal electrical power supply is not available. The system is comprised of separate bulbs located in the ceiling. The standby lights are powered from the aircraft batteries through the emergency DC bus and are controlled by selecting the EMER PWR switch located on the forward overhead panel to the ON position.

Emergency Lighting

Emergency evacuation lighting provides escape path lighting for the flight deck and passenger compartment. Flight deck emergency evacuation lighting consists of two peanut bulbs on the aft overhead panel in the flight deck. Passenger compartment emergency evacuation lighting consists of proximity escape path lighting and ceiling lights. In addition, overdoor exit, overwing exit, aft passenger stair and tail section, and exterior overwing lights are illuminated. Emergency evacuation lights are powered by individual rechargeable battery packs that supply power for approximately 15 minutes. The emergency evacuation light system is activated in one of 3 ways:

- Position EMER LTS (emergency evacuation lights) switch in flight deck to ARM and lose power to the EMERGENCY DC BUS.
- Position EMER LTS (emergency evacuation lights) switch in flight deck to ON.
- Position EMERGENCY LIGHTS switch at flight attendant's panel to ON.

Emergency Evacuation Lighting



Passenger Information Signs

Illuminated pictographic type signs located throughout the passenger compartment provide specific instructions or pertinent information for the passengers and cabin attendants. These signs are controlled by the NO SMOK and SEAT BELTS switches located on the forward overhead panel.

When cabin altitude exceeds 10,000 feet, both the NO SMOKING and FASTEN SEAT BELTS signs illuminate regardless of switch position. The RETURN TO CABIN signs in the lavatories, however, do not illuminate.

The LAVATORY OCCUPIED signs are illuminated when the lavatory door is locked.

Oxygen Systems

Flight Crew Oxygen

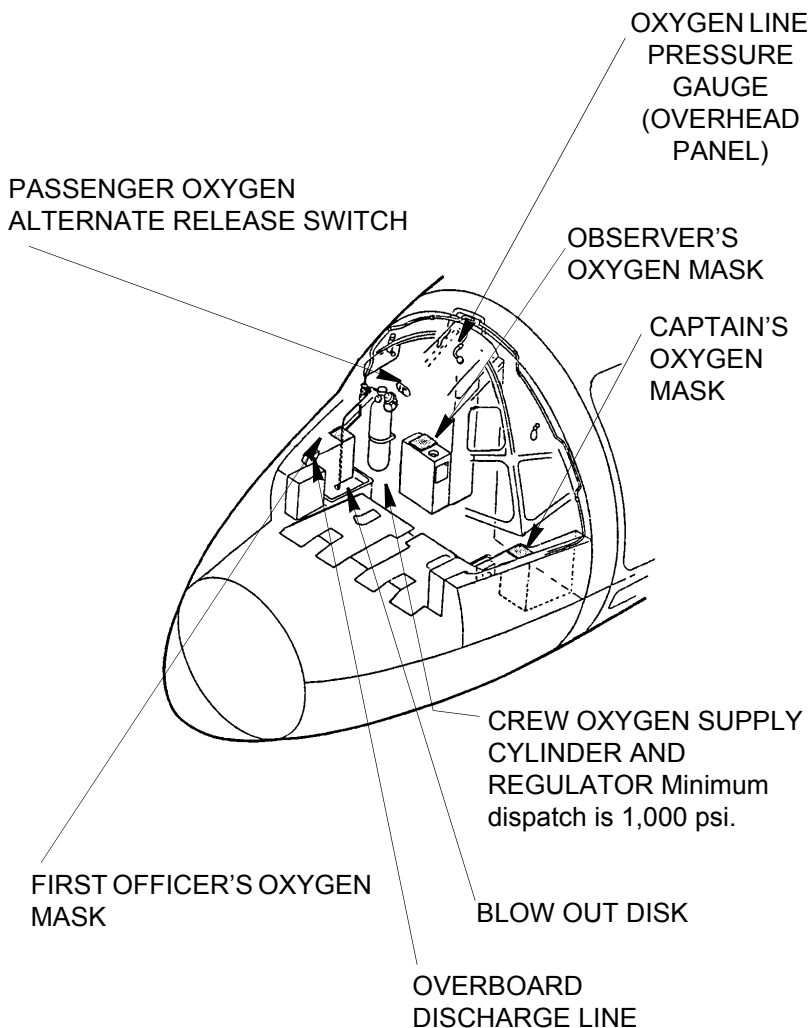
The flight crew oxygen system is completely separate from the passenger oxygen system. It uses quick donning mask regulators located at each crew station. Oxygen is supplied from a single cylinder located behind the First Officer's seat. The cylinder is equipped with a bottle pressure gauge and a shutoff valve that controls oxygen supply to the system. System line pressure is indicated on the aft overhead panel. The absence of the green blow out disk on the forward right side of the fuselage provides a visual indication of an overpressurized oxygen bottle.

A mask regulator is stored in a box at each crew station. The mask incorporates a manually operated goggle venting valve.

The mask may be used by squeezing the red release levers with the thumb and forefinger and removing from stowage. Squeezing and holding the release levers inflates the mask harness. The flow indicator shows yellow momentarily as the harness inflates. After placing the mask over your head, releasing the levers contracts the mask harness, fitting the mask to your head and face.

Oxygen flow is controlled by a regulator mounted on the mask. The regulator may be adjusted to supply 100% oxygen by pushing the NORMAL 100% switch.

Rotating the emergency selector to the EMERGENCY position on the mask regulator supplies 100% oxygen under positive pressure at all altitudes. The goggle vent valve will be supplied oxygen only when the emergency selector is rotated to the EMERGENCY position. The goggle vent valve is operated by sliding the vent selector on the mask downward. This action uncovers two red bands on the mask allowing 100% oxygen to flow from the vent in the mask. The smoke goggles, located in the stowage compartment outboard of each pilot's seat, are designed to be used with the venting mask.



Passenger Oxygen

The passenger oxygen system is supplied by individual chemical oxygen generators located at each passenger service unit (PSU).

WARNING: Oxygen generators become hot when activated. The presence of a burning odor is normal during use.

Constant flow masks are connected to each generator - four masks on each left side generator, three at each right side generator. A generator with two masks is located above each flight attendant's station and in each lavatory. The mask doors open automatically at a cabin altitude of approximately 14,000 feet. Mask doors may be opened at any time by selecting the OXYGEN MASK switch behind the First Officer to EJECT.

Note: When aircraft AC electrical power is lost, all the cabin mask doors must be opened manually.

Pulling any mask down in a unit activates that oxygen generator, and 100% oxygen begins to flow to all masks in that unit. A green flow indicator is visible in the transparent oxygen reservoir bag whenever oxygen is flowing to the mask. The mask supplies a mixture of pure oxygen and ambient air to the passenger. If the passenger oxygen is activated and a PSU oxygen mask compartment does not open, the masks may be dropped manually. Oxygen will continue to flow for approximately 15 minutes and cannot be shut off once activated. Once used, there is no further supply of oxygen available to that particular PSU.

Passenger Seats

Each seat is equipped with a seat belt, ashtray, folding utility tray, and literature stowage pocket.

All seat backs, except on the outboard seats adjacent to each overwing exit, are adjustable in the recline position by means of a push-button control in the armrest. The seat will return to the normal upright position when the push-button is pressed and no backward force is present.

Each seat back, except on the outboard seats adjacent to each overwing exit, can be forced by twenty-five pounds of force (approximate) to fold from its normal upright position to lay flush with the seat cushion. The seats may be returned to normal upright position by manually lifting with approximately ten pounds of force.

All armrests, except the one adjacent to the aisle and the ones mounted on the overwing exit doors, may be folded up flush with the seat back. The seat bottom cushions are equipped with hand straps to facilitate use as flotation gear.

On some airplanes, the aisle armrest of the second and thirtieth row of seats on the right side of the airplane may be raised to facilitate the seating of wheel chair passengers.

On some airplanes, the aisle armrest of the second row and twenty-ninth row of seats on the right side of the airplane may be raised to facilitate the seating of wheelchair passengers.

Doors

Flight Deck Door Control

If a valid Access Code is entered into the remote keypad, a 60 second time delay will start during which the following will occur:

- A short aural alert will sound and the amber AUTO UNLK light will illuminate on the flight deck door control panel.
- After 30 seconds, a second short aural alert will sound.
- After 40 seconds, the aural alert will pulsate and the AUTO UNLK light will flash.
- After 60 seconds, the AUTO UNLK light will extinguish, the door will unlock for 5 seconds, the LOCK FAIL light will illuminate, and the aural alert will sound.

At any time during this sequence, the switch may be selected to UNLK to allow entry or DENY to prohibit entry.

Passenger Entrance Doors and Stairs and Service Doors

The passenger forward entrance door is installed on the left side of the fuselage, and the forward service door is installed on the right side. Either door can be opened from either inside or outside the airplane. The doors swing outward after the hinge has moved inward, permitting the doors to move edgewise through the doorway. An evacuation slide is installed on each door. Operating instructions for the door and the slide are stenciled on the door and slide container, respectively.

With the parking brakes set, the DOOR cue light will flash four times when first door is opened and remain on without flashing as other doors are opened.

Annunciations will not appear on display screen. With DOOR cue light on steady, push DOOR cue light to display door annunciations on screen. DOOR cue light extinguishes when all doors are closed.

When the parking brakes are released, the DOOR cue light will flash four times each time a new door annunciation is displayed on screen. Push DOOR cue light to display only door annunciations. If DOOR cue light is pushed and held, door annunciations will be displayed for 10 seconds and go off. DOOR cue light will be on steady to indicate door annunciations whether on or off screen. DOOR cue light cannot be dimmed.

Passenger Aft Cabin Door

The passenger aft entrance door is mounted on the aft pressure bulkhead and hinged on the right side to swing forward against the lavatory wall. A viewing window is installed in the door handle recess to allow inspection of the stairway area with the door closed. The aft cabin attendant's seat is attached to the door and automatically folds into a recess in the door when not in use. The seat bottom must be folded into the recess when the door is opened. A barrier strap is installed to be placed across the aisle forward of the door for takeoff and landing, to preclude passenger interference when opening the door. A hold open latch is installed on the right side of the aisle to hold door in the open position.

Door warning annunciations and door cue light on the annunciator panel will remain on when either door is not closed and locked.

Passenger Aft Entrance Stairway

The aft entrance stairway is hydraulically actuated and powered by the right hydraulic system. When retracted, the stairway is automatically locked in the up position by mechanical locks.

The stairway may be operated from the exterior of the airplane. The exterior control is located on the aft left fuselage adjacent to the stairway door jamb and is covered by a latched access door. There are no indicator lights at the external control station. Door warnings and DOOR cue light on the annunciator panel function when the stairway is operated from the external control station.

In the normal extended position, the stairway does not touch the ground. However, under certain conditions, such as an uneven runway apron, the folding step may touch, and the lower step extension will fold to accommodate the variations. If the airplane is subjected to extreme conditions, such as high winds over the nose or abnormal aft section loading, the airplane may tip aft causing the lower step extension to fold until the main step contacts the ground. The lower steps of the stairway are designed to absorb ground contact without damage. In addition, the stairway is equipped with shock absorbing tubes. If the shock absorbing tubes become deformed by stairway-ground contact, they must be replaced before normal operation can be resumed.

Tailcone

A jettisonable tailcone is attached to the fuselage. When jettisoned, the opening provides an emergency exit accessible from the passenger compartment through the aft cabin door and aft accessory compartment. The tailcone can be released from inside or outside the aircraft.

Galleys

Four galley units are installed in the cabin. Galleys G1 and G2 are located forward on the right side of the cabin adjacent to the forward service door. Galleys G3 and G4 are located aft of the cabin near the aft service door. Galleys G1 and G4 are wet galleys and water is supplied from the pressurized potable water system.

Lavatories

Three lavatories are installed in the cabin. One is located on the forward left side just aft of the forward passenger door and two are located aft on either side of the aft passenger door.

Note: A locked lavatory door can be unlocked from the outside by inserting a screwdriver or other sharp instrument into a slot on the OCCUPIED sign on the door latch and sliding the sign to the vacant position. Water is supplied to the lavatories from the pressurized potable water system. A water shutoff valve is located under the washbasin to shut-off or adjust flow of water to the basin. Hot water is provided by a water heater located under the washbasin in each lavatory.

Note: The lavatories contain integral waste tanks which are drained through exterior service panels.

Potable Water System

A pressurized potable water tank, located just forward of the mid cargo compartment door, supplies water to the galleys and lavatories.

The potable water tank is normally pressurized from the aircraft air conditioning system. On the ground when the air conditioning system is not operating, the tank can be pressurized from a ground source at the water service panel or by an integral standby electric pump. The standby pump is activated by using a push button switch located on the forward wall in both galleys. The time required to pressurize the tank is dependent upon volume of water in the tank. The pump shuts off after reaching the proper pressure, and will not restart automatically if the pressure drops. The pump is inoperable when the external potable water service door is open.

The water service panel, located on the lower right side of the fuselage, contains controls/indicators for determining automatic water fill levels.

Emergency Exits

There are ten emergency exits on the aircraft:

- Two flight deck sliding windows.
- Forward cabin door.
- Forward galley door.
- Aft galley door.
- Aft cabin door (through tailcone).
- Four overwing exits.

Operating instructions for each door are located on its interior and exterior surface.

Flight Deck Emergency Exits

Normally, cabin exits will be utilized by flight crew members. However, two sliding clearview windows, adjacent to the windshields, provide an alternate escape route. Escape lines are provided adjacent to the clearview windows for use by crew members to lower themselves to the ground.

To open clearview window:

After aircraft is unpressurized,

- Pull handle aft to disengage overcenter lock.
- Pull handle inboard to move window inboard.
- Pull handle further aft so that window slides aft to an open locked position.

Cabin Emergency Exits

There are eight cabin emergency egress doors; a forward entrance door, service doors (right forward fuselage and left aft fuselage), four overwing emergency exit doors, (two each fuselage side), and, when the tail cone is jettisoned, the aft entrance door. Operating instructions for each door are located on the interior and exterior surface of each door. Both service doors and forward entrance door have identical handles and similar operating instructions. The overwing emergency exit doors have identical handles and emergency operating instructions.

The forward entrance door and both service doors are equipped with slides that deploy automatically when the door is opened with the girt bar installed in airplane floor fittings.

When the aft entrance door is opened using the emergency exit handle, the tail cone is jettisoned and a slide is automatically deployed and inflated. A back-up inflation handle is provided on the aft entrance door slide should the slide fail to inflate automatically. All door slides, except aft entrance door slide, have integral emergency lighting.

Overwing Emergency Exits

The overwing exit hatches are removed by pulling inward on the upper handle which has the PULL label. The hatch is then lifted inside and stowed.

Escape Slides

The forward cabin door and both galley doors are equipped with slides that inflate and deploy automatically when the door is opened with the girt bar installed in airplane floor fittings. A back-up manual inflation handle is provided on each door slide should the slide fail to inflate automatically.

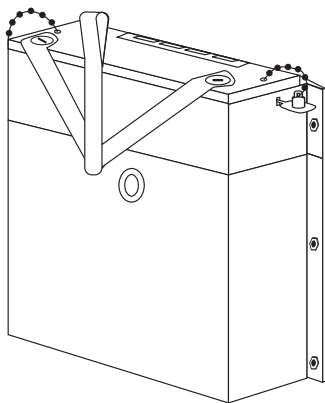
When the aft cabin door is opened using the emergency exit handle, the tailcone is jettisoned and a slide is automatically inflated. A back-up inflation handle is provided on the slide should the slide fail to inflate automatically. All door slides have integral emergency lighting.

Protective Breathing Equipment (PBE)

Four PBEs, one in the flight deck, and three in the passenger cabin are designed to protect crew members from the effects of smoke, carbon dioxide, or other harmful gases while combatting fires.

PBE Container

The preflight consists of inspecting the two red seals and ensuring the PBE is intact. If one seal is broken, the PBE is okay for flight, but the second seal must be installed at the next Delta maintenance station. There is no visual service indicator



To operate the PBE:

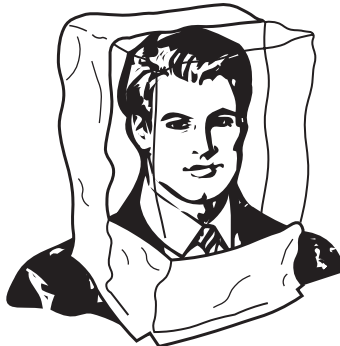
- Remove the pouch from the compartment.
- Open the pouch by pulling the loose ends apart.

- Remove and unfold the hood.
- Position the hood so the clear side is facing downward, with the neck opening positioned toward you
- Activate the oxygen flow by pulling apart the two oxygen cylinders sharply. The cylinders are activated simultaneously when pulled apart. One cylinder discharges rapidly to purge the hood of any contaminated air. In order to receive the full benefit of purging, you must get the hood on quickly (within 15 seconds). The second oxygen cylinder releases slowly, lasting 7 - 8 minutes. After both cylinders have fully discharged, the hood provides an additional 7 - 8 minutes of breathable air.
- Insert hands, palms together, into the neck opening and spread/separate hands to enlarge opening
- Slip hood over your head.
- Verify oxygen flow by illumination of the green light located inside lower front of mask. If flow were to stop, green light would still be on.

Special Considerations

Once the hood is activated and donned, be aware of the following:

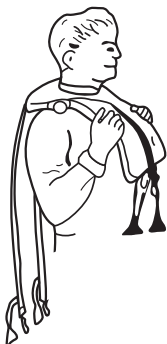
- A good neck seal is important; long hair should be pushed into the hood.
- Your ears may pop as the hood is pressurized.
- You may experience light headedness; this is due to the relatively high oxygen content in the hood.
- You may feel warm inside the hood from the combined warmth of your body temperature, your exhaled breath and chemical process within the hood.
- Normal interphone and face-to-face communication procedures are recommended. Use the hand held mic with both flight deck speaker volumes high.
- A flashing red light illuminates after 15 minutes, indicating the oxygen supply depleted. Leave the area, if possible, then remove the hood.



Flotation Equipment

Red life vests are located adjacent to each crew seat. Passenger seat cushions may also be used as a flotation device. Straps are provided on the underside as handholds.

Yellow life vests are located under each passenger seat. Spare life vests are located behind the last row of first class seats on the left side of the aircraft.



LIFE VEST

- (1) Put vest on over head with back piece behind.

LOCATOR LIGHT

- (2) Fasten snaps to ring in front.



- (3) Pull straps snug.



- (4) After leaving aircraft, inflate vest by pulling down sharply on red inflation tabs or by blowing into oral tubes.

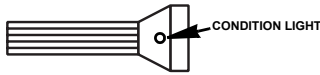
For night use only - pull light tab to activate battery.



INFLATION TABS

Flashlights

Five emergency flashlights are located in the cabin. They are mounted in holders with an anti pilferage shield over each unit. A blinking red light on the flashlight indicates a serviceable battery in the unit. The flashlight illuminates continuously when removed from its holder.



Fire Extinguishers

Portable fire extinguishers include three halon 1211 and two water extinguishers. The halon 1211 extinguisher can be used on all types of fires. The water extinguishers are designed for use on smoldering trash fires and are more effective than halon on these fires.

Lavatory Trash Container Extinguisher

A self activating fire extinguisher is installed with the trash bin in each lavatory. A temperature sensitive indicator is installed adjacent to each unit to show when it has been activated.

Emergency Locator Transmitter (ELT)

Passenger Cabin

One emergency locator transmitter is installed in the cabin.

Flight Deck

One emergency locator transmitter is installed in the flight deck.

ELT Operation

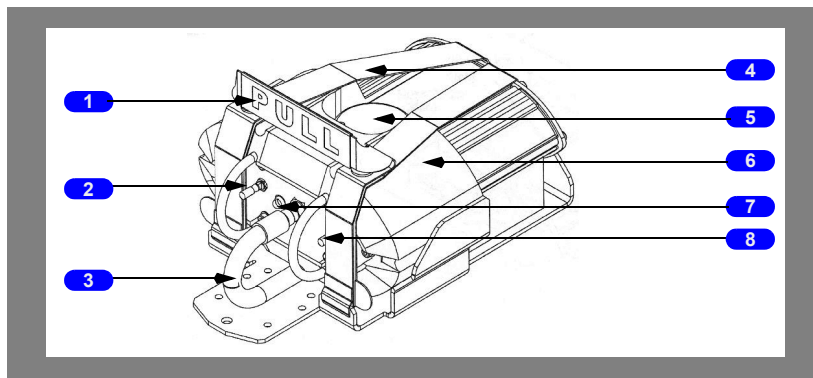
CAUTION: Use caution when removing ELT from support bracket. Whip antenna release can cause injury.

- (1) To remove the ELT from the bracket, pull the fabric harness release to unsnap the straps and lift it out by pulling on one of the metal loop shaped handles while holding on to the antenna with the other hand.
- (2) If the toggle switch is in the ARMED position and the ELT is submerged in water, the water sensor will activate transmission. The ELT can be activated at any time by manually positioning the toggle switch to the ON position.

- (3) When in use, check regularly that the antenna is vertical. For maximum transmission power, the antenna must be in an unobstructed area far from any metallic objects.

Note: Due to its portability, the ELT can be taken with the crew after a ditching or land evacuation.

Portable ELT System Description



- 1 Harness Release**
- 2 ELT Mode Switch (ARMED/OFF/ON)**
- 3 Whip Antenna**
- 4 Velcro Harness**
- 5 Water Sensor/Identification Assembly**
- 6 Float**
- 7 Transmit LED**
- 8 TEST Push Button**

Emergency and Cabin Equipment Symbols



PORTABLE
OXYGEN BOTTLE



WATER
EXTINGUISHER



HALON
EXTINGUISHER



PORTABLE
BREATHING
EQUIPMENT



EXIT PATH
WITHOUT ESCAPE
STRAP



EXIT PATH
WITH ESCAPE
STRAP



EXIT PATH
WITH ESCAPE
SLIDE



LIFE RAFT



LIFE
VEST



EMERGENCY
TRANSMITTER



CRASH
AXE



FIRST AID
KIT



RED
MEDICAL
ACCESSORY
POUCH



AED



ENHANCED
EMERGENCY
MEDICAL
KIT



CABIN
DISCREPANCY
LOG



SECURITY
KIT



FLASHLIGHT



WHEELCHAIR

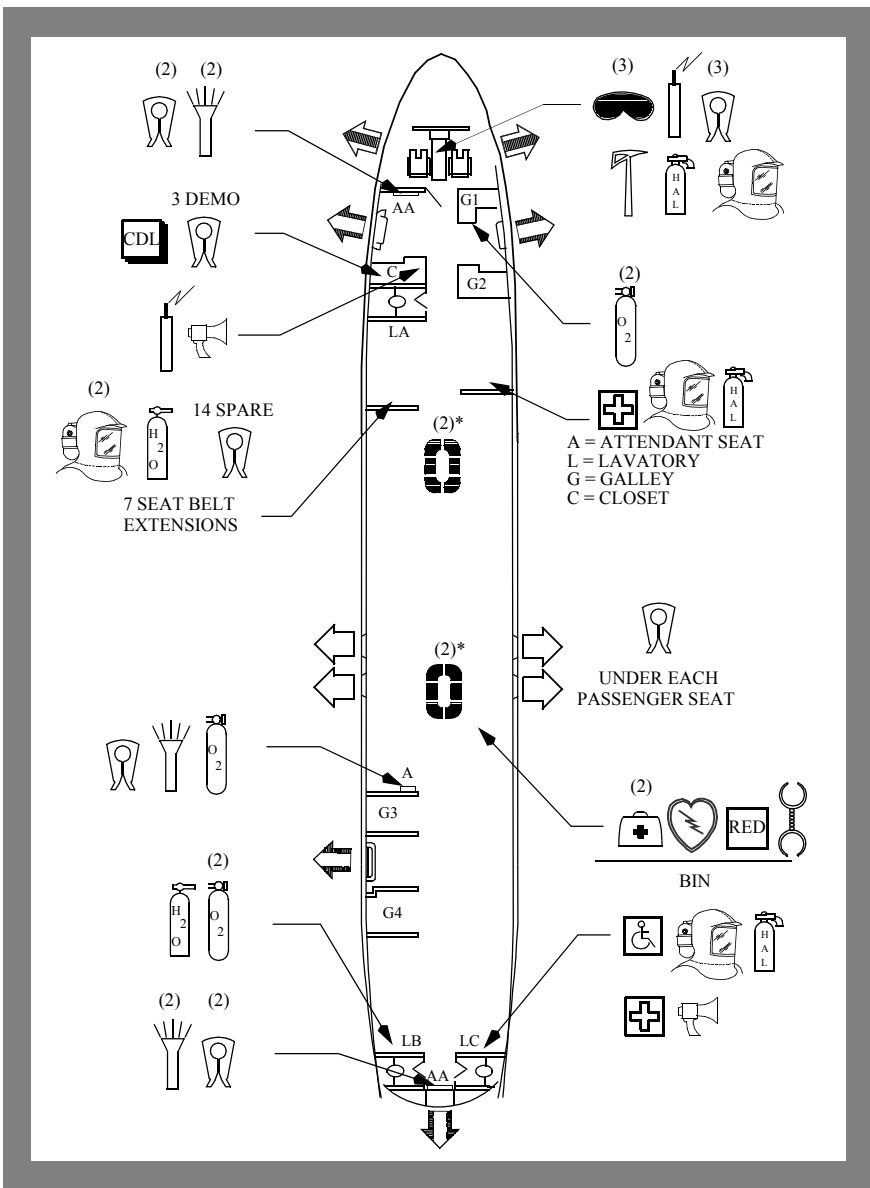


MEGAPHONE

NOTE: SOME SYMBOLS DO NOT APPLY TO ALL CONFIGURATIONS.

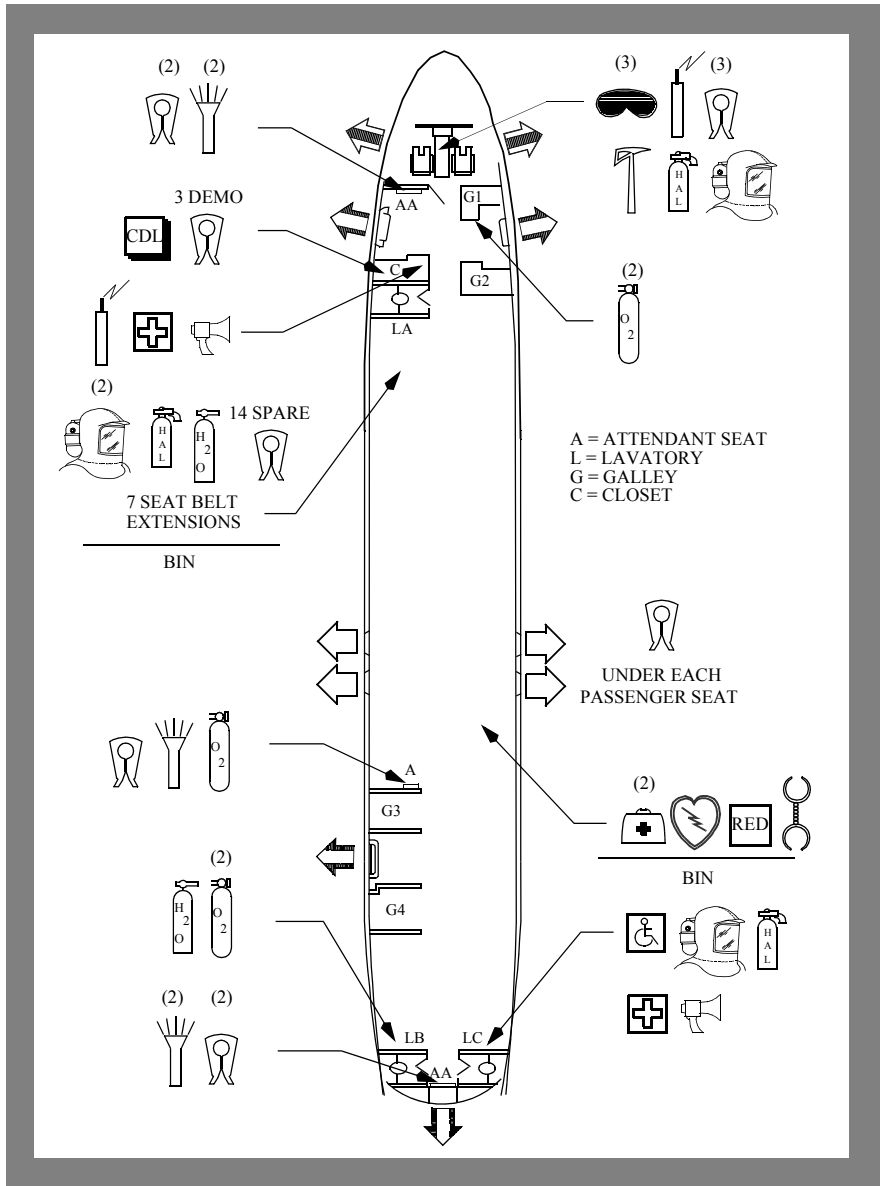
Emergency and Cabin Equipment Locations

Two Class Configuration



* Denotes overwater configuration.

One Class Configuration



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**Aircraft General, Emergency
Equipment, Doors, Windows
OAP Messages/Lights**

Chapter 1

Section 50

OAP Messages/Lights

Blue Advisory Lights

CABIN OXYGEN ON - Left and right aft cabin oxygen door latches have been activated.

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

ACCESS COMPT DOOR (DOOR) - Access compartment door is not closed.

AFT CABIN DOOR (DOOR) - Passenger aft entrance door is open and/or unlatched.

AFT CARGO DOOR (DOOR) - Aft cargo door is not closed and/or latched.

AFT GALLEY DOOR (DOOR) - Aft galley door is not closed and/or latched.

AFT STAIRWAY DOOR (DOOR) - Stairway door is unlatched.

ALL DOORS CLOSED (DOOR) - DOOR cue light is pushed and all doors are closed and latched.

ELECT COMPT DOOR (DOOR) - Electrical compartment door is not closed and/or latched.

EMER LIGHT NOT ARMED (ELEC) - Indicates DC power is available to aircraft and EMER LTS switch on overhead panel is not at ARM position.

FWD CABIN DOOR (DOOR) - Forward cabin door is not closed and/or latched.

FWD GALLEY DOOR (DOOR) - Forward galley service door is open and/or unlocked.

FWD CARGO DOOR (DOOR) - Forward cargo door is not closed and/or latched.

FWD STAIRWAY DOOR (DOOR) - Forward stairway door is not closed and/or latched.

MID CARGO DOOR (DOOR) - Mid cargo door is not closed and/or latched.

TAILCONE UNSAFE (DOOR) - Tailcone is unlatched or compromised.

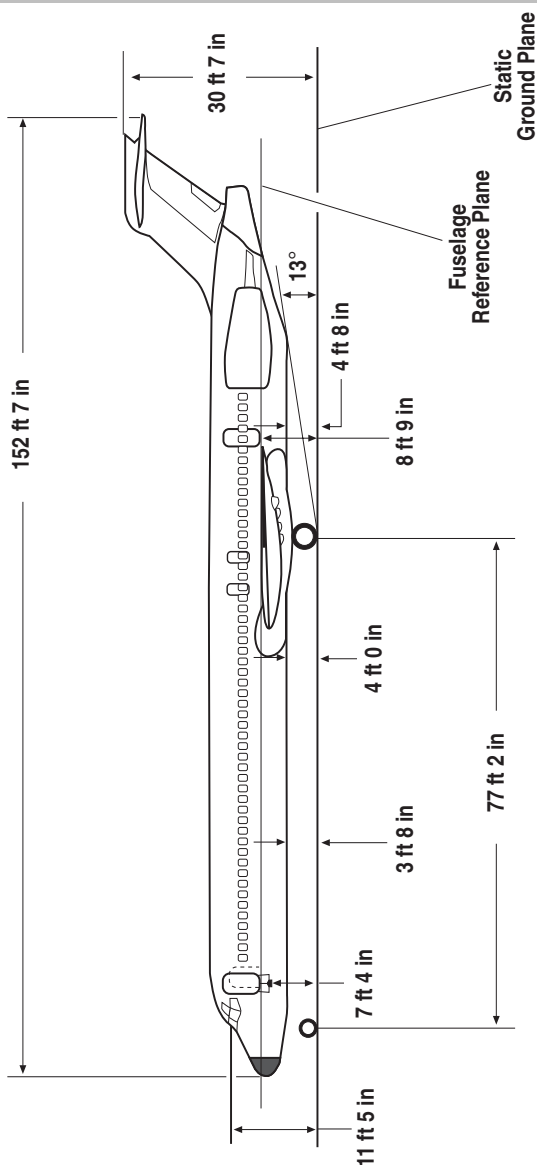
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Airplane General, Emergency Equipment, Doors, Windows MD-90 Differences

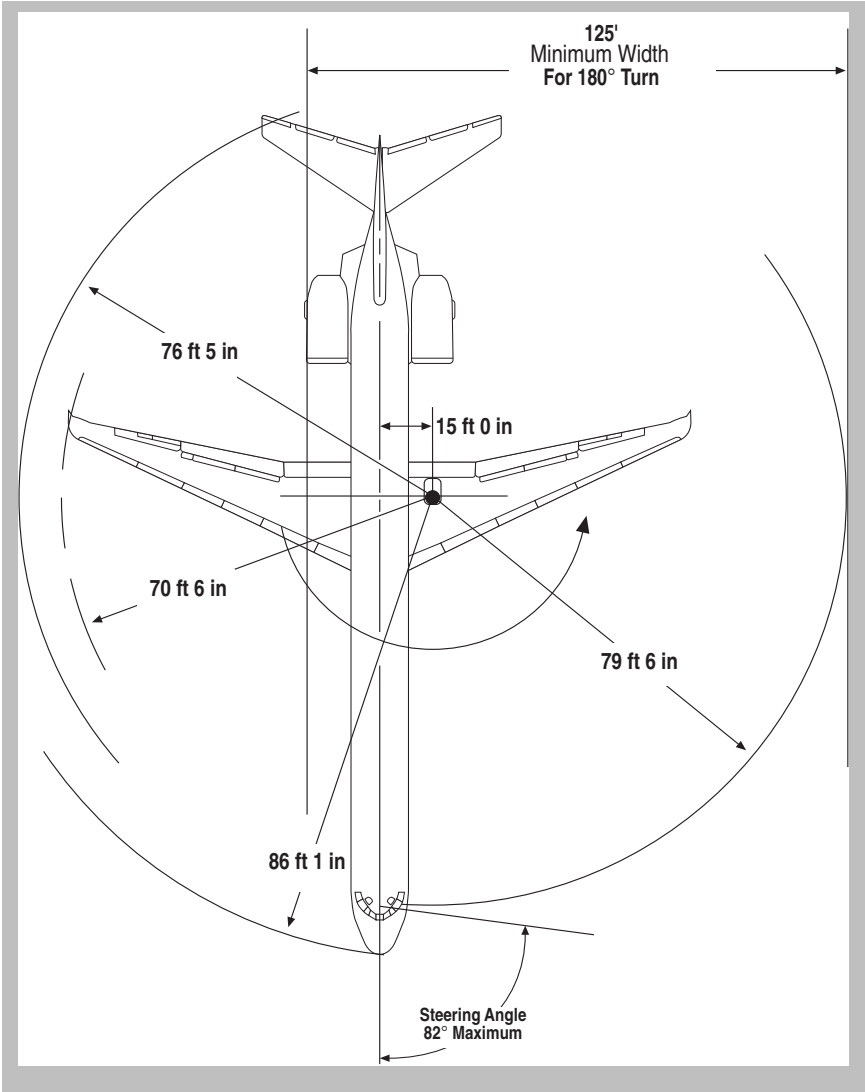
Chapter 1

Section 90

Principle Dimensions

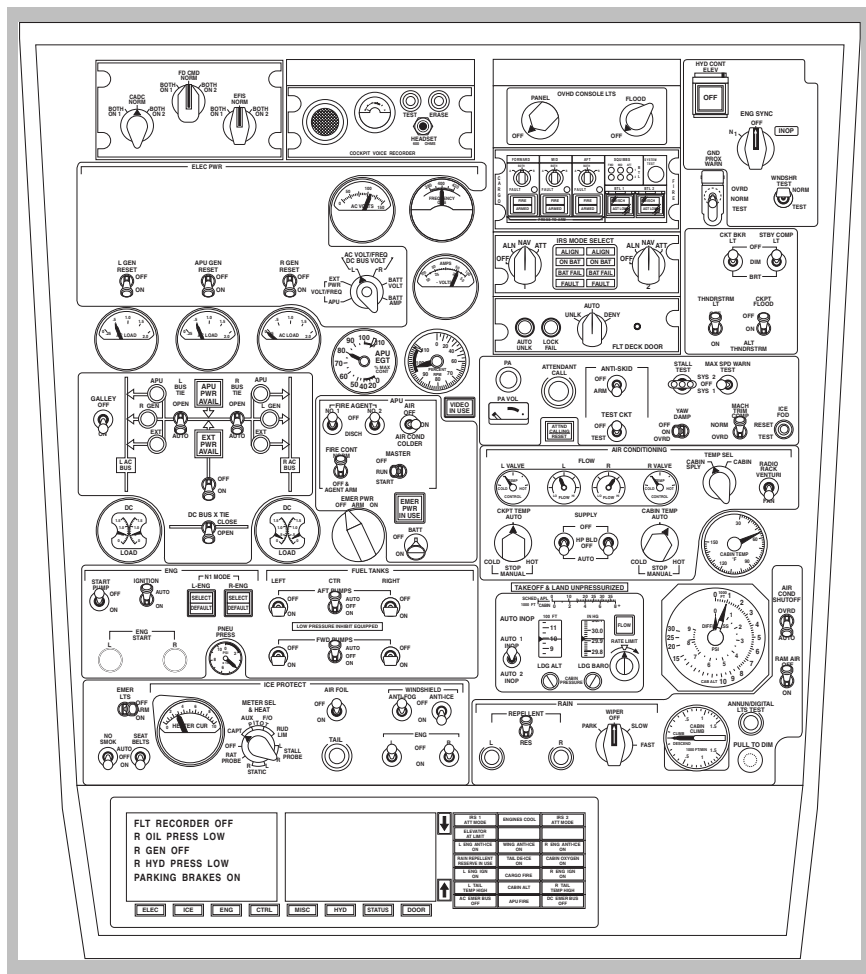


Turning Radius

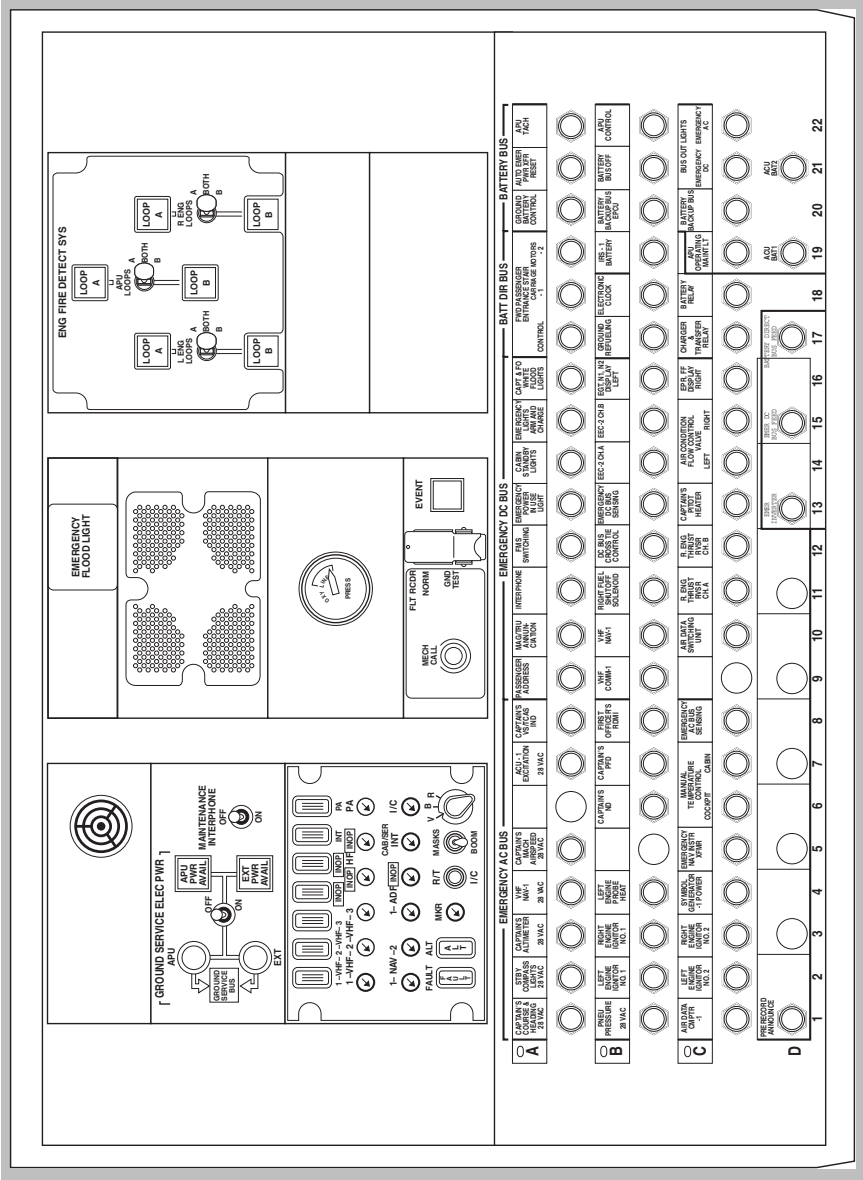


Instrument Panels

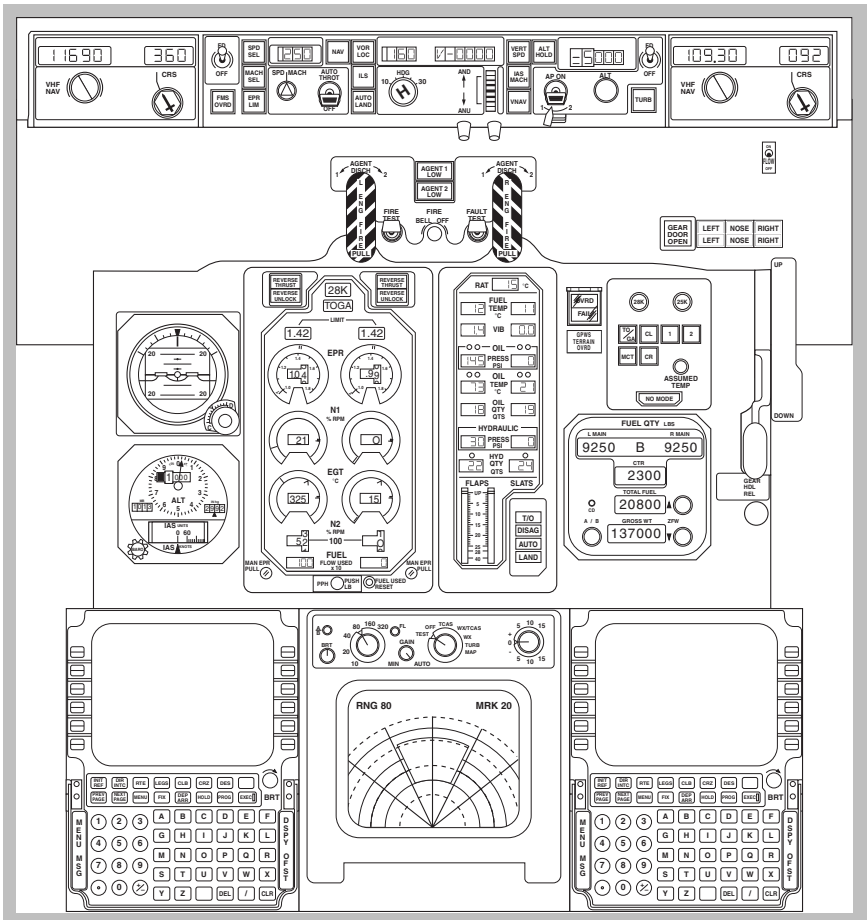
Forward Overhead Panel



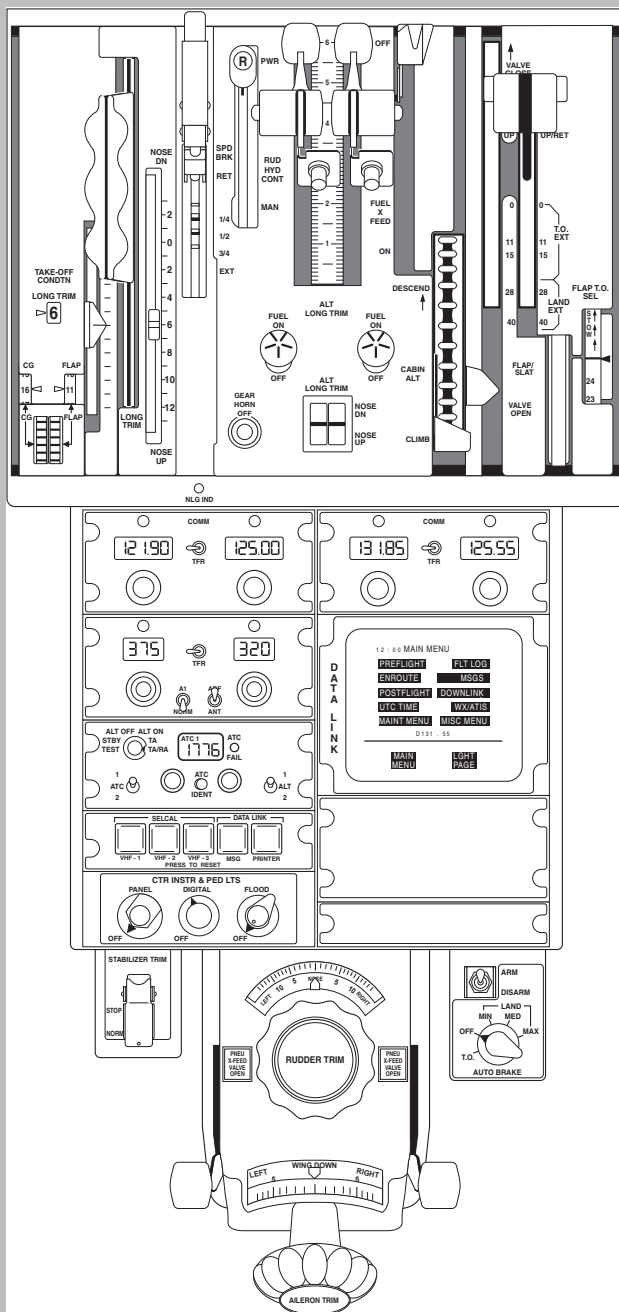
Aft Overhead Panel



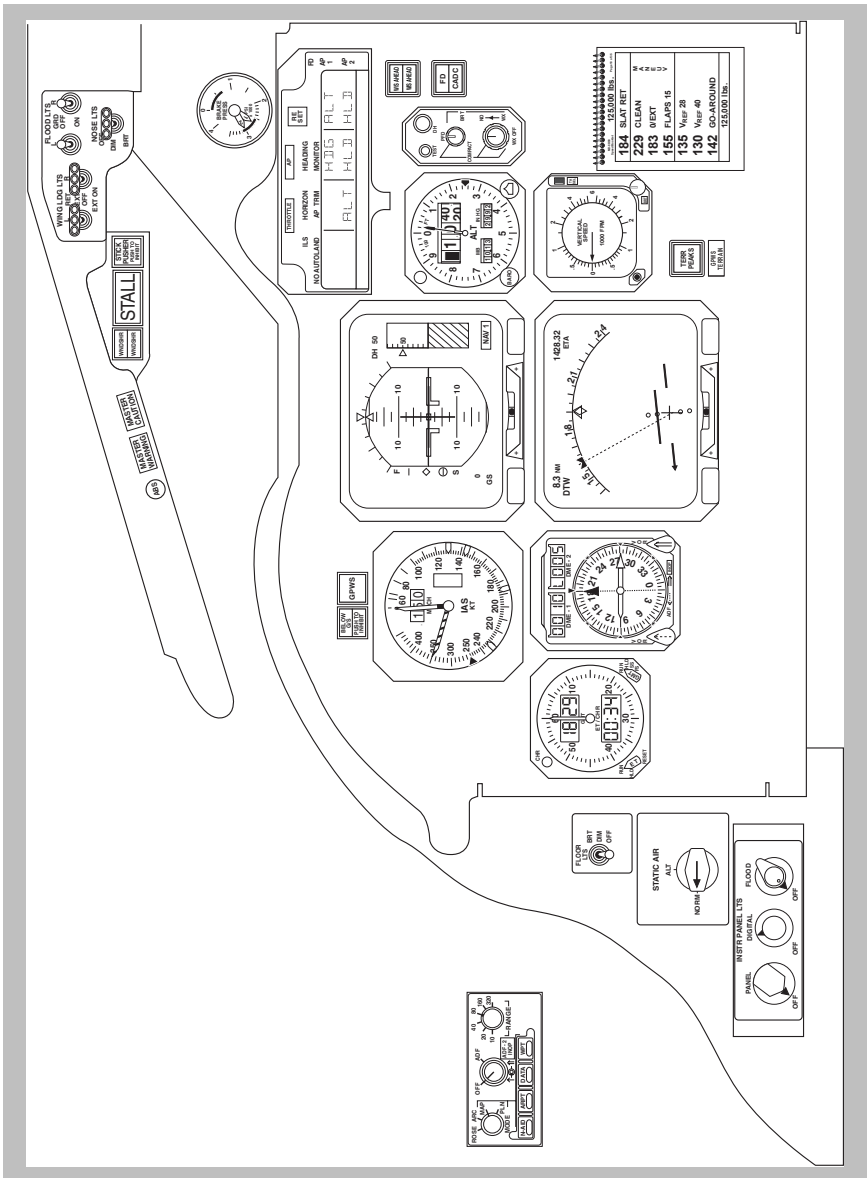
Center Instrument Panel



Aft Pedestal

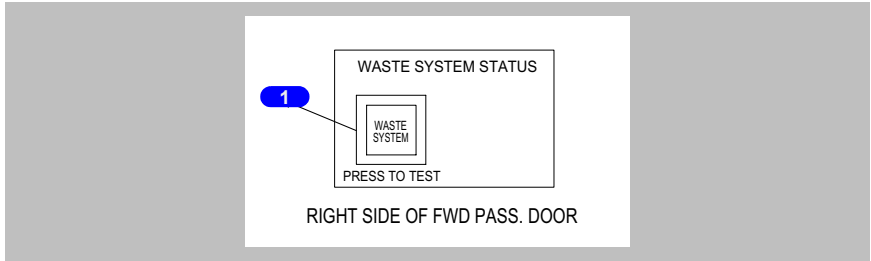


Captain's Instrument Panel



Controls and Indicators

Lavatory

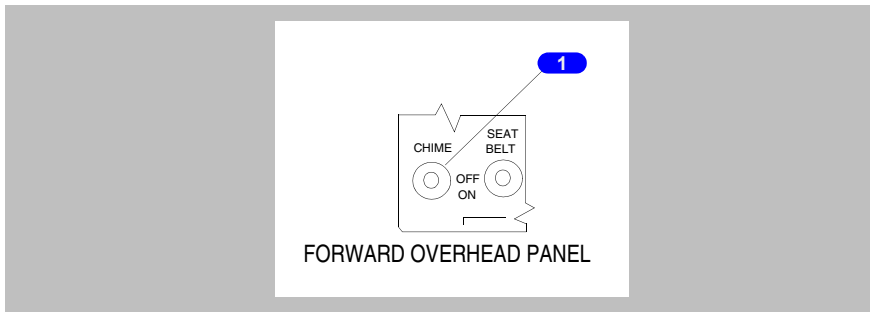


1 WASTE SYSTEM Switch/Light

Indicates the waste system is inoperative.

PRESS TO TEST - Pushing the switch initiates a waste system BITE test. A successful test is indicated by the illumination of the WASTE SYSTEM light 5 seconds after pushing the switch, then the extinguishing of the light.

Passenger Information Signs



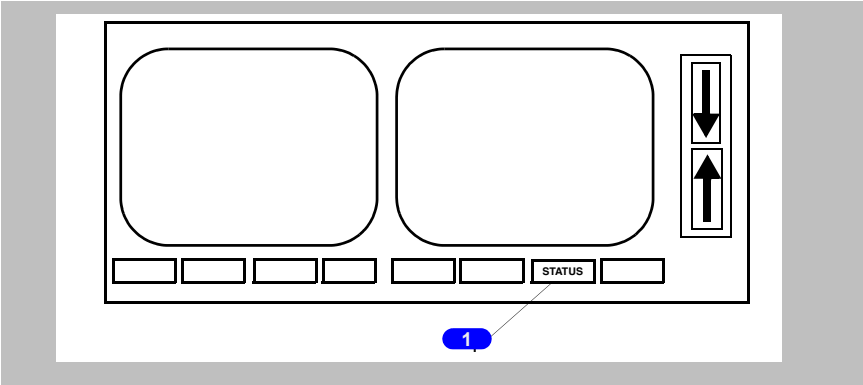
1 CHIME Switch

AUTO - Chime sounds when landing gear is extended.

OFF - Deactivates chime.

ON - Activates chime.

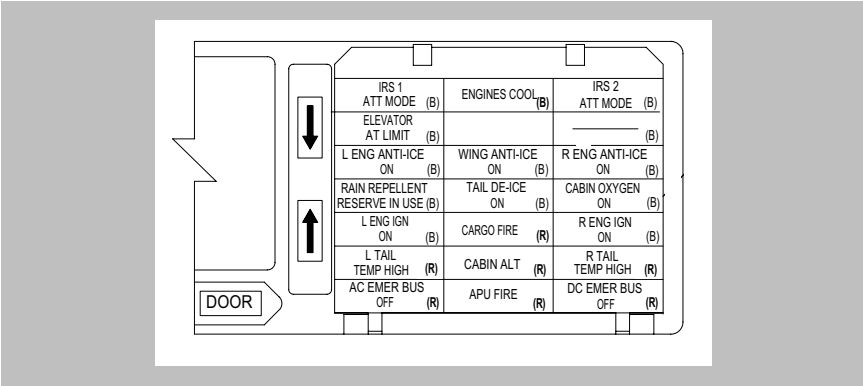
EOAP (Sheet 1))



1 Status Cue Light (blue)

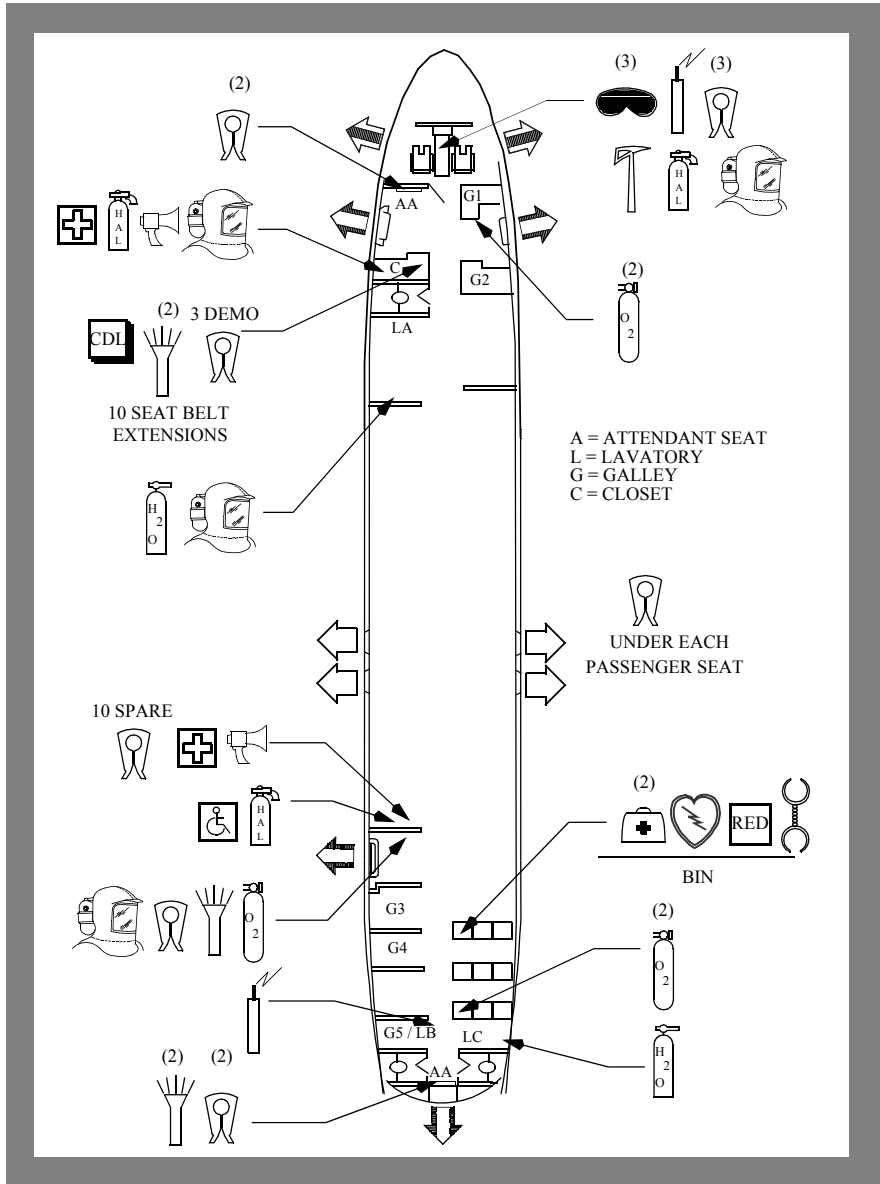
Status cue light illuminates when a second level message is stored in the status buffer (status requires no crew action). Status buffer messages may be reviewed by pressing STATUS cue.

EOAP (Sheet 2))



Systems Description

Emergency and Cabin Equipment Locations



Lavatory Smoke Detection

Each lavatory is equipped with a smoke detector. When smoke in a lavatory is detected, four chime-type tones will be sounded by the PA system and an amber light, located on the ceiling adjacent to the lavatory, will illuminate. A red light will also illuminate on the forward and aft cabin attendant's call-light fixture. These lights/annunciation will remain until the smoke in the lavatory has dissipated.

Passenger Entertainment System

Music may be played over the passenger address system. The music is turned on and off and the volume is controlled by operation of the MUSIC OFF/ON volume control located on the forward cabin attendants' control panel.

A VU meter, located on the flight deck overhead panel and the forward and aft cabin attendants' panels, provides an indication of passenger entertainment system audio output level.

Note: PA and passenger entertainment system volume level is automatically boosted when either engine is started.

Air Systems

Chapter 2

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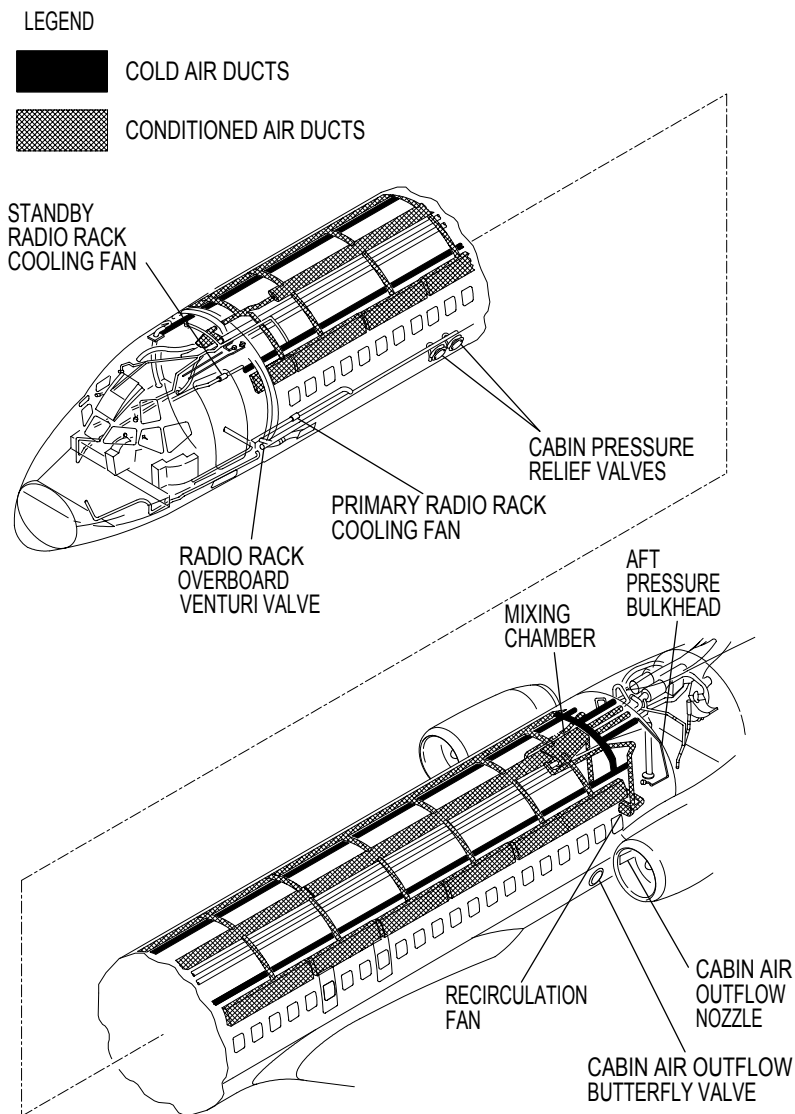
Air Systems

Chapter 2

Controls and Indicators

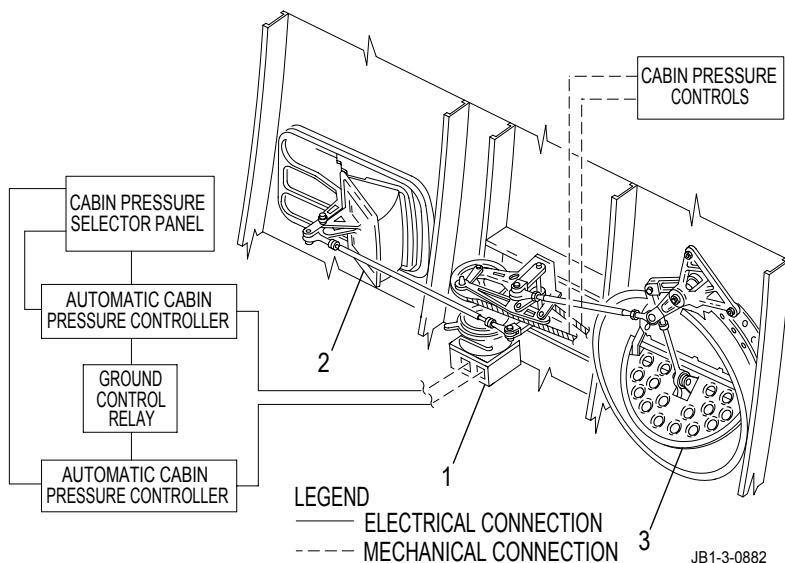
Section 10

Major Component Location



JB1-3-0881

Cabin Pressure Components



1. Actuator

Automatic Pressurization Control - Receives input from the cabin pressure selector panel through either the primary or the standby controller. Adjusts the outflow butterfly valve and/or nozzle opening to maintain the required pressurization.

Manual Pressurization Control - The actuator is declutched.

2. Cabin Air Outflow Valve Nozzle

The variable opening controls pressurization.

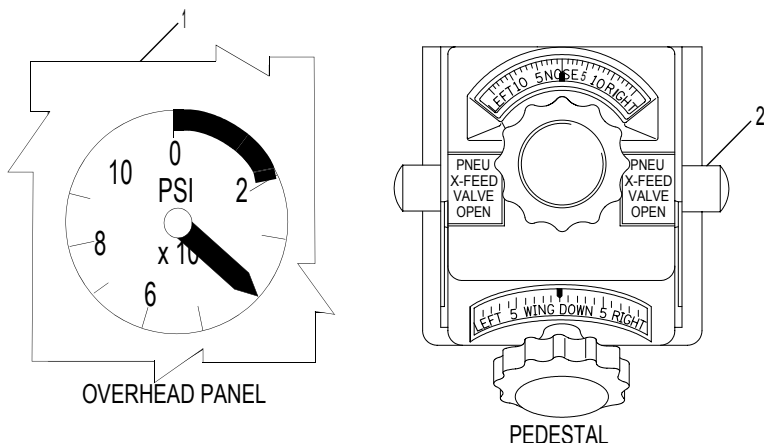
NOTE: The outflow nozzle and the butterfly valve are mechanically interconnected in order to operate in proper sequence.

3. Cabin Air Outflow Butterfly Valve

Initially controls pressurization and provides for full depressurization.

NOTE: The butterfly valve and the outflow nozzle are mechanically interconnected in order to operate in proper sequence.

Pneumatic Pressure Gauge and Crossfeed Valve Levers



JB1-3-0958

1. PNEU PRESS Gauge

Indicates pneumatic pressure in the crossfeed manifold available for systems operation.

2. L/R PNEU X-FEED VALVE Lever

OPEN - Opens respective X-FEED valve.

On the ground, supplies APU bleed air or air from a pneumatic ground source for operation of one or both air conditioning packs, and for engine start.

In flight, supplies the bleed air requirements for airfoil ice protection.

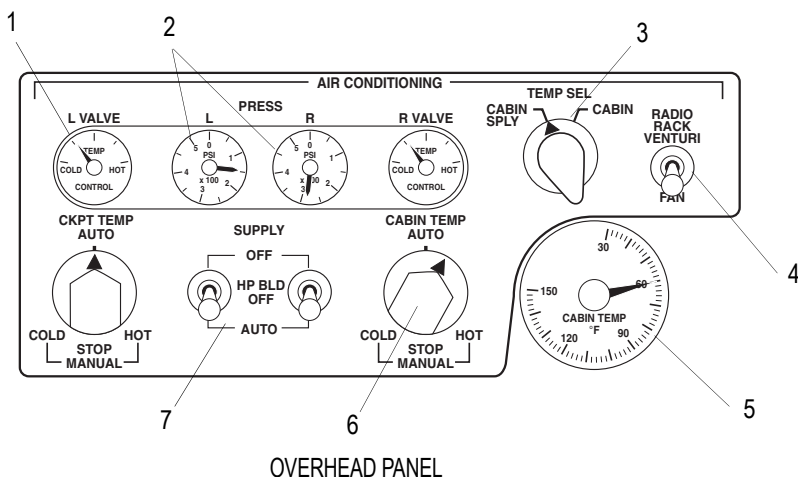
CLOSED - Closes respective X-FEED valve.

On the ground, shuts off APU bleed air or air from a pneumatic ground source used for operation of one or both air conditioning packs, or for engine start.

In flight, shuts off bleed air supply for the airfoil ice protection system and for opposite engine pneumatic starts. Air conditioning pack pneumatic supply is from its respective engine only.

***NOTE:** Pneumatic crossfeed valve may be set in any position from fully open to fully closed.*

Air Conditioning Panel



1. L/R VALVE TEMP CONTROL Indicator

Indicates position of temperature control valve.

COLD - Temperature control valve is closed and blocking hot air supply.

HOT - Temperature control valve is fully open to allow maximum hot air supply.

2. L/R PRESS Gauge

Indicates pneumatic supply pressure available for operation of each air conditioning system.

3. TEMP SEL Display Selector

CABIN SPLY - Selects cabin supply duct temperature to be displayed on the CABIN TEMP gauge.

CABIN - Selects cabin temperature to be displayed on the CABIN TEMP gauge.

4. RADIO RACK Switch

NOTE: On the ground, both primary and standby radio rack fans are on, and the venturi valve is closed.

VENTURI - (Inflight) Turns off radio rack fan. Opens venturi valve.

FAN - (Inflight) Turns on primary radio rack fan and closes venturi valve to cool radio rack and heat forward cargo compartment. If the primary fan fails in flight, the standby radio rack fan automatically comes on.

5. CABIN TEMP Gauge

Indicates cabin temperature or cabin supply duct temperature, as selected with the cabin TEMP SEL display selector.

6. CKPT/CABIN TEMP Selector

AUTO - Temperature automatically adjusts toward HOT or COLD when the selector is moved left or right of the index mark.

MANUAL (COLD/STOP/HOT) - Spring loaded to stop. In MANUAL, momentarily moving the selector toward HOT or COLD opens or closes the temperature control valve. This is displayed on the L/R VALVE TEMP CONTROL indicator.

7. L/R SUPPLY Switch

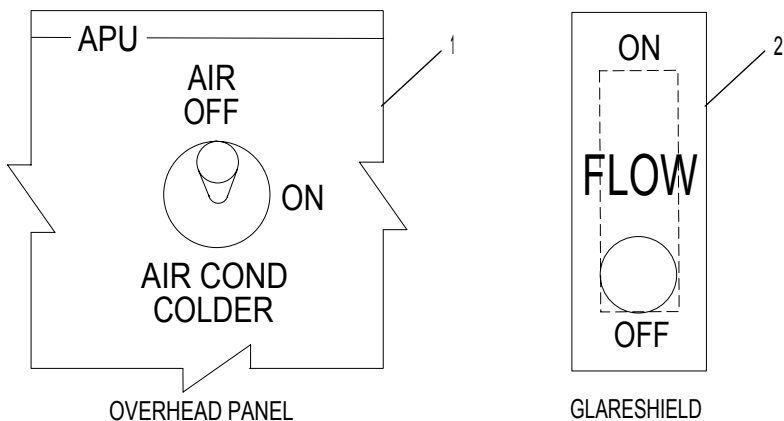
OFF - Closes the air conditioning pressure regulator and flow control valve. On the ground, turns off the heat exchanger cooling fan.

HP BLD OFF - Opens the air conditioning pressure regulator and flow control valve, and, when the airplane is on the ground, turns on the heat exchanger cooling fan. Closes the augmentation valve.

AUTO - Opens the air conditioning pressure regulator and flow control valve, and, when the airplane is on the ground, turns on the heat exchanger cooling fan. If the low stage pneumatic supply pressure is too low, the augmentation valve opens to supply the pressure.

NOTE: During airfoil ice protection (PNEU X-FEED VALVE(s) OPEN and AIR FOIL switch in ON) the augmentation valve opens and temperature and pressure are provided by high stage bleed air regardless of the position of the air conditioning supply switch(es).

APU Air Switch and Air Flow Indicator



JB1-3-0887

1. APU AIR Switch

OFF - Closes APU air shutoff valve to isolate the APU from the airplane pneumatic system.

ON - Provides APU bleed air to the airplane crossfeed manifold.

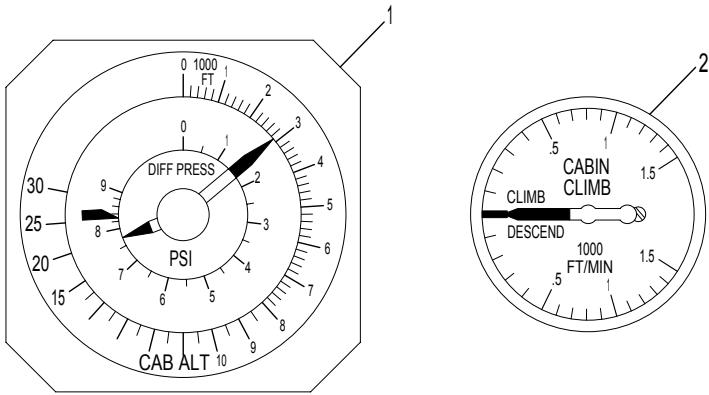
AIR COND COLDER - Closes turbine bypass valves and increases differential pressure across the air conditioning turbine for additional cooling air capacity during ground operation.

2. Instrument Cooling Air FLOW Indicator (Ground Only)

ON - With both air conditioning packs OFF, indicates instrument cooling air flow provided by the instrument cooling fan.

OFF - With both air conditioning packs OFF, indicates a failure of the instrument cooling fan.

Cabin Altitude/Differential Pressure Gauge and Cabin Climb Gauge



OVERHEAD PANEL

JB1-3-0889

1. CAB ALT/DIFF PRESS Gauge

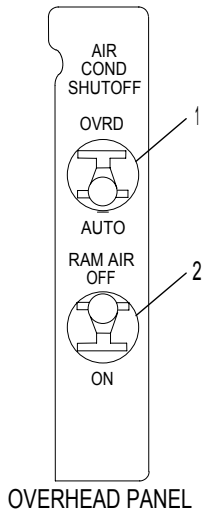
CAB ALT - Indicates existing cabin altitude.

DIFF PRESS PSI - Indicates the differential pressure in psi between cabin pressure and ambient pressure.

2. CABIN CLIMB Gauge

Indicates the rate of change in cabin altitude.

Air Conditioning Shutoff Switch and Ram Air Switch



JB1-3-0888

1. **AIR COND SHUTOFF Switch**

OVRD - Deactivates automatic shutdown of air conditioning packs.

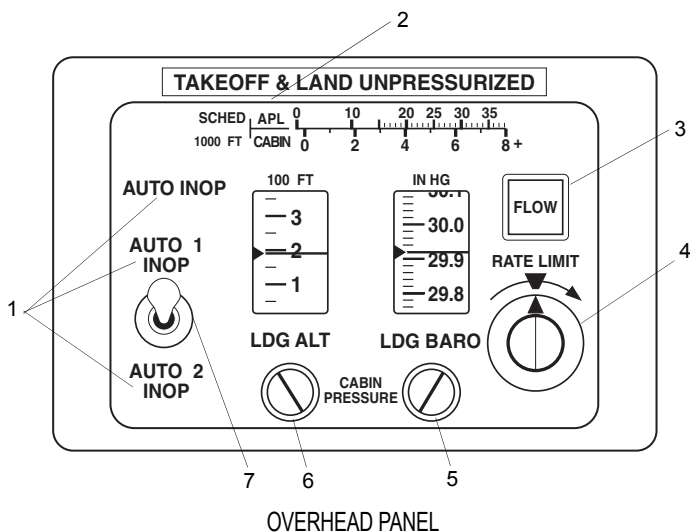
AUTO - Automatically shuts down packs if either engine fails during takeoff.

2. **RAM AIR Switch**

OFF - Closes ram air valve.

ON - Opens ram air valve and allows ram air to enter the conditioned air ducts in the right air conditioning system at a point prior to the mixing chamber.

Cabin Pressure Control Panel



1. CABIN PRESSURE System Selector Panel

AUTO INOP (amber) - Illuminates when both automatic systems fail. Pressurization is manually monitored and controlled.

INOP (2) (blue) - Illuminates when that system fails. The standby system automatically controls pressurization.

2. APL/CABIN Altitude Scale

Scale shows relationship between airplane altitude and cabin altitude in thousands of feet.

3. FLOW Light (amber)

Illuminates with a closed outflow valve and a cabin climb rate is detected.

4. RATE LIMIT Control Knob

Adjusts cabin climb/descend rate. At index mark, climb rate is 700 fpm and descent rate is 300 fpm.

Cabin climb rates between 50 and 2000 fpm and descent rates between 21 and 857 fpm are available for selection.

5. LDG BARO Knob and Window

Turn to select destination barometric pressure. Selection displays in IN HG window.

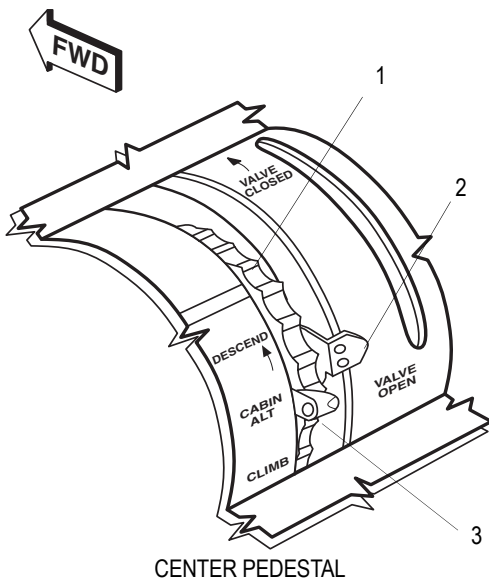
6. LDG ALT Knob and Window

Turn to select destination airport altitude. Selection displays in 100 FT window.

7. CABIN PRESSURE System Selection Switch

Used to select either AUTO 1 or AUTO 2 as the primary system. The remaining system is the standby system.

Cabin Altitude Control



1. CABIN ALT Control Wheel

When cabin altitude control is selected to auto, the control wheel rotates as the cabin air outflow valve automatically adjusts to maintain cabin altitude.

When cabin altitude control is selected to manual, the control wheel is locked in position. To adjust cabin altitude, push down on the control wheel and rotate in the desired direction.

2. Outflow Valve Position Indicator

Indicates position of cabin air outflow valve.

3. CABIN ALT Control Lever

Used to select automatic or manual cabin altitude control.

When moved up, cabin altitude is automatically controlled. When moved down, cabin altitude is manually controlled by rotating the control wheel.

Air Systems

Chapter 2

System Description

Section 20

Pneumatic System

In flight pneumatic pressure is supplied by the low (8th) or high (13th) stage compressors of both engines. Normally, bleed air from the left and right engines is supplied to the respective air conditioning systems. Bleed air from both engines is supplied to the ice protection system simultaneously. Pneumatic crossfeed valves permit operation of the air conditioning systems and ice protection system from either engine.

An augmentation valve automatically regulates the flow of high stage bleed air into the system when low stage bleed air is not sufficient to satisfy flow or temperature requirements.

APU bleed air is normally used only for engine starting and for ground air conditioning when the engines are not operating.

Air Conditioning Systems

The airplane has two identical air conditioning systems. Normally the right system operates from right engine bleed air and controls the cabin temperature. The left system operates from left engine bleed air and controls the cockpit temperature. Either system is capable of supplying the requirements of both compartments.

Pack pressure gauges indicate air conditioning supply for each (L/R) system. A flow control valve for each operating pack limits maximum air flow. Two air conditioning SUPPLY switches, one for each system, open or close the respective pressure regulator and flow control valve. When moved to OFF, the pressure regulator and flow control valve closes. When moved to either the HP BLD OFF or AUTO position, the pressure regulator and flow control valve opens.

System Protection

Both air conditioning packs automatically shutdown if an engine fails with a cabin differential pressure of less than 1.3 psid.

NOTE: Excessive thrust during one engine taxi may activate this automatic shutdown circuit and shut off both packs. Subsequent thrust reduction will restart the packs.

Thermal shutdown switches protect the air conditioning systems against overheating. When air conditioning temperatures are excessive, the air conditioning pressure regulator and flow control valve close, preventing bleed airflow to its respective system.

Finally, if cooling airflow is not registered across a heat exchanger, the respective pack flow control valve will close, tripping the pack. With this trip, supply pressure continues to be indicated on the respective AIR CONDITIONING PRESS gauge.

RAM Air

In flight, with air conditioning packs inoperative, the RAM AIR system may be used to ventilate the airplane. Moving the RAM AIR switch on the overhead panel to ON opens the ram air valve located in the right heat exchanger cooling duct. This allows ram air to enter the mixing chamber for airplane ventilation.

Air Distribution

The air distribution system uses both cold air and conditioned air.

Cold air from the pack is ducted to individual eyeball outlets for each passenger and an overhead vent for each crew member.

Hot air is mixed with cold air to create conditioned air, which is distributed throughout the airplane to satisfy air conditioning requirements. Conditioned air from the air conditioning systems passes through a mixing chamber for distribution to the cabin and cockpit. Conditioned air for the cabin is discharged from outlets below the overhead bins, and from an overhead vent in the cabin entryway. Conditioned air for the cockpit is discharged through two adjustable nozzles adjacent to the instrument panel, and one adjustable overhead diffuser.

In flight, a recirculating fan, located forward of the rear pressure bulkhead, returns the cabin air to the overhead ducts for recirculation to the cabin only. The recirculating fan has no cockpit controls or indicators.

Cockpit and Cabin Temperature Control

Cockpit and cabin temperatures are controlled from the cockpit. Temperatures may be adjusted in either AUTO or MANUAL mode with the CKPT TEMP and CABIN TEMP selectors.

When operating in the AUTO mode, a temperature range of 65°F to 80°F is available.

When operating in the MANUAL mode, the CKPT TEMP and CABIN TEMP selectors are spring-loaded to the STOP position and must be momentarily held in HOT or COLD positions until the desired temperature is obtained.

A CABIN TEMP gauge displays temperature in the cabin or cabin supply ducting, as selected by the cabin TEMP SEL switch.

When operating on emergency power, cabin and cockpit temperatures are controlled in the MANUAL mode only.

Radio Rack Cooling Fans

Cockpit exhaust air cools the electronic equipment in the electrical/electronic (E/E) compartment. This air is drawn through the E&E compartment by a primary radio rack fan and a standby radio rack fan. During flight, only the primary fan operates.

In flight, with the RADIO RACK switch in FAN, failure of the primary fan causes the standby fan to automatically operate. A failure of both fans causes the RADIO FAN OFF message to be displayed on the overhead annunciator panel (OAP). With the RADIO RACK switch in VENTURI, the venturi valve (normally closed with switch in FAN) opens, thus allowing the air to exhaust overboard. When VENTURI has been selected, the RADIO FAN OFF message is canceled.

During ground operation both fans operate. The RADIO FAN OFF message is displayed only when there is a failure of the primary fan.

Instrument Cooling Fan

Instrument cooling is normally provided by the air conditioning system; however, on the ground with neither pack operating, instrument cooling is provided by an integral fan (which operates only on the ground) located under the First Officer's flight kit stowage area. Flow from the cooling fan is indicated by an indicator above the First Officer's instruments.

Pack Cooling

The heat exchanger fans (which operate only on the ground) provide cooling air to the respective heat exchangers when the air conditioning systems are operating on the ground. With an air conditioning SUPPLY switch moved from OFF, the respective fan automatically operates.

The left heat exchanger cooling fan draws cooling air from the ram air scoop at the base of the vertical stabilizer. To reduce tail compartment temperatures, the right heater exchanger cooling fan draws air from the tail compartment area. Air enters the tail compartment through louvers on the empennage.

In flight, cooling air enters the ram air scoop, then is ducted to the heat exchangers for both packs where it is exhausted overboard.

Ground Sources for Air Conditioning

There are three methods used to cool the aircraft on the ground:

- using a conditioned air source connected at either the left side of the fuselage at the mid cabin area or at the right rear of the aircraft.
- using the APU pneumatics to operate the packs or,
- using an external pneumatic source connected at the aft left side of the fuselage to run the packs.

APU Air Conditioning

The APU can be used to supply pneumatics for air conditioning during ground operations only.

The APU AIR switch, in the ON position allows the APU to supply air to the pneumatic system. The OFF position shuts off supply air. The AIR COND COLDER position closes both pack turbine bypass valves. This allows for reduced conditioned airflow at a cooler temperature. Since both valves close, the AIR COND COLDER position of the APU AIR switch may not be used in conjunction with engine operation which could overspeed the packs.

Airplane Pressurization

A pressurization system, consisting of two identical but independent controllers, is powered from different electrical sources. The selected system maintains primary control, while the other system serves as a standby.

With at least one pack operating, pressurization levels are maintained by regulating escape air through the cabin air outflow valves. Normally, the outflow valves are automatically positioned by the pressurization system.

For automatic operation of the outflow valves, the CABIN ALT control lever must be in the up position. The CABIN ALT control wheel rotates as the system automatically adjusts to maintain pressurization. An outflow valve position indicator next to the wheel moves to indicate valve position.

If the selected cabin pressure controller fails, a blue INOP light on the cabin pressure selector panel illuminates below the failed system and an automatic transfer occurs. If both systems have failed, a blue INOP light illuminates below each system and an amber AUTO INOP light also illuminates.

For manual operation, the CABIN ALT control lever must be placed to the down position. The wheel is pressed down and rotated in the desired direction. The indicator moves in the same direction to indicate outflow valve position.

Dual pressure relief valves protect the airplane structure from over pressurization. Inward movement of the galley service and passenger entrance door seals, and a negative pressure relief valve installed in the aft pressure bulkhead, relieves negative pressure.

When the pressurization system fails to maintain cabin altitude below 10,000 feet, a red CABIN ALT warning light on the OAP illuminates and a warning horn and vocal ("Cabin Altitude") sounds (5 seconds) .

With the airplane on the ground, the automatic system pressurizes the cabin when the throttles are advanced for takeoff. At this time, a 60-second timer is also started. If the airplane is not in flight within 60 seconds after throttles are advanced for takeoff, the cabin depressurizes. In the event of a rejected takeoff, the cabin automatically depressurizes when the throttles are retarded.

During climb and cruise, the cabin automatically pressurizes according to the climb schedule, as a function of airplane altitude. Once a descent has been detected, the pressurization system will begin its depressurization schedule to be depressurized at landing field elevation.

If landing altitude is set below actual field altitude, at airplane touchdown, a signal from the ground control relay will depressurize the cabin at a controlled rate for 20 seconds, at which time the cabin outflow valves will drive full open.

Pneumatic Air Distribution

Engine bleed air from either the low pressure (8th-stage) or high pressure (13th-stage) compressors is ducted into separate air manifolds (low and high) and then into the pneumatic system ducting for distribution. Pneumatic air is regulated for pressure and temperature. Low stage bleed air use is utilized as much as possible to maximize engine performance. High stage bleed air is used only during reduced engine power to maintain pressure. High stage air is always utilized for temperature control during airfoil anti-ice operations.

The pneumatic system is divided into a left, a right, and a crossfeed manifold. Left engine bleed air operates the left system, and right engine bleed air operates the right system. When both pneumatic crossfeed valves are closed, the crossfeed manifold is isolated from left and right engine bleed air. The pneumatic ground connection, the APU supply duct, the ice protection system supply duct, and the pneumatic pressure transmitter are located in the crossfeed manifold.

Pneumatic Indication System

The pneumatic indication system incorporates a PNEU PRESS gauge, red warning lights, and amber caution messages.

The pneumatic pressure gauge, located on the cockpit overhead panel, displays crossfeed manifold pressure.

The red warning light (TAIL COMP TEMP HIGH), located on the overhead annunciator panel (OAP), indicates excessive tail compartment temperature.

Air Conditioning Pneumatic Supply

Pressure and temperature controlled engine bleed air is distributed into the pneumatic ducting from each engine and routed to the pneumatic manifold in the aft accessory compartment. It is then delivered to the respective air conditioning units.

Low stage bleed air is normally sufficient to supply the requirements of either the right or the left air conditioning system. High stage bleed air is automatically selected, as required, to maintain adequate air conditioning demands.

Hot air from the pneumatic system is mixed with cold air from the air conditioning system to provide temperature control for the cabin and cockpit.

Airfoil Ice Protection and Engine Anti-ice Pneumatic Supply

Hot air is used for the airfoil ice protection and engine anti-ice systems. High stage bleed air only is used for airfoil ice protection.

High and low stage bleed air provide engine anti-ice protection.

Depending on crossfeed valve(s) position, bleed air from the left, right, or both engines supplies the ice protection system.

Ground Operation Pneumatic Supply

Pneumatic pressure for ground operation and engine start is supplied by the APU, by ground power equipment, or by an operating engine.

When the engines are not operating, APU bleed air or a ground source pressurizes the pneumatic crossfeed manifold for engine start and air conditioning. Selective positioning of the respective crossfeed valves (left or right system) pressurizes the left, right, or both systems. A check valve prevents backflow into the engine low stage manifold. The APU is equipped with a check valve to prevent air from entering the APU when the APU is not operating.

With both crossfeed valves open, engine bleed air pressure from one operating engine can be used to start the opposite engine, or to operate both left and right air conditioning systems.

Pneumatic Supply Inflight

Generally, pneumatic pressure for air conditioning is supplied by the low stage compressors for takeoff, climb, and cruise. During low power settings and when using airfoil ice protection bleed air is supplied by the high stage compressors.

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OAP Messages/Lights

Red Warning Lights

CABIN ALT - Cabin altitude exceeds 10,000 feet.

TAIL COMP TEMP HIGH - Tail compartment temperature exceeds normal.

Amber Caution Messages

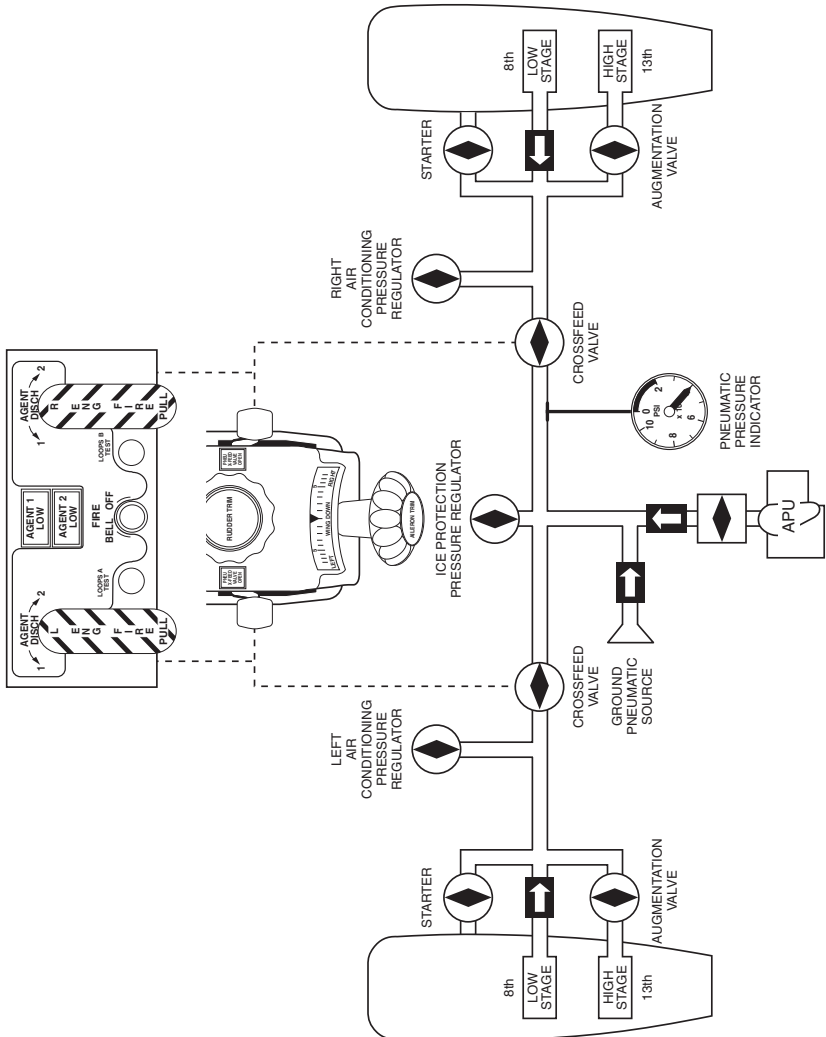
NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

(L/R) AIR COND TEMP HIGH (MISC) - Indicates air conditioning pneumatic supply exceeds normal operating temperature. Indicates possible malfunction of augmentation valve. MASTER CAUTION lights also illuminate.

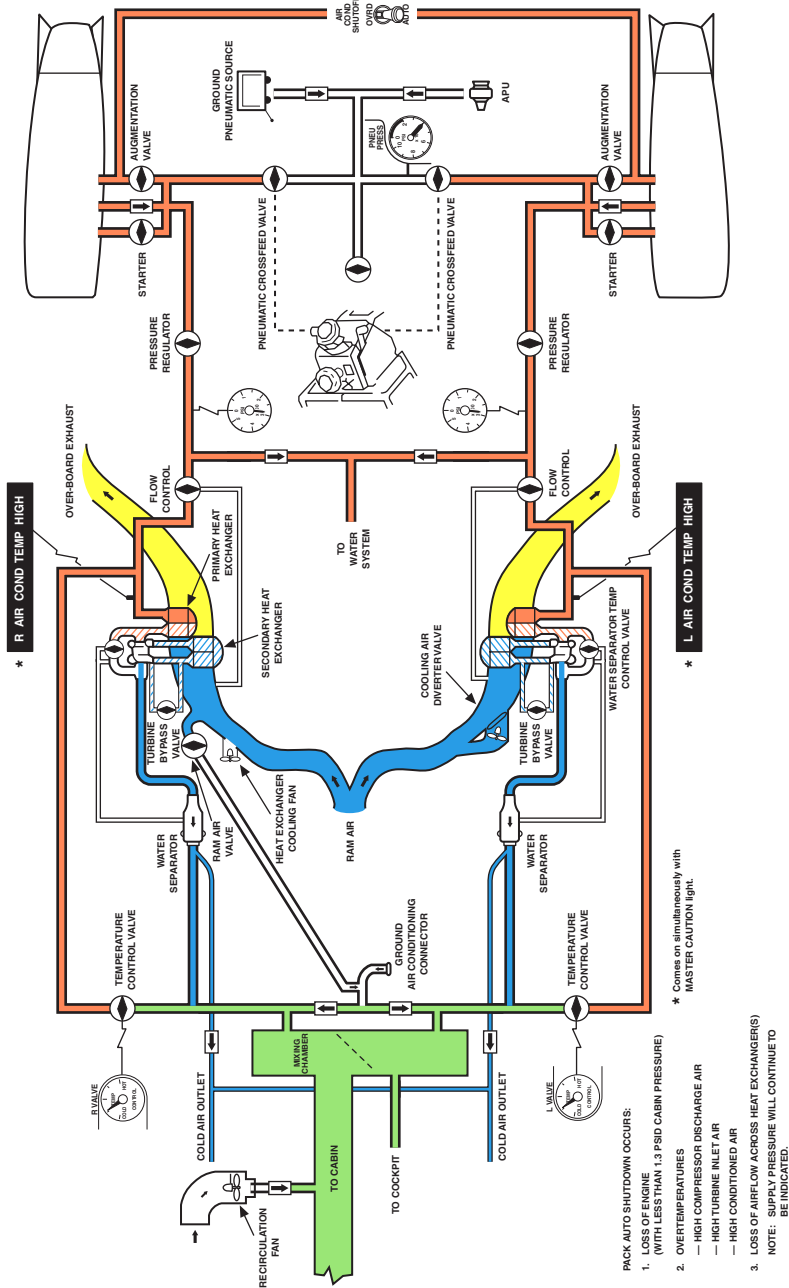
RADIO FAN OFF (MISC) - Illuminates in flight to indicate RADIO RACK switch is in FAN position and primary and standby fans are inoperative. On ground, message illuminates if primary fan is inoperative.

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MD-88 Pneumatic Schematic

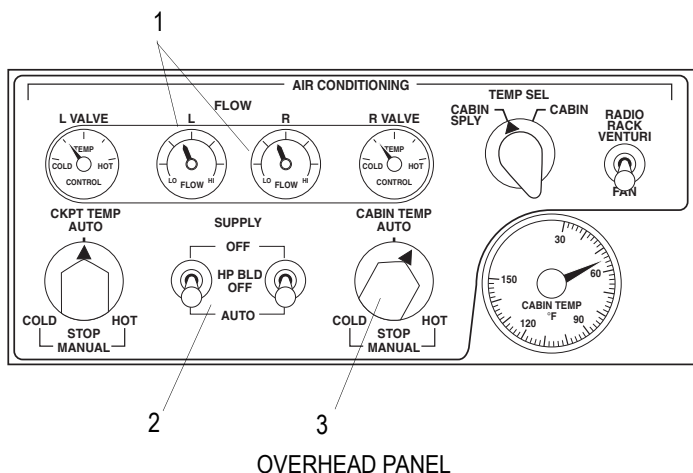


MD-88 Air Conditioning Schematic



Controls and Indicators

Air Conditioning Panel



1. L/R FLOW Gauge

Indicates air conditioning supply flow from the respective system.

2. L/R SUPPLY Switch

NOTE: During airfoil ice protection (PNEU X-FEED VALVE OPEN and AIR FOIL switch in ON) the pressure regulator and shutoff valve opens and pressure is supplemented by the high stage valve regardless of the position of the AIR CONDITIONING SUPPLY switch.

OFF - Closes the air conditioning flow control valve. On the ground, turns off the heat exchanger cooling fan.

With the PNEU X-FEED VALVE lever fully closed, the switch in **OFF** closes the pressure regulator and shutoff valve and the high stage valve.

HP BLD OFF - Opens the air conditioning flow control valve, the pressure regulator and shutoff valve, and, when the airplane is on the ground, starts the heat exchanger cooling fan. Closes the high stage valve.

AUTO - Opens the air conditioning flow control valve, the pressure regulator and shutoff valve, and, when the airplane is on the ground, turns on the heat exchanger cooling fan. If the low stage pneumatic supply pressure is too low, the high stage valve opens to supplement the pressure.

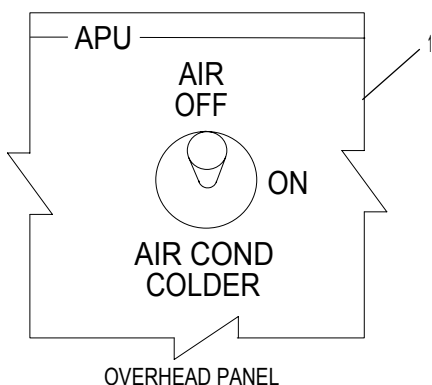
NOTE: Instrument cooling fan shuts down automatically when both pack switches are out of OFF.

3. CKPT/CABIN TEMP Selector

AUTO - Temperature automatically adjusts toward HOT or COLD when the selector is moved left or right of the index mark. The water separator temperature control valve regulates the cold air supply to 35°F.

NOTE: In MANUAL, the water separator 35°F temperature control valve is inoperative, and the pneumatic control backup system prevents the water separator from freezing.

APU Air Switch



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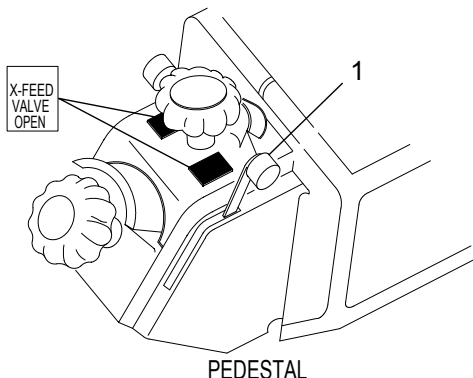
1. APU AIR Switch

OFF - Closes APU air shutoff valve to isolate the APU from the airplane pneumatic system. Retracts ram air inlet door for clearance during takeoff and landing.

ON - Provides APU bleed air to the airplane pneumatic system. Opens the ram air inlet door during ground operation to maximize APU performance.

AIR COND COLDER - Closes turbine bypass valve and increases differential pressure across the air conditioning turbine for additional cooling air capacity during ground operation.

Crossfeed Valve Lever



JB1-3-0963

1. L/R PNEU X-FEED VALVE Lever

OPEN - Opens respective X-FEED valve.

In flight, supplies the bleed air requirements for airfoil ice protection, single engine operation of both air conditioning packs, and an opposite engine pneumatic start.

System Description

Air Conditioning Systems

Cockpit FLOW (L/R) gauges indicate air conditioning supply from each (L/R) system.

Cabin Air Recirculation Fan

On the ground, on a moderate temperature day when maximum cabin cooling is not needed, the APU cuts back bleed air output, thus minimizing APU fuel consumption. To compensate for the cutback, the recirculation fan operates to increase the total cabin ventilation rate.

APU On-ground Air Conditioning

On the ground with AIR switch ON, the APU RAM door will open for enhanced APU cooling.

Pneumatic Air Distribution

Engine bleed air from either or both the low pressure (7th-stage) or high pressure (10th-stage) compressors is ducted into separate bleed air manifolds and then into the pneumatic system for distribution. Pneumatic air is regulated for pressure and temperature. Low stage bleed air is utilized as much as possible to minimize engine performance. High stage bleed air is used only during reduced engine power to maintain pressure and temperature demands.

Pneumatic Indication System

Red warning lights (L TAIL TEMP HIGH/R TAIL TEMP HIGH), located on the overhead annunciator panel (OAP), indicate excessive tail compartment or pylon temperatures.

The amber (L/R) PNEU SYSTEM FAULT message indicates excessive supply pressures in the supply ducting, or failure of the (L/R) manifold pressure sensor, or pneumatic system controller (PSC) failure to control the left/right pneumatic system, or a loss of controller power.

The amber TAIL TEMP FAULT message indicates both channels of the pneumatic overheat detection system (PODS) controller are unable to detect a high tail temperature.

Pneumatic System Controller (PSC)

The PSC, located in the electrical/electronics (E/E) compartment, controls pneumatic temperature and pressure, based on requirements for air conditioning and ice protection.

The PSC electronically monitors and controls pneumatic supply to the system through the high stage valve and pressure regulator and shutoff valve (PRSOV) on each engine.

Pneumatic Precooler

The pneumatic precooler is a heat exchanger, located downstream of the high and low stage engine bleed air ducts. Acceptable bleed air temperature is maintained by cooling it with fan air.

Fan air flow is regulated by the fan air valve. The PSC modulates the fan air valve by electronically controlling the fan air pilot valve.

At altitudes above 20,000 feet, when ice protection is not selected, the PSC controls bleed air temperature to a higher temperature, thus requiring less fan air for cooling, and reducing fuel consumption.

Pneumatic Overheat Detection System (PODS)

The pneumatic overheat detection system (PODS) records the locations of pylon and/or tail compartment overheat conditions, and any sensor failures.

The red (L/R) TAIL TEMP HIGH light(s) and MASTER WARNING lights illuminate whenever an overheat condition is detected, or, on takeoff, if both sensors have failed simultaneously just prior to takeoff.

The TAIL TEMP FAULT message indicates that PODS cannot detect an overheat condition. The message is displayed if one sensor fails, or both sensors on a side fail, or, if one or both controller channels fail.

Airfoil Ice Protection and Engine Anti-ice Pneumatic Supply

Depending on crossfeed valve(s) position, bleed air from the left, right, or both engines supplies the ice protection system. The PSC maintains adequate temperature and pressure to operate the system.

OAP Messages and Alerts

Red Warning Lights

L/R TAIL TEMP HIGH - Tail compartment or pylon temperature exceeds normal. Or, during takeoff, both PODS sensors have simultaneously failed just prior to the takeoff. Illuminates MASTER WARNING lights.

Amber Caution Messages

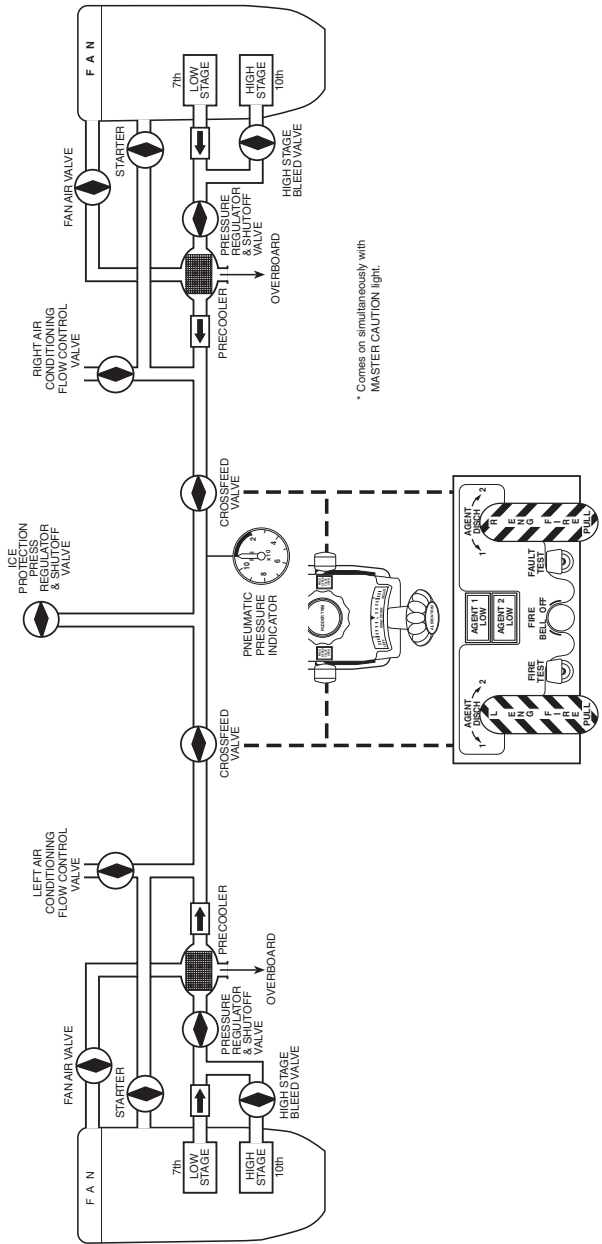
NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

(L/R) PNEU SYSTEM FAULT (MISC) - Supply pressure exceeds normal due to malfunction of pressure regulator and shutoff valve (PRSOV) and/or high stage valve, or, malfunction of L/R pneumatic system controller, or, failure of pneumatic manifold sensor, or, loss of controller pressure.

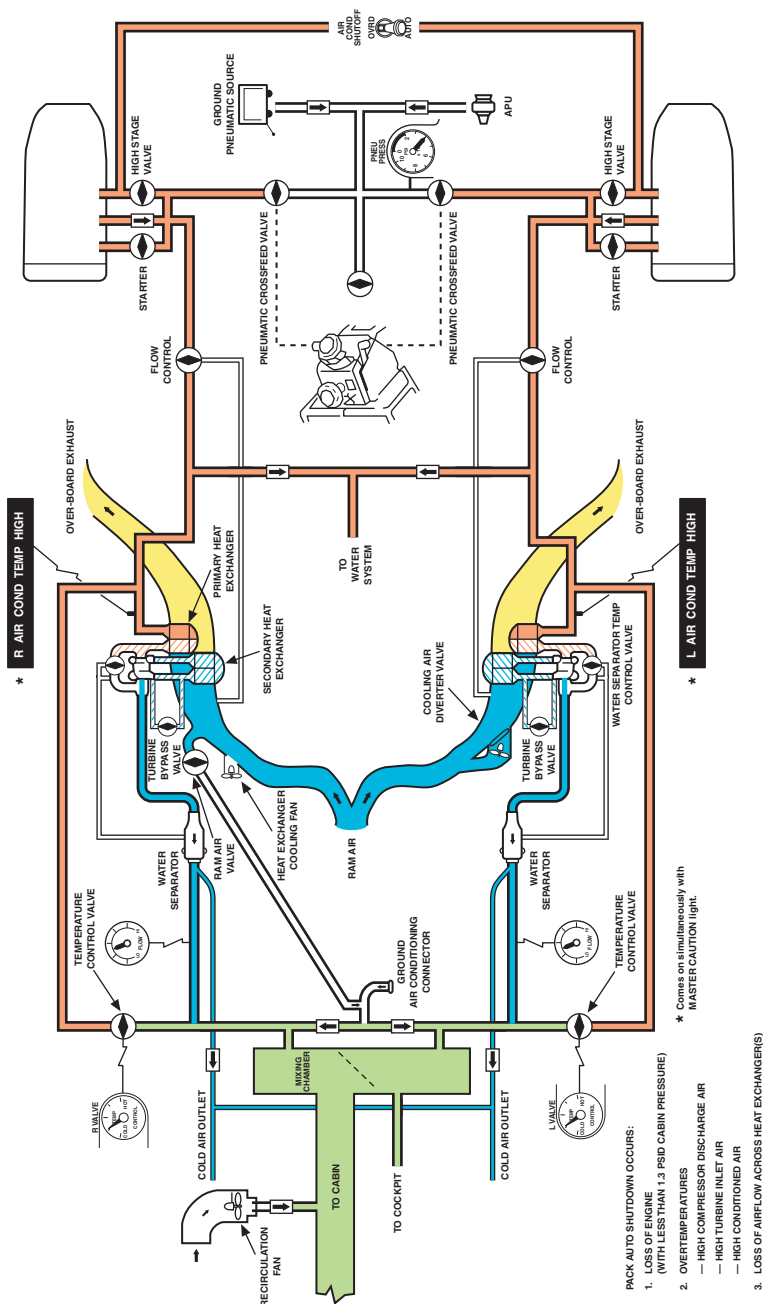
TAIL TEMP FAULT (MISC) - One or both channels of the tail temperature high controller is unable to detect a high tail temperature.

Functional Schematic

MD-90 Pneumatic Schematic



MD-90 Air Conditioning Schematic



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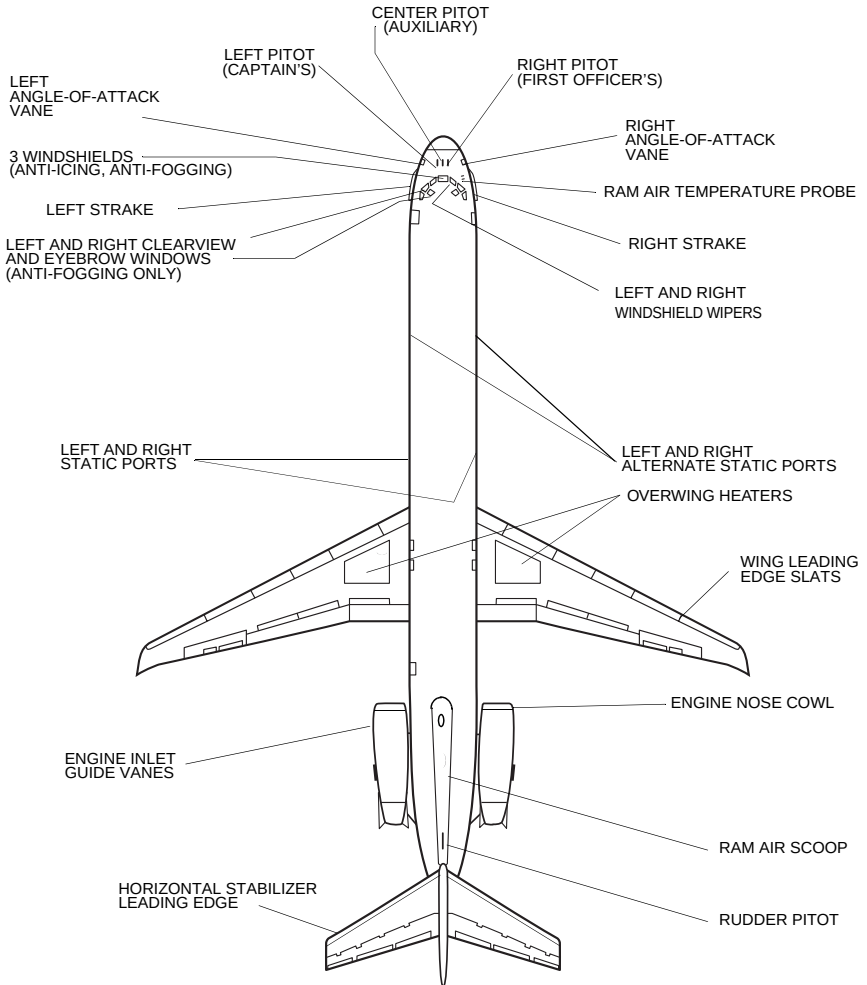
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Anti-Ice, Rain Controls and Indicators

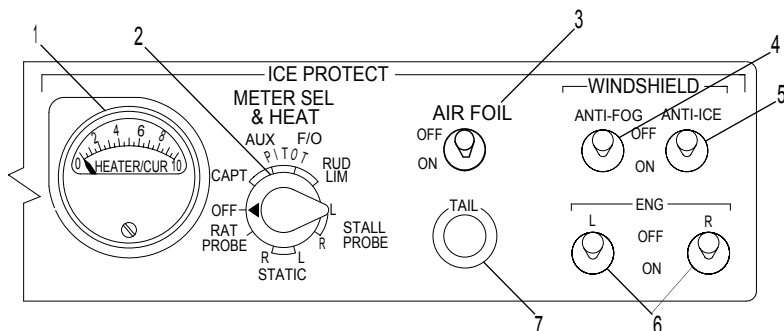
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Component Location



Ice and Rain Protection

Ice Protection Panel



OVERHEAD PANEL

JB1-3-0983

1. HEATER/CUR Meter

Displays current flow to the respective heater, as selected by the METER SEL & HEAT selector.

2. METER SEL & HEAT Selector

Moving the selector to any position except OFF energizes all heater circuits, except the RAT probe while on the ground.

3. AIR FOIL Anti-Ice Switch

OFF - Closes the ice protection pressure regulator valve.

ON - Opens the ice protection pressure regulator valve.

4. WINDSHIELD ANTI-FOG Switch

OFF - Deactivates the anti-fog system.

ON - Provides electrical heat to the inside surface of the windshields, the clearview windows, and the eyebrow windows.

5. WINDSHIELD ANTI-ICE Switch

OFF - Deactivates the windshield anti-ice system.

ON - Provides electrical heat to the outside of the three windshields.

6. L/R ENG Anti-Ice Switch

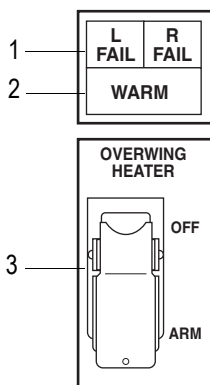
OFF - Closes the eighth and thirteenth stage valves to the respective engine anti-ice system.

ON - Opens the eighth and thirteenth stage valves to the respective engine anti-ice system.

7. TAIL De-Ice Pushbutton

Push - (Air foil system in-use) Closes the shutoff valve to the wing and opens the shutoff valve to the tail to allow 2.5 minutes of tail de-ice. The system automatically reverts to wing anti-ice function following the 2.5 minutes of tail de-ice function.

OVERWING HEATER Switch



CAPT'S INSTRUMENT PANEL

1. L/R FAIL Lights (amber)

Illuminates when any fault is detected with power applied to the system. If a failure is detected, the WARM light will not illuminate or, if illuminated, will extinguish.

2. WARM Light (green)

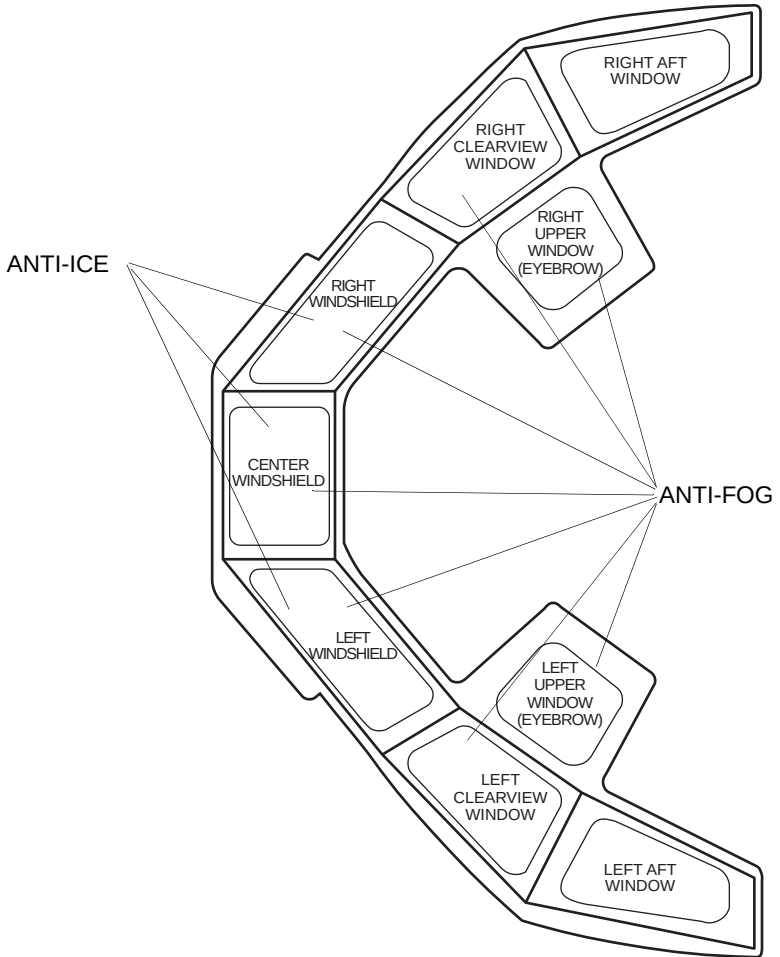
Illuminates when both heaters are 40°F (4°C) or above.

3. OVERWING HEATER Switch

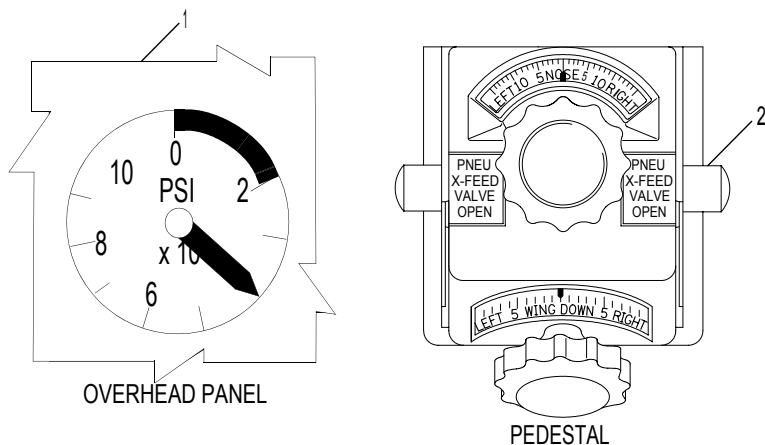
ARM - Provides electrical power to the wing heater control units when the airplane is on the ground. The switch is **normally guarded to this position**.

OFF - Removes electrical power from the heater control units.

ANTI-ICE and ANTI-FOG Electrical Resistance Heating



Pneumatic Pressure Gauge and Crossfeed Valve Levers



JB1-3-0958

1. **PNEU PRESS Gauge**

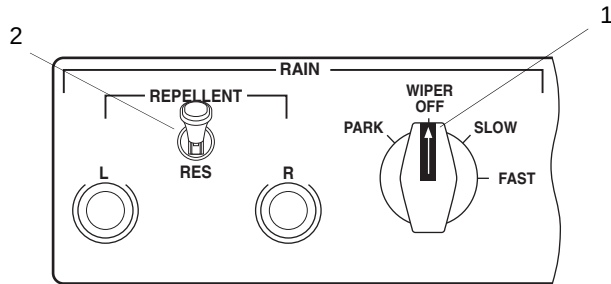
Indicates pneumatic pressure in the crossfeed manifold available for systems operation.

2. **L/R PNEU X-FEED VALVE Lever**

OPEN - Opens respective X-FEED valve.

CLOSED - Closes respective X-FEED valve.

Windshield Wiper and Rain Repellent System



OVERHEAD PANEL

1. RAIN WIPER Selector

PARK - Positions wiper to parked.

OFF - Deactivates wiper.

SLOW/FAST - Controls wiper operating speed.

2. RAIN REPELLENT - Deactivated

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Anti-Ice, Rain System Description

Chapter 3 Section 20

General

The aircraft ice protection systems employ hot air and electrical resistance heating for anti-icing, de-icing, and anti-fogging functions. Rain removal is accomplished by electrically operated windshield wipers.

Heated air for anti-icing of wing leading edge slats, forward strakes, air conditioning ram air inlet, and de-icing of the horizontal stabilizer leading edge is supplied by engine bleed air.

A pneumatic crossfeed system allows 13th stage engine bleed air from either or both engines to supply heat for air foil ice protection. A separate system on each engine utilizes 8th and 13th stage air for anti icing of the EPR probe, nose bullet, inlet guide vanes and the nose cowl.

Electrical resistance heating elements provide anti-icing and anti-fogging of the pilot's three windshields and for anti-fogging the clearview and eyebrow windows. The windshield anti-ice system also provides for bird impact resistance.

Electrical resistance heating elements are used for anti-icing the pitot tubes, static port areas, stall angle of attack vanes, and ram air temperature probe.

An overwing heater system is installed to prevent formation of ice on the upper wing surface due to cold-soaked fuel.

Air Foil Ice Protection

Air foil ice protection is only available in-flight.

The system utilizes 13th stage bleed air and is activated by selecting the AIR FOIL switch to ON and placing the crossfeed valve(s) to OPEN. This action provides a continuous cycle of heat for the leading edge of the wings (slats) and the forward strakes for fifteen minutes, followed by 2 1/2 minutes of heat to the horizontal stabilizer. The ram air inlet is heated during both cycles.

The automatic cycle can be overridden by the TAIL button which, when pushed, provides for 2 1/2 minutes of horizontal stabilizer de-icing, after which a new wing cycle starts. Placing the AIR FOIL switch in the OFF position causes the horizontal stabilizer de-icing cycle to be activated for 2 1/2 minutes. Closing the pneumatic crossfeed valves during air foil ice protection operation causes the de-icing airflow to be deactivated and illuminate the AIRFL ICE PRESS ABNML message. On the ground the air foil ice protection system is disabled.

Engine Ice Protection

Engine anti-ice protection is provided by two independent systems controlled by individual switches located on the ice protection panel. Each system consists of three engine anti-ice valves, two eighth stage and one thirteenth stage. The eighth stage anti-ice valves control heat to the inlet guide vanes, EPR probe, and nose bullet. The thirteenth stage anti-ice valve controls heat to the engine nose cowl.

Control of the system is operated by a switch for each engine. When selected ON, an amber (L/R) ENGINE VALVE message will appear on the overhead annunciator panel indicating the valves are in transit and disagree with the switch position. When at least one valve is fully open, a blue (L/R) ENGINE ANTI-ICE ON light on the overhead annunciator panel illuminates. When all three valves are fully open, the amber message extinguishes, and the blue light remains illuminated indicating normal system operation.

Probe Heat

Electrical resistance heat is used to anti-ice the pitot tubes, the static port areas, the stall angle of attack vanes, and the ram air temperature (RAT) probe.

Moving the METER SEL & HEAT selector out of OFF energizes the anti-ice heating circuits for the pitot tubes, including the rudder limiter pitot on the leading edge of the vertical stabilizer, the stall angle of attack probes, the static ports, and the RAT probe. The RAT probe heater functions only in flight.

Overwing Heater System

The overwing heater system prevents the buildup of ice on the inboard corner of the upper wing. The overwing heater system does not de-ice the entire wing nor does it provide anti-ice or de-ice capability for environmental icing conditions.

The heater blankets operate on the ground to warm the upper surface of the wing. When the surface temperature of both heater blankets reaches 40°F (4°C) the WARM light (located on the Captain's instrument panel) illuminates indicating that all portions of the heater surfaces are clear of ice or frost. The WARM light is then on continuously regardless of power application to the heaters. When the aircraft is on the ground, power continues to be applied as necessary to maintain a heater surface temperature between 65°F (18°C) and 85°F (29°C). If the heater surface temperature exceeds 85°F (29°C), the heating function is terminated until the heater surface temperature drops to 65°F (18°C), when heating is then resumed.

System operation is enabled with:

- Aircraft on the ground
- AC power on the buses
- OVERWING HEATER switch in ARM

System status is monitored by a WARM/FAIL light. The heater control units continuously monitor the system for electrical faults and will remove AC electrical power to the affected heater and deactivate the WARM light when a fault is detected. When any fault is detected, the associated L FAIL or R FAIL light will illuminate. The WARM/FAIL lights are tested using the ANNUN/DIGITAL LTS TEST switch and dimmed using the ANNUN/DIGITAL LTS PULL TO DIM switch.

Warm Light Inhibit

The system is designed with a startup delay of approximately one minute before electrical power is applied to the heaters. Once power is applied and if no system faults or failures exist, the WARM light should illuminate within 12 minutes. If the WARM light does not illuminate within 12 minutes, the WARM light is inhibited (locked out). For this to occur, the aircraft must have been on the ground for an extended period and exposed to the conditions conducive for upper wing ice formation or environmental airframe icing.

Warm Light Reset

Once inhibited, the WARM light will remain inhibited until the heater surface reaches 40°F (4°C) and the flight crew presses the WARM/FAIL light assembly to reset the system. Once pressed, the WARM light will:

- Illuminate immediately indicating the heater blanket surfaces have reached 40°F (4°C); or
- Remain off, illuminating later when the heater blanket surfaces do reach 40°F (4°C). Should the WARM light need to be reset, a visual inspection for ice on the heater blanket surface (from the ground) will be required after the WARM light illuminates. If the WARM light does not illuminate, a tactile check (poles and ladders) will be required.

Load Shedding

The electrical power required by the overwing heaters may require the automatic shedding of some non-essential loads, depending on the available power source. With the APU or external power only, automatic shedding of #3 galley will occur whenever the heaters are in operation. There are no load-shedding requirements when two generators are operating (two engine-driven generators or one engine-driven generator and the APU).

NOTE: *The overwing heater system is not designed to provide any environmental anti-ice or de-ice capability and the switch must be OFF for environmental icing conditions. This is to prevent runback icing which is caused by melted precipitation re-freezing in the flap well area.*

Rain Removal

Windshield Wipers

A windshield wiper is provided for the left and right windshield. Both wipers are electrically operated. The selector provides a selection of slow or fast speeds and controls the stowing of the wiper blades to the park position when the system is not in use.

Windshield Heat

Windshield anti-icing and anti-fogging are electric and automatically controlled. There is a separate switch for each system.

The anti-icing system heats the outer surface of the Captain's, Center, and First Officer's windshields. The anti-fog system heats the inner surface of all windows except the left and right aft windows.

Externally Powered Waterline Heater

An externally powered AC receptacle, located on the forward left side of the aircraft, is installed to provide heat for the potable water lines. Its use is primarily for freeze protection during extended layovers at cold temperatures.

OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

AIRFL ICE PRES ABNML (ICE) - Low or unscheduled pressure in wing and/or duct to horizontal stabilizer. Malfunction of ice protection pressure regulator and shutoff valve if AIR FOIL switch selected OFF after tail cycle complete. MASTER CAUTION lights illuminate.

ANTI-ICE SUPPLY HIGH (ICE) - Malfunction of the ice protection pressure regulator and shutoff valve causing excessive duct pressure. MASTER CAUTION lights illuminate.

L/R ENG VALVE (ICE) - One or more of the engine valve position disagrees with ENG anti-ice switch position.

L/R ICE PROT TEMP HIGH (ICE) - Malfunction of augmentation valve, resulting in high duct temperature. MASTER CAUTION lights illuminate.

L/R ICE PROT TEMP LOW (ICE) - Low engine power or malfunction of augmentation valve resulting in low duct temperature.

PITOT/STALL HEAT OFF (ICE) - Electrical power loss to one or more Pitot probes or Stall/AOA vanes. MASTER CAUTION lights illuminate.

WINDSHIELD OVERTEMP (ICE) - One or more windshield panes is overheated, resulting in the removal of anti-ice power from the overheated windshield(s). Requires ground maintenance to restore system.

Blue Advisory Lights

L/R ENG ANTI-ICE ON - One or more engine anti-ice valves open.

NOTE: When any engine anti-ice valve(s) is open, R ENG ANTI-ICE ON or L ENG ANTI-ICE ON light will be illuminated regardless of ENG anti-ice switch position.

RAIN REPELLENT RESERVE IN USE - Deactivated.

TAIL DE-ICE ON - Horizontal stabilizer leading edge and ram air scoop de-ice heat selected. Will also be illuminated for 2.5 minutes after switch is turned OFF.

WING ANTI-ICE ON - Wing leading edge and ram air scoop anti-ice heat selected.

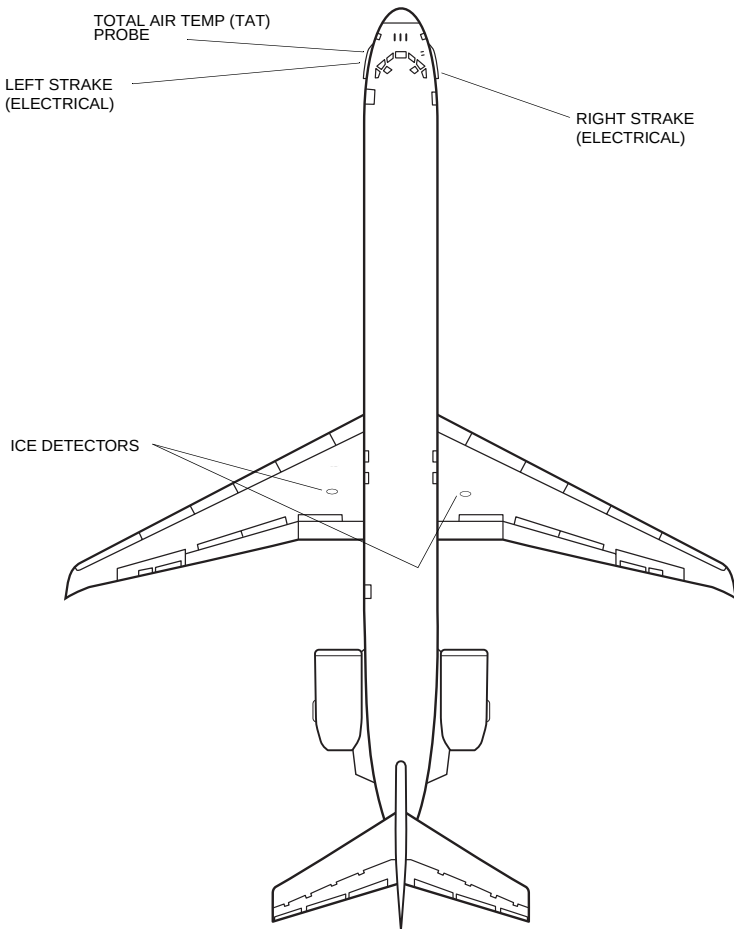
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Anti-Ice, Rain MD-90 Differences

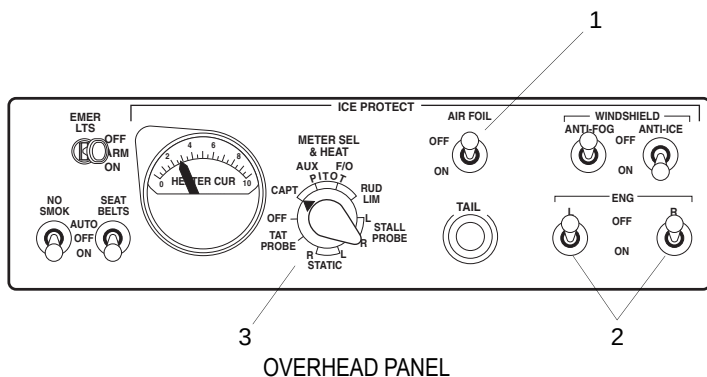
Chapter 3 Section 90

Controls and Displays

Component Location



Ice Protection Panel



1. AIR FOIL Anti-Ice Switch

With air foil ice selected to ON and flaps at 40, simultaneous Wing and Tail de-icing occurs.

2. L/R ENG Anti-Ice Switch

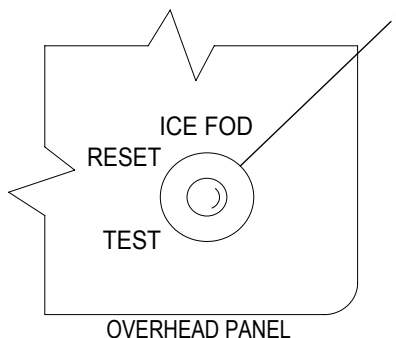
OFF - Closes the seventh stage valve to the respective engine anti-ice cowl.

ON - Opens the seventh stage valve to provide air for engine anti-icing to the cowl only. Activates electrically heated fuselage strakes.

3. METER SEL & HEAT Selector

The MD-90 has a total air temperature (TAT) probe for air data inputs. It is located on the forward left side of the fuselage. Ground control relays inhibit energizing the TAT probe heater circuit while on the ground.

ICE FOD Switch



JB1-3-0957

1. ICE FOD Switch (Ground Operation Only)

RESET - (Momentary) Resets system following ice FOD detection. Removes L/R ICE FOD ALERT messages, as applicable, from OAP.

System will not reset until ice no longer exists on sensors.

TEST - (Momentary) Tests ice FOD alert system. Displays (L/R) ICE FOD ALERT and (L/R) ICE FOD SYS INOP alerts on the OAP during the test sequence.

Description and Operation

Pneumatics

High Stage Bleed Air

The MD-90 system includes a pneumatic system controller which is located in the avionics compartment. The controller monitors and controls pneumatic supply to the system through a high stage valve on each engine high stage compressor.

A precooler, located downstream of the junction of high and low stage bleed air ducts, maintains acceptable high and low stage bleed air temperatures as they enter the system.

Tail Compartment Overheats

A pneumatic overheat detection system (PODS) provides overheat detection for the tail compartment and engine pylons. If the PODS detects an overheat condition in the tail compartment or in the pylons, it will generate either the red L or R TAIL TEMP HIGH annunciation on the OAP. The MASTER WARNING lights will also illuminate. During a L/R TAIL TEMP HIGH condition, PODS will close the APU bleed air valve except during engine start.

The TAIL TEMP FAULT message indicates that the PODS cannot detect an overheat condition.

Ice and Rain Protection

Air Foil Anti-Icing

With air foil ice selected, moving the flaps to 40 will activate both wing and tail anti-ice valves simultaneously, and the WING ANTI-ICE ON and TAIL DE-ICE ON lights will illuminate until the airplane is on the ground or flaps are repositioned to less than 40.

Engine Anti-Ice

Engine anti-ice is controlled by two switches on the overhead panel. Turning either switch on, activates respective engine anti-ice and ignition. Engine anti-ice is provided to the cowl only by seventh stage bleed air.

The rubber coated spinner tip is mounted slightly off-center to prevent ice build up. Both forward fuselage strakes, which are electrically heated, are activated at this time.

Ice FOD Alert System

An ice FOD alert system, active only on the ground, is designed to alert the pilots to the presence of wing upper surface ice caused by cold-soaked fuel. Overwing ice sensors, located near the inboard aft corner of each main wing tank, detect ice buildup in these areas. Four alert messages associated with this detection system may be displayed on the OAP. A ICE FOD RESET/TEST switch (spring-loaded to center) is located on the overhead panel to test and to reset this system.

The system and OAP message display may be tested by moving the switch out of the spring-loaded center position and holding it momentarily to the TEST position. Check for L/R ICE FOD ALERT and L/R ICE FOD SYS INOP messages. A successful test is indicated if all messages are displayed and then extinguish when the switch is released.

Any fault in the alert system activates the appropriate message(s), L/R ICE FOD SYS INOP. The alert message(s) remain displayed.

L/R ICE FOD ALERT, when displayed, indicate the presence of ice build-up on the wing upper surface.

Following ice removal, the system must first be reset by moving the switch out of the spring-loaded center position and holding it momentarily to the RESET position. The alert messages extinguish until the sensors again detect the presence of ice. The system cannot be reset if ice continues to be detected.

OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

ANTI-ICE FAULT or STRAKE ICE FAULT (ICE) - Anti-ice fault in left or right strake with no ice protection for one or both strakes when L and/or R ENG anti-ice switch is selected ON.

L/R ICE FOD ALERT (ICE) - Ground advisory of ice buildup on wing upper surface.

L/R ENG VALVE (ICE) - The engine anti-ice valve position disagrees with ENG anti-ice switch position.

L/R ICE FOD SYS INOP (ICE) - Ground advisory ice FOD alert system is inoperative.

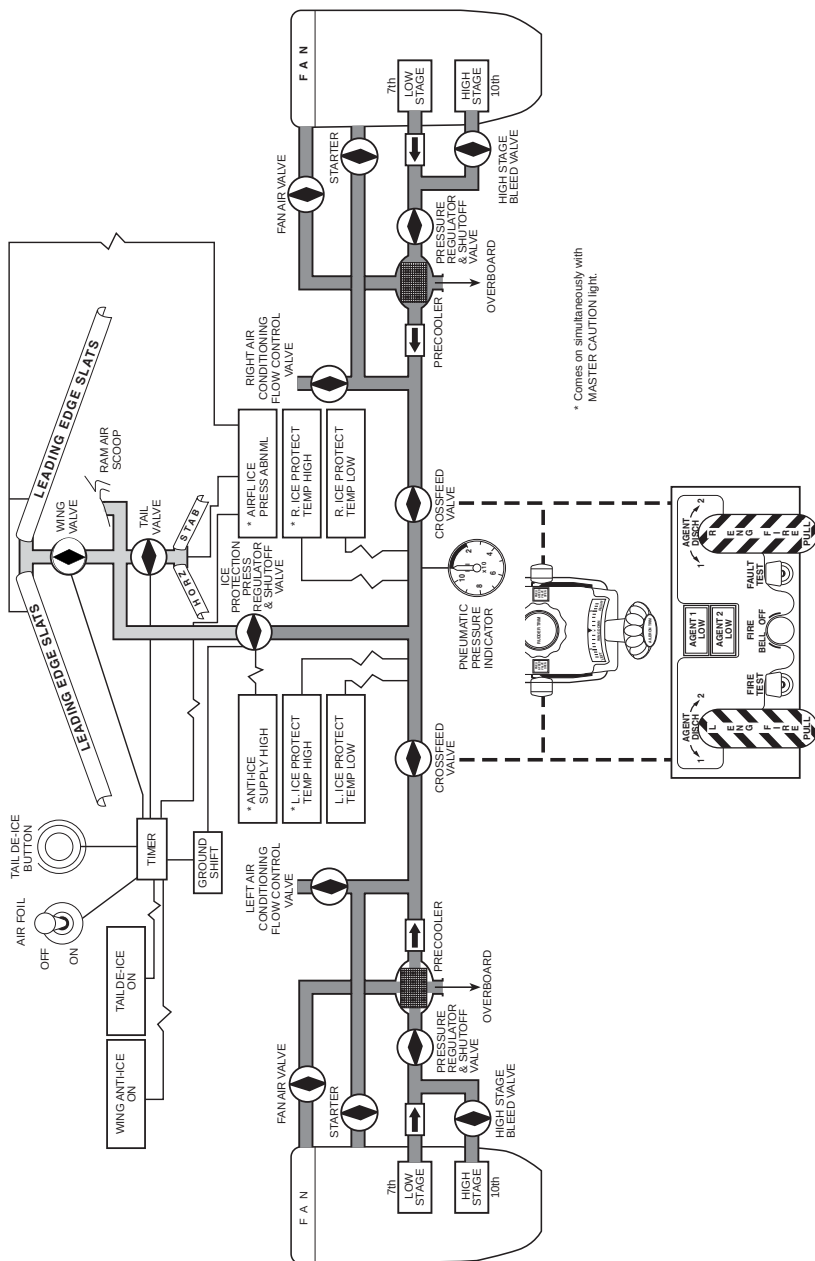
WINDSHIELD OVERTEMP (ICE) - One or more windshield panes is overheated, resulting in the removal of anti-ice power from the overheated windshield(s). Requires ground maintenance to restore system.

Blue Advisory Lights

L/R ENG ANTI-ICE ON - Engine nose cowl and fuselage strakes anti-ice selected.

Functional Schematic

MD-90 Ice and Rain System



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Automatic Flight

Chapter 4

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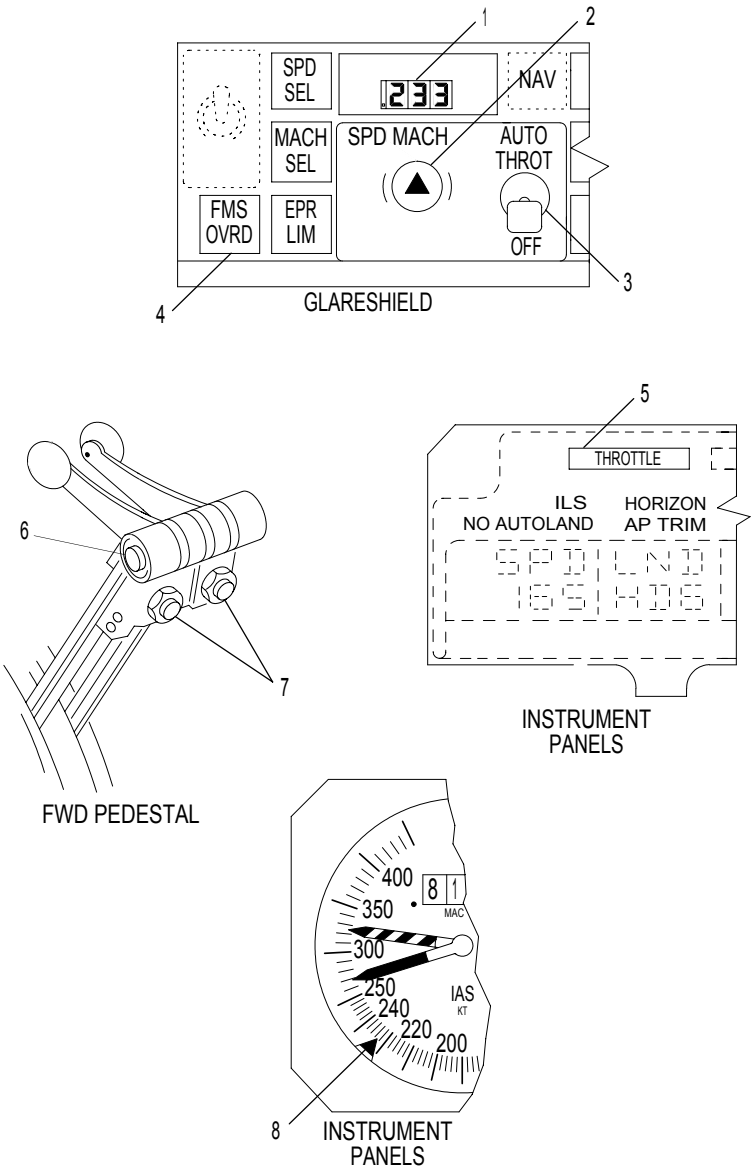
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Flight Guidance Control Panel (FGCP) - Autothrottle Section



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1. Autothrottle SPD/MACH Readout

Indicates airspeed or Mach selected with SPD/MACH select knob.

2. Autothrottle SPD/MACH Select Knob

Knob has three positions, spring returned to normal.

Normal - Selects SPD/MACH at a slow rate of 1 knot increments.

Pushed to Mid Detent - Selects SPD/MACH at a fast rate of 10 knot increments.

Pushed to Maximum Detent - Alternately switches SPD and MACH readout.

If other than SPD/MACH SEL mode is engaged, the SPD/MACH value will be stored in DFGC. Airspeed command bug on Mach/airspeed indicator is also set to airspeed appearing in readout.

3. AUTO THROT Switch

AUTO THROT - (Solenoid held) Engages autothrottle. Returns to OFF with a loss of electrical power, autothrottle disconnect button pressed, malfunction occurs, or when reverse thrust is selected.

4. Autothrottle Mode Select Buttons

SPD SEL - Push to select airspeed mode.

MACH SEL - Push to select Mach mode.

EPR LIM - Push to select EPR LIM mode.

FMS OVRD - Pushing button enables IAS selected by SPD/MACH knob to be used by FMS. Pushing button second time reverts to FMS computed IAS.

5. THROTTLE Warning Light (red)

Flashes when autothrottle is disengaged. Pushing autothrottle disconnect button on either throttle or re-selecting AUTO THROT switch to AUTO THROT position extinguishes light.

6. Autothrottle Disconnect Button

Push - (Either Button) Disengages autothrottle. AUTO THROT switch automatically returns to OFF and THROTTLE warning light on FMA flashes. Pushing button second time extinguishes THROTTLE light.

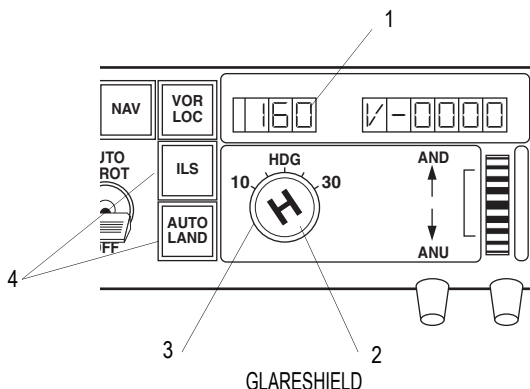
7. Takeoff and Go-Around (TOGA) Button

Push - (Either Button) Initiates respective takeoff or go-around mode.

8. Airspeed Command Bug

Set with SPD/MACH select knob to airspeed set in SPD/MACH readout.

FGCP - Navigation Arm and Roll Control Sections



1. HDG Readout

Digital readout of heading display, changed with HDG select knob.

2. HDG Select Knob

Knob has four position, spring-loaded to normal.

Normal - Provides fine heading adjustment.

Pushed to First Detent - Provides fast heading adjustment.

Pushed to Full Detent - Engages heading hold mode.

Pull - Engages heading select mode.

3. Bank Angle Select Knob

Sleeve provides selection of bank limits for HDG HLD, HDG SEL and VOR.

4. Roll Mode Select Buttons

NAV - Pushing arms DFGS to capture and track an FMS generated course if the airplane is on intercept heading.

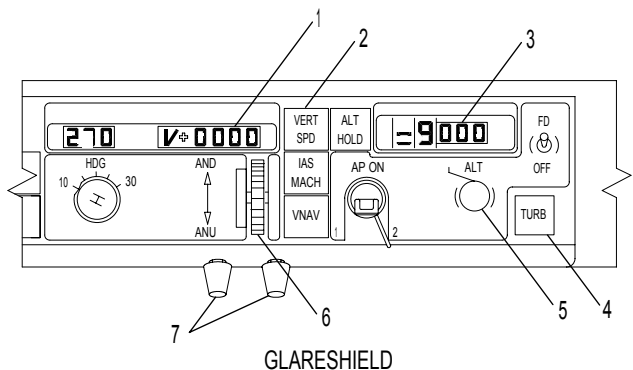
VOR LOC - Pushing arms DFCS to capture and track a selected VOR or LOC course if the airplane is on intercept heading.

ILS - Pushing arms DFGS to capture and track a selected localizer course and glideslope capture and track, if the airplane is on intercept heading.

AUTO LAND - Pushing arms DFCS to establish AUTO LAND mode after localizer and glide slope capture and track, if the airplane is on intercept heading. ILS mode does not need to be selected prior to selecting AUTO LAND.

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FGCP - Pitch Control Section



JB1-3-0900

1. Pitch Profile Readout

First Window - Displays selected operating mode: V (vertical speed), M (Mach), S (indicated airspeed), or P (turbulence, pitch).

Second Window - Displays pitch reference: + (climb/nose up) or - (descend/nose down).

Remaining Windows - Display appropriate numerical values.

2. Pitch Mode Select Buttons

ALT HOLD - Pushing selects existing altitude for DFGS altitude hold mode.

VERT SPD - Pushing selects DFGS vertical speed mode.

IAS MACH - Pushing selects existing Indicated Airspeed (below 27,000 feet) or Mach (above 27,000 feet and above .5 Mach) for DFGS pitch mode. Mach is not available at any altitude if airspeed is below .5 Mach.

VNAV - Pushing selects FMS vertical guidance function if autothrottle is already engaged. Pitch commands are provided to FD and AP, while thrust commands are provided to the autothrottle.

3. ALT Preselect Readout

Digital readout of preselect altitude set with ALT set knob.

Symbology: =9000 (Below 10000); ==500 (Below 1000)

4. TURB Mode Select Button

Pushing commands DFGS to maintain existing pitch and wings level attitude for turbulence penetration. Also disengages autothrottle and altitude arm function.

5. ALT Set Knob

Knob has three positions, spring loaded to center.

Center - Provides 1000-foot increment altitude adjustments above 1000 feet or 100-foot increments below 1000 feet.

Pushing provides 100-foot increment altitude adjustments and resets altitude warnings.

Selecting a new altitude or pulling arms DFGS for preselected altitude capture.

6. Pitch Wheel

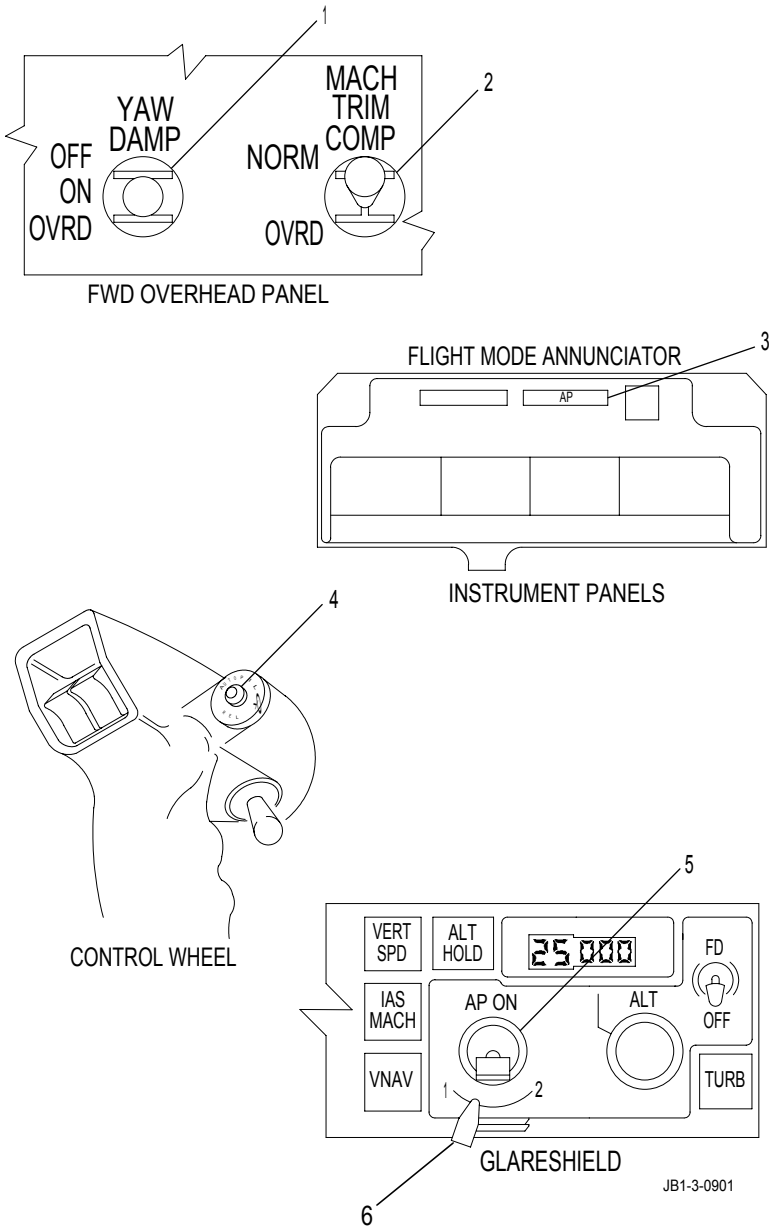
In IAS/MACH, VERT SPD or TURB modes, movement of pitch wheel adjusts values. In ALT CAP, ALT HLD or VNAV modes, movement of pitch wheel will change existing mode to VERT SPD mode.

7. FGCP Light Intensity Knobs

Left Knob - Controls light intensity for mode buttons and panel back lighting.

Right Knob - Controls light intensity for digital readouts. Readout intensity is overridden by thunderstorm light switch on overhead panel.

Stability Augmentation and Autopilot



1. **YAW DAMP Switch**

OFF - Yaw damper operation is disabled if AP is disengaged. If AP is engaged, yaw damper operation is automatically provided.

ON - Yaw damper operation is provided with AP engaged or disengaged.

OVRD - Inhibits yaw damper operation with AP engaged or disengaged.

2. **MACH TRIM COMP Switch**

OVRD - System is deactivated.

NORM - Mach trim compensation mode is in operation.

3. **AP Warning Light (red)**

Flashes when AP is disengaged, accompanied by aural and vocal warnings.

4. **AUTOPILOT REL Button**

First push of the AUTOPILOT REL button disengages the autopilot.

Second push of the AUTOPILOT REL button on either control wheel resets light and applicable aural/vocal warning.

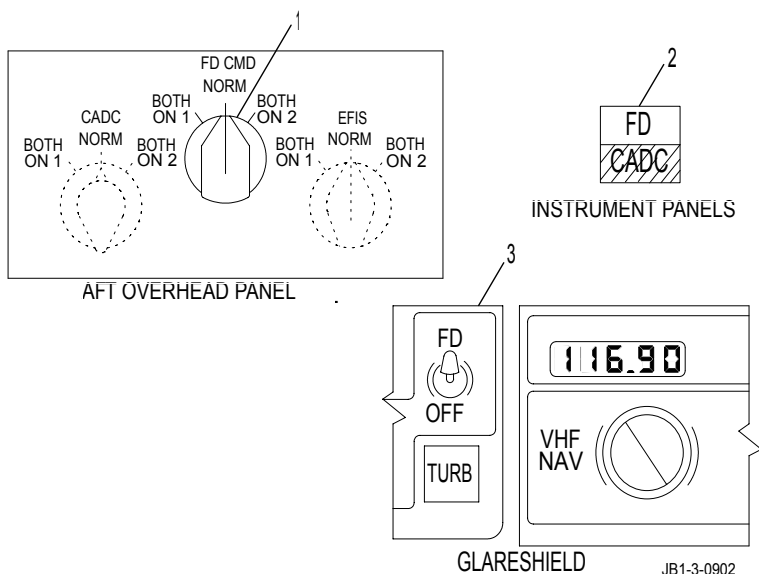
5. **AP ON Switch**

(Solenoid held) Engages autopilot (AP). Automatically disengages with a loss of electrical power, malfunction and disengages with AUTOPILOT release button.

6. **AP ON 1/2 Selector Switch**

Allows selection of AP 1 or AP 2.

Flight Director (FD)



1. **FD CMD Selector**

NORM - Normal position. Digital Flight Guidance Computer (DFGC) -1 and -2 provide data to respective FD.

BOTH ON 1 - DFGC-1 provides data to both FDs.

BOTH ON 2 - DFGC-2 provides data to both FDs.

2. **FD Light (amber)**

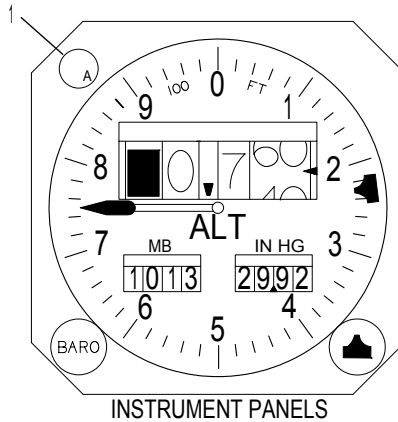
Indicates FD CMD selector is out of **NORM** position.

3. **FD Switch (2)**

FD - Turns on respective Captain's or F/O's flight director and FMA.

OFF - Turns off respective Captain's or F/O's flight director. The FMA will operate if autothrottles or autopilot are engaged.

Altitude Alert



JB1-3-0903

1. **Altitude Alert Light (amber)**

Illuminates when aircraft is within 750 feet of selected altitude.

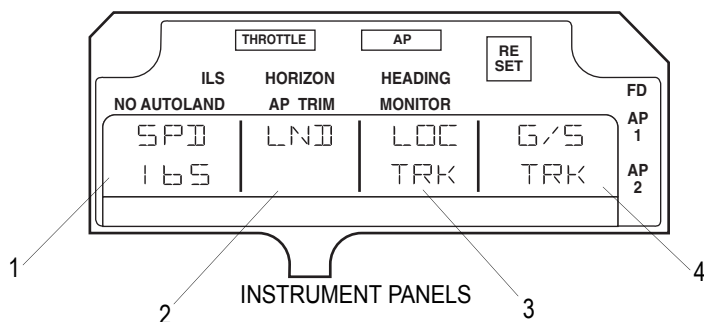
In addition, the aural warning sounds.

Flashes when a deviation of 250 feet or more occurs from the selected altitude.

In addition to the aural warning, vocal warning “altitude” also sounds.

Warnings can be reset by returning to selected altitude or by setting a new altitude.

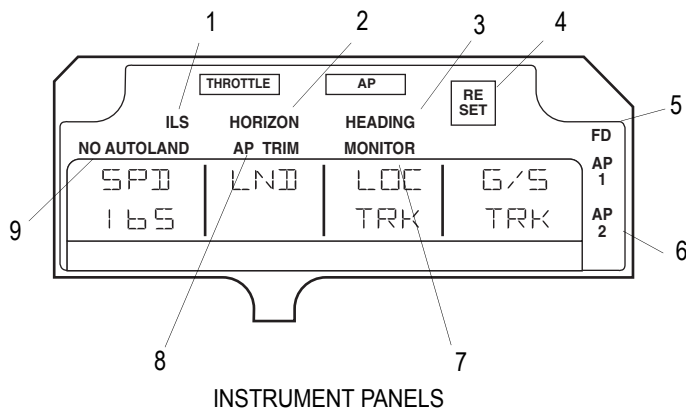
Flight Mode Annunciator (FMA)



1. **FMA Thrust Window (green)**
Displays existing autothrottle mode.
2. **FMA Arm Window (amber)**
Displays armed mode for roll or pitch.
3. **FMA Roll Window (green)**
Displays existing roll mode.
4. **FMA Pitch Window (green)**
Displays existing pitch mode.

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FMA Lights



1. ILS (amber)

Lights illuminate on both FMAs to indicate a deviation between LOC/GS -1 and -2 signals. When a failure is detected (flag in view), light on side that has failed will flash and light on opposite side will illuminate.

2. HORIZON (amber)

Lights illuminate on both FMAs to indicate a difference in pitch and roll attitude between Captain's and F/O's PFDs. When a failure is detected (flag in view), light on side that has failed will flash and light on opposite side will illuminate.

3. HEADING (amber)

Lights illuminate on both FMAs to indicate a difference between heading information. When a failure is detected (flag in view), light on side that has failed will flash and light on opposite side will illuminate.

4. RESET Button

Push - Resets ILS, HORIZON, HEADING, MONITOR, and NO AUTOLAND lights, which can be recalled by pushing the button a second time.

5. FD (blue)

Indicates associated flight director is engaged.

6. AP1/AP2 (blue)

Indicates respective DFGC selected and engaged.

7. **MONITOR (amber)**

Lights illuminate on both FMAs to indicate a failure of comparator monitor. ILS, HORIZON, and HEADING lights are not reliable.

8. **AP TRIM (amber)**

Indicates a sustained out-of-trim horizontal stabilizer condition of autopilot. Light cannot be reset and will remain illuminated until condition is corrected or autopilot is disengaged.

9. **NO AUTOLAND (amber)**

Indicates autoland is not available.

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Automatic Flight System Description

Chapter 4 Section 20

General

Automatic flight is provided by the digital flight guidance system (DFGS). The system consists of two digital flight guidance computers (DFGC) to provide the following functions:

- Autothrottle/speed control
- Autopilot (AP)
- Flight director (FD)
- Stability augmentation (yaw damping, mach trim)
- Altitude alert
- Engine thrust rating selection (TRP)
- Engine synchronization
- Autothrottle Advance
- Windshear alert and guidance

Flight guidance information is displayed on the EFIS primary flight display (PFD), navigation display (ND) and flight mode annunciator (FMA). The flight management system (FMS) can be coupled to the AP, FD and autothrottle to provide guidance and commands for roll, pitch, and thrust controls. Refer to Engines chapter for description of engine synchronization and Autothrottle Advance system.

Digital Flight Guidance Computer

Two DFGC's are provided, one of which functions while the other is in standby. DFGC 1 or 2 is selected by placing the DFGC switch to the respective position. The DFGC receives inputs from the central air data computers (CADC), VHF navigation systems (VOR/LOC), inertial reference systems (IRS), FMS, radio altimeters and airplane systems sensors.

A flight guidance control panel (FGCP), located on the glareshield, contains controls and indicators for automatic flight. The panel is divided into four different control sections: autothrottle, arm, roll, and pitch control. In addition, the NAV, VNAV and FMS OVRD buttons are provided to couple the FMS to control lateral and vertical navigation, and allow for temporary pilot selected speeds (FMS OVRD) without disengaging VNAV.

Autothrottle Section

The autothrottle section contains SPD/MACH select knob and window, SPD SEL, MACH SEL, EPR LIM and FMS OVRD buttons, and AUTO THROT switch.

A three-position SPD/MACH select knob allows setting of the SPD/MACH readout, and positioning the command bug on the airspeed indicators. In the normal position, one knot adjustments are accomplished. In the first detent, fast slewing of the selected readout occurs. Pushing the knob to second detent alternately switches the speed or Mach readout which has no effect on the engaged mode of the autothrottle. If other than SPD/MACH SEL mode is engaged, the SPD/MACH value will be stored in DFGC. Airspeed command bug on Mach/airspeed indicator is also set to airspeed appearing in readout.

Airspeed control mode of the autothrottle is engaged by momentarily pushing the SPD SEL button in flight. The FMA thrust window displays SPD and the airspeed selected in the SPD/MACH readout.

Mach control mode of the autothrottle is engaged by momentarily pushing the MACH SEL button in flight. The FMA thrust window displays MACH and the Mach number selected in the SPD/MACH readout.

EPR limit mode is engaged by momentarily pushing the EPR LIM button in flight. Thrust is set to the limit computed by the thrust rating system. The FMA thrust window displays EPR and applicable thrust rating selected on the thrust rating panel (TRP). If a takeoff flex mode is selected, EPR and assumed temperature annunciation is displayed.

A two-position, spring-loaded and solenoid held, AUTO THROT switch allows engagement and disengagement of the autothrottle.

Arm Section

The arm section contains VOR/LOC, ILS and AUTO LAND buttons for selection of the various modes.

VOR/LOC mode is armed to capture and track a VOR or localizer course by momentarily pushing the VOR/LOC button.

ILS mode is armed to capture and track a selected localizer course and glide slope by momentarily pushing the ILS button.

Automatic landing mode is armed to capture and track an ILS for an automatic landing by momentarily pushing the AUTO LAND button.

NAV mode is armed to capture and track the FMS course by momentarily pushing the NAV button.

Roll Control Section

Roll control section contains HDG select knob and HDG window for lateral control.

The HDG select knob consists of a knob and sleeve. The knob (spring-loaded to normal) has four positions. Normal position provides fine tuning of heading. When the knob is pushed to the first detent, fast rate of heading select is provided. When the knob is fully pushed in, the heading hold mode is engaged. With this mode engaged, the AP/FD either maintains the existing heading or, if the bank angle is more than 3 degrees, rolls the airplane wings level and maintains that heading. Pulling the knob engages the heading select mode which acquires and maintains the heading selected in the HDG window. The sleeve, with five detents from 10 to 30 degrees, limits bank angle during HDG SEL, HDG HOLD and VOR modes. Bank angle limiting is inhibited during LOC CAP and FMS NAV modes.

At VOR or LOC CAP, the FD displays roll commands and the AP (if engaged) will maneuver to capture and track the selected course if the airplane is on an intercept heading. The FMA displays an amber VOR or LOC annunciation when armed, VOR or LOC CAP at course capture, VOR or LOC TRK when tracking course, and VOR CRS during station passage.

At ILS capture, the FD displays roll and pitch commands and the AP (if engaged) will maneuver to capture and track the localizer and glide slope. The FMA displays ILS annunciation when armed, LOC CAP at localizer capture, LOC TRK when tracking localizer, GS CAP at glide slope capture and GS TRK when tracking glide slope.

During Auto Land at 1500 feet radio altitude, the FMA displays AUT LND annunciation and all other AP control modes, except go-around, are inhibited. The AP automatically executes a runway alignment maneuver at 150 feet radio altitude.

At main gear touchdown, automatic nose lowering takes place and the rudder will keep the airplane on localizer beam center. The AP will disengage automatically 5 seconds after nosewheel touchdown.

Pitch Control Section

The pitch control section contains a pitch profile window and pitch wheel, VERT SPD, IAS/MACH, TURB, and ALT HOLD mode buttons. This section also contains the ALT window and set knob.

Control of the pitch profile is provided by the pitch wheel and the pitch profile window. On the first window, a constant vertical rate is indicated by a "V" symbol and the desired rate of change. Using pitch to control speed is indicated by an "S" or "M" symbol and the desired airspeed or Mach respectively.

The vertical speed mode is engaged by pushing the VERT SPD button, or if ALT HLD or VNAV was engaged, by selecting a vertical speed with the pitch wheel. The window displays "V" symbol followed by a "+" or "-" symbol for climb or descent respectively and the vertical speed readout. Vertical speed is changed by rotating the pitch wheel.

Vertical speed rate adjustments, after altitude capture, will disengage the altitude capture mode, and will revert to the vertical speed mode.

The PFD displays FD pitch commands and the AP (if engaged) will adjust pitch attitude to obtain the commanded vertical speed.

Indicated airspeed or Mach mode is engaged by pushing the IAS MACH button. When the airplane altitude is below 27,000 feet, the pitch window displays an "S" symbol followed by existing airspeed which can be changed by rotating the pitch wheel. If the airplane altitude is above 27,000 feet, when IAS MACH button is pressed, the Mach mode is engaged. The PFD displays FD commands to maintain selected Mach or indicated airspeed and the AP (if engaged) will adjust pitch attitude to maintain selected speed. MACH or IAS annunciation is displayed on the FMA.

Altitude hold mode can be engaged by pushing the ALT HOLD button or selecting zero vertical speed in the pitch window. The PFD displays FD pitch commands and the AP (if engaged) will return to the altitude where the button was pushed. ALT HLD annunciation is displayed on the FMA.

A preselected altitude can be set by the ALT set knob and displayed in the ALT window. The knob has three positions and spring-loaded to center.

The center position provides 1000 foot increments if greater than 1000 foot is selected, and 100 foot increment altitude adjustment if below 1000 foot selected. Pushing and rotating provides 100 foot increment if the altitude selected is above 1000 feet. If the knob has been previously pushed in to select "100's" and is released to the center position, the next "click" is a 100 foot increment if done immediately. Thereafter, it reverts to 1000 foot increments.

The selected altitude is armed automatically after setting.

Pulling the knob also arms the selected altitude for capture.

Turbulence mode is engaged by momentarily pushing the TURB button which disengages the autothrottle and altitude hold mode and rolls the airplane wings-level. The THROTTLE warning light flashes and the pitch profile window displays "P" followed by a "+" or "-" symbol and the pitch attitude. The pitch attitude can be changed by rotating the pitch wheel. The PFD displays FD commands and the AP (if engaged) will maneuver to maintain the displayed pitch attitude. The FMA displays WNG LVL and TURB annunciations.

During autoland at 50 feet, the FMA will annunciate "FLAR" and the autopilot will flare the airplane until touchdown.

Flight Mode Annunciator

Two FMA's, each located at the top of the instrument panel, provide the following information:

- Flight instrument comparisons and failure indications (ILS, HORIZON and HEADING lights).
- AP/Autothrottle disengaged warning (AP, THROTTLE warning lights).
- AP out-of-trim indication (AP TRIM light).
- No autoland indication (NO AUTOLAND light).
- Throttle, arm, roll and pitch mode annunciations.

Throttle, Arm, Roll and Pitch (TARP) mode annunciations are displayed on the FMA in four separate windows, corresponding to four applicable FGCP control sections, for autothrottle/thrust, arm, roll and pitch (TARP) functions.

An ANNUN/DIGITAL LTS TEST button on the overhead panel tests the annunciations and lights on both FMA's. When the button is pushed, all the lights on the FMA's illuminate and annunciations are displayed in the form of "starburst" symbols.

When the button is released, the lights and "starburst" symbols remain displayed for five seconds, except the THROTTLE and AP warning lights extinguish immediately. Refer to Airplane General chapter for complete description of the ANNUN/DIGITAL LTS TEST button.

Autothrottle Mode Annunciations (Green)	
ATS OFF.	VNAV mode selected, autothrottle off. Light flashes as reminder to engage autothrottle.
CLMP FMS.	Throttles clamped with FMS engaged in CRZ DES.
FMS EPR.	(FMS VNAV mode engaged.) Throttles being controlled by FMS to maintain EPR.
FMS SPD.	(FMS VNAV mode engaged.) Throttles being controlled by FMS to maintain speed.
FMS IDLE.	(FMS VNAV mode engaged.) Throttles being controlled by FMS for idle setting.
AUTO LND.	Autoland preflight ground test is in progress. Appears for approximately 20 seconds.
CLMP.	ATS in clamp mode. Power is removed from ATS servo (throttles remain stationary).
RETD.	ATS in retard mode. Throttles automatically retarded at 50 feet.

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Autothrottle Mode Annunciations (Green)	
ALFA SPD.	ATS in ALFA speed mode. Throttles controlled to maintain a safe margin above stall speed.
MACH 784.	ATS in Mach select mode. Throttles controlled to maintain .784 Mach as selected in SPD MACH readout.
SPD 250.	ATS in speed select mode. Throttles controlled to maintain 250 KIAS as selected in SPD MACH readout.
FLAP LIM.	ATS controlling throttles to prevent exceeding flap limit airspeed. Occurs automatically when a reference airspeed greater than flap design limit airspeed is selected.
SLAT LIM.	ATS controlling throttles to prevent exceeding slat limit airspeed. Occurs automatically when a reference airspeed greater than slat design limit airspeed is selected.
VMO LIM.	Indicates that ATS is automatically limited to not exceed maximum operating airspeed (VMO).
MMO LIM.	Indicates that ATS is automatically limited to not exceed maximum operating Mach number (MMO).
SPD ATL/ MACH ATL.	ATS limit when operating in SPD SEL or MACH SEL mode, as applicable. Automatically occurs when ATS throttle command would exceed EPR limit.
LOW LIM.	Occurs automatically when ATS throttle command would require a throttle setting lower than the minimum authority limit.
EPR T/O.	ATS in EPR LIM mode with T/O thrust selected. Throttles controlled to maintain EPR limit takeoff thrust.
EPR 50.	ATS in EPR LIM mode with 50° selected on ASSUMED TEMP Selector (assumed temperature selected will be displayed) and TO FLX thrust selected. Throttles controlled to maintain derated takeoff thrust.
EPR G/A.	ATS in go-around mode with G/A thrust selected. Throttles controlled to maintain EPR G/A thrust limit.
EPR MCT.	ATS in EPR LIM mode with MCT thrust selected. Throttles controlled to maintain maximum continuous thrust.
EPR CL.	ATS in EPR LIM mode with CL thrust selected. Throttles controlled to maintain climb thrust.
PWR.	Automatic power-up test in progress. (Occurs approximately 2 minutes after landing).
WND SHR.	ATS is engaged and windshear is detected, a speed bias is being added by the windshear computer.

Arm Mode Annunciations (Amber)	
PRE.	Autoland preflight ground test in progress. Appears approximately 20 seconds.
LND.	Automatic landing mode armed for automatic capture of selected ILS for automatic landing.
ILS.	ILS mode armed for automatic capture of localizer and glideslope of selected ILS.
LOC.	LOC mode armed for automatic capture of selected localizer course.
VOR.	VOR mode armed for automatic capture of selected VOR course.
ATL.	Altitude preselect armed for automatic capture of selected altitude.
LND ATL.	Automatic landing mode armed for automatic capture of selected ILS and altitude preselect armed for automatic capture of selected altitude.
ILS ATL.	ILS mode armed for automatic capture of selected ILS and altitude preselect armed for automatic capture of selected altitude.
LOC ALT.	LOC mode armed for automatic capture of selected localizer course and altitude preselect armed for automatic capture of selected altitude.
VOR ALT.	VOR mode armed for automatic capture of selected VOR course and altitude preselect armed for automatic capture of selected altitude.
AUT G/A.	Flight guidance system armed for full automatic go-around capability.
FD G/A.	Flight guidance system armed for Flight Director command capability for manual go-around.
MAN G/A.	Flight guidance system not armed for go-around capability.
UP.	Automatic power-test in progress (Occurs approximately 2 minutes after landing).
NAV.	FMS LNAV mode is armed.

Roll Mode Annunciations (Green)	
FLT.	Autoland preflight ground test in progress. Appears for approximately 20 seconds.
HDG HLD.	Heading hold (roll basic mode) engaged and existing magnetic heading maintained.
HDG SEL.	Heading select mode engaged and heading selected in HDG readout maintained.
VOR CAP.	Capture of selected VOR course has occurred.
VOR TRK.	Airplane tracking selected VOR course.
VOR CRS.	Station passage is occurring. Airplane will maintain existing heading during station passage.
LOC CAP.	LOC, ILS, or LAND mode engaged and capture of localizer course has occurred.
LOC TRK.	LOC, ILS, or LAND mode engaged and airplane is tracking localizer course.
NAV CAP.	Nav engaged and capturing a new lateral course, or if bank angles greater than 10° are required.
NAV HLD.	NAV engaged and FMS is in an internal heading hold mode, e.g., in discontinuity and airplane on intercept track.
NAV TRK.	Nav engaged, tracking desired course.
TAK OFF.	Flight Director takeoff mode engaged. After lift-off, roll command bar on PFD will command wings level to maintain heading.
WNG LVL.	Turbulence mode engaged. Roll command bar on PFD will command wings level.
GO RND.	Go-around mode engaged. Existing magnetic heading maintained and roll command bar on PFD commands wings level.
AUT LND.	LAND mode engaged. Logic for mode is satisfied to perform automatic landing.

Roll Mode Annunciations (Green)	
ALN.	Align mode engaged. Airplane maneuvered to maintain runway alignment.
ROL OUT.	Main gear wheel spin-up has occurred. FD provides steering commands to maintain runway alignment. AP maintains runway alignment with nosewheel steering.
TST.	Automatic power-up test in progress. (Occurs approximately 2 minutes after landing.).

Pitch Mode Annunciations (Green)	
TEST.	Autoland preflight ground test in progress. Appears for approximately 20 seconds.
VNAV CLB.	(VNAV mode engaged.) Climb pitch attitude as determined by FMS.
VNAV LVL.	(VNAV mode engaged.) Altitude maintained by pitch attitude as determined by FMS.
VNAV DES.	(VNAV mode engaged.) Descent altitude maintained by pitch attitude as determined by FMS.
VNAV CAP.	FMS is coupled with DFGC and is in the VNAV path capture mode.
VERT SPD.	Vertical speed (a pitch basic mode) engaged. Airplane vertical speed maintained by pitch attitude.
ATL CAP.	Altitude preselect mode engaged and altitude capture has occurred.
ATL HLD.	DFGS is providing Flight Director/Autopilot with guidance commands to maintain the steady state barometric altitude at which altitude hold mode was engaged. (A pitch basic mode).
IAS.	IAS hold mode engaged and indicated airspeed maintained by pitch attitude.
MACH.	MACH hold mode engaged and Mach number maintained by pitch attitude.
TURB.	Turbulence mode engaged. Pitch attitude controlled by use of pitch wheel.
TAK OFF.	Flight Director takeoff mode engaged. After lift off, pitch command bar on PFD will display pitch commands to maintain V2 or V2 + 10 KIAS.
G/S CAP.	ILS or LAND mode engaged and glideslope capture has occurred.

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Pitch Mode Annunciations (Green)	
G/S TRK.	ILS or LAND mode engaged and airplane is tracking glideslope.
GO RND.	Go-around mode engaged. Airplane controlled to maintain a safe margin above stall airspeed while establishing a climb attitude. Pitch command bar on PFD will display commands to maintain a safe margin above stall airspeed.
AUT LND.	LAND mode engaged. Logic for mode is satisfied to perform automatic landing.
FLAR.	LAND mode engaged and flare mode initiated.
NO FLR.	ILS mode engaged and autopilot remains engaged at radio altitude of 100 feet. This is a flashing annunciation.
ROL OUT.	Main gear wheel spin-up has occurred. Annunciation remains until autopilot is disengaged.
SPD LOW.	The engaged pitch mode is commanding a pitch attitude that results in an airspeed below the ALFA reference speed. SPD LOW annunciation will flash alternately with engaged pitch mode annunciation when airspeed decreases to 10 percent below the ALFA reference speed.
BOX 1 (2).	Automatic power-up test in progress (Occurs approximately 2 minutes after landing.).
WND SHR.	Windshear pitch mode is engaged.

Autothrottle/Speed Control

The autothrottle/speed control function provides a full flight regime automatic throttle that can control airspeed, Mach number and engine thrust from takeoff to landing.

Appropriate annunciations including numerical values (when applicable) appear on the FMA to indicate existing operating mode of autothrottle/speed control.

Autothrottle

Autothrottle function is engaged by moving the AUTO THROT switch from OFF to AUTO THROT position. The switch will not remain in the AUTO THROT (on) position unless all interlocks and engage requirements are satisfied. The switch will automatically revert to OFF when electrical power is lost, a malfunction is detected or the autothrottle disconnect button on either throttle is pushed. The red THROTTLE warning light on the FMA flashes when the above occurs or when the AUTO THROT switch is manually moved to OFF. Pushing either autothrottle disconnect button or manually turning the AUTO THROT switch on extinguishes the THROTTLE light. If autothrottle ON, the autothrottles will disconnect when reverse thrust is selected. The red throttle warning light will not illuminate with the use of reverse thrust.

Three primary autothrottle operational modes may be selected on the FGCP: speed select (SPD SEL); Mach select (MACH SEL) and EPR limit (EPR LIM). The thrust rating panel (TRP) is used to select a thrust EPR for EPR LIM mode.

Secondary modes that occur automatically are: SPD ATL, MACH ATL, LOW LIM, FLAP LIM, SLAT LIM, VMO LIM, MMO LIM, ALFA SPD, RETD, and CLMP.

Thrust EPR that may be selected include takeoff (TO), takeoff flex (TO XX), go-around (GA), maximum continuous thrust (MCT), climb (CL) and cruise (CR).

Airspeed/Mach Select (SPD/MACH SEL) Mode

The SPD SEL or MACH SEL mode can be engaged during any phase of flight except when TO, GA or TO FLX is selected on the TRP or retard mode is engaged. With autothrottle in SPD SEL or MACH SEL mode, the autothrottle seeks and maintains reference speed/Mach selected in the SPD/MACH window except when the Alpha speed reference is a higher value. If the autothrottle is engaged in SPD SEL or MACH SEL mode after the autopilot/flight director was engaged in either IAS or MACH mode, the autopilot/flight director will revert to the vertical speed mode at the existing vertical speed and the VERT SPD annunciation will flash for approximately 5 seconds on the FMA.

EPR Limit (EPR LIM) Mode

Autothrottle EPR LIM mode is initiated by pressing the EPR LIM button if the autothrottle is already engaged; or by selecting TO, GA or TO FLX on the TRP, pushing the TO/GA button on either throttle, and engaging the autothrottle. The airplane must be on the ground more than 20 seconds to initiate takeoff mode. Pushing either TO/GA button selects the TAK OFF mode of the flight director. Go-around mode is also initiated by pushing either TO/GA button as for takeoff mode except airplane must be airborne or on the ground for less than 20 seconds.

Upper and lower authority limits are provided for throttle control. The autothrottle function provides upper authority limits by means of EPR limit control modes. Lower limit authority is a function of the DFGC retarding the throttles to just above idle (when FMS mode is engaged, the throttles retard to idle stop). The upper limit protects against exceeding EPR limits. The lower limit prevents the throttles from being driven to the idle stops.

The autothrottle automatically reverts from EPR limit to airspeed or Mach control mode when preselected altitude capture occurs. The throttles are controlled to acquire and maintain the value preset in the SPD/MACH readout. Automatic reversion occurs at altitude capture and the pilot follows FD commands (autopilot disconnected). The transition is fully automatic when the autopilot is engaged.

Clamp (CLMP) Mode

The CLMP mode is engaged (power removed from throttle servo motor and CLMP annunciation displayed on the FMA) when the following conditions exist:

- The airplane is on the ground for more than 20 seconds with autothrottle in EPR mode and airspeed is greater than 60 KIAS.
- In flight, the autothrottle is in SPD SEL or MACH SEL mode and IAS or MACH mode is selected.

Alpha Speed (ALFA SPD) Mode

ALFA SPD mode is engaged automatically when the autothrottle is in SPD SEL or MACH SEL mode and the selected SPD/MACH value is less than the safe minimum airspeed for the existing slat/flap configuration. The FMA displays ALFA SPD and the throttles are controlled to seek and maintain the Alpha speed reference indicated by the Fast/Slow display on the PFD.

Retard (RETD) Mode

The RETD mode is engaged as a function of radio altitude and landing flap configuration (autopilot/flight director may or may not be engaged). The FMA displays RETD and the throttles are retarded towards idle.

Autothrottle Limit Mode (SPD/MACH ATL)

The SPD ATL or MACH ATL mode is displayed when the autothrottle is engaged and a speed control input would cause a throttle command that would exceed the thrust rating EPR limit. The autothrottles will not exceed EPR limit and the FMA displays SPD ATL or MACH ATL. When the throttle command returns to the normal operating thrust range, the autothrottle will revert to the previously engaged mode.

Flap/Slat Limit Mode (FLAP/SLAT LIM)

The FLAP LIM or SLAT LIM mode is engaged when the autothrottle is in SPD SEL or MACH SEL mode and the selected SPD/MACH value exceeds the design limit airspeed for the existing flap/slat configuration. The FMA displays FLAP LIM or SLAT LIM. The autothrottle will seek and maintain the flap/slat design limit and the Fast/Slow display on the PFD will be centered when the design limit is achieved. When the selected SPD/MACH value is reduced below the flap/slat design limit, or the flap/slat configuration is changed, the FMA annunciation will revert to the engaged SPD/MACH mode.

Low Limit Mode (LOW LIM)

The LOW LIM mode is engaged when the autothrottle commands a throttle setting lower than the minimum authority limit. The FMA displays LOW LIM, and the throttles retard to just above idle. When the throttles are commanded to advance from the minimum authority stops, the FMA annunciation will revert to the original operating mode.

Speed Limit Mode (VMO/MMO LIM)

The VMO LIM or MMO LIM mode is engaged when the autothrottle is in SPD SEL or MACH SEL mode and the indicated airspeed approaches the maximum operating limit. The throttles will be controlled to maintain airspeed below VMO/MMO limit. The VMO LIM or MMO LIM annunciation is displayed on the FMA. The annunciation will revert to the original mode when the indicated airspeed drops below the speed limit.

Speed Control

Speed control inputs for attitude control are displayed by the command bar and fast/slow (F/S) display on the PFD during flight director takeoff and go-around modes. Full scale deflection is ± 10 knots.

During takeoff, the command bar on the PFD commands a pitch attitude to maintain V_2+10 KIAS for two-engine operation. In the event of an engine failure, pitch commands for one engine operation will be as follows: If the airspeed is at or below V_2 KIAS at the time of engine failure, the command bar will command a pitch attitude to maintain V_2 KIAS. If the airspeed is between V_2 and V_2+10 KIAS at the time of engine failure, the command bar will command a pitch attitude to maintain existing airspeed. If the airspeed is V_2+10 KIAS or greater, the command bar will command a pitch attitude to maintain V_2+10 KIAS.

During go-around mode, the command bar commands a pitch attitude to maintain DFGC computed go-around speed (airspeed at TOGA switch activation, but not less than $1.3 V_S + 5$ KIAS or greater than $1.3 V_S + 25$ KIAS of the landing flap configuration).

The Fast/Slow (F/S) display indicates the deviation between actual and selected Mach or indicated airspeed for the range of selected airspeeds between maximum limit and minimum safe (Alpha speed) airspeed for the existing flap/slat configuration. If the selected speed lies outside of this range, the F/S displays the deviation between actual and maximum limit or minimum safe airspeed as applicable. There are some exceptions, as follows:

- Takeoff/Go-Around Mode (TO/GA): During takeoff or go-around (TO/GA selected), the F/S display indicated the speed deviation relative to the computed takeoff or go-around reference speeds.
- Retard Mode (RETD): In the RETD mode, the F/S display is removed.
- Flight Management System (FMS): With VNAV mode selected, the F/S display is referenced to the FMS target speed.
- Gust Integration (Autothrottles Engaged): During approach in turbulent conditions, with flaps set at 26 degrees or more, an automatic increase in reference speed, up to a maximum of 5 knots, is added to compensate for wind gusts. The F/S display reflects this change in the reference speed.
- Windshear Encounter: During a detected windshear encounter, the F/S display indicates relative angle of attack (Alpha).

Any desired airspeed can be selected on the FGCP but speed control inputs are limited to prevent commands which exceed flap/slat and VMO/MMO limit speeds and to prevent commands lower than minimum maneuvering speed (safe stall margin speed). Speed control inputs for F/S display and the autothrottle command the pilot or autothrottle to adjust the throttles to maintain the higher reference speed of either the minimum maneuvering speed (Alpha speed) or the airspeed selected on the FGCP.

Autopilot

The AP function, operating in conjunction with the yaw damper, automatically controls the airplane in pitch, roll, and yaw maneuvering axes. Appropriate control surfaces are actuated by the AP to fly a computed flight path automatically.

The AP includes functions to maintain an existing altitude; descend or climb to and maintain a preselected altitude; maintain a selected vertical speed, indicated airspeed, or Mach number; fly a FMS optimized profile; maintain an existing heading; fly to and maintain a preselected heading; fly to, capture, and track a selected VOR or localizer course; capture and track a glide slope; maintain runway alignment, flare and momentarily maintain rollout for automatic landing. Appropriate annunciations appear on both FMA's to indicate existing AP operating modes.

The AP is engaged by placing the AP switch on the FGCP in AP ON position. The switch is spring loaded to off and solenoid held in AP ON position.

The AP is disengaged and the red AP warning light on the FMA flashes in the following conditions:

- AP switch is off.
- AP malfunction is detected.
- DFGC switch is moved from selected position.
- AUTOPILOT REL button on either control wheel is pushed.
- Primary horizontal stabilizer trim is manually operated.
- Activation of the stick pusher.

In addition, the flashing AP light is accompanied by aural and vocal warnings in all AP disengagements. The loss of electrical power will also disengage the autopilot. The red AP warning light will not illuminate and vocal warnings will not sound with loss of electrical power.

Pushing the AUTOPILOT REL button a second time will cancel the AP warning.

An AP TRIM light on the FMA illuminates to indicate the horizontal stabilizer is out of trim.

Flight Director

The FD function provides visual guidance commands on the PFD to fly the airplane manually or to visually monitor AP response to the guidance commands.

Captain's and First Officer's FD switches are provided on the FGCP. When a FD switch is in FD, pitch and roll commands are displayed on the respective PFD and pitch and roll annunciations are displayed on the respective FMA. If the AP is engaged, both FMA's display AP armed and operating modes and the blue AP 1 or AP 2 lights on each FMA respectively illuminates to indicate the controlling AP.

A FD CMD selector, located on the overhead panel, selects either DFGC-1 or -2 for control of the guidance commands and the fast/slow (F/S) displays. When the selector is in NORM, guidance commands and F/S display are provided by the respective DFGC. When the selector is placed in either BOTH ON 1 or BOTH ON 2, guidance commands and F/S displays are provided by the selected DFGC.

With AP disengaged, FD basic mode (heading hold and vertical speed if vertical speed is zero, Altitude hold) is provided by placing either FD switch to FD position. Guidance commands are displayed on the PFD to roll wings level for heading hold and then to maintain existing heading and vertical speed. All modes except VOR/ILS modes are interfaced with the opposite DFGC. When the opposite-side FD switch is then turned on, the FD will engage the previously selected and engaged mode. When VOR/ILS mode is selected, both FD switches are in FD and the FD CMD selector is in NORM, guidance commands are displayed to acquire and track radio courses selected by the respective VHF NAV control panel. For ILS modes, both VHF NAV control panels should be set to the ILS frequency and inbound ILS course. Armed and operating modes of each FD are displayed on the respective FMA and the blue FD light illuminates.

With AP engaged, the FD is primarily used to monitor all AP operating modes from climb-out to automatic landing. Both FMA's display appropriate AP armed and operating modes and the respective blue AP 1 or AP 2 light illuminates to indicate the controlling AP.

Stability Augmentation

The DFGS provides two-axis stability augmentation which includes yaw damper and Mach trim compensation.

Yaw Damper

The yaw damper function derives yaw rate to provide damping of the Dutch roll characteristic. In addition, the function provides automatic turn coordination except during coupled approach localizer track mode. The function is activated automatically with the AP engagement or may be controlled separately with the YAW DAMP switch located on the overhead panel. Yaw damper operation is a function of both the YAW DAMP and AP switches. With AP switch in ON, yaw damping is engaged with the YAW DAMP switch in either ON or OFF position. With AP switch off, yaw damping is engaged only with the YAW DAMP switch in ON. The OVRD position of YAW DAMP switch disables yaw damper, regardless of AP status.

Yaw damp and turn coordination functions are normally handled by a series rudder actuator. This means that the actuator does not move the rudder pedals. This actuator has limited authority (+/- 2 degrees). In some critical modes (T/O, Approach and G/A) the autopilot is capable of handling the yaw caused by an engine failure. This additional authority is achieved by the autopilot using parallel rudder servo. This means that the autopilot drives the rudder pedals. The parallel rudder servo has full rudder authority.

Parallel rudder engagement automatically occurs when the A/P is engaged in the takeoff mode. The parallel rudder provides automatic yaw compensation in case of engine failure, however; the autopilot should not be engaged in T/O mode if an engine has already failed. The parallel rudder servo will be phased out when a new roll mode is selected. If parallel rudder is engaged during the transition to windshear mode, it will remain engaged.

In approach mode (LAND/ILS), parallel rudder engagement is available when radio altitude is less than 1,500 feet radio altitude and in LOC TRK, G/S TRK mode. If parallel rudder is engaged during the transition to auto G/A or windshear mode, it will remain engaged. The parallel rudder is disengaged when the A/P is disconnected at DH or upon exit from ground rollout mode.

Mach Trim Compensation

Mach trim compensation provides nose-up trim to compensate for the normal pitch down (tuck) characteristic encountered at high Mach operation. The function is controlled by the MACH TRIM COMP switch located on the overhead panel. With the switch in NORM, the mach trim compensator positions the First Officer's control column aft at speeds greater than .80 mach.

Altitude Alert

The altitude alert functions when the airplane is approaching a preselected altitude or deviating from an acquired altitude. An amber alert light on each altimeter indicates the alert for the above situations.

In addition, the aural warning, which consists of a continuing series of 1-second aural tones, and the vocal warning "altitude" are generated.

The DFGC receives and monitors altitude information from both CADC's to provide the altitude alert function.

Selected altitude alert is set by the ALT set knob on the FGCP and is automatically armed by selecting a new altitude.

In addition, the selected altitude is also armed manually by pulling the set knob.

Engaging the AP/FD into any pitch mode other than go-around, from glide slope capture or track mode, will automatically arm the preselected altitude. In go-around mode, the preselected altitude is automatically armed whenever the preselected altitude is at least 1000 feet above ground level (AGL).

The alert lights illuminate (steady) and the aural warning sounds when the airplane is between 750 feet and 250 feet from the preselected altitude.

If the airplane deviates more than 750 feet from the preselected altitude after the 750-foot threshold has been reached and before the 250-foot threshold has been reached, the lights will flash and the aural and vocal warnings will sound. If the airplane deviates more than 250 feet from the preselected altitude after the 250-foot threshold has been reached, the lights will also flash and the aural and vocal warnings will sound.

A different desired altitude may be preselected at any time. The warnings can be reset by selecting another altitude or by maneuvering the airplane within 250-foot capture limit.

The altitude alert function is inhibited at glide slope capture.

The altitude alert function is also inhibited if the flaps are extended to landing configuration.

Thrust Rating Panel

The engine thrust rating panel selects engine thrust rating modes for a specific phase of flight. The EPR limit for the selected mode is computed by the TRP and is based on existing RAT or assumed temperature, altitude and engine bleed air. The EPR limit is also supplied to the autothrottle to be used as upper throttle authority limit when operating in the SPD SEL or MACH SEL modes, or as the commanded EPR when operating in the EPR LIM mode. The EPR limit for the flex takeoff mode is less than maximum or normal EPR but not less than CL (climb) EPR.

OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

MACH TRIM FAULT (CONT) - Indicates mach trim system is inoperative, as detected by DFGC, when MACH TRIM COMP switch is in NORM.

MACH TRIM OFF (CONT) - Indicates MACH TRIM COMP switch is OFF.

YAW DAMP OFF (CONT) - Indicates yaw damper is inoperative or YAW DAMP switch is in OVRD.

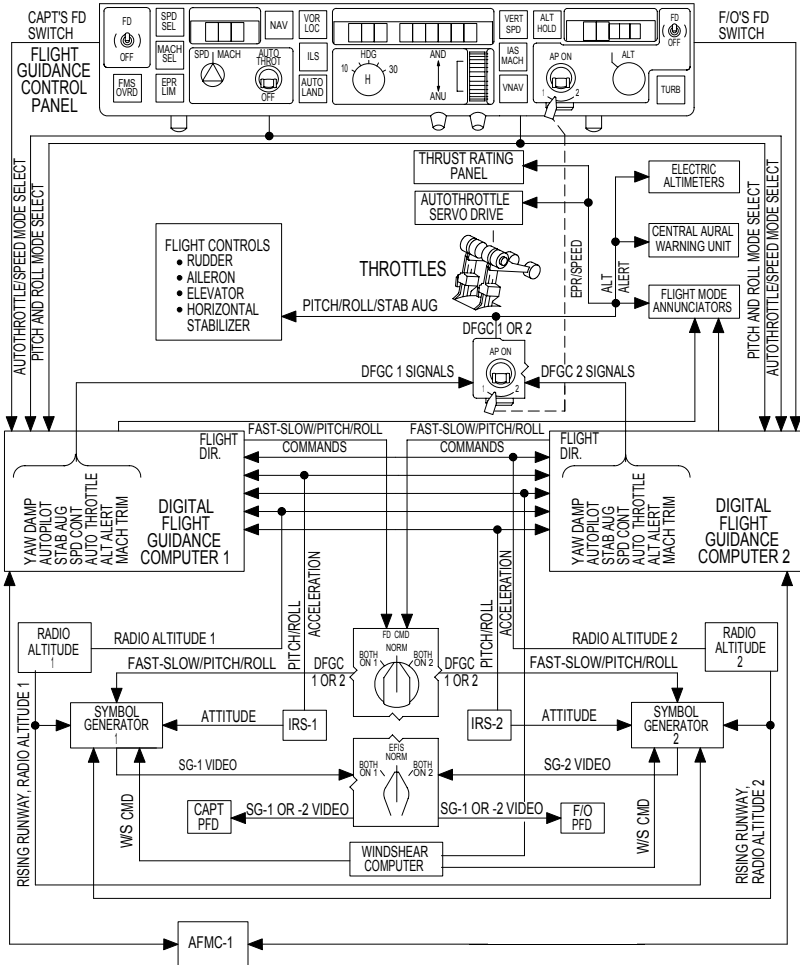
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Automatic Flight Functional Schematic

Chapter 4

Section 40

Automatic Flight



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System Description

Automatic Thrust Cut-Back

An automatic thrust cutback function is available for takeoff noise abatement. Prior to takeoff, a cutback EPR and altitude above field elevation (AFE) are entered into the multipurpose control display unit (MCDU). An armed status is displayed on the MCDU and in the throttle mode window of the FMA. Normal takeoff procedures are conducted. Approximately two seconds prior to reaching the cutback altitude (alert point), an aural warning "CUTBACK" is annunciated and additional cutback EPR limit bugs are displayed on the EDP. Upon reaching the cutback altitude, the autothrottle unclamps and retards the throttles to maintain the preselected cutback EPR limit. Autopilot/flight director guidance is provided to maintain the takeoff reference speed. The pilot may override/cancel an automatic thrust cutback by momentarily holding the throttles at or following the cutback initiation. In addition, an automatic thrust cutback is disarmed if any of the following occur:

- DFGC/AFMC/EEC/IRU failure detected
- FD takeoff pitch guidance not available
- TRP mode change
- Engine failure
- Windshear (Caution or Warning)
- Engine fire warning activated
- Master warning activated
- A/T disconnect
- Stick shaker activated
- TCAS RA activated
- Either throttle is moved from position at liftoff
- Gear handle is lowered after being raised
- Negative climb rate for 5 seconds
- Indicated airspeed < (Takeoff reference speed-5 knots) at alert point

MACH Trim

With the switch in NORM, the DFGC commands alternate trim motor, through the elevator load feel system, to schedule required alternate trim.

Thrust Rating Panel (TRP)

The engine thrust rating panel selects engine thrust rating modes for a specific phase of flight. The EPR limit for the selected mode is computed by each EEC based on existing total air temperature (TAT) or assumed temperature, altitude and engine bleed. Refer to Chapter 7, Engines, APU, Section 90, for further discussion on the TRP.

Communications

Chapter 5

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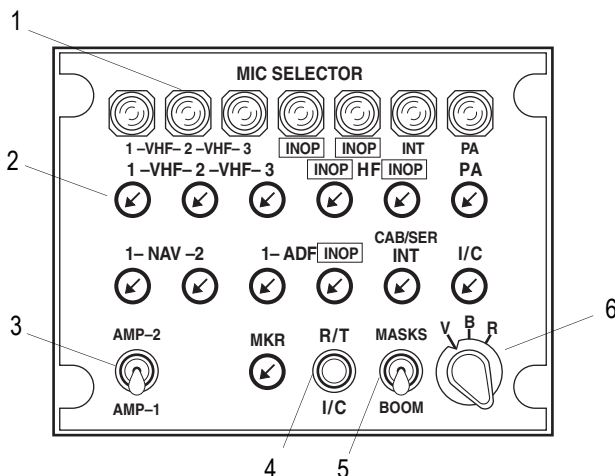
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Audio Control Panel



1. Microphone Switchlights

Push to select desired transmitter. Integral light illuminates. VHF switchlights also select respective receive function without independently selecting the corresponding receive switch.

A mechanical interlock prevents the selection of more than one transmitter at a time.

2. Control Knobs

Push to monitor audio. Push again to discontinue monitoring audio. All receivers may be simultaneously monitored.

Rotate knob to adjust volume.

3. Amplifier Switch

Used to select the desired amplifier for the audio selector panel.

4. Radio/Intercom Switch

Momentary in either position.

R/T - Keys radio transmitter for mask or boom microphone operation.

I/C - Keys flight interphone for mask or boom microphone operation.

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5. MASKS/BOOM Microphone Switch

MASKS - Oxygen mask microphone connected to communications system.

BOOM - Boom microphone connected to communications system.

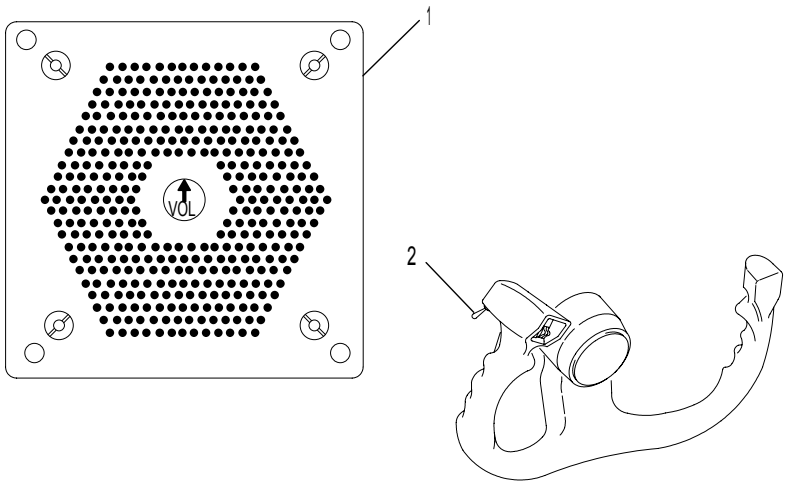
6. Voice/Range Selector

V - (Voice) Morse code signals filtered out.

B - (Both) Unfiltered reception. Morse code, voice, and DME is received.

R - (Range) Voice signals filtered out.

Flight Interphone System MIC Switches/Speakers



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1. (Captain's/First Officer's) Speaker

VOL - Turn to adjust volume.

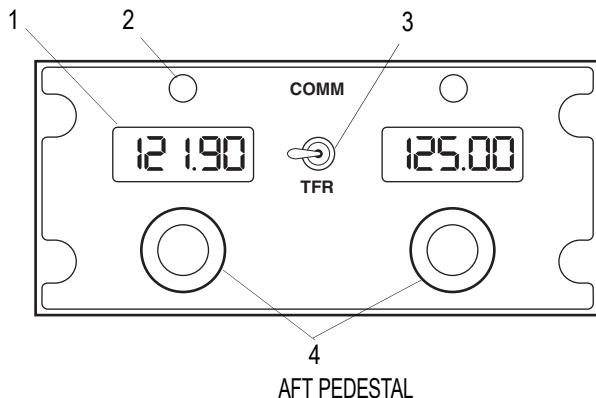
2. (Captain's/First Officer's) Control Wheel MIC Switch

Aft - Hold for radio transmission.

Center (Spring-loaded) - Off.

Forward - Hold for interphone transmission.

VHF COMM Control Panel



1. Active/Standby Frequency Readout (2)

Tuned frequency, which is either active or standby, as selected.

2. Annunciator Lights (2) (green)

Illuminates to show readout of frequency in use.

3. TFR Switch

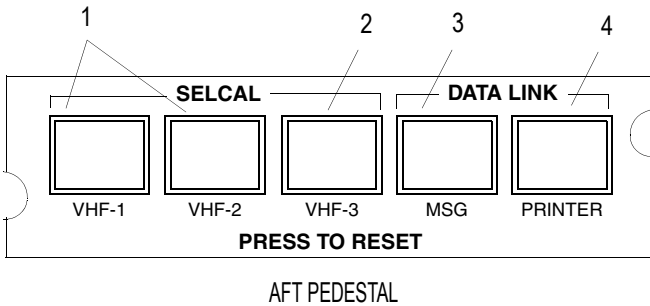
Selects either of the tuned frequencies.

4. VHF Frequency Selector Knobs

Outer Knob - Selects second and third digits of frequency.

Inner Knob - Selects fourth and fifth digits of frequency.

SELCAL Control Panel



1. VHF-1/VHF-2 Switchlights (blue)

Respective switchlight illuminates with chime from CAWS when called by a ground station.

Push respective switchlight to reset switchlight and chime.

2. VHF-3 Switchlights (blue)

Flashes in conjunction with a single chime when an ACARS uplink message is received. Will also indicate a SELCAL if VHF-3 is in VOICE mode and tuned to proper frequency.

Push respective switchlight to reset switchlight and chime.

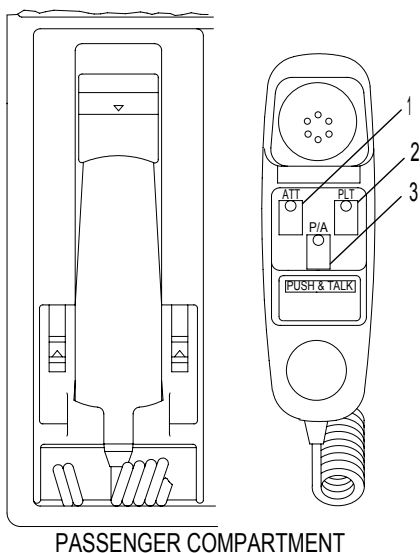
3. MSG

Illuminates when an ACARS message has been received and is intended for display on the touchscreen. Pushing indicator resets system.

4. PRINTER

Illuminates when an ACARS message has been received and is intended for the printer. Pushing the indicator or the reset button on the printer resets the system.

Flight Attendant Handset



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1. ATT Call Switchlight

Push - Actuates chime for attendant-to-attendant call.

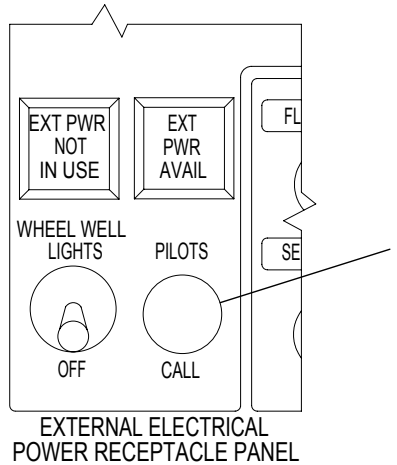
2. PLT Call Switchlight

Push - Actuates chime and ATTND CALLING light in cockpit.

3. P/A Switchlight

Push - Connects handset to passenger address system.

External Electrical Power Receptacle Panel

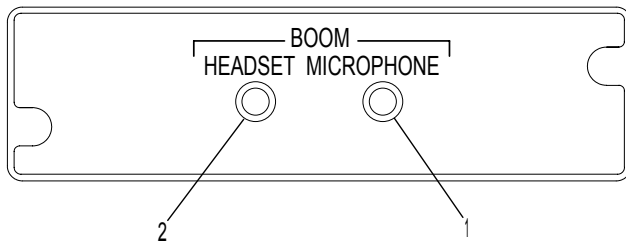


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1. **Mechanic-To-Pilot Call Button**

PILOTS CALL - Push to call pilot. Chime sounds in cockpit.

Jack Box Control Panel



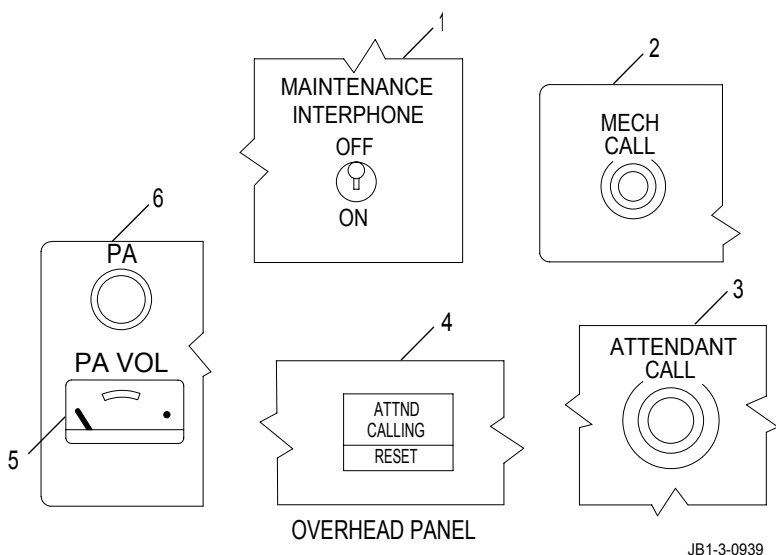
1. **MICROPHONE Jack**

Used to plug the boom microphone into the communication system.

2. **HEADSET Jack**

Used to plug the headset into the communication system.

Service/Interphone Communications



1. MAINTENANCE INTERPHONE Switch

OFF - Disconnects all maintenance interphone jacks from the service interphone.

ON - Connects all maintenance interphone jacks to the service interphone.

2. MECH CALL Button

Push - Horn sounds in nose wheel well.

3. ATTENDANT CALL Button

Push - Actuates chime and pink master call lights in the cabin.

4. ATTND CALLING/RESET Switchlight

ATTND CALLING - Illuminates simultaneously with chime when flight attendant pushes handset PLT switchlight.

RESET - Resets switchlight when pushed.

5. PA VOL Meter

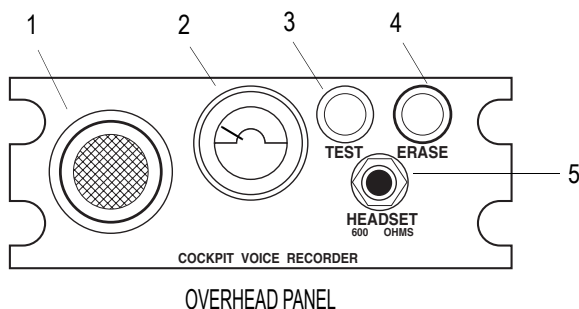
Needle indicates output level of passenger address.

6. PA Switchlight

When PA switchlight is momentarily pushed (handset off hanger), handset connects to passenger address system and the switchlight illuminates.

The switchlight extinguishes and the handset reverts to service interphone function when replaced on its hanger.

Cockpit Voice Recorder



1. Cockpit Voice Recorder Microphone

The microphone picks up all audible sounds on the flight deck.

2. Monitor Indicator

Needle in green band during testing indicates normal system operation.

3. TEST Button

When pushed, initiates a self test of all input channels.

4. ERASE Button

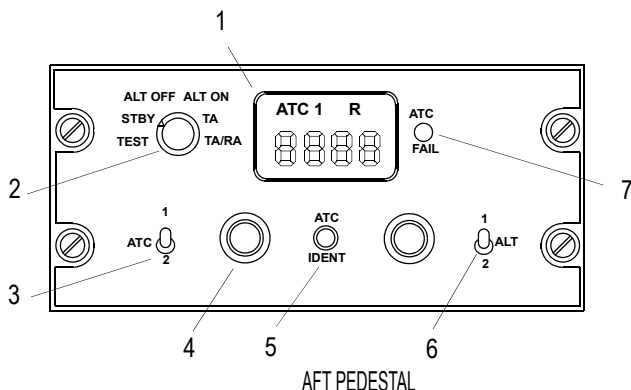
When pushed, disables playback of previously stored data.

The airplane must be on the ground with the parking brake set and normal power for the ERASE button to function.

5. Cockpit Monitor Headphone/Headset Jack

With a headset plugged into the jack, audible tones indicate proper operation of each function.

ATC Transponder/TCAS Control Panel



1. Display Window

Indicates selected four digit code.

Displays ATC active channel code.

A blinking R is a reply of transponder interrogation.

2. Transponder Function Selector

TEST - Initiates transponder and TCAS test.

STBY - Power applied for warm-up only.

ALT OFF - Altitude reporting inhibited; PWS enabled.

ALT ON - Activates altitude reporting. TCAS system in standby; PWS enabled.

TA - Normal transponder operation, enables TCAS traffic advisories; PWS enabled.

TA/RA - Normal transponder operation, enables TCAS traffic and resolution advisories; PWS enabled.

3. Reporting Transponder

ATC 1 - # 1 Mode S transponder.

ATC 2 - # 2 Mode S transponder.

4. CODE Selectors (2)

Rotate two pairs to selected code.

5. ATC IDENT Button

Press for positive identification on controller's scope.

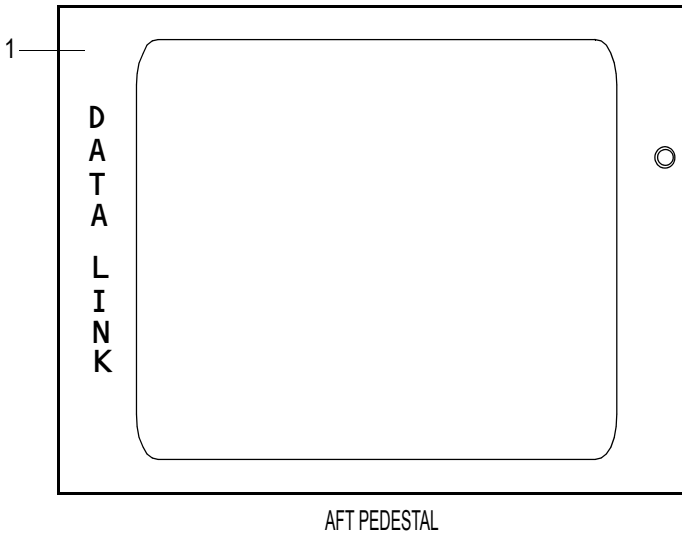
6. AIR Data Source

Indicates which CADC is being used for altitude reporting.

7. ATC FAIL Light

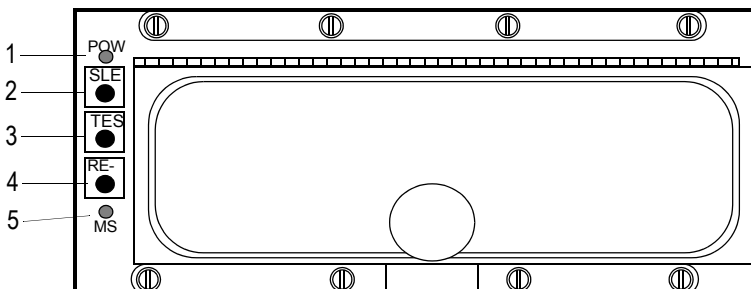
Indicates failure of selected transponder.

ACARS Control



1. ACARS Touchscreen Interactive Display Unit (IDU)

ACARS Printer



1. **POWER Indicator (green)**

Indicator lights when POWER is applied to the printer.

2. **SLEW**

Push-button activates paper feed process. Each time SLEW is pressed, paper is advanced through the printer. Pressing and holding down SLEW advances the paper continuously.

3. **TEST**

Push-button automatically prints test data.

4. **RESET**

Push-button resets the MSG indicator.

NOTE: If the MSG Indicator is extinguished, continuously holding down the RESET push-button for 4 seconds clears the print queue.

5. **MSG (green)**

The MSG indicator illuminates whenever a complete message is received by the printer.

Communications

System Description

Chapter 5

Section 20

General

The airplane communication systems consists of a flight interphone system and audio control panels, VHF communication systems and control panels, selective calling (SELCAL) system, service interphone system, call system, passenger address (PA) system, and cockpit voice recorder (CVR) system.

Flight Interphone System

The flight interphone is activated by pressing the INT MIC selector and the I/C RECEIVER switches to allow the crew to use microphones and handsets for cockpit communications. Two speaker assemblies are installed overhead in the flight compartment to monitor all audio signals selected by the Captain and First Officer. Operation of the microphone at either station mutes the speaker at that station. Speakers are not muted when the pedestal handset is keyed on passenger address (PA).

Audio Selector Panel

An audio selector panel is installed at the Captain's, First Officer's, and aft overhead panels. The audio selector panel permits two way communication capability from the flight interphone, cabin/service interphone and VHF comm radios systems. It provides voice and identification monitoring of selected navigation aids. Receiver volumes and microphone selections are controlled from this panel.

Selection of oxygen masks or boom microphones is controlled at the audio selector panel. Transmissions using the oxygen mask or boom microphone are keyed with the PUSH-TO-TALK switch or the control wheel microphone switch.

VHF Communication System

Three communications radios are installed. Two control panels are provided on the pedestal for normal operations. The transmitting and receiving frequency selection for VHF-1 and 2 is controlled from the VHF COMM control panels. The VHF-3 frequency selection is controlled from the ACARS control unit when voice mode is selected.

Each VHF COMM panel has two frequency readouts and a transfer switch for selection of the active frequency, a light emitting diode above each frequency readout to indicate the active frequency, and two frequency selector knobs.

On some airplanes, with the microphone continuously keyed, VHF transmission is available for 30 seconds. Four warning beeps sound during the last 5 seconds prior to transmit capability cutoff. On these airplanes, transmit capability may be continued beyond the 30-second segment by releasing and then re-keying the microphone switch.

Selective Calling (SELCAL) System

The selective calling (SELCAL) system operates in conjunction with the VHF system and provides a visual and aural indication when the airplane is being called. SELCAL enables ground facilities to selectively call an individual airplane.

When a SELCAL is received, the respective SELCAL switchlight illuminates and a chime from the central aural warning system (CAWS) sounds, indicating that the ground station is calling the airplane. Audio is controlled at the audio control panel. Changes in receiver volume do not affect SELCAL operation. Communication with the calling station is established by pushing the appropriate MIC button on the audio control panel. The SELCAL switchlight and chime are reset to receive a new call when the applicable switchlight is pushed, or when the respective transceiver is keyed for transmission.

Service Interphone System

The service interphone system allows communication between the various service and maintenance areas, the cockpit and the cabin attendant stations. Handsets in the cockpit and at the forward, mid and aft attendant panels are used for both the service interphone and the PA system.

The MAINTENANCE INTERPHONE switch on the aft overhead panel, when in OFF, disconnects all external maintenance interphone jacks from the service interphone system except the ground power panel. When the switch is ON, all service interphone jacks are active.

Call System

Call lights and aural signals alert the flight crew, cabin attendants or ground maintenance personnel of a call from another station. A visual and aural signal alerts the cabin attendants of passengers requiring assistance at the passenger seats or in the lavatories.

Passenger Address System

The passenger address (PA) system enables the pilots and cabin attendants to address passengers from the cockpit or the cabin through speakers located in the cabin, galleys and lavatories. PA announcements from the cockpit have priority over the passenger entertainment system and announcements made from any cabin station.

PA announcements from the cockpit are made through the service interphone handset, the mask or boom microphones, or the handheld microphone.

When using the service interphone handset for PA announcements, the PA switchlight on the overhead panel must be momentarily pushed. The blue PA light illuminates to indicate the PA has been activated.

With the PA microphone switchlight on the audio control panel selected, announcements using the mask or boom microphones are made by pulling the control wheel microphone switch aft for transmission or by selecting the radio transmitter position of the radio/intercom switch. The handheld microphone may also be used to make PA announcements by keying the hand microphone PTT switch (PA microphone switchlight selected).

PA announcements are made from the cabin attendant panels through the service interphone handsets. A PA push-to-announce switch on the handset, when pushed, connects the handset to the PA system for announcements.

Voice Recorder System

The cockpit voice recorder (CVR) continuously records the last 30 minutes of cockpit sounds and communications, any time there is normal electrical power available.

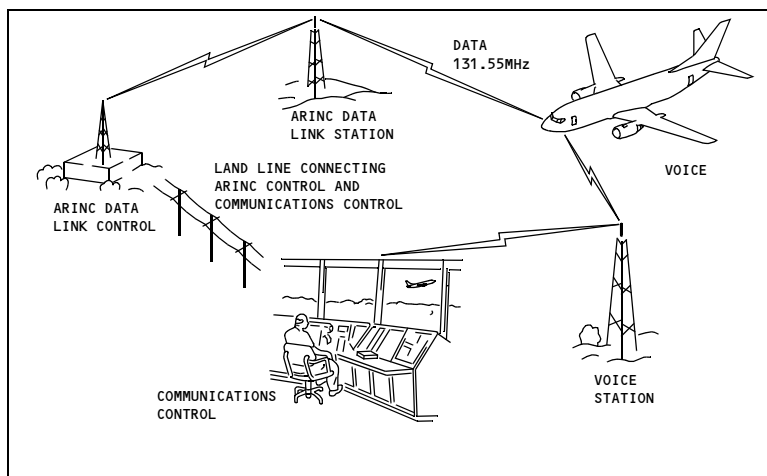
All sounds and communications are recorded through the cockpit voice recorder monitor microphone. All communications through the Captain's and First Officer's audio control panels, as well as the cockpit handset, are also recorded.

The cockpit monitor unit of the voice recorder contains a microphone to record cockpit sounds, two separate push-buttons (a TEST pushbutton to test the recorder and an ERASE pushbutton to erase previous recordings), a headset jack (used to monitor a system test), and a test indicator.

The TEST pushbutton activates a self test. A successful self test is indicated by the needle moving into the green band.

Whenever the airplane is on the ground with the parking brake set and normal electrical power, the erase function may be activated by pushing the ERASE pushbutton. When activated, the last 30 minutes of sounds and communications are erased.

ACARS Touchscreen DATA LINK



ACARS (ARINC Communications Addressing and Reporting System) is a data communications system which allows flight information to be transmitted between individual aircraft and the company host computer.

There are currently two different software versions of ACARS installed on MD-88 aircraft. The -201 software is being replaced by the -501 version. Both are detailed in the following sections.

System Information

ACARS consists of the following aircraft components:

- The management unit (MU) which contains system memory, message transmission logic, and a UTC clock.
- An Interactive display unit (IDU) that provides crew input and control of the system.
- A VHF-3 comm radio which normally serves as the primary transceiver for ACARS.
- A data link panel with annunciators to alert the crew of ACARS message activity.
- A cockpit printer which provides hardcopy capability.

Coverage

ACARS is designed for domestic and international use. The system will automatically scan for VHF communications and will automatically utilize any available authorized air/ground system depending on aircraft position.

Operational Overview

ACARS normally operates in the DATA mode and assumes control of the VHF-3 radio. In this mode, a frequency is automatically selected and the VHF transceiver is unusable for voice communications. When the VHF-3 comm radio is in the DATA mode, ACARS transmissions occur:

- Automatically for OUT, OFF, ON and IN reports.
- When the SEND prompt is selected.
- When transmitting and receiving messages for cockpit printers.
- When communications are re-established after a period of NO COMM, if there are stored messages present.
- When transferring from VOICE to DATA mode if stored messages are present.

VOICE Mode

- May be selected on the IDU, the frequency tuned on the VHF 3 COMM panel and then utilized for voice communication.
- If VOICE mode is selected, the system must be manually returned to the DATA mode.

ACARS Printer Unit

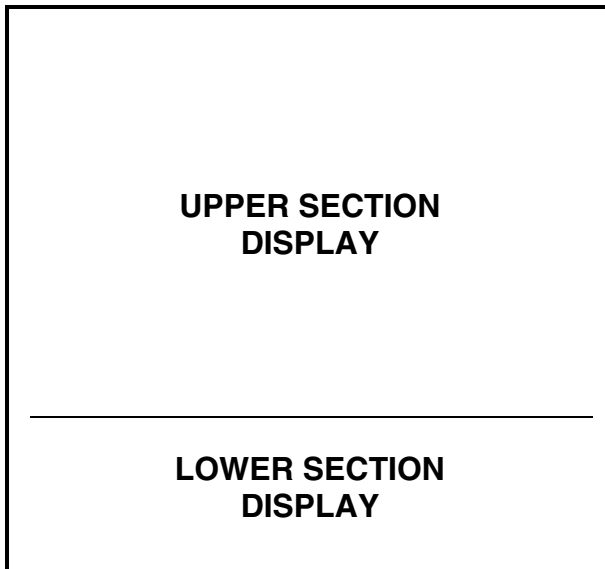
A cockpit printer (summit full format), is mounted aft of the First Officer's briefcase holder in a vertical fashion. The printer allows hardcopies of company transmissions, as well as crew requested messages, to be printed when requested.

The printer includes: the front panel controls, an access door, and paper exit.
April 01, 2004

ACARS 501**Interactive Display Unit (IDU)**

The touchscreen interactive display unit has a flat display screen activated by objects which break the infrared grid projecting over the screen. As finger tips or pencils touch the screen, the grid calculates the location and expands the displayed selection into an outlined mode. When the finger tip is lifted off the screen, the prompt displaying an outlined mode will be entered in the computer. This allows the crew to slide a finger over the screen to select the desired function without inadvertently entering the wrong selection.

The basic menu and sub-menu page displays are divided into two horizontal sections as shown below:



The upper section can contain the following during normal system operations.

- Menu or sub-menu title.
- Menu items listed in two columns.
- PRINT prompt will send pages or messages to the aircraft printer and only appears if printer is operative.
- SEND prompt will initiate a downlink from the cockpit. This prompt only appears after all required entries have been completed.
- RETURN prompt which will return the system to the previous menu or page.
- Alert advisory messages.
- Informational advisory messages.

The lower section can contain the following selections during normal system operations:

- INDX prompt returns the system to the DATA LINK INDEX page.
- PREV prompt returns the system to the previously displayed screen.
- NEXT prompt moves the system to the next display screen.
- LGHT prompt displays the lighting control screen.
- The system to the MENU page.

IDU Lighting Control

The AUTO/MAN prompt toggles between AUTO and MAN mode for screen lighting control. During normal operation, it is recommended that crews leave the lighting control in the AUTO mode so that the screen will automatically adjust to ambient light conditions. However, the screen brightness level can be adjusted in MAN mode by touching and holding the DECREASE or INCREASE prompt. Continually touch either prompt until the lighting is optimal.

NOTE: If the brightness has been turned down so far that the display cannot be seen, touch and hold the screen in the uppermost left hand corner to increase the brightness.

The NORM / INV prompt toggles between NORM and INV mode of background and character contrast. The INV mode is recommended for night use as the lighter characters on a dark background are more easily seen. The NORM mode displays dark characters on a lighter background.

The lighting control screen is shown below:

HH:MM		LIGHTING	
SCREEN MODE			
AUTO/MAN		NORM/INV	
AAAA		AAAA	
BRIGHTNESS LEVEL			
DECREASE		INCREASE	
MENU			

Automatic Messages

OUT, OFF, ON, and IN reports are automatically transmitted based on signals from the cabin doors, anti-collision light, and air-ground sensing. Minimum requirements for automatic transmission of these times are:

- Entry of initialization data.
 - Manually or automatically (INIT RQ).
- Available communication link
- ACARS in DATA mode.

All the communication networks can be operationally tested at any time by using the LINK TEST on the LINK STATUS page.

OUT time processing:

- The OUT time is automatically recorded and transmitted immediately when all cabin doors are closed and the anti-collision light has been turned ON. Fuel on board is also transmitted with the OUT time if entered on the INIT DATA page during pre-flight.

OFF time processing:

- is recorded at lift-off and transmitted immediately.

After attaining a stable cruise condition, the flight data acquisition unit will collect engine data and automatically transmit this data via ACARS.

ON time processing:

- The ON time is recorded at touchdown and transmitted immediately.

IN time processing:

- The IN time is immediately recorded and transmitted anytime any cabin door is opened or when the anti-collision light is turned OFF.

OUT, OFF, ON, and IN messages that cannot be transmitted due to a NO COMM condition will be stored up to a total of 5 more flight segments or until a communication link is established.

Crew Generated Messages

In addition to the automatic messages, ACARS is used to send other messages. Prepared menus and prompts are provided as described in the following pages. Refer to section 5 of the QRH or the FOM for proper usage of ACARS messages.

Message Indications

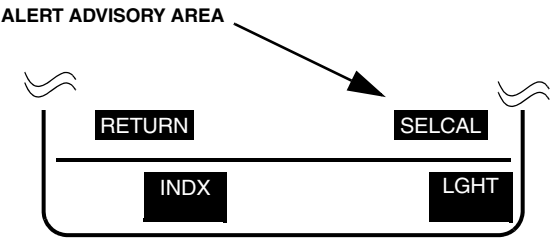
Flight crews are notified of incoming messages by the flashing MESSAGE advisory on the touchscreen, the MSG light on the data link annunciator panel, and chime.

Alert Advisory

The flashing advisory messages on the touchscreen alert the flight crew to abnormal conditions or annunciate the need for necessary crew actions. On menu pages, the alerts appear in the lower right corner above the LGHT prompt. Touching the advisory will automatically access the required menu.

The messages shown below are listed in order from highest to lowest priority:

FAIL	Internal failure of Management Unit. Refer to QRH Section 5.
POWER	Power interruption resulting in loss of initialization data.
SELCAL	SELCAL uplink message received.
ATC MSG	New ATC uplink message received and ready for display.
OCEANCL	New ATC oceanic clearance uplink message received and ready for display.
DEPT CL	New ATC predeparture clearance message received and ready for display.
MESSAGE	New company uplink message received and ready for display.
INIT	Initialization data incomplete.
DATAMD	Data Link attempted with ACARS in VOICE Mode or ACARS in VOICE Mode for greater than 3 minutes.
ATIS	ATC ATIS message received and ready for display.
INRANGE	In Range Report should be sent.
ARRDLA	Arrival Delay Report should be sent.
DEPDLA	Departure Delay Report should be sent. Appears 20 minutes after OUT if no OFF.
SUMMARY	Summary Report should be sent.



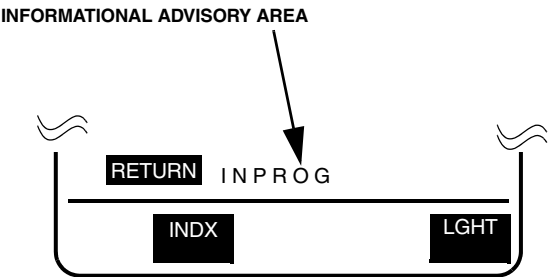
Informational Advisory

Informational advisory messages appear on the touchscreen to display operational status of ACARS. On menu pages, these messages appear on the immediate right of the RETURN prompt. On the keyboard displays, these messages appear in the top right-hand corner next to the ENT prompt.

The messages shown below are listed in order from highest to lowest priority:

IN PROG	Message is actively being sent.
UTC OK	UTC TIME updated by uplink.
VOICE	VHF is in voice mode.
NO COMM	No DATA LINK is available.

NOTE: If the data link is functioning normally in the DATA mode, there will be no advisory shown.



Touchscreen Keyboards

There are two different categories of input keyboards: data input and free text. The data input keyboards include alphabetical, numeric, and hexadecimal. The free text keyboards include alphabetical, numeric, and symbolic. The appropriate keyboard will automatically appear depending on the prompt that is selected from the displayed page.

Each keyboard will have some of the following functions:

CLR

- Used on data input keyboards. Clears the character under the cursor and all characters to the right of the cursor.

ESC

- For optional fields - aborts current data entry and returns to calling page.
- For required (auto-sequence) fields, aborts data entry for current field entry and goes to calling page while retaining data for all previously filled fields of the auto-sequence list.
- For free text fields, aborts current free text entry and returns to calling page.

DEL

- Used on free text keyboards.
- Deletes the character under the cursor. If the cursor is at the end of the text, deletes the character to the left of the cursor.

DFT

- Used on data input keyboards.
- Restores the field's default value if one exists. If no default value exists, the field is cleared.

ENT

- For optional fields, accepts entered data and returns to calling page.
- For required (auto-sequence) fields - accepts entered data for current field and proceeds to data entry for next field in sequence.
- For free text entry, start new line in message.

SYM - Selects the free text symbolic keyboard.

NUM - Selects the free text numeric keyboard.

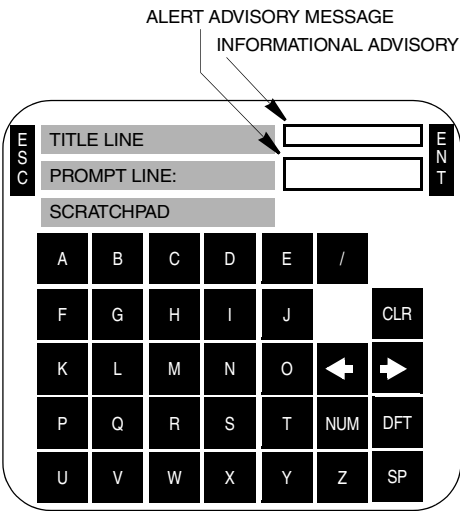
ALP - Selects the free text alphabetic keyboard.

Data Input Keyboards

These keyboards include alphabetical, numerical, and hexadecimal.

The area above each keyboard displays three lines: the title of the menu page in use, the prompt selected and the data input line (or scratchpad). Entered data or text appears on the scratchpad with an underscore character to act as an entry cursor and a rectangle character to act as an overwrite cursor. Touching the ENT prompt will enter the data into the message. The left and right arrows allow movement of the cursor across the scratchpad.

Alphabetic Keyboard



Numeric Keyboard

ALERT ADVISORY MESSAGE
INFORMATIONAL ADVISORY

ESC

TITLE LINE

PROMPT LINE:

SCRATCHPAD

ENT

1	2	3	L	R		
4	5	6	C	X		CLR
7	8	9	/	*	←	→
.	0	+	-	N	ALP	DFT
,	"	W	S	E	SP	

Hexadecimal Keyboard

ALERT ADVISORY MESSAGE
INFORMATIONAL ADVISORY

ESC

TITLE LINE

PROMPT LINE:

SCRATCHPAD

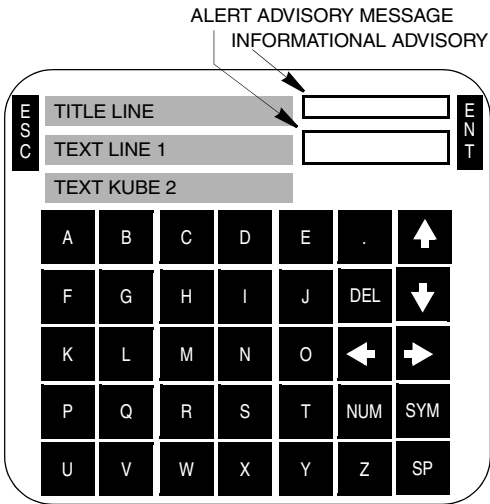
ENT

D	1	2	3	/		
4	5	6	7			CLR
8	9	A	B	←	→	
C	D	E	F			DFT

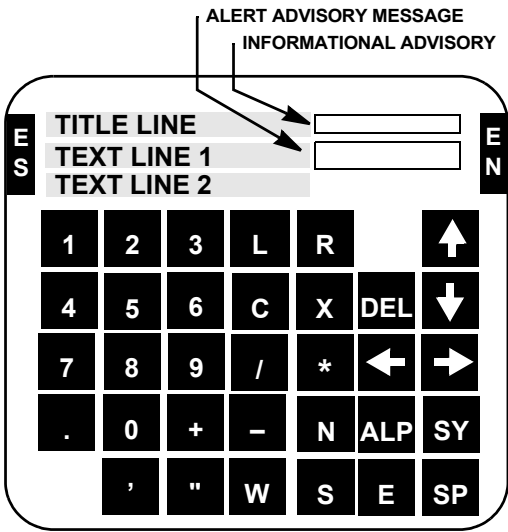
Free Text Keyboards

These keyboards include alphabetical, numeric, and symbolic. The area above each keyboard displays three lines: the title of the menu page in use and two text lines. Up and down arrows are provided to scroll through the text message.

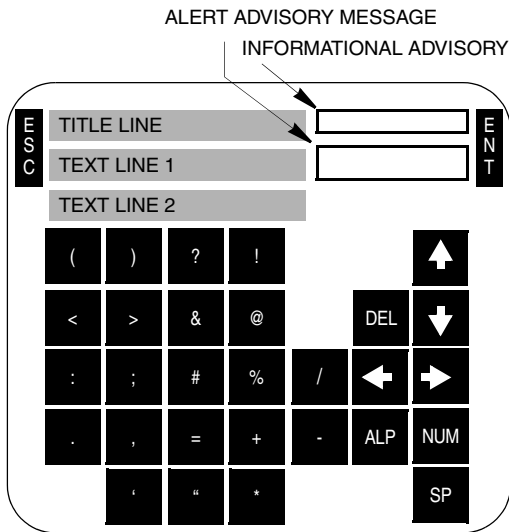
Alphabetic Keyboard



Numeric Keyboard



Symbolic Keyboard



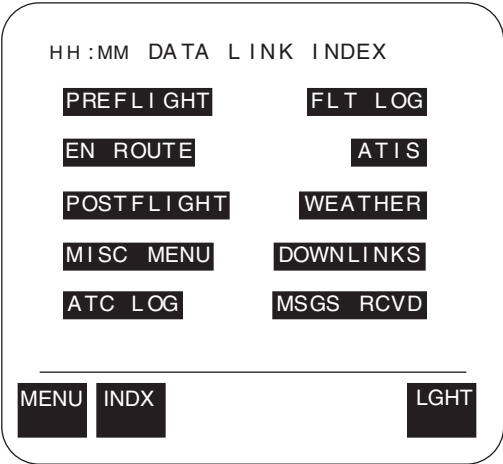
ACARS Keystroke Entry

For all ACARS IDU page depictions, the following key applies:

Acars Keystroke Entry Table	
Example	Entry Allowed
AAAA	Use alpha characters only.
NNNN	Use numeric characters only.
XXXX	Alpha or numeric characters may be used.
<u>ZZZZ</u>	Alpha or numeric characters or symbols may be used.

Data Link Index

The DATA LINK INDEX is the initial screen displayed and provides access to the following menus and function:



PREFLIGHT

Selecting PREFLIGHT from the DATA LINK INDEX page accesses the PREFLIGHT page. This provides the crews access to items normally used prior to takeoff.

HH:MM PREFLIGHT

INIT DATA	DEPT DELAY
FLT PLN RQ	GND SVC RQ
CLEARANCES	WEATHER
AWAB S	FUEL RPT
UTC TIME	ICE INSPECT
RE TURN	
MENU	INDX
LGHT	

INIT DATA

This prompt allows the crew to load initialization data for the DATA LINK. Selecting INIT RQ automatically inputs all fields, except GW, FOB, FUEL BOARDED, and ETE, through a downlink/uplink message exchange with the host computer if ground network and initialization data are available. GW, FOB, FUEL BOARDED, and ETE must be manually input. Required entries may also be entered manually on the INIT DATA page, paying close attention to the correct flight number, date, and city pair on the flight plan. The destination is automatically transferred to the IN RANGE page and the ATIS page after "OFF" is sent. The ETE is also used together with OFF time to calculate the ERT displayed on the IN RANGE page and the FLIGHT LOG page. All entries are required to complete this page. If any items are missing, the INIT advisory will appear at the OUT event. If this occurs, touch INIT to access the INIT DATA page and fill in any incomplete data.

HH:MM INIT DATA

FLT NO
□□□□

ORIG
□□□□

FOB
- - - . -

GW
- - - . -

DATE
□□

DEST
□□□□

FUEL BOARDED
- - - . -

ETE
□□ : □□

PRINT

INIT RQ

RE TURN

MENU

INDX

LGHT

FLT PLN RQ

This prompt allows the delivery of the flight plan to the cockpit printer, provided ground computer link and programming are available.

HH:MM FLT PLN RQ

RE TURN

INDX

SEND

LGHT

CLEARANCES

This prompt allows access to the CLEARANCES menu page.

HH:MM CL E A R A N C E S

O C E A N I C R Q

P R E D E P A R T R Q

A T C L O G

P D C (C O M P A N Y)

R E T U R N

M E N U

I N D X

L G H T

OCEANIC RQ

[NOT FUNCTIONAL AT THIS TIME]

HH:MM OCEANIC CLEARANCE

ENTRY FIXETA

MACHFLIGHT LEVELFL

EDIT TEXT

[]

[]

FACILITYSEND

RE TURN

INDX

LGHT

PREDEPART RQ

[NOT FUNCTIONAL AT THIS TIME]

HH:MM PREDEPART CLX 1/2

FLT NOORIG

ATISGATE

AC TYPEDEST

MD88

FACILITY

SEND

RE TURN

INDX

PREV

NEXT

LGHT

HH :MM PREDEPART CLX 2 / 2

CLR TEXT

EDIT TEXT

[

]

[

]

SEND

RE TURN

INDX

PREV

NEXT

LGHT

AC TYPE	MD-88 MD-90
FACILITY	ATC facility for predeparture clearance request.

ATC LOG

[NOT FUNCTIONAL AT THIS TIME]

HH :MM ATC LOG NN / N N

HH :MM A A A A A A A A

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

HH :MM A A A A A A A A

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

HH :MM A A A A A A A A

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

HH :MM A A A A A A A A

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

RE TURN

INDX

PREV

NEXT

LGHT

PDC COMPANY

Selecting PDC (COMPANY) from the CLEARANCES page causes delivery request message to be readied for downlink

HH:MM PDC (COMPANY)

SEND

RE TURN

INDX

LGHT

AWABS 1/2

Selecting AWABS provides access to two pages of AWABS data

HH:MM AWABS 1 / 2

SN / RWY / CONT TEMP

□□/□□□□□□□□□□/D --- / F

FC / CC / YC WIND (DIR/VEL)

--- / --- / --- --- / ---

TOLERANCE ALT IMETER

--- ---

PRINT

RE TURN

MENU

INDX

PREV

NEXT

LGHT

SN	Sequence number - (for future use). To satisfy ACARS requirements, enter 88 when utilizing this screen.	
RWY	Runway identifier. Enter desired takeoff runway. AWABS data will only be sent for this runway. The runway label must be recognizable by AWABS (consult the existing WDR for the exact label). Some examples: 26 R 26 LTWYE13 - 26 Left at Taxiway E 13. 25 LPOSNF - 25 Left at Position NF. If the runway ID is not recognized, ACARS will uplink a message with a list of possible runway labels.	
CONT	Contamination code. Enter contamination code for the condition you desire.	
	D	Dry (default entry)
	W	Wet
	I	Icy
	Q	Quarter Clutter 25 CTR
	H	Half Clutter 50 CTR
	If you are overweight for the requested contaminant, you will receive a message uplink advising you of this, but you will not receive a WDR uplink.	

The remaining fields are optional and should only be used if you desire a change from the existing WDR conditions.

Temp	Current Temp / F or C Default = F
FC/CC/YC	Passenger loading distribution. Enter only changes from the existing WDR passenger distribution. Example: to change 12/30/183 (WDR) to 12/20/183, enter /20/. Express aircraft will fill FC and CC fields with zero.

Wind	Wind direction and velocity.
Tolerance	Passenger/Cargo Tolerance. Toggle through selections: - - -:(default) will leave the tolerance as it was on the latest WDR. OFF: forces the tolerance off. ON: forces the tolerance on. Refer to FOM (if desired) for a detailed explanation of tolerance.
Altimeter	Current altimeter setting. Range of entries is: 850 - 1150 hPa. 2700 - 3300 inHg. Any entry greater than 2000 is considered inches of mercury (inHg) while any entry less than or equal to 2000 is considered Hectopascals (hPa).

AWABS 2/2

The entries on AWABS page 2 are for future use and should be left blank. You must move to page 2 in order to access the SEND prompt.

HH :MM AWABS2 / 2

CGO- F UEL E 1 INC ADJ ZFW

-----/-----

CGO- F UEL E 2MEL CDL

-----/-----

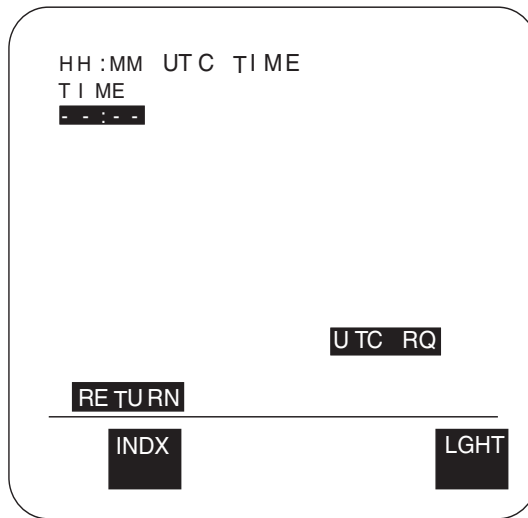
PRINTSEND

RE TURN

MENUINDXPREVNEXTLGHT

UTC TIME

Selection provides access to UTC TIME page and allows flight crews to update the ACARS UTC clock. Touching UTC RQ sends a message to automatically synchronize the internal ACARS clock with UTC. When the update is complete a UTC OK message is displayed at the screen bottom.



Manual input allowed only when system is not in communication with authorized ground facility.

DEPT DELAY

Selection allows access to revise the estimated time off (ETO). Workload permitting, the reason for the delay should be entered in the EDIT TEXT field.

HH:MM DEPT DELAY
EST TIME OFF
□□:□□

EDIT TEXT

[
[
[
[
[

PRINT

SEND

RE TURN

INDX

LGHT

Selection of any weather type on menu provides access to WEATHER RQ page with selected type provided in type selection area.

HH :MM WEATHER RQ
T Y P E
A A A A A A A A

ST A 1
□ □ □ □
ST A 2
- - - -
ST A 3
- - - -

PRINTSEND
RETURNDIV>

INDX

LGHT

STA1	Defaults to departure station prior to OFF event. Defaults to destination station after OFF event. Enter the desired station of interest.
STA 2	Enter other stations, if desired.
STA 3	
For area forecast, the city used must be ANC, BOS, SHI, DFW, FIA, HNL, JNU, MIA, SFO, or SLC. Enter the city as a 4 character input, with the 4th character being one of the following:	
H - will report hazards S - Synopsis T - Turbulence C - Clouds I - Icing Blank - all of the above. For example, to obtain icing forecast for SLC, input SLCI.	

ATIS

Selecting this prompt from the DATA LINK INDEX page accesses the ATIS page.

HH:MM ATIS
AIRPORT

TYPE

AUTO UPDATE

ATIS MSG

SEND

RE TURN

LGHT

AIRPORT	Defaults to departure station prior to “OFF” event. Defaults to destination station after the “OFF” event. Enter airport for which ATIS is desired.
TYPE	Arrival. Departure. Arrival/Departure. Enroute info service. (Toggle selection).
AUTO UPDATE	Start. Stop. (Toggle selection, START should be entered).
ATIS MSG	Allows access to ATIS display page (only available if uplink message has been received).
SEND	Displayed only when required information has been entered.

FUEL RPT

Selection provides access to FUEL RPT page.

```
HH:MM FUEL RPT          FLT PHASE  
FOB                      0000000000000000  
000.0  
GW                        FLT LEVEL ALT  
000.0                      FL000  
TIME                      SAT  
00:00                     000  
HOURS . . . . APU . . . . CYCLES  
- - - - -                - - - - -  
  
PRINT                      SEND  
  
RE TURN  
  
INDX                       LGHT
```

FOB	Enter current fuel on board.
FLT PHASE	Enter the current phase of flight, i.e., BLOCK OUT, TAKEOFF, TOP OF CLIMB, etc. Default value is current flight phase. Selection of this item accesses the FLIGHT PHASE Page described below.
APU	Inputs are optional.

FLIGHT PHASE

Selection of any item inserts that phase into the FLT PHASE area of FUEL RPT page and returns display to FUEL RPT page.

HH:MM FLIGHT PHASE

BLOCK OUT

TOUCHDN

TAKEOFF

BLOCK IN

TOP OF CLIMB

CRUISE

TOP OF DESNT

RE TURN

INDX

LGHT

ICE INSPECT

[NOT FUNCTIONAL AT THIS TIME]

HH:MM ICE INSPECT RQ

RE TURN

SEND

INDX

LGHT

Selection of SEND allows request for ice inspection data to be transmitted if in data link communications.

EN ROUTE

Selecting EN ROUTE from the DATA LINK INDEX page accesses the EN ROUTE page. This provides the crew with the necessary prompts for en route operation.

HH:MM EN ROUTE

DI V E R S I O N

I N R A N G E

A I R B O R N E R T N

A T I S

P O S I T I O N R P T

W E A T H E R

E N R T E D E L A Y

F U E L

R E V F L T P L N

D O W N L I N K S

R E T U R N

INDX

LGHT

DIVERSION

Selecting this prompt accesses the DIVERSION page. Enter the divert field in the DIVERTING TO area. All other data is helpful to Flight Control, but not necessary to send the message. The SEND prompt will appear after the divert field is entered. The EDIT TEXT prompt is provided to allow any additional pertinent information or requests. After sending, the divert to airport automatically replaces the destination on the INIT, FLT LOG, ATIS pages, and all subsequent downlinks. If this report is sent, the IN RANGE menu will have the ERT and DESTINATION updated to reflect these inputs.

HH:MM DIVERSION
FOB

DIVERTING TO

ERT

[]

[]

[]

[]

[]

PRINT

RE TURN

INDX

[]

EDIT TEXT

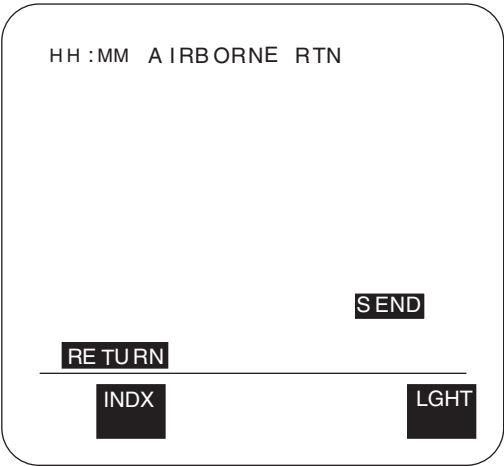
SEND

LGHT

FOB	Enter current fuel on board.
ERT	Estimated ramp time. The default value is the ETA shown on page 1 of the FLT LOG plus 5 minutes.

AIRBORNE RTN

Selecting this prompt accesses the AIRBORNE RTN page. Touching the SEND prompt will relay a message that the crew has decided to return and land at the previous departure station.



POSITION REPORT Page 1 of 2

This prompt is used to enter company position report information. This report consists of 2 pages, the second of which can be accessed through the use of the PREV or the NEXT prompt. If NEXT POSITION and ETA are entered, they will automatically move to POSITION and TIME for the next POSITION RPT once SEND is pressed. Partially completed pages will retain entered data until report is sent or the end of the flight.

HH:MM POSITION RPT 1/2
POSITION

FLT LEVEL ALT
FL

TIME

MACH

FOB

NEXT POSITION

ENSUEING POSITION

ETA

Position, flight level, Mach number, and FOB are automatically input on MD-90 only.

POSITION RPT Page 2 of 2

SAT must be entered manually, but ICING, TURBULENCE, and SKY COND have scroll through selections which change at the touch. Select SEND to downlink the report before leaving the second page.

HH:MM	POSITION RPT	2 / 2
WIND (DIR/VEL)		SAT
- - - / - - -		- - -
TURBULENCE		ICING
A A A A A A A A A A		A A A A A A A A
		SKY COND
		A A A A A A A A
PRINT		SEND
RETURN		
INDX	PREV	NEXT
		LGHT

The TURBULENCE scroll through selections are:

- SMOOTH
- LT CHOP
- LT TURB
- MOD CHOP
- MOD TURB
- SEV TURB
- EXT TURB

The ICING scroll through selections are:

- NONE
- TRACE
- LIGHT
- MODERATE
- SEVERE

The SKY COND scroll through selections are:

- CLEAR
- SCATTERED
- BROKEN
- OVERCAST
- UNDERCAST
- IN CLOUD
- BTWN LAYER
- CIRRUS

EN RTE DELAY

This prompt is used to report enroute delays which affect arrival time. The report provides space for expect further clearance (EFC) time. The SEND prompt appears when the EFC TIME is entered. Use of EDIT TEXT field is optional.

HH:MM ENROUTE DELAY

EFC TIME

EDIT TEXT

[

[

[

[

]

]

]

]

PRINT

SEND

RE TURN

INDX

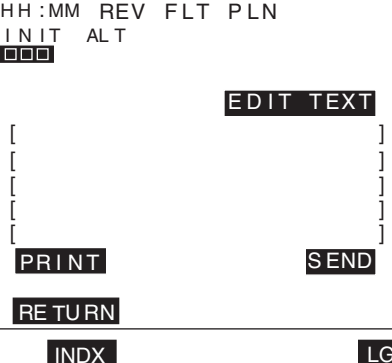
LGHT

February 28, 2005

5.23.33

REV FLT PLN

Request flight plan from dispatcher.



HP-41C calculator display showing the program listing for the 'REV' program. The display shows the program name 'REV' and the program number '1'. The program code is displayed in a grid format, with the first column containing the program number and the second column containing the program code. The program code is: 1: INIT, 2: ALT, 3: EDIT TEXT, 4: PRINT, 5: SEND, 6: RETURN, 7: INDX, 8: LGHT.

IN RANGE 1/2

This screen is used to provide arrival assistance information and the estimated ramp time at the gate. This report consists of 2 pages, the second of which can be accessed through the use of the PREV or the NEXT prompt. Enter the appropriate information and execute the downlink with the SEND prompt. The destination and ERT will be automatically filled in using information from the INIT DATA Page or DIVERSION page (if this report has been sent). Page 2 provides a text format for sending special requests not listed in the menu sections of page 1. WHEEL CHR and UNACC MINOR fields should reflect numbers over that required in Flight Attendant departure report.

HH:MM IN RANGE
1 / 2

DEST
□□□□
ERT
□□:□□

WHEEL CHR
--
UNACC MINOR
--

RED COAT
AAA
MEDICAL
AAA

SECURITY
AAA
LANG ASSIST
AAA

PRINT

RETURN

INDX

PREV

NEXT

LGHT

The RED COAT, MEDICAL, SECURITY, and LANG ASSIST fields are toggle YES or NO selections.

IN RANGE 2/2

HH:MM IN RANGE2 / 2

LAV SRVCCABIN SRVC

AAA

AAA

EDIT TEXT

[

[

[

[

PRINT

SEND

RE TURN

INDX

PREV

NEXT

LGHT

The LAV SRVC and CABIN SRVC fields are toggle YES or NO.

Intentionally
Blank

POSTFLIGHT

Selection from DATA LINK INDEX page allows access to the POSTFLIGHT menu page.

HH:MM POSTFLIGHT

FLT SUMMARY

FUEL RPT

ARRIVAL DELAY

RETURN

INDX

LGHT

FLT SUMMARY 1/2

Selection provides access to the FLT SUMMARY pages. This page is automatically displayed after the IN event if no pilot entry is in progress.

HH:MM FLT SUMMARY 1/2

EMP NO--TAKEOFF--T/O PWR

XXXXXXXX

AAAAA

OTHER PWR

EMP NO--LANDING-----FOB

XXXXXXXX

□□□.□

HIMAIN FUEL

XXXXXXXXXX

HOURS-----APU-----CYCLES

RETURN

INDX

PREV

NEXT

LGHT

EMP NO	Selection displays EMPLOYEE NUMBER page containing the employee numbers from the INIT RQ uplink. If the desired Employee Number is not listed, input the correct number on the EMPLOYEE NUMBER page.
T/O PWR	MAX TO AT 45 AT 50 OTHER
OTHER PWR	This is only available if OTHER is selected in T/O PWR. Enter the actual AWABS setting.
FOB	Enter on Board. (90) Auto Fill.
HI MAIN FUEL	NO DATA 0 - 5.5 5.5 - 9.9 (Toggle through selection)
APU	Enter applicable 2 digit APU use code.

EMPLOYEE NUMBER

HH :MM EMPLOYEE NUMBER

XXXXXX

XXXXXX

XXXXXX

XXXXXX

XXXXXX

XXXXXX

XXXXXX

EMP NO

RE TURN

INDX

LGHT

FLT SUMMARY 2/2

Selecting NEXT allows input of autoland and IRU error information.

HH:MM FLT SUMMARY 2 / 2

AUTOLAND IRU ERROR

AAA

AIRPORT

1

RUNWAY

2

SAT /UNSAT

PRINT

SEND

RE TURN

INDX

PREV

NEXT

LGHT

AUTOLAND	YES NO (Toggle Selection)
AIRPORT	Enter arrival airport.
RUNWAY	Enter Runway identifier (8R, 9L, 25L, 24R, etc.).
SAT/UNSAT	SAT UNSAT (Toggle Selection)
IRU ERROR	Input appropriate IRU errors.

NOTE: Must enter YES in AUTOLAND Prompt for AIRPORT, RUNWAY, and SAT/UNSAT to be available.

ARRIVAL DELAY

Selection provides access to ARRIVAL DELAY Page. Enter the estimated gate time and any relevant information for the dispatchers. Press SEND Prompt. This message is for use when experiencing taxi delays after landing.

HH : MM ARRIVAL DELAY
EST GATE TIME
□□ : □□

EDIT TEXT

[
[
[
[
[

]
]
]
]
]

PRINT

SEND

RE TURN

INDX

LGHT

MISC MENU

Selection from DATA LINK INDEX page provides access to the MISC MENU page.

HH :MM

MISC MENU

UNDEL MSGS

LINK STATUS

MISC RPT

PRN PAPER

7 500 RPT

UTC TIME

MAINT MENU

RETURN

INDX

LGHT

UNDEL MSG

Selection provides access to the UNDEL MSGS pages. This page displays the messages currently being held in the downlink message buffer. Select the message for display. Typically this page will display no cued messages unless the aircraft is in NO COMM, VOICE mode, or the air/ground network is highly congested.

HH:MM UNDEL MSGS01 / N N

HH:MM
MSG 1 TITLE

HH:MM
MSG 2 TITLE

HH:MM
MSG 3 TITLE

HH:MM
MSG 4 TITLE

HH:MM
MSG 5 TITLE

RETURN

INDX

PREV

NEXT

LGHT

MISC RPT

This is a special prompt for unit program testing, which requires a specific format code (FRMT NO). Flight crews should not use this selection unless specifically requested to do so.

HH:MM MISC RPT

FRMT NO

ZZ

EDIT TEXT

[

[

[

[

PRINT

SEND

RETURN

INDX

LGHT

PRN PAPER

Selection provides access to PRINTER PAPER page, which will advise Delta's host computer that the aircraft is out of paper. This downlink, if sent, will prevent Delta personnel and systems from attempting to uplink messages directly to the cockpit printer.

HH : MM PRN PAPER

RE TURN

INDX

SEND

LGHT

LINK STATUS

This prompt is available from the MISC MENU page and is used to check the status or invoke a test of the air/ground communication link.

HH : MM L I N K S T A T U S

V H F		S T A T U S
L I N K T E S T		A V A I L
S A T C O M		S T A T U S
L I N K T E S T		N O C O M M
H F		S T A T U S
L I N K T E S T		N O C O M M
	V H F	M O D E / F R E Q
V H F C N T R L		A / N N N . N N

RE TURN

INDX

LGHT

Selecting the LINK TEST prompt initiates a test on the respective link. The STATUS is displayed, and the options are:

STATUS	AVAIL
	UPLINK
	DNLINK
	UP/DNLINK
	NO COMM

VHF CNTRL page can be invoked from this menu. If VHF is in VOICE mode, selecting will cause the VHF VOICE CNTRL page to be displayed. The current VHF mode and frequency is also displayed. The mode definition is as follows:

D	data mode
V	voice mode
S	frequency search or establishment in progress
A	Alternate tuned frequency. This occurs when ground network has automatically tuned the radio to alternate data frequency. This is also a normal data mode of operation.

VHF CONTROL

This prompt is activated from the LINK STATUS page. The current mode (DATA, VOICE, SCAN, ATUNE) and active VHF frequency are displayed. CHANGE MODE will toggle VHF-3 from data to voice. A VHF LINK TEST can also be performed from this page. The various worldwide ACARS VHF frequencies are displayed along the right side.

HH:MM VHF CNTRL

MODE FREQ
US / PACIFIC

AAAAA NNN,NN
131.55

CHANGE MODE
EUR / ASIA

131.72

JAPAN

131.45

LINK TEST

RETURN

INDX
LGHT

VHF VOICE CONTROL

The page is displayed by selecting the VHF CONTROL prompt on the LINK STATUS page while VHF-3 is in VOICE mode or from the CHANGE MODE selection on the VHF CNTRL page. VHF-3 frequencies can be entered on this page and the active voice frequency altered by touching TRANSFER (similar to a dual head radio).

The CHANGE MODE will toggle from VOICE to DATA mode and invoke the VHF CNTRL page.

HH:MM VHF VOICE CNTRL

CHANGE MODE

TRANSFER

FREQ 1
NNN.NN

<

FREQ 2
NNN.NN

RETURN

INDX

LGHT

7500 RPT

This prompt supplies the crew a way to report a hijacking emergency. As you can see below, the prompts are displayed backwards to confuse any understanding by the hijackers. The SEND prompt appears immediately to allow transmittal of the message with no other data entries required. The 7500 Page will remain (even after SEND is selected) until the crew selects RETURN. Do not send this message unless the situation warrants it. This screen is active and Flight Control will respond accordingly.

HH :MM 7500 RPT

ELAM
--
MEF
--

PAEW
AAA
PMET
AAAA

TPCNI
AAA
TAES

[
]

[
]

PRINT
SEND

RETURN

INDX
LGHT

The list below provides an explanation of each prompt:

ELAM	Number of males?
PAEW	Are weapons involved?
	SEY (Yes) or ON (No) - Toggle Selection.
TPCNI	Are the hijackers in the cockpit?
	SEY (Yes) or ON (No) - Toggle Selection.
MEF	Number of females?
PMET	Temperament: - unknown. - calm. - intense.
	NKNU - unknown.
	MLAC - calm.
	NTNI - intense.
	(Toggle selection)
TAES	Seat numbers of hijackers, if known.

ATC LOG

[NOT FUNCTIONAL AT THIS TIME]

HH :MM ATC LOG NN / N N

HH :MM A A A A A A A A

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

HH :MM A A A A A A A A

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

HH :MM A A A A A A A A

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

HH :MM A A A A A A A A

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

HH :MM A A A A A A A A

XXXXXXXXXXXXXXXXXXXXXXXXXXXX

RE TURN

INDX

PREV

NEXT

LGHT

FLT LOG

Selection allows access to the FLT LOG pages. Information is included for present flight leg as well as the previous four flight legs. All data is entered automatically at event times. This page is automatically displayed after the OFF event if no pilot entry is in progress

HH:MM FLT LOG		N / 5
FLT NO / DATE		OR IG / DEST
---- / --		---- / ----
ETA	BLK T M	
-- : --	-- : : : --	
EVT	TIME	FOB
OUT	-- : --	----
OFF	-- : --	----
ON	-- : --	----
IN	-- : --	----
PRINT		
RETURN		
INDX	PREV	NEXT
		LGHT

DOWNLINKS

This prompt allows access to the menu items displayed below. Selection is available on the DATA LINK INDEX page as well as the EN ROUTE page.

HH :MM DOWNLINKS

MTC COORD

FLT CTRL

CAL SEL

OTHER

ENGINE RPT

RETURN

INDX

LGHT

MTC COORD

Selection allows access to MTC COORD page. This message will be sent to the ATL Technical Management Center with a copy to Flight Control. Enter text in the text fields or enter a FRM code to get send prompt.

HH:MM MTC REPORT
FRM/FIM/CDL/ CODE
□□□□□□□□□□/□□□/□□□

CLR TEXTEDIT TEXT

□□□□□□□□□□□□□□□□□□□□□□□□

[]

[]

[]

PRINTSEND

RE TURN

INDXLGHT

The FRM/FIM code must be input in the free text block. Do not use the FRM/FIM code field. A detailed discussion of the required entry procedure is provided in the Fault Reporting Manual, provided on-board the aircraft.

CALSEL

[NOT FUNCTIONAL AT THIS TIME]

HH :MM CALSEL

WHO

AA AA AA AA

MEDIUM

AA A

STATUS

AA AA AA AA

SUBJECT

AA AA AA AA

VHF FREQ

□□□ .□□

HF FREQ

□□□□□ .□

SAT CHAN

AAAAA

SEND

RETURN

INDX

LGHT

WHO	DISPATCH TMC FLT OPS RADIO (Toggle selection)
MEDIUM	VHF HF SAT (Toggle selection)
STATUS	ROUTINE PRIORITY (Toggle selection)

Continued on Next Page

SUBJECT	ALTN REROUTE ACS METRO If the WHO is TMC: AVIONICS SYSTEMS (Toggle selection)
VHF FREQ HF	Frequency to call back on.
SAT CHAN	AORW AORE POR IOR

ENGINE RPT

Selection allows access to the ENGINE RPT page.

HH :MM ENGINE RPT

AUTO RQ

STATUS
AAAAAAAAAA

RETURN

INDX

LGHT

AUTO RQ	Selection causes an automatic engine report to be generated and sent to ground station when in communication.
STATUS	INACTIVE REQUESTING ACCEPTED NO DATA INACTIVE
MANUAL	Used to enter engine data manually should the automatic feature be inoperative.

NOTE: Engine data is sent automatically. Do not use AUTO RQ unless requested by Maintenance or Flight Control.

FLT CTRL

Selection allows access to the FLT CTRL communications page. This downlink is automatically routed to the correct dispatcher.

HH:MM FLT CTRL

[

[

[

[

[

[

[

]

]

]

]

]

]

]

EDIT TEXT

PRINT

RE TURN

INDX

SEND

LGHT

April 01, 2004

5.23.57

OTHER

Selection allows access to OTHER communications page.

HH:MM OTHER
ADDRESS
[][][][][][][][]

EDIT TEXT

[
[
[
[
[
[
[
[

PRINT

SEND

RETURN

INDX

LGHT

The address should be the teletype address used to route the downlink.

NOTE: Game score requests can be sent via the OTHER page. Use the address ATLXGDL for game day listings, and place appropriate information in the EDIT TEXT field.

MSGS RCVD

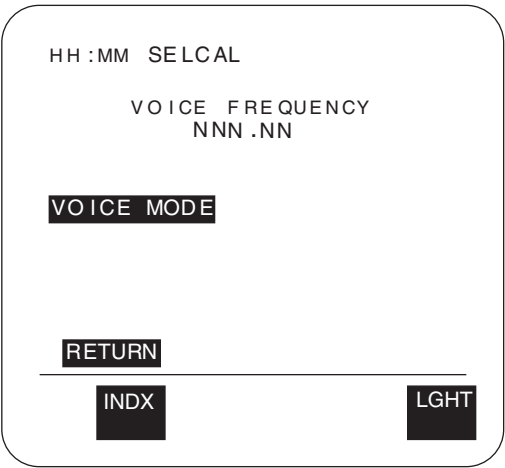
Selection allows access to the MSGS RCVD pages and is available on the DATA LINK INDEX page.

HH:MM	MSGS RCVD	01 / N N
HH:MM		STAT
	MSG 1 TITLE	AAA
HH:MM		
	MSG 2 TITLE	AAA
HH:MM		
	MSG 3 TITLE	AAA
HH:MM		
	MSG 4 TITLE	AAA
HH:MM		
	MSG 5 TITLE	AAA
RE TURN		
INDX	PREV	NEXT
LGHT		

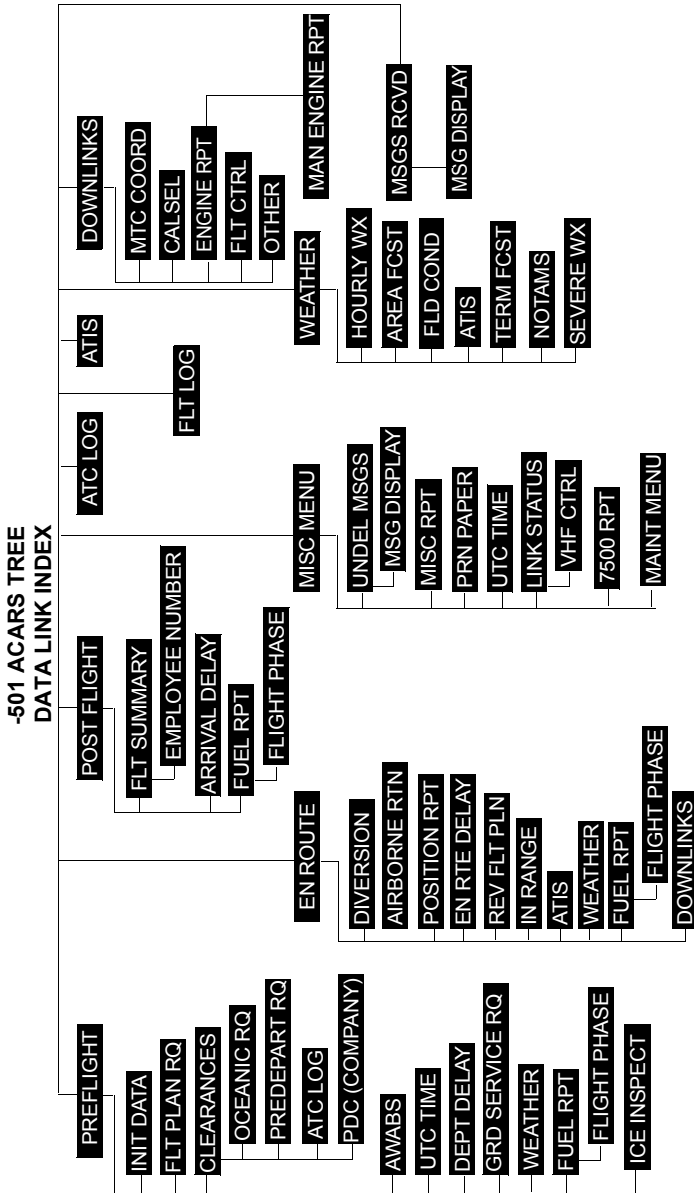
STAT	Status
	NEW
	OLD

SELCAL

SELCAL advisory displayed on control screen along with chime and light on radio panel. Selection provides access to SELCAL page.



501 Touchscreen (Quick Reference)



Intentionally
Blank

System Description

ACARS Automatic Messages

After attaining a stable cruise condition, the flight data acquisition unit will collect engine data and automatically transmit this data via ACARS.

Additionally, ACARS will collect present position, time, weather, and engine exceedance reports and automatically transmit this data. These functions are transparent to the flight crew.

Intentionally
Blank

Electrical
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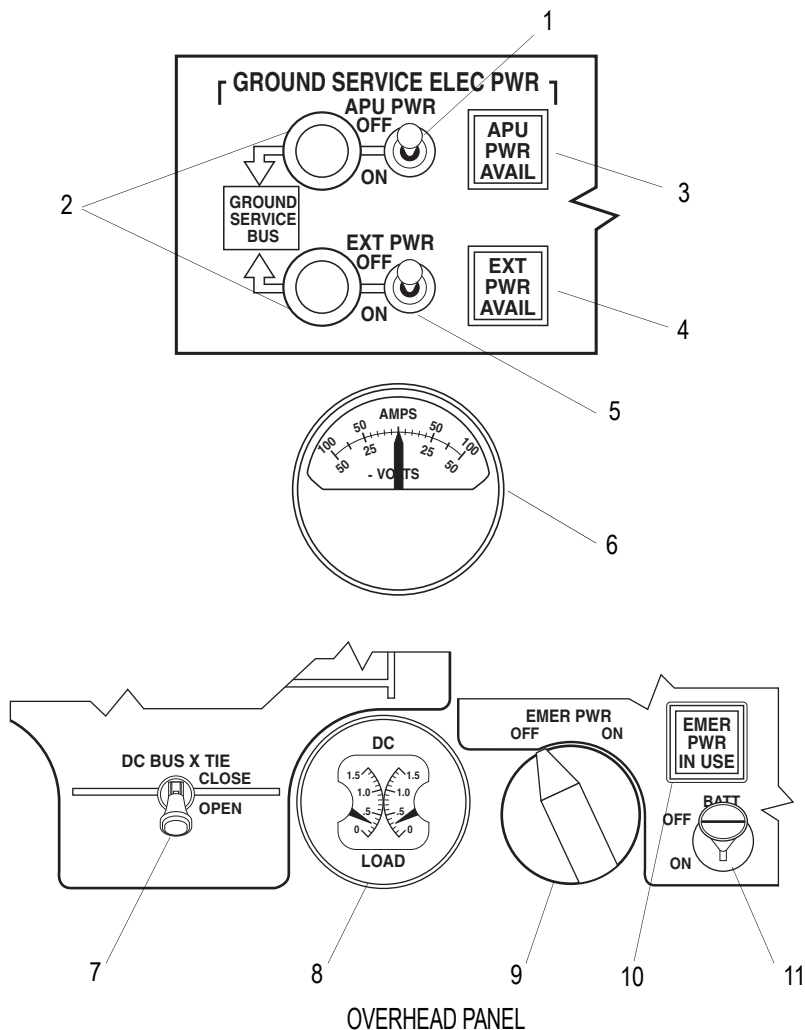
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Intentionally
Blank

Overhead Electrical Panel Controls and Indicators



1. APU PWR Switch

OFF - Removes APU generator from ground service bus.

ON - Selects APU generator to ground service bus. (EXT PWR switch must be OFF)

2. Ground Service Bus Power In Use Light (2) (blue)

Indicates power source selected is connected to ground service bus.

3. **APU PWR AVAIL Light (blue)**

Indicates APU generator power is available.

4. **EXT PWR AVAIL Light (blue)**

Indicates external power is available.

5. **EXT PWR Switch**

OFF - Removes external power from ground service bus.

ON - Selects external power to ground service bus (APU PWR switch must be OFF).

6. **DC VOLT/AMPS Meter**

Indicates DC voltage when indicator selector is selected to BATT VOLT or L/R. Indicates DC current in amps to or from batteries when BATT AMP is selected.

7. **DC BUS X TIE Switch**

CLOSE - Closes DC cross-tie relay and connects the left and right DC buses. Supplies DC power from one side to the other in case both transformer rectifiers fail on either the left or right system.

OPEN - (Normal position) Left and right DC buses are isolated.

8. **L/R DC LOAD Meter**

Dual scale, one for each of the four transformer rectifiers (TR). Indicates current output proportional to TR rating, 1.0 is 100 percent.

9. **EMER PWR Switch**

OFF - Removes batteries as source of emergency power.

ON - Connects batteries as source of emergency AC and DC power. Power to DC emergency bus is now supplied from battery direct bus. AC power is supplied to AC emergency bus by emergency inverter. Inverter is powered from battery direct bus, standby lights illuminate.

10. **EMER PWR IN USE Light (white)**

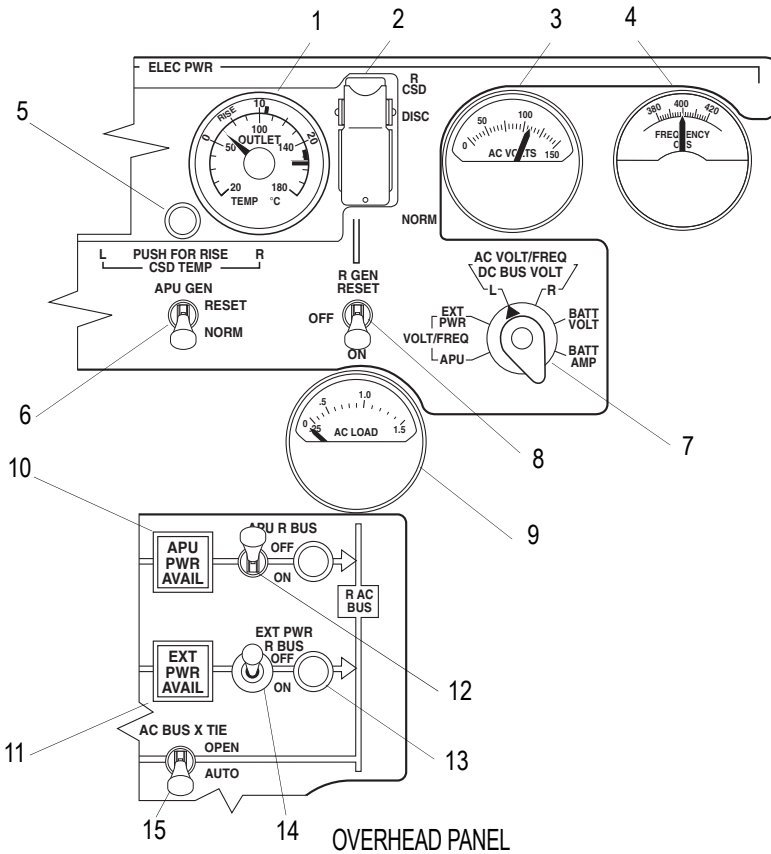
Indicates emergency power is on.

11. **BATT Switch (Pull And Twist To Lock On)**

OFF - Removes batteries from battery bus, battery charger, and DC transfer bus.

ON - Connects battery direct bus to battery bus. Selects batteries to battery charger, and DC transfer bus. White line, positioned horizontally, indicates locked.

Electrical Power Panel



1. L/R CSD OIL TEMPERATURE Gauge

Indicates CSD oil outlet temperature or oil temperature rise across the drive.

2. L/R CSD DISCONNECT Switch

NORM - Guarded switch normally in this position.

DISC - (Momentary) Disconnects CSD from engine drive.

3. AC VOLTS Meter

Indicates voltage output of generators or external power.

4. FREQUENCY Meter

Indicates frequency output of generator or external power in cycles per second.

5. CSD TEMP PUSH FOR RISE Button

When pushed, temperature rise (outlet temperature minus inlet temperature) is displayed on outer scale of indicator.

6. APU GEN Switch

RESET - (Momentary) Resets generator control circuit.

NORM - For normal operation.

7. Indicator Selector Switch

APU or EXT PWR - Selects AC voltage on AC VOLTS meter and frequency on FREQUENCY CPS meter.

L/R - Selects AC voltage on AC VOLTS meter and frequency on FREQUENCY CPS meter. Also selects DC bus voltage on DC VOLTS meter.

BATT VOLT - Selects DC voltage of batteries on DC VOLTS meter.

BATT AMP - Selects DC current in amps to or from batteries on DC VOLTS meter.

8. L/R GEN Switch

RESET - (Momentary) Resets generator control circuit.

OFF - Disconnects generator from AC power distribution system.

ON - Connects generator to AC power distribution system.

9. A/C LOAD Meter

Indicates load each AC generator is delivering to distribution system. Indicates from 0 to 1.5 with 1.0 indicating 100% of generator rated capacity.

10. APU PWR AVAIL Light (blue)

Indicates APU power is available.

11. EXT PWR AVAIL Light (blue)

Indicates external power is available.

12. L/R APU BUS Switch

OFF - Removes APU power from respective buses.

ON - Selects APU power to respective buses.

13. POWER IN USE Light (blue)

Indicates selected power source is connected to respective bus.

14. L/R EXT PWR BUS Switch

OFF - Removes external power from respective buses.

ON - Selects external power to respective buses.

15. A/C BUS X TIE Switch

OPEN - Opens AC crosstie relay, isolates left and right generator buses.
Prevents closing of relay.

AUTO - The AC crosstie relay will operate automatically.

NOTE: Under certain fault conditions, AC crosstie relay will lock open.

Electrical System Description

Chapter 6 Section 20

General

The airplane electrical power system consists of a 115 volt, 3-phase, 400 Hz, constant-frequency alternating current (AC) system and a 28-volt direct current (DC) system.

For instrument bus power, 115 volt single phase AC power from the AC buses is reduced to 28 volt AC power by step down transformers.

Battery power can be used for a portion of the DC distribution system when the main DC power distribution system is not powered. Power for APU control and starting is supplied by the aircraft batteries. Battery power will also supply power for engine ignition and indication when the main power distribution system is not powered.

An emergency inverter, powered from the battery direct bus when the EMER PWR switch is ON, supplies single phase 115 volt, 400 hz AC power to the emergency AC bus. If normal AC power is unavailable, selecting the IGNITION switch to A, B, BOTH (with FUEL CONTROL lever and BATTERY Switch ON), or OVERRIDE also powers the emergency inverter.

During ground refueling operation, the emergency inverter will supply fuel indicator power when normal electrical power is not available.

A battery charger, powered by the ground service bus, maintains the batteries in a fully charged condition. For a fully operational battery charger, the BATT switch must be ON with the EMER PWR switch OFF.

AC Power Generating System

The APU generator is mounted directly on the APU and is driven at a constant speed by the APU governing system. It is capable of supplying sufficient power for operation of electrical systems.

Each engine generator is capable of supplying sufficient power for operation of electrical systems.

Each engine driven generator is driven through a constant speed drive (CSD). The CSD's maintain a constant voltage and frequency output from the generators regardless of varying engine speeds and electrical loads.

An oil indicating system for each CSD shows the oil outlet temperature and the oil temperature rise across the drive. The rise indication is used primarily for maintenance evaluation and is not normally used by the cockpit crew. Each CSD has a disconnect switch which will uncouple the CSD from the engine if required. Once disconnected, a CSD can only be reengaged manually at the engine, after engine shutdown.

Fault protection is incorporated in each generator control circuit to automatically remove the generator from its bus and de-energize the generator in the event of certain circuit malfunctions. Pulling the ENG FIRE handle also de-energizes the generator. The generator may be restored to operation by the reset function of the L or R GEN (generator) switch when the malfunction is corrected (ENG FIRE handle must be reset first, if pulled).

AC Power Distribution

The AC power distribution system is divided into left and right independent systems with crosstie capabilities. Engine driven generators supply power directly to their respective generator bus for distribution. Power from the APU generator may be selected to either or both generator buses, or directly to the ground service bus. When desired, all buses may be energized through an external power receptacle.

Each generator bus supplies heavy load items such as galley power, air conditioning cooling fans and wing heater blankets. They also supply subordinate left and right AC buses respectively. The right generator bus also supplies the ground service bus. The left generator bus also powers the primary trim motor and the auxiliary hydraulic pump.

The ground service bus provides power to only those circuits necessary for ground servicing. If the right engine generator is not powering the right generator bus, external power or the APU generator may provide power for this bus. The ground service bus supplies power to the battery charger and the right #2 TR. When the right generator bus is powered, the ground service bus functions as a part of the right AC distribution system, receiving power directly from the right generator bus.

There is a priority control of the AC power distribution system. The order of operation is as follows.

- Respective engine driven generator.
- APU generator.
- External power.
- Opposite generator (crosstie).

The deselection of a generator, for any reason other than a fault on its generator bus, automatically transfers the load from that generator to the remaining operating generator, through the AC crosstie relay. The AC Crosstie system attempts to use 2 aircraft generators if possible. The AC Crosstie system has 3 functions:

- Prevents paralleling.
- Powers unpowered generator bus.
- Isolates generator bus faults.

Should a generator become inoperative because of a fault on its own bus, or due to fault protection, the AC crosstie relay locks open, isolating that bus from the rest of the system. Items connected to the bus will remain deenergized until the fault is cleared. Electrical loads on the other generator are not affected. Galley power is shed when the AC crosstie relay is closed and regained when at least two generators are operating.

The #3 galley power is also shed if the overwing heater blankets are energized and the aircraft is operating from a single power source such as the APU or external power.

DC Power Distribution

The function of the DC power distribution system is similar to the AC system in that the right and left systems function independently. The DC system has manual crosstie capability in the event of a failure of either system. In addition to the left and right systems, DC power can be supplied by the batteries.

Power is supplied to the left DC system by two TR's, both receiving power from the left AC bus. In the right system, the #1 TR is powered from the right AC bus, and the #2 TR is powered from the ground service bus. When the ground service bus is receiving power from the generator bus, the two TR's are connected through the DC ground service tie relay to supply power to the right DC bus. When the ground service bus is powered directly from either external power or the APU generator, the right #1 TR is isolated and only the right #2 TR supplies power to the DC transfer bus.

The DC bus crosstie differs from the AC bus crosstie in that the DC bus crosstie is not automatic and must be operated manually. In addition to supplying power to the respective DC buses, the TR's supply power to the emergency DC bus, and the DC transfer bus. The DC crosstie system incorporates a built-in fuse to protect either the left or right side should a fault exist when attempting to crosstie.

Batteries

Two 14 volt batteries, connected in series, supply DC power to the battery direct bus regardless of BATT switch position. When the BATT switch is positioned to ON, the battery bus is powered. When no other source of power is available, the DC transfer bus is powered by the batteries with the BATT switch ON.

Battery Charger

The battery charger will operate when:

- BATT switch is ON.
- EMER PWR switch is OFF.
- Ground service bus is powered.

When the battery is fully charged, the battery charger will be in a pulsating mode. If the battery is in a low state of charge, the ammeter will indicate approximately 40 amperes and transition into a pulsating mode as the batteries becomes fully charged. Pulse intervals will range from 5 seconds to 30 minutes.

NOTE: Some aircraft have pulse chargers which cycle the ammeter to the left and back to zero until the battery is fully charged. Others have constant current chargers which show a steady charge until the battery is fully charged.

Emergency AC and DC Power

During normal operation, the emergency AC bus receives power from the left AC bus, and the emergency DC bus receives power from the left DC bus. Loss of power to the left generator bus will transfer the emergency AC bus to the right AC bus, and the emergency DC bus to the right DC bus.

In the event of complete loss of power, the ship's batteries will provide both AC and DC emergency power when the EMER PWR switch is ON. The DC emergency bus will be powered from the battery direct bus, which will also power the emergency inverter to provide power to essential equipment for approximately 30 minutes. When emergency electrical power is in use, the battery charger is not available.

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Electrical OAP Messages/Lights

Chapter 6 Section 30

OAP Messages/Lights

Red Warning Lights

AC EMER BUS OFF - Indicates emergency AC bus is not powered.
MASTER WARNING lights illuminate.

DC EMER BUS OFF - Indicates emergency DC bus is not powered.
MASTER WARNING lights illuminate.

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

AC CROSSTIE LOCKOUT (ELEC) - Indicates AC crosstie relay is locked open and automatic AC crosstie is inoperative.

APU GEN OFF (ELEC) - Indicates the APU generator power is available but not selected. MASTER CAUTION lights illuminate.

DC BUS OFF (ELEC) - Indicates a DC bus is de-energized. MASTER CAUTION lights illuminate.

DC XFER BUS OFF (ELEC) - Indicates DC transfer bus is de-energized.

L/R AC BUS OFF (ELEC) - Indicates the respective AC bus is not powered. MASTER CAUTION lights illuminate.

L/R CSD OIL PRESS LOW (ELEC) - Indicates oil pressure in left/right CSD is below operating limits. MASTER CAUTION lights illuminate.

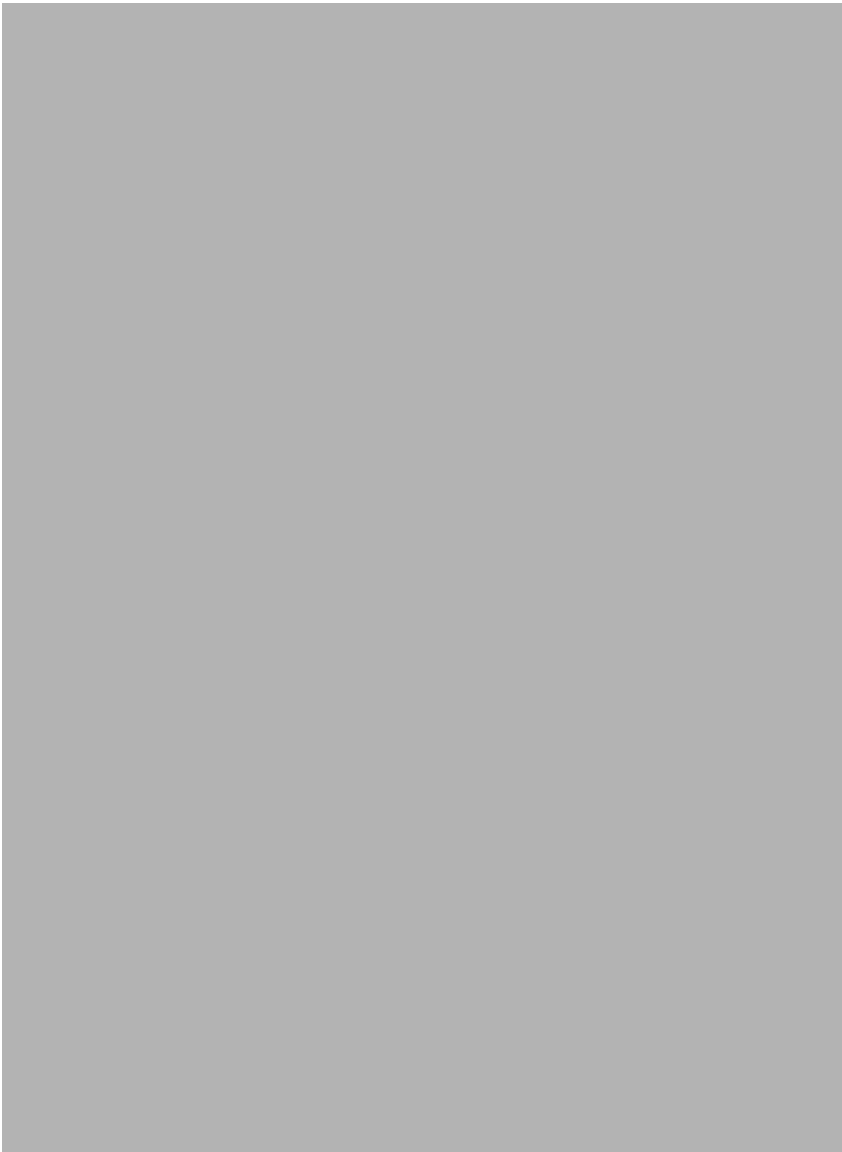
L/R GEN OFF (ELEC) - Indicates the respective generator relay is open, disconnecting generator from its bus. MASTER CAUTION lights illuminate.

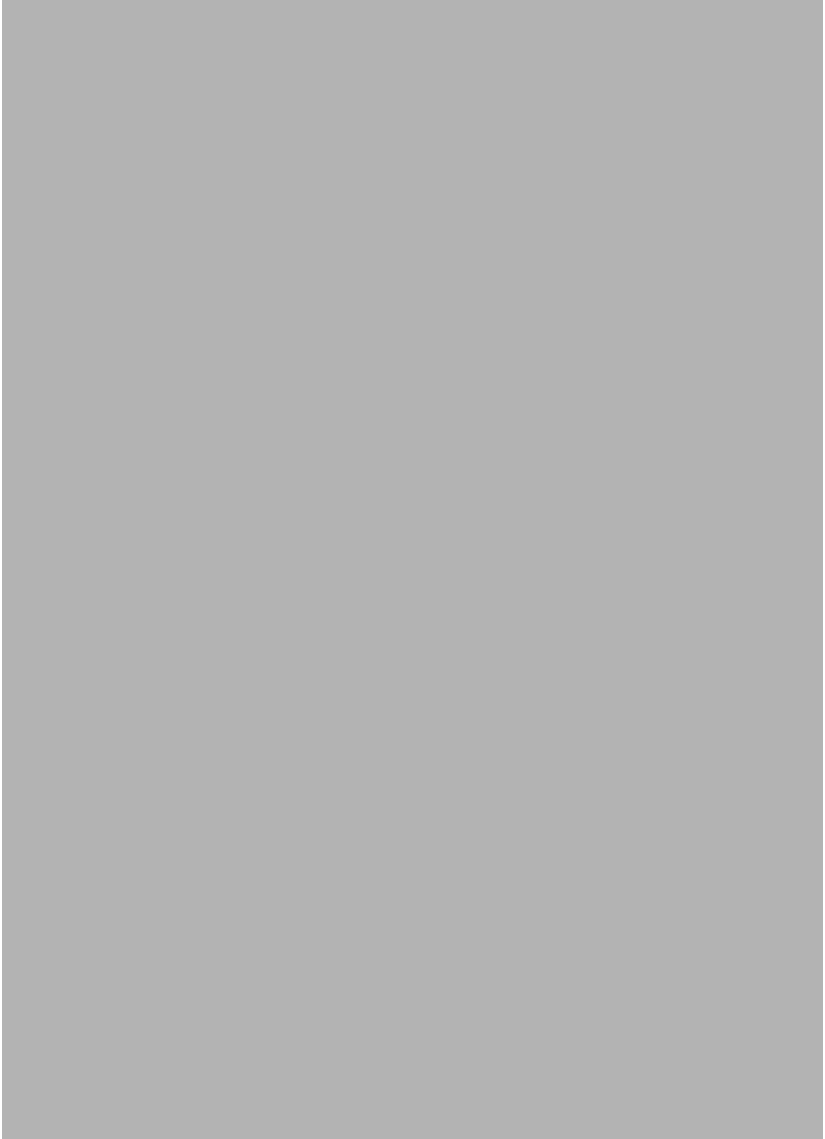
NO ELEC FAULTS (ELEC) - Illuminates when ELEC cue light is pushed if no electrical system faults exist.

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MD-88 Power Distribution





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Electrical Circuit Breaker Locations

Chapter 6 Section 50

Circuit Breaker Locations

A 1* to D 21*	=	COCKPIT OVERHEAD C/B PANEL
A 1 to Z 42	=	ELECTRICAL POWER CENTER (BEHIND CAPTAIN)
Lt GB	=	LEFT GENERATOR BUS
Rt GB	=	RIGHT GENERATOR BUS
L CON	=	LEFT CONSOLE (CAPTAIN'S LEFT SIDEWALL)
C, or F CON	=	CAPTAIN, OR F/O CONSOLE (FORWARD OF FLIGHT KITS)
STEP	=	FLIGHT DECK STEP
E & E	=	E & E COMPARTMENT
EXT	=	EXTERNAL POWER PANEL
CABIN	=	VARIOUS CABIN LOCATIONS

CIRCUIT BREAKER	CB REF		BUS
	88	90	
AC Bus, Left	Lt GB	Lt GB	GENERATOR
AC Bus, Right	Rt GB	Rt GB	GENERATOR
AC Bus Sensing, Left	Lt GB	Lt GB	GENERATOR
AC Bus Sensing, Right	Rt GB	Rt GB	GENERATOR
AC Bus Sensing, EPCU, Left		Lt GB	GENERATOR
AC Bus Sensing, EPCU, Right		Rt GB	GENERATOR
AC Bus Warning Lights, Left	X40		DC TRANSFER
AC Bus Warning Lights, Right	X39		DC TRANSFER
ACARS	F18	F18	LEFT RADIO AC
ACARS Aux Unit	F22		LEFT RADIO AC
ACARS Datalink IDU	F26	F14	LEFT RADIO AC
ACARS Datalink DC	B18*	B19*	BATT DIR
ACARS Datalink MU	B18* & F25		LEFT RADIO AC
ACARS Printer	F18	F23	LEFT RADIO AC
ACU-1		S42	DC TRANSFER
ACU-2		R37	RIGHT DC
ACU-1 Excitation		A7*	EMERGENCY AC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
ACU-2 Excitation		A1	RIGHT INST
ACU Battery-1		D19*	LEFT RADIO DC
ACU Battery-2		D21*	RIGHT RADIO DC
ADF-1	C15 & F24	F24	LEFT RADIO AC
ADF-1	E17	E17	LEFT RADIO DC
ADF-2	C6 & D 12	D12	RIGHT RADIO AC
ADF-2	E5	E5	RIGHT RADIO DC
Air Cond Auto Shutoff	U28	U28	LEFT DC
Air Cond Flow Valve, Left	C13*	C14*	EMERGENCY DC
Air Cond Flow Valve, Right	C14*	C15*	EMERGENCY DC
Air Cond Purging Relay	U28	U28	LEFT DC
Air Cond Reg Valve, Left	B13*	T25	EMERGENCY DC
Air Cond Reg Valve, Right	B14*	S25	EMERGENCY DC
Air Cond Turbine Nozzle	X34	X34	DC TRANSFER
Air Data Computer-1	C1*	C1*	EMERGENCY AC
Air Data Computer-2	F12	F12	RIGHT RADIO AC
Air Data Switching Unit	C9*	C10*	EMERGENCY DC
Airfoil Advisory	M21	M21	LEFT DC
Airfoil Ice Prot, Auto	N29	N29	RIGHT DC
Airfoil Ice Prot Control, Left	M30	M30	LEFT DC
Airfoil Ice Prot, Control, Right	N30	N30	RIGHT DC
Airfoil Ice Prot, Tail, Timer	N31	N31	RIGHT DC
Air Fone	D16	L29	LEFT RADIO AC
Airspeed, Capt	A5*	A5*	EMERGENCY AC
Airspeed, F/O	B3	B3	RIGHT RADIO
Alternate Fuel Burn	M37	M37	LEFT DC
Altimeter, Capt	A3*	A3*	EMERGENCY AC
Altimeter, F/O	B1	B1	RIGHT RADIO
Altitude Alert	R38	R38	RIGHT DC
Altitude Alert, Capt	G15	G15	LEFT RADIO DC
Altitude Alert, F/O	G2	G2	RIGHT RADIO DC
Altitude Bias Control, Left	U24		LEFT DC
Altitude Bias Control, Right	U24		RIGHT DC
Angle Of Attack Heater, Left	X22	X22	LEFT AC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Angle of Attack Heater, Right	Z22	Z22	RIGHT AC
Annunciator Lights, Spare, Test	N35	N35	RIGHT DC
Annunciator Panel	U35	U35	DC TRANSFER
Annunciator Panel	U34		DC TRANSFER
Annunciator Panel	T24	T24	RIGHT DC
Anti-Collision Light, Lower	K11	K11	LEFT AC
Anti-Collision Light, Upper	L11	L11	RIGHT AC
Anti-Fog, CAPT, F/O, CTR	X26	X26	LEFT AC
Anti-Fog, Clearview & Eyebrow	Z26	Z26	RIGHT AC
Anti-Fog, Clearview, Control	Z25	Z25	RIGHT AC
Anti-Ice Valve Caution, Left	S37		LEFT DC
Anti-Ice Valve Caution, Right	T37		RIGHT DC
Anti-Icing Valve, Left Cowl	K30	S33	LEFT AC
Anti-Icing Valve, Left Engine	K32		LEFT AC
Anti-Icing Valve, Left Engine	K31		LEFT AC
Anti-Icing Valve, Right Cowl	L30	T33	RIGHT AC
Anti-Icing Valve, Right Engine	L32		RIGHT AC
Anti-Icing Valve, Right Engine	L31		RIGHT AC
Anti-Skid Power, Inboard	P40	P40	LEFT DC
Anti-Skid Power, Outboard	R40	T38	RIGHT DC
Anti-Skid, Test	A12		LEFT INST
Anti-Skid, Test	R41	R41	RIGHT DC
Approach Idle Control	S40		LEFT DC
APU Control	B21*	B22*	BATTERY
APU Door Control	U39	U39	DC TRANSFER
APU Fire Central Aural Warning	W33	W33	DC TRANSFER
APU Fire Warning Horn	W34	W34	DC TRANSFER
APU Left Engine Start		U32	DC TRANSFER
APU Maintenance Light		C19*	BATTERY
APU Power	E & E	E & E	MISCELLANEOUS
APU Starter	E & E	E & E	MISCELLANEOUS
APU Tach	A21* or B19*	A22*	BATTERY
ART Solenoid, Left	X32		DC TRANSFER
ART Solenoid, Right	Z32		DC TRANSFER

CIRCUIT BREAKER	CB REF		BUS
	88	90	
ART Status Lights	W32		DC TRANSFER
ATC-1	D13	D13	LEFT RADIO AC
ATC-1	E13	E13	LEFT RADIO DC
ATC-2	D1	D1	RIGHT RADIO AC
ATC-2	E1		RIGHT RADIO DC
Audio Control		G19	LEFT RADIO AC
Auto Brake Annunciation	R30	R30	RIGHT DC
Auto Slat Extend	R36	R36	RIGHT DC
Autobrake System	P30	P30	LEFT DC
Autoland Light Retract	35	M35	LEFT DC
Autopilot and Alt Long Trim	D10	D10	RIGHT RADIO AC
Autopilot and Alt Long Trim	D9	D9	RIGHT RADIO AC
Autopilot and Alt Long Trim	D11	D11	RIGHT RADIO AC
Autopilot - 1	E24	E24	LEFT RADIO DC
Autopilot - 2	E12	E12	RIGHT RADIO DC
Autopilot OFF Lights	W31 & Z31	W31 & Z31	DC TRANSFER
Autothrottle - 1	D18	C16	LEFT RADIO AC
Autothrottle - 1	E18	E18	LEFT RADIO DC
Autothrottle - 2	E6	E6	RIGHT RADIO DC
Autothrottle - 2	D6	C9	RIGHT RADIO AC
Autothrottle OFF Lights	W31 & Z31	W31 & Z31	DC TRANSFER
Aux Hydraulic Pump	Lt GB	Lt GB	GENERATOR BUS
Aux Hydraulic Pump Control	H17	H17	LEFT AC
Battery Backup Bus		C20*	BATTERY
Battery Backup Bus EPCU		B20*	BATTERY BUS
Battery Bus OFF		B21*	BATTERY
Battery Charger	L Con	L Con	GROUND SERVICE
Battery Direct Bus Feed	STEP	D17*	MISCELLANEOUS
Battery Relay	C17*	C18*	BATT DIR
Bleed Air Filter	U25	U25	LEFT DC
Boarding Music		B4*	EMERGENCY AC
Brake Pressure, Left	B11	B11	LEFT INST
Brake Pressure, Right	A4	A4	RIGHT INST
Brake Temp Indicator	P25	P25	LEFT DC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Bus Out Light, DC Transfer		X37	BATTERY
Bus Out Light, Emergency AC	C21*	C22*	BATTERY
Bus Out Light, Emergency DC	C19*	C21*	BATTERY
Bus Tie, Left		S40	LEFT DC
Bus Tie, Right		T39	DC TRANSFER
Cabin Altitude Warning	P38	P38	LEFT DC
Cabin Interphone		G8	RIGHT RADIO DC
Cabin Low Pressure Warning	W21	W21	RIGHT DC
Cabin Manual Temp Ctrl		C7	EMERGENCY AC
Cabin Medical Outlet (2)	L Con	LCon	GROUND SERVICE
Cabin Oxygen Light	U30	U30	LEFT DC
Cabin Pressure Chime	P23	P23	LEFT DC
Cabin Pressure Control-1	U22	U22	LEFT DC
Cabin Pressure Control-1	H2	H2	LEFT AC
Cabin Pressure Control-2	J2	J2	RIGHT AC
Cabin Pressure Control-2	W22	W22	RIGHT DC
Cabin Standby Lights	A13*	A14*	EMERGENCY DC
Cabin Temp	W27	W27	RIGHT DC
Cabin Temp Ctrl	J1	J1	RIGHT AC
CADC 1	C1*	C1*	EMERGENCY AC
CADC 2	F12	F12	RIGHT RADIO AC
CADC Switching Unit	C9*	G17	EMERGENCY DC
CADC Switched Light	G17	G17	LEFT RADIO DC
Call System (chime)	P37	P37	LEFT DC
Cargo Compt Heater (Fwd)	J14	J14	RIGHT AC
Cargo Compt Heater (Fwd)	J12	J12	RIGHT AC
Cargo Compt Heater (Fwd)	J13	J13	RIGHT AC
Cargo Compt Heater Fan (Mid)	H13	H13	LEFT AC
Cargo Compt Heater Fan (Mid)	H14	H11	LEFT AC
Cargo Compt Heater Fan (Mid)	H12	H12	LEFT AC
Cargo Fire Aural Alert	R33	P27	RIGHT DC
Cargo Fire Left Bus Supply	P36	P29	LEFT DC
Cargo Fire Right Bus Supply	R37	R40	RIGHT DC
CAWS Ovspd, Eng Fire, Stab	U31	U31	DC TRANSFER

CIRCUIT BREAKER	CB REF		BUS
	88	90	
CAWS SSRS-2 Alt Alert	R38	R38	RIGHT DC
CAWS Ldg Gr, T/O, A/P, SB, Cab Alt	P38	P38	LEFT DC
Charger and Transfer Relay	C16*	C17*	BATT DIR
Charger and XFER Bus Interlock	L Con	L Con	GROUND SERVICE
Charger Relay Control	N38	N38	DC POWER FEED
Clock, Electronic	B17*	B18*	BATT DIR
Clocks	S38	S34	LEFT DC
Cockpit Door Unlock	P24	P24	LEFT DC
Cockpit Voice Recorder	F6	F6	RIGHT RADIO AC
Course and Heading, Capt	A1*	A1*	EMERGENCY AC
Course and Heading, F/O	B4	B4	RIGHT RADIO
CSD Disconnect, Left	T26		RIGHT DC
CSD Disconnect, Right	S26		LEFT DC
CSD Oil Temp, Left	S25		LEFT DC
CSD Oil Temp, Right	T25		RIGHT DC
Data Link DC	B18*	B19*	BATTERY DIR
Data Link IDU	F26	F14	LEFT RADIO AC
Data Link MU	B18* & F25	F18	LEFT RADIO AC
Data Link Printer	F18	F23	LEFT RADIO AC
DC Bus Cross Tie Control	B11*	B12*	EMERGENCY DC
DC Bus Off Sensing	R23	R23	RIGHT DC POWER
DC Transfer Bus Feed	N36	N36	DC POWER FEED
DC Trans Bus Feed (Bat)	E & E	E & E	MISCELLANEOUS
DC Transfer Bus Sensing	X37	X37	DC TRANSFER
DC Voltmeter, Left	P22	P22	LEFT DC POWER
DC Voltmeter, Right	R22	R22	RIGHT DC POWER
DCAS, Capt		S39	LEFT DC
DCAS, F/O		G3	RIGHT RADIO AC
DCAS, Obsv. 1		G12	RIGHT RADIO DC
DCAS, Obsv. 2		T42	DC TRANSFER
Dead Bus Slave Relays, Left	X40		DC TRANSFER
Dead Bus Slave Relays, Right	X39		DC TRANSFER
DFDAU		F22	LEFT RADIO AC
DFG, Switch A	C17	C17	28 VAC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
DFG, Switch B	C18	C18	28 VAC
DFG, Switch C	C19		28 VAC
DFGC ALPHA-1	C12	C12	LEFT RADIO
DFGC ALPHA-2	C3	C3	RIGHT RADIO
DFGC Flap Position-1	C13	C13	LEFT RADIO
DFGC Flap Position-2	C4	C4	RIGHT RADIO
DFGC-1	E20	E20	LEFT RADIO DC
DFGC-1	D20	D20	LEFT RADIO AC
DFGC-1	C1	C1	RIGHT RADIO
DFGC-1	C10	C10	LEFT RADIO
DFGC-1	E9	E9	RIGHT RADIO
DFGC-2	C2	C2	RIGHT RADIO
DFGC-2	E21	E21	LEFT RADIO DC
DFGC-2	C11	C11	LEFT RADIO
DFGC-2	D8	D8	RIGHT RADIO AC
DFGC-2	E8	E8	RIGHT RADIO DC
DFGS Light Control	L16	L16	RIGHT AC
Digital Audio System, CAPT		S39	DC TRANSFER
Digital Audio System, F/O		G3	RIGHT RADIO AC
Digital Audio System, OBSV-1		G12	RIGHT RADIO DC
Digital Audio System, OBSV-2		T42	DC TRANSFER
Digital Display, CAPT	M32	M32	LEFT DC
Digital Display, Center	N32	N32	RIGHT DC
Digital Display, F/O	N33	N33	RIGHT DC
Digital Display, Warn Lt & Tes	N34	N34	RIGHT DC
Digital Flight Guidance Sys-1	D20	D20	LEFT RADIO AC
Digital Flight Guidance Sys-1	E9	E9	RIGHT RADIO DC
Digital Flight Guidance Sys-1	E20	E20	LEFT RADIO DC
Digital Flight Guidance Sys-2	E21	E21	LEFT RADIO DC
Digital Flight Guidance Sys-2	E8	E8	RIGHT RADIO DC
Digital Flight Guidance Sys-2	D8	D8	RIGHT RADIO AC
DME-1	D14	D14	LEFT RADIO A
DME-2	D2	D2	RIGHT RADIO AC
Door Warning		R24	RIGHT DC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Drain Mast Heater, Aft	Z27	Z27	RIGHT AC
Drain Mast Heater, Aft	N27		RIGHT DC
Drain Mast Heater, Fwd	X27	X27	LEFT AC
Drain Mast Heater, Fwd	M27		LEFT DC
Drain Mast Htr, Ann.		M27	LEFT DC
Drain Valve	LCon	L Con	GROUND SERVICE
EEC 1, Ch A		W32	DC TRANSFER
EEC 1, Ch B		X32	DC TRANSFER
EEC 1 Relay		U41	DC TRANSFER
EEC 2, Ch A		B14 *	EMERGENCY DC
EEC 2, Ch B		B15*	EMERGENCY DC
EEC 2 Relay		C9*	EMERGENCY DC
EGT, Left	B15*	B16*	EMERGENCY DC
EGT, Right	X35	X35	DC TRANSFER
Elevator Power On Advisory	P27		LEFT DC
ELFA-1		T40	RIGHT DC
ELFA-2		R33	RIGHT DC
Emergency AC Bus Feed	K7	K7	LEFT AC
Emergency AC Bus Feed-Alt	L8	L8	RIGHT AC
Emergency AC Bus Sensing	C7*	C8*	EMERGENCY AC
Emergency Bus Warning Light	Z40	Z40	DC TRANSFER
Emergency DC Bus Feed	N37	D15* or N37	DC POWER FEED
Emergency DC Bus Sensing	B12*	B13*	EMERGENCY DC
Emergency Inverter	C18*	D13*	BATT DIR
Emergency Lights Arm & Charge	A14*	A15*	EMERGENCY DC
Emergency Lights Charging	Z37	Z37	DC TRANSFER
Emergency Nav Instrument XFMR	C4*	C5*	EMERGENCY AC
Emergency Power In Use Light	A12*	A13*	EMERGENCY DC
EMER Power Auto Transfer Reset			BATTERY
Engine Cooldown		T37	DC TRANSFER
Engine Inst Display Pnl, Left	X36	X36	
	B15*, S34	B16*, S32	LEFT DC
Engine Inst Display Pnl, Right	X35	X35	

CIRCUIT BREAKER	CB REF		BUS
	88	90	
	C15*, T34	C16*, T32	RIGHT DC
Engine Fire Warning	U31	U31	DC TRANSFER
Engine Start Switch, Left		U34	DC TRANSFER
Engine Start Switch, Right		X39	DC TRANSFER
Engine Sync	T40		RIGHT DC
Engine Thrust, Ch A		S37	DC TRANSFER
Engine Vibration Monitor		K30	LEFT AC
EPCU Battery Backup Bus		B20*	BATTERY
EPR, Fuel Flow Display, Left	X36	X36	DC TRANSFER
EPR, Fuel Flow Display, Right	C15*	C16*	EMERGENCY DC
EPR, Left (Transmitter)	C8*		EMERGENCY AC
EPR, Right (Transmitter)	L25		RIGHT AC
External Power	E & E		MISCELLANEOUS
External Power	EXT	EXT	MISCELLANEOUS
External Power Control	E & E		MISCELLANEOUS
External Power Relay	X38		DC TRANSFER
Fill Drain Valve Control	Z33	Z33	DC TRANSFER
Fill Valve	L Con	L Con	GROUND SERVICE
Fire Agent Low Light	R26 or U32	R26	RIGHT DC
Fire Detectors, APU, Loop A	W35	W35	DC TRANSFER
Fire Detectors, APU, Loop B	W36	W36	DC TRANSFER
Fire Detectors, Left, Loop A	W39	W39	DC TRANSFER
Fire Detectors, Left, Loop B	W40	W40	DC TRANSFER
Fire Detectors, Right, Loop A	W37	W37	DC TRANSFER
Fire Detectors, Right, Loop B	W38	W38	DC TRANSFER
Fire Extinguishing, Bottle 1	X41	X41	DC TRANSFER
Fire Extinguishing, Bottle 2	X42	X42	DC TRANSFER
Fire Warning, APU, Aural	W33	W33	DC TRANSFER
Fire Warning, Aural	W41	W41	DC TRANSFER
Fire Warning Horn, APU	W34	W34	DC TRANSFER
Fire Warning, Lights	W42	W42	DC TRANSFER
Flap Position, Left	A11	A11	LEFT INST
Flap Position, Right	A2	A2	RIGHT INST
Flight Display (PFD), CAPT	B4*	B7*	EMERGENCY AC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Flight Display (PFD), F/O	F11	F11	RIGHT RADIO AC
Flight Guidance Status	G25		LEFT RADIO DC
Flight Interphone-1	A10*	A11*	EMERGENCY DC
Flight Interphone-2	T42		DC TRANSFER
Flight Recorder	C14		LEFT RADIO
Flight Recorder	G21	G21	LEFT RADIO DC
Flight Recorder	F21	F21	LEFT RADIO AC
Flight Recorder	B7		RIGHT RADIO
Flush Motors/Vacuum Blowers	L Con	L Con	GROUND SERVICE
FMA/Mode Select, Capt	E19	E19	LEFT RADIO DC
FMA/Mode Select, F/O	E7	E7	RIGHT RADIO DC
FMS Data Loader	H15	H15	LEFT AC
FMS-1 CDU	D22	D22	LEFT RADIO AC
FMS-1 Computer	D21	D21	LEFT RADIO AC
FMS-2 CDU	F10	F10	RIGHT RADIO AC
FMS-2 Computer	F9	F9	RIGHT RADIO AC
FMS Switching		A12*	RIGHT RADIO AC
Fuel Boost Pump, CTR AFT	J21	J21	RIGHT AC
Fuel Boost Pump, CTR FWD	H21	H21	LEFT AC
Fuel Boost Pump, LT AFT	H23	H23	LEFT AC
Fuel Boost Pump, LT FWD	J23	J23	RIGHT AC
Fuel Boost Pump, RT AFT	J19	J19	GROUND SERVICE
Fuel Boost Pump, RT FWD	H19	H19	LEFT AC
Fuel Filter Press Drop, Left	S35		LEFT DC
Fuel Filter Press Drop, Right	T35		RIGHT DC
Fuel Flow, Left	K27 & X36	X36	LEFT AC
Fuel Flow, Right	L27 & C15*	C16*	RIGHT AC/ EMERG DC
Fuel Heat, Left, Control	K28		LEFT AC
Fuel Heat, Left, Timer	K29		LEFT AC
Fuel Heat ON, Left	S36		LEFT DC
Fuel Heat ON, Right	T36		RIGHT DC
Fuel Heat, Right, Control	L28		RIGHT AC
Fuel Heat, Right, Timer	L29		RIGHT AC
Fuel Press, CTR Low Press	T41	T41	DC TRANSFER

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Fuel Qty XFMR, Alternate	H16		LEFT AC
Fuel Quantity Power Transfer	J17	J17	GROUND SERVICE
Fuel Quantity Power Transfer		H14	LEFT AC
Fuel Level Low	S41	S41	DC TRANSFER
Fuel Shutoff Solenoid, Left		Z32	DC TRANSFER
Fuel Shutoff Solenoid, Right		B11*	EMERGENCY DC
Fuel Switch, Left		U42	DC TRANSFER
Fuel Switch, Right		X40	DC TRANSFER
Galley Control	L4	L4	RIGHT AC
Galley-1 Power, Fwd	Lt GB	Lt GB	GENERATOR
Galley-2 Power, Fwd	Rt GB	Rt GB	GENERATOR
Galley-3 Power, Aft	Rt GB	Rt GB	GENERATOR
Galley-4 Power, Aft	Lt GB	Lt GB	GENERATOR
Generator Control, APU	U36	U36	DC TRANSFER
Generator Control, Left	U38	U38	DC TRANSFER
Generator Control, Right	U37	U37	DC TRANSFER
GPS-1		D18	LEFT RADIO AC
GPS-2		D6	RIGHT RADIO AC
GPWS Computer	F20	F20	LEFT RADIO AC
GPWS Lights	G20	G20	LEFT RADIO AC
GPWS Terrain Switching	G11		RIGHT RADIO DC
Ground Air Cond Regulator	U27	U27	LEFT DC
Ground Battery Control		A20*	BATTERY
Ground Control Relay, Left	K33	K33	LEFT AC
Ground Control Relay, Right	L33	L33	RIGHT AC
Ground Refuel	Z38	Z38	DC TRANSFER
Ground Refueling	B16*	B17*	BATT DIR
Ground Service Bus Control	L5	L5	RIGHT AC
Ground Service Power	Rt GB	Rt GB	GENERATOR
Handrail Lighting Controller		P36	LEFT DC
Heat Exchanger Fan, Left	Lt GB	Lt GB	GENERATOR
Heat Exchanger Fan, Left, Ctrl	H11	H10	LEFT AC
Heat Exchanger Fan, Right	Rt GB	Rt GB	GENERATOR
Heat Exchanger Fan, Rt, Ctrl	J11	J11	RIGHT AC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Heater, Pneu. Pilot Valve, Left		K24	LEFT AC
Heater, Pneu. Pilot Valve, Right		L24	RIGHT AC
Heater, Pri Trim Motor	H10	H9	LEFT AC
Heater, Strake, Right		Rt GB	GENERATOR
Heater, Strake, Left		Lt GB	GENERATOR
Horizontal Stabilizer Warning	U31	U31	DC TRANSFER
Hydraulic Oil Quantity, Left	B12	B12	LEFT INST
Hydraulic Oil Quantity, Right	A5	A5	RIGHT INST
Hydraulic Power Xfer, Ctrl	R27	R27	RIGHT DC
Hydraulic Press Low, Left	P28	P28	LEFT DC
Hydraulic Press Low, Right	R28	R28	RIGHT DC
Hydraulic Pump, Aux	Lt GB	Lt GB	GENERATOR
Hydraulic Pump, Aux Control	H17	H17	LEFT AC
Hydraulic Pump Control, Left	S27	S 2	LEFT DC
Hydraulic Pump Control, Right	T27	T27	RIGHT DC
Hydraulic System Press, Left	B10	B10	LEFT INST
Hydraulic System Press, Right	A3	A3	RIGHT INST
Ice Detection, Wing	M34	M34	LEFT DC
Ice Protect Aug Valve, Left	M23		LEFT DC
Ice Protect Aug Valve, Right	N23		RIGHT DC
Ice Protection System		L10	RIGHT AC
Ignition A Advisory	S32	S31	LEFT DC
Ignition B Advisory	T32	T31	RIGHT DC
Ignition, Left	K26	K26	LEFT AC
Ignition, Right	L26	L26	RIGHT AC
Ignitor, L1		B2*	EMERGENCY AC
Ignitor, L2		C2*	EMERGENCY AC
Ignitor, R1		B3*	EMERGENCY AC
Ignitor, R2		C3*	EMERGENCY AC
Inst Cooling Fan	H8	H8	LEFT AC
Inst XFMR, Left	K9	K9	LEFT AC
Inst XFMR, Right	L9	L9	RIGHT AC
Instrument Vibrator	P31	P31	LEFT DC
Interphone	A10*	A11*	EMERGENCY DC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
IRS - 1 Annun	G18		RIGHT RADIO DC
IRS - 2 Annun	G4		RIGHT RADIO DC
IRS 1 - BAT	E14	E14	LEFT RADIO DC
IRS 2 - BAT	E4	E4	RIGHT RADIO DC
IRU 1	F15	F15	LEFT RADIO AC
IRU 1 Synchro Excitation	A6*		EMERGENCY DC
IRU 2	F2	F1	RIGHT RADIO AC
Landing Gear Warning	P26	P26	LEFT DC
Landing Gear Warning, Aural	P38	P38	LEFT DC
Lavatory Smoke Detector		R34	RIGHT DC
Lavatory Water Htr, Left, Aft	X28	X28	LEFT AC
Lavatory Water Htr, Left, Fwd	X29	X29	LEFT AC
Lavatory Water Htr, Right, Aft	Z28	Z28	RIGHT AC
Light Control, DFGS	L16	L16	RIGHT AC
Light Test		X38	DC TRANSFER
Lights, Bagrack		L20	RIGHT AC
Lights, Briefcase	W29	W29	RIGHT DC
Lights, Cabin	Cabin	Cabin	MISCELLANEOUS
Lights, Cabin, Standby	A13*	A14*	EMERGENCY DC
Lights, Cabin and Lavatory	L Con	L Con	GROUND SERVICE
Lights, CAPT Inst Panel	K15	K15	LEFT AC
Lights, Cargo	L Con	L Con	GROUND SERVICE
Lights, Capt White Floods	A15*	A16*	EMERGENCY DC
Lights, Ceiling (3)	L Con	L Con	GROUND SERVICE
Lights, Cockpit White Floods	Z39	Z39	DC TRANSFER
Lights, F/O Inst Panel	L17	L17	RIGHT AC
Lights, F/O White Floods	A15*	A16*	EMERGENCY DC
Lights, Galley Work	L Con	L Con	GROUND SERVICE
Lights, Ground Flood (2)	L Con	L Con	GROUND SERVICE
Lights, Handrail		L20	RIGHT AC
Lights, Handrail Controller		P36	LEFT DC
Lights, Inst, Capt, Integral	C Con	C Con	MISCELLANEOUS
Lights, Inst, F/O, Integral	F Con	F Con	MISCELLANEOUS
Lights, Inst Panel, Fluorescent	L18	L18	RIGHT AC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Lights, Instrument Panel, CTR	K18	K18	LEFT AC
Lights, Landing, Left Wing	K12	K12	LEFT AC
Lights, Landing, Lt Wing, Ctrl	K13	K13	LEFT AC
Lights, Landing, Nose, Left	K14	K14	LEFT AC
Lights, Landing, Nose, Right	L14	L14	RIGHT AC
Lights, Landing, Right Wing	L12	L12	RIGHT AC
Lights, Landing, Rt Wing, Ctrl	L13	L13	RIGHT AC
Lights, Lavatory Mirror (3)	L Con	L Con	GROUND SERVICE
Lights, Map	W29	W29	RIGHT DC
Lights, Observer		R29	RIGHT DC
Lights, Overhead Flood	M33	M33	LEFT DC
Lights, Overhead Panel	H29	H29	MISCELLANEOUS
Lights, Overhead Panel	H30	H30	MISCELLANEOUS
Lights, Overhead Panel AFT	K17	K17	LEFT AC
Lights, Overhead Panel FWD	K16	K16	LEFT AC
Lights, Overhead Sw. Panel, Aft	H29	H29	MISCELLANEOUS
Lights, Overhead Sw. Panel, Aft	J29	J29	MISCELLANEOUS
Lights, Overhead Sw. Panel, Aft	H30	H30	MISCELLANEOUS
Lights, Overhead Sw. Panel, Fwd	J30	J30	MISCELLANEOUS
Lights, Overhead Sw. Panel, Fwd	J31	J31	MISCELLANEOUS
Lights, Overhead Sw. Panel, Fwd	J32	J32	MISCELLANEOUS
Lights, Panel, Integral, Ctr	C Con	C Con	MISCELLANEOUS
Lights, Panel, Integral, F/O	F Con	F Con	MISCELLANEOUS
Lights, Passenger Entrance Str	L Con	L Con	GROUND SERVICE
Lights, Passenger Warning	K23	K23	LEFT AC
Lights, Pax Reading, AFT	K22	K22	LEFT AC
Lights, Pax Reading, CTR	K21	K21	LEFT AC
Lights, Pax Reading FWD	K20	K20	LEFT AC
Lights, Pedestal	K19	K19	LEFT AC
Lights, Position	L Con	L Con	GROUND SERVICE
Lights, Reading	Cabin	Cabin	MISCELLANEOUS
Lights Retract, Auto. Land	M35	M35	LEFT DC
Lights, Sidewall (6/3)	L Con	L Con	GROUND SERVICE
Lights, Taxi, Nose, Left	K14	K14	LEFT AC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Lights, Taxi, Nose, Right	L14	L14	RIGHT AC
Lights, Thunderstorm, Alt	W28	W28	MISCELLANEOUS
Lights, Wheelwell & Utility Outlet	L Con	L Con	GROUND SERVICE
Lights, White Flood, Capt	A15*	A16*	EMERGENCY DC
Lights, White Flood, F/O	A15*	A16*	EMERGENCY DC
Lights, Wing and Nacelle Flood	L Con	L Con	GROUND SERVICE
Longitudinal Trim, A/P and Alt	D11	D11	RIGHT RADIO AC
Longitudinal Trim, A/P and Alt	D10	D10	RIGHT RADIO AC
Longitudinal Trim, A/P and Alt	D9	D9	RIGHT RADIO AC
Longitudinal Trim, Primary	Lt GB	Lt GB	GENERATOR
Longitudinal Trim, Primary, Brake	G23	G23	LEFT RADIO DC
Longitudinal Trim, Primary, Cntrl	G22	G22	LEFT RADIO DC
Longitudinal Trim, Pri Mtr Htr	H10	H9	LEFT AC
Mach Airspeed Ind, Capt	A5*	A5*	EMERGENCY AC
Mach Airspeed Ind, F/O	B3	B3	RIGHT RADIO
Mach Trim Inop Light	U33	U33	DC TRANSFER
Mach Trim Override	X33		DC TRANSFER
Mach Trim-1	G26		LEFT RADIO DC
Mach Trim-2	G12		RIGHT RADIO DC
Mag/True Annum	A9*	A10*	EMERGENCY DC
Marker Beacon	G6	G6	RIGHT RADIO DC
Master Caution	Z42		DC TRANSFER
Master Caution, Capt		Z42	DC TRANSFER
Master Caution, F/O		T22	RIGHT DC
Master Warning	Z41		DC TRANSFER
Master Warning, Capt		Z41	DC TRANSFER
Master Warning, F/O		T23	RIGHT DC
N1 Gauge, Left	B15*	B16*	EMERGENCY DC
N2 Gauge, Left	B15*	B16*	EMERGENCY DC
N1 Gauge, Right	X35	X35	DC TRANSFER
N2 Gauge, Right	X35	X35	DC TRANSFER
Nav Display, Capt	B3*	B6*	EMERGENCY AC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Nav Display, F/O	D7	D7	RIGHT RADIO AC
Nav Inst XFMR-1	F16	F16	LEFT RADIO AC
Nav Inst XFMR-2	F13	F13	RIGHT RADIO AC
Oil Pressure, Left	A10	S21	LEFT INST/DC
Oil Pressure, Right	A1	T21	RIGHT INST/DC
Oil Quantity, Left		S21	LEFT DC
Oil Quantity, Right		T21	RIGHT DC
Overheat Wheelwell Sensor	U21	U21	LEFT DC
Overspeed Warning	U31	U31	DC TRANSFER
Overwing Heater, Left	LTGB		GENERATOR
Overwing Heater, Right	RTGB		GENERATOR
Overwing Heater, Left Control	P29		LEFT DC
Overwing Heater, Right Control	R29		RIGHT DC
Oxygen Release, Passenger	K34	K34 & P32	LEFT AC
Oxygen Release, Passenger, Alt	L34	L34 & R32	RIGHT AC
Parking Brake Control	M36	M36	LEFT DC
Passenger Address	A8*	A9*	EMERGENCY DC
Passenger Music	G19	G19	LEFT RADIO DC
Passenger Music	F19	F19	LEFT RADIO AC
Passenger Oxygen Control	P32	P32	LEFT DC
Passenger Oxygen Control, Alt	R32	R32	RIGHT DC
Passenger Oxygen Release	K34	K34	LEFT AC
Passenger Oxygen Release, Al	L34	L34	RIGHT AC
Passenger Warning Signs	K23 & W30	W30 & K23	RIGHT DC
Pitot Heater, Aux	M28	M28	LEFT DC
Pitot Heater, Capt	C12*	C13*	EMERGENCY DC
Pitot Heater, F/O	N28	N28	RIGHT DC
Pneumatic Pilot Valve Htr, Left		K24	LEFT AC
Pneumatic Pilot Valve Htr, Right		L24	RIGHT AC
Pneumatic Pressure	B1*	B1*	EMERGENCY AC
Pneumatic Pres. Reg/Shutoff Valve, Left		S25	LEFT DC
Pneumatic Pres. Reg/Shutoff Valve, Right		T25	RIGHT DC
Pneumatic Protection System		L10	RIGHT AC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Pneumatic System, Ctrl, Left		S26	LEFT DC
Pneumatic System Ctrl, Right		T26	RIGHT DC
Prerecorded Announcements		B4*	EMERGENCY AC
Pressure Abnormal Light	M21	M21	LEFT DC
Primary Flight Display, Capt	B4*	B7*	EMERGENCY AC
Primary Flight Display, F/O	F11	F11	RIGHT RADIO AC
Primary Long Trim, Brake	G23	G23	LEFT RADIO DC
Primary Long Trim, Control	G22	G22	LEFT RADIO DC
Printer	F18	F23	LEFT RADIO AC
Probe Heat, Left Engine		K27	EMERGENCY AC
Probe Heat, Right Engine		L27	RIGHT AC
Proximity Switch Cont, Left	P39	P39	LEFT DC
Proximity Switch Cont, Right	R39	R39	RIGHT DC
Radio Altimeter-1	F17	F17	LEFT RADIO AC
Radio Altimeter-2	F3	F2	RIGHT RADIO AC
Radio DC Bus Feed, Left	P21	P21	LEFT DC POWER
Radio DC Bus Feed, Right	R21	R21	RIGHT DC POWER
Radio Rack Fan Caution	U29	U29	LEFT DC
Radio Rack Fan, Power	H6	H6	LEFT AC
Radio Rack Fan, Power	H5	H5	LEFT AC
Radio Rack Fan, Power	H4	H4	LEFT AC
Radio Rack Fan, Standby	J6	J6	RIGHT AC
Radio Rack Fan, Standby	J5	J5	RIGHT AC
Radio Rack Fan, Standby	J4	J4	RIGHT AC
Radio Rack Fan, Stby Control	H7	H7	LEFT AC
Radio Rack Fan, Venturi	H3	H3	LEFT AC
Rain Repellent, Left	M26	M26	LEFT DC
Rain Repellent, Right	N26	N26	RIGHT DC
Ram Air Exhaust Control	H9		LEFT AC
Ram Air Probe Heater	Z29	Z29	RIGHT AC
Ram Air Temp Probe	Z29	Z29	RIGHT AC
Ram Air Valve	J3	J3	RIGHT AC
Razor Outlets, Fwd & Aft		L Con	RIGHT AC
RDMI, Capt	F7	F7	RIGHT RADIO AC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
RDMI, F/O	B7*	B8*	EMERGENCY AC
Recirculation Fan	J9	J9	RIGHT AC
Recirculation Fan	J10	J10	RIGHT AC
Recirculation Fan	J8	J8	RIGHT AC
Recirculation Fan, Control	J7	J7	RIGHT AC
Remote Access System Keypad	P24	P24	Left DC
Remote Access System Control	R34	T36	Right DC
Reverse Thrust, Left, Ch A		S37	DC TRANSFER
Reverse Thrust, Left, Ch B		S38	DC TRANSFER
Reverse Thrust, Right, Ch A		C11*	EMERGENCY DC
Reverse Thrust, Right, Ch B		C12*	EMERGENCY DC
Reverse Thrust Light, Left	S31	S30	LEFT DC
Reverse Thrust Light, Right	T31	T30	RIGHT DC
Reverser Accum Low, Left	S29	S28	LEFT DC
Reverser Accum Low, Right	T29	T28	RIGHT DC
Reverser Accum Shut-Off, Left	S28		LEFT DC
Reverser Accum Shut-Off, Right	T28		RIGHT DC
Reverser Unlock Light, Left	S30	S29	LEFT DC
Reverser Unlock Light, Right	T30	T29	RIGHT DC
Rudder Q-Limiter Heater	Z30	Z30	RIGHT AC
Rudder Travel Unrestricted Lt	W25		RIGHT DC
SAT Indicator	B6	B6	RIGHT RADIO
SELCAL	G14	G14	LEFT RADIO DC
Service Interphone	G8 or C9		RIGHT RADIO DC
Smoke Detector Fan		J15	RIGHT AC
Speed Brake Warning	P38	P38	LEFT DC
Spoiler Control	P33	P33	
Spoiler Control	X30	X30	
Spoiler Deployed Indicator	R31	R31	
Spoiler Flap Extended Advisory	P34	P34	
Spoiler Lockout	M31	M31	
SSRS-1 Aural Warning	P38	P38	LEFT DC
SSRS-2 Aural Warning	R38	R38	RIGHT DC
Stabilizer Motion Indicator	G24		LEFT RADIO DC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Stabilizer Warning	U31	U31	DC TRANSFER
Stair Doors and Stairs Indicator	R24	R24	RIGHT DC
Stall Warning Alpha Flap-1	A13	A13	LEFT INST
Stall Warning Alpha Flap-2	A9	A 9	RIGHT INST
Stall Warning, Auto Slat-1	P35	P35	LEFT DC
Stall Warning, Auto Slat-2	R 35	R35	RIGHT DC
Stall Warning, CAPT	X23	X23	LEFT AC
Stall Warning, F/O	Z23	Z23	RIGHT AC
Standby Compass Light	A2*	B2*	EMERGENCY AC
Standby Horizon	X31	X31	DC TRANSFER
Standby Horizon Light Control	E16	E16	LEFT RADIO DC
Start Pump	U40	U40	DC TRANSFER
Start Valve, Left	U42	U42	DC TRANSFER
Start Valve, Right	U41	X39	DC TRANSFER
Static Air Temperature	B6	B6	RIGHT RADIO
Static Port Heater, Left	X21	X21	LEFT AC
Static Port Heater, Right	Z21	Z21	RIGHT AC
Strake Heater, Left		Lt GB	GENERATOR
Strake Heater, Right		Rt GB	GENERATOR
Strobe Lights	K10	K10	LEFT AC
Supply Air High Press Aug, Lt	U23		LEFT DC
Supply Air High Press Aug, Rt	W23		RIGHT DC
Supply Air Press Regulator	N21	N21	RIGHT DC
Supply Air Press/Flow, Left	B14	S35	LEFT INST
Supply Air Press/Flow, Right	A7	T35	RIGHT INST
Supply Air Temp Caution, Left	M22	M22	LEFT DC
Supply Air Temp Caution, Right	N22	N22	RIGHT DC
Supply Air Temp High, Left	U26	U26	LEFT DC
Supply Air Temp High, Right	W26	W26	RIGHT DC
Supply Press High Light, Left	M22	M22	LEFT DC
Supply Press High Light, Right	N22	N22	RIGHT DC
Symbol Generator - 1	C3*	C4*	EMERGENCY AC
Symbol Generator - 2	F4	F3	RIGHT RADIO AC
Systems Display Panel, Left	S34	S 32	LEFT DC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Systems Display Panel, Right	T34	T 32	RIGHT DC
Tail Compt Temp High Warning	N24		RIGHT DC
Tail Comp Temp High Warn, Left		M 23	LEFT DC
Tail Comp Temp High Warn, Right		N 23	RIGHT DC
Tail Deice Timer	N31	N 31	RIGHT DC
Tail Deice Valves	M24	M 24	LEFT DC
Tail Temp Ovht Ctrl, Left		K 8	LEFT AC
Tail Temp Ovht Ctrl, Right		L 19	RIGHT AC
Takeoff Warning	P38	P 38	LEFT DC
TAS Indicator	B6	B 6	RIGHT RADIO
TA/VSI, Capt	A7*	A 8*	EMERGENCY AC
TA/VSI, F/O	L10 or J16	J 16	RIGHT AC
Taxi Speed	R34		RIGHT DC
TCAS Computer	K8 or H25	H 16	LEFT AC
Telephone, Passenger	D16	L 29	RIGHT AC
Temp Control, Cabin	J1	J 1	RIGHT AC
Temp Control, Cockpit	H1	H1	LEFT AC
Temp Control, Manual, Cabin	C6*	C7*	EMERGENCY AC
Temp Control, Manual, Cockpit	C5*	C 6*	EMERGENCY AC
Temp Control Valve Posit, Lt	B13	B13	LEFT INST
Temp Control Valve Posit, Rt	A6	A6	RIGHT INST
Thunderstorm Light, Alternate	W28	W28	RIGHT DC
Transfer Relay Control	N38	N 38	DC POWER FEED
Transformer Rectifier, Left-1	K3	K3	LEFT AC
Transformer Rectifier, Left-1	K2	K2	LEFT AC
Transformer Rectifier, Left-1	K1	K1	LEFT AC
Transformer Rectifier, Left-2	K6	K6	LEFT AC
Transformer Rectifier, Left-2	K5	K5	LEFT AC
Transformer Rectifier, Left-2	K4	K4	LEFT AC
Transformer Rectifier, Right-1	L1	L1	RIGHT AC
Transformer Rectifier, Right-1	L3	L3	RIGHT AC
Transformer Rectifier, Right-1	L2	L2	RIGHT AC
Transformer Rectifier, Right-2 (3)	L Con	L Con	GROUND SERVICE

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Transponder-1	D13	D13	LEFT RADIO AC
Transponder-1	E13	E13	LEFT RADIO DC
Transponder-2	D1	D1	RIGHT RADIO AC
Transponder-2	E1		RIGHT RADIO DC
True Airspeed	B6	B6	RIGHT RADIO
Utility Outlet	L Con	L Con	GROUND SERVICE
Vacuum Waste Vent Htr		L23	RIGHT AC
Venturi	H3	H3	LEFT AC
VHF COMM-1	B8*	B9*	EMERGENCY DC
VHF COMM-2	G5	G5	RIGHT RADIO DC
VHF COMM-3	G16	G16	LEFT RADIO DC
VHF NAV-1	A4*	A4*	EMERGENCY AC
VHF NAV-1	B9*	B10*	EMERGENCY DC
VHF NAV-2	G7	G7	RIGHT RADIO DC
VHF NAV-2	B5	B5	RIGHT RADIO
Video Control		G19 & F25	LEFT RADIO AC/DC
Voice Recorder	F6	F6	RIGHT RADIO AC
VSCF Cooling Fan, Left		Lt GB	GENERATOR
VSCF Cooling Fan, Right		Rt GB	GENERATOR
VSCF Drain Mast Heater		L15	RIGHT AC
VSI, Capt-See TA/VSI			
VSI, F/O-See TA/VSI			
Warning Light Dimming	R25	R25	RIGHT DC
Water Heater	EXT	EXT	MISCELLANEOUS
Water Pump, Aux (3)	L Con	L Con	GROUND SERVICE
Water Quantity	L Con	L Con	GROUND SERVICE
Water Sys Freeze Prot, Aft	L Con	L Con	GROUND SERVICE
Water Sys Freeze Prot, Fwd	L Con	L Con	GROUND SERVICE
Weather Radar Indicator	F1	F4	RIGHT RADIO AC
Weather Radar Transceiver	F5	F5	RIGHT RADIO AC
Windshear Computer	L7	L7	LEFT/RIGHT AC
Windshear Warn & Caut, Left	E23	E23	LEFT RADIO DC
Windshear Warn & Caut, Right	E11	E11	RIGHT RADIO DC
Windshield Anti-Fog, Control	Z25	Z25	RIGHT AC

CIRCUIT BREAKER	CB REF		BUS
	88	90	
Windshield Anti-Fog, Power	Z26	Z26	RIGHT AC
Windshield Anti-Fog, Power	X26	X26	LEFT AC
Windshield Anti-Ice, Center	X25	X25	LEFT AC
Windshield Anti-Ice, Left	X24	X24	LEFT AC
Windshield Anti-Ice, Right	Z24	Z24	RIGHT AC
Windshield Overheat	M31		LEFT DC
Windshield Wiper, Left	M25	M25	LEFT DC
Windshield Wiper, Right	N25	N25	RIGHT DC
Wing Deice Valves	M24	M24	LEFT DC
Wing Ice Detection	M34	M34	LEFT DC
Yaw Damper Off Light	U33	U33	DC TRANSFER
Yaw Damper-1	G27	G27	LEFT RADIO DC
Yaw Damper-2	G13	G13	RIGHT RADIO DC

Circuit Breaker Location by Panel

	88	90
BATT DIR BUS	OVERHEAD PANEL	
	B16 - B18	A17 - A19
	88	90
BATT DIR BUS	OVERHEAD PANEL	
	88	90
BATT DIR BUS	OVERHEAD PANEL	
	B16 - B18	A17 - A19
	C16 - C18	B17 - B19
		C17 - C18
BATTERY BUS	OVERHEAD PANEL	
	B19, B20	A20 - A22
	C19 - C20	B20 - B22
		C19 - C22
DC TRANSFER BUS	LOWER EPC CB PANEL	
	T41, T42	S37 - S42
	W31 - W42	T37 - T4
	X31 - X42	U31 - U42
	Z 1 - Z42	W31 - W42
		X31 - X42
		Z31 - Z42
EMERG AC BUS	OVERHEAD PANEL	
	A1 - A7	A1 - A8
	B1 - B7	B1 - B8
	C1 - C8	C1 - C8
EMERG DC BUS	OVERHEAD PANEL	
	A8 - A15	A9 - A16
	B8 - B15	B9 - B16
	C9 - C15	C9 - C16
GENERATOR BUS	LOCATION	
AC Bus, Left	Lt GB	Lt GB
AC Bus, Right	Rt GB	Rt GB
AC Bus Sensing, Left	Lt GB	Lt GB
AC Bus Sensing, Right	Rt GB	Rt GB

	88	90
Galley-1 Power, Fwd	Lt GB	Lt GB
Galley-1, Fwd	Rt GB	Rt GB
Ground Service Power	Rt GB	Rt GB
Heat Exchanger Fan, Left	Lt GB	Lt GB
Heat Exchanger Fan, Right	Rt GB	Rt GB
Hydraulic Pump, Aux	Lt GB	Lt GB
Longitudinal Trim, Primary	Lt GB	Lt GB
Overwing Heater, Left	Lt GB	
Overwing Heater, Right	Rt GB	
GROUND SERVICE	LOCATION	
	J17, J19	J17, J19
	L Con	L Con
LEFT AC BUS	UPPER/LOWER EPC CB PANEL	
	H1 - H25	H1 - H23
	K1 - K34	K1 - K39
	X21 - X30	X21 - X30
LEFT DC BUS	LOWER EPC CB PANEL	
	M21 - M36	M21 - M37
	P21 - P40	P23 - 40
	S21 - S40	S21 - S36
	U21 - U30	U21 - U30
LEFT INST BUS	UPPER EPC CB PANEL	
	A10 - A13	A10 - A13
	B10 - B16	B10 - B16
LEFT RADIO AC BUS	UPPER EPC PANEL	
	D13 - D20	D13 - D22
	F14 - F26	F14 - F26
LEFT RADIO BUS	UPPER EPC CB PANEL	
	C10 - C16	C10 - C16
LEFT RADIO DC BUS	UPPER EPC CB PANEL	
	E13 - E24	D13 - D22
	G14 - G27	E13 - E24
		G14 - G27
RIGHT AC BUS	UPPER/LOWER EPC CB PANEL	
	J1 - J23	J1 - J17

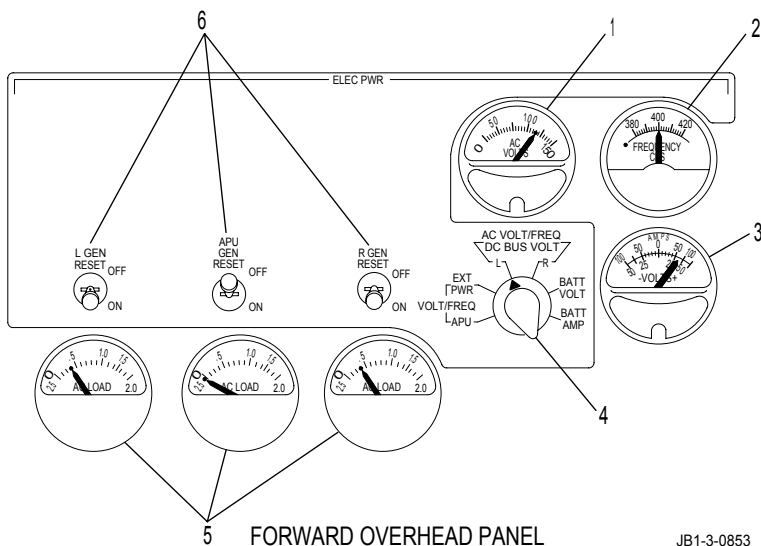
	88	90
	L1 - L34	J21 - J23
	Z21 - Z30	L1 - L36
		Z21 - Z30
RIGHT DC BUS	LOWER EPC CB PANEL	
	N21 - N35	N21 - N35
	R21 - R41	R24 - R41
	W21 - W30	W21 - W30
RIGHT INST BUS	UPPER EPC CB PANEL	
	A1 - A9	A1 - A9
RIGHT RADIO AC BUS	UPPER EPC CB PANEL	
	D1 - D12	D1 - D12
	E11	F1 - F13
	F1 - F13	
RIGHT RADIO BUS	UPPER EPC CB PANEL	
	B1 - E12	B1 - B9
	C1 - C9	C1 - C9
RIGHT RADIO DC BUS	UPPER EPC CB PANEL	
	E1 - E12	D1 - D12
	G1 - G13	E1 - E12
		G1 - G13
28 VAC	UPPER EPC CB PANEL	
	C17 - 19	C17 - C19
D.C. POWER FEED	LOWER EPC CB PANEL	
	N26 - N38	N36 - N38

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Controls and Indicators

Electrical Control Panel



JB1-3-0853

1. AC VOLTS Meter

Indicates voltage output of the source selected by the indicator selector.

2. FREQUENCY Meter

Indicates frequency output of the source selected by the indicator selector.

3. DC VOLTS/AMPS Meter

Indicates DC voltage when indicator selector is selected to BATT VOLT or L/R. Indicates DC current in amps to or from batteries when BATT AMP is selected.

4. Indicator Selector

APU or EXT PWR - Selects AC voltage on AC VOLTS meter and frequency on FREQUENCY CPS meter.

L/R - Selects AC voltage on AC VOLTS meter and frequency on FREQUENCY CPS meter. Also selects DC bus voltage on DC VOLTS meter.

BATT VOLT - Selects DC voltage of batteries on DC VOLTS meter.

BATT AMP - Selects DC current in amps to or from batteries on DC VOLTS meter.

5. L/APU/R AC LOAD Meter

Indicates load each AC generator is delivering to distribution system.
Indicates from 0 to 1.5 with 1.0 indicating 100% of generator rated capacity.

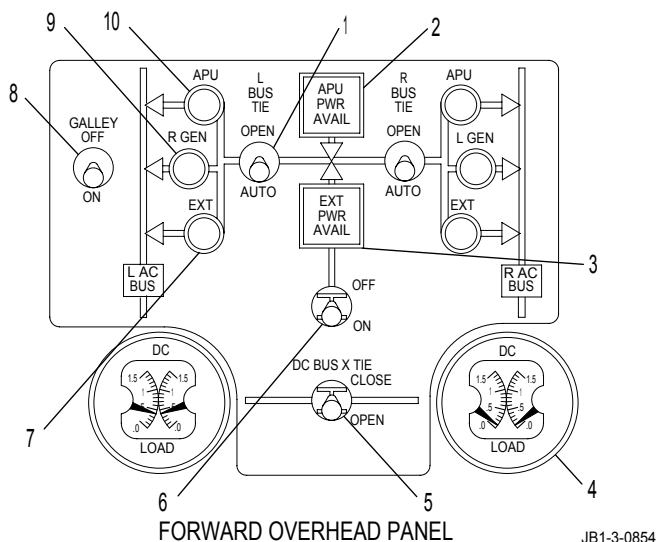
6. L/APU/R GEN Switch

RESET - (Momentary) Resets the generator.

OFF - Results in generator disconnecting from AC generator bus.

ON - (Normal position) Generator supplies power to respective generator bus, providing all protection circuits are satisfied, and generator is operating.

Electrical Power Panel



1. BUS TIE Switches (2)

OPEN - Isolates the L/R generator bus from the tie bus.

AUTO - (Normal position) EPCU automatically opens and closes bus tie relays as required to maintain electrical power to respective buses.

2. APU POWER AVAIL Light (blue)

Indicates APU generator switch is ON, APU generator frequency and voltage are within required limits.

3. EXT PWR AVAIL Light (blue)

Indicates external power switch is ON and external power frequency and voltage are within the required limits.

4. L/R DC LOAD Meter

Dual scale, one for each of the four transformer rectifiers (TR). Indicates current output proportional to TR rating, 1.0 is 100 percent.

5. DC BUS X TIE Switch

CLOSE - Closes DC cross-tie relay and connects the left and right DC buses. Supplies DC power from one side to the other in case both transformer rectifiers fail on either the left or right system.

OPEN - (Normal position) Left and right DC buses are isolated.

6. External Power Switch

OFF - Results in opening of the main external power relay (MEPR) removing external power from the AC tie bus.

ON - Enables closure of the MEPR. External power is supplied to the AC tie bus when external power has priority.

7. EXT Power In-Use Light (2) (blue)

Indicates external power is powering the respective generator bus.

8. GALLEY Switch

OFF - Galley power is off.

ON - Galley power is on. In flight, if only one AC generator is providing power, the system automatically sheds power to the galleys.

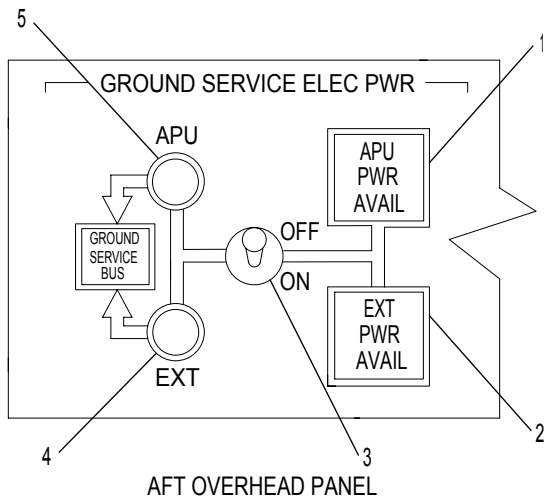
9. L/R GEN Power In-Use Light (blue)

Indicates opposite generator is powering both generator buses.

10. APU Power In-Use Light (2) (blue)

Indicates APU generator is powering respective generator bus.

Ground Service Electrical Power Control Panel



JB1-3-0855

1. **APU POWER AVAIL Light (blue)**

Indicates APU generator switch is ON, APU generator frequency and voltage are within required limits.

2. **EXT PWR AVAIL Light (blue)**

Indicates external power switch is ON and external power frequency and voltage are within the required limits.

3. **Ground Service Power Switch**

OFF - Disconnects APU or external power from the AC tie bus to the ground service bus.

ON - Connects APU or external power from the AC tie bus to the ground service bus, providing the right generator bus is not powered. APU power has priority over external power for powering the ground service bus.

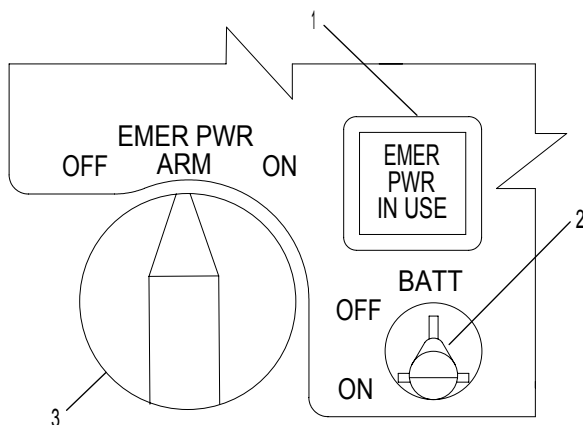
4. **EXT Ground Service Power In-Use Light (blue)**

Indicates external power is supplying power to the ground service bus.

5. **APU Ground Service Power In-Use Light (blue)**

Indicates APU generator is powering the ground service bus.

Emergency Power Selector And Battery Switch



OVERHEAD PANEL

JB1-3-0856

1. EMER PWR IN USE Light (white)

Indicates emergency power is being supplied.

2. BATT Switch (Pull And Twist To Lock On)

OFF - Disconnects battery bus from battery direct bus, prevents the battery charger operation and disconnects the DC transfer bus from the batteries.

ON - Connects battery bus to battery direct bus and enables connections of the DC transfer bus to the batteries.

3. EMER PWR Selector

OFF - Disarmed and resets the Automatic Emergency Power System.

ARM - (Normal position) Emergency power relay is placed in the standby mode for automatic activation (requires at least one FUEL switch ON) when the electrical power control unit (EPCU) detects a power loss to the emergency AC, DC or DC transfer bus.

ON - Emergency power is energized, prevents battery charger operation. The battery supplies power for AC emergency bus (through the emergency inverter), DC emergency bus and DC transfer bus.

System Description

General

The airplane electrical power system consists of a 115 volt, 3-phase, 400 Hz, constant-frequency alternating current (AC) system and a 28-volt direct current (DC) system. The system incorporates a no break power transfer function which allows uninterrupted power switching under normal conditions.

AC Generation and Control

The primary source of AC power is two variable speed constant frequency (VSCF) generating systems (left and right). Each system consists of an oil cooled engine driven generator on each engine and it's associated converter. The converter unit for the left engine is located in the right tunnel area (forward of the wing) and the right engine converter is located in the right nosewheel well. The converter units supply 115 volt, 3-phase, 400 Hz power to their respective left and right generator bus for system distribution.

Each system has an AC LOAD meter located on the overhead panel and a generator relay between the converter, generator bus and the bus tie relays. The AC LOAD meters indicate the percentage of load demand from 0 to 2.0 (1.0 represents 100% full load rating). The generator relays are controlled by the generator (L/R GEN) switches, one for each generator, on the overhead panel. The RESET position is momentary and is used to reset a generator that has tripped off line. The OFF position results in opening of the relay to prevent power flow to the respective buses. The ON position enables closure of the relay to supply power from the converter to the respective generator bus.

The systems normally operate independently of each other. When required, a single generator can power both systems through the two bus tie relays and the AC tie bus. The bus tie relays may be controlled manually by the BUS TIE switches, or automatically by the electrical power control unit (EPCU). The OPEN position opens the respective relay isolating the associated AC generator bus from the AC tie bus. The AUTO position (which is the normal position), permits automatic operation of the relays through the EPCU. The EPCU opens and closes the relays as required to maintain electrical power to the respective buses. The converters prevent power that does not meet the proper quality from powering any bus.

An AC voltmeter (AC VOLTS), and a frequency (FREQUENCY) meter located on the overhead panel, indicate voltage and frequency of the source selected by the Indicator Selector (APU, EXT PWR L,R). External power and APU power available lights (EXT PWR AVAIL, and APU PWR AVAIL) located on the overhead panel illuminate when power is available from the respective source. There are six blue power in-use (two APU, R and L GEN, and two EXT) lights that illuminate to indicate which alternate power source is providing power to the associated generator bus. The priority for the generator buses are: associated engine generator, APU generator, external power, and the opposite side main engine generator (cross-tie).

There is one GALLEY switch that controls power to the galleys. Galley power is shed automatically when only one power source is available in flight with both bus tie relays closed.

AC Power Distribution

The left and right generator buses are the main distribution buses for the AC system. Loads are distributed independently for each system. Power from the left generator bus is distributed to the left AC bus then to the left transformer rectifiers (TR No.'s 1 and 2) for DC power. AC power from the right generator bus is distributed to the right AC bus then to the right TR No. 1 for DC power. Power to the right TR No. 2 is provided through the ground service AC bus.

Auxiliary Power

When APU power is available, the APU power available (APU PWR AVAIL) lights illuminate. When the APU generator (APU GEN) switch, located on the overhead panel, is in ON, the APU-Generator relay will open or close as required for system operation.

The APU generator relay allows power from the APU generator to power the AC tie bus. When the APU GEN switch is in OFF, the generator relay opens isolating the generator from the tie bus. The RESET position is momentary and is used to reset the generator.

External Power

External power is provided through the ground power receptacle located in the left forward fuselage, and controlled by the EPCU. The EPCU ensures that the external power is within voltage and frequency limits. When power of the proper phase and voltage is supplied to the airplane, and the external power (EXT PWR) switch located on the overhead panel is in ON (normal position), the external power available (EXT PWR AVAIL) lights illuminate.

When the EXT PWR switch is in ON, external power is supplied to the AC tie bus automatically through the main external power relay (MEPR). The OFF position of the EXT PWR switch results in opening of the MEPR disconnecting external power from the AC tie bus. To power the ground service bus only, the ground service switch must be selected ON and AC TIE BUS switches opened.

DC Generation and Control

DC power is provided by four TR's (left No. 1 and No. 2, and right No. 1 and No. 2) that convert AC to 28 VDC power. The output from the left TR's supply power to the left DC bus. Under normal conditions the left DC bus powers the DC transfer bus and the emergency DC bus. The output from the right TR's supply power to the right DC bus. When the ground service AC bus is powered by external power or the APU on the ground, right TR No. 2 supplies power to the DC transfer bus.

A manually controlled DC bus cross-tie (DC BUS X-TIE) switch, located on the overhead panel, controls the cross tie relay. When the switch is in OPEN, the left and right DC buses are isolated from each other. When the switch is in CLOSE, the left and right DC buses are connected together. Two DC LOAD meters with dual scales located on the overhead panel indicate the percentage of load output from the TR's from 0 to 1.5 (1.0 is 100% load output).

The DC VOLTS/AMPS meter on the overhead panel indicates DC bus voltage as selected by the indicator selector (DC BUS VOLT L and R, BATT VOLT, BATT AMP).

Emergency DC and AC Power Supply

Emergency DC power is provided by three 9-volt batteries installed in the E/E compartment, connected in series that supply power directly to the battery direct bus.

When the battery (BATT) switch, located on the overhead panel, is ON, the battery direct bus powers the battery bus. When the BATT switch is OFF, the battery relay opens preventing power to the battery bus. The batteries provide power for approximately 45 minutes. The batteries are charged by a 28-volt charger when power is on the ground service AC bus, the BATT switch is ON, and emergency power is off.

Emergency AC power is provided to the emergency AC bus by a single phase AC inverter that converts 28-volt DC power from the batteries to 115-volt, 400 Hz AC power.

Emergency power may be selected manually or armed for automatic operation by the emergency power selector (EMER PWR), located on the overhead panel. When the selector is in ARM, emergency power is transferred automatically when normal power is lost to the emergency AC, emergency DC, or DC transfer buses. During normal operation, the emergency AC bus is powered from the left AC bus. If power is lost to the left AC bus, the emergency power transfer relay shifts and power will be supplied to the emergency AC bus from the right AC bus. If the normal and alternate sources of power fail, emergency power is activated automatically. The ON position permits testing of the emergency power system, and serves as a manual backup by closing the emergency power relay allowing power transfer. The emergency power in use (EMER PWR IN USE) light located on the overhead panel, will illuminate when emergency power is on. When the emergency power is being supplied, the battery charger is inhibited. Automatic emergency power activation is inhibited when both fuel switches are in OFF to preclude accidental battery discharge. When emergency power is on, in addition to the battery bus and battery direct bus, the emergency AC, emergency DC and DC transfer buses are powered.

Ground Service Bus

Electrical supply for ground servicing is provided by the ground service bus. The bus normally receives power from the right generator bus. If the right generator bus is unpowered, the ground service bus may be powered from the APU or external power through the AC tie bus.

The GROUND SERVICE ELEC PWR panel is located on the aft overhead panel. When the ground service switch is OFF, the ground service bus is powered from the right AC bus. With the right generator bus unpowered, the ON position will allow power from the APU or external power to be applied to the bus directly from the tie bus. The APU PWR AVAIL and EXT PWR AVAIL lights illuminate when power is available from the respective source. The blue APU or EXT ground service power in-use lights illuminate to indicate which unit is supplying power to the bus.

OAP Message/Alerts

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

BATTERY BUS OFF (ELEC) - Indicates battery bus is de-energized.

EMER POWER ON (ELEC) - Indicates emergency power is in use.

EMER PWR AUTO FAULT (ELEC) - Indicates EMER PWR selector is in ARM and the electrical power control unit (EPCU) unsuccessfully attempted to switch the emergency power in use automatically.

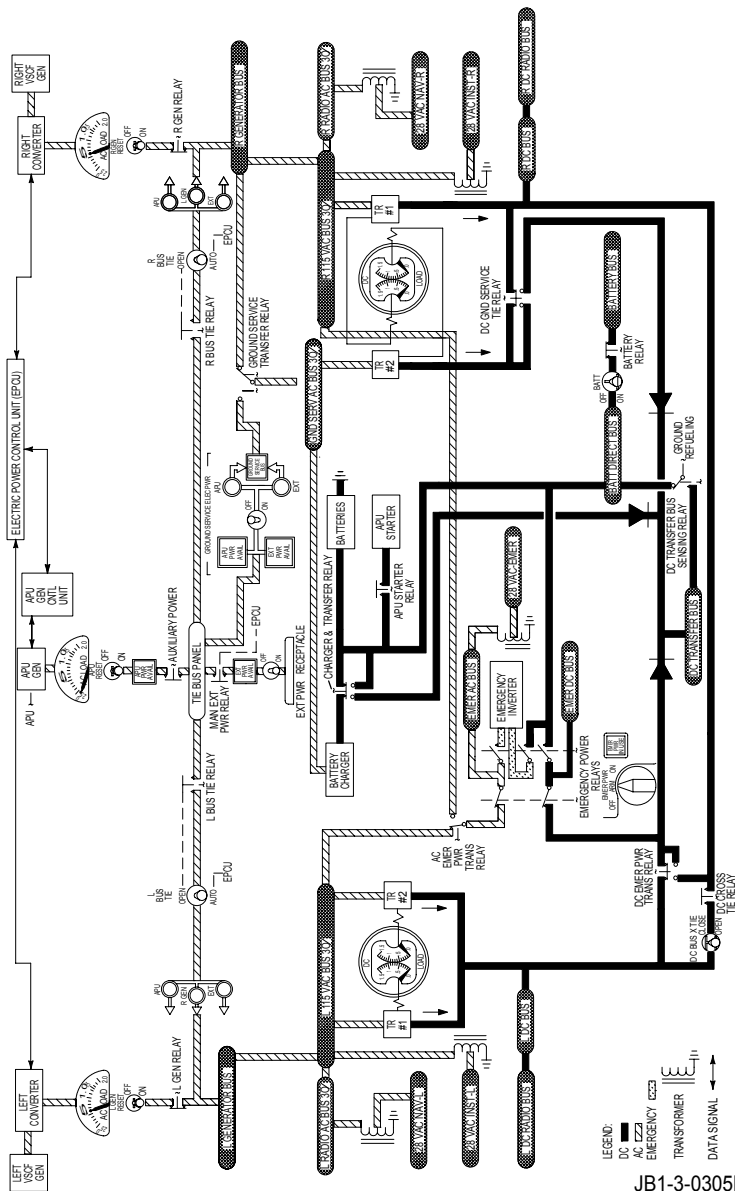
EMER PWR SW OFF (ELEC) - Indicates EMER PWR selector is in OFF.

L/R/APU AC PWR FAULT (ELEC) - Indicates an "out-of-limit" condition on the respective bus feed, converters, generator, or generator feed which has or may result in power loss.

L/R BUS TIE LOCKOUT (ELEC) - Indicates the respective bus tie is locked out from closing due to a fault in the distribution system.

TIE BUS FEEDER FAULT (ELEC) - Indicates a feeder fault in the tie bus.

MD-90 Power Distribution



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Engines, APU
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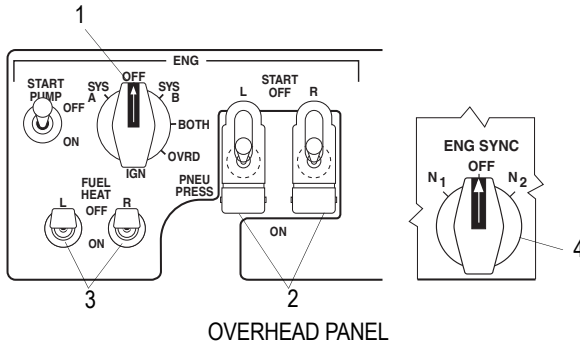
Engines, APU

Engine Controls and Indicators (JT8D-219)

Chapter 7

Section 11

Engine Controls



1. ENG IGN Switch

SYS A - Selects igniter A with fuel control lever ON.

SYS B - Selects igniter B with fuel control lever ON.

OFF - Removes power from all ignitors.

BOTH - Provides power to all ignitors with fuel control lever ON.

OVRD - Provides power to ignitors in both engines, bypassing fuel control levers.

2. L/R ENG START Switch

OFF - Removes power from engine start valve.

ON - Provides power to open start valve if pneumatic air is available. When start valve is open, START VALVE OPEN message is displayed on OAP.

3. L/R FUEL HEAT Switch

OFF - Removes power from fuel heat circuit following completion of fuel heat cycle.

ON - (Momentary) Timer is energized for one minute, which opens respective fuel heat valve, supplying high stage bleed air to the air/fuel heat exchanger.

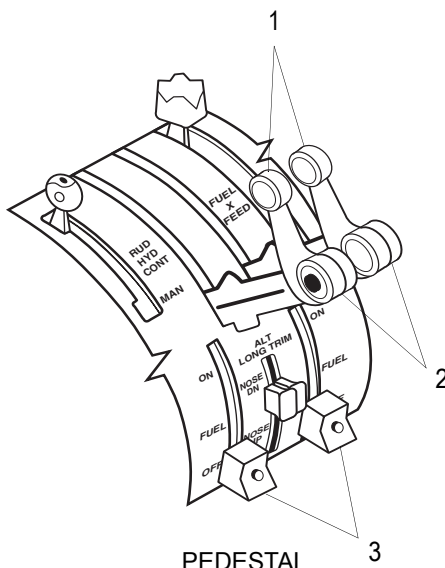
4. ENG SYNC Selector

OFF - EPR synchronization is available. N1 and N2 synchronization is disabled.

N1 - Left engine N1 rpm is matched to the right engine N1 rpm.

N2 - Left engine N2 rpm is matched to the right engine N2 rpm.

Throttles And Reverser Levers/Indicators



1. L/R Thrust Reverser Levers

Moving thrust reverser lever aft actuates deployment of respective thrust reverser and controls reverse thrust. Can only be accomplished with throttle at IDLE.

2. L/R Throttles

Each throttle is cable connected to its respective engine fuel control unit to regulate engine thrust.

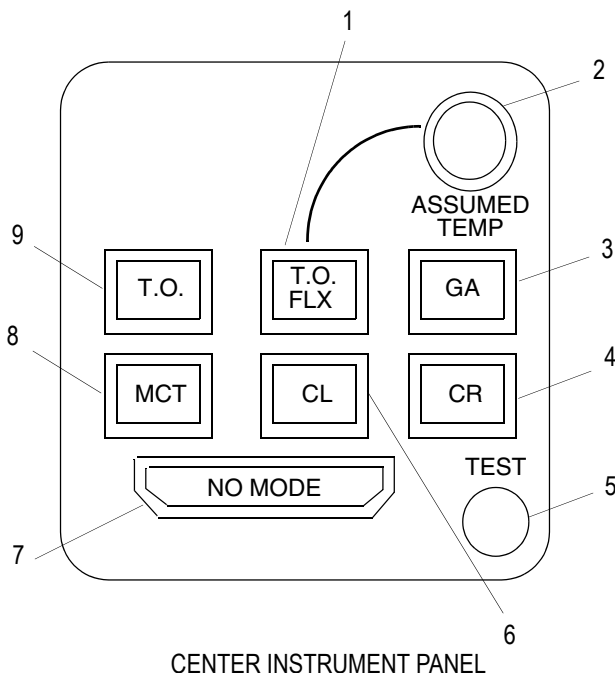
3. L/R FUEL Control Levers

ON - Normally completes ignition circuit, then turns on fuel.

OFF - Shuts off fuel, then ignition.

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Thrust Rating Panel (TRP)



1. T.O. FLX Button

Pushing button allows a reduced EPR limit for flexible takeoff thrust mode to be displayed in the EPR LIMIT readout and automatically positions the EPR reference bug on EPR indicator. Reduced EPR limit is determined by selecting an assumed temperature that is higher than ambient temperature.

NOTE: When using T.O. FLX, the ART switch must be OFF.

2. ASSUMED TEMP Selector

Rotate knob to set assumed temperature for derated takeoff flexible (T.O. FLX) mode operation. Temperatures from 1° to 59° C can be selected. Assumed temperature will be displayed in ATS readout of FMA's.

The EPR displayed will be based on the maximum thrust EPR limit at the assumed temperature.

NOTE: When using T.O. FLX, the ART switch must be OFF. Delta currently uses 25° through 50° C for alternate power takeoffs.

3. GA Mode Button

Pushing button causes EPR limit for go-around thrust mode to be displayed in the EPR LIMIT readout and automatically positions the EPR reference bug on the EPR indicator.

4. CR Mode Button

Pushing button causes EPR limit for cruise thrust mode to be displayed in the EPR LIMIT readout and automatically positions the EPR reference bug on the EPR indicator.

5. TEST Button

Pushing button causes following readout displays:

- RAT: Displays 12 ± 1 .
- EPR LIMIT: Displays $2.08 \pm .01$.
- All lights on the panel to extinguish.

When button is released, NO MODE light illuminates and all mode button lights remain extinguished.

6. CL Button

Pushing button causes EPR limit for climb thrust mode to be displayed in the EPR LIMIT readout and automatically positions the EPR reference bug on the EPR indicator.

7. NO MODE Annunciator Light (amber)

Indicates one of the following conditions:

- No selection made since initial power up or power interruption.
- No selection made since TRP was tested.
- An abnormal engine bleed configuration exists for the mode selected.
- T.O. flex selected and ART switch is not OFF.

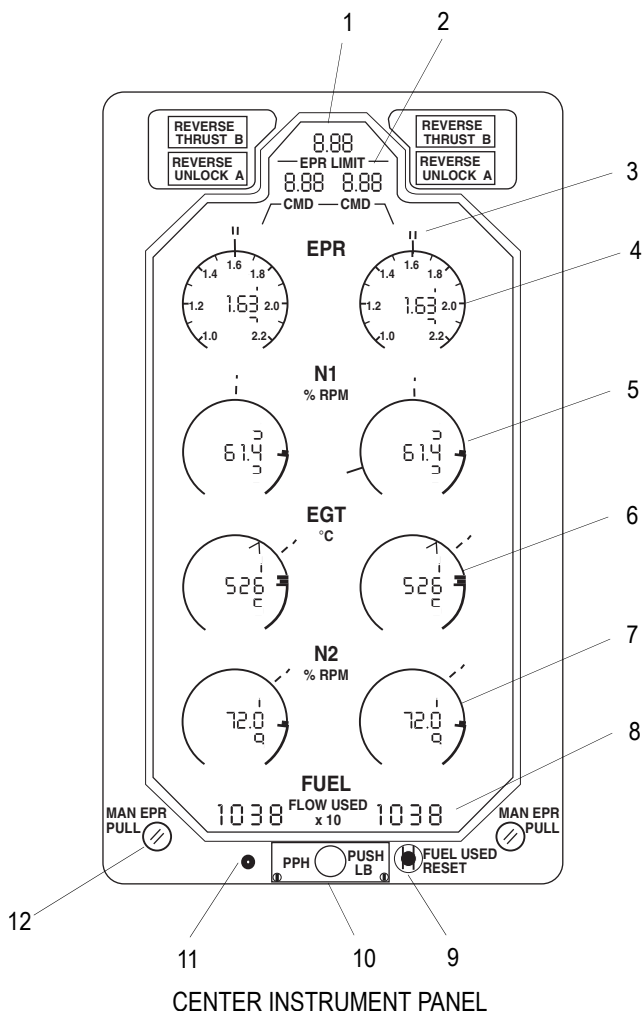
8. MCT Mode Button

Pushing button causes EPR limit for maximum continuous thrust mode to be displayed in the EPR LIMIT readout and automatically positions the EPR reference bug on the EPR indicator.

9. T.O. Mode Button

Pushing button causes EPR limit for takeoff thrust mode to be displayed in the EPR LIMIT readout and automatically positions the EPR reference bug on the EPR indicator.

Engine Display Panel



1. EPR Limit Readout

Displays digital readout of EPR limit for selected operating mode.

2. CMD EPR Readout (2)

Digital readout of EPR reference set with MAN EPR set knob.

NOTE: CMD EPR readout will be blank unless MAN EPR SET knobs have been pulled.

3. EPR Limit Reference Bug

Indicates EPR reference selected by thrust rating panel or manually set using MAN EPR set knob.

4. EPR Indicator

Digital readout of engine EPR. EPR pointer simultaneously displays a corresponding EPR value.

5. N1 Indicator

Digital readout of N1 compressor in percent of RPM. Pointer indicates corresponding N1. N1 digits flash when they exceed redline limits.

6. EGT Indicator

Digital readout of exhaust gas temperature in degrees centigrade. EGT digits will flash when start EGT rate or start EGT values exceed predetermined values. In addition, EGT digits also flash when normal operating EGT values exceed redline limit.

7. N2 Indicator

Digital readout of N2 compressor in percent of RPM. Pointer indicates corresponding N2. N2 digits flash when they exceed redline limits.

8. FUEL FLOW/USED Readout (2)

Readouts indicate fuel flow rate delivered to engine. Fuel flow digits will flash during start if fuel flow exceeds normal starting parameters.

9. FUEL USED/RESET Button

Push - Resets FUEL FLOW/USED readout to "0". Button is recessed to prevent inadvertent reset.

10. PPH Button

Push - Momentary display of fuel used, a blue light illuminates behind FUEL FLOW/USED legend.

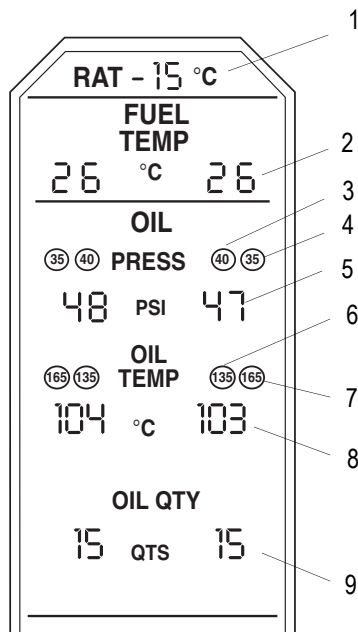
11. Test Button (On ground only)

Pushed once, panel performs self-test. Pushed twice provides engine exceedance information if exceedance has occurred.

12. MAN EPR SET Knob (2)

Pull knob and rotate to set desired EPR in CMD EPR readout. EPR reference bug will move to corresponding value on EPR indicator. When knob is pushed in CMD EPR Readout will blank, EPR reference bug will move to EPR value set with TRP.

System Display Panel



CENTER INSTRUMENT PANEL

1. RAT Readout

Indicates ram air temperature.

2. FUEL TEMP Readout

Indicates temperature of fuel after it has flowed through the air/fuel heat exchanger.

3. Engine OIL PRESS 40 PSI Light (amber)

Illuminates at or below 40 psi.

4. Engine OIL PRESS 35 PSI Light (red)

Illuminates at or below 35 psi.

5. Engine OIL PRESS Readout

Indicates oil pressure. Flashing numbers indicate oil overpressure.

6. Engine OIL TEMP 135° Light (amber)

Illuminates at or above 135°.

7. Engine OIL TEMP 165° Light (red)

Illuminates at or above 165°.

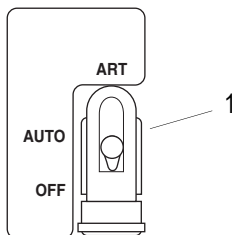
8. Engine OIL TEMP Readout

Indicates temperature of oil that has passed through the fuel/oil heat exchanger.

9. Engine OIL QTY Readout

Indicates usable oil in tank.

ART Switch



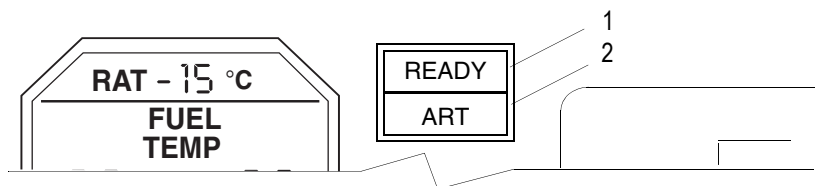
UNDER GLARESHIELD

1. ART Switch

AUTO - Automatic reserve thrust is available if an engine fails during takeoff.

OFF - Automatic reserve thrust system is disabled.

READY and ART Lights



CENTER INSTRUMENT PANEL

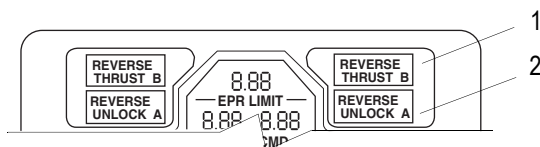
1. **READY Light (green)**

READY - Indicates ART is capable of operating.

2. **ART Light (amber)**

ART - Indicates the automatic reserve thrust system has been activated.

Thrust Reverser Lights



CENTER INSTRUMENT PANEL

1. **L/R REVERSE THRUST Light (blue)**

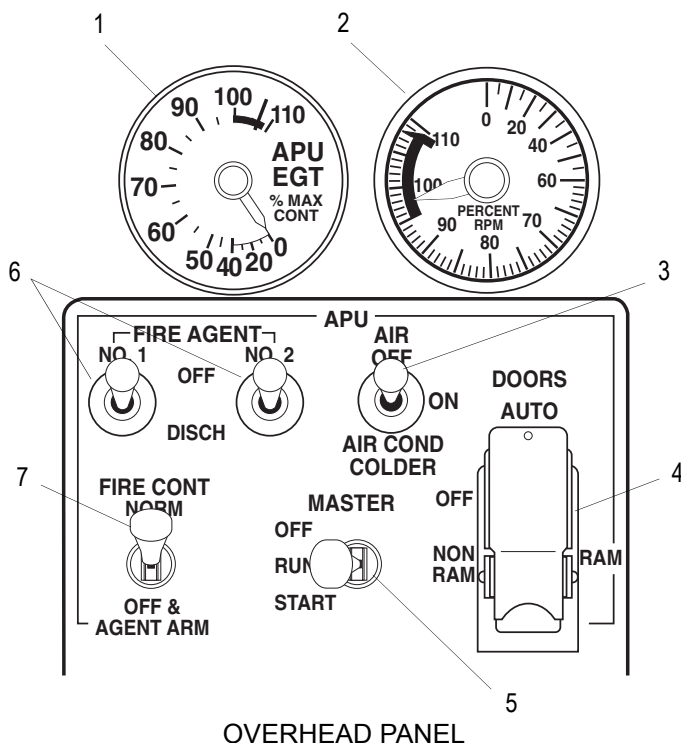
REVERSE THRUST - Illuminates when thrust reverser is fully extended.

2. **L/R REVERSE UNLOCK Light (amber)**

REVERSE UNLOCK - Illuminates when thrust reverser is unlatched.

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APU Controls



1. APU EGT Indicator

Displays the percent of maximum continuous APU exhaust gas temperature.

2. APU PERCENT RPM Indicator

Displays the APU RPM as a percentage of normal operating rpm. The normal operating range is indicated by a green arc, with the range between 95 and 105 percent rpm.

3. APU AIR Switch

OFF - The APU bleed air valve closes.

ON - The APU bleed air valve opens.

AIR COND COLDER - The turbine bypass valves close, resulting in increased differential pressure across the air conditioning turbine to provide colder air, but at a reduced volume.

4. APU Doors Switch

AUTO - (Normal position, red guard closed) Automatically selects ram door position for starting and non-ram door position for ground and flight operation.

OFF - Removes electrical power from door control circuit.

NON RAM - (Momentary) Provides manual override to open non-ram doors.

RAM - (Momentary) Provides manual override to open ram doors.

5. APU MASTER Switch

OFF - Closes APU bleed air valve if opened, initiates 60 second cool down, then APU shuts down.

RUN - This is the normal operating mode.

START - (Momentary) Initiates APU start and releases to RUN.

NOTE: Up to 1 minute delay may elapse before RPM observed in order to allow the ram door to fully extend.

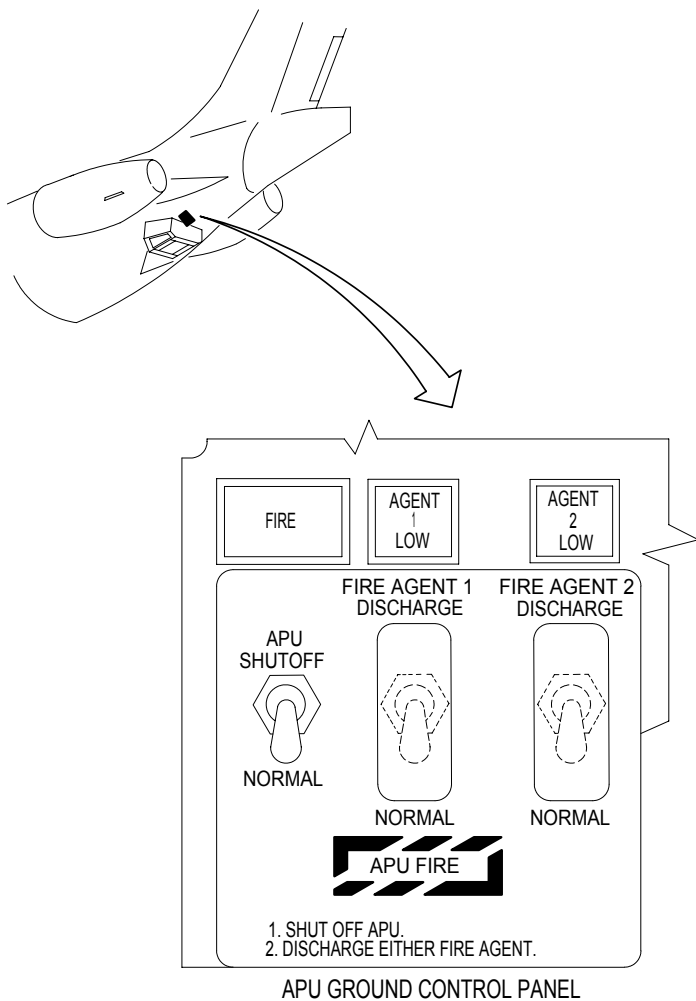
6. APU FIRE AGENT (NO.1/NO.2) Switches

Refer to Section 8, Fire Protection for description.

7. APU FIRE CONT Switch

Refer to Section 8, Fire Protection for description.

APU Ground Control Panel



9

(Refer to Section 8, Fire Protection for Description)

JB1-3-0895

Engines, APU

Engine System Description

Chapter 7

Section 21

General

The MD-88 has two Pratt and Whitney JT8D-219 engines. Each engine has a maximum takeoff thrust rating of 21,700 pounds.

Engine Instruments

For monitoring engine operation, an engine display panel (flat plate) and systems display panel are installed on the center instrument panel. The following indications/readouts are provided.

- Engine pressure ratio (EPR).
- N1 and N2 RPM.
- Exhaust gas temperature (EGT).
- Fuel flow/used.
- Oil pressure and oil temperature.
- Fuel temperature.
- Oil quantity.

Note: N1, N2, EGT, and oil pressure digits will flash if their respective red line limits are exceeded. EGT digits will flash if a hot start is imminent. Flashing fuel flow digits may indicate a hot start is imminent, unless EGT and other engine indications are within normal starting parameters.

There is a small, recessed self-test button that also serves as an engine exceedance device should engine parameters be exceeded. When pushed twice (double-click) while on the ground, engine parameters and duration of the engine exceedance will flash on the panel. If the button is pressed once, a panel self-test will be performed.

Note: Do not press the recessed self-test button in flight.

Ignition Systems

Two independent ignition systems (A and B) are provided for each engine. The dual systems are controlled by a single ignition selector located on the overhead panel. The selector has five positions. A blue advisory light on the OAP indicates the system(s) selected.

Engine Starting

Pneumatic air for engine start may be supplied by APU bleed air, an external pneumatic source, or bleed air from an operating engine.

L and R START switches, with ON and OFF positions, are located on the overhead panel. When either START switch is held ON, the respective engine start valve opens (with pneumatic pressure available). The L or R START VALVE OPEN message on the OAP indicates the applicable engine start valve is open. When either START switch is released, the respective engine start valve closes, and the L or R START VALVE OPEN message, as applicable, extinguishes.

Engine Synchronizer System

The engine synchronizer system, when used, automatically matches the N1 or N2 RPM speed of both engines. The system includes an ENG SYNC selector, an ENG SYNC ON message, and a control box.

When the ENG SYNC selector is placed in N1 or N2, speeds from both engines are fed into the control box. Differences in speeds cause the control box to synchronize the left engine speed to that of the right engine within specified limits. The system can be overridden at any time by manual use of the throttles. Autothrottles are not required for operation of N1 or N2 sync.

An ENG SYNC ON message on the OAP illuminates when the LANDING GEAR handle is in the DOWN position and ENG SYNC selector is in N1 or N2 position.

EPR is automatically synchronized when the ENG SYNC selector is in the OFF position, the autothrottle engaged and not clamped, both EPR's are valid, and one EPR is greater than 1.1 EPR. The EPR synchronizer, within specified limits, matches the left engine EPR to that of the right engine.

Note: All synchronization takes place through the fuel control with no throttle movement.

Automatic Reserve Thrust (ART) System

The ART system provides an increase in thrust with an engine failure or a windshear encounter. If either condition occurs during a normal power takeoff the operating engines(s) will automatically advance to MAX thrust.

The ART system green READY light is illuminated when:

- The ART switch is in AUTO.
- Aircraft is on the ground (minimum 20 seconds).
- Both engines operating (valid N1).
- Slats extended.

The green READY light indicates that the self-test function has been successfully completed, and once both N1's are above 64%, the ART system is ready to function.

The amber ART light indicates the ART system has been activated. This occurs with a 30% differential in N1, or windshear is detected. In addition, the amber ART light illuminates and the ART system activates if the selected DFGC fails, N1 input fails, or DFGC's are manually switched.

When ART has activated, maximum takeoff EPR is displayed in the EPR LIMIT readouts on the engine display panel.

Note: With ART activation throttles do not move.

Retracting the slats, retarding both throttles below 49% N1, or positioning the ART switch to OFF disables the ART system. The OFF position is used when accomplishing an alternate or maximum power takeoff (anything other than a normal power takeoff).

Note: An OAP message "ART INOP" will be displayed when alternate or maximum power is selected.

If the system fails the self-test, an ART INOP message illuminates on the OAP.

Thrust Rating Panel

Engine thrust (EPR) limits are computed in the DFGC based on ram air temperature and pressure altitude. The limits are modified by the selected operating mode and engine bleed air configuration. The TRP is equipped with the following mode buttons.

- T.O. (normal or maximum takeoff).
- T.O. FLX (alternate takeoff).
- GA (go-around).
- MCT (maximum continuous thrust).
- CL (climb).
- CR (cruise).

The DFGC's supply data for the RAT readout and to the EPR indicators for automatic display of EPR limit for mode selected.

The TRP has a NO MODE light that illuminates after a test, during initial power up, or when no thrust mode is selected.

Note: Autothrottles will not function when no mode is selected.

The NO MODE light will also illuminate when the ART switch is not OFF with T.O. FLX selected, or an abnormal engine bleed exists. The following is a list of the abnormal bleeds.

ABNORMAL BLEED CONFIGURATIONS THAT CAUSE A NO MODE LIGHT ON THE TRP AND DASHES IN THE EPR LIMIT READOUT ON THE EDP.	
Note: Autothrottles will function.	
TRP MODE SELECTED	BLEED CONFIGURATION
T.O., T.O. FLX, GA, MCT, CL or CR	Airfoil ice protection on and one or both pneu xfeed open and engine anti-ice off.
T.O. or T.O. FLX	Engine anti-ice on and RAT greater than 10° C.
GA	Engine anti-ice on and RAT greater than 14° C.
MCT	Airfoil ice protection on and both pneu xfeeds open.
CL	Airfoil ice protection on and one pneu xfeed open.
MCT, CL, or CR	Both packs off.

Engine Fuel System

AC powered fuel tank boost pumps, located inside their respective tanks, supply fuel under pressure to the engine driven fuel pumps. The pressure is sensed by an inlet pressure switch located on the engine. When the inlet pressure is too low, the INLET FUEL PRES LO message on the OAP illuminates which causes the MASTER CAUTION lights to illuminate. Next, fuel passes through the engine driven first stage low pressure pump, then through the air/fuel heat exchanger.

Fuel is then filtered. If the DIFFERENTIAL PRESSURE switch senses clogging at the filter, the FUEL FIL PRES DROP message and MASTER CAUTION lights illuminate. A bypass valve allows fuel to bypass a clogged filter. An engine driven second stage high pressure pump pressurizes fuel. A fuel flow transmitter measures the pounds per hour (PPH) of fuel delivered to the engine. Fuel flow is displayed on the engine display panel. Heat from engine oil is transferred to the fuel through the fuel/oil heat exchanger. Finally, the fuel is sent to the fuel nozzles for combustion.

Fuel Heat

Each engine has a fuel heat system which incorporates a FUEL HEAT switch and a blue L/R FUEL HEAT ON annunciator light.

Bleed air is supplied to the air/fuel heat exchanger. The FUEL HEAT valve is controlled by a switch and timer which controls the blue L/R FUEL HEAT ON annunciator light. When the FUEL HEAT switch is placed to ON (momentary), the valve will open, and bleed air is supplied to the air/fuel heat exchanger for one minute. After one minute, the timer automatically closes the valve. Fuel heat is used to prevent or remove ice at the fuel filter. Fuel temperature is sensed downstream from the air/fuel heat exchanger and is displayed on the systems display panel.

Approach Idle

This system provides adequate engine acceleration from idle during approach.

Approach idle is 7 - 10% higher N2 than idle. Approach idle is activated when the gear is extended. Engine speed increases without throttle movement.

Note: If electrical power is lost, the engine's idle rpm will revert to approach idle.

Engine Oil System

Engine oil quantity is sensed in the 16 quart oil tank. Oil quantity is displayed for each engine on the system display panel. A differential pressure transmitter senses pressure on both sides of the filter. When the differential pressure reaches a pre-determined value, the L/R OIL STRAINER CLOG message and the MASTER CAUTION lights illuminate to indicate excessive differential pressure. A pressure regulating valve maintains oil pressure at approximately 45 psi. The oil is cooled as it flows through the fuel/oil heat exchanger.

Oil temperature is displayed on the system display panel. An amber light illuminates when the temperature reaches 135°C. A red light illuminates when the temperature reaches 165°C.

There are two oil pressure sensors. The first is utilized for pressure on the system display panel. An amber light illuminates when oil pressure drops to 40 psi. A red light illuminates when oil pressure drops to 35 psi. The second is utilized to illuminate an L/R ENG OIL PRESS LOW message on the OAP. The MASTER CAUTION lights also illuminate. An oil overpressure is indicated by flashing oil pressure indication.

Thrust Reversers

The thrust reversers are used on the ground only. The reversers are hydraulically powered. The thrust reverser on each engine consists of two doors (deflectors) which form the aft nacelle fairing when stowed. The door linkage system overcenters to provide positive locking in the stowed position. When extended, the doors direct fan and exhaust gases over and under the nacelle.

As each thrust reverser unlatches, an amber REVERSE UNLOCK light illuminates on the engine display panel. When each reverser is extended, a blue REVERSE THRUST light illuminates on the engine display panel. Once the blue light illuminates, reverse thrust can be increased.

Each reverser is equipped with an accumulator. The accumulator may be used as a backup source of actuation in the event of a hydraulic system failure. A L/R REVERSER ACCUM LOW message indicates low pressure in the accumulator.

Engines, APU
APU System Description

Chapter 7
Section 30

General

The APU is installed to supply pneumatic requirements for cabin air conditioning and engine starting as well as electrical power. Electrical requirements have priority over bleed air extraction. The APU is located in the unpressurized area of the lower fuselage, aft of the rear pressure bulkhead. On the ground, the APU is used to supply pneumatic and electrical requirements. In flight, the APU is used for electrical power only.

Fuel is normally supplied to the APU from the right main tank. However, fuel from the left main or center tank may be utilized if necessary.

Electrical power for starting the APU is supplied by the aircraft batteries. APU bleed air is used for ground starting the main engines and operating the air conditioning system. Bleed air is controlled by a switch on the overhead panel in the cockpit. A check valve is provided in the pneumatic ducting to prevent reverse airflow from the engines into the APU.

The APU features an electronic control unit (ECU), APU FAULT annunciation, EGT and RPM gauges. The ECU controls and monitors the APU. An APU FAULT message illuminates on the OAP if the ECU detects one of several APU faults. Certain faults cause the APU to automatically shut down in flight. If a fault is detected in flight that does not cause an automatic shutdown, the APU will shut down after 10 minutes in the ground mode of operation. Any fault detected while on the ground will cause an immediate shutdown.

APU Operation

The APU Master Switch controls APU operation which includes a warm-up and cool-down cycle. After start a 60 second warm-up will occur. During shutdown a 60 second cool-down will occur. During the warm-up and cool-down periods APU bleed air is not available.

The APU DOORS switch provides for manual or automatic selection of the inlet doors position. The guarded position of the APU DOOR switch allows automatic door operation. There are 3 doors (2 non ram and 1 ram door) located directly under the APU. The ram door opens automatically at the beginning of the start cycle, then closes when the APU rpm reaches 95%. Normally, all APU starts will be made using the aircraft batteries and APU starter. If left and right AC buses lose power in flight, the ram air door will allow ram air to windmill the APU for starting.

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OAP Messages/Lights

Red Warning Lights

APU FIRE - APU fire detection system is activated and the APU automatically shuts down. Aural and vocal ("APU fire") warning sounds. MASTER WARNING lights illuminate.

TAIL COMP TEMP HIGH - The tail compartment temperature exceeds normal. MASTER WARNING lights illuminate.

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

APU FAULT (MISC) - Illuminates when APU system fault is detected. In flight mode, if the APU does not automatically shut down and no pilot action is taken, the APU shuts down automatically after 10 minutes in ground mode. In the ground mode, APU shutdown is immediate. MASTER CAUTION lights illuminate.

APU OIL PRESS LOW (MISC) - APU oil pressure is below normal. Message is normally displayed during APU start, but disappears as oil pressure rises. The message is inhibited during a pilot-commanded shutdown.

ART INOP (MISC) - Indicates automatic reserve thrust is unavailable or ART switch is OFF.

ENG SYNC ON (ENG) - Indicates ENG SYNC selector switch is in N1 or N2 position when LANDING GEAR handle is in the DOWN position.

FIRE DETECTOR LOOP (ENG) - Indicates at least one loop light is illuminated on the overhead panel. MASTER CAUTION lights illuminate.

L/R FUEL FIL PRES DROP (ENG) - Indicates a high differential pressure across respective engine fuel filter. MASTER CAUTION lights illuminate.

L/R INLET FUEL PRES LO (ENG) - Indicates low fuel supply pressure at respective engine. MASTER CAUTION lights illuminate.

L/R OIL PRESS LOW (ENG) - Indicates respective engine oil pressure low. MASTER CAUTION lights illuminate.

L/R OIL STRAINER CLOG (ENG) - Indicates an excessive differential pressure across respective oil filter. MASTER CAUTION lights illuminate.

L/R REVERSER ACCUM LOW (HYD) - Indicates hydraulic pressure at respective reverser accumulator is low.

L/R START VALVE OPEN (ENG) - Indicates the respective engine start valve is not closed.

NO ENGINE FAULTS (ENG) - Illuminates when ENG cue light is pushed if no engine faults exist.

Blue Advisory Lights

IGNITION SYSTEM A SELECTED - Indicates ignition system A has been selected.

IGNITION SYSTEM B SELECTED - Indicates ignition system B has been selected.

NOTE: Both lights illuminate when BOTH or OVRD is selected.

L/R FUEL HEAT ON - Indicates shutoff valve in engine bleed air supply line to air/fuel heat exchanger is open.

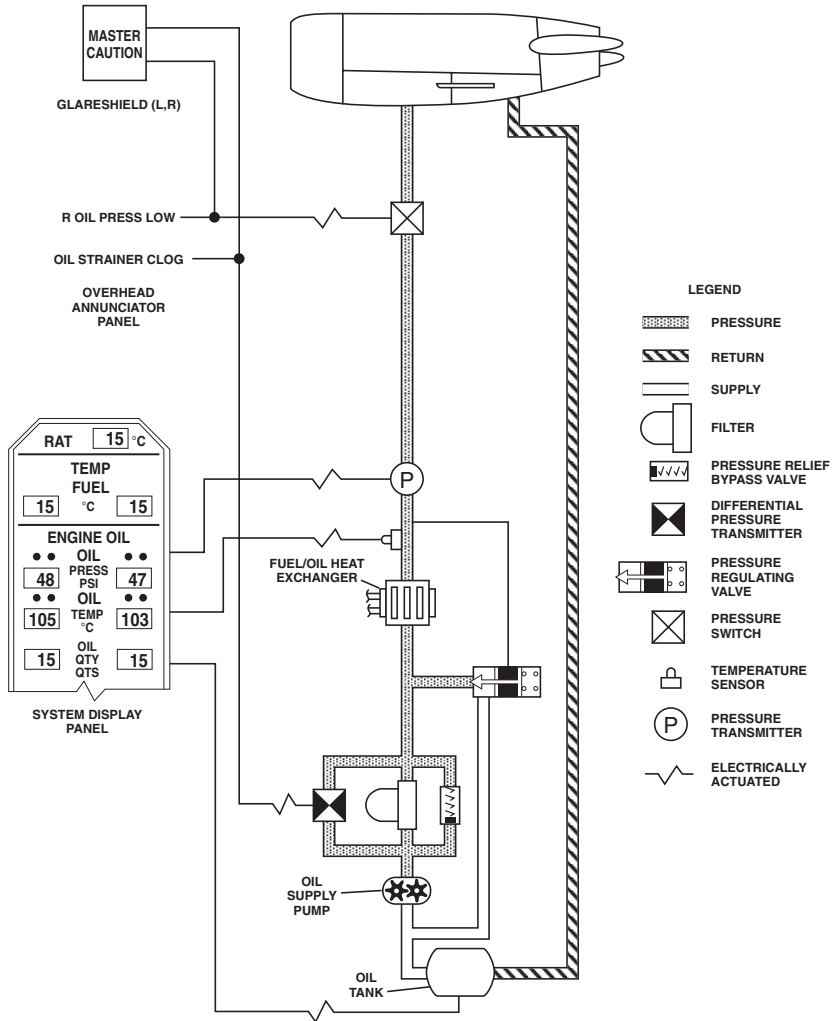
Engines, APU

Functional Schematic

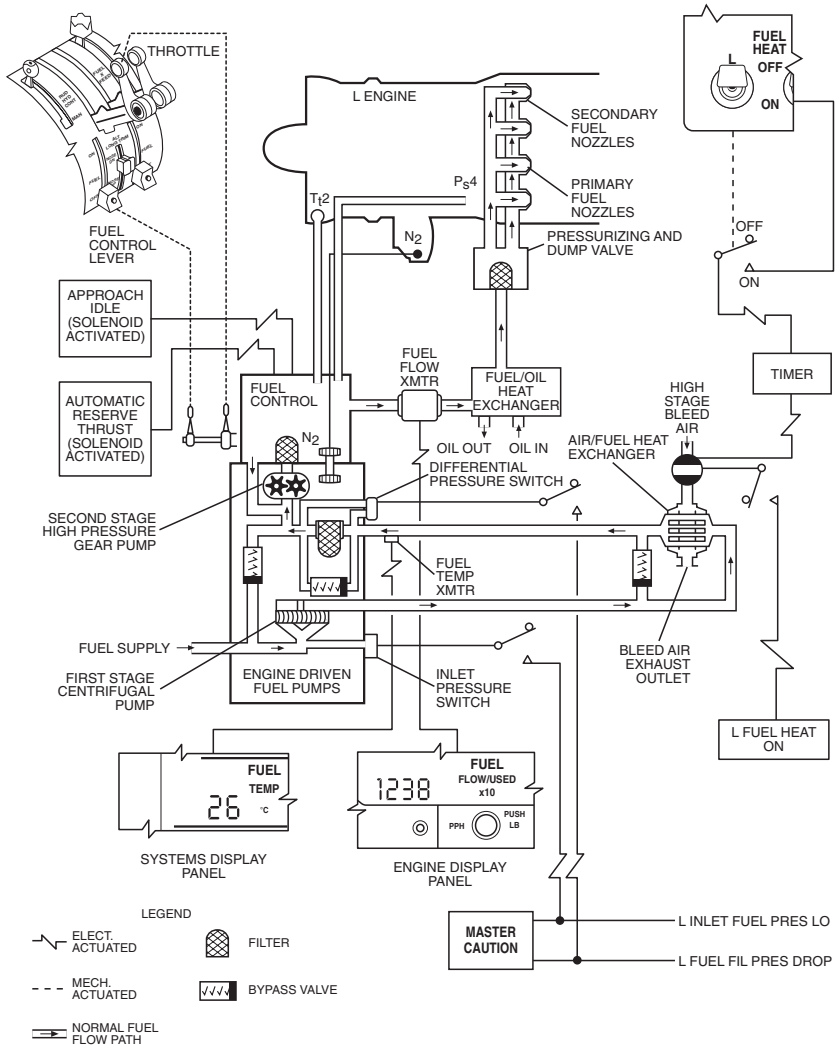
Chapter 7

Section 50

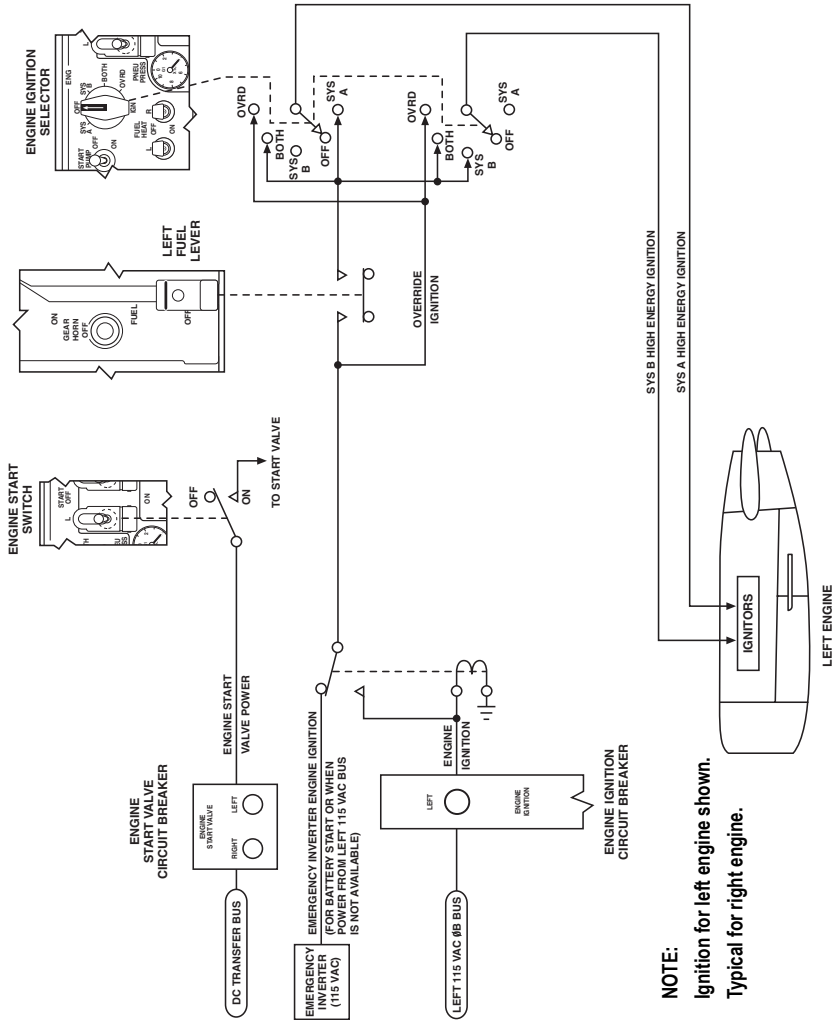
Engine Oil System Schematic



Engine Fuel System Schematic



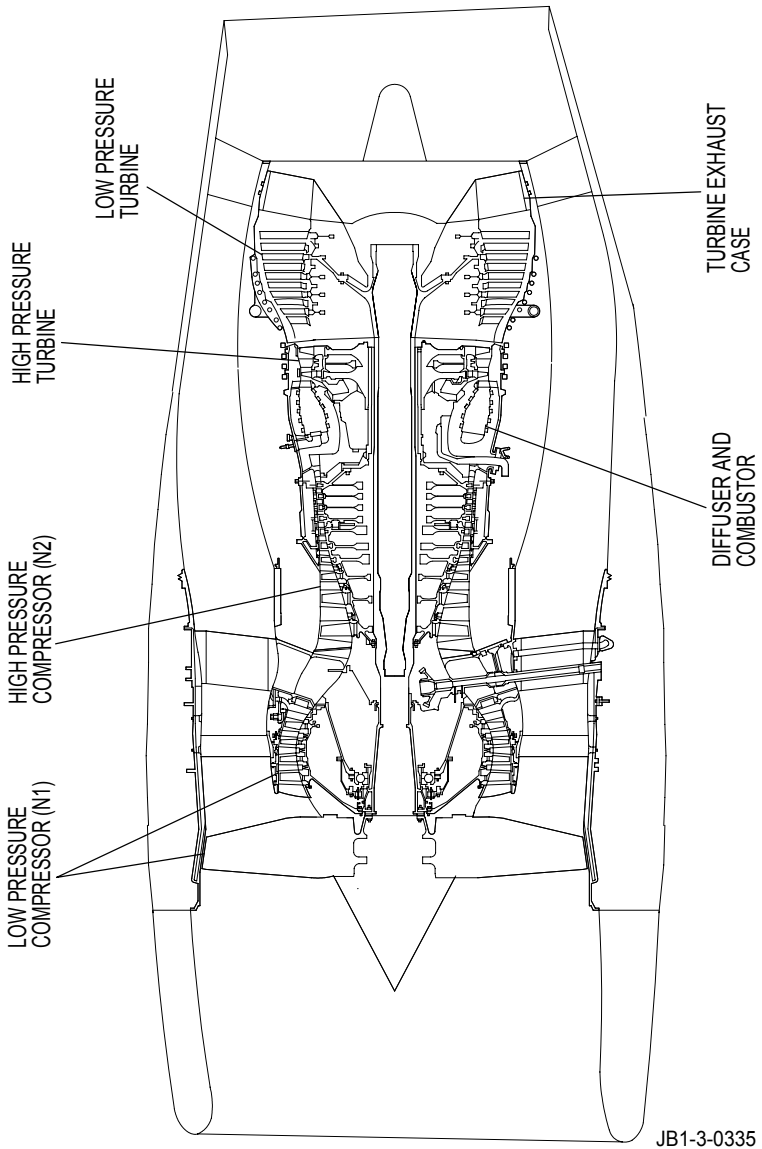
Engine Ignition System Schematic



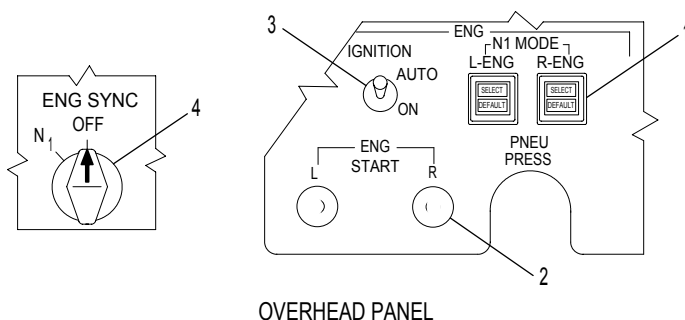
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Engine Controls and Indicators (V2500)

Engine Cross Section



Engine Controls



JB1-3-0774

1. N1 MODE Select Switches (L-ENG/R-ENG)

When the EEC is in EPR mode, the N1 MODE select switch is not illuminated.

DEFAULT - Indicates the EEC is not able to measure or control to a valid EPR. EEC defaults to N1 MODE of operation.

SELECT - Indicates N1 MODE selected either by pressing the switch, pushing the throttles beyond the OVERRATED THRUST gate, or by utilizing emergency reverse thrust.

2. L/R ENG START Switch

Off - Spring-loaded in.

Pull - Solenoid held out. Switch illuminates when solenoid is energized.

3. IGNITION Switch

AUTO - (Normal) Ignition functions controlled by the EEC (auto-abort available).

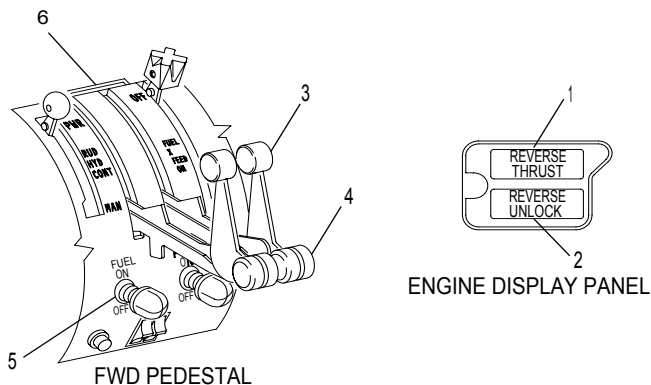
ON - EEC continuously powers both ignitors (auto-abort not available).

4. ENG SYNC Selector

OFF - (EPR sync selected) The system matches the left engine EPR command to the right engine.

N1 - (N1 sync selected) The system matches the left engine N1 to the right engine's.

Throttles and Reverser Levers/Indicators



JB1-3-0775

1. **L/R REVERSE THRUST Light (blue)**
Illuminates when thrust reversers are extended.
2. **L/R REVERSE UNLOCK Light (amber)**
Illuminates when thrust reversers unlock.
3. **L/R Thrust Reverser Levers**
Moving thrust reverser lever aft initiates deployment of respective thrust reverser and controls reverse thrust.
4. **L/R Throttles**
Each throttle transmits an electronic position signal to the EEC.
5. **L/R FUEL Switch**
ON - Allows EEC to open fuel valve at fuel metering unit.
OFF - EEC closes fuel valve.

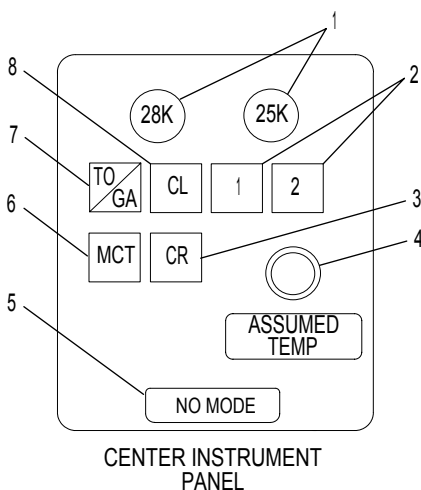
NOTE: A light is located in each switch. The light is illuminated if that engine's fire detection circuit detects a fire while the switch is selected ON or if that engine's fire handle is pulled. The light remains illuminated until the respective switch is placed to OFF or fire is extinguished.

6. OVERRATED THRUST Gate (mechanical)

With throttles up against overrated thrust gate, approximately 28,000 pounds of thrust is produced. Going through the overrated thrust gate increases engine power to 100% N1. The N1 mode is automatically selected when this occurs.

OFF - EEC closes fuel valve.

Thrust Rating Panel



1. Thrust Limit Buttons (28K/25K)

Pushing the 28K or 25K button selects the corresponding thrust limit and cancels any derate or reduced thrust setting.

2. Fixed Derate Buttons (1/2)

Pushing the 1 or 2 button with 25K TO/GA or 25K CL displayed selects associated fixed derate of TO/GA or CL. Once derate mode is selected, the other fixed derate may be obtained by pushing the 1 or 2 button.

3. CR Mode Button

Pushing button will select cruise thrust mode.

4. ASSUMED TEMP Selector

Selects FLEX takeoff and sets assumed temperature for FLEX takeoffs.

5. NO MODE Annunciator Light

Indicates that EPR limit mode has not been selected or uncertified engine bleed has been selected.

6. MCT Mode Button

Pushing button will select max continuous thrust mode.

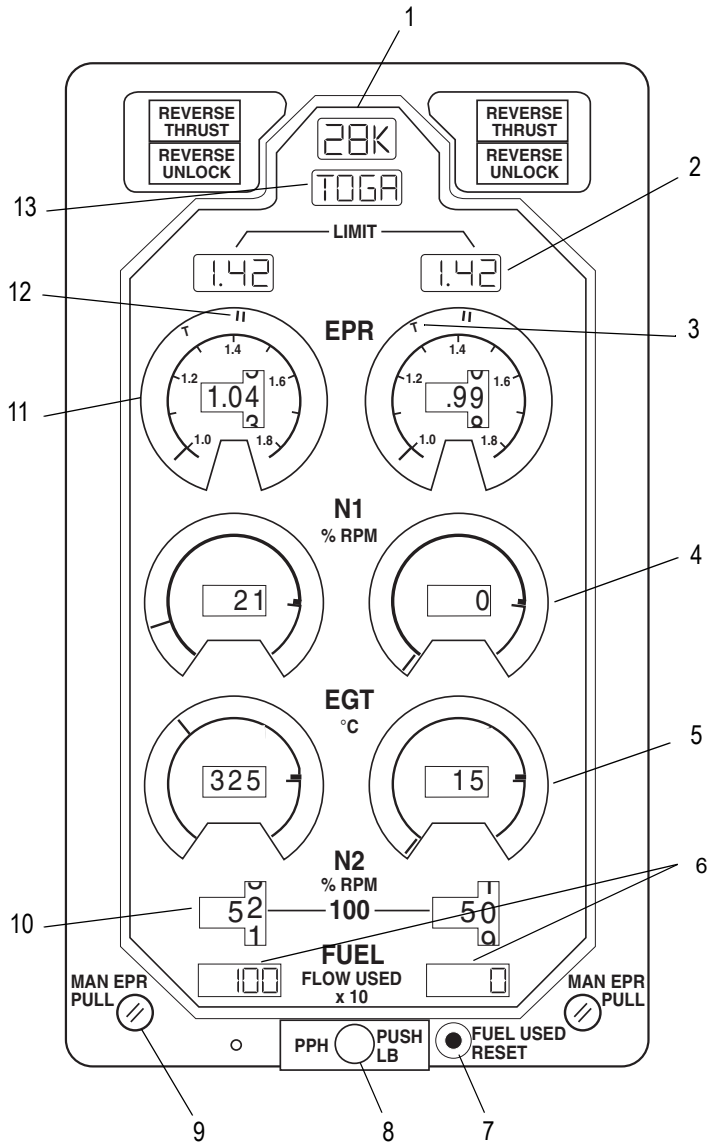
7. TO/GA Mode Button

Pushing button will select takeoff/go-around thrust mode.

8. CL Mode Button

Pushing button will select climb thrust mode.

Engine Display Panel



CENTER INSTRUMENT PANEL

1. **Engine Rating Annunciator**

Displays selected engine rating.

2. **EPR Limit Readout (2)**

Indicates EPR limit as determined by thrust rating mode selected on TRP or manually set with MAN EPR set knob.

3. **T Bug**

Indicates EPR commanded by throttle position.

NOTE: Not displayed when EEC is in the N1 mode.

4. **N1 Indicator**

Digital readout of N1 compressor percent RPM. Pointer indicates trend. N1 digits flash when they exceed redline limits.

5. **EGT Indicator**

Indicates exhaust gas temperature in degrees centigrade. EGT digits will flash when start EGT rate or start EGT values exceed predetermined values. In addition, EGT digits also flash when normal operating EGT values exceed redline limits.

6. **FUEL FLOW / USED Readout (2)**

Indicates fuel flow rate delivered to engine. Fuel flow digits will flash during start if fuel flow exceeds normal starting parameters.

Readouts indicate total fuel used by engine when FUEL FLOW/USED button is pushed.

7. **FUEL USED / RESET Button**

When pushed, resets FUEL FLOW/USED readout to "0". Button is recessed to prevent inadvertent reset.

8. **FUEL FLOW / USED Button**

Momentary display of fuel used when button is pushed, a blue light illuminates behind USED legend.

9. **MAN EPR SET Knob (2)**

Pull knob and rotate to set EPR limit readout. EPR limit reference bug will move to corresponding value on EPR limit readout. When knob is pushed, EPR limit reference bug will move to EPR value applicable for EPR limit thrust mode, and EPR limit readout will display this value.

10. N2 Indicator

Digital readout of N2 compressor percent RPM. Pointer indicates trend. N2 digits flash when they exceed redline limits.

11. EPR Indicator

Digital readout of engine EPR. EPR pointer simultaneously displays an approximate EPR value.

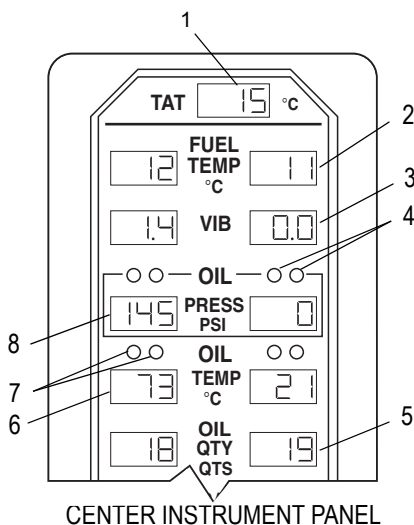
12. EPR Limit Reference Bug

Indicates EPR reference manually set with MAN EPR set knob or automatically set to an EPR limit value applicable for EPR limit thrust mode selected on thrust rating panel.

13. Thrust Rating Mode Annunciator

Displays current thrust rating mode selected.

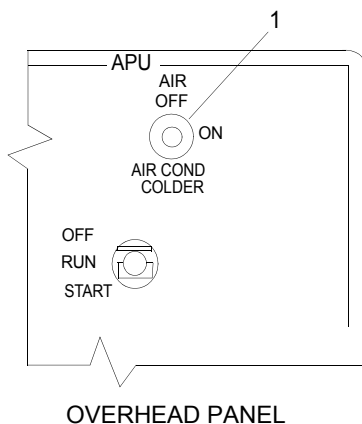
System Display Panel



- 1. TAT Readout**
Indicates total air temperature.
- 2. FUEL TEMP Readout**
Indicates temperature of wing tank fuel.
- 3. Engine VIB Readout**
Indicates engine vibration level for each engine from 0 to 9.9.
- 4. Engine OIL PRESS Light**
Amber - Illuminates at or below 80 psi.
Red - Illuminates at or below 60 psi.
- 5. Engine OIL QTY Readout**
Indicates usable oil in tank.
- 6. Engine OIL TEMP Readout**
Indicates oil temperature.
- 7. Engine OIL TEMP Light**
Amber - Illuminates when oil temperature is at or above 155°.
Red - Illuminates at or above 165°.
- 8. Engine OIL PRESS Readout**
Indicates oil pressure.

APU Controls and Indicators

APU Controls



1. APU AIR Switch

ON - The APU shutoff valve opens to provide APU air to the pneumatic system; the ram inlet door opens during ground operation to maximize APU performance. There is no warm up period when selected ON.

Engine System Description (V2500)

General

The airplane is equipped with two V2528-D5 high by-pass ratio, twin spool turbofan International Aero engines with a take-off thrust at sea level of 28,000 pounds.

The nacelle compartments are isolated from the fuselage by a firewall within the pylon and by a secondary firewall at the fuselage. To allow relative motion between the pylon and fuselage a fireseal is located between the pylon and engine/nacelle interface. To provide additional protection, the secondary fireseal extends above and below the pylon on the fuselage surface.

The engine display panel (EDP), located on the center instrument panel, displays current engine data. The data displayed on the EDP are engine rating, engine thrust rating mode/assumed (FLEX) temperature, engine pressure ratio (EPR) limit, EPR, EPR command, N1 rotor speed, N2 rotor speed, exhaust gas temperature (EGT), fuel flow/fuel used, reverse thrust and reverser unlock status indicators. The N1, N2, and EGT digits will flash if their respective red line limits are exceeded. The EGT digits will also flash if a hot start is imminent.

The engine rating window shows the maximum engine thrust, e.g., 28K=28,000 LBS, etc. The engine thrust rating mode annunciator indicates the engine thrust rating mode selected on the TRP. The thrust rating mode annunciator also displays the assumed temperature selected with the TRP rotary switch for flex-takeoffs.

EPR is displayed for each engine and indicates the current engine thrust. Actual EPR data is measured by the electronic engine control (EEC) using various engine sensors. Manual EPR limit can be set on the EDP by pulling a manual EPR (MAN EPR) limit knob, located at the bottom corners of the EDP for the respective engine. Manual EPR limit knobs are utilized only when the TRP is inoperative. The EPR command display indicates the commanded engine thrust level with T-bugs.

The N1 and the N2 rotor speeds indicate engine rpm in terms of the percentage of the maximum operating speed.

The exhaust gas temperature (EGT) is displayed for each engine and indicates the engine's exhaust temperature in degrees celsius. EGT data is measured by the EEC's using engine EGT sensors located in the exhaust gas path of each engine.

The fuel flow/used windows indicate the current fuel flow rate in pounds per hour that is being delivered to the respective engines. A FUEL FLOW/ USED button, located on the lower portion of the EDP, is pushed to temporarily display fuel used data, which is calculated within the EDP. A blue light behind the fuel used legend will illuminate when the display is showing fuel used data. In addition, a recessed FUEL USED RESET button is used to reset the fuel used on both displays to zero.

REVERSE THRUST and REVERSE UNLOCK lights are located on the EDP for each engine. The blue REVERSE THRUST light indicates that the reversers are extended. The amber REVERSE UNLOCK light indicates that the reversers are not fully stowed and locked. If the reverser and throttle position disagree, the EEC will reduce engine thrust to idle.

The systems display panel (SDP), located on the center instrument panel, displays current engine data. The data displayed on the SDP are fuel temperature, engine vibration, oil pressure, oil temperature, and oil quantity.

The fuel temperature readout indicates fuel temperature for each wing tank. Fuel temperature is sensed by a probe in each wing and is processed by the EEC and then sent to the SDP.

The engine vibration readout indicates engine vibration level for each engine. Engine vibration is sensed on the engine fan case and is processed by the engine vibration monitoring system (EVMS) and then sent to the SDP.

Engine oil pressure is displayed for each engine. Red and amber lights are located above each of the oil pressure readouts that indicate when the oil pressure is at or below 60 psi (red) or 80 psi (amber).

Engine oil temperature is displayed for each engine. Red and amber lights are located above each of the oil temperature readouts that indicate when the oil temperature is at or above 165°C (red) or 155°C (amber).

The oil temperature readout will temporarily flash when the engine oil temperature is lower than -10°C and the throttle is moved above idle.

Engine oil quantity is displayed for each engine. Oil quantity is sensed by a probe in the oil tank.

Full-Authority Digital Electronic Control System (FADEC)

The main component of the full-authority digital electronic control (FADEC) system is the electronic engine control (EEC). There are two power sources for each engine's EEC. The primary power source for the EEC is a dedicated permanent magnet alternator (PMA) driven by the respective engine. The secondary power source is the aircraft electrical system.

The EEC has two identical channels which receive airplane and engine supplied data including throttle position, total air pressure, total air temperature, pressure altitude, rotor speeds (N1 and N2), and EGT.

Functions controlled by the EEC:

- Engine acceleration and deceleration limits

- Engine pressure ratio (EPR)

- Idle speed governing

- Overspeed limits (N1 and N2)

- Fuel flow

- Compressor stator vane system

- Compressor bleed systems

- Turbine cooling air

- Air-cooled and fuel-cooled oil coolers

- Active clearance control system

- Thrust reverser

- Automatic start of the engine

- Fuel on/off torque motor

- Starter air valve

Ignition relay
Thrust reverser control solenoids
Engine maintenance function

The EEC also transmits engine data which are used for cockpit display, thrust management, and monitoring systems.

Automatic Thrust Restoration (ATR) System

The Digital Flight Guidance Computer (DFGC) Automatic Thrust Restoration (ATR) is a feature that increases thrust after a thrust cutback on takeoff in the event of an engine failure. Once activated, the ATR will unclamp the throttles (if the autothrottle system is engaged) and move both throttles equally until one of the engines reaches TOGA EPR limit.

The ATR is armed if:

1. Thrust cutback has been performed or throttles manually retarded.
2. The flight director pitch axis is in takeoff mode.
3. The airplane is above 350 feet radio altitude.

After arming, the ATR system continuously monitors for engine surge, engine failure, and negative climb rate. The ATR is activated if the differences between the engines are greater than 14% N1, or the airplane descends for 5 seconds.

After ATR activation, a subsequent engine compressor stall results in autothrottles clamping.

Thrust Management

The EPR mode is the primary mode of thrust control for the EEC. When the EEC is no longer able to control thrust using EPR, the respective N1 MODE select switch DEFAULT light illuminates indicating N1 mode operation. N1 operation may be commanded by pushing the throttle beyond the overrated thrust gate, selecting emergency reverse thrust, or by pressing the N1 MODE Select switch. Autothrottles are inoperative in the N1 MODE.

***NOTE:** Manually resetting the gate does not return the engine to the EPR mode.*

Thrust Rating Panel (TRP)

The thrust rating panel (TRP), located on the center instrument panel, allows the flight crew to select a variety of thrust ratings. The TRP consists of 28K and 25K thrust limit buttons, TO GA, CL, MCT, and CR mode buttons, fixed derate buttons (1, 2), an ASSUMED TEMP selector, and a NO MODE annunciator light.

The ASSUMED TEMP selector is used to select FLEX takeoff and set assumed temperatures for FLEX takeoffs. When the knob is turned past the first detent, FLEX mode is selected and FLX followed by numerical digits representing the assumed temperature will be displayed in the thrust rating mode annunciator. Further movement of the ASSUMED TEMP selector selects the desired assumed temperature which is displayed in the thrust rating mode annunciator and in the FMA autothrottle window. If the autothrottle system is engaged, the word EPR is displayed above the assumed temperature value in each FMA. The EPR limit readout will display the limit EPR and the EPR limit reference bugs will display the corresponding limit.

The 28K and 25K thrust limit buttons, when pushed, select EPR limit values to be calculated by the EEC for takeoff, go-around, climb, max continuous thrust based on the respective thrust schedule.

The TO GA button is used to select the takeoff/ go-around thrust rating mode. When pushed, "TOGA" will be displayed in the thrust rating mode annunciator and the EPR limit value will be displayed in the EPR limit readout and reflected by the EPR limit reference bugs.

The CL button is used to select the climb thrust rating mode. When pushed, "CL" will be displayed in the thrust rating mode annunciator and the EPR limit value will be calculated according to the climb thrust schedule and displayed in the EPR limit readout and reflected by the EPR limit reference bugs.

The fixed derate buttons (1, 2) are used only with the 25K thrust limit in TO GA or CL modes to derate the thrust 12% or 18% respectively. When pushed "T/O 1", "T/O 2", "CL-1", or "CL-2" is displayed in the thrust rating mode annunciator depending on the selected configuration. The EPR limit readout will display the limit EPR and the EPR limit reference bugs will display the corresponding limit.

The MCT button is used to select the maximum continuous thrust rating mode. When pushed, the maximum continuous thrust schedule is used to calculate EPR limit values and "MCT" will be displayed in the thrust rating mode annunciator. The EPR limit readout will display the limit EPR and the EPR limit reference bugs will display the corresponding limit.

The CR button is used to select the cruise thrust rating mode. When pushed, the cruise thrust schedule will be used to calculate EPR limit values and "CRZ" will be displayed in the thrust rating mode annunciator. The EPR limit readout will display the limit EPR and the EPR limit reference bugs will display the corresponding limit.

The NO MODE annunciator light indicates that EPR limit mode has not been selected or an uncertified engine bleed has been selected.

Engine Starting

Either engine may be started by using a pneumatic ground supply or by pneumatic supply from the auxiliary power unit (APU). When one engine is operating, the opposite engine may be started by using the crossbleed start procedure. Two starting modes, automatic (IGNITION switch in AUTO), and manual (IGNITION switch in ON), are provided for starts on the ground.

The left and right engine start (L/R ENG START) switches, spring-loaded to the "off" position, are located on the overhead engine panel. When either engine start switch is pulled to "on," the switch illuminates and a solenoid latches and holds the switch in "on." The EEC opens an electrically controlled, pneumatically actuated starter air valve on each engine, which controls air pressure to the starter motor of the respective engine. The L/R START VALVE OPEN message is displayed on the overhead annunciator panel (OAP) to indicate the respective starter air valve is not closed. Ignition and fuel flow will not be initiated by the EEC (with the ENG IGNITION switch in AUTO) until 30 seconds after the starter valve opens. When the N2 reaches 43%, the solenoid is de-energized, the engine start switch light extinguishes and the switch returns to the "off" position.

The EEC has direct control over the starter air valve, fuel metering unit (FMU), and the igniters during engine start. In addition, the EEC has the capability to terminate (auto-abort) the starting cycle during ground autostarts when it detects any of the following conditions:

Hot start

Hung start

Locked N1 rotor

Ignition failure

EEC control of igniters/starter air valve lost

Engine surge

EGT failure (both EEC channels)

***NOTE:** The EEC will not auto-abort inflight, or until N2 reaches idle or during a battery start.*

To extend starter life and reduce chance of failure of the starter shear section, do not engage the starter (except for an abnormal or emergency condition) when the compressors are rotating.

Ignition System

Two independent ignition systems (A and B) are installed on each engine. The dual systems for both engines are controlled by a single, two-position IGNITION switch (AUTO and ON) located on the overhead panel.

When the IGNITION switch is in AUTO, the EEC controls the engine ignition automatically and provides auto-abort capability. When the ignition switch is in ON, the EEC powers the ignitors continuously and inhibits auto-abort capability.

Engine Oil System

The oil system is a recirculating type and supplies oil to the engine bearing compartments, and the external gearbox to lubricate and cool components. The SDP provides cockpit indications of oil pressure, oil temperature and oil quantity.

Oil is pumped from the oil tank by the pressure pump assembly containing a filter and pressure relief valve set at approximately 450 psi. Oil quantity (OIL QTY) is sensed at the oil tank and displayed on the engine oil quantity readout located on the SDP. Oil is then routed through a secondary air-cooled oil cooler and a separate primary fuel-cooled oil cooler. The air-cooled oil cooler is controlled by the EEC whereas the fuel-oil cooler provides for a continuous transfer of heat from the oil to the fuel to prevent fuel-icing. In addition, some of this fuel is returned to the main tanks. This system is called return to tank (RTT). Refer to Fuel chapter for further description. Oil pressure is sensed by an oil pressure transmitter. If oil pressure drops below normal, the L/R OIL PRESS LOW message will be displayed. An amber oil pressure light illuminates when oil pressure drops to 80 psi. A red oil pressure light illuminates when oil pressure drops to 60 psi.

Oil temperature is displayed on the engine oil temperature readout on the SDP. An amber oil temperature light illuminates when oil temperature reaches 155°C. A red oil temperature light illuminates when oil temperature reaches 165°C. The scavenge filter contains a differential pressure switch. The L/R OIL STRAINER CLOG message will be displayed to indicate an excessive differential pressure indicating probable contaminants in the oil strainer.

Engine Fuel System

Fuel pressure entering the engine is monitored by an inlet pressure switch. When the inlet pressure is low, the INLET FUEL PRES LO message will be displayed. Fuel then passes into a low/high pressure (LP/HP) pump assembly. The fuel enters the LP pump before it flows to the fuel-cooled oil cooler. The fuel-cooled oil cooler lowers the oil temperature and increases the fuel temperature. This prevents ice particles from forming in the fuel. The fuel temperature displayed on the SDP is sensed at the wing tank.

Fuel is filtered before entering the HP pump inlet. A differential pressure switch senses clogging of the fuel filter and a bypass valve is installed to bypass a clogged filter. The L/R FUEL FIL PRES DROP message is displayed to indicate a clogged filter.

The FMU receives signals from the EEC to control the fuel supplied to the engine. Within the FMU, an overspeed valve is held open by system fuel pressure. If the EEC detects an engine overspeed the L/R ENGINE OVERSPEED message will display and the overspeed valve receives a signal to close reducing fuel flow to a minimum. The FMU also supplies HP fuel for a number of actuators. Excess fuel from the FMU is returned to the LP side of the system. The fuel flow transmitter measures fuel delivered to the fuel distribution valve from the FMU. Fuel flow is displayed on the fuel flow readout located on the EDP.

Thrust Reversers

The thrust reversers provide reverse thrust from fan air only. Thrust reverser control signals are sent to the EEC only when weight is on the main wheels, the throttles are in the reverse position, and the N2 is 7% or more.

The thrust reverser system consists of cold-ducts (C-ducts), translating sleeves, blocker doors and cascades. As the translating sleeve moves aft, it moves the blocker doors down and uncovers the cascades, which direct the flow of fan air outward and forward through the cascades. The doors are shaped to fit together to form a complete barrier across the air duct and block the flow of air through the duct.

The amber REVERSER UNLOCK light, located on the EDP, illuminates when the reversers unlatch. When the reversers are extended, the blue REVERSE THRUST light, also on the EDP, illuminates.

Ground speed determines reverse thrust capability. If speed is less than 60 kts at reverse thrust initiation, available reverse thrust is 1.07 EPR. When initiating reverse thrust above 60 kts, available reverse thrust is 1.3 EPR.

The ENGINES COOL light, located on the OAP, illuminates 1.5 minutes after cancellation of reverse thrust as a reminder when an engine may be shut down based on elapsed time, not engine temperature.

Emergency Reverse

Under extreme circumstances, emergency reverse thrust is available if initiated above 60 kts. Moving the reverse levers through a reverse thrust detent activates emergency reverse thrust. Approximately 1.4 EPR will now be available.

This action generates an “ENGINE SYSTEM FAIL” message on the OAP.

Engine Synchronizer System

The engine synchronizer matches either the EPR's or the N1's between the left and the right engines. The system includes a two-position (N1, OFF) ENG SYNC selector and an ENGINE SYNC ON message displayed on the OAP. The system is controlled by the EEC's and the DFGC's.

In the OFF position, with the autothrottle engaged, EPR sync is selected. During EPR sync operation, the left EEC matches its EPR command to the right EEC's EPR command. With landing gear extended and if N1 is selected, the ENGINE SYNC ON message on the OAP will be illuminated. During N1 sync operation, the left engine's N1 is matched to the right engine's N1.

N1 Default Mode

When an engine is in N1 mode, full throttle can cause the EEC to control the engine at a thrust level in excess of that allowed by the maximum EPR limit. In this mode, overspeed protection is provided but the EGT must be monitored to ensure that EGT limits are not exceeded. N1 mode may be manually selected or the engine will automatically default to the N1 mode when the EEC is no longer able to control the thrust using EPR. If the N1 default mode has occurred, the amber DEFAULT light in the N1 select switch(es) will illuminate. When the EEC defaults the engine to the N1 mode, EPR pointer, EPR command T-Bug and EPR limit reference bugs are removed and dashes appear in EPR and EPR limit readouts. Autothrottles are not available when engine(s) are in N1 mode.

N1 Select Mode

The engine(s) may be placed in the N1 mode either by pushing the respective N1 MODE select switch(es) on the overhead panel, pushing either throttle beyond the overrated thrust gate, or selecting emergency reverse thrust. When an engine is selected in the N1 mode, the SELECT light in the respective N1 MODE switch illuminates and the T-bugs in the EPR indicators are removed from view. Engine(s) may be returned to EPR mode by resetting the gate, then pushing the respective N1 MODE select switch(es) to extinguish the SELECT light.

APU System Description

APU General

The APU has electrics and pneumatics available on the ground and in flight. They are both available immediately when the APU is running. Anytime the APU air switch is on, the RAM air door is open. All APU starts, both in flight and on the ground, receive DC power from the airplane battery.

OAP Messages/Lights

Red Warning Lights

(L/R) TAIL TEMP HIGH - The respective left/right tail compartment or pylon temperature exceeds normal.

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

APU OIL PRESS LOW (MISC) - APU oil system pressure is low. Message is normally displayed during APU start, but disappears as oil pressure rises. The message is inhibited during a pilot-commanded shutdown.

APU FIRE DET FAULT (ENG) - The fire detection capability of both fire detection loop systems is inoperative, or, a fire/overheat condition is detected in a loop.

FIRE LOOP INOP (ENG) - Maintenance Alert. Indicates one of two fire loops, for an engine or APU, is faulted while the other loop is normal.

L/R/APU ENG FIRE DET FAULT (ENG) - Indicates both fire loops from respective indicated system are inoperative.

L/R EEC/EDP BUS FAIL (ENG) - Indicates one respective EEC channel has failed at the EDP.

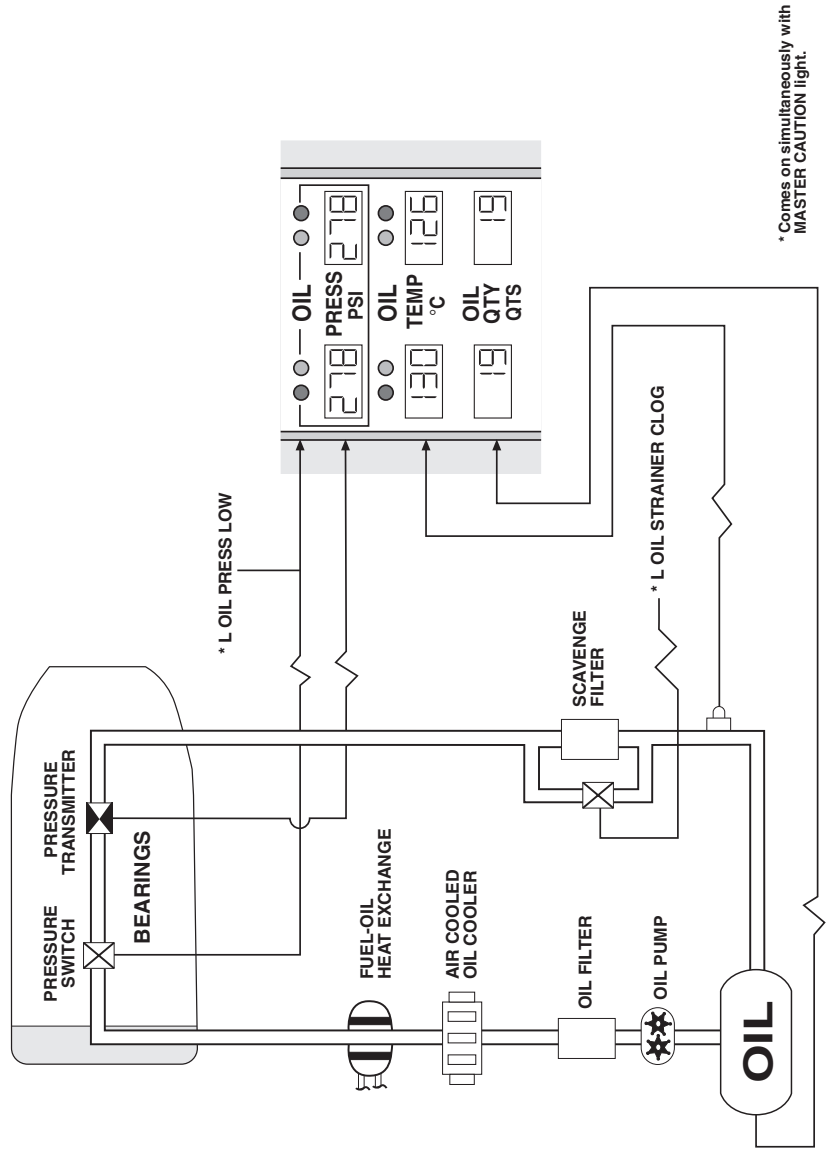
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- L/R EEC FAULT (ENG) - Indicates that respective EEC has detected a Class 2 fault. Time limited dispatch allowed per MMEL.
- L/R ENGINE OVERSPEED (ENG) - Indicates the respective EEC detects engine rotor (N1 or N2) speed beyond maximum limit. EEC commands FMU overspeed valve to minimum flow position.
- L/R ENGINE SURGE (ENG) - Indicates the respective EEC detects engine compressor surge or starting stall.
- L/R ENG MANUAL START (ENG) - Indicates manual start selected (ENG IGNITION switch in ON), or, a battery powered start, or, detection of a failed signal between the respective DFGC and EEC (inhibited above idle).
- L/R ENG START ABORTED (ENG) - Indicates respective EEC detects an abnormal start and that EEC automatically aborted the start (autostarts only).
- L/R ENG SYSTEM FAIL (ENG) - Indicates that respective EEC has detected a Class 1 fault condition. No dispatch until fault is fixed.
- L/R ENG VIB HIGH (ENG) - Indicates high respective engine vibration.
- L/R FUEL OFF (ENG) - Indicates the respective FMU fuel-on/-off valve is in the off position.
- L/R REVERSER FAULT (ENG) - Indicates the respective EEC has determined the thrust reverser may not be deployed.
- L/R REV PRESSURIZED (ENG) - Indicates respective EEC auto restow commanded or EEC detection of isolation valve failure.
- L/R START VALVE OPEN (blank, -A, -B) (ENG) - Indicates the respective start valve is not fully closed (Suffix indicates ignitor selected).
- L/R STATOR VANE FAIL (ENG) - Indicates when respective stator vane actuator has been fail-safed and cannot be controlled.

Blue Advisory Lights

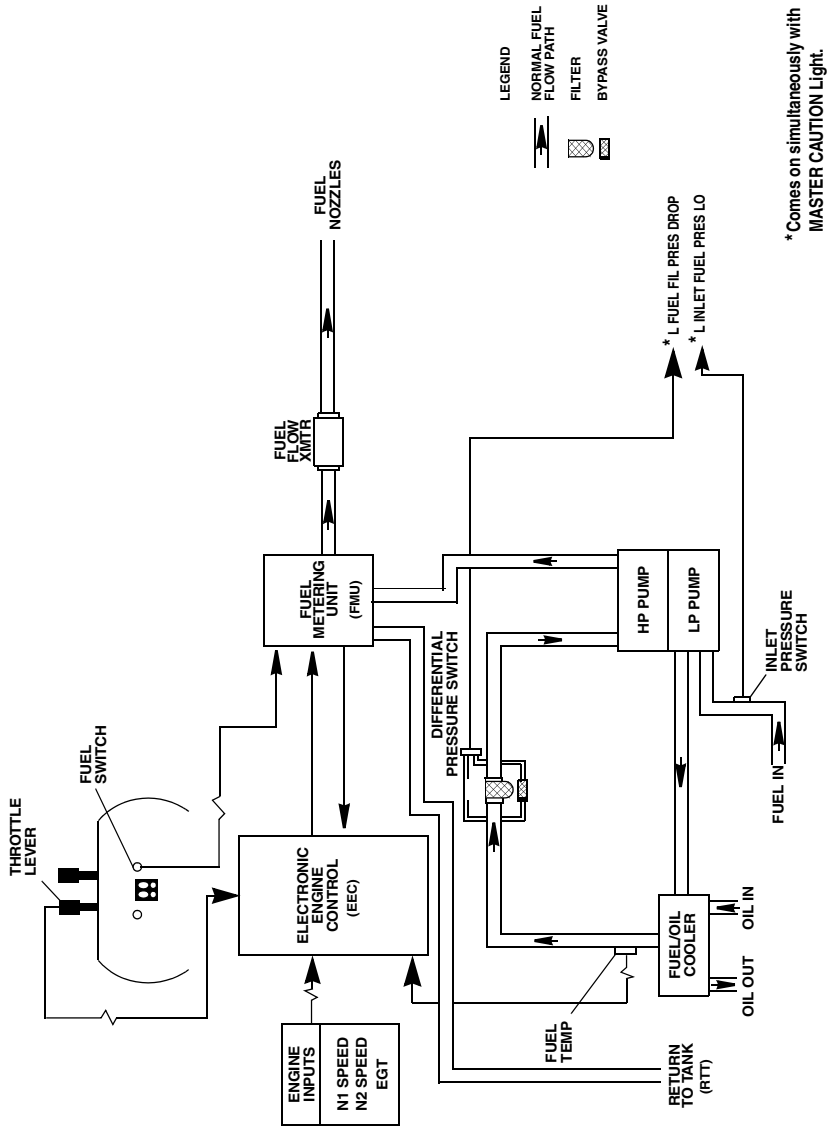
- L/R ENG IGN ON - Respective engine ignition system in use.

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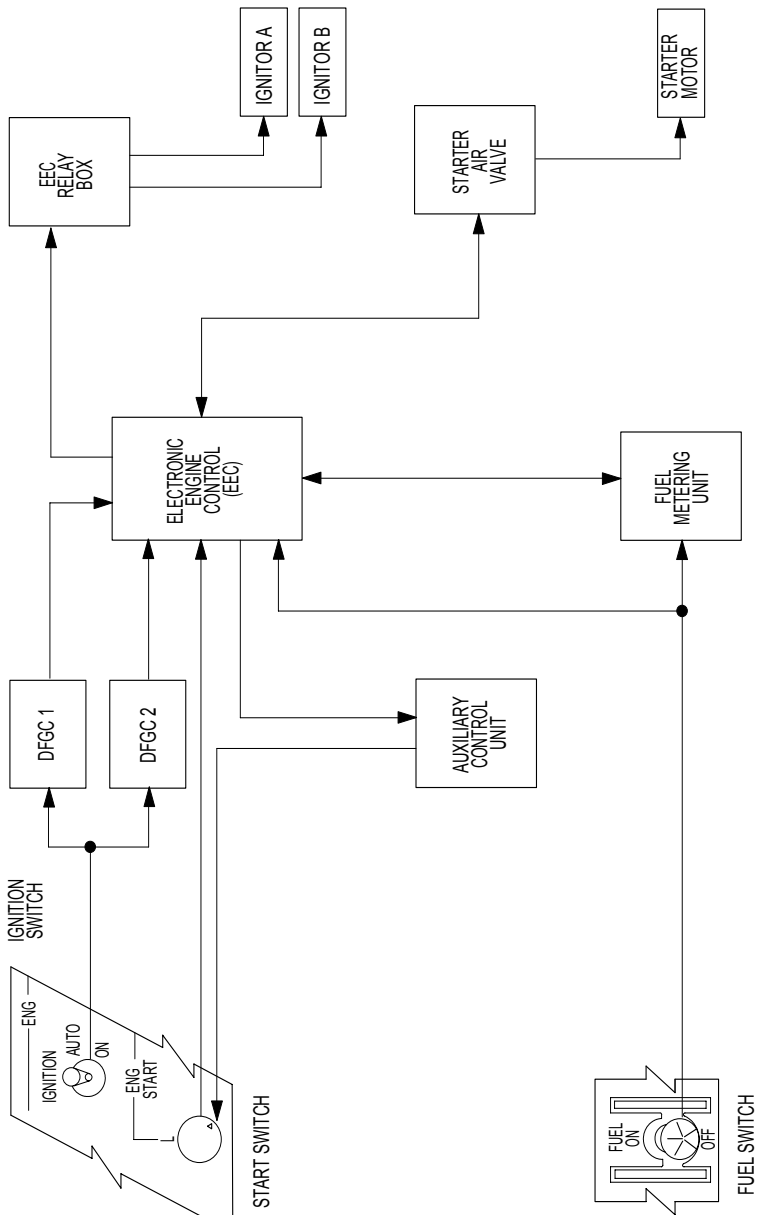
Functional Schematic
Engine Oil System Schematic



Engine Fuel System Schematic



Engine Start and Ignition System Block Diagram



JB1-3-0127B

Fire Protection

Chapter 8

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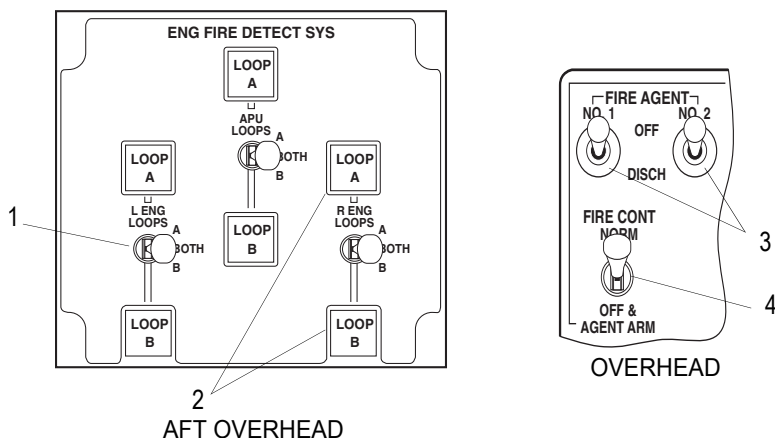
Fire Protection

Controls and Indicators

Chapter 8

Section 10

Cockpit Fire Controls/Indicators



1. **LOOPS Switch (L ENG/R ENG/APU)**

BOTH - Normal position.

A/B - Selects respective fire detector loop for engine or APU fire detection system.

2. **LOOP A and B Lights (L ENG/R ENG/APU) (amber)**

Illuminate when activated by associated fire detection loop or loops test switch. Indicates possible fire detection malfunction.

3. **APU FIRE AGENT Switch (NO 1/NO 2)**

OFF - Normal position.

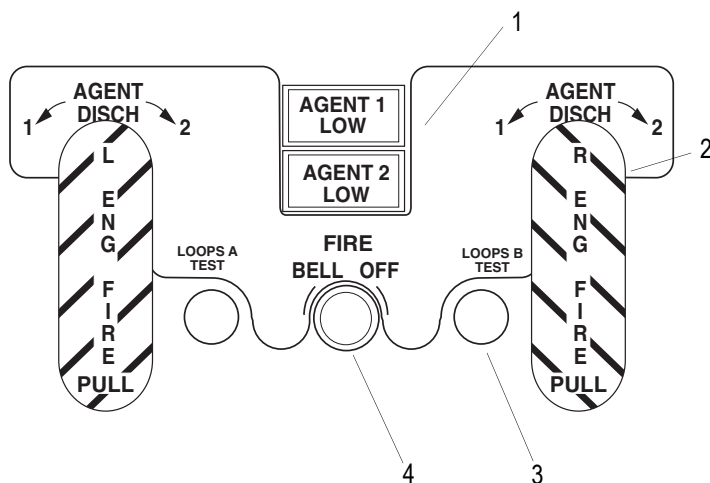
DISCH - (Momentary) Discharges selected fire extinguishing agent into the APU compartment.

4. **APU FIRE CONT Switch**

NORM - Normal position.

OFF & AGENT ARM - Immediately shuts down APU and arms the fire extinguishers.

Engine Fire Extinguishing Controls/Indicators



UPPER CENTER INSTRUMENT PANEL

1. **AGENT LOW Light (1/2) (amber)**

Illuminated - Respective fire extinguishing agent has been discharged (pressure low).

2. **L/R ENG FIRE Handle (red)**

Light Illuminated - Associated engine fire is detected or the system fire test is in progress.

Pull - (Fully extended position) Silences the aural warning, shuts off associated engine fuel, hydraulic and pneumatic systems, and trips generator.

Rotate - (With additional pulling) Discharges respective fire extinguishing agent into the engine cowling.

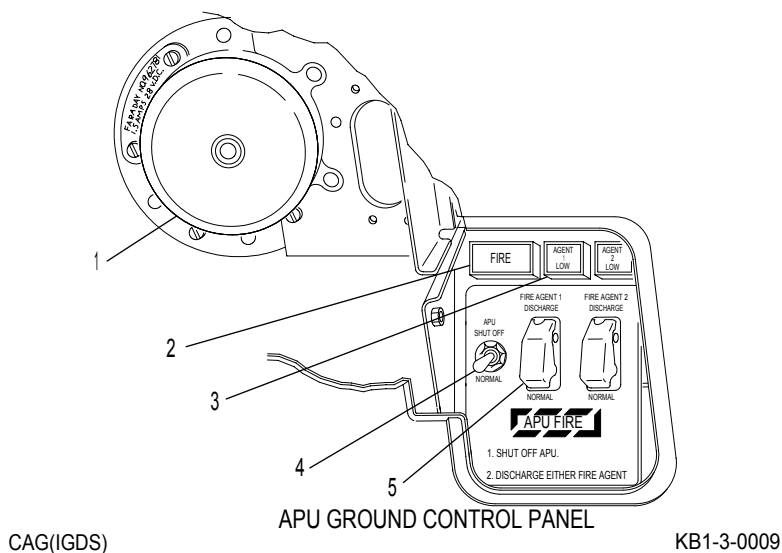
3. **LOOPS TEST Button (A/B)**

Push - Tests associated fire detection system loop(s) circuits.

4. **FIRE BELL OFF Button**

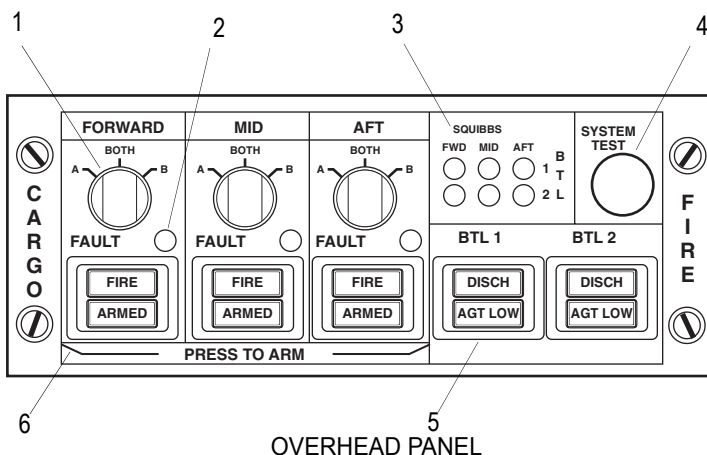
Push - Silences aural warnings for engine fire or cargo fire.

APU Fire Extinguishing Controls/Indicators



1. **APU Fire Warning Horn**
Sounds while APU fire is detected.
2. **APU FIRE Light (red)**
Illuminated - APU fire is detected.
3. **AGENT LOW Light (1/2) (amber)**
Illuminated - Respective fire extinguishing agent has been discharged.
4. **APU SHUT OFF Switch**
NORMAL - Normal position.
SHUT OFF - (Momentary) Shuts down APU and arms fire extinguishers.
5. **FIRE AGENT DISCHARGE Switch (1/2)**
NORMAL - (Guarded) Normal position.
DISCHARGE - (Momentary) Discharges respective fire extinguishing agent into the APU compartment.

Cargo Fire Control Panel



1. Loop Selector Switch (FORWARD/MID/AFT)

BOTH - Normally in the BOTH position.

A/B - Used to isolate faults or for checking loops.

2. Fault Light (FORWARD/MID/AFT) (amber)

Illuminated - Indicates fire detection loop malfunction. Also causes MASTER CAUTION to illuminate.

3. SQUIBB Lights (green)

These lights verify the integrity of the squibb, which are used in discharging the fire bottles.

4. SYSTEM TEST

Push and hold to test.

5. DISCHARGE/AGT LOW Switch (1/2)

DISCH - Indicates cargo fire bottle is armed.

Pressing switch after DISCH light illuminated will discharge fire bottle.

AGT LOW - Indicates fire extinguishing agent has been discharged.

6. FIRE/ARMED Switch Light (FORWARD/MID/AFT)

FIRE - Indicates cargo fire detection system has detected heat or smoke.

ARMED - Indicates cargo fire suppression system is armed.

Pressing switch will arm the suppression system.

General

Fire protection systems provide the means to detect and extinguish a fire in the engine nacelles and the auxiliary power unit (APU).

Each system consists of fire detection, warning, and extinguishing systems.

Detection Systems

A fire detection system, powered by the DC transfer bus, is provided for each engine and the APU. Each detection system is equipped with two fire detector loops. Electrical resistance of the fire detector loops in each of these areas is monitored by a control unit. When both loops in one area detect a fire/overheat condition, they electrically trigger the control units and energize the warning system. In normal operation (LOOPS switch in BOTH), the fire warning system is activated when both loops sense a fire; however, with BOTH selected, when a single loop senses a fire/overheat (or is triggered by an electrical short), the applicable loop light illuminates, accompanied by the FIRE DETECTOR LOOP message and MASTER CAUTION lights.

Extinguishing System

The fire extinguishing system, powered by the DC transfer bus, consists of two fire bottles, distribution lines, control circuits, and agent low lights (agent low lights require DC power). Each bottle has separate discharge heads and distribution lines to each engine and the APU. The ENG FIRE handles and the APU FIRE AGENT DISCHARGE switches are used to select the desired bottle and dispense the fire extinguishing agent. Agent low lights on the upper instrument panel and the exterior APU ground control panel illuminate when the fire extinguishing agent has been discharged.

Engine Fire Warning System

The engine fire warning system consists of illuminated L/R ENG FIRE handles located on the upper center instrument panel, LOOP A and LOOP B lights on the overhead panel, a FIRE DETECTOR LOOP message on the overhead annunciator panel, both MASTER CAUTION lights on the glareshield, and an aural warning (master warning is not illuminated). The aural warning, illuminated ENG FIRE handle, and loop lights on the overhead panel identify which engine has a fire/overheat condition.

The engine aural warning can be silenced by pushing the FIRE BELL OFF button, or pulling the fire handle. The MASTER CAUTION lights can be extinguished by pushing the MASTER CAUTION light. The engine fire handle and loop lights and message remain illuminated until the fire is extinguished.

Engine fire indications:

- Fire bell, then vocal warning “FIRE, LEFT/RIGHT ENGINE”.
- Illuminated L/R ENG FIRE handle.
- L/R LOOP A and LOOP B lights.
- FIRE DETECTOR LOOP message.
- Both MASTER CAUTION lights.

Pulling the engine fire handle accomplishes the following for the affected engine:

- Disables the aural/vocal warning.
- Mechanically closes the pneumatic crossfeed valve.
- Shuts off fuel (valve at wing spar).
- Shuts off engine hydraulic pump (engine pump supply line).
- Trips the generator control relay.

APU Fire Warning System

The APU fire warning system consists of LOOP A and LOOP B lights on the overhead panel, a FIRE DETECTOR LOOP message and APU FIRE light on the annunciator panel, both MASTER WARNING and MASTER CAUTION lights on the glareshield, and an aural “APU FIRE” vocal and a warning horn in the cockpit. These aural warnings will cease automatically after three cycles. The MASTER WARNING and MASTER CAUTION lights can be extinguished by pushing the respective lights. The APU LOOP lights, FIRE DETECTOR LOOP message, and APU FIRE light remain illuminated until the fire is extinguished.

Additional warnings are an external fire warning horn and an APU FIRE light located at the external APU ground control panel on the left side of the fuselage adjacent to the APU. The external APU FIRE light remains illuminated until the fire is extinguished. The external horn sounds until the fire is extinguished.

When an APU fire is detected, the APU fire warning system is activated and the APU will automatically shut down.

APU fire indications:

- Aural/vocal warning “APU FIRE” (3 cycles).
- Horns (cockpit [3 cycles] and external [continuous]).
- APU FIRE lights (cockpit and external).
- Both MASTER WARNING lights.
- APU LOOP A and B.
- FIRE DETECTOR LOOP message.
- Both MASTER CAUTION lights.

NOTE: With the APU master switch in the OFF position, all APU aural warnings are inhibited.

Cargo Fire Detection and Suppression

General

The cargo fire protection system is comprised of a detection and suppression system. The detection system alerts the flight crew in the event of cargo smoke or heat in the forward, mid, or aft cargo compartment.

Cargo Fire Protection

The cargo fire protection system consists of the following:

- Smoke/heat detector units located in each cargo compartment.
- A cargo fire control panel located on the overhead panel in the cockpit.
- An aural alerter on the Aft Overhead Panel.
- A red CARGO FIRE light on the OAP, MASTER CAUTION and MASTER WARNING lights on the glareshield.
- Two fire bottles.

The system is powered by the left and right DC buses.

Detection System Description

Cargo fire detection is accomplished through the use of a dual loop system located in each smoke detector unit. Each detector unit incorporates two smoke detectors and two heat sensors. One smoke detector and one heat sensor make up one loop. Loop selection is manually controlled by three selectors, one for each cargo compartment located on the cargo fire control panel. For normal operations, the loop selectors remain in the BOTH position. With the selectors in BOTH, the flight crew will be alerted to any smoke or heat condition sensed by both an A and B loop in any combination within the respective cargo compartment. With a loop selector positioned to A or B, any respective A or B loop within the cargo compartment will create an alert when smoke and/or heat is detected.

A loop fault light is located on the cargo fire control panel adjacent to each loop selector switch. Should a loop fault be detected, the amber fault light will illuminate with the MASTER CAUTION lights on the glareshield. There is no OAP message associated with this indication.

If smoke and/or heat is detected in a cargo compartment, the flight crew will be alerted by:

- The red CARGO FIRE light on the OAP.
- MASTER WARNING lights on the glareshield.
- A high pitched tone from the aural alerter which can be silenced by pushing the FIRE BELL OFF button between the engine fire handles or the MASTER WARNING lights.
- The FIRE light on the cargo fire control panel from the alarming compartment.

In addition, the ARMED light of the alarming compartment will illuminate with the BTL 1 DISCH light to indicate automatic suppression system arming has occurred.

Suppression System Description

Cargo fire suppression is accomplished through the use of two fire bottles. Bottle #1 is a high rate discharge bottle that is used to rapidly flood the affected cargo compartment with halon and smother the fire. Bottle #2 is a low rate discharge bottle that slowly releases halon into the cargo compartment, extending fire suppression effectiveness. The two bottles working together give the flight crew approximately sixty minutes of fire suppression.

Automatic Arming

Normally, the cargo fire detection system will automatically arm the fire suppression system when smoke and/or heat is sensed in a cargo compartment. This will be indicated by the illumination of the forward, mid, or aft cargo compartment ARMED switch light and the BTL 1 DISCH switch light.

The #1 bottle must be discharged by raising the plastic guard and depressing the BTL 1 DISCH switch light. After discharge of the #1 bottle, the BTL 1 AGT LOW light will illuminate after approximately 15 seconds, followed by the illumination of the BTL 2 DISCH switch light.

The #2 bottle will automatically begin to discharge into the compartment approximately fifteen minutes after the first bottle is discharged. After discharge of the #2 bottle, the BTL 2 AGT LOW light will illuminate after approximately 20 minutes. Bottle #2 will not automatically discharge if landing has occurred.

Manual Arming

In the event that automatic arming of bottle #1 does not occur, the system can be manually armed by depressing the illuminated FIRE switch light on the fire control panel. This action causes the ARMED light and the DISCH light for BTL 1 to illuminate. Bottle #1 is then discharged by raising the plastic guard and depressing the switch light. Bottle #2 should then be manually discharged in the same manner after 15 minutes.

NOTE: The #1 bottle should always be discharged first to achieve the maximum fire knockdown. The #2 bottle should be discharged 15 minutes later. Due to discharge rate differences, firing both fire bottles at the same time will DECREASE fire suppression capability.

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OAP Messages/Lights**Red Warning Lights**

APU FIRE - APU fire is detected. MASTER WARNING lights illuminate.

CARGO FIRE - Cargo fire is detected. MASTER WARNING lights illuminate.

Amber Caution Messages

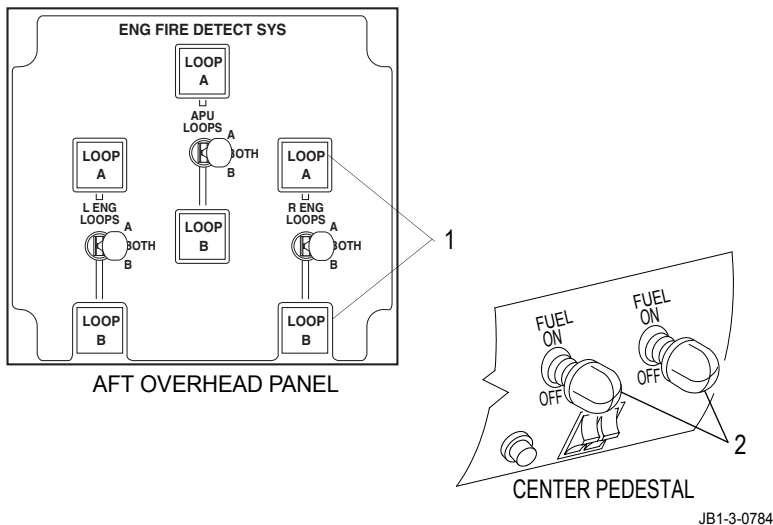
NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

FIRE DET LOOP (ENG) - At least one of the six loop lights is illuminated. MASTER CAUTION lights illuminate.

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Controls and Indicators

Cockpit Fire Controls/Indicators



1. LOOP A and B Light (L ENG/R ENG/APU)

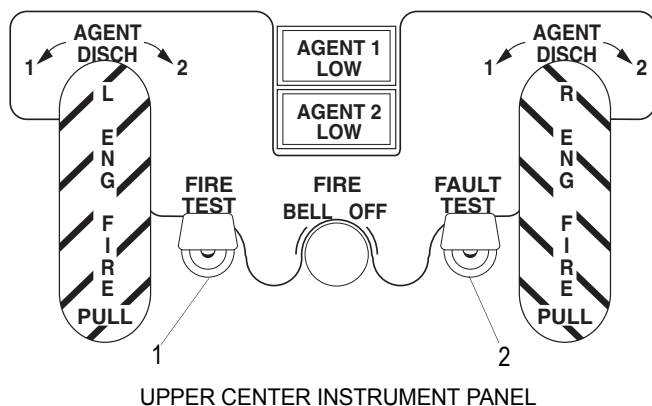
Illuminated - Activated by associated fire detection loop or FAULT TEST switch. Indicates possible fire detection loop malfunction when single LOOP (A or B) light illuminates and associated engine APU FIRE warning light does not illuminate.

2. FUEL Switch Light

Illuminated - Associated engine fire is detected or the system fire test is in progress (with FUEL switch ON).

NOTE: The FUEL switch light is normally tested with the annunciator/digital lights test button while the FUEL switch is OFF.

Engine Fire Extinguishing Controls/Indicators



1. FIRE TEST Switch (Momentary)

Tests both A and B loops. A successful test is indicated by the aural and vocal warnings, for each engine, and illumination of two MASTER WARNING lights, two ENG FIRE handles and an APU FIRE light.

2. FAULT TEST Switch (Maintenance Test) (Momentary)

Tests both A and B loops and components for faults.

System Description

Fire Warning System

Each system consists of ENG FIRE lights located in the fire handles on the upper center instrument panel (engine), a red APU FIRE light (APU), LOOP A and B lights located on the loop selector overhead panel, FIRE LOOP INOP and (L/R/ENG or APU) FIRE DET FAULT messages on the Overhead Annunciator Panel (OAP), aural and vocal warnings and a lighted FUEL switch located on the center pedestal.

Two independent fire loops (A and B) are installed for each engine and the APU. In normal operation, with the LOOPS switch in BOTH, both loops must be subjected simultaneously to fire or overheat conditions before they will activate the fire warning system. When a fire signal in one loop is detected by the control unit, the control unit tests the other loop for its capability to detect a fire. If the other loop is capable of detecting a fire, but is not yet detecting a fire (STBY condition), the system will wait for it to be heated to the alarm point before activating the fire warning. If the other loop is not capable of detecting a fire, the fire warning system is activated, and the initial LOOP light illuminates.

If one loop has a short circuit or loses power and the other loop is not capable of detecting a fire, the (L/R/ENG or APU) FIRE DET FAULT message on the OAP will be displayed and both LOOP lights on the overhead loop selector panel will illuminate indicating that the fire detector circuit is inoperative.

Engines

If both loops are detecting a fire, the ENG FIRE handle lights and the aural vocal warnings identify which engine has the fire or overheat condition. In addition, the respective FUEL switch light will illuminate to indicate the fire warning system has been activated.

NOTE: The FUEL switch will remain illuminated until the switch is placed in the OFF position, or the fire/overheat condition no longer exists, whichever occurs first.

Lavatory Smoke Detection System

The lavatory smoke detection system is designed to detect smoke inside the lavatory. Smoke detected in the lavatory will relay alert indications to the Flight Attendant through the aircraft call system, and the flight crew members through an OAP message "LAVATORY SMOKE". The cabin chime will sound 3 emergency Hi/Lo chimes. A red master call light on both the forward and aft attendant call light fixtures will illuminate. The amber call light located on the ceiling panel outside the lavatory with the smoke condition will also illuminate upon smoke detection. The red master call lights and the amber lavatory call light can only be reset by the removal of the smoke condition from the aircraft.

OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

FIRE LOOP INOP (ENG) - Fire detection loop is inoperative. Respective LOOP light also illuminates.

L/R APU ENG FIRE DET FAULT (ENG) - Both loops for respective indicated system are inoperative.

LAVATORY SMOKE (MISC) - Illuminates when smoke is detected in a lavatory.

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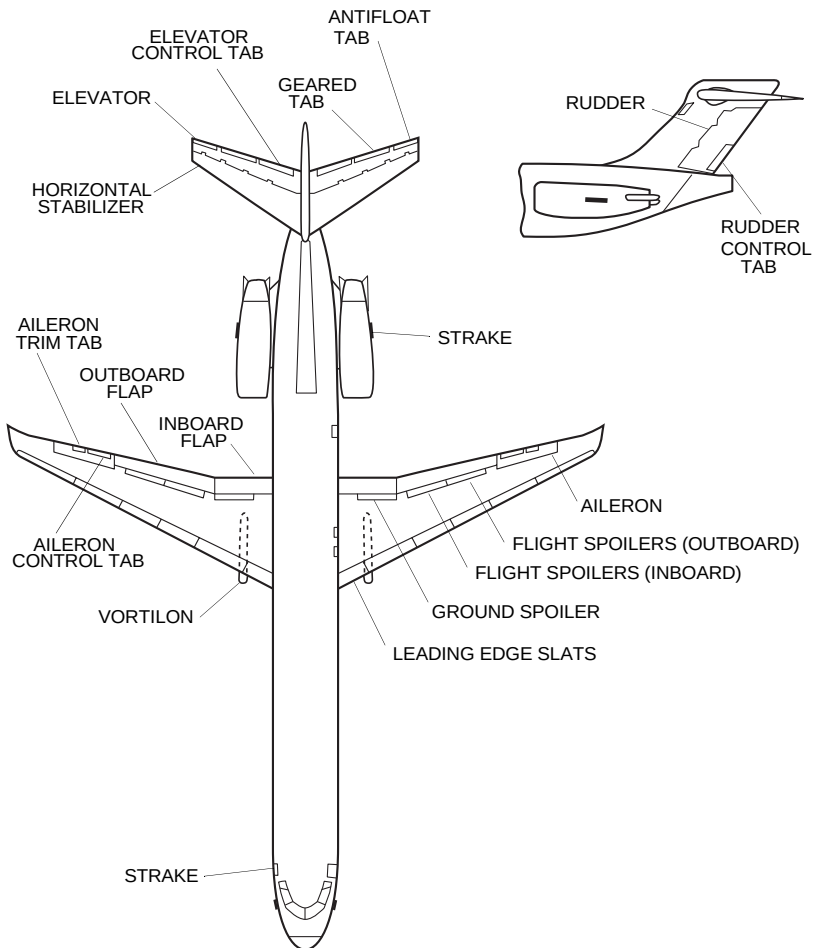
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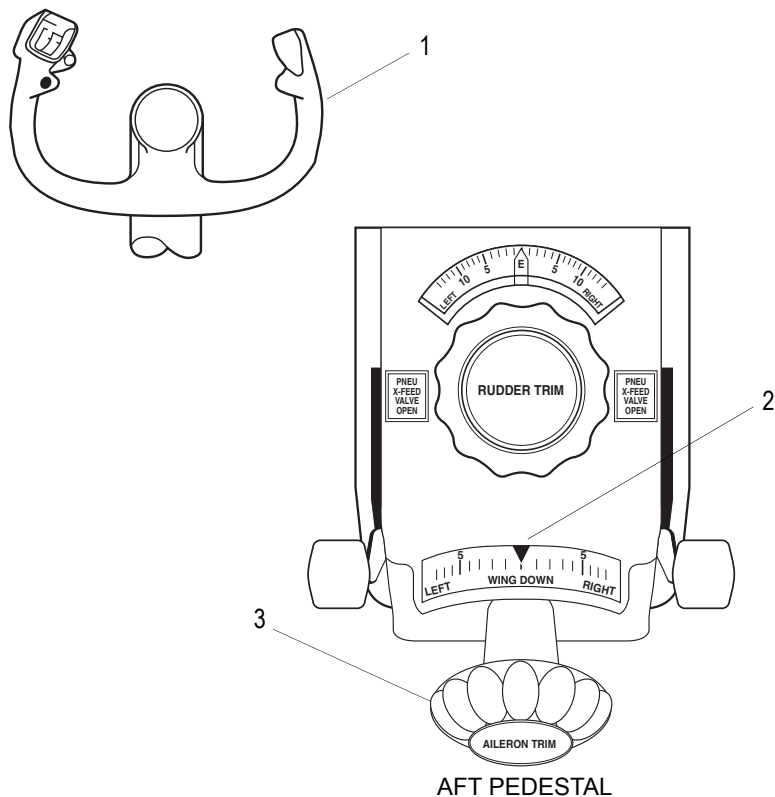
Flight Controls Controls and Indicators

Chapter 9 Section 10

Major Component Location



Lateral Control And Trim



1. Control Wheel (2)

Movement of the control wheel deflects the aileron control tab on each aileron.

2. Aileron Trim Indicator

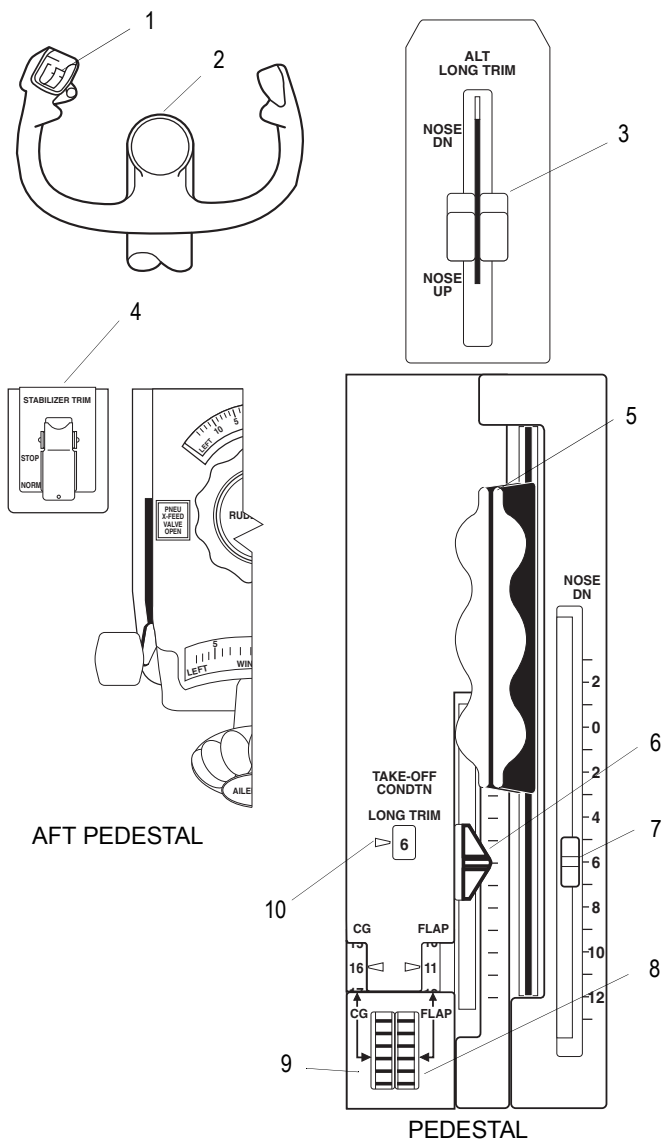
Provides reference point for amount of LEFT or RIGHT WING DOWN aileron trim.

3. Aileron Trim Knob

Rotation of trim knob deflects a trim tab on each aileron.

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Longitudinal Control And Trim



1. Control Wheel Trim Switches (2)

Switches activate primary trim. Both switches must be actuated simultaneously to electrically move the horizontal stabilizer. Actuation of both switches on both control wheels in the opposite direction at the same time cancels stabilizer trim.

2. Control Column (2)

During normal operation, movement of either control column is transmitted aft by two independent cable systems which are connected to their respective control tabs.

3. ALT LONG TRIM Levers (2)

The ALT LONG TRIM levers activate the alternate trim motor. Both levers must be activated simultaneously and in the same direction to electrically move the horizontal stabilizer.

4. STABILIZER TRIM Primary Brake Switch

This guarded switch is used only to stop a runaway horizontal stabilizer condition.

STOP - A brake stops horizontal stabilizer movement.

NORM - Normal horizontal stabilizer trim operation.

5. LONG TRIM Handles (2)

The LONG TRIM handles activate the primary trim. Both handles must be moved simultaneously to activate horizontal stabilizer movement. The trim handles override the electric control wheel switches as well as the ALT LONG TRIM levers.

6. LONG TRIM Takeoff Position Indicator (green)

The pointer is positioned by the computer when the CG and FLAP values are entered.

7. LONG TRIM Indicator (white)

The LONG TRIM indicator is mechanically connected to the horizontal stabilizer and indicates position and movement of the stabilizer.

8. FLAP Thumbwheel

Rotated to set takeoff flap position to be used.

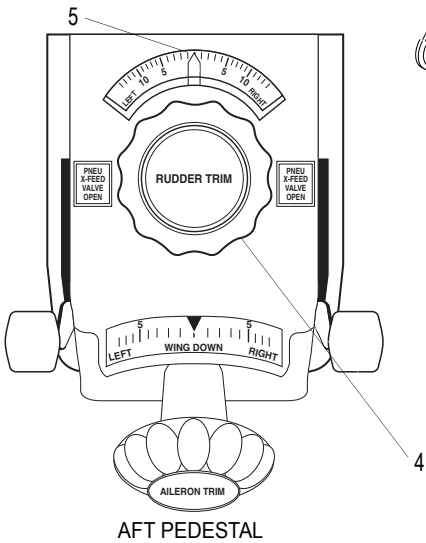
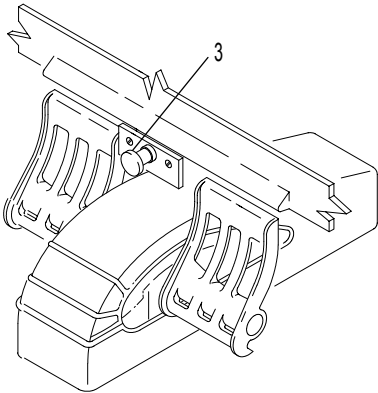
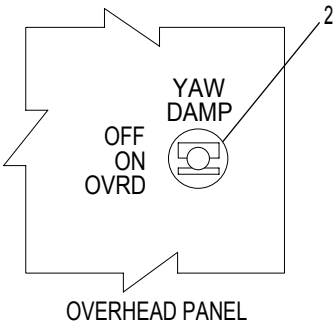
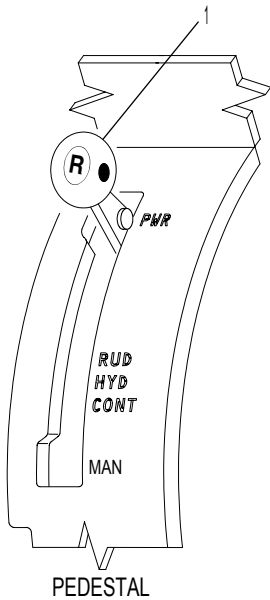
9. CG Thumbwheel

When rotated, desired CG appears in the CG readout.

10. TAKEOFF CONDTN LONG TRIM Readout Window

The calculated LONG TRIM setting appears when the takeoff CG and the FLAP values are entered in the computer.

Directional Control And Trim



JB1-3-0949

1. RUD HYD CONT Lever

PWR - Allows hydraulic pressure to power the rudder and lock the rudder control tab in a faired position.

MAN - Shuts off hydraulics to the rudder, unlocking the rudder control tab to respond to rudder pedal movement.

2. YAW DAMP Switch

OFF - Yaw damper operation is disabled if autopilot is disengaged. If autopilot is engaged, yaw damper operation is automatically provided.

ON - Yaw damper operation is provided with autopilot engaged or disengaged.

OVRD - Inhibits yaw damper operation with autopilot engaged or disengaged.

3. Rudder Pedal Adjustment Knob

Pedal adjustment is made by pulling out on the rudder pedal adjustment knob and positioning the pedals to the desired position.

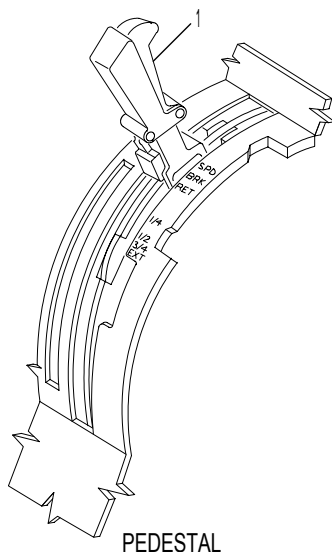
4. Rudder Trim Knob

Rotation of the knob towards NOSE LEFT/RIGHT displaces the rudder pedals to establish rudder trim.

5. Rudder Trim Indicator

Provides a reference point for the set amount of NOSE LEFT/RIGHT rudder trim.

Spoiler/Speed Brake



JB1-3-0950

1. SPD BRK Lever

Manual - In flight, the lever is used to control the flight spoilers to act as speed brakes when squeezed and pulled aft. Positions available are 1/4, 1/2, 3/4, or EXT.

On the ground, the lever deploys all spoilers when pulled up-aft-up. The lever is also used to release spoiler actuation when pushed down and allowed to move forward to RET.

Automatic - When armed (squeezed and pulled up), a red placard labeled ARM can be seen on both sides of the lever.

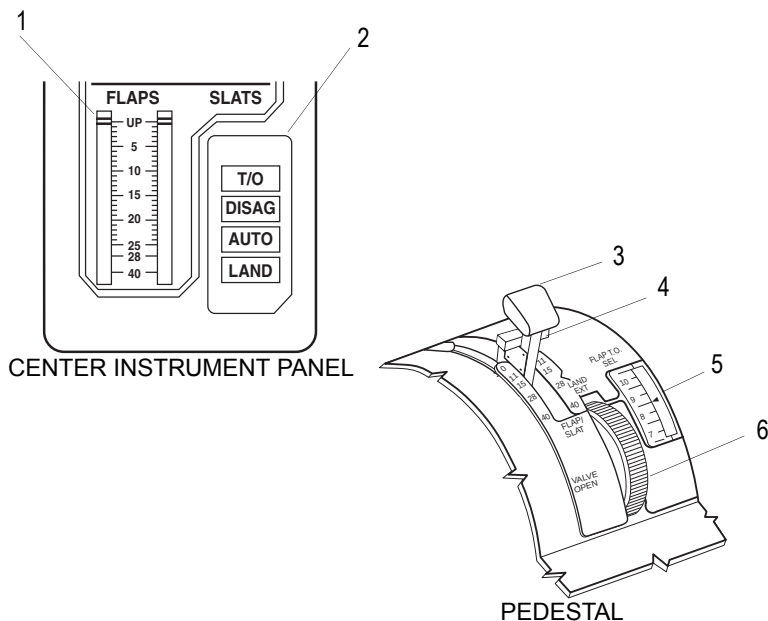
When armed prior to takeoff and a rejected takeoff is initiated (nosewheel on ground and throttles retarded), the flight and ground spoilers automatically extend to 60° upon actuation of reverse thrust.

When armed prior to landing, the flight and ground spoilers automatically extend to 60° upon main wheel spinup or nose wheel compression (groundshift).

When the spoiler lever moves aft, the flight and ground spoilers are fully extended to 60°.

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Flap/Slat System



1. FLAPS Position Indicators

Position of left outboard and right outboard flaps is indicated.

2. SLATS Advisory Lights

T/O - The FLAP/SLAT handle, flaps and the slats are in the takeoff range.

DISAG - The left and right wing slat positions do not agree with handle position and/or with each other.

AUTO - The slats have automatically extended from mid to extend position in response to the stall warning system (autoslat).

LAND - The FLAP/SLAT handle, flaps and slats are in the landing range.

3. FLAP/SLAT Handle

To extend flaps and slats, the left detent lever must be pulled up and the FLAP/SLAT handle is pulled aft until it latches in the 0° flap/slat extend, 11° flap, 15° flap, preselected takeoff detent, or the 28°/40° landing flap detent.

To set the takeoff DIAL-A-FLAP detent, the FLAP T.O.SEL thumbwheel is rotated until the proper takeoff flap setting is indicated in the FLAP T.O. SEL window.

The 15° go-around detent is provided with a gate to prevent retraction of the flaps to less than 15°.

To retract landing flaps, the flight crew must lift the left detent lever and move it forward past the go-around gate.

4. Left/Right Detent Levers

Left detent lever must be raised to move the FLAP/SLAT handle out of any fixed detent.

Right detent lever must be raised to move the FLAP/SLAT handle out of any Dial-A-Flap detent.

5. DIAL-A-FLAP T.O. SEL Window

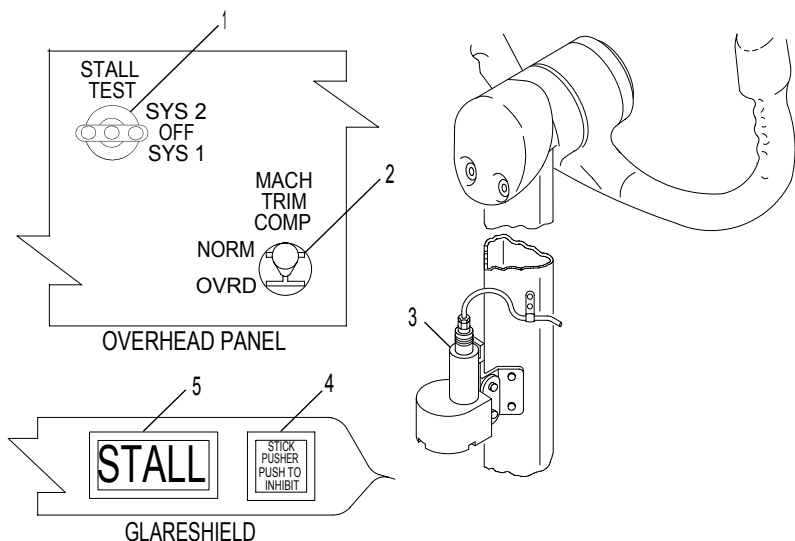
Indicates, in degrees, the preselected takeoff flap setting detent.

6. DIAL-A-FLAP T.O. SEL Thumbwheel

Provides a takeoff flap setting detent for any Dial-A-Flap setting between 0° and 13°, and 15° and 24°.

NOTE: Flap settings between 13° and 15° are not permitted.

Mach Trim And Stall Warning



JB1-3-0952

1. **STALL TEST Switch**

SYS 1 - Tests stall system. Operates stick shakers on both control columns. Turns on **STALL** and **STICK PUSHER PUSH TO INHIBIT** lights and sounds both stall recognition speakers.

OFF - Turns test off. Normal operating mode.

SYS 2 - Tests opposite system, indications are identical.

2. **MACH TRIM COMP Switch**

NORM - System automatically provides Mach trim.

OVRD - System is inoperative.

3. **Stick Shaker (2)**

The stick shaker on each control column actuates during a test of either stall warning system, and during an approach to stall condition. Vibration from either stick shaker is felt in both control columns.

4. STICK PUSHER PUSH TO INHIBIT Switchlight (2) (white)

Illuminates whenever the post stall recovery system (stick pusher) is activated, and during the stall warning test.

Push - Disengages the post stall recovery system (stick pusher) and extinguishes the switchlights.

NOTE: The post stall recovery system is inhibited anytime the red windshear warning light is illuminated.

5. STALL Light (2) (red)

Flashes during stall or during a test of the stall warning system.

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Flight Controls

System Description

Chapter 9

Section 20

General

Primary flight controls consist of aileron, rudder, and elevator control systems. Secondary flight controls consist of leading edge slats, flight and ground spoilers, inboard and outboard flaps, and horizontal stabilizer. Warning and recovery systems are provided for stall and adverse takeoff conditions, slats position, and windshear conditions.

Primary Flight Controls

Lateral Control

Control wheels are used for lateral control. Control wheels are cable-connected to respective aileron control tabs, and are linked together by a torque tube arrangement that causes both control wheels to move together. Should any part of the system between the torque tube and control tab become jammed, either control wheel will drive the unjammed aileron tab cable system by application of approximately 50 pounds of force at wheel rim. Aerodynamic forces on the control tabs move the ailerons. The ailerons are cable-connected in a manner that each aileron must respond to movement of the opposite aileron. Each aileron contains a trim tab that is cable-connected to the pedestal trim knob. Aileron lateral control is augmented by flight spoilers operating in proportion to control wheel displacement and/or speed brake input.

Pitch Control System

The MD-88 has a “T” type tail configuration. Two elevators are attached to the rear of the horizontal stabilizer. The elevators are displaced by aerodynamic control tabs (one on each elevator). Each control tab is driven by an independent two way cable system from the corresponding control column in the cockpit. The only connection between the two control systems is a bus torque tube that connects the control columns. Movement of the control column moves both control tabs and aerodynamic force generated by the tabs moves the elevators. As each elevator moves, an additional tab, geared to elevator movement (geared tab), moves to assist the control tab in displacement of the elevator.

An anti-float tab is installed on each elevator outboard of the geared tab to improve the longitudinal trim in an extreme forward center-of-gravity (beyond 10° trim aircraft nose up) landing configuration. The tabs bring the elevators up to a more faired position with the stabilizer. This prevents the elevators from floating in an extreme angle of attack condition.

Aerodynamic load feel forces are supplemented by a variable load feel system which is connected by cables to the longitudinal trim system. Control column force varies with stabilizer movement and decreases with forward center of gravity conditions.

A hydraulic power augments system provides elevator control for additional nose down capability in extreme, high angle of attack flight conditions. Supplied by the left hydraulic system, the power augments system activates during an extreme stall condition after elevator control tabs have been displaced approximately 10° airplane nose down with respect to elevator surface. (This power augments system hydraulically displaces the elevators full down.) A blue ELEVATOR POWER ON light on the overhead annunciator panel illuminates when hydraulic pressure is being applied to the elevator.

Mach Trim Compensation

Operating on a Mach schedule, the Mach trim compensator pulls the First Officer's control column aft as Mach number increases. As the control column moves aft, an indicator rod on the left side of the First Officer's column extends, giving visual indication of Mach trim operation. Mach trim can be selected to NORM (normal) or OVRD (override) by a switch on the overhead panel.

Directional Control

Directional control is obtained through rudder pedals that control rudder movement. The rudder is powered by the right hydraulic system, but may be operated aerodynamically without hydraulic power.

The Captain's and First Officer's rudder pedals are connected by a torque tube forward of the pedals. Each set of rudder pedals is individually adjustable.

Nose strakes on the fuselage enhance directional stability.

Powered Rudder

During powered rudder operation, the rudder control tab is locked hydraulically. Rudder pedal movement activates the rudder. Trim is accomplished by turning the rudder trim knob on the pedestal. Rotation of the trim knob LEFT or RIGHT trims the rudder by adjusting the position of the rudder pedals. Hydraulic power to the rudder may be shut off by moving the RUD HYD CONT lever to MAN. When hydraulic power to the rudder is shut off, or when pressure is lost, the rudder automatically reverts to manual operation, unlocking the rudder control tab. The message, RUD CONTROL MANUAL, is displayed on the OAP, indicating manual rudder operation, and MASTER CAUTION lights illuminate.

Manual Rudder

During manual rudder operation, rudder pedal movement operates a control tab on the rudder. Aerodynamic force on the control tab moves the rudder. Trim is accomplished by turning the rudder trim knob on the pedestal, which adjusts the position of the rudder pedals.

Rudder Throw Limiter

A rudder throw limiter is installed to protect the empennage from overload in case of inadvertent application of excessive rudder control. The limiter operates by ram air pressure from an electrically heated pitot tube on the leading edge of the vertical stabilizer. The higher the airspeed, the greater the limit on rudder movement. During acceleration, the throw limiter is scheduled to vary between the maximum throw of 22° (unrestricted) up to 2½° (fully restricted) at approximately 300 knots. The blue RUDDER TRAVEL UNRESTRICTED light must be extinguished above 200 knots. On deceleration, the throw increases until reaching 22° at a minimum speed of 144 KIAS. The rudder throw limiter is monitored by the blue RUDDER TRAVEL UNRESTRICTED light on the OAP.

Yaw Damper

A yaw damper is installed in the rudder system to provide automatic damping of any lateral oscillation. Yaw damper operation is selected with the YAW DAMP switch on the forward overhead panel. The YAW DAMP OFF message on the OAP is displayed when the yaw damper is not active.

Yaw damper operation is a function of both the 3-position YAW DAMP switch, and autopilot engagement. With the autopilot selected ON, the yaw damper is active with the YAW DAMP switch in either ON or OFF. With the autopilot selected OFF, the yaw damper is active only with the YAW DAMP switch in ON. When the YAW DAMP switch is selected to OVRD, the yaw damper is disabled, regardless of autopilot function.

Secondary Flight Controls

Spoiler System

Each wing has two flight spoilers that are operational during all phases of flight and a ground spoiler that is operational only on the ground. The spoiler system provides the following:

1. Lateral control augmentation in all modes of flight spoiler operation.
2. Automatic ground and flight spoiler extension upon touchdown and main wheel spin-up to spoil lift, thereby increasing braking efficiency.
3. Manual extension of ground and flight spoilers during landing or rejected takeoff.
4. Selectable extension of flight spoilers to serve as speed brakes.

Flight Spoilers

An inboard and outboard spoiler on each wing supplement the ailerons for lateral control. Movement of the spoilers occurs as the control wheel actuates the aileron control tabs, which are cable-connected to the spoiler system. Both the inboard and outboard spoiler systems are interconnected to both aileron control systems. The aileron/spoiler mixer assembly provides control of spoiler movement in relation to aileron control tab movement.

When the control wheel is rotated (ailerons deflected) past approximately a 5-degree wheel angle, the flight spoilers start to extend on the downward moving wing. Further control wheel movement extends the flight spoilers in proportion to lateral control demands.

When the spoiler/speed brake lever is manually moved aft, and the control wheel is rotated, the aileron/spoiler mixer assembly operates the flight spoilers asymmetrically, increasing spoiler extension on the downward moving wing and decreasing spoiler extension on the upward moving wing. During landing rollout, when the spoilers are at the maximum extend position (60 degrees), use of down aileron (to lift wing) causes the flight spoilers on that wing to partially retract.

Inboard and outboard flight spoilers are powered by separate hydraulic systems. If one hydraulic system fails, the operative spoilers still function.

Speed Brakes (In Flight)

During flight, manually moving the pedestal-mounted spoiler/speed brake lever aft extends the four flight spoilers to serve as speed brakes. These surfaces may be symmetrically extended to a maximum of 35 degrees.

Use of aileron control during speed brake operation results in asymmetrical extension of the spoilers to aid in lateral control.

In flight, speed brakes may be extended with slats extended.

In flight, if the flaps are extended with speed brakes extended, the SPOILER FLAP EXTEND message is displayed, and the MASTER CAUTION lights illuminate. In addition, aural and vocal "SPEED BRAKE" warnings sound.

Spoilers (RTO)

The system is armed for automatic operation by pulling up on the SPD BRK lever until a red armed placard is exposed and the lever latches in the up position. When armed prior to takeoff and a rejected takeoff is initiated (nosewheel on ground and throttles at idle), flight and ground spoilers will automatically extend to 60° with reverse thrust.

Spoilers (After landing)

The system is armed for automatic operation by pulling up on the SPD BRK lever until a red armed placard is exposed and the lever latches in the up position. When the system is armed and the throttles are moved towards idle, the spoilers automatically extend after wheel spin-up or after the nosegear actuates ground shift. After landing, all spoilers (flight and ground) are extended to a maximum of 60° to serve as ground spoilers. The spoilers retract and the SPD BRK lever will be disarmed if the throttles are advanced for a go-around.

If the automatic system is inoperative, all spoilers can be manually extended to full deployment by moving the speedbrake lever up and then aft to the lever stop. Once in this aft position, the lever may be pulled upward once again if desired to engage a lever latch.

Spoiler/Speedbrake Annunciations

On the ground, if either throttle is advanced with the SPD BRK lever not full forward, the vocal warning "SPOILERS" will sound.

On the ground, a SPOILER DEPLOYED message illuminates if any spoiler panel is deployed and the SPD BRK lever is full forward (stowed or armed). The message is inhibited when the throttles are advanced for takeoff. The SPOILER DEPLOYED message also illuminates in flight if either ground spoiler is extended.

In flight, speedbrake extension with the flaps beyond 6° will produce a SPOILER/FLAP EXTEND message, MASTER CAUTION lights, and an aural "SPEEDBRAKE" warning will sound.

The SPOILER/FLAP EXTEND message is illuminated on the ground during manual deployment of spoilers with the flaps extended.

Flaps

The trailing edge flap system consists of inboard and outboard flap segments on each wing. Each flap has an inboard and outboard cylinder powered by separate hydraulic systems. Although the flaps normally operate on both hydraulic systems, one hydraulic system is capable of operating the flap system at a reduced rate. All flap segments are mechanically bussed together for simultaneous extension and retraction.

Flaps may be positioned in any of the permanent detents in a 0 to 40 degree range by movement of the FLAP/SLAT handle. A FLAP T.O. SEL detent selector that positions a movable takeoff detent anywhere in the 0 to 13 degree and 15 to 24 degree range may also be used to set takeoff flaps.

Flaps Position Indicator

FLAPS position is displayed on the systems display panel on the center instrument panel. Left and right flap positions are indicated by a horizontal bar on the left and right sides of the indicator in degrees of flap travel. The bars respond to actual flap position rather than flap handle position. Each outboard flap is linked to a separate flap position transmitter that sends a signal to the flap position indicator in the cockpit.

Leading Edge Slat System

The slats are divided into six segments on each wing and are fastened together to operate as a single unit. The slats normally operate by pressure from both hydraulic systems but continue to operate at a reduced rate with single system hydraulic pressure.

The slats are manually actuated by the FLAP/SLAT handle. Three slat positions may be selected: retracted, mid, and extended. When the FLAP/SLAT handle is in the UP/RET position, the slats are retracted. When the FLAP/SLAT handle is in the 0 to 13 degree range, the slats are in the mid position. The slats will be in the extended position whenever the FLAP/SLAT handle is in the 15 to 40 degree range.

Four SLATS advisory lights on the center instrument panel provide slat configuration status. The four lights advise proper settings of the flaps and slats for takeoff (T/O), and for landing (LAND) configurations. Any discrepancy between slat positions (left and right wing) or between FLAP/SLAT handle setting and slats position causes the DISAG light to illuminate. The AUTO light illuminates when slats are extended from mid to extend position by the stall warning system.

Horizontal Stabilizer (Longitudinal Trim)

A movable horizontal stabilizer provides longitudinal trim. The stabilizer is moved by a jackscrew driven by either a primary or an alternate electric motor. Primary trim control is accomplished by actuating dual switches on either control wheel or by moving dual handles on the pedestal. Operation of the primary trim control moves the stabilizer 1/3 degree per second. Alternate stabilizer operation is provided by two ALT LONG TRIM levers mounted on the center of the pedestal. Operation of the alternate trim control moves the stabilizer 1/10 degree per second. The alternate trim motor is also used by the autopilot.

All stabilizer operation is protected by dual switches and dual circuits. One switch/circuit controls an electric brake; the second controls power to the jackscrew motor.

Whenever the control wheel trim switches or LONG TRIM handles are actuated (primary trim control), both switches/handles must be moved simultaneously and in the same direction to result in stabilizer movement. When the dual switches in one control wheel are being operated, selection of opposite direction movement by switches in the other wheel will cancel stabilizer movement.

Whenever the ALT LONG TRIM levers are activated (alternate trim control), both levers must be moved simultaneously to result in stabilizer movement.

Movement of the primary trim control in one direction and the alternate trim control simultaneously in the opposite direction will result in a stabilizer movement rate that is the difference of the two inputs, in the direction of the primary trim.

A red guarded switch on the aft pedestal is used to stop a runaway stabilizer caused by the primary trim motor. When the switch is moved to STOP, power is removed from the stabilizer trim brake. Springs then force the brake to clamp on the primary trim motor. The primary trim motor is protected by thermal cutout switches should the motor overheat. The thermal switches auto reset when the trim motor cools.

When the horizontal stabilizer is being moved an audible signal sounds once for each 1/2 degree of stabilizer movement.

A vocal warning "STABILIZER MOTION" sounds when the stabilizer is moved by the autopilot more than 2 degrees in 30 seconds.

Take-Off Condition Computer

Stabilizer takeoff settings are determined by entering calculated takeoff values for CG and flap setting into the pedestal mounted computer. When the appropriate CG and flap settings are in their respective readout windows, the approximate stabilizer setting numeric value appears in the TAKE OFF CONDTN LONG TRIM window. The AWABS numeric value may then be set using either the LONG TRIM handles or the control wheel trim switches. When the LONG TRIM indicator matches the LONG TRIM position takeoff indicator, the stabilizer is set for takeoff.

Take-Off Warning

With the airplane on the ground, and the throttles advanced for takeoff, any of the following conditions will cause the aural and vocal system to activate:

- FLAP/SLAT handle not in agreement with the value set in the FLAP window of the TAKE OFF CONDTN computer - "FLAP"
- Horizontal stabilizer not set within the green-band area of the LONG TRIM indicator - "STABILIZER"
- Slats not extended - "SLAT"
- Spoiler/speed brake lever not in the retract detent - "SPOILERS"
- Parking brake set - "BRAKES"
- Spoiler/speed brake lever armed when autobrakes are not selected for takeoff - "AUTO BRAKE"
- Autobrakes selected for takeoff and spoiler/speed brake lever not armed - "AUTO SPOILER"

Flap/Landing Gear Warning

If the flaps are extended beyond 26 degrees and the landing gear is not down and locked, the aural and vocal warning systems sound and cannot be silenced by the GEAR HORN OFF button until the landing gear is down and locked.

With throttles at idle, airspeed is less than 210 KIAS, altitude is less than 1500 feet, and the gear is not down and locked, the aural and vocal "LANDING GEAR" warning system sounds. The aural and vocal warnings may be silenced by pushing the GEAR HORN OFF button if the flaps are set less than 26 degrees. However, the warning(s) reactivate if throttles are advanced then retarded to idle again.

Stall Protection

An approach to stall is detected by either of two independent stall warning systems. There are two stall warning computers that receive inputs from the angle of attack sensors and other various flight control surface position transmitters. There can be four functions initiated by the stall warning system in a stall condition.

Auto Slats

If the FLAP/SLAT handle is set in the 0 to 13 degree flap range, airspeed is 240 KIAS or less, and either of the two stall warning computers detects an approach-to-stall, the slats extend automatically from the mid to the extended position. The slat DISAGREE and AUTO lights illuminate with autoslat extension. When the approach-to-stall condition ceases to exist, the slats retract automatically to the mid position.

On the ground, the autoslat system automatically undergoes a self test whenever takeoff flaps/slats are first selected. When the FLAP/SLAT handle is moved from UP/RET to any position less than 14°, the slats extend from the retracted position through mid to extended position and back to mid position. While the slats are at the extended position, the slat DISAGREE and AUTO lights illuminate. If the AUTO SLAT FAIL message also is displayed, a failed test is indicated. The AUTO SLAT FAIL message can be reset and the test re-accomplished by cycling the FLAP/SLAT handle to UP/RET and back to 0°- 13° range.

Stick Shaker

As the aircraft continues into a deeper pre-stall with the angle of attack increasing, the stick shakers are activated. Both control columns will vibrate when this is sensed by either stall warning computer.

Stall Warning Lights and Audio

As the aircraft continues toward a stall, either stall warning computer will activate the stall warning horn, vocal "STALL", and illuminate the red glareshield STALL lights.

Stick Pusher System

Whenever a stall condition is detected by both stall warning systems and the slats are not retracted, the control columns are abruptly moved forward, the STICK PUSHER PUSH TO INHIBIT glareshield lights illuminate, and the autopilot, if engaged, will disconnect.

The post stall pusher system keeps forward pressure on the control columns until the stick pusher is shut off by a g-force reduction to approximately 0.6g or pushing either of the STICK PUSHER PUSH TO INHIBIT white glareshield lights. This will illuminate the STALL IND FAILURE message. In addition, the stick pusher may be manually overridden by pulling aft on the control column. However, if stall persists and aft pressure is released, the stick pusher will again force the column forward.

The following is a summary of three possible aircraft configurations with their stall warning indications:

Stall - Flaps 0°, 5°, or 11°, Slats Mid

- Auto Slat extend.
- Stick Shaker.
- Stall warning lights and audio.
- Stick pusher.

Stall - Flaps 15°, 18°, 28°, or 40°, Slats Extended

- Stick Shaker.
- Stall warning lights and audio.
- Stick pusher.

Stall - Clean Wing

- Stick Shaker.
- Stall warning lights and audio.

The post stall recovery system is inhibited anytime a decreasing performance shear (tail windshear) is detected and the red WND SHR warning lights on the glareshield illuminate. The STICK PUSHER PUSH TO INHIBIT lights illuminate and the STALL IND FAILURE message is displayed.

Windshear Detection

A windshear detection system provides detection, warning and guidance during windshear conditions through a single windshear computer. The Windshear Computer interfaces with two stall warning computers to receive stick shaker signals for pitch limit indication.

OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

RUD CONTROL MANUAL (HYD) - There is no hydraulic power to the rudder.

STALL IND FAILURE (MISC) - A system channel is inoperative or malfunctioning, or the post stall recovery system has been shut off either by a reduction in "g" force or by activation of the STICK PUSHER PUSH TO INHIBIT switch.

AUTO SLAT FAIL (CONT) - Auto slat system malfunction.

AUTO SPOILER FAIL (CONT) - Malfunction in ground spoiler system; does not preclude use of manual spoilers.

MACH TRIM INOP (CONT) - Illuminates when system deactivated by Mach trim compensator monitor or switch.

SPOILER DEPLOYED (CONT) - A ground spoiler is extended in flight. On the ground, any spoiler is deployed with the spoiler/speed brake lever stowed. The message is inhibited on the ground when the throttles are advanced for takeoff.

SPOILER FLAP EXTEND (CONT) - Speed brakes and flaps are extended in flight.

YAW DAMP OFF (CONT) - The yaw damper is inoperative, or, the YAW DAMP switch is in OVRD, or, the autopilot is not engaged and the switch is OFF.

Blue Advisory Lights

ELEVATOR POWER ON - Indicates hydraulic elevator augmentation system activated.

RUDDER TRAVEL UNRESTRICTED - Indicates full rudder travel is available.

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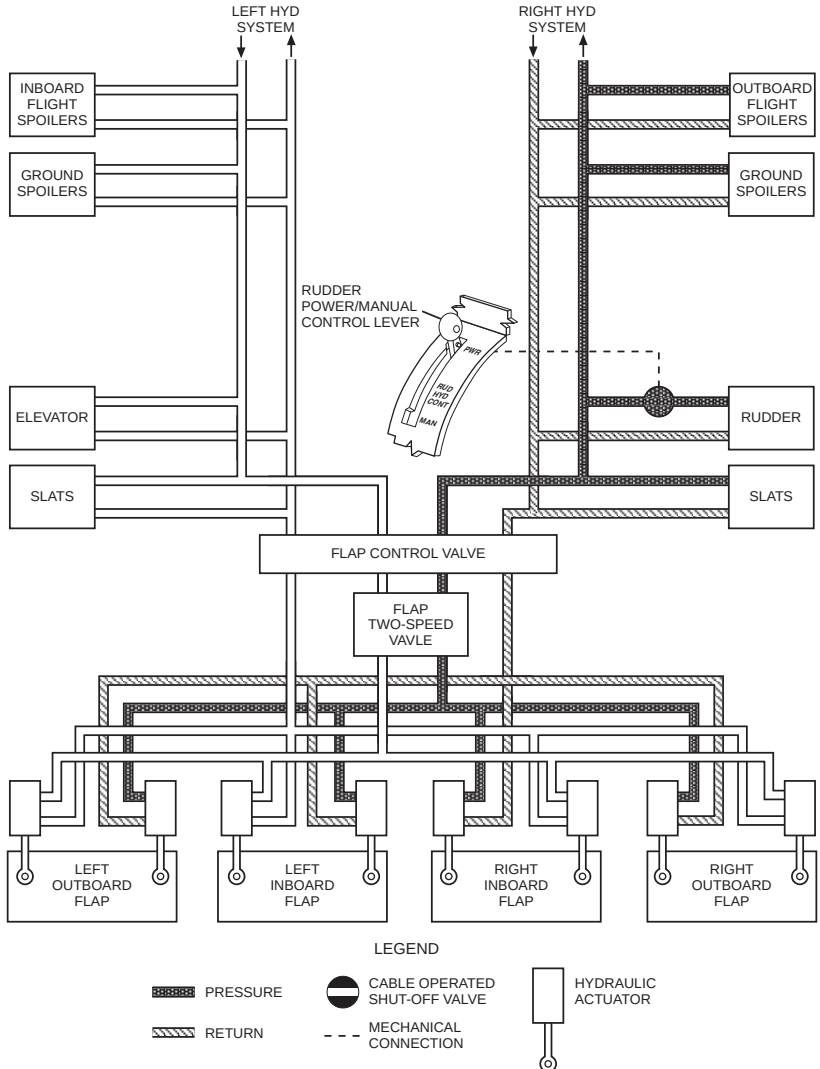
Flight Controls

Functional Schematic

Chapter 9

Section 40

Flight Control Hydraulics



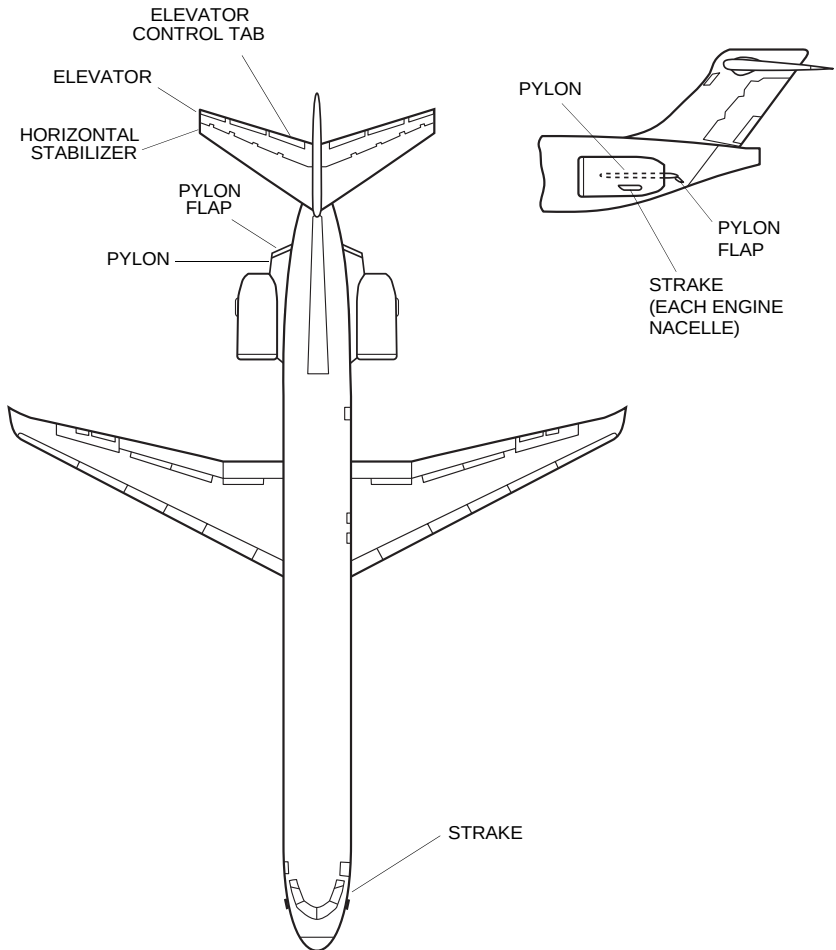
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Flight Controls MD-90 Differences

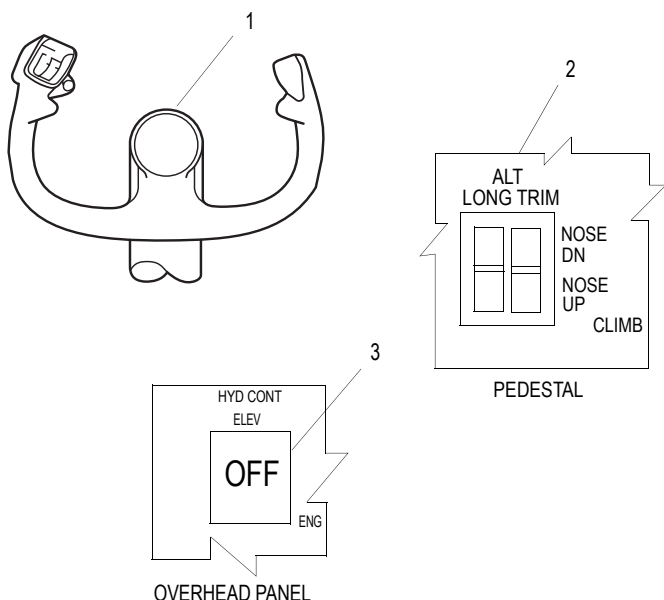
Chapter 9 Section 90

Controls and Indicators

Major Component Location



Longitudinal Control And Trim



1. Control Column (2)

During normal, powered operation, movement of either control column is transmitted aft by two independent cable systems. The cable sectors are connected to left and right tandem actuators and tandem control valves, which move both elevators.

During manual operation, the control tabs are unlocked and the resulting aerodynamic force on the tabs move the elevators.

2. ALT LONG TRIM Switches (2)

The ALT LONG TRIM switches activate the alternate trim motor. Both switches must be activated simultaneously and in the same direction to electrically move the horizontal stabilizer.

3. HYD CONT ELEV Switch - (amber)

(Momentary) Push to remove or restore hydraulic power to the elevator. The switch will illuminate when OFF is selected.

System Description

Auxiliary Control System

The auxiliary control system (ACS) provides automatic control, monitoring and fault data storage and retrieval of several flight control functions. The auxiliary control unit (ACU), installed in the electrical/ electronic (E/E) compartment, contains two separate channels. Except for the elevator load feel (ELF) function, in the event of failure of one channel, most functions can be provided by the other channel.

Functions included in the system are ELF, horizontal stabilizer in motion detector, elevator hydraulic power control, rudder stop limiter, and rudder hook monitor.

Longitudinal Control

Longitudinal control is provided by elevators attached to the horizontal stabilizer. Elevator control, for all normal flying, is hydraulically powered, with manual operation (non-powered) capability. Two elevator power control units, one for each elevator, position the elevators hydraulically for normal operation.

During normal, powered operation, the elevators are positioned through movement of the control columns. Control column motion is transmitted aft by two independent cable systems to the left and right cable sectors in the vertical stabilizer. The cable sectors are connected to left and right tandem actuators and tandem control valves, which move the elevator surfaces.

Elevator hydraulic control is accomplished through the ACU. The ACU monitors hydraulic pressure to the actuators, controls the two motor-operated shutoff valves, and generates the ELEV CONTROLS MANUAL message on the overhead annunciator panel (OAP) during manual elevator operation.

The digital flight guidance computer (DFGC) performs a continuous comparison between the left and right elevator positions. If the DFGC detects a difference between the left and right elevator positions it sends a split elevator signal to the ACU. The ELEVATOR SPLIT message is displayed on the OAP and the MASTER CAUTION lights illuminate.

The elevators are supplied hydraulic pressure by both hydraulic systems. Each system supplies 3000 psi of hydraulic pressure to a pressure regulator, where the pressure is reduced to 1500 psi. Each system then independently supplies 1500 psi of hydraulic pressure to the elevator actuators for a combined output force capability equivalent to one system at 3000 psi. If a failure occurs in either hydraulic system, the remaining system pressure is not reduced at the pressure regulator, but remains at the 3000 psi required to drive the elevators.

By pushing the HYD CONT ELEV switch on the overhead panel, powered elevator control is eliminated and manual control is established. Powered control may be reselected by pushing the switch a second time. A slight delay is experienced while the ACU verifies that the system is in the correct configuration before power is applied to the elevators. By selecting manual control the HYD CONT ELEV switch illuminates (with the word OFF), and ELEV CONTROLS MANUAL is displayed on the OAP to confirm reversion to manual control. MASTER CAUTION lights also illuminate.

In the event of a total loss of hydraulic pressure or a malfunction of the powered elevator system, elevator control automatically reverts to manual operation by unlocking the elevator control tabs to position the elevators aerodynamically. This event generates the message ELEV CONTROLS MANUAL on the OAP and causes the MASTER CAUTION lights to illuminate.

During manual operation of the elevators, a manual reversion mechanism operates a single control tab (faired for powered operation, and unlocked when reverting to manual control) on each elevator. Each unlocked control tab is driven by an independent two-way cable system from the corresponding control column in the cockpit.

The left and right control columns are connected by means of an override mechanism. Should any part of the two systems become jammed, an override mechanism allows the pilot on the non-jammed side to override the jam.

Elevator Standby Cable Loop System

A standby cable loop system automatically activates to provide elevator control in the event that both sets of elevator cables are severed due to an uncontained engine failure.

The standby cable loop system, using a different pathway to the elevator, provides elevator control. Reduced pitch response and increased column forces may be expected due to the increased friction and free play of the system.

Elevator Load Feel

Load feel forces are simulated by two variable load feel mechanisms, which are attached to the control columns. Electromechanical actuators change the load feel based on signals received from the elevator load feel (ELF) function of the ACU. The ELF varies control column forces in response to changes in airspeed and aircraft configuration. The ACU is dual channel, each channel controlling a single load feel actuator. Failure of both ACU channels generates the message ELEV LD FEEL INOP on the OAP. The MASTER CAUTION lights illuminate.

Mach Trim Compensation

Mach trim compensation is accomplished with horizontal stabilizer trim. The digital flight guidance computer (DFGC) commands the alternate trim motor to provide corrective Mach trim during high Mach number conditions. Mach trim can be selected NORM or OFF by the MACH TRIM COMP switch. A MACH TRIM OFF message on the OAP advises that Mach trim is not selected. A MACH TRIM FAULT message advises that Mach trim is inoperative as detected by the DFGC when the MACH TRIM COMP switch is in NORM.

Rudder Throw Limiter

Primary and backup rudder throw limiter systems protect the empennage from inadvertent overload. Failures in either the primary or the backup limiting systems generate messages on the OAP.

The primary rudder throw limiter operates by ram air pressure from the pitot tube on the leading edge of the vertical stabilizer. The throw limiter is scheduled to vary the maximum available rudder throw from unrestricted to maximum restriction, functioning as a result of the changing (increasing or decreasing) airspeed. A rudder hook monitor verifies that the primary limiter is in the proper position.

The backup rudder throw limiter is hydraulically powered, and protects the empennage from overload in the event excessive rudder control is attained due to a failure in the primary system.

The backup rudder throw limiter functions hydraulically through a two-position rudder stop limiter. The rudder stop limiter has a stop arm attached to the rudder torque tube and two hydraulic actuators. The ACU monitors the rudder stop limiter, and commands the hydraulic actuators based on airspeed. Hydraulic power is supplied to each actuator by its associated hydraulic system.

The backup limiter continues to operate with single system hydraulic failure. The backup limiter is retracted by springs in the event both hydraulic systems fail.

In-Flight Spoiler Lockout

An in-flight spoiler lockout mechanism prevents manual movement of the speed brake lever in flight when the flaps are extended 8 degrees or greater.

Horizontal Stabilizer (Alternate Trim)

Operation of the alternate trim switches move the stabilizer 1/5 degree per second. The alternate trim motor is also used by the autopilot for longitudinal trim and Mach Trim compensation.

Pylon Flap Pitch Augmentation

A pylon flap system, installed on the trailing edge of each pylon, provides increased aircraft nose-down pitching moment in the event a deep stall is encountered.

The pylon flap system receives hydraulic pressure from the left hydraulic system. The left system elevator accumulator provides system pressure in the event of a failure of the left hydraulic system.

Moving either control column to the forward stop activates the system. The pylon flap surfaces move from neutral position to fully deployed. Moving the control column off the forward stop causes the pylon flap surfaces to return to the neutral position.

The blue ELEVATOR AT LIMIT light on the OAP illuminates to indicate that the pylon flaps and the elevators have reached the full down position, and will also indicate full up position of the elevator.

The message PYLON FLAP FAULT is displayed on the OAP to indicate pylon flap position disagrees with the commanded position. The MASTER CAUTION lights also illuminate.

OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

TAKEOFF WARNING FAIL (MISC) - The takeoff warning is not available when throttles are advanced for takeoff.

10 DEG RUD RESTRICT (CONT) - Indicates 10 degree limiter is engaged at low airspeed.

BKUP RUD LIM FAULT (CONT) - 10 degree limiter not in proper position.

ELEV CONTROLS MANUAL (CONT) - No hydraulic power to the elevator. MASTER CAUTION lights illuminate.

ELEV LD FEEL INOP (CONT) - Failure of both channels of the auxiliary control unit. MASTER CAUTION lights illuminate.

ELEVATOR SPLIT (CONT) - Left and right elevator position differs. MASTER CAUTION lights illuminate.

MACH TRIM FAULT (CONT) - DFGC detects Mach trim is inoperative with MACH TRIM COMP switch in NORM.

MACH TRIM OFF (CONT) - MACH TRIM COMP switch selected OFF.

NO BKUP RUD LIM (CONT) - Indicates failure of backup system only.

PRIMARY RUD LIM FAULT (CONT) - The primary rudder limiter is not in proper position. MASTER CAUTION lights illuminate.

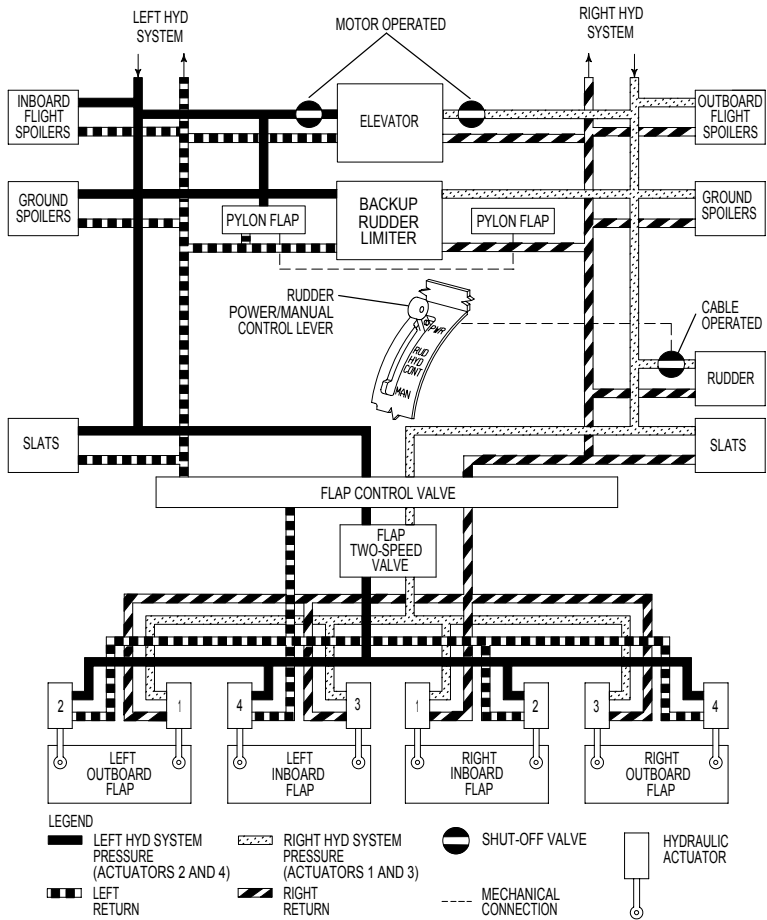
SNGL ELEV FEEL FAULT (CONT) - Indicates the failure of a single channel of the auxiliary control unit.

PYLON FLAP FAULT (CONT) - The pylon flap position disagrees with the commanded position.

Blue Advisory Lights

ELEVATOR AT LIMIT - Indicates elevators and pylon flaps full down, or elevators full up.

Functional Schematic
Flight Control Hydraulics



JB1-3-0945

Flight Instruments, Displays

Chapter 10

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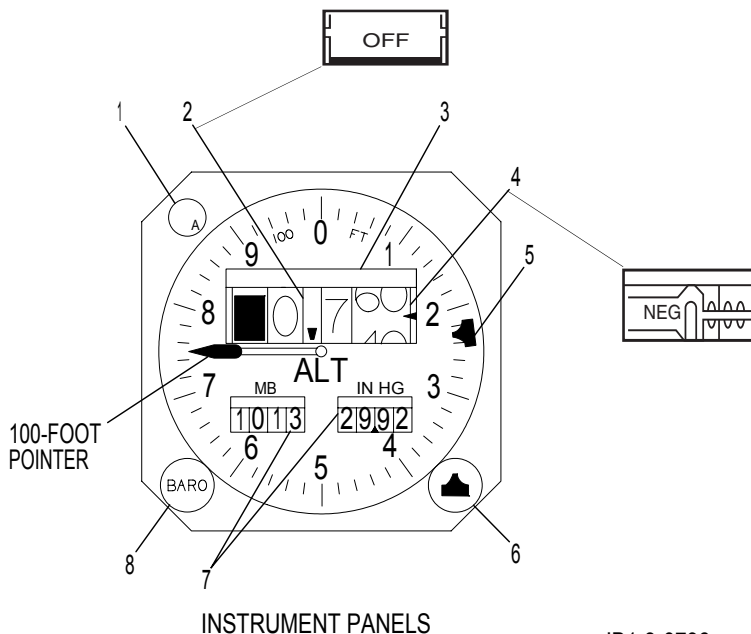
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Flight Instruments, Displays Controls and Indicators

Chapter 10 Section 10

Altimeter



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1. Altitude Alert Light (amber)

Indicates airplane is approaching a preselected altitude or deviating from acquired altitude.

2. Altitude OFF Flag (red)

Indicates a failure.

3. Digital Readout

Indicates baro altitude from -1000 to 50,000 feet. The "0" position of the ten-thousands drum is green for indication of altitudes less than 10,000 feet.

4. NEG Flag (red)

A negative altitude flag obscures digital readout to annunciate altitudes less than 0.

5. Altitude Reference Index

Index is set with the reference index knob.

6. Reference Index Knob

Sets altitude reference index as desired.

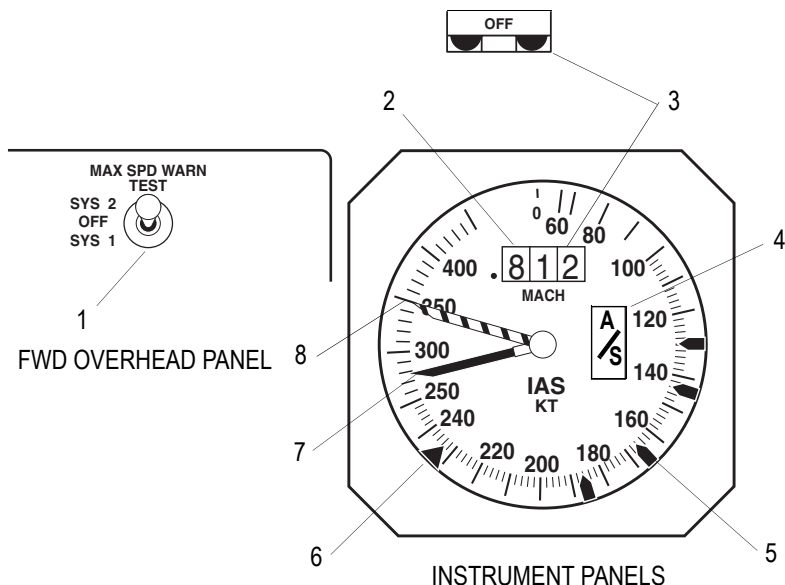
7. MB/IN HG Readout

Indicates selected barometric pressure as expressed in millibars and inches of mercury.

8. BARO Set Knob

Push-to-Set - Changes barometric pressure values in the MB/IN HG readout.

MAX SPD WARN Test Switch and MACH/Airspeed Indicator



1. MAX SPD WARN TEST Switch

SYS 1 - (Momentary) Tests overspeed warning system.

OFF - (Spring-loaded) Normal position.

SYS 2 - (Momentary) Tests overspeed warning system.

2. MACH Readout

Indicates Mach number. Minimum Mach readout is 150.

3. MACH Readout OFF Flag (red)

Appears if Mach data is unusable.

4. A/S Flag (red)

Indicates airspeed data is unusable.

5. Airspeed Reference Bugs (4) (white)

Set target airspeeds.

6. Airspeed Command Bug (orange)

Indicates SPD/MACH readout set on the flight guidance control panel.

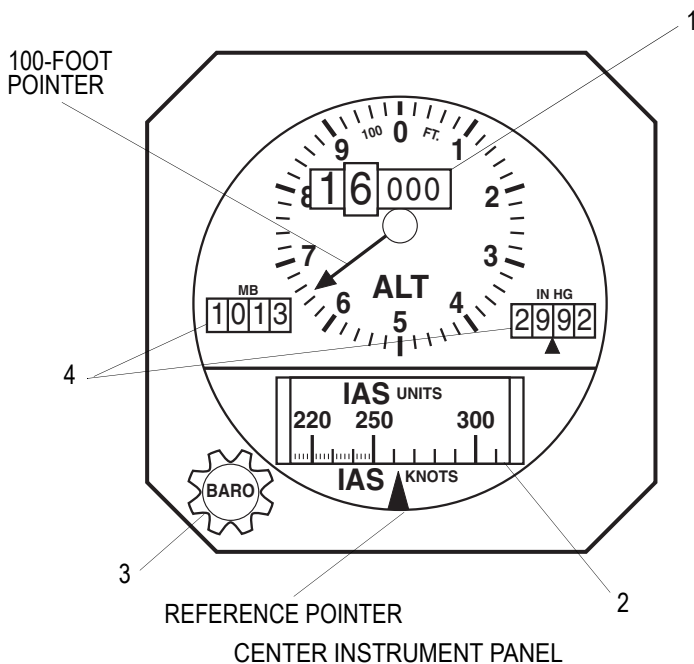
7. **Airspeed Pointer**

Indicates airspeed.

8. **VMO Pointer**

Indicates maximum permissible airspeed as related to altitude. Failure of the VMO advisory system will drive the pointer to 257 knots.

Standby ALT/Airspeed Indicator



1. **Digital Readout**

Indicates baro altitude from -1000 to 50,000 feet in 1000 foot increments. The "0" position of the ten-thousand drum is green for indication of altitudes less than 10,000 feet.

2. **Standby Indicated Airspeed Readout**

Indicated airspeed is read above the reference pointer.

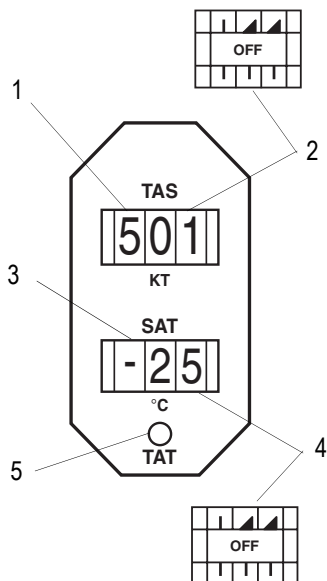
3. **BARO Set Knob**

Changes barometric pressure values in MB/IN HG readouts.

4. **MB/IN HG Readout**

Indicates selected barometric pressure in millibars and inches of mercury.

TAS/SAT Indicator



F/O's INSTRUMENT PANEL

1. TAS Readout

Indicates true airspeed. When airspeed is below 100 kts TAS, 130 will be displayed in the readout.

2. TAS OFF Flag (red)

Appears when TAS data is unusable.

3. SAT Readout

Indicates static air temperature in degrees centigrade.

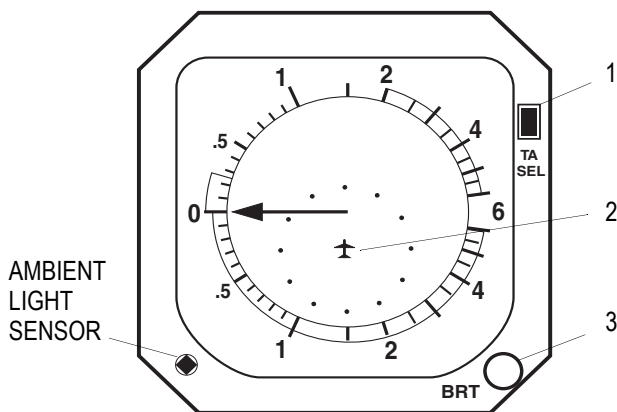
4. SAT OFF Flag (red)

Appears when SAT/TAT data is unusable.

5. TAT Button

Push to read total air temperature in SAT readout.

Vertical Speed Indicator (TA/VSI)



1. **TRAFFIC ADVISORY Selector**

Only active while TCAS display is present. Pushbutton will cancel TA/VSI traffic display.

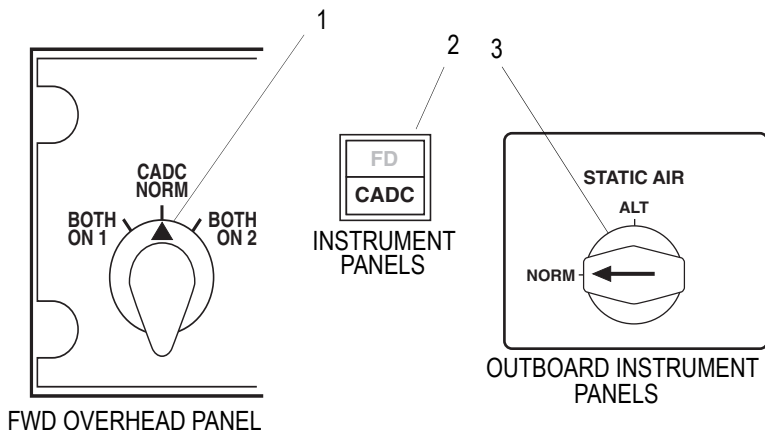
2. **Aircraft Symbol**

Fixed in position.

3. **Brightness Control**

Adjustment knob will allow limited adjustment of indicator brightness.

CADC and STATIC AIR Selectors



1. CADC Selector

NORM - Captain's MACH/AS, altimeter and VSI/TCAS indicators receive data from CADC 1. First Officer's MACH/AS, altimeter and VSI/TCAS indicators receive data from CADC 2.

BOTH ON 1 - Captain's and F/O's MACH/AS, altimeter and VSI/TCAS indicators receive data from CADC 1. Captain's BARO set knob controls both Captain's and F/O's altimeters (F/O's BARO set knob is inoperative).

BOTH ON 2 - Captain's and F/O's MACH/AS, altimeter and VSI/TCAS indicators receive data from CADC 2. F/O's BARO set knob controls both Captain's and F/O's altimeters (Captain's BARO set knob is inoperative).

2. CADC Lights (2) (amber)

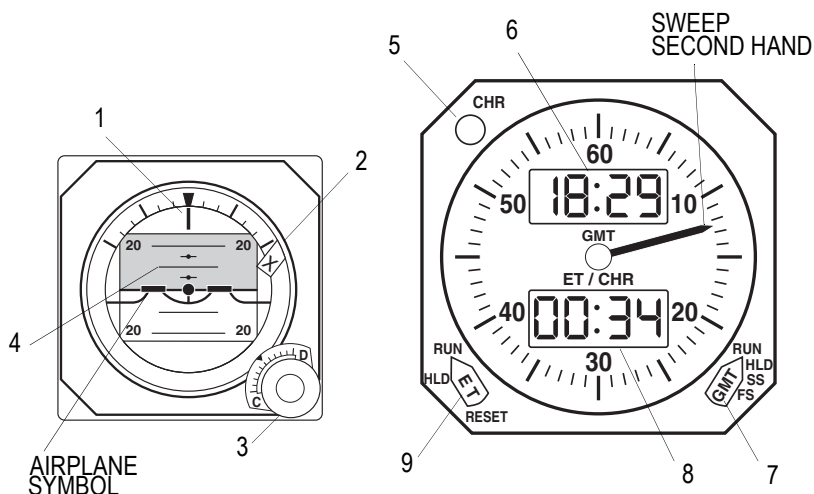
Illuminated - Indicates CADC selector is out of NORM.

3. STATIC AIR Selector (2)

NORM - When Captain's selector is in NORM, CADC 1 receives static inputs from Captain's static system. When F/O's selector is in NORM, CADC 2 receives static inputs from F/O's static system.

ALT - When Captain's or F/O's selector in ALT, respective CADC receives static inputs from alternate static system. No indicator light with ALT selected.

Standby Horizon Indicator and Digital Clock



INSTRUMENT PANELS

1. Roll Attitude Pointer

Indicates roll attitude on fixed roll index marks. Index marks are in 10-degree increments.

2. Power Off Flag (red)

Appears when power to indicator is lost. Gyro will continue to function for approximately seven minutes after power loss.

3. Caging/Pitch Trim Knob

When pulled out, caging of gyro occurs. Turning knob adjusts airplane symbol.

4. Pitch Attitude Scale

Indicates pitch attitude in 5-degree increments up and 10-degree increments down.

5. CHR Pushbutton

Push once to start chronograph. Second push freezes chronograph numeric displays, and sweep-second hand. Third push resets chronograph display and returns sweep-second hand to zero.

6. GMT Display

GMT displayed in 00 hours, 00 minutes. Time is set using GMT control knob.

7. GMT Control Knob

RUN - GMT display starts.

HLD - Stops GMT display and holds time.

SS - (Slow Slew) Advances minutes only at rate of one minute per second.

FS - (Fast Slew) Advances hours only at rate of one hour per second.

8. ET/CHR Display

Displays elapsed time (ET) in range 00 hours, 00 minutes to 99 hours, 59 minutes with a colon between hours and minutes.

Displays chronograph (CHR) in minutes. Seconds are displayed by sweep-second hand.

CHR display has priority over ET. If ET is operating and CHR is selected, display goes to zero and starts showing CHR time. When CHR is reset, ET display will reappear. CHR operation does not affect ET accuracy.

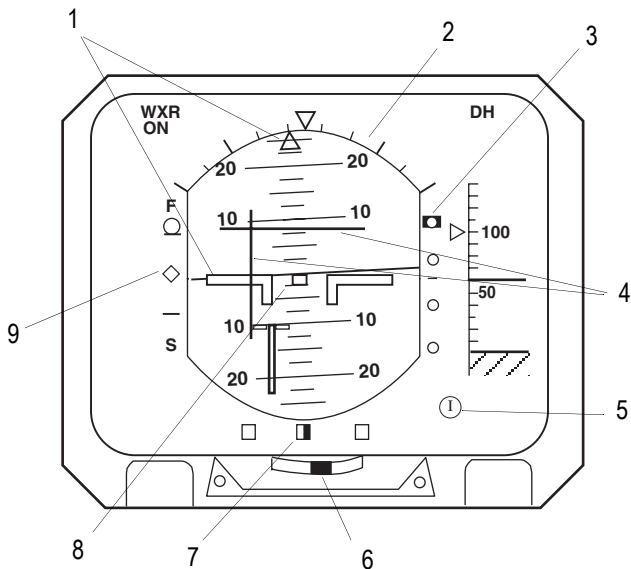
9. ET Control Knob

RESET - (Momentary) Resets and blanks ET/CHR display when CHR function not being used.

HLD - Stops ET display and holds time.

RUN - Allows ET to accumulate time.

Primary Flight Display (PFD)



1. Bank Indicator and Horizon Bar

Bank angle is displayed by pointer read against fixed bank angle index. Roll attitude is shown by horizon bar rotation relative to the fixed airplane symbol. Horizon moves vertically to display pitch attitude as read against pitch calibration scale on the sphere, using the airplane symbol center dot as a reference.

2. Bank Angle Index

Markings at 10, 20, 30, 45, and 60 degrees.

3. Glide Slope Deviation Display

Shows vertical deviation from glide slope. Display is removed from view when an ILS frequency is not selected on VHF NAV control panel.

4. Command Bars

Provide pitch and roll guidance commands from the DFGC. Command bars removed from view if pitch or roll guidance command is invalid or if guidance information is not compatible with engaged autopilot.

5. Marker Beacon Symbols

Indicated by a color coded circle enclosing the appropriate marker beacon indication: I - Inner (white), M - Middle (yellow), O - Outer (blue). There is no failure indication for the marker beacon.

6. Slip Indicator

If ball is displaced from center, the airplane is either slipping or skidding.

7. Expanded Localizer Deviation

Indicated by a rectangular pointer moving over a scale consisting of two small squares and a center reference line. Full scale deflection indicates deviation of 1/3 dot of course deviation bar from LOC course. When MAP or PLAN mode is displayed on the ND, pointer indicates deviation from FMS flight route (3.75 nm per dot).

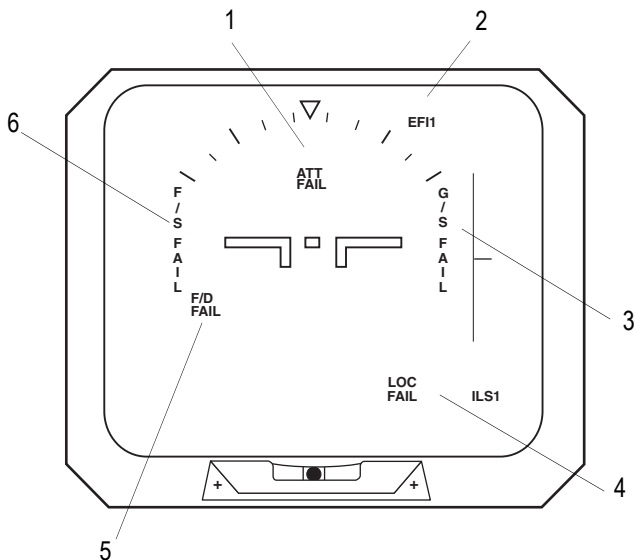
8. Airplane Reference Symbol

Indicates position of airplane in relation to horizon index.

9. F/S Display

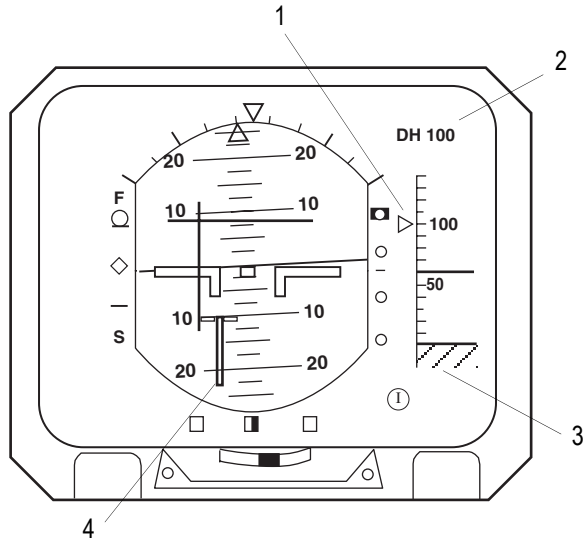
Indicates fast/slow indications referenced to autothrottle SPD/MACH readout (+/- 10 knots), FMS generated speed, VMO/MMO limit, slat/flap limit or safe stall margin speed (ALFA SPD). Full deflection either side of center equals approximately 10 knots. If selected airspeed is less than minimum safe percentage above stall for existing configuration, pointer will be centered when ALFA SPD is maintained. In takeoff and go-around mode, pointer will display airspeed error between computed and actual speeds ($V_2/V_2 + 10$ or go-around speeds KIAS). Display will be removed from view when speed control data are invalid or when ATS is in the RETD (retard) mode.

PFD Warning Flags



1. **ATT Fail Flag (red)**
Appears if attitude information is lost and removes associated display.
2. **Symbol Generator Status Flag (amber)**
Appears when the EFIS switch is out of the NORM position.
3. **G/S Fail Flag (red)**
Appears if attitude information is lost and removes associated display.
4. **LOC Fail Flag (red)**
Appears with loss of valid localizer and removes associated display.
5. **F/D Fail Flag (red)**
Appears if flight director information is lost and removes associated display.
6. **F/S Fail Flag (red)**
Appears with loss of valid speed deviation information and removes associated display.

Primary Flight Display Radio Altimeter



1. DH Reference Bug

Reference index that is set in conjunction with digital reading in DH set readout. Both are adjusted simultaneously by rotating DH (decision height) SET knob on EFIS control and dimming panel.

2. DH Symbol

DH (green) - Symbol is followed by set value (0-500 feet).

DH (yellow) - At decision height, DH set value is removed, symbol changes to larger letters, blinks for three seconds, then remains steady.

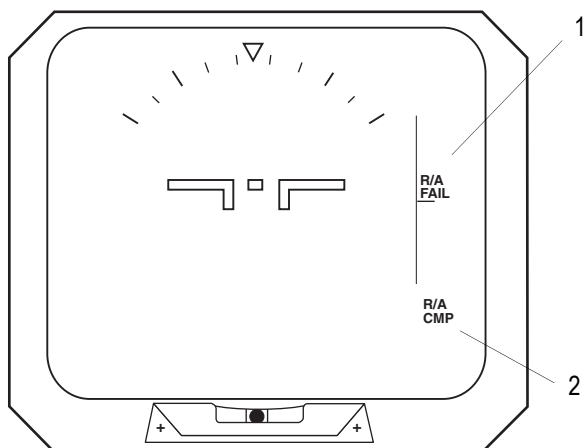
3. Height Reference Index

A fixed index (tape moves) which indicates current altitude above terrain. Tape indicates 0 to 2,500 feet.

4. Rising Runway Symbol

Indicates deviation from LOC course. When actuated by radio altimeter at 200 feet AGL, runway symbol starts rising until it appears to touch the fixed airplane symbol at actual touchdown. Rising runway is removed from view if not tuned to a LOC frequency.

PFD Radio Altimeter Fail Flags



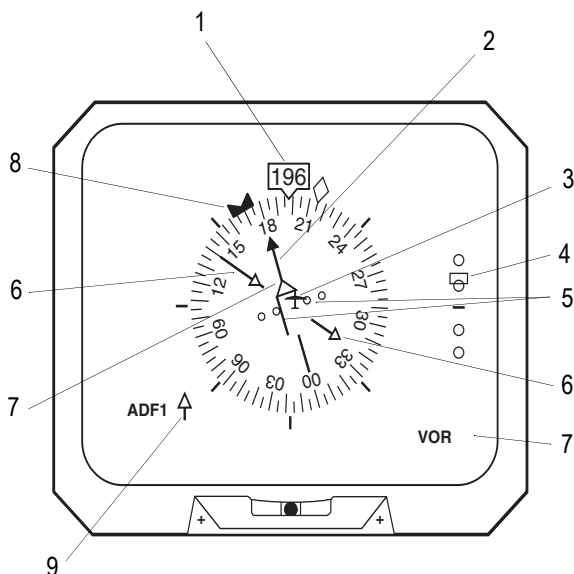
1. **R/A Fail Flag (red)**

Appears with loss of valid radio altimeter information and removes associated display.

2. **R/A CMP Flag (red)**

Appears when the computed radio altitude signal of SG-1 and SG-2 disagree.

Navigation Display (ND) ROSE Mode



1. **Heading Indication**

Digital display of current aircraft heading.

2. **Course Pointer (magenta)**

Indicates selected VOR/LOC course as set by CRS SELECT knob on applicable VHF NAV control panel.

3. **Miniature Airplane Symbol**

Symbol is fixed and represents the airplane in relation to movable parts of the indicator.

4. **Glide Slope Deviation Display**

Shows vertical deviation from glide slope. Glide slope display is removed from view when an ILS frequency is not selected on applicable VHF NAV control panel.

5. **Course Deviation Bar and Scale**

Indicates deviation from a selected VOR/LOC course. One dot equals 5 degrees with VOR selected and 1.25 degrees with LOC selected. Bar aligns with course pointer when airplane is on course.

6. ADF 1 Pointer (blue)

Indicates ADF bearing to selected facility when selected with ADF-1 knob.
Pointer removed from view when signal is lost.

7. TO/FROM VOR and ILS Display

TO VOR - Indicates direction to selected station.

FROM VOR - Indicates direction from selected station.

ILS - ILS mode is selected.

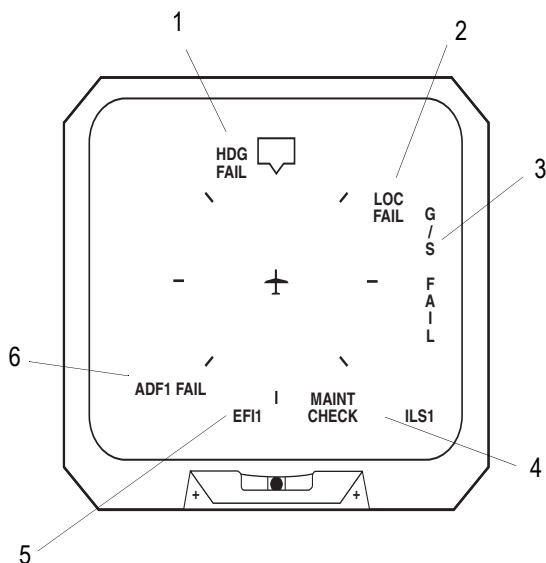
8. Heading Select Cursor (green)

Indicates selected heading set by HDG knob on the flight guidance control panel.

9. ADF 1 Indicator

Indicates ADF is selected ON.

ND Warning Flags ROSE Mode



1. HDG Fail Flag (red)

Comes into view when heading displayed on ND is not usable and removes associated symbology.

2. LOC Fail and VOR Fail Flag (red)

LOC FAIL - Comes into view when course display is not usable.

VOR Fail - Comes into view when course display is not usable.

3. G/S Fail Flag (red)

Comes into view when glide slope display is not usable.

4. MAINT CHECK Flag (white)

Affected symbol generators(s) not programmed to Delta's configuration.
Contact Maintenance.

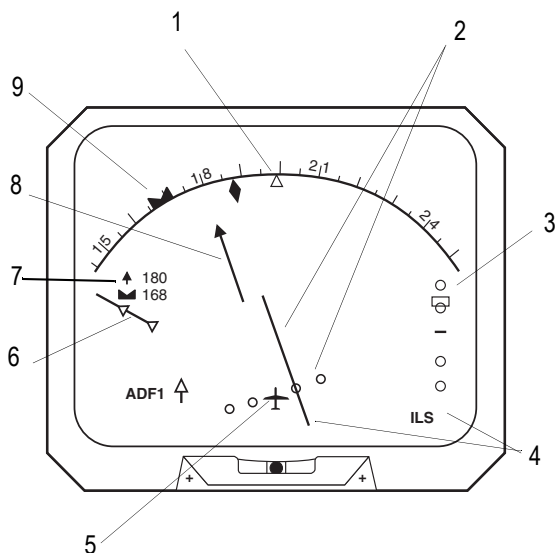
5. Symbol Generator Status Flag (amber)

Appears when EFIS switch is out of NORM position.

6. ADF 1 Fail Flag (amber)

Indicates failure of ADF system.

Navigation Display (ND) ARC Mode



1. Heading Indicator (white)

Reference indication of current aircraft heading.

2. Course Deviation Bar (magenta) and Scale (white)

Indicates deviation from a selected VOR/LOC course. One dot equals 5 degrees with VOR selected and 1.25 degrees with LOC selected. Bar aligns with course pointer when airplane is on course.

3. Glide Slope Deviation Display (magenta)

Shows vertical deviation from glide slope. Glide slope display is removed from view when an ILS frequency is not selected on applicable VHF NAV control panel.

4. VOR, ILS, or NAV Display

VOR - VOR mode is selected.

ILS - ILS mode is selected.

NAV - FMS mode is selected.

- NAV 1 in amber indicates both pilots in MAP or PLAN mode.
- Box around NAV indicates aircraft below 10,000 feet.

5. **Miniature Airplane Symbol**

Symbol is fixed and represents the airplane in relation to movable symbology of the indicator.

6. **ADF 1 Pointer (blue)**

Indicates ADF bearing to selected facility when selected with ADF-1 knob.

7. **Digital Course and Heading**

Indicates course and/or heading is being changed.

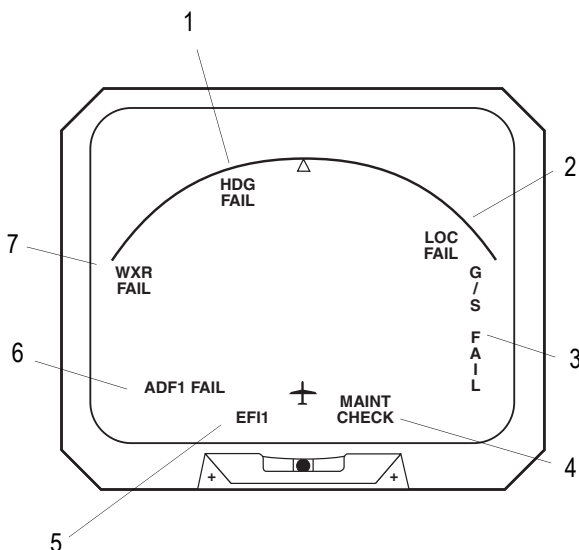
8. **Course Pointer (magenta)**

Indicates selected VOR/LOC course as set by CRS knob on applicable VHF NAV control panel.

9. **Heading Select Cursor (green)**

Indicates selected heading set by HDG knob on the flight guidance control panel.

ND Warning Flags ARC Mode



1. HDG Fail Flag (red)

Comes into view when compass heading displayed on ND is not usable and removes associated symbology.

2. LOC Fail and VOR Fail Flag (red)

LOC FAIL - Comes into view when course display is not usable.

VOR Fail - Comes into view when course display is not usable.

3. G/S Fail Flag (red)

Comes into view when glide slope display is not usable.

4. MAINT CHECK Flag (white)

Affected symbol generators(s) not programmed to Delta's configuration.
Contact Maintenance.

5. Symbol Generator Status Flag (amber)

Appears when EFIS switch is out of NORM position.

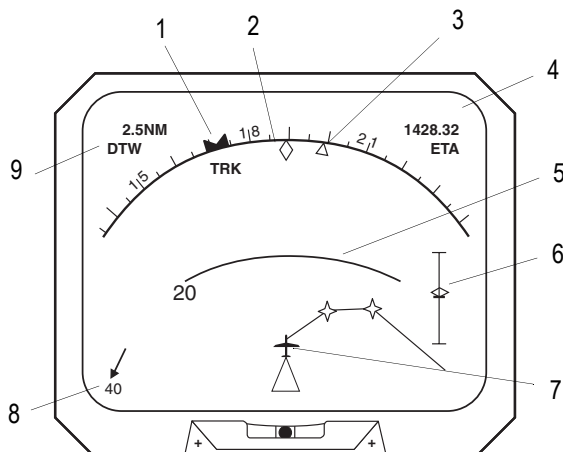
6. ADF 1 Fail Flag (amber)

Indicates failure of ADF system.

7. WXR Fail (amber)

Displayed if there is a R/T fault, antenna fault, or control fault. Weather Radar imagery is removed.

Navigation Display (ND) MAP Mode



1. Heading Select Cursor (green)

Indicates heading set by HDG knob on the flight guidance control panel.

2. Track Indicator (magenta)

Indicates current aircraft track.

3. Heading Marker (white)

Indicates current aircraft heading.

4. Estimated Time of Arrival (ETA)

Displays a digital readout of ETA (in zulu time to the nearest tenth of a minute) to next waypoint.

5. Range Mark

Located outside of range circle and labeled with one-half the weather radar range selected on mode select panel.

6. Vertical Navigation Deviation

Indicates vertical navigation deviation on descent only ($\pm 1,000$ feet).

7. Miniature Airplane Symbol

Symbol is fixed and represents the airplane in relation to movable symbology of the indicator.

8. **WIND Display (Direction and Magnitude)**

NOTE: Displayed by a pointer and digital readout.

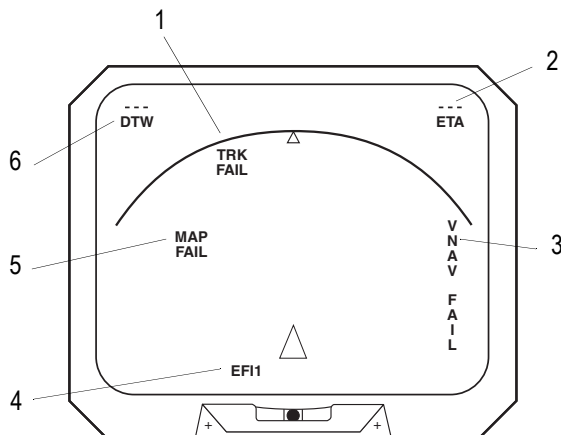
9. **Distance To Waypoint (DTW)**

Displays a digital readout of distance to next waypoint.

Less than 100 nm distance is shown to nearest tenth nm.

More than 100 nm distance is shown to nearest nm.

ND Warning Flags MAP Mode



1. TRK Fail Flag

Comes into view when heading information is not usable and removes symbology.

2. ETA Failure

Blank indicates ETA, as applicable, is unusable. Three dashes indicate no computed data.

3. VNAV Fail Flag

Comes into view when FMS fails and removes associated symbology.

4. Symbol Generator Status Flag

Appears when EFIS switch is out of NORM position.

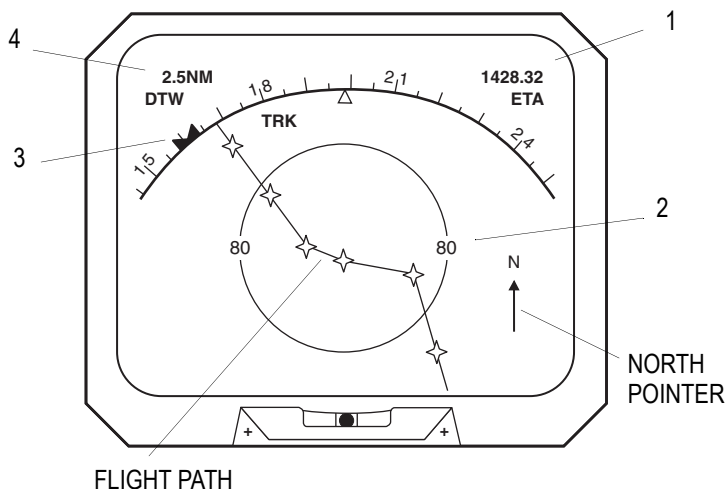
5. MAP Fail Flag

Comes into view when FMS fails and removes associated symbology.

6. DTW Failure

Blank indicates distance to waypoint, as applicable, is unusable. Three dashes indicate no computed data.

Navigation Display (ND) PLAN Mode



1. **ETA (Estimated Time of Arrival)**

Displays a digital readout of ETA (in zulu time to the nearest tenth of a minute) to next waypoint.

2. **Range Mark**

Located outside of range circle and labeled with one-half the ND range selected.

3. **Heading Select Cursor (green)**

Indicates selected heading set by HDG knob on the flight guidance control panel.

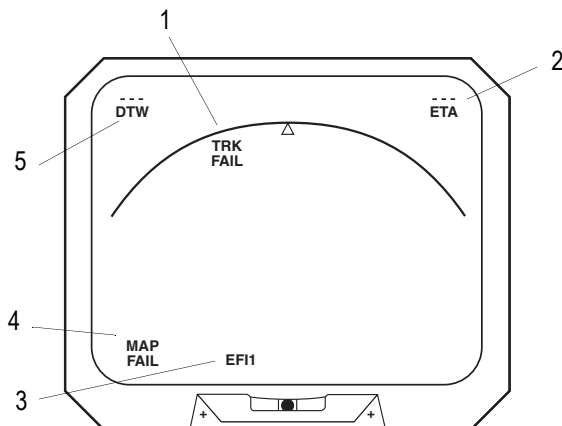
4. **DTW (Distance To Waypoint)**

Displays a digital readout of distance to next waypoint.

Less than 100 nm distance is shown to nearest tenth nm.

More than 100 nm distance is shown to nearest nm.

ND Warning Flags PLAN Mode



1. TRK Fail Flag (red)

Comes into view when heading information is not usable and removes symbology.

2. ETA Failure

Blank indicates ETA, as applicable, is unusable. Three dashes indicate no computed data.

3. Symbol Generator Status Flag (amber)

Appears when EFIS switch is out of NORM position.

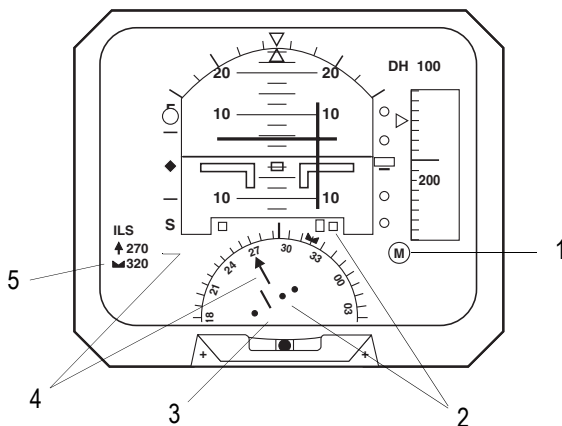
4. MAP Fail Flag (red)

Comes into view when FMS fails and removes associated symbology.

5. DTW Failure

Blank indicates distance to waypoint, as applicable, is unusable. Three dashes indicate no computed data.

Compacted Display (PFD or ND)



1. Marker Beacon Symbols

Indicated by a color coded circle enclosing the appropriate marker beacon indication: I - Inner (white), M - Middle (yellow), O - Outer (blue). There is no failure indication for the marker beacon.

2. Course Deviation Bar and Scale

Indicates deviation from a selected VOR/LOC course. Bar aligns with course pointer when airplane is on course.

3. Compacted Lateral Deviation

Indicated by lateral movement of center portion of pointer across a scale of four small circles.

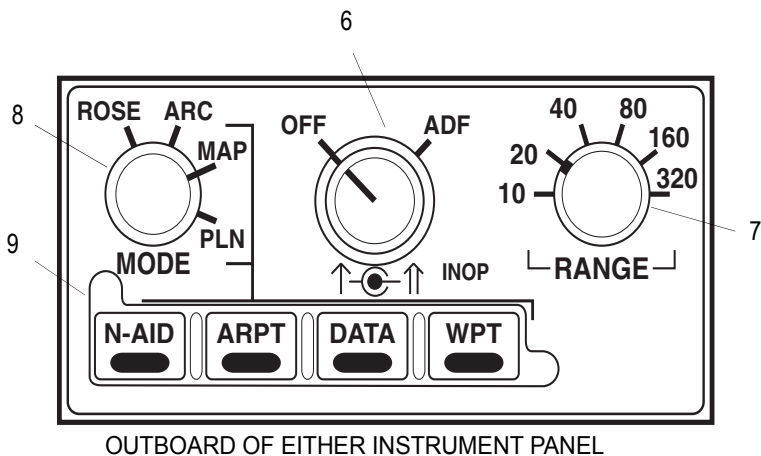
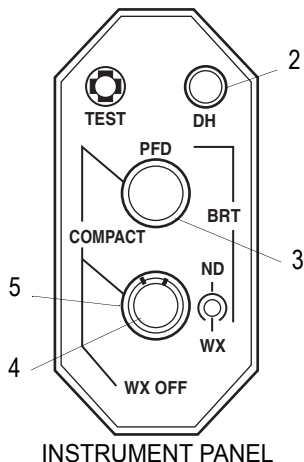
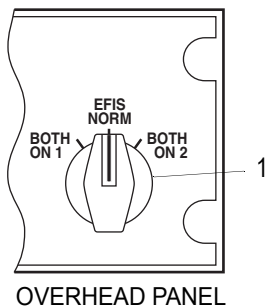
4. Course Pointer

Indicates selected VOR course as set by CRS knob on applicable VHF NAV control panel.

5. Selected Heading Indication

Indicates selected heading set by HDG knob on the flight guidance control panel.

EFIS Controls



1. **EFIS Symbol Generator Selector (SG)**

NORM - SG-1 provides input for Captain's PFD and ND. SG-2 provides input for F/O's PFD and ND.

BOTH ON 1 - SG-1 provides input for both Captain's and F/O's PFD and ND.

BOTH ON 2 - SG-2 provides input for both Captain's and F/O's PFD and ND.

2. **DH Knob**

Sets decision height value on PFD.

3. **PFD Knob**

Clockwise rotation sets brightness. When turned counterclockwise past detent, the PFD is blanked and a compact PFD/ND format is set on the ND.

4. **WX Knob**

Clockwise rotation of inner knob sets ND radar display brightness. When turned fully counterclockwise, weather radar display is turned off. If in compact mode, controls intensity of background color.

5. **ND Knob**

Clockwise rotation of outer knob sets ND brightness. When turned fully counterclockwise past the detent, the ND is blanked and a compact PFD/ND format is set on the PFD.

6. **ADF Selector**

OFF - No ADF pointers are displayed on ND.

ADF - Outer knob displays ADF-1 on ND. ADF-2 inoperative.

7. **RANGE Selector**

Selects desired range for ARC, MAP and PLAN modes.

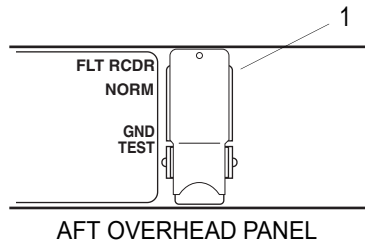
8. **MAP Declutter Buttons (4)**

Push to display navaids (N-AID), airports (APRT), data (DATA) and waypoints data (WPT).

9. **MODE Selector**

Selects ROSE, ARC, MAP or PLAN mode on ND.

FLT RCDR Switch

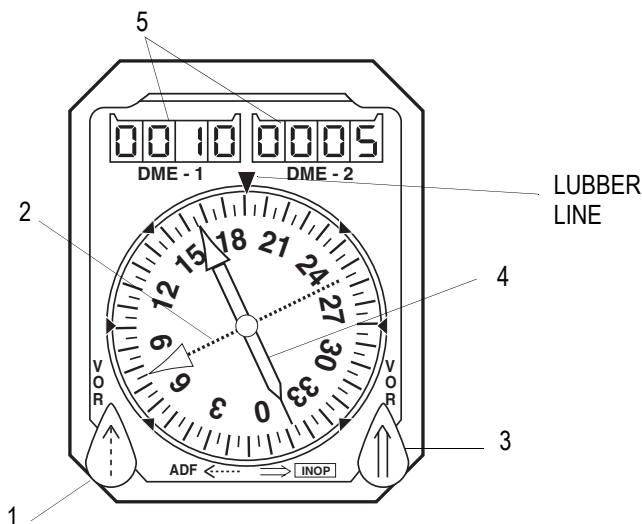


1. FLT RCDR Switch

GND TEST - Applies power to recorder. If recorder is operating properly, FLIGHT RECORDER OFF message will not be displayed.

NORM - Recorder operates when parking brake is released and either FUEL lever is on.

Radio Distance Magnetic Indicator (RDMI)



1. **VOR/ADF 1 Selector Knob**

VOR - VOR/ADF 1 pointer displays bearing to VOR facility selected on Captain's VHF nav control panel.

ADF - VOR/ADF 1 pointer displays bearing to ADF facility selected on ADF control panel.

2. **VOR/ADF 1 Pointer**

Indicates bearing to VOR or ADF facility selected on Captain's VHF nav control panel or selected on dual ADF control panel. VOR or ADF function is selected with VOR/ADF 1 selector knob.

3. **VOR/ADF 2 Selector Knob**

VOR - VOR/ADF 2 pointer displays bearing to VOR facility selected on First Officer's VHF nav control panel.

ADF - Not installed.

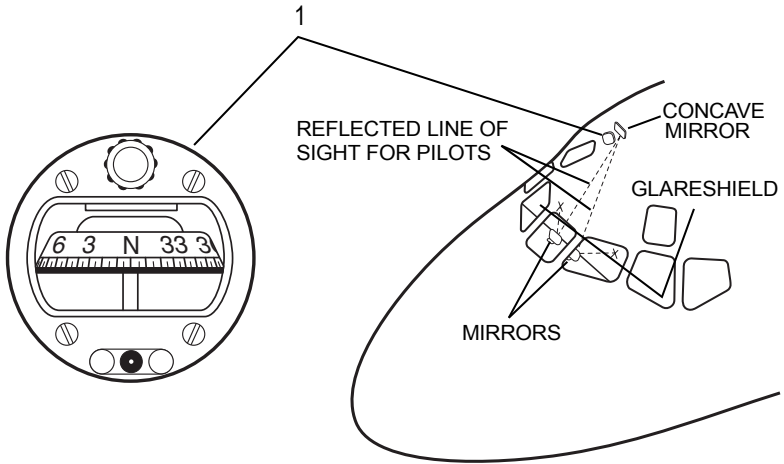
4. **VOR/ADF 2 Pointer**

Indicates bearing to VOR facility selected on First Officer's VHF nav control panel. ADF function is inoperative.

5. **DME 1/2 Indicators**

Displays slant range distance to station selected on NAV 1/2 in nautical miles. Indicators are blank if data is unreliable (flag) or show - - - - for no computed data.

Standby Compass



1. Standby Compass

A standby magnetic compass is located in the ceiling above the First Officer.

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Flight Instruments, Displays System Description

Chapter 10 Section 20

General

Flight instrumentation and navigation equipment and systems are covered in this chapter. The equipment and systems display airplane attitude, airspeed, altitude, vertical speed, heading, direction, course, and time.

Pitot/Static Systems

Three pitot tubes are located on the nose of the airplane, one each for the Captain's, First Officer's and auxiliary pitot system. A rudder pitot tube is located on the leading edge of the vertical stabilizer to provide pitot pressure to operate the rudder throw limiter bellows. Two static plates with four static ports, symmetrically located on each side of the airplane, and two alternate ports provide static pressure.

During normal operation, the Captain's pitot/static systems provide inputs to the central air data computer (CADC)-1, and the First Officer's to CADC-2. The CADC supplies calculated data to the altimeter, vertical speed/TCAS, mach/airspeed, and TAS/SAT indicators through the CADC switching unit. In addition, the CADC also provides outputs to other avionics systems. A CADC selector is provided to select normal operation, or to select from CADC-1 or CADC-2. A third system, auxiliary pitot/alternate static, drives the standby altimeter and standby airspeed indicator. A STATIC AIR selector shuts off the normal static source to the Captain's and/or First Officer's static system, if selected, and uses the alternate static source. The auxiliary and cabin static systems provide static pressure for the cabin pressure controllers and cabin differential pressure gage.

Overspeed Warning

When the CADC detects that the airplane has reached the maximum operating airspeed or mach, a signal is sent to the central aural warning system (CAWS). The CAWS will then generate a "clacking" sound, alternating with the spoken word "overspeed" or "slat overspeed" (as applicable). A MAX SPD WARN TEST switch is provided for simulating an overspeed condition.

TAS/SAT Indicator

The TAS/SAT indicator provides a digital readout of true airspeed (TAS), static air temperature (SAT), and total air temperature (TAT). TAS and SAT are normally supplied by CADC-2 or if selected, CADC-1. Total air temperature may be read in the SAT readout by pushing the TAT button on the indicator.

Standby Magnetic Compass

The standby magnetic compass provides a heading reference in relation to magnetic north. The Captain's and First Officer's viewing mirrors are mounted on hinged brackets on the glareshield to permit them to be adjusted. The compass is illuminated by internal and external lights. Both lights are controlled by the STBY COMP LT switch located on the overhead panel. The compass correction card is located on the First Officer's instrument panel.

Clock

Two digital electronic clocks are installed, one for the Captain and one for the First Officer. The Captain's clock inputs to the advance flight management computer (FMC) and the First Officer's inputs to the digital flight data acquisition unit (DFDR).

Electronic Flight Instrument System

The electronic flight instrument system (EFIS) is a dual independent system. The instruments associated with the EFIS include a primary flight display (PFD) and a navigation display (ND). One set of instruments is installed on the Captain's instrument panel and the other on the F/O's instrument panel. These instruments depend on the inertial reference system (IRS) for attitude and heading information, the navigation radios for radio navigation information, and the flight management computer (FMC) for flight progress and map background data.

Symbol Generator

The central part of each EFIS system is the symbol generator (SG). It processes data and generates the proper output for presentation on the PFD and ND. When not powered or the SG has failed, the displays are blank.

EFIS Selector

An EFIS symbol generator (SG) selector switch on the overhead panel provides the capability to select a single symbol generator source for both sets of instruments. The selector is normally positioned to NORM, but may be selected to BOTH ON 1 or BOTH ON 2 as needed in the event of a symbol generator failure. When BOTH ON 1 or BOTH ON 2 is selected, an amber EFI 1/2 will be illuminated on all operable PFDs and NDs.

Dimming Panel

The dimming panel is located on each crew member's instrument panel. It consists of four knobs for control of display, brightness, decision height (DH) and weather radar. Full counter-clockwise rotation of the brightness control past a detent for the PFD or ND results in selection of the compact mode on the remaining display. The TEST button is normally used by maintenance.

Remote Light Sensor

A single remote light sensor, mounted on the top of the center glareshield, is shared by both EFIS systems. The sensor measures outside lighting and available light in the flight deck and automatically adjusts EFIS instrument lighting intensity throughout the flight.

Display Units

Two display units, a primary flight display (PFD) and a navigation display (ND), receive display data from the symbol generator. If a display unit fails, both PFD and ND information can be displayed on the remaining display unit in a compact mode.

Primary Flight Display

The primary flight display (PFD) is mounted in the upper position of each crew member instrument panel. It performs the functions of the conventional attitude director indicator (ADI) and more. The PFD information includes the following:

- Aircraft attitude.
- Flight director information.
- Glide slope and localizer deviation.
- Expanded localizer.
- Radio altitude.
- Rising runway.
- Decision height.
- Marker beacon indications.
- Fast/slow indication.
- Message information.
- Ground speed.

Mode Select Panel

The mode select panel controls ND modes, ADF, RANGE and MAP declutter buttons. The MODE control is a four-position selector that selects the ROSE, ARC, MAP or PLAN mode on the ND. The ADF control is a two-position selector that controls the ADF pointer on the ND. The RANGE control is a six-position selector used to select various ranges in the ARC, MAP and PLAN modes. The MAP declutter buttons consist of four pushbuttons for displaying navaids, airports, data and waypoints. When the EFIS selector is out of the NORM position, the selected system's EFIS selector panel controls the display for both ND's.

Navigation Display

The navigation display (ND) is mounted in the lower position on each crew member instrument panel. The ND performs the functions of a conventional horizontal situation indicator (HSI) and more. The ND has four modes of display operation which can be selected through an EFIS control panel. The first two modes are used for radio navigation, and the second two are used for flight management system (FMS) operation. The ND information includes the following:

- Compass rose.
- Aircraft heading.
- Selected heading.
- Selected course.
- ADF-1 pointer.
- Wind direction and speed.
- TO/FROM information.
- Weather radar.
- Drift angle and ground track.
- Distance to waypoint.
- Estimated time of arrival.
- Lateral and vertical deviation.

The four operating modes of the ND are:

- ROSE mode (WX not available).

The ROSE mode presents a conventional full compass rose. This mode depicts deviation from the selected course and heading.

- ARC Mode (WX available).

The ARC mode presents an expanded track scale with heading orientation (approximately 110 degrees wide).

- MAP mode (WX available).

The MAP mode presents information with track orientation against a moving map background. Displayed information comes from the FMC. The MAP mode is the recommended mode of display for most phases of flight.

- PLAN mode (WX not available).

The PLAN mode displays a static map background with data oriented to north. In this mode, any portion of a flight plan stored in the FMS can be viewed. Pilot action is required for viewing the route. The top part of the ND maintains a display of track and heading information as in the MAP mode.

Inertial Reference System

The inertial reference system (IRS) provides attitude, heading and navigation information to its respective symbol generator for display on the PFD, ND and heading information on the opposite radio distance magnetic indicator (RDMI). The IRS consists of two inertial reference units (IRU) which are controlled by a single IRS control panel located on the overhead panel.

Standby Horizon Indicator

A standby horizon indicator is powered by the DC transfer bus and will continue to operate as long as airplane battery power is available. If power is lost, it will continue to function for approximately 7 minutes.

Radio Distance Magnetic Indicators

Two radio distance magnetic indicators (RDMI) are installed, one on each pilot's instrument panel. The compass card in each RDMI reflects heading from the offside IRS or AHRS. Each RDMI displays DME-1 and -2 distance and VOR bearings.

Distance Measuring Equipment

The distance measuring equipment system provides slant range nautical miles to VHF-VORTAC stations (ILS and VOR).

Automatic Direction Finding System

One automatic direction finding (ADF) system, ADF-1 is installed and controlled by a single ADF control knob.

The ADF system drives the pointer on the Captain's and First Officer's ND and RDMI. Audio for ADF-1 is selected on the audio control panel.

Marker Beacon System

Outer, middle and inner marker beacons are displayed on the PFD. Volume for the marker beacon is controlled on the audio control panel.

Air Traffic Control Transponder

Two air traffic control (ATC) Mode-S transponders are installed. One control panel allows selection of either transponder. The other transponder remains in a standby status. The control panel also controls TCAS modes. A switch also selects altitude reporting sources CADC-1 or CADC-2.

Radio Altimeters

When the aircraft is below 2,500 feet AGL, data generated by the radio altimeters is displayed on an altimeter scale that appears on the right side of the PFD's. The radio altitude (RA) data from number 1 radio altimeter is indicated on the Captain's PFD while number 2 information is displayed on the F/O's PFD. Number 1 interfaces with the enhanced ground proximity warning system (EGPWS), and both radio altimeters interface with the digital flight guidance computers (DFGC's).

A set knob, located on the EFIS dimming panel, permits the selection of a DH. Decision height information is available when the green letters DH appear above the radio altimeter scale. The DH is followed by a selected decision height value (between 0 to 500 feet). The scale is in view at 2,500 feet AGL and below. The decision height is indicated by a green DH reference bug. When reached, the green DH and numeric value change size and color to an amber DH only and flashes 3 times. It may be reset by descending below 10 feet AGL or by climbing 75 feet above the current DH setting.

A rising runway symbol is displayed on the PFD when the radio altitude is less than 200 feet. The symbol moves laterally with the expanded localizer deviation pointer and rises to touch the airplane reference symbol at actual touchdown.

Digital Flight Data Recording System

The digital flight data recorder (DFDR) stores the last 25 hours of flight operations on a crash survivable magnetic tape. The DFDR is activated by selecting either FUEL lever to ON with the parking brake released and normal electrical power. The message FLT RECORDER OFF on the overhead annunciator panel (OAP) indicates when the flight recorder is not operating. A switch which is guarded to the NORM position is provided on the overhead panel for testing the flight recorder.

OAP Messages/Lights

Amber Caution Messages

Note: The associated cue light is shown in parenthesis (XXX) following the message.

FLT RECORDER OFF (MISC) - Indicates flight recorder deenergized or built-in-test requirements are not met.

GPWS FAIL - Indicates ground proximity warning system is inoperative.

IRS-1/-2 BATTERY FAIL (MISC) - Indicates battery could not support the IRU if AC power should be interrupted or lost.

IRS-1/-2 NO AIR (MISC) - Indicates loss of cooling air to the respective IRU.

IRS-1/-2 ON BATTERY (MISC) - Indicates respective IRU being powered by IRU back-up battery instead of AC power.

NO MISC FAULTS (MISC) - Indicates no miscellaneous faults exist when MISC cue light is pushed.

Blue Advisory Lights

IRS 1/2 ATT MODE - Indicates that the respective IRU is providing attitude information only. Accuracy of data is downgraded and heading information should be updated via MCDU using an alternate source.

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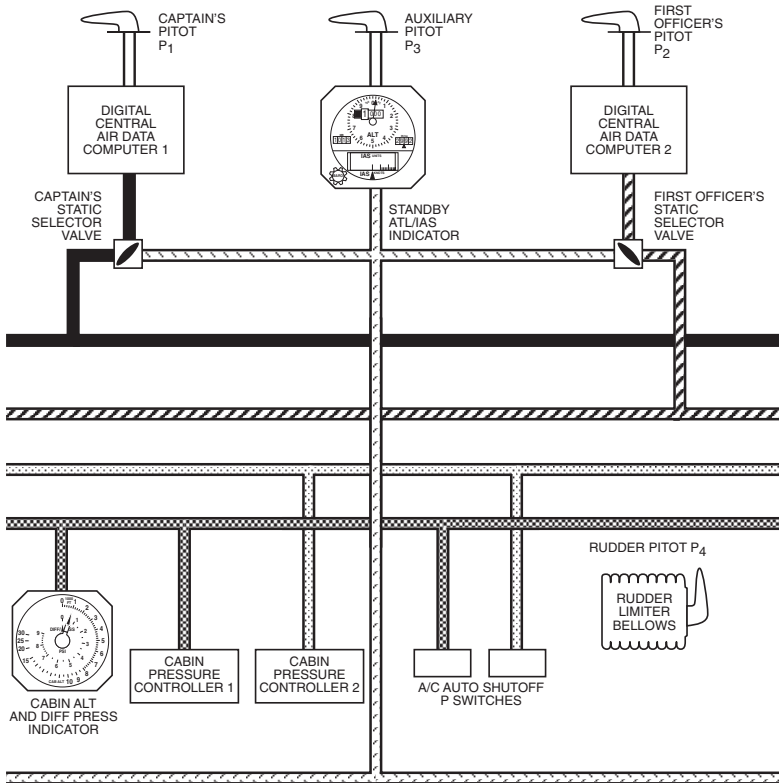
Flight Instruments, Displays

Functional Schematic

Chapter 10

Section 40

Pitot/Static Systems



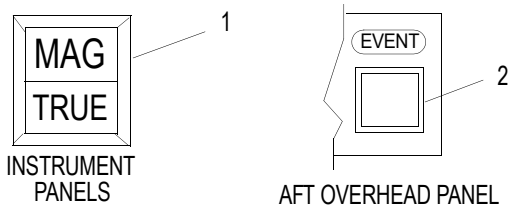
LEGEND

	CAPTAIN'S STATIC
	FIRST OFFICER'S STATIC
	ALTERNATE STATIC
	AUXILIARY STATIC
	CABIN STATIC

Intentionally
Blank

Controls and Indicators

MAG/TRUE Light and EVENT Switches



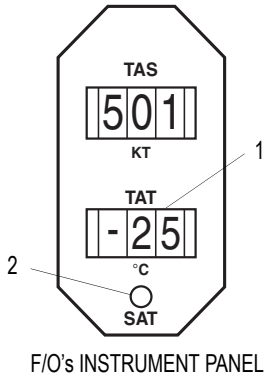
1. MAG/TRUE Switch-Light (Inoperative)

Push - Selects magnetic (green MAG light illuminated) or true (amber TRUE light illuminated) heading reference for PFD and ND.

2. EVENT Pushbutton

Push - Marks an abnormal event in flight on system memory.

TAS/TAT Indicator



1. TAT Readout

Indicates total air temperature in degrees centigrade.

2. SAT Button

Push to read static air temperature in TAS readout.

OAP Messages/Alerts

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

IRS-1/-2 ON BATTERY (MISC) - IRS-1 ON BATTERY indicates IRU-1 being powered by the airplane battery.

TRANSPONDER INOP (MISC) - Indicates failure of selected transponder

Flight Management, Navigation

Chapter 11

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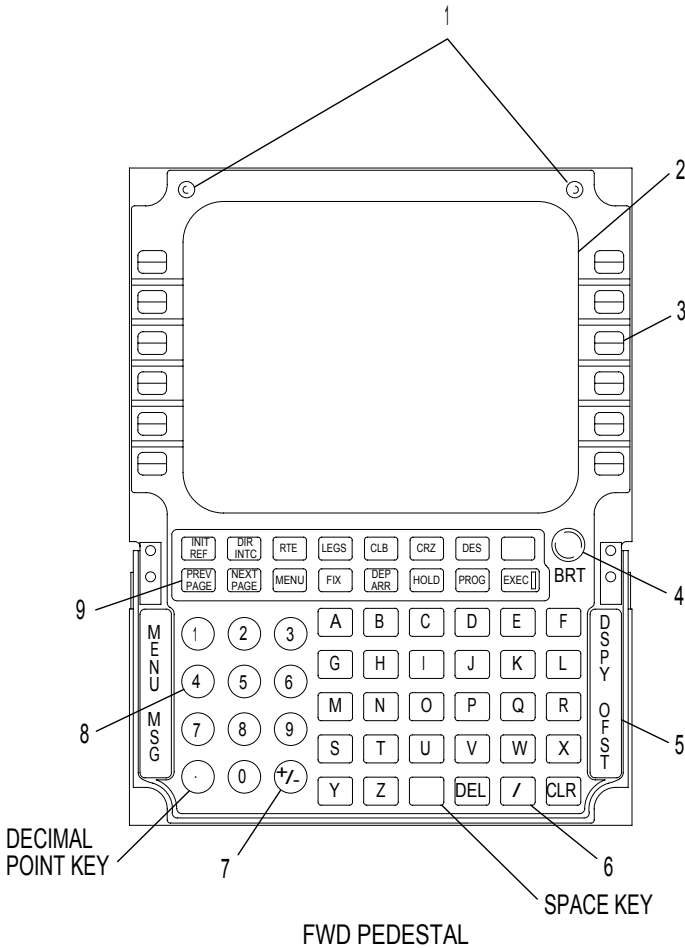
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Intentionally
Blank

FMS - MCDU



1. Light Sensor

Senses ambient light and automatically adjusts reference brightness level.

2. Data Display Area

CRT is partitioned into three areas:

Left Field - Divided vertically into 6 lines of information that extend from the left side of the display to the center.

Right Field - Divided vertically into 6 lines of information that extend from the center to the right side of the display.

Scratchpad - Located at the bottom of the display. Displays typed alphanumeric characters and FMC generated messages. The scratchpads for the two MCDUs operate independently for the data entry. Clearing a scratchpad entry on one MCDU has no effect on the other MCDU.

3. Line Select Keys (LSK)

Push - Provides for the entry, selection, or deletion of information on an adjacent line.

- Entry - Moves information to a selected line from scratchpad.
- Selection - Selects a page, procedure, or performance mode as required. Moves information to scratchpad from selected line when the scratchpad is blank.
- Deletes information from the selected line after pushing the DEL key.

4. BRT Knob

Rotate - Manually adjusts brightness of CRT display.

5. Message Light

MENU - Illuminates when any non active subsystem has a request pending.

MSG - Illuminates when the FMS generates a message displayed in the scratchpad.

DSPLY - Illuminates when the current display is not related to the active flight plan leg or current performance mode.

OFST - Illuminates when the airplane is flying a parallel offset of the active flight plan.

6. Miscellaneous Keys

- CLR Key - Push to clear data in the scratchpad.
- / Key - Used as a data separator.
- DEL Key - Used to delete data in a data field if allowed.

7. +/- Key

Numeric values entered are assumed to be positive. If it is a negative value, pushing the key enters a minus. Pushing a second time changes to a plus.

When the MCDU is controlled by the ACARS, the key functions as a minus key and subsequent actuations of the key provide additional minuses.

8. Alpha/Numeric Keys

Push - Enters selected character into the scratchpad.

9. Function Keys

EXEC - Command key of the FMS. Used to implement changes to the active flight plan.

NEXT PAGE - Displays next page of multiple pages.

PREV PAGE - Displays previous page of multiple pages.

INIT REF - Selects POS INIT page for initialization.

RTE - Selects RTE 1 and RTE 2 pages.

DIR INTC - Selects page for flying direct to, or intercepting a course to an off-route waypoint while on active leg.

HOLD - Allows definition of a holding pattern at any desired waypoint or present position.

LEGS - Provides detailed data concerning every leg of a flight plan and allows data to be entered for each leg.

DEP ARR - Provides for selection of departure and/or arrival procedures and runways.

PROG - Displays of current dynamic flight information such as distance to go, fuel weight, wind,...

FIX - Allows creation of waypoint fixes from the intersection points between present route and selected radials from known waypoints.

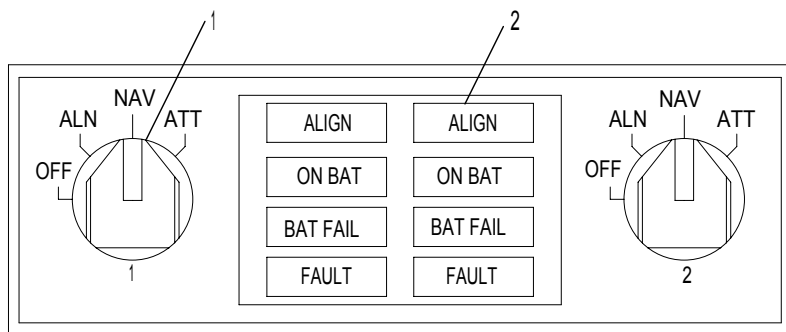
CLB - Displays current or planned climb mode.

CRZ - Displays current or planned cruise mode.

DES - Displays current or planned descent mode.

MENU - Selects MENU page to choose subsystems.

IRS Control Panel



FWD OVERHEAD PANEL

JB1-3-0807

1. Mode Selector

OFF - Deenergizes system 3 seconds after selection.

ALN - Initiates alignment mode. IRU aligns its reference axis to local vertical.

NAV - Normal position. IRU will automatically function through alignment mode and enter navigation mode once position data has been entered. Selector should be pulled to rotate out of NAV position.

ATT - Selects back-up attitude mode.

2. Advisory Lights

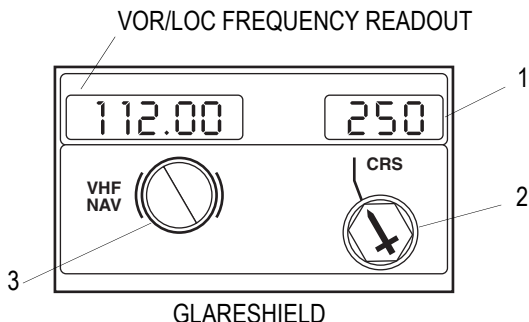
ALIGN (white) - Indicates IRU is in alignment mode. Light flashes if the position data has not been entered after alignment time completed or incorrect data entry.

ON BAT (amber) - Indicates IRU is operating from its back-up battery.

BAT FAIL (amber) - Indicates battery voltage is less than required.

FAULT - Indicates IRU has detected a problem in its alignment and navigation modes.

VHF Navigation System



1. Course Readout

Digital readout of course selected with CRS select knob.

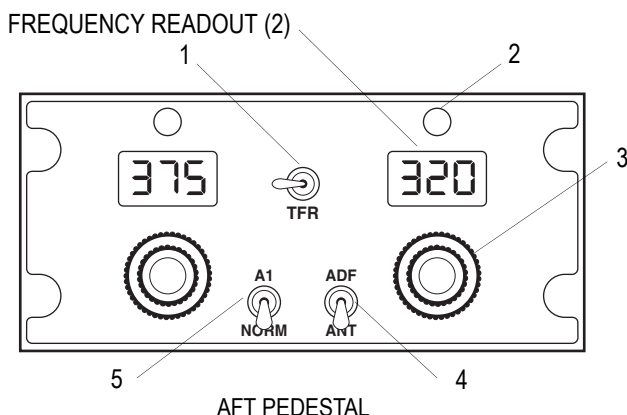
2. CRS Select Knob

Selects VOR course and positions course pointer on ND. Push in for fast course selection.

3. VHF/NAV Frequency Select Knob

Selects VOR/LOC frequency.

ADF Control Panel



1. TFR (Transfer) Switch

Selects either of the tuned frequencies.

2. ADF Select Light (2) (Green)

Illuminates to show frequency readout in use.

3. Frequency Select Knob (2)

Selects desired ADF frequency. Large outside knob permits selection of megahertz and 100-kHz frequency. Middle knob permits selection of 10-kHz frequency. Long inner knob permits selection of 1-kHz and 0.5-kHz frequency.

4. ADF/ANT Switch

ADF - Antenna automatically seeks signal source and displays relative bearing on RDML.

ANT - Used for range navigation or monitoring commercial broadcast signal.

5. A1/NORM Switch

A1 - Superimposes an aural signal on unmodulated carrier waves so the pilot can hear station identification.

NORM - Removes aural signal permitting normal signal monitor.

Flight Management, Navigation

Navigation Systems Description

Chapter 11

Section 20

General

Navigation systems on the MD-88 include the following:

- 2 Inertial Reference Systems (IRS).
- 2 VHF NAV receivers with DME.
- 1 ADF.
- 2 Radio Distance Magnetic Indicators.
- 1 Marker beacon system.
- 1 Flight Management System.

These systems supply data to the PFDs, NDs, RDMIs, flight recorder, and flight guidance computers.

Inertial Reference System

The system is composed of three laser gyros and accelerometers representing each axis. The inertial reference system (IRS) uses laser gyros and accelerometers in place of directional gyros, vertical gyros, and flux valves to determine aircraft position, heading, attitude, and velocities.

The IRS determines true north, aircraft heading, and aircraft latitude during its alignment by sensing the earth's rotation. When aircraft position is entered into the IRS, the system determines the magnetic variation for latitude and longitude in order to reference the heading to magnetic north. Its ability to store, retrieve, and compute this information negates the need for flux valves, directional gyros, and vertical gyros.

Primary power is supplied by 115 VAC, with 28VDC providing power for panel annunciations and internal battery charging. The left AC and DC buses power IRU-1 while the right AC and DC buses provide power to IRU-2. Each unit has an integral nicad battery to provide backup power in the event of a loss of AC power. Backup power will provide 30 minutes of continuous operation.

The inertial reference unit (IRU) provides all attitude and heading data (true and magnetic), inertial velocities, accelerations, and present position.

Controls And Indicators

The IRS controls consist of a mode selector unit (MSU) located on the overhead panel. Indicators and annunciations are located on the MSU, overhead annunciator panel, and scratch pad of the MCDU.

MODE Selector Unit

- **OFF** - Removes electrical power after a three second time delay, to protect against inadvertent selection. After the delay, the system begins to power down, and in-flight faults, last position, and auto calibrate information is transferred to memory.
- **ALN** - Selecting OFF to ALN powers up the IRU and performs an internal BITE check. During BITE check, ON BAT annunciates on MSU for 15 seconds. After BITE check, IRU enters align submode continuing a fine leveling process until switched to NAV. At latitudes above 70° N, the align time is approximately 15 minutes. Full alignment requires from 2.5 to 10 minutes. Selecting ALN from NAV on the IRU provides a 30 second downmode alignment (quick align) which zeros all computed velocity errors and updates heading accuracy. IRU alignment continues indefinitely in the ALN mode.

The position accuracy may be enhanced by sustained operation in the ALN mode. The aircraft must remain stationary in this mode. The ALIGN light will remain illuminated while this position is selected.

- **NAV** - This mode may be selected directly from the OFF or ALN modes. If selected from the OFF mode or ALN mode prior to completion of the alignment sequence, the IRU will begin the alignment phase automatically terminating at the end of the alignment sequence. Upon completion of the align sequence, the ALIGN lights will extinguish, and EFIS attitude and heading data will be displayed.
- **ATT** - This mode may be selected directly in flight following a partial failure of an IRU (indicated by a FAULT annunciation on the MSU). When either IRS is in the attitude mode, autoland is inhibited. Heading updates are required for the failed system.

Aural Warning Circuit

In order to protect the backup batteries from being inadvertently discharged, an alerting circuit is installed. Any time aircraft power is removed with either of the mode selectors switches in other than the OFF position, the mechanic's call horn in the nose wheel well will sound.

VHF Navigation Systems

There are two independent VHF navigation systems, VOR/LOC/GS-1 and -2. VOR/LOC/GS-1 is controlled by the Captain's VHF NAV control panel, and VOR/LOC/GS-2 is controlled by the First Officer's VHF NAV control panel. VOR/LOC and glide slope deviations are displayed on the PFD and ND. VOR bearing is displayed on the RDMI when VOR is selected.

Audio for VOR/LOC-1 and -2 is selected on the audio control panel. Refer to Communications chapter for description of audio control panel.

VHF NAV Radios

The #1 VHF NAV receiver provides data to the Captain's flight instruments, and the #2 VHF NAV receiver provides data to the First Officer's flight instruments. Control switching and volume adjustment is accomplished from the audio selector panels.

Distance Measuring Equipment

The distance measuring equipment (DME) system provides slant range in nautical miles to VHF-VORTAC stations.

Radio Distance Magnetic Indicators

A radio distance magnetic indicator (RDMI) is installed on each pilot's instrument panel. The RDMI's display magnetic heading, DME-1 and DME-2 distance, and VOR and ADF bearing as selected by the left hand switch on the indicator face.

The Captain's RDMI receives heading information from IRS-2. The First Officer's RDMI receives heading information from IRS-1.

Marker Beacon

The marker beacon system consists of outer marker lights (blue), middle marker lights (amber), and inner marker lights (white) with corresponding low, mid and high frequency tones that indicate passage over airways and ILS markers.

A single receiver operates on 75 MHz and a set of marker lights are located on the Captain's and First Officer's PFD display. Audio reception is controlled through individual audio selector panels.

Weather Radar System

The weather radar system displays weather and mapping targets on the ND and pedestal radar indicator. The system consists of a receiver/transmitter, antenna and radar control panel.

Weather and mapping targets are displayed in magenta, red, amber, and green colors. Magenta areas indicate possible turbulence. Red areas represent areas of high density precipitation or ground targets with high level reflectivity. Amber areas represent areas of lower density precipitation or ground targets with moderate level reflectivity. Green areas represent areas of light density precipitation or ground targets with low level reflectivity. Displays of the selected mode, range, and antenna tilt angle are also presented.

The radar antenna is normally stabilized in pitch and roll by IRS. The antenna tilt is controllable from 15 degrees up to 15 degrees down.

Navigation Display Weather Radar

Weather radar data is displayed on the ND in both ARC and MAP modes. The brightness is adjusted by the WXR contrast control on the EFIS dimming panel.

Each Symbol Generator checks for valid range information and overheat condition. If the check detects a range fault, the "WXR RANGE" message is displayed. If the check detects an overheat condition, the "NO WX" message is displayed.

Pedestal Weather Radar

A color weather radar displays weather and TCAS traffic on the radar indicator with selective ranges of 10, 20, 40, 80, 160 and 320 nautical miles. All controls are provided on the indicator, and a test mode is included. TCAS traffic can be displayed on the radar indicator up to 40 nm.

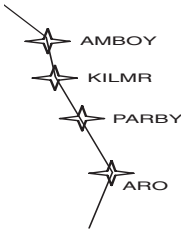
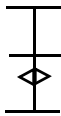
A monitor automatically checks for faults and compares certain functions of the radar. If the checks or comparisons detect a fault or abnormality, one or more fault messages will be displayed on the indicator. When the mode selector is in TEST, line replaceable unit (LRU) fault messages are displayed.

Navigation Display (ND) Symbology

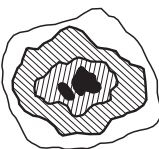
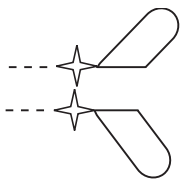
The following symbols can be displayed on each ND depending on EFIS control panel.

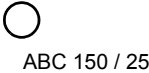
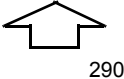
Note: In the NAME column are the parenthetical display colors: W=white; G=green; M=magenta; C=blue; R=red; A=amber; Y=yellow.

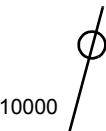
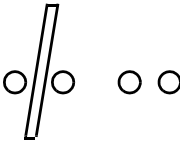
SYMBOL	NAME	APPLIC- ABLE MODE(S)	REMARKS
200 NM / 4.4 NM	DISTANCE DISPLAY (W)	PLAN, MAP	Distance is displayed to next AFMC waypoint (NM).
	HEADING ORIENTATION (W), INDICATOR (W) AND REFERENCE BUG (G)	ROSE	Indicates number under pointer is a heading. Box displays actual heading. Compass is referenced to magnetic north.
0835.4z ETA	ETA DISPLAY (W)	MAP, PLAN	Indicates time to active waypoint.
	SELECTED HEADING MARKER (G)	ROSE, ARC, MAP, PLAN	Indicates the heading set in the FGCP. A dashed line (G) extends from the airplane symbol for ease in tracking the marker.
	EXPANDED COMPASS ROSE (W)	MAP, ARC, PLAN	360 degrees are available but approximately 100 degrees are displayed.
	HEADING POINTER (W)	MAP, ARC, PLAN	Indicates airplane heading.
	RANGE SCALE (W)	MAP	Displayed range mark is one-half the actual selected range.
	AIRPLANE SYMBOL (W)	MAP	Represents the airplane and indicates its position at the apex of the triangle.

SYMBOL	NAME	APPLICABLE MODE(S)	REMARKS
	WAYPOINT: ACTIVE (M)	MAP, PLAN	Active - Represents the waypoint the airplane is currently navigating to. Inactive - Represents a navigation point making up the selected active route.
	ALTITUDE RANGE ARC (G)	MAP	When intersected with the track line, it predicts the point where the reference altitude will be reached at current vertical rate.
	ACTIVE ROUTE (M), ACTIVE ROUTE MODIFICATIONS (W) INACTIVE ROUTE (W)	MAP, PLAN	The active route is displayed with continuous lines (M) between waypoints. Active route modifications are displayed with short dashes between waypoints. When a change is activated in the AFMC, the short dashes are replaced with a continuous line. Inactive routes are displayed with long dashes (C) between waypoints.
	VERTICAL POINTER (M) and DEVIATION SCALE (W)	MAP	Displays vertical deviation from selected vertical profile (pointer) in MAP mode during descent only. Scale indicates +/- 1,000 feet deviation.

SYMBOL	NAME	APPLIC- ABLE MODE(S)	REMARKS
	GLIDESLOPE POINTER (M) and DEVIATION SCALE (W)	ROSE, ARC MAP	Displays glide slope and deviation in the ILS mode. The pointer is not displayed when track and the front course of the ILS panel differ by more than 90 degrees.
	DRIFT ANGLE POINTER (M)	ROSE, ARC MAP, PLAN	Displays magnetic track.
	WIND SPEED and DIRECTION (W)	ROSE, ARC MAP	Indicates wind speed in knots and wind direction with respect to the map display orientation compass reference.
	OFFSET PATH and IDENTIFIER (M)	MAP, PLAN	Presents dot-dash line parallel to and offset from the active route.
	NORTH POINTER (W)	PLAN	Indicates map background is oriented and referenced to true north.
	VERTICAL PROFILE POINT and IDENTIFIER (G)	MAP	Represents an AFMC calculated point and is labelled on the flight plan patch as: TC (top of climb), SC (step climb), TD (top of descent), and ED (end of descent). Deceleration points have no identifier.

SYMBOL	NAME	APPLICABLE MODE(S)	REMARKS
	RADAR RETURNS (G, A, R)	ARC, MAP	Multi-colored returns are presented when the radar mode selector switch is either in the WX or TURB position and the ND/WX knob is out of the OFF position. Most intense areas are displayed in red, less intense in amber, and least intense in green.
	MARKER BEACON (W)	MAP, PLAN	Appears when in the database and required for the procedure.
	PROCEDURE TURN ACTIVE (M) MODIFICATION (M) INACTIVE (W)	MAP, PLAN	A fixed size procedure turn appears when in the flight plan and nav database. It increases to correct size when the ND range is 80 nm or less and the airplane passes the waypoint prior to the procedure turn.
	AIRPORT IDENTIFICATION: ORIGIN and DESTINATION (W) OTHERS (C)	MAP, PLAN	This symbol displays (for EFIS range of 80 nm or greater) the origin and destination airports. It also displays airports within EFIS map range when the ARPT pushbutton is selected.
	RUNWAY and EXTENDED CENTERLINE (W)	MAP, PLAN	This symbol is displayed for the origin and destination airports when current EFIS range is 40 nm or less.

SYMBOL	NAME	APPLIC- ABLE MODE(S)	REMARKS
	SELECTED FIX (G)	MAP, PLAN	Presents a selected reference point (fix) via the MCDU FIX key. The fix can appear with any number of special map symbols, i.e., VOR, VORTAC, airport or waypoint, etc. if contained in the existing database.
	DOWN TRACK FIX (DNTKFX): CONDITIONAL (W) ACTIVE (M)	MAP, PLAN	Defines the intersection of selected fix radials and present track. It appears with the fix identifier.
	SELECTED COURSE POINTER	ARC	Momentarily displays the selected course as appropriately set by the VOR/ILS course selector.
	VOR (C) DME/TACAN (C) VOR-DME/VORT A Green (G) for manually tuned	MAP	These symbols denote NAV stations which are manually tuned or stations within current EFIS range when the N-AID pushbutton is selected.
	ROUTE DATA (M, W)	MAP, PLAN	When the RTE DATA pushbutton is selected, the altitude and ETA for the route waypoints are displayed.
	OFF ROUTE WAYPOINTS (C)	MAP, PLAN	This symbol displays database waypoints not on the active route, when the WPT pushbutton is selected and the EFIS range is 40 nm or less.

SYMBOL	NAME	APPLICABLE MODE(S)	REMARKS
	CONDITIONAL WAYPOINT (W), (M) IF ALSO THE ACTIVE WAYPOINT	MAP, PLAN	This symbol displays the prediction point where an active route leg will terminate at the indicated altitude.
	VOR (C) DME/TACAN (C), VOR-DME/TACAN (C) AMBER X	MAP	These symbols denote NAV stations blackballed via MCDU action.
	COURSE DEVIATION INDICATOR (M) and SCALE (W)	ROSE, ARC	Displays ILS deviation when the ILS frequency is selected and valid signals are present. VOR deviation is displayed when a VOR frequency is selected and valid signals are present.
	HOLDING PATTERN INACTIVE (W) ACTIVE (M)	MAP, PLAN	This symbol displays holding patterns on the route within current EFIS range.
	NAVAID POINTERS	MAP	These symbols represent position verification arrows for the manually tuned nav aids.

Flight Management, Navigation
Flight Management System Description**Chapter 11**
Section 21

Overview

The flight management system (FMS), in conjunction with other interfacing equipment on the aircraft, provides automatic navigation guidance, map display, and in-flight performance optimization. It eliminates many routine tasks and computations normally performed by the flight crew. When coupled to the autopilot, flight director, and autothrottles, the system provides guidance for controlling roll, pitch, and engine thrust.

FMS Functions

The following are major functions of the integrated FMS:

- Storage of navigation, aerodynamic, and engine data.
- Means for entry, storage, and in-flight modification of a complete flight plan from the departure gate to the destination runway.
- Computations of the optimum vertical profile based on pilot entries and the performance database.
- Transmission of data to generate maps of the route on the EFIS ND.
- Calculation of the aircraft's position and transmission of this information for display on the EFIS nav displays and multipurpose control and display unit (MCDU).
- Capability to select and tune DME stations that will yield the most accurate estimate of aircraft position.

FMS Components

The FMS consists of one advanced flight management computer (AFMC) and two multipurpose control and display units (MCDU's). The FMS performs the general functions of performance management and three dimensional navigation. These functions are available as long as the AFMC and either MCDU is operative.

The AFMC uses inputs from a number of sources to compute navigation and performance information. This information is displayed in the flight deck and sent to the autopilot, flight directors, and autothrottles as roll, pitch, airspeed, and thrust commands. The following systems and components provide inputs to the AFMC.

- IRS aircraft - Provides position and velocity information.
- Captain's digital clock - Source of GMT for the AFMC.
- CADC's - Provide pressure altitude, vertical speed, and airspeed.
- DME - Source of updating estimate of aircraft position.

- VHF nav receivers - Manually tuned source of radio positioning.
- DFGC - Provides vertical accelerations and attitudes (pitch and roll).

The AFMC uses these inputs, flight crew entries to the MCDU, and stored data (AFMC database) for its computations in forming an estimate of the aircraft's position and velocity.

AFMC Database

The information stored in the AFMC is called its database and is divided into two major sections: performance and navigation.

- Performance data.
 - Airplane drag and engine characteristics.
 - Optimal speed data.
 - Maximum and minimum speeds.

- Navigation data.

Includes most information that the pilot would normally determine by referring to navigation charts. This information may be displayed on the MCDU or ND map or plan mode and includes the following:

- Published airways, nav aids, and intersections in the U.S.
- Normal Delta on and off line airports, runways, SIDS, STARS, and approaches, including missed approach procedures.
- Selected data in Southern Canada and Northern Mexico.
- Most airports in the U.S. with runways of 8,000 feet or longer.

The AFMC contains two sets of navigation data. Each set corresponds to the normal revision cycle for navigation charts. The navigation database is updated by maintenance every 28 days. During preflight the flight crew can select which set is active.

The FMS is capable of providing fully automatic guidance along a lateral flight path (NAV) and a vertical flight path (VNAV). These modes are coupled to the flight director and/or autopilot and autothrottles by engaging the NAV and VNAV switches on the flight guidance control panel (FGCP).

Multipurpose Control and Display Unit

Two MCDU's (Captain's and First Officer's), located on the center console, provide the pilots with a means of entering data into the AFMC. Each multipurpose control and display unit (MCDU) has a CRT display, keyboard, mode and function keys, line select keys, and annunciator lights.

FMS Flight Guidance Modes

The FMS is capable of providing fully automatic guidance along a lateral flight path (NAV) and a vertical flight path (VNAV). These modes are coupled to the flight director and/or autopilot and autothrottles by engaging the NAV and VNAV switches on the flight guidance control panel (FGCP).

NAV Mode

NAV (lateral guidance) outputs from the AFMC are normally great circle courses between the waypoints making up the active route. However, when a procedure stored in the AFMC database is entered into the active route, the AFMC can supply commands to fly a constant heading, track, or follow a DME arc.

The AFMC generates lateral steering commands along the programmed route of flight based on its calculated present position. In flight, the AFMC estimates its position and velocity based on inputs from the IRS, DME, VOR, and ILS. As the aircraft progresses along its flight path, the AFMC uses its current estimate of the aircraft's position and internal database to auto tune the DME receivers to the stations that will yield the most accurate estimate of position. Aircraft position is determined using facilities in the following order.

- LOC
- Multi-DME (3-5 stations)
- VOR/DME (co-located)
- Dead reckoning/inertial navigation-loss of radio position

In the terminal area, the aircraft position can be refined by use of a localizer signal. The fifth DME and VOR / DME modes require a valid manually tuned VHF frequency. If both the #1 and #2 nav receivers have valid signals, the closer of the two will be used. The MCDU progress page #1 displays manually selected and auto tuned VOR's.

Loss of Radio Position

If the FMS loses all valid radio information, IRS equipped aircraft transition to IRS NAV ONLY (annunciated in MCDU scratch pad), and the FMS position and MAP displays remain valid.

Heading Hold Submode

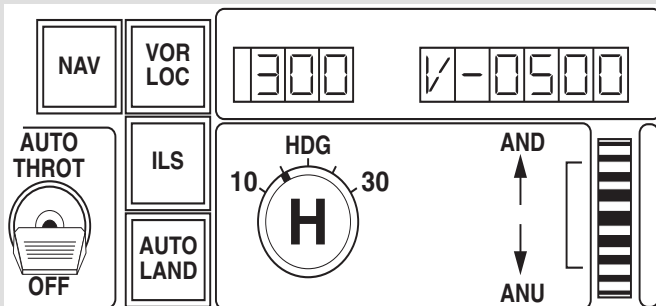
A submode of NAV exists which is designed to maintain the aircraft on current heading during the following conditions:

- When flying past the last route waypoint.
 - The MCDU message END OF ROUTE is displayed.
- When flying into a route discontinuity.
 - The MCDU message END OF ROUTE is displayed.
- When flying past the end of a lateral offset.

- Approaching the end of an offset, the MCDU message END OF OFFSET is displayed.
- When executing an INTERCEPT/COURSE TO procedure while the aircraft is outside the NAV capture band of the active leg.
 - If current aircraft heading intercepts the active leg, NAV maintains that heading until course capture.
 - If current aircraft heading will not intercept the active leg, NAV maintains heading and the MCDU message NOT ON INTERCEPT HEADING is displayed.

FMS Generated Roll Commands

During NAV mode operations, commanded roll angles and roll limits do not consider the FGCP bank angle limiter. Normally, FMS commanded turns are limited to 25° of bank. However, the bank limit is 15° if NAV is engaged, the slats are extended, and the airspeed is less than an AFMC computed minimum speed.



NAV Engagement

The flight crew may couple the FMS NAV mode to the DFGS by selecting NAV on the FGCP as long as the following conditions are satisfied:

- Valid input data (DFGC, IRS, CADC, etc.).
- The following FMS data is present and valid.
 - Aircraft position.
 - True airspeed and altitude data from the CADC.
 - Roll and pitch attitudes from the platform.
 - Active route.
 - Gross weight, cost index, and cruise altitude.
- Autopilot or flight director, or both, are engaged.
- The FGCP NAV button is pushed.
- Engagement will occur if:
 - The cross track distance from the aircraft is 2.5 nm or less, or
 - The aircraft is on an intercept heading with the active route and the FMS calculates a smooth intercept.

NAV will annunciate in the FMA arm window if neither of these conditions are met. If the aircraft track will not intercept the active route, the MCDU will annunciate NOT ON INTERCEPT TRACK. Flight crew action will be necessary for NAV engagement if not on an intercept track.

Conditions Resulting in NAV Disengagement

- The flight crew engages another roll mode, such as HDG SEL.
- An armed mode becomes engaged, e. g., a transition from LOC armed to LOC CAP.
- A loss of input data that is required for NAV mode operation.
- A loss of navigation data (position or velocity) data.
- The autopilot and both flight directors are de-selected.
- Switching from an active to an inactive route without performing a DIR TO.
- An END OF OFFSET, DISCONTINUITY (if not on an intercept track) or END OF ROUTE is encountered.

When NAV disengages, the DFGS reverts to HDG HLD.

NAV Mode Holding

The FMS will provide automatic navigation guidance for entering and flying a holding pattern. When the pilot programs a holding pattern into the route of flight, the ND MAP or PLAN mode will display the holding pattern. When coupled to the autopilot, flight director, and autothrottles, the system will enter and fly the pattern.

Database Holding Patterns

The FMS database contains only those holding patterns that are associated with a missed approach procedure. These holding patterns become part of the route of flight automatically when the flight crew selects an approach on the DEP/ARR page.

Constructing a Holding Pattern

The flight crew may use the HOLD page of the MCDU to construct other holding patterns. The HOLD page offers the option of creating a holding pattern either at the aircraft's present position or at any enroute waypoint. Additionally, the flight crew may specify the holding radial, direction of turns, leg length or time, and holding speed and altitude. If not modified by the flight crew, the HOLD page will default to the following parameters:

- Direction of the inbound course defaults to the course along the active route of flight to the holding fix.
- Leg length defaults to:
 - One minute at or below 14,000 feet.
 - 1.5 minutes above 14,000 feet.

- Direction of turn defaults to right turns.
- The FMS hold speed defaults to the higher of 1.5 Vs clean and the minimum 1.25g buffet speed.

Once programmed, the FMS will display the holding pattern as part of the route of flight on the ND MAP or PLAN mode display.

Holding Pattern Entry

The aircraft must first cross the hold waypoint before entering the holding pattern. The FMS uses three types of hold entries: parallel, teardrop, and direct entry. The FMS uses standard pattern entry methods with the following exceptions:

- The entry method is a function of actual aircraft track as it crosses the holding fix as opposed to aircraft heading.
- Teardrop entries use a 40° angle.

Hold Guidance

The FMS builds the holding pattern assuming a 25° bank angle. However, the FMS allows up to 30° of bank to stay on the computed path. When operating near the minimum speed, the bank angle compensation function will increase the speed target approximately 10 to 15 knots during turns. Each time the aircraft crosses over the holding fix, the FMS recomputes the holding pattern turn radius based on programmed airspeed.

Exiting the Holding Fix

The flight crew may exit the hold by either of two methods:

- Select and execute the EXIT HOLD prompt on the HOLD page. The FMS will provide guidance directly back to the fix and then along the remainder of the route.
- Change the route of flight by any other means, such as changing the active waypoint on the DIR/INTC page or selecting a roll mode other than NAV.

VNAV Mode

The VNAV function of the FMS provides vertical guidance and speed/thrust control through the climb, cruise, and descent phases of flight.

Climb

During climb, the FMS controls thrust and speed by VNAV pitch and EPR commands to the DFGC. The aircraft will climb at climb limit thrust to each altitude constraint, fly level at cruise thrust until past the constraining waypoint, and then resume the climb at climb limit thrust. The normal VNAV climb speed schedule is 250 knots below 10,000 feet, then economy speed above 10,000 feet. Economy climb speed is a function of gross weight at top of climb, entered cruise altitude, and cost index.

Cruise

The FMS defaults to economy speed until the top of descent (TD) point. The pilot may enter other speeds/mach on the MCDU CRZ page.

Descent

The AFMC calculates a descent path when a pilot enters an end of descent (ED) point. The ED point is a waypoint altitude constraint that requires a descent from cruise altitude. The pilot may enter an ED on the LEGS page of the MCDU or by selecting a STAR or approach on the DEP/ARR page.

The AFMC computes the descent path by starting at the ED point then projecting up to the cruise altitude. The point where this path intersects the cruise altitude is the top of descent (TD) point.

At the TD the AFMC commands idle thrust and pitch to track the descent path provided the FGCP altitude preselect readout altitude is set to an altitude below the airplane's current altitude. The pilot may initiate a VNAV descent prior to TD by selecting and executing the DES NOW prompt on the DES page. The aircraft will not begin a descent below the altitude set in the altitude preselect readout.

The descent path to the first constraint assumes idle thrust, speed brakes retracted, a wind speed that decreases with altitude, and the AFMC target airspeed. The AFMC defaults to economy speed above 10,000 feet and 240 knots below 10,000 feet. The pilot may alter the descent profile calculation by entering forecast winds, anti-ice requirements, or changing the target speed. The pilot may make this input using the RTE DATA prompt on the legs page or the FORECAST prompt on the DES page.

If the pilot modifies the descent path, the AFMC will recompute an idle descent profile. The FMS will correct any deviations from below the vertical profile through throttle position. For deviations above the glide path (with throttles idle), airspeed will increase 10 to 15 knots above target airspeed and a DRAG REQUIRED message will annunciate in the MCDU scratchpad. If this airspeed increase will not maintain the descent profile, the aircraft will depart the descent profile and maintain an airspeed slightly above target.

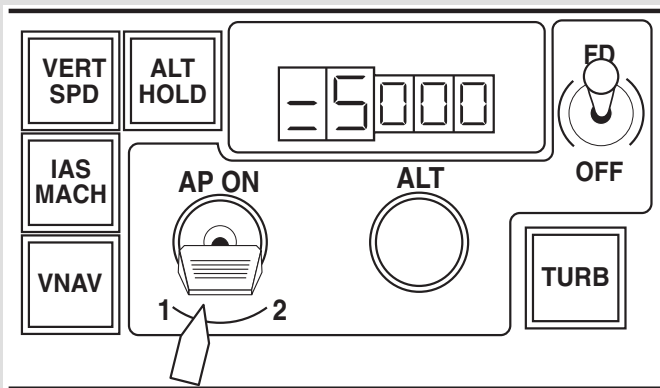
FMS Speed Override

FMS override allows the pilot to manually select a speed while remaining in VNAV. The pilot may engage FMS override by pushing the FMS OVRD button on the FGCP. When in the FMS OVRD mode, the SPD/MACH SELECT KNOB on the FGCP allows selection of the desired speed. When in the FMS OVRD mode:

- The selected speed is displayed in the FGCP SPD/MACH readout window and takes priority over FMS vertical path.
- The FMA throttle window annunciates OVRD followed by the selected speed.
- PROGRESS page 1, line 5L will read OVRD SPD.

FMS OVRD mode does not cause the FMS to re-compute the descent path. Changing the speed on the MCDU does cause the FMS to re-compute the descent path. When FMS OVRD is selected, that OVRD speed takes priority over maintaining FMS computed descent path.

VNAV Engagement



The flight crew may couple the FMS VNAV mode to the DFGS by selecting VNAV on the FGCP as long as the following conditions are satisfied:

- The following FMS data is present and valid:
 - Aircraft gross weight, cost index, and initial cruise altitude.
 - Aircraft position, CADC data, IAS, MACH, SAT, TAT, and baro non-corrected pressure altitude and vertical speed.
 - Roll and pitch attitudes from the platform.
 - FGCP clearance altitude (altitude preselect readout).
 - Acceleration data from the platform.
 - Vertical flight plan.
- Autopilot or flight director, or both, are engaged.

-
- The TRP is not in T.O., T.O. FLX, or GA (VNAV will not engage until 2 seconds after T.O. or T.O. FLEX is deselected).
 - VNAV is selected on the FGCP.
 - The autothrottles are engaged or will be engaged within 5 seconds of selecting VNAV on the FGCP.

Conditions Resulting in VNAV Disengagement

- The flight crew engages another vertical mode such as VERT SPD.
- The armed mode becomes engaged, e. g., a transition from G/S armed to G/S CAP.
- A loss of sensor data required for VNAV mode.
- A loss of navigation data (position or velocity).
- The autopilot and both flight directors are de-selected.
- The autothrottles are disengaged.
- The gross weight parameter is changed so that the aircraft altitude exceeds maneuver limited altitude.
- The TRP is changed to T.O. or T.O. FLX.

When VNAV is disengaged, the DFGS reverts to ALT HLD from VNAV CAP or VNAV LVL and IAS from VNAV CLB or VNAV DES.

MCDU Page Description

The following MCDU pages are examples of a typical JFK to ATL flight. Due to the dynamic nature of database programs and FAA route structure, these pages are intended to describe system capability and MAY NOT REFLECT CURRENT ROUTE DATA.

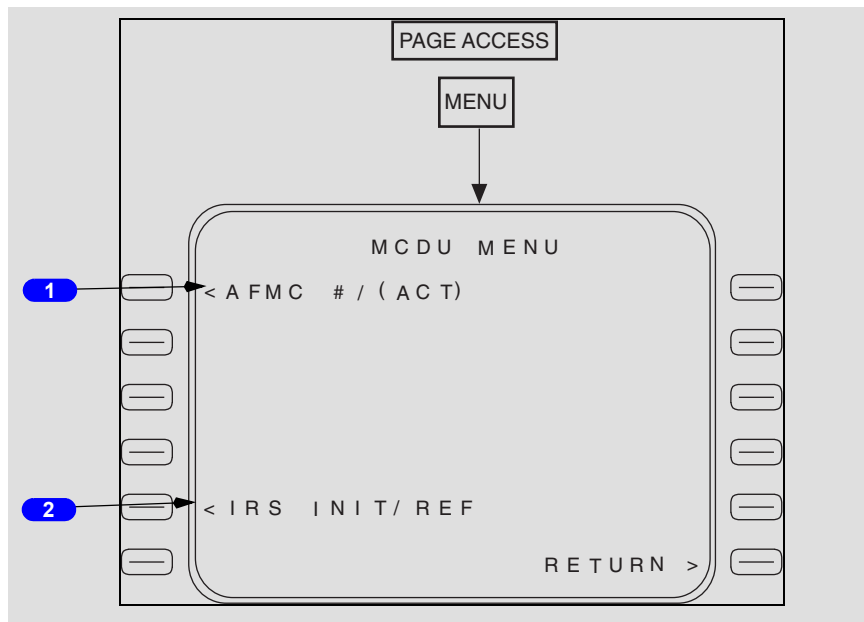
Page access diagrams are presented for each page. They present typical methods used for displaying a page, but may not show all methods available.

MCDU Preflight Page Logic

The Ident page is displayed when power is applied to the AFMC. Subsequent selection of LSK 6R will allow the flight crew to access those MCDU pages required for preflight initialization. If the ident page is not displayed prior to preflight programming, the following key selections will display it:

- INIT REF function key.
- LSK (6L) adjacent to Index
- LSK (1L) adjacent to Ident

Menu Page



1 AFMC #1

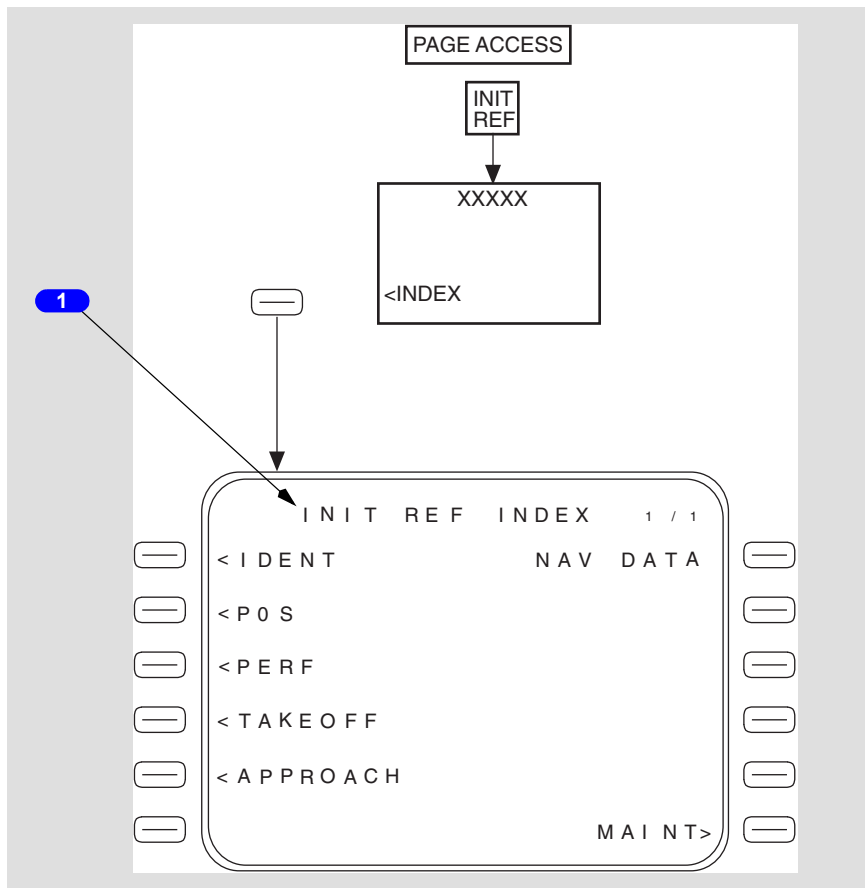
Selecting AFMC #1 accesses the flight management computer.

- ACT - Indicates AFMC #1 is the active subsystem.
- REQ - Indicates AFMC #1 is not active. Selecting AFMC #1 will activate it.

2 IRS INIT/REF

Alternate means of accessing IRS INIT/REF page (Refer to IRS FULL ALIGNMENT - ALTERNATE METHOD in navigation section of Vol 1).

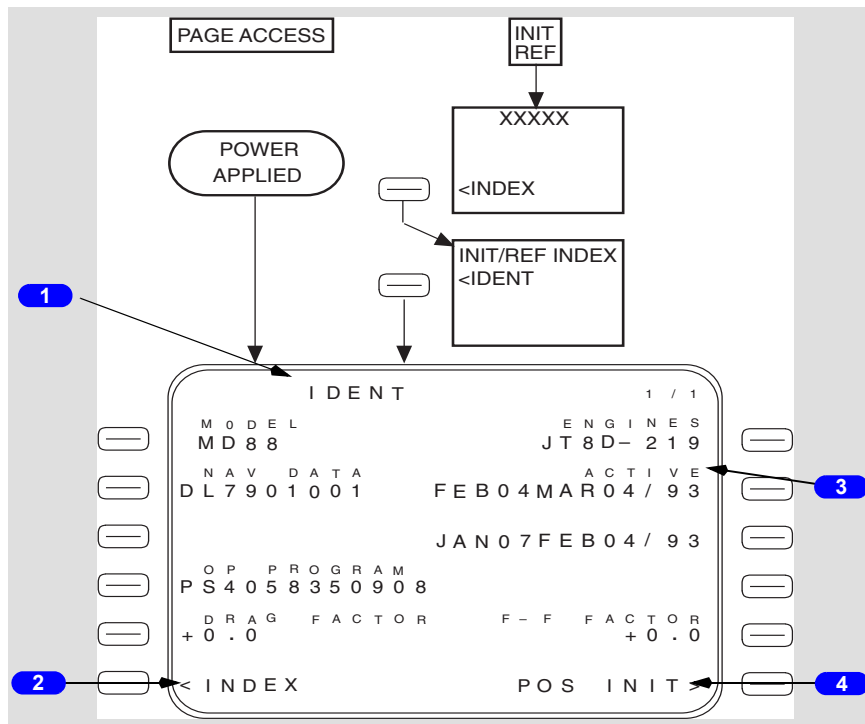
Initialization Reference Index



1 INIT REF INDEX Page 1/1

Provides access to pages of data required for initialization of the AFMC plus other reference data.

Identification



1 IDENT PAGE 1/1

Provides a review of the FMC database and program configuration.

Check performance and navigation database.

Select active navigation database (no other data can be changed directly on this page).

2 INDEX

Selection displays INIT/REF INDEX page.

3 ACTIVE

Displays effective NAV DATA dates.

Line selection permits activating applicable database on the ground.

Selecting clears any previously selected flight plan.

4 POS INIT

Selection displays POS INIT page.

Position Initialization

PAGE ACCESS

IDENT

POS INIT>

POS INIT

1 / 2

N 40° 38.0W

LAST POS

073° 46.4

REF AIRPORT

GATE

SET POSITION

GMT

1432.2Z

SET IRS HDG

INDEX

ROUTE >

1 POS INIT Page 1/2

Displays position page for starting AFMC alignment and IRUs, if installed.

Dashes indicate helpful entries but are not required.

Box prompts indicate required preflight entries.

Enter present position into FMC during preflight alignment.

Check MCDU time reference.

2 REF AIRPORT

Displays reference airport identifier and position.

Valid entries are four character ICAO airport identifiers contained in the database

Entries delete previous gate numbers.

Display clears at liftoff.

Lat/Lon of REF AIRPORT (this is the AIRPORT REFERENCE POINT stored in the database) will be automatically displayed on line 2.

Ref airport will transfer to RTE origin if no origin previously entered.

3 GATE

Not currently available.

4 GMT

Captain's clock provides the time input to the AFMC.

- The first two digits (hours) may be changed by MCDU entries.
- The minute can only be changed by resetting the Captain's clock.

5 INDEX

Selection displays INIT REF INDEX page.

6 LAST POS

Displays present FMC stored position.

7 SET POSITION

Boxes displayed when FMC present position not yet entered.

Entries can be via keyboard or line selecting LAST POS, REF AIRPORT, or GATE.

IRS A/C will display boxes on ground and set position when IRU is in ALIGN mode.

8 SET IRS HDG

On IRS equipped aircraft, when either IRS is in the ATT mode, the SET IRS HEADING line will appear. Enter a magnetic heading value between 0 and 360.

9 ROUTE

Selection displays active RTE 1 (2 if active) page.

Position Reference - IRS Aircraft

The screenshot shows the POS REF Page 2/2. It features a central display area with several lines of text and data. On the left and right sides of the display area are vertical columns of rectangular buttons. Numbered callouts (1-6) point to specific elements:

- 1** points to the title "POS REF" and the page indicator "2 / 2".
- 2** points to the "AFMC POS" section, which displays "N 40° 38.1 W 073° 46.0" and "1 KT".
- 3** points to the "IRS # 1" section, which displays "USE".
- 4** points to the "INDEX" button at the bottom left.
- 5** points to the "GS" (Ground Speed) section, which displays "2 KT".
- 6** points to the "ROUTE" button at the bottom right.

The display also shows "IRS (1)" and "IRS (2)" positions, and an "(AVG)" (average) position. The "ROUTE" button is labeled "ROUTE" with a right-pointing arrow.

1 POS REF Page 2/2

Displayed after pushing NEXT or PREV key from POS INIT page 1/2.

Displays current initialized position as computed by the AFMC.

2 Position Lines (AFMC POS)

Displays present AFMC initialized position.

Displays present IRS 1 and 2 positions.

3 Use Lines

The selection of IRS 1, or IRS 2, or averaging the two IRS positions and velocities for use by the navigation function is performed on this page.

4 INDEX

Selection displays INIT REF INDEX page.

5 Ground Speed Lines (GS)

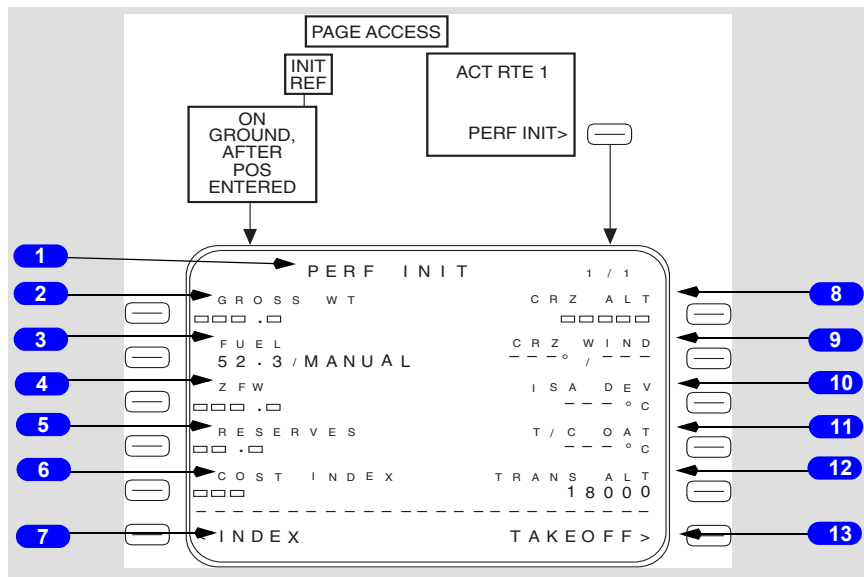
Display ground speed as calculated by flight management computer.

Value frozen at engine shutdown following a flight until power removed.

6 ROUTE

Selection displays RTE page

Performance Initialization



1 PERF INIT Page 1/1

Provides for insertion of data to initialize the AFMC for performance calculations.

Box prompts indicate required preflight entries before VNAV can be used.

Dash prompts indicate helpful (optional) preflight entries

Entered values clear at engine shutdown on the ground.

2 GROSS WT

Valid entry is XXX or XXX.X.

Entered automatically if ZFW and fuel quantity are entered.

2 FUEL

The FMS will not calculate fuel consumption during single engine taxi (both fuel levers must be on).

Valid entry is XXX or XXX.X followed by:

- /N for standard fuel burn configuration.
- /A for alternate fuel burn configuration.

MANUAL appears following the fuel value after the flight crew has made a manual entry. The crew may enter a fuel value at any time during the flight.

4 Zero Fuel Weight (ZFW)

Valid entry is XX or XX.X.

Entered automatically if GROSS WT and fuel quantity are entered.

5 RESERVES

Valid entry is XX or XX.X.

Enter reserves plus fuel to alternate.

6 COST INDEX

Used in computations of ECON speeds.

In general, a low cost index means lower speed and fuel consumption while a higher cost index results in higher speed and fuel consumption.

When required by cost environment changes, the index will be updated by Engineering.

0 makes ECON speed same as MAX RANGE speed. 999 used for minimum time flight

7 INDEX

Selection displays INIT REF INDEX page.

8 Cruise Altitude (CRZ ALT)

Valid entry is XXX (flight level), FLXXX or XXXXX (feet).

9 Cruise Wind (CRZ WIND)

Valid wind direction and speed are each 3 digits.

Entry is propagated to RTE DATA page.

Use DELETE key to delete an entered CRZ WIND value. The operation results in dashes being displayed.

10 ISA Deviation (ISA DEV)

Entered automatically if T/C OAT is entered.

Use DELETE key to delete an entered ISA DEV value. The operation results in dashes being displayed for both the ISA DEV and the T/C OAT.

11 Top Of Climb OAT (T/C OAT)

Entered automatically if ISA DEV is entered.

Use DELETE key to delete an entered T/C OAT value. The operation results in dashes being displayed for both the T/C OAT and the ISA DEV.

12 Transition Altitude (TRANS ALT)

18000 when power applied.

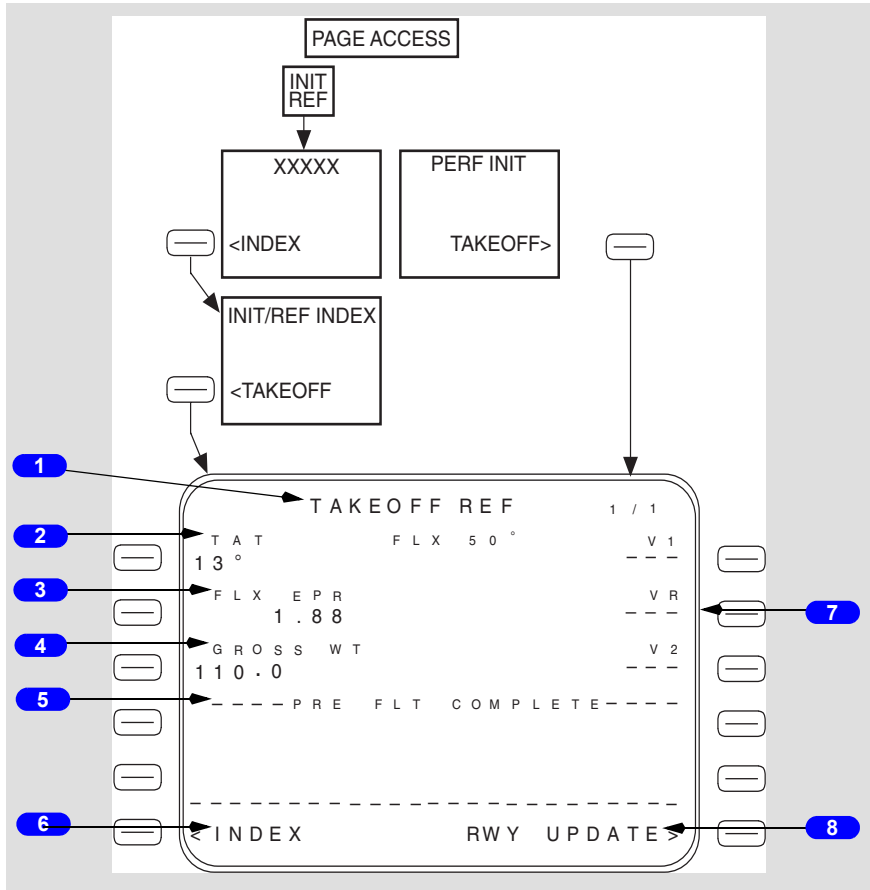
Can be changed by crew.

Changed automatically after selecting a departure procedure containing a different stored value (if not previously changed by crew).

13 TAKEOFF

Selection displays TAKEOFF REF page.

Takeoff Reference



1 TAKEOFF REF Page 1/1

Displays preflight status.

Allows access to runway update prompt.

Allows entry and viewing of takeoff V speeds.

2 TAT Line

Displays temperature received from DFGC.

Reflects assumed temperature entered by the crew (data line 1C) if T.O. FLX is used. The data field will be blank if T.O. (normal takeoff power) is used.

3 Takeoff EPR (FLX EPR)

Displays FLX or TO EPR calculated by the DFGC.

4 GROSS WT

Displays gross weight entered or computed on the performance page

5 PRE FLT COMPLETE

Displayed when preflight information is complete on POS INIT, PERF INIT, ROUTE, and DEPARTURE pages.

If MCDU initialization is not complete, PRE-FLT STATUS appears. Pages requiring preflight entries will appear.

6 INDEX

Selection displays INIT REF INDEX page

7 V1, VR, AND V2

Values may be entered by crew for display purposes only.

8 RWY UPDATE

Updates AFMC position to end of departure runway.

Approach Reference

PAGE ACCESS

INIT
REF

IN
FLIGHT

1 →

2 →

3 →

4 →

5 →

6 →

1 / 1

GROSS WT
FLAPS
V REF

□ □ □ □ □

< INDEX

→

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→

→

2 →

3 →

4 →

5 →

6 →

1 / 1

GROSS WT
FLAPS
V REF

1 2 7 . 7
2 8 °
1 3 5 K T

4 0 °
1 3 0 K T

K A T L 2 6

1 0 0 0 0 F T 3 0 4 8 M

I L S 2 6 L
FRONT
CRS

1 0 8 . 7 I B R U

2 7 0 °

< INDEX

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→

→

→

1 Approach Reference Page

Prior to gross weight and runway entry.

2 APPROACH REF Page 1/1

Displays reference data related to the approach.

3 GROSS WT

Displays AFMC computed weight, pilot entered weight, or boxes.

Displays boxes prior to entering gross weight on PERF INIT or this page.

Leaving page causes AFMC computed weights or boxes to replace any manually entered weights.

4 RUNWAY LENGTH

Displays length of destination runway as entered in the active route after 50 nm from departure point or after the halfway point, whichever is less.

Displays length of entered departure runway when within 50 nm of departure point or before the halfway point, whichever is less.

Blank prior to entering runway en route and after engine shutdown on ground.

5 ILS

Displays the selected runway identifier and corresponding ILS frequency and facility identifier as stored in the nav database.

6 INDEX

Selection displays INIT REF INDEX page.

7 VREF

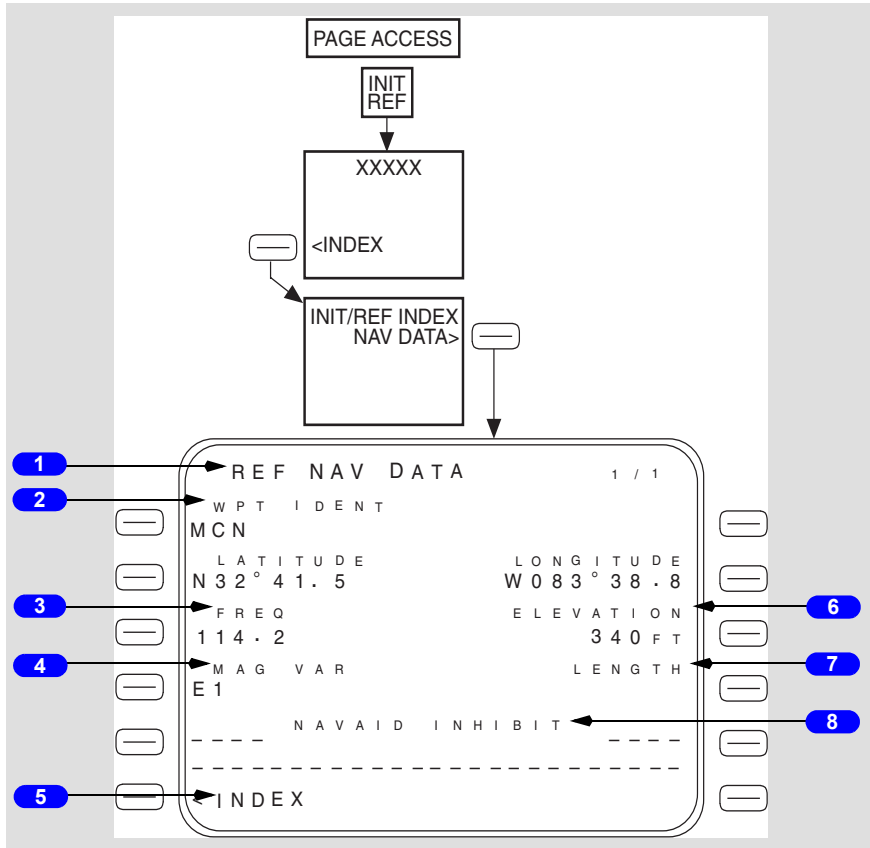
Displays computed VREF for indicated landing flap settings at displayed gross weight.

Blank prior to entering gross weight on PERF INIT or this page.

8 FRONT CRS

Displays the front course in degrees for the ILS displayed in 5L.

Reference Navigation Data



1 REF NAV DATA Page 1/1

Displays associated data of any selected waypoint or navaid contained in database or active route.

Used to select navigation aid inhibit.

2 Waypoint Identification (WPT IDENT)

Valid entry is any waypoint in database: airport, navaid, or runway.

Changing the page causes waypoint to be replaced with dashes and associated data is removed.

3 FREQ

Blank unless waypoint is a navaid; then associated frequency is displayed.

4 MAG VAR

Displays declination at navaid waypoints, otherwise blank.

5 INDEX

Selection displays INIT REF INDEX page.

6 ELEVATION

Displayed for navaids, runways, and airports, otherwise blank.

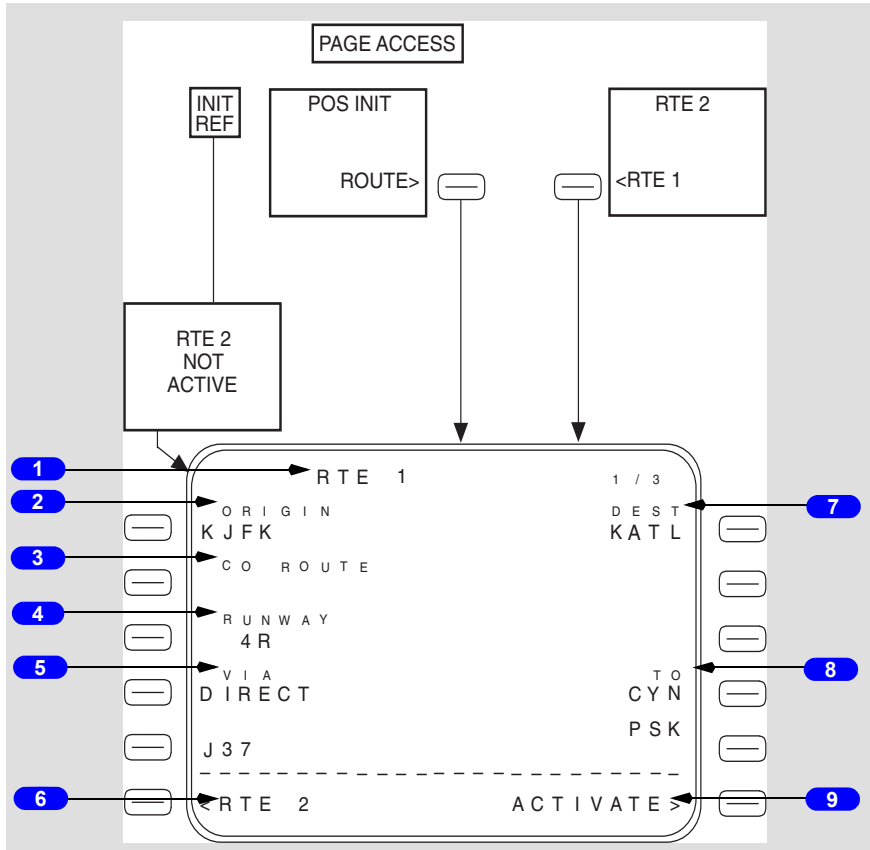
7 LENGTH

Displayed for runways only, otherwise blank.

8 NAVAID INHIBIT

VOR's entered here are restricted from use for navigation updating and automatic tuning.

Route



1 RTE 1 Page 1/3

Display provides for entering a desired route into the AFMC in clearance language for subsequent reference and guidance.

Active route clears at engine shutdown after flight.

Active route deactivated with loss of electrical power.

2 ORIGIN

Origin valid if already entered on POS Page 1.

Valid entries are four letter ICAO airport identifiers contained in the database.

Entry clears previous route.

Entries allow entry of departure or arrival procedures.

Entry inhibited in flight for active route.

Entry transfers to POS Page 1 if pos has not yet been entered.

3 Company Route (CO ROUTE)

Delta company routes are not in the database.

4 RUNWAY

Valid entries are origin airport runways contained in the database.

May be entered by line selection on DEPARTURES page or by manually typing Rwy Fix, i.e., 27R.

If initial runway selection is subsequently changed, the first route entry will revert to DIRECT regardless of previous entries.

5 VIA

Valid entries are DIRECT or airways contained in the database.

Airway entries are allowed if waypoint on previous line is stored in database as airway waypoint

Procedure names (SID, STAR, etc.) automatically appear when selected on DEPARTURES or ARRIVALS page.

6 RTE 2

Selection displays RTE 2 page.

7 Destination (DEST)

Valid entries are ICAO airport identifiers in database.

Entry allows entry of arrival procedures from DEPARTURES/ARRIVALS page.

8 TO

The following entries are valid waypoint identifiers contained in the database or defined geographic points:

- Published waypoints, e.g., entered and displayed as KINKY.
- Intersections (place bearing/place bearing) e.g., entered as ROD 357/SVM 205, displayed as ROD 66 where 66 is AFMC assigned.
- Place bearing/distance, e.g., entered as TCMO94/35 and displayed as TCM35, where 35 is AFMC assigned.
- Along track offsets, entered as waypoint/distance, e.g., GVE/-30 or GVE/30 for 30 miles before or after GVE.
- VHF navaid, e.g., entered and displayed as ATL.

-
- Destination airport runway, e.g., entered as 8 and displayed as RW08.
 - Four letter ICAO airport identifier.
 - Latitude/longitude, e.g., entered as N3338.7 W008425.7 and displayed as WPTNN, where NN is AFMC assigned. Entries require leading zeroes. Trailing zeroes are optional when latitude and longitude are even degrees, e.g. N43W040.
 - Conditional waypoints associated with procedure selected on DEPARTURES or ARRIVALS pages.
 - Boxes are displayed for discontinuities (gaps in route).
 - Dashes displayed at end of route.

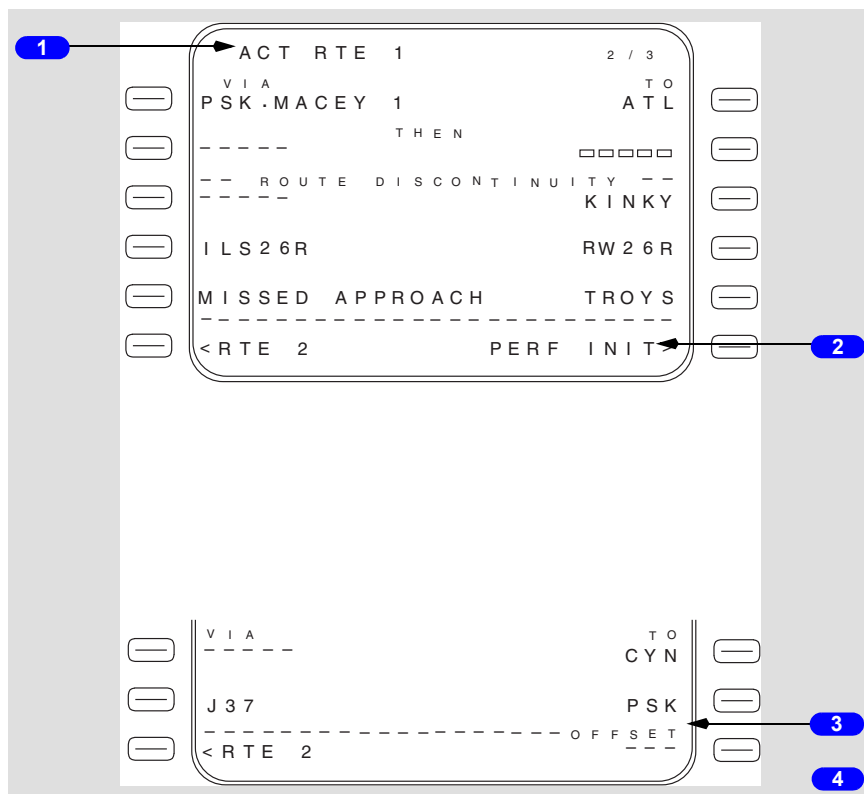
9 ACTIVATE

Displayed only on non-active RTE pages.

After activation on the ground, ACTIVATE prompt is replaced with PERF INIT, TAKEOFF, or OFFSET- - -.

After actuation in flight, RTE LEGS (DIR/INTC) Page 1 is displayed.

Route (Continued)



The screenshot displays the 'Route (Continued)' page of the Delta Flight Management System. The page is divided into two main sections. The top section, labeled '1' in a blue circle, shows the 'ACTIVE RTE 1' page (2 / 3). It displays a route from PSK to MACEY 1, then to ATL. The route is marked as 'ROUTE DISCONTINUITY' with a 'KINKY' indicator. The bottom section, labeled '2' in a blue circle, shows the 'PERF INIT' page. It displays the route from PSK to MACEY 1, then to ATL, with a 'ROUTE DISCONTINUITY' indicator. The 'PERF INIT' page is labeled '3' in a blue circle. The 'PERF INIT' page is labeled '4' in a blue circle. The 'PERF INIT' page is labeled '3' in a blue circle. The 'PERF INIT' page is labeled '4' in a blue circle.

1 ACTIVE RTE 1 Page 2/3

Title changes to ACTIVE after execution.

Display is continuation of RTE 1.

Display illustrates a route discontinuity. The route termination identifier under TO is not a part of the selected approach procedure. This requires entries to link the defined route segments.

2 PERF INIT

Displayed only on ground on active or modified pages with incomplete PERF INIT entries.

Selection displays PERF INIT page.

3 OFFSET

Displayed only on active or mod RTE pages while airborne.

Valid entries are pilot entered right or left lateral offsets of up to 20 nm in alphanumeric format, i.e., L10.

Offset propagates along the route to the end of route waypoint or the beginning of an approach procedure or approach transition or a route discontinuity or holding pattern.

DIR/INTC cancels entered offset as does entry of 0 in 6R.

When offset is active, the MCDU OFST annunciator illuminates.

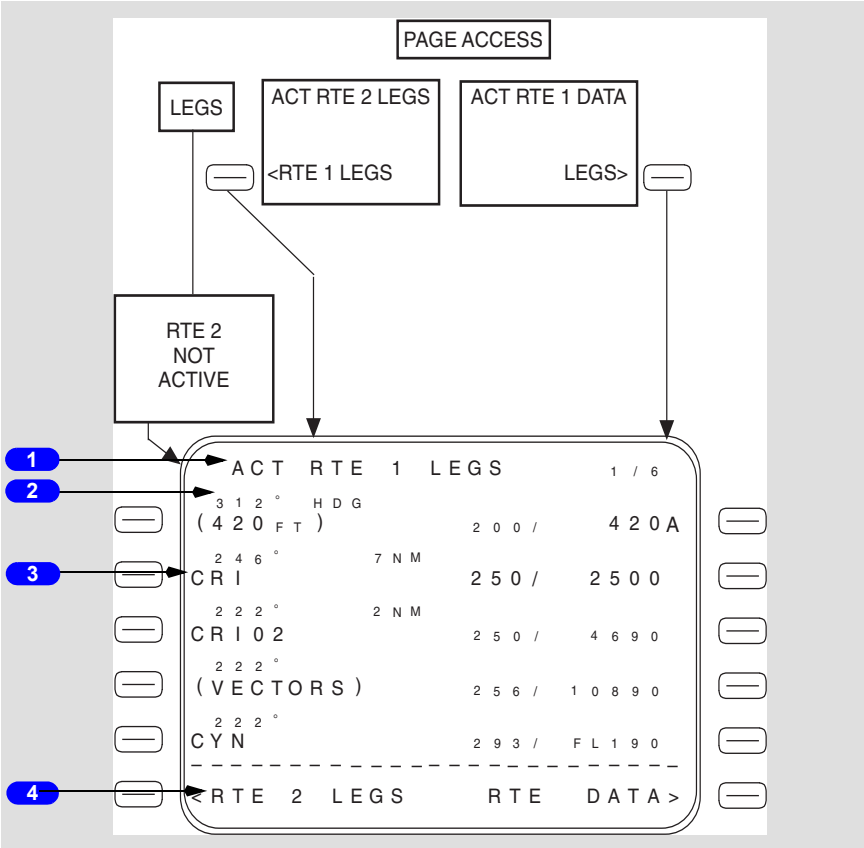
FMS computes 45° intercept from original to offset path if outside 2 nm, 10° intercept within 2 nm.

4 Delete Key (FMS CDU Keypad)

May be used to remove an airway, arrival, or departure procedure from a route. The operation results in the entire procedure being deleted unless any leg within the procedure is currently active.

In this case, the active leg remains active and all points beyond the active waypoint associated with the procedure are deleted.

Route Legs



1 ACT RTE 1 LEGS Page 1/6

Permits entering and displaying details of each leg of the route.
Used to modify route of flight.

2 LEG DIRECTION

First direction is active leg.
Displays computed course to waypoint (246°), heading between waypoints (312° HDG) or procedure (PROC TURN) (HOLD AT).
Directions are magnetic.
Dashes displayed for undefined course.
Displayed directions may be slightly different than value on charts.

3 Waypoint Identifier (WPT IDENT)

First waypoint is active.

All waypoints making up route are displayed on legs pages in flight sequence.

Waypoint sequence may be changed and new waypoints added.

The pilot may add waypoints to the route by line selecting them into the desired point in the route. Waypoints may be navaids, intersections, or points specified with reference to an existing waypoint. To use an existing waypoint as a reference for example, enter CYN/-5 for five miles before CYN or CYN/5 for five miles after CYN. There must not be another waypoint between the original waypoint and the new waypoint. Make the entry by overwriting CYN.

Displayed parenthetical waypoint identifiers are non-geographic and are entered from the database, i.e., procedure altitude (420 ft.) and intercept course (INTC).

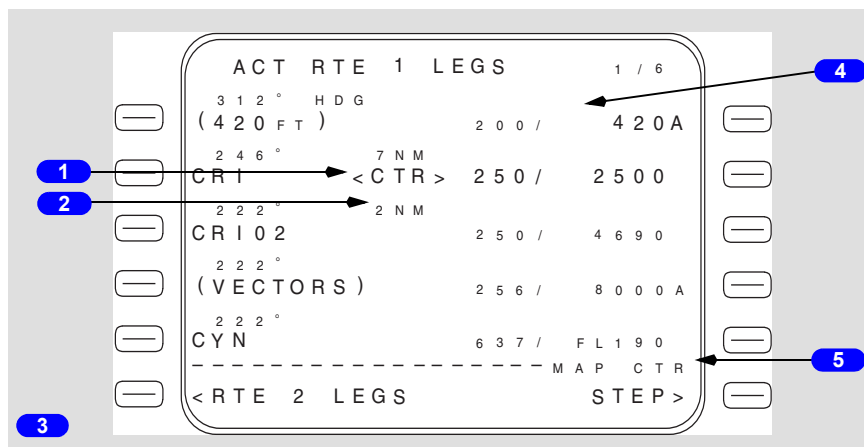
Boxes displayed for route discontinuities.

Dashes displayed at end of route.

4 RTE 2 LEGS

Selection displays RTE 2 LEGS page.

Route Legs (Continued)



The screenshot shows a flight management system display for 'ACT RTE 1 LEGS'. The display is divided into several sections with callouts:

- Callout 1:** Points to the '< CTR >' field, which is centered around a waypoint.
- Callout 2:** Points to the 'COMPUTED LEG LENGTH' field, which is blank for the active leg.
- Callout 3:** Points to the 'ROUTE DATA' section, which includes fields for 'CR I', 'CR I 0 2', and '(VECTORS)'.
- Callout 4:** Points to the 'SPEED / ALTITUDE' field, which shows '4 2 0 A'.
- Callout 5:** Points to the 'MAP CTR' field, which is blank.

The display also shows various other fields such as '3 1 2 ° HDG', '2 0 0 /', '2 5 0 /', '2 5 6 /', '6 3 7 /', 'FL 1 9 0', and '< RTE 2 LEGS STEP >'.

1 < CTR >

Appears adjacent to the waypoint around which the ND plan mode is centered.

2 COMPUTED LEG LENGTH (blank for active leg).

Length in nautical miles between waypoints displayed.

3 ROUTE DATA

Displayed on active or modified RTE LEGS pages and ND not in PLAN mode.
Selection displays RTE DATA page.

4 SPEED / ALTITUDE

Valid entry for airspeed is 3 digits followed by a slash mark (/).

Valid entry for Mach (in place of airspeed) is decimal point followed by either one, two, or three digit Mach number followed by a slash mark (/).

Valid entry for altitude is XXX (flight level), FLXXX, or XXXXX (feet).

Speed constraint entries also require a corresponding altitude constraint entry.

Small characters are estimates computed by AFMC.

Large characters are pilot entered or database airspeed/altitude constraints.

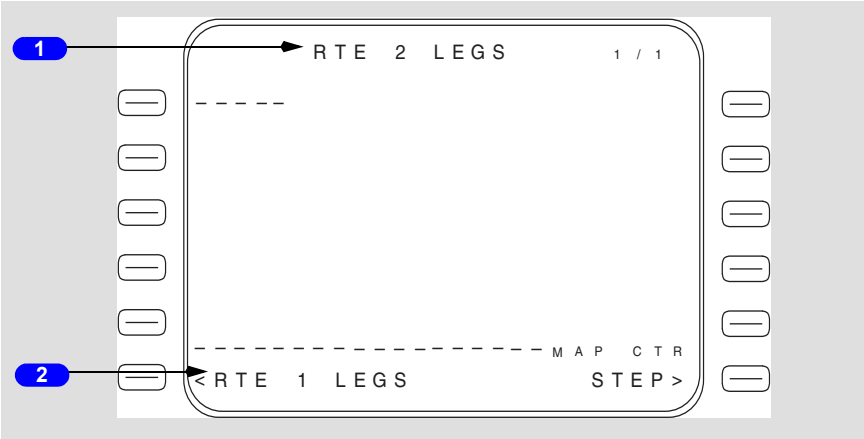
Constraints may be entered by crew on this page or may be entered automatically as part of a procedure.

If constraint is to cross the waypoint at a specific altitude, enter the altitude only. If constraint is to cross at or above altitude, enter A after altitude. If constraint is to cross at or below altitude, enter B after altitude. If constraint is to cross between two altitudes, enter lower altitude followed by A, then enter upper altitude followed by B (example: 220A240B).

5 MAP CTR STEP >

MAP CTR STEP prompt displayed when ND in PLAN mode.

Route Legs (Continued)



1 RTE 2 LEGS

Displayed after pushing RTE 2 LEGS line select key on RTE 1 LEGS page.
Permits entering waypoints for each leg of route 2.

2 RTE 1 LEGS

Selection displays RTE 1 LEGS page.

Route Legs (Continued)

The screenshot shows a flight management system display for 'ACT RTE 1 LEGS' on page 3 of 6. The display is divided into several sections with callouts:

- Callout 1:** Points to the title 'ACT RTE 1 LEGS' and the page indicator '3 / 6'.
- Callout 2:** Points to the 'THEN' section, which includes a 'ROUTE DISCONTINUITY' warning and the word 'KINKY'.
- Callout 3:** Points to the 'PROC TURN' section, which includes '(INTC)' and 'KINKY'.

The route data is as follows:

Waypoint	Distance (NM)	Altitude (ft)
ATL	250	5000
KINKY	250	5000
KINKY	250	3800

The display also shows a 'ROUTE DISCONTINUITY' warning and a 'PROC TURN' section with '(INTC)' and 'KINKY'.

1 ACT RTE 1 LEGS Page 3/6

Example of a ROUTE DISCONTINUITY.

2 THEN

Displayed when an entry is required to link a route discontinuity.

3 Procedure Turn (PROC TURN)

Indicates after KINKY the route includes the published procedure turn. Indicates conditional waypoint at point where procedure turn is completed and 270° course to KINKY is intercepted.

Route Legs (Continued)

1	ACT RTE 1 LEGS	4 / 6
	2 7 0 °	4 NM
	REDAN	1 3 3 / 2 6 0 0
	2 7 0 °	4 NM
	RW 2 6 L	1 3 3 / 9 9 5
2	2 7 0 ° H D G	2 NM
	(1 4 0 0 F T)	2 1 0 / 1 4 0 0 A
	3 6 0 °	1 3 NM
	TROYS	2 1 0 / 3 5 0 0
3	H O L D A T	
	TROYS	2 1 0 / 3 5 0 0

	< RTE 2 LEGS	RTE DATA >

1 ACT RTE 1 LEGS Page 4/6

Example of conditional waypoint.

Example of holding pattern.

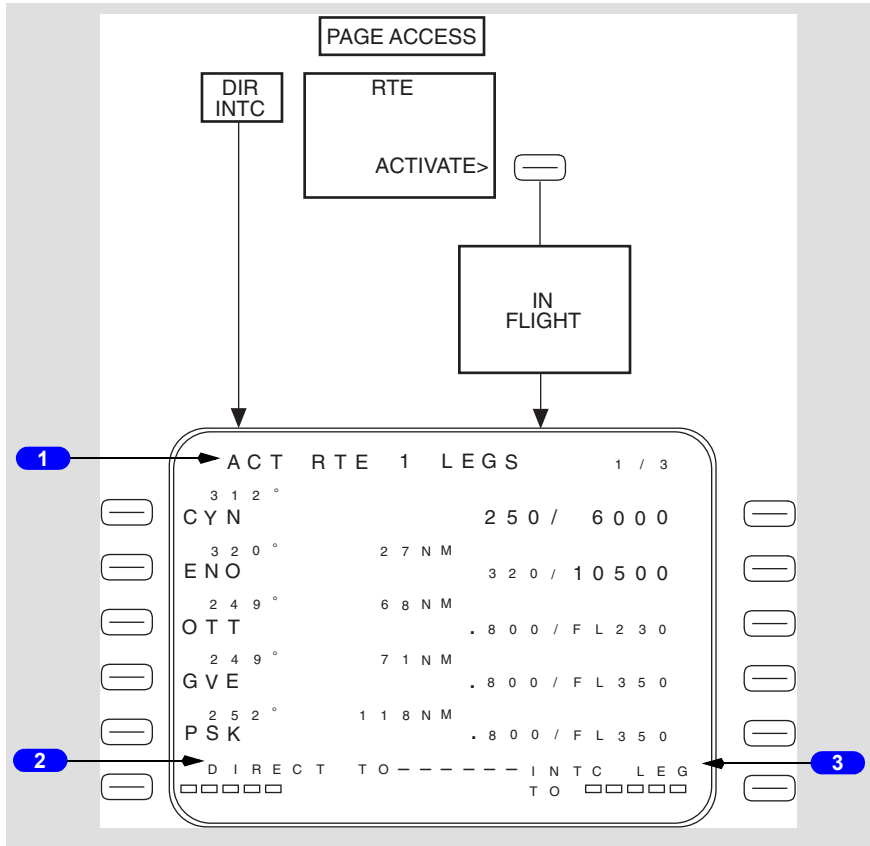
2 (1,400 FEET)

Indicates a conditional waypoint at 1,400 feet. With NAV engaged guidance from runway 26L will be a 270° heading until above 1,400 feet. Then, a turn to track course 360° to TROYS.

3 HOLD AT

Indicates a specific databased holding procedure exists at TROYS.

Direct To/Intercept Leg To



1 ACT RTE 1 LEGS Page 1/3

Display enables flying direct to or intercepting a course to any waypoint in the database or to any entered geographically defined point and subsequent linking to an existing active route.

2 DIRECT TO

Valid entry is any waypoint.

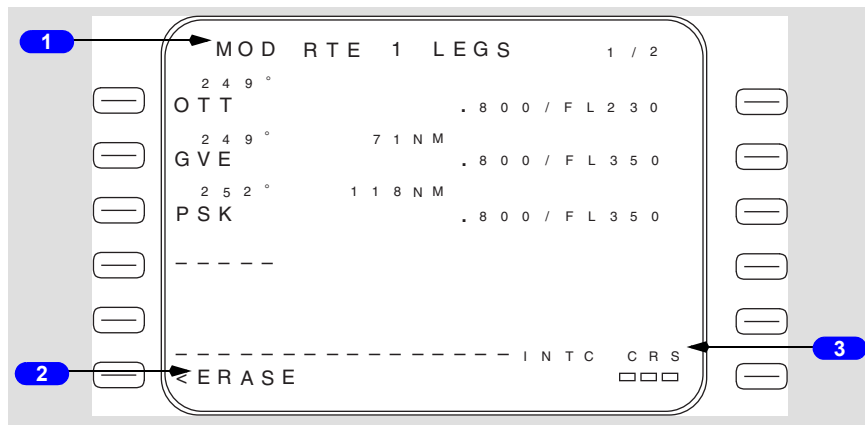
Airplane flies from present position direct to entered waypoint.

3 Intercept Leg To (INTC LEG)

Valid entry is any waypoint.

After waypoint entry, INTC CRS line appears. (See next page.)

Direct To/Intercept Leg To (Continued)



1 MOD RTE 1 LEGS 1 / 2

249°
OTT . 8 0 0 / F L 2 3 0

249° 7 1 N M
GVE . 8 0 0 / F L 3 5 0

252° 1 1 8 N M
PSK . 8 0 0 / F L 3 5 0

----- INTC CRS

2 ERASE

3

1 MOD RTE 1 LEGS Page 1/2

Displayed after pushing DIR/INTC key or ACTIVATE line select key or any RTE page and then pushing the INTC LEG TO line select key.

Permits entry of a course intercept to a waypoint. After course entry and appropriate waypoint line selection, EXECUTING activates the MOD RTE and initiates the intercept leg to the modified route.

2 ERASE

Displayed only on MOD pages.

Selection displays previous unmodified page.

3 Intercept Course (INTC CRS)

Displayed after pushing INTC LEG TO line select key on direct intercept page.

Permits entry of an intercept course to the selected waypoint. After course entry, pushing the EXEC key activates the intercept leg to path.

Direct To/Intercept Leg To (Continued)

1

MOD RTE 1 LEGS 1 / 2

2 6 5 °

X Y Z

T H E N

- - R O U T E D I S C O N T I N U I T Y - -

C Y N

3 2 9 °

E N O

2 4 9 °

O T T

- - - - -

< E R A S E

2 5 0 / 6 0 0 0

2 5 0 / 6 0 0 0

2 7 N M

3 2 0 / 1 0 5 0 0

. 8 0 0 / F L 2 3 0

1 MOD RTE 1 LEGS Page 1/XX

Route discontinuity is displayed when a DIRECT TO entry is not an existing down path waypoint.

The box prompts invite selection of next waypoint after direct to waypoint.

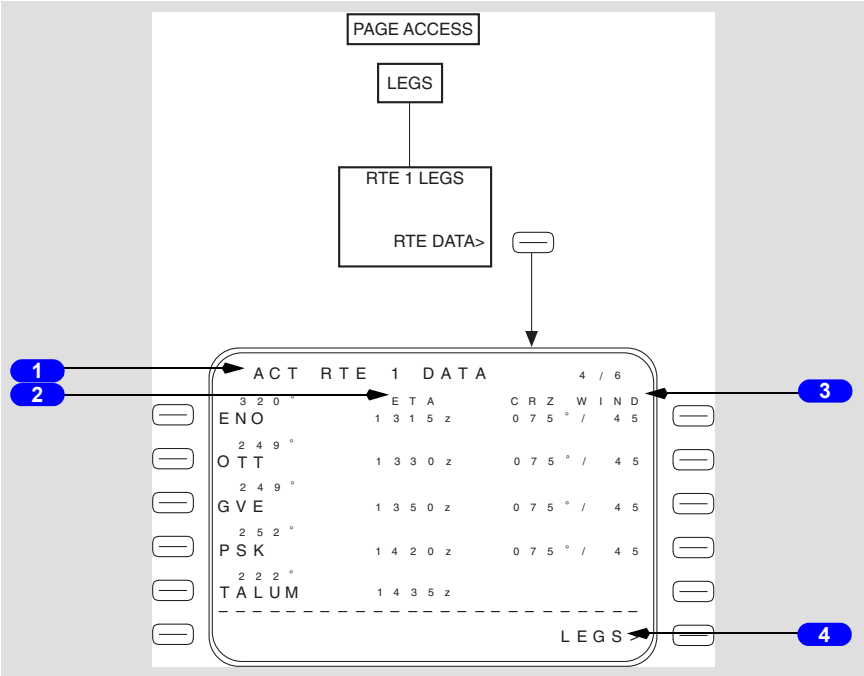
Pushing the EXEC key activates the MOD RTE.

August 11, 2008

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11.21.39

Route Data/Select Desired Waypoint



1 ACT RTE 1 DATA

Displays ETA at all route waypoints.
Permits entry of forecast winds at cruise waypoints.

2 Estimated Time of Arrival (ETA)

AFMC calculated time at waypoint.
ETA calculations assume flying planned vertical profile speeds and a direct flight across discontinuities

3 CRZ WIND

Transferred from PERF INIT page to cruise waypoints.
If no wind entry is made on the PERF INIT page, 000°/00 is displayed.
Can be overwritten by pilot entry.
Wind field is blank at other than cruise waypoints.

4 LEGS

Selection displays RTE LEGS page.

Route Data/Select Desired Waypoint (Continued)

1

→
SELECT DESIRED WPT

E N O	1 1 4 . 8 N 4 0 ° 3 8 . 0 W 0 6 4 ° 3 1 . 5		
E N O	1 1 2 . 4 N 4 4 ° 2 7 . 4 E 1 0 1 ° 1 5 . 7		
E N O	1 1 6 . 6 N 5 0 ° 4 5 . 2 W 0 7 0 ° 1 2 . 2		

1 SELECT DESIRED WAYPOINT (WPT)

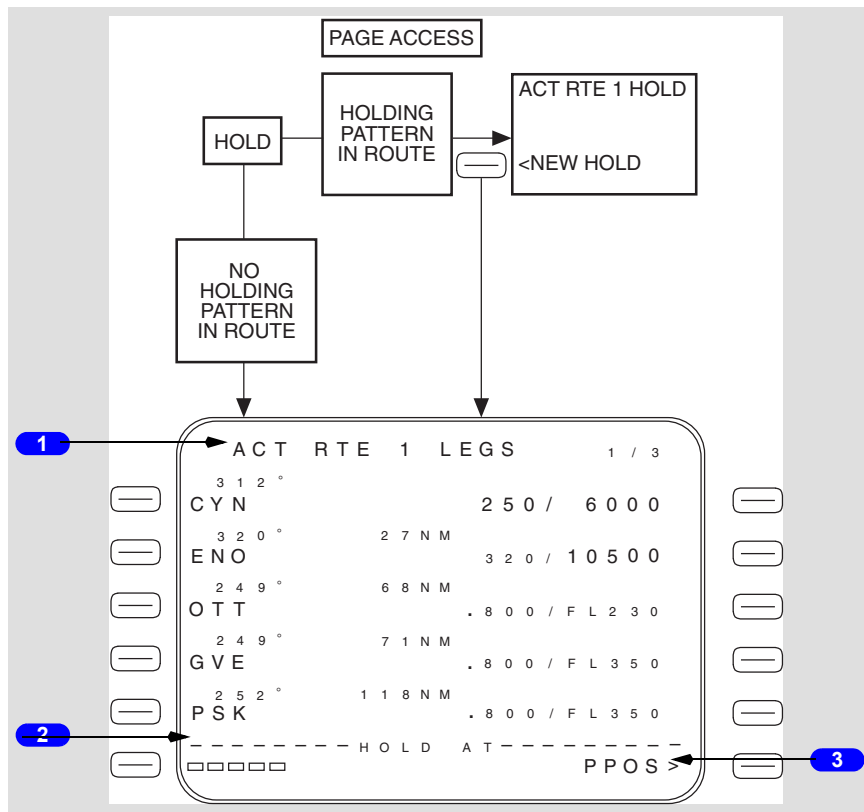
Displayed automatically when a databased identifier is called for and has more than one geographic location.

Permits selecting a specific waypoint when the identifier is not unique.

Line selection selects that waypoint location for use and returns to the page previously in use.

Latitude and longitude of desired waypoint must be known.

Hold



1 ACT RTE 1 LEGS 1/XX

Used to enter a holding pattern in route.

2 HOLD AT

Invites selecting any geographical point as a holding fix.

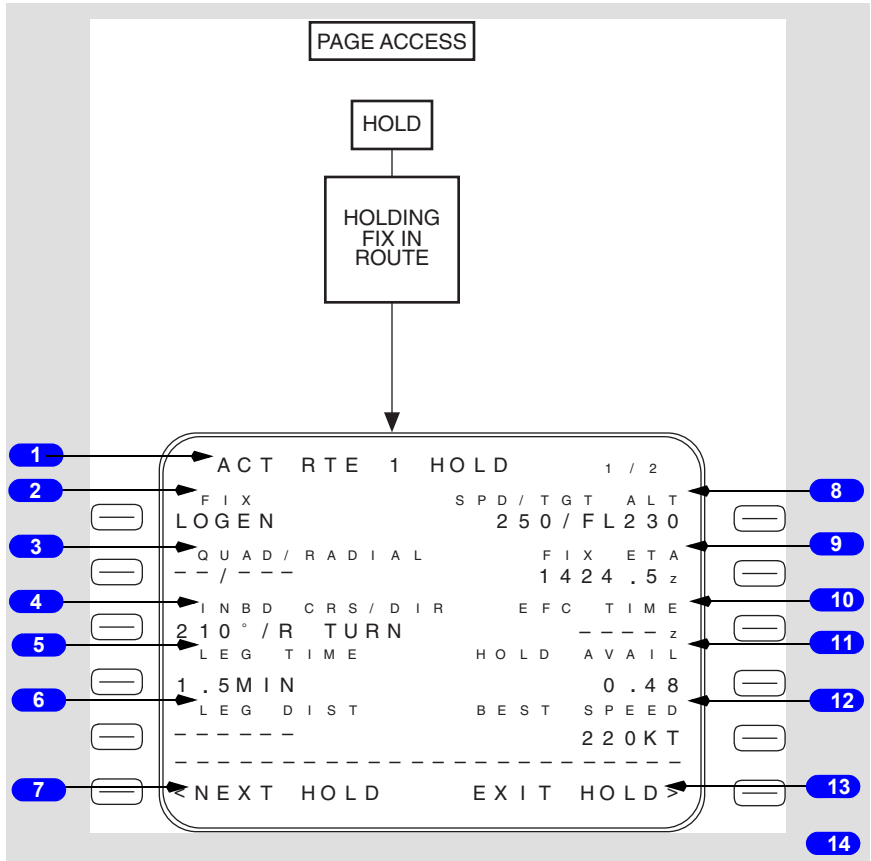
If on an offset path, the airplane will not enter a pre-planned holding pattern.

3 Present Position (PPOS)

Selecting transfers PPOS to scratch pad. Then line selecting PPOS to prompt boxes creates a holding pattern with the fix at present position when the EXEC key is pushed

May be used when flying on an offset path. Holding is in relation to the offset path. Cancelling the offset deletes the holding pattern. Exit from the hold on an offset path deletes the offset path.

Hold (Continued)



1 ACT RTE 1 HOLD Page 1/1

Used to modify holding pattern.

Modifications made to a holding pattern while active in the hold only become effective on the next crossing of the holding fix.

Used to exit holding pattern.

Indicates two holding patterns in Active RTE (1/2). To view other holding pattern, push NEXT page key.

2 FIX

Identifies inserted holding fix.

3 QUAD/RADIAL

Normally displays dashes.

Permits entry of holding quadrant/radial.

Overrides INBD CRS/DIR

Valid entry is X/XXX or XX/XXX.

4 INBD CRS/DIR

Permits keyboard entry for inbound holding course and direction. Default direction is right hand patterns.

Overrides QUAD/RADIAL.

Valid entry is XXX (course).

XXX/X or /X (turn direction).

5 LEG TIME

Displays 1.0 minute at or below 14,000 feet and 1.5 minutes above 14,000 feet.

Can be changed by crew entry.

Overrides LEG DIST display.

Displays dashes if LEG DIST value is entered.

6 LEG DIST

Normally displays dashes.

Value can be entered by crew or by stored procedure.

Overrides LEG TIME display, if selected.

7 NEXT HOLD

Selection creates prompts for entering new holding fix.

8 Speed/Target Altitude (SPD/TGT ALT)

Displays target speed/altitude. If not specified, dashes are displayed

Entry of TGT ALT higher than fix waypoint altitude results in climb after entering holding.

Entry of TGT ALT lower than fix waypoint altitude results in cruise descent after entering holding.

Valid entry is a combination of SPD/ TGT ALT; XXX/ (for SPD), XXX, XXXX or XXXXX (for TGT ALT).

9 FIX ETA

Displays the next time the fix will be passed.

10 EFC TIME

Displays crew entered expect further clearance time.

Entry alters downstream predictions.

11 Hold Available (HOLD AVAIL)

Displays holding time available before exit is required to reach destination with RESERVES entered on PERF INIT page

12 BEST SPEED

Displays best holding speed for current altitude and conditions.

13 EXIT HOLD

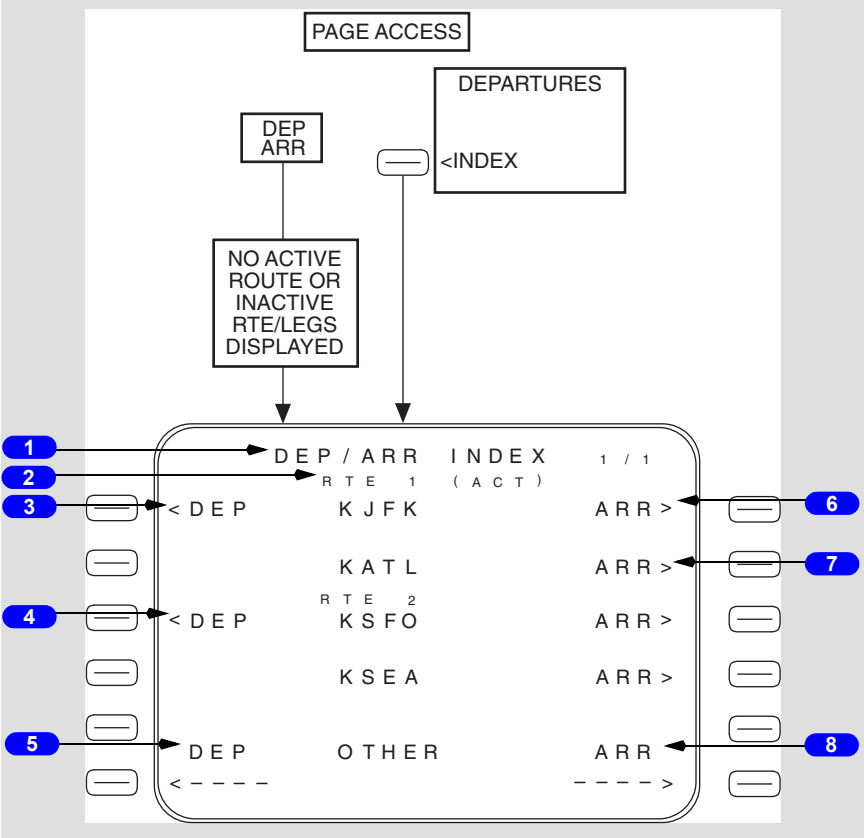
Selection causes EXIT ARMED to appear.

14 EXIT ARMED

Displayed after EXIT HOLD line select key is pushed.

Pushing EXEC key results in flight directly back to the fix and along the active route.

Departure/Arrival Index



1 DEP/ARR INDEX Page 1/1

Display permits access to the departure and arrival pages for the origin and destination of each route and for any other airport in the database.

2 Active Label (ACT)

Displayed beside route number when it is active.

3 DEP RTE 1

Selects departures for origin airport in route 1.

4 DEP RTE 2

Selects departures for origin airport in route 2.

5 DEP OTHER

Upon entering airport identifier, departures page for the entered airport is displayed.

Valid entry is four character ICAO airport identifier in database.

6 ARR RTE 1

Selects arrivals for origin or destination in route 1.

7 ARR RTE 2

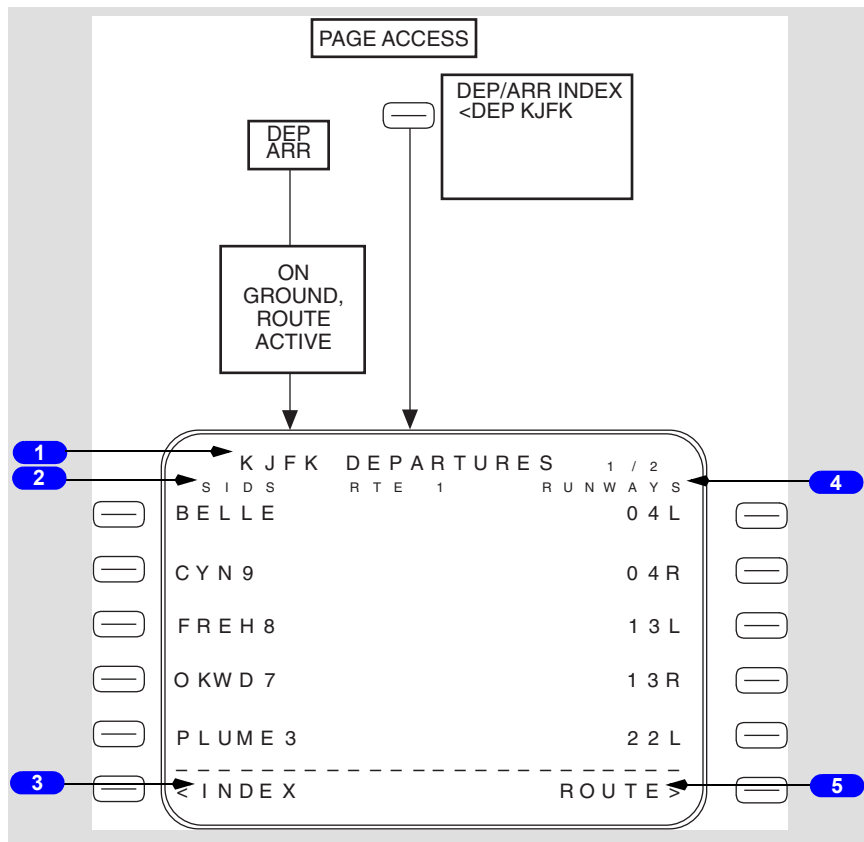
Selects arrivals for origin or destination in route 2.

8 ARR OTHER

Upon entering airport identifier, arrivals page for the entered airport is displayed.

Valid entry is four character ICAO identifier.

Departures



1 DEPARTURES Page 1/2

Displays airport identifier.

Second line displays route number.

Display provides an alphabetical list for selecting standard instrument departures and available runways at departure point.

2 Standard Instrument Departures (SIDS)

Selection of a SID causes all other SIDS to disappear, and transitions for the selected SID are displayed. <SEL> appears beside the selected SID.

If the SID is runway dependent, a runway must be selected before the EFIS displays the procedure and the EXEC key illuminates.

Selection of a transition changes display to DEPARTURE 1/X with the selected transition displayed with SEL indicating the selection

3 INDEX / ERASE

INDEX displayed when inactive route or other airport has been selected on DEP/ARR INDEX. Selection displays DEP/ARR INDEX

ERASE displayed after any selection has been made and prior to execution. Selection deletes any selection and re-displays the entire list.

4 RUNWAYS

Selection displays that runway for use in the route. ERASE prompt appears.

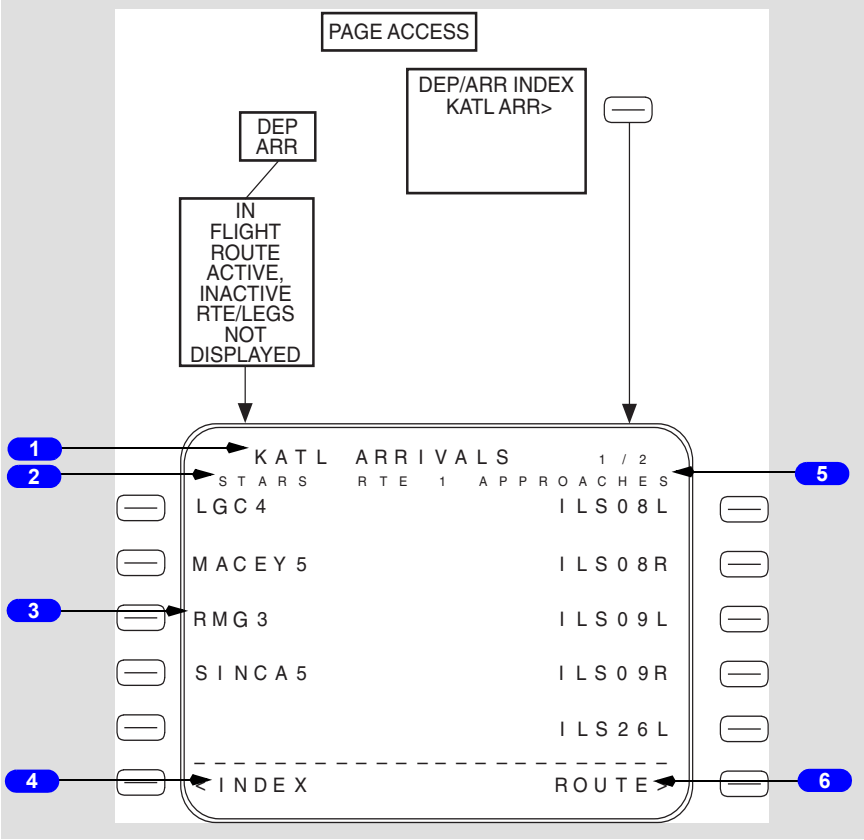
<SEL> appears beside the selected runway. All other runways disappear.

SIDS associated with selected runway remain and all others disappear.

5 ROUTE

Selection displays appropriate RTE 1 or 2 page.

Arrivals



1 ARRIVALS Page 1/2

Displays airport identifier.

Second line displays route number.

Display provides an alphabetical list for selecting standard terminal arrivals, profile descents, and approaches and transitions for the destination airport.

2 Standard Terminal Arrival Routes/Profile Descents (STARS)

Selection causes that STAR or PROF DES to be used in the route.

<SEL> appears beside the selected arrival procedure. All other arrival procedures disappear and transitions for the selected procedure are displayed.

Selecting a procedure deletes any previously selected procedure.

NONE - displayed if no STARS in database.

3 TRANSITION

Selection causes that transition to be entered into the route.

<SEL> appears beside the selected transition. All other transitions disappear.

If no transition is selected, the approach will be a straight in approach starting at a waypoint 4-8 miles outside the final approach fix. This waypoint may be a charted fix or CFXXX (XXX is the runway number).

4 INDEX/ERASE

Same as for DEPARTURES page.

5 APPROACHES

Selection causes that approach to be used in the route.

<SEL> appears beside the selected approach. All other approaches and runways disappear and transitions for the selected approach are displayed.

Selecting an approach deletes any previously selected approach.

6 ROUTE

Same as for DEPARTURES page.

Arrivals (Continued)

The screenshot shows a flight management system display for KATL ARRIVALS. The display is divided into sections: KATL ARRIVALS 2 / 3, RTE 1 APPROACHES, ILS 27R, and RUNWAYS. The RUNWAYS section lists four options: 08 L, 08 R, 09 L, and 09 R. A blue circle with the number 1 points to the first runway option, 08 L. The display also includes a dashed line with the text <ERASE and ROUTE>.

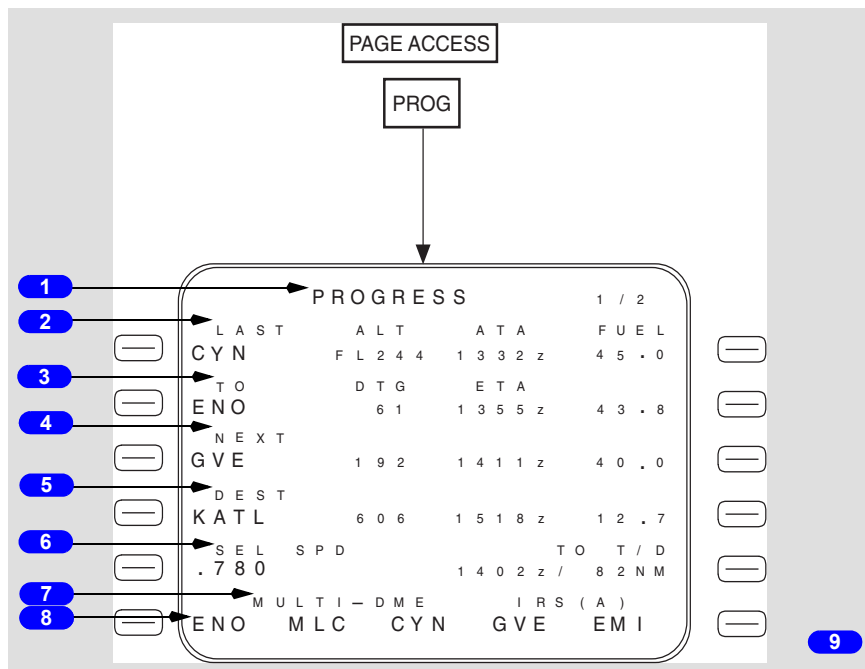
1 RUNWAY

Enters selected runway and an eight mile final approach fix in route.

May enter final approach fix waypoint constraint of 170 knots and 2000 feet above runway on LEGS page.

<SEL> appears beside the selected runway. All other runways and approaches disappear and a VFR APPR prompt may appear.

Progress



1 PROGRESS Page 1/2

Displays flight progress data.

2 LAST

Displays last waypoint and altitude, time, and fuel remaining at that waypoint.

3 TO

Displays waypoint identifier, distance to go, estimated time of arrival, and estimated fuel remaining for the active waypoint.

4 NEXT

Displays waypoint identifier, distance to go, estimated time of arrival, and estimated fuel remaining for the waypoint after the active waypoint.

5 DEST

Displays destination identifier, distance to go, estimated time of arrival, and estimated fuel remaining for the destination.

If a modification is in progress, information is relative to the modified flight plan. The DEST label is replaced with MOD.

Alternate destination waypoint may be entered over the displayed destination. The DEST label is replaced by DIR TO ALTERNATE and the information shown is based on flying direct to the alternate. May be reset to destination by use of delete key or both pilots leaving page.

6 Speed Display

Displays active command speed and mode.

LRC SPD or ECON SPD are displayed if active on performance page.

SEL SPD is displayed when a selected airspeed or Mach is active.

LIM SPD is displayed if speed is being limited by VMO, MMO, FLAP limit, or ALPHA limit.

SPD OVRD is displayed when FMS override is active.

E/OUT SPD is displayed when the engine out mode is active.

For IRS equipped aircraft, this field displays IRS (A) if two IRS positions and velocities are being averaged or IRS (1) if IRS number one or IRS (2) if IRS number two is being utilized for navigation.

7 TO TD Display

Displays ETA and distance to top of descent when cruise is active and within 200 miles of TD.

Other displays are:

- TO TC - When climb is active.
- TO ED - When descent is active.
- TO STEP - Displays 2000 feet higher than cruise altitude when remaining cruise distance permits.
- Crew can overwrite with a different value until a new cruise altitude is entered.

LEVEL AT.

- When ENG OUT CRZ DES is active.

8 FMC Update Display

Indicates update mode of the FMC.

Displays are:

- MULTI-DME.
- DME-DME.
- DME-VOR (1) or DME-VOR (2).
- LOC (1).

9 IDENTIFIER Display

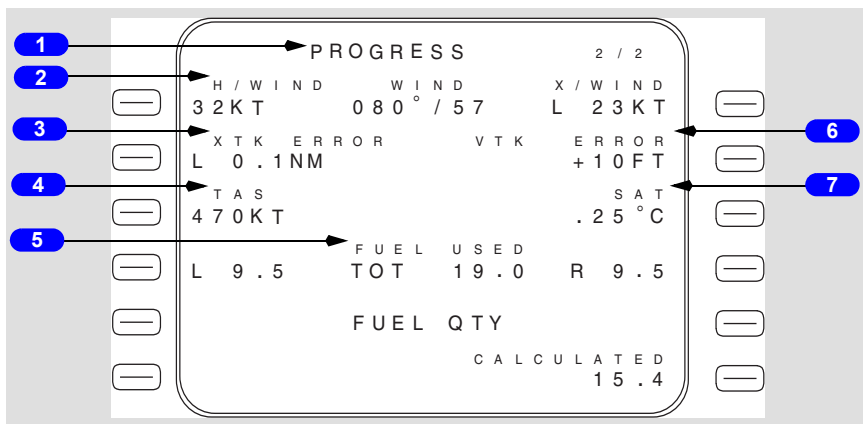
Displays identifier of tuned frequency.

Displays up to 5 navaid identifiers. The manually tuned station will be left justified in line 6L.

10 Delete Key

May be used to delete a previously entered alternate destination. The operation results in the alternate destination being replaced with the planned route destination.

Progress (Continued)



PROGRESS				2 / 2
1	H / WIND	WIND	X / WIND	6
2	3 2 KT	0 8 0 ° / 5 7	L 2 3 KT	7
3	X TK ERROR	V TK	ERROR	
4	L 0 . 1 NM		+ 1 0 FT	
5	T A S		S A T	
	4 7 0 KT		. 2 5 ° C	
	F U E L U S E D			
	L 9 . 5	T O T 1 9 . 0	R 9 . 5	
	F U E L Q T Y			
	C A L C U L A T E D			
	1 5 . 4			

1 PROGRESS Page 2/2

Displayed after pushing NEXT or PREV PAGE key from page 1/2.

Displays current dynamic flight data. No selections are possible except when a fuel discrepancy occurs.

2 WIND Line

Displays headwind (H/WIND), tailwind, (T/WIND), and crosswind (X/WIND).

Wind is resolved on heading.

3 Crosstrack Error Display (XTK ERROR)

Indicates distance airplane is left or right of active route.

4 TAS Line

Displays calculated true airspeed.

5 FUEL USED Line

Displays total fuel used.

Displays fuel used by each engine as calculated from fuel flow.

Blank if fuel value manually entered on PERF INIT page.

6 Vertical Track Error Display (VTK ERROR)

Displays distance airplane is off vertical path.

Blank when descent is not active.

7 SAT Line

Displays static air temperature.

8 CALCULATED (FUEL QTY)

Fuel quantity calculated by subtracting fuel used from fuel on board at engine start.

Value can be changed manually on PERF INIT page.

Fix Information

PAGE ACCESS

FIX

↓

1

2

3

4

5

6

1 / 2

FIX INFO

F I X	B R G / D I S	F R
ABC	111 / 29	
D N T K F X E T A D T G A L T		
130 / 24	2004 . 5	10 12000
180 / 26	2008 . 9	32 FL190

A B E A M 		
150 / 23	2006 . 5	18 15500
< E R A S E 		
ABC180 . 0 / 26 . 4		

1 FIX INFO Page 1/2

Permits creating waypoints (fixes) from the intersection of active route and bearings from the entered fix.

Bearings are magnetic.

EXEC key is not active for this page.

Note: NEXT PAGE permits selection of three radials and a point abeam from a second fix.

2 FIX

Permits selecting or entering navaid or waypoint identifiers contained in the database.

Displayed on ND map mode.

Entering fix displays the bearing and distance from that fix to the airplane.

3 Down Track Fix (DNTKFX)

Valid entry is 3 character bearing from fix. Up to 3 entries can be made.

Entering bearing, displays the radial and distance from the FIX to the intersection with the flight plan path. Estimated time of arrival at the intersection, distance to go to the intersection, and predicted altitude at the intersection is displayed.

4 ABEAM

Selection displays bearing and distance from the FIX to the point abeam of the FIX on the active route. ETA, DTG, and predicted altitude are displayed.

5 ERASE

Selection results in all FIX data being deleted from the MCDU display and the ND.

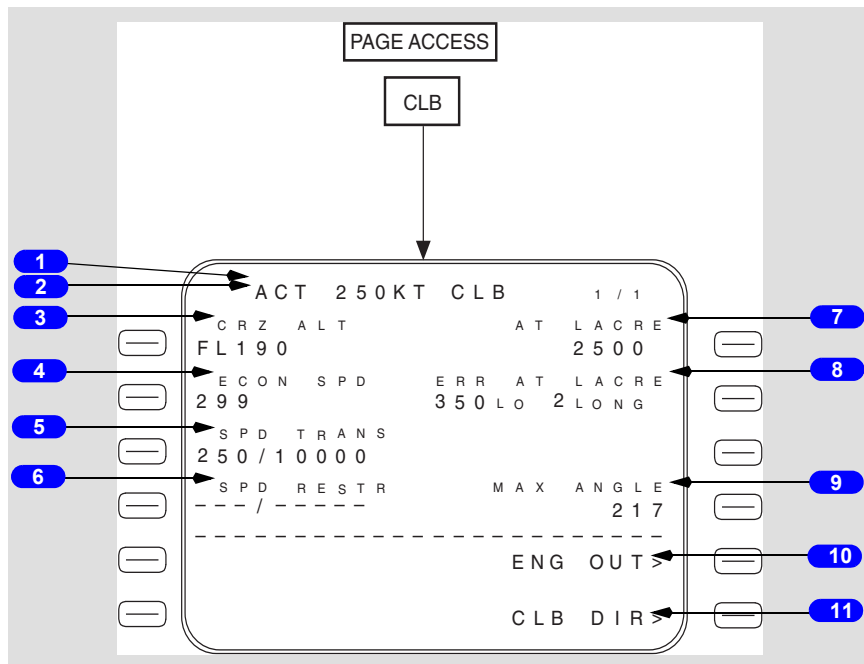
6 Scratch Pad Entry

Line selection of any of the intersection points into the scratch pad for subsequent entry into the flight plan results in the distance values being displayed to the nearest tenth with the format of place/bearing/distance.

7 Delete Key

May be used to delete any of the entered radials or the abeam radial selection. The operation of deleting a radial results in dashes being displayed in place of the radial and the blanking of the associated data and deleting the EFIS display. The operation of deleting the abeam radial selection results in the blanking of the associated data and deleting the EFIS display.

Climb



1 ACT 250 KT CLB Page 1/1

Used to select climb performance modes.

Available modes are economy, selectable speed, and engine out.

2 Page Title

Displays active climb mode: XXX KT if controlling to a fixed speed, M.XXX if controlling to a fixed Mach, or ECON if controlling to economy speed based on cost index set on PERF INIT page.

If the engine out mode is selected, ENG OUT is displayed in title.

If airplane is being controlled at a limit speed, e.g., flap placard, LIM SPD is displayed in title.

3 Cruise Altitude (CRZ ALT)

Propagated from the PERF INIT page valid entry is XXX (flight level), FLXXX or XXXXX (feet). Entries are automatically displayed as flight levels or altitudes based on the transition altitude on the PERF INIT page.

Value greater than SPD TRANS altitude results in two climb segments.

- 250 knots to SPD TRANS altitude.
- Economy speed to CRZ ALT.

Boxes displayed after reaching cruise altitude.

4 Economy/Selected Speed (ECON SPD)

Displays economy speed and Mach.

Speed and/or Mach may be entered. Valid Mach entry is .X, .XX, or .XXX. Label changes to SEL SPD.

5 Speed Transition (SPD TRANS)

Displays database speed limit to an altitude. Associated with the ORIGIN airport.

Automatically displays 250/10000 if no ORIGIN is specified in the RTE page.

Blank above SPD TRANS altitude.

Deleting causes the airplane to fly economy or selected speed if not limited by a waypoint constraint or speed restriction.

6 Speed Restriction (SPD RESTR)

Permits entry of a speed limit to an altitude less than cruise altitude. Above the selected altitude, or if no restriction is entered, dashes are displayed.

7 Waypoint Constraint (AT _ _ _ _ _)

Displays the first waypoint speed/altitude constraint when constraints have been entered on a RTE LEGS page by procedure or crew entry. After passing this constraint, the next one is automatically displayed.

Can be deleted here or on the RTE LEGS page.

The airplane will fly the constraint speed or the current performance speed, whichever is less.

Label can also be HOLD AT XXXXXX (XXXXXX is the holding fix) followed by a speed/altitude constraint.

8 Error At Waypoint (ERR AT _ _ _ _ _)

Displays predicted undershoot for the constraint waypoint. Display shows altitude discrepancy and distance past the waypoint that the altitude will be reached.

Blank (including label) if no error is predicted.

9 MAX ANGLE

Displays maximum angle of climb speed.

10 ENG OUT

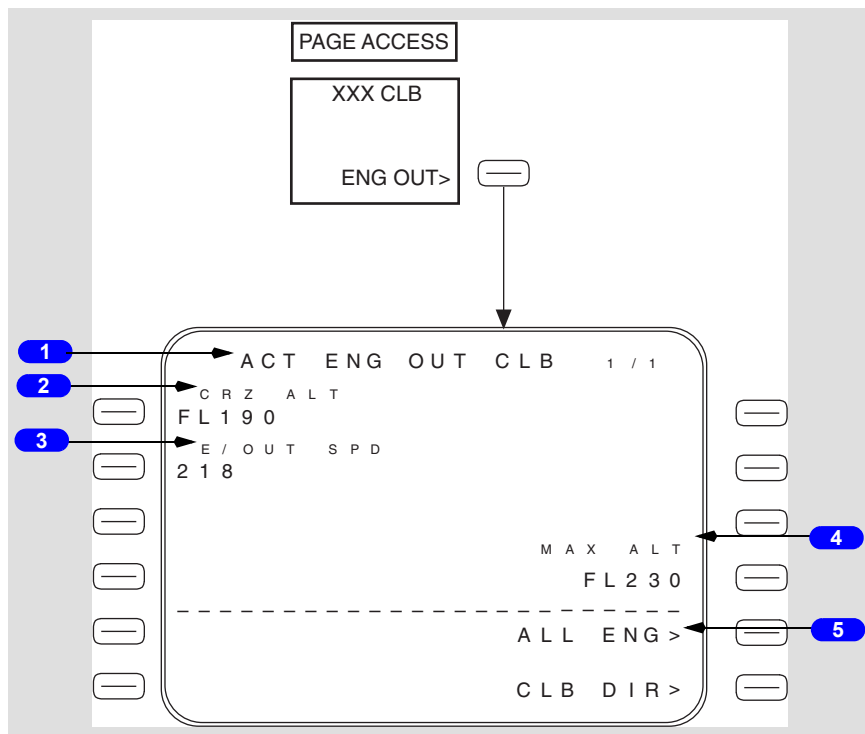
Selection changes page to the ENGINE OUT mode. ENG OUT climb speed is propagated through all climb segments and ENG OUT cruise speed into the cruise segments.

11 Climb Direct (CLB DIR)

Displayed when climb is active and an altitude constraint exists at a waypoint between current altitude and cruise altitude.

Selection deletes all altitude constraints at waypoint between the current altitude and the FGCP altitude preselect readout.

Engine Out Climb



1 ACT ENG OUT CLB Page 1/1

Execution of ENG OUT CLIMB causes a recalculation of all climb and cruise performance data, based on single engine performance values.

2 Cruise Altitude (CRZ ALT)

Automatically displays MAX ALT when selected CRZ ALT is more than MAX ALT and current altitude is below MAX ALT.

When current altitude is above MAX ALT, the display changes to the ENG OUT CRZ D/D page with the DRIFT DOWN ALT displayed as CRZ ALT.

Crew may enter another altitude less than maximum altitude. If lower than the current altitude, page changes to ENG OUT CRZ DES page.

3 E/OUT SPD

Displays engine out climb speed.

Cannot be changed by crew.

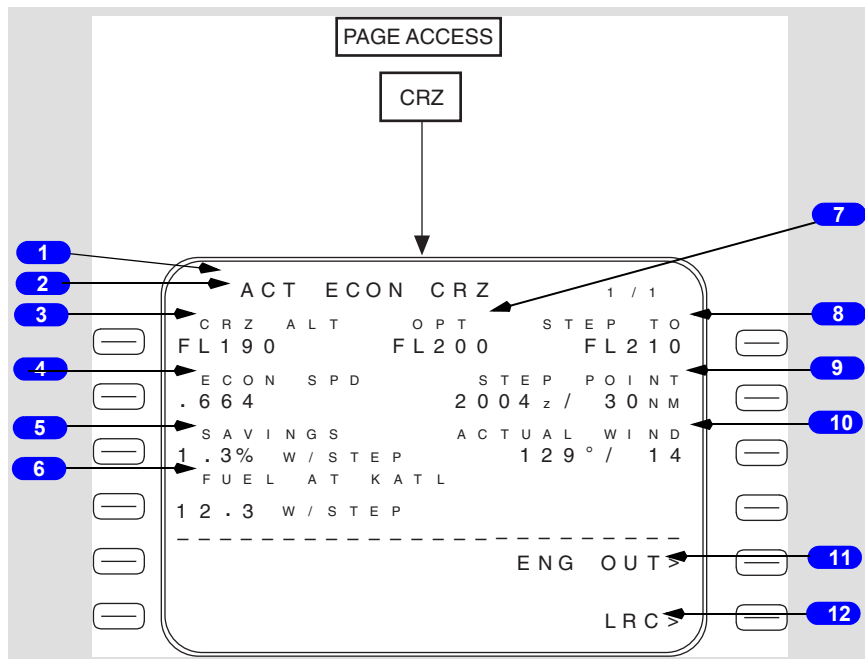
4 MAX ALT

Displays the maximum attainable altitude with one engine out, maximum continuous thrust, and engine out LRC speed.

5 All Engine Line Select Key (ALL ENG)

Selection causes display to return to the all engine performance profile.

Cruise



1 ACT ECON CRZ Page 1/1

Used to evaluate or change cruise mode.

Available modes are economy, selected speed, long-range, engine out, cruise climb, and cruise descent.

2 Page Title

Displays active cruise mode: XXXKT if controlling to a fixed speed, M.XXX if controlling to a fixed Mach, or ECON if controlling to economy speed based on cost index set on PERF INIT page.

LRC displayed if long range cruise selected.

ENG OUT displayed if engine out selected.

LIM SPD displayed if controlling to a limit speed, e.g., VMO/MMO.

CRZ CLB or CRZ DES displayed if new cruise altitude entered on active page.

3 Cruise Altitude (CRZ ALT)

Valid entry is XXX (flight level), FLXXX or XXXXX (feet). Entries are automatically displayed as flight levels or altitudes based on the transition altitude on the PERF INIT page.

Value is forwarded to all pages displaying CRZ ALT.

Changes while the page is active cause the page to change to CRZ CLB or CRZ DES.

4 Speed (SPD)

Displays active command speed or Mach.

Label can show ECON, LRC, SEL, or EOUT SPD.

Flight crew selected speed will transfer to DESCENT page (provided descent constraint is present).

5 SAVINGS

Displays predicted savings or penalty associated with flying the step climb or descent as displayed.

After passing the STEP POINT, it is based on making a step from the current position.

Label is PENALTY if appropriate.

SAVINGS or PENALTY label is suffixed by W/MOD if a flight plan modification is pending.

Blank when active cruise mode is displayed and no step altitude is displayed.

6 Fuel At Destination (FUEL AT K _ _ _)

Displays predicted fuel at destination.

If step information is displayed, fuel display assumes step will occur as displayed, and fuel value is suffixed by W/STEP.

After passing the STEP POINT, the fuel value is based on making a step from the current position.

Label is suffixed by W/MOD if a flight plan modification is pending.

7 Optimum Altitude (OPT)

Displays the most economical altitude to fly based on gross weight, cost index, and trip length.

8 Step To Altitude (STEP TO)

Displays 2000 feet higher than CRZ ALT.

May be overwritten by crew. New value remains until a new CRZ ALT is entered.

Valid entry is XXX (flight level), FLXXX or XXXXX (feet).

Blank when there is no active flight plan or when within 200 miles of TD.

9 STEP POINT

Displays ETA and distance to go to optimum step climb point if the airplane is more than 200 miles from TD.

Label changes to TD when within 200 miles of TD, ETA and distance are relative to TD.

10 ACTUAL WIND

Displays current wind.

May be overwritten by crew with wind at the STEP TO altitude for trade computation. Label changes to EST WIND.

DELETE the EST WIND to return to ACTUAL WIND.

11 ENG OUT

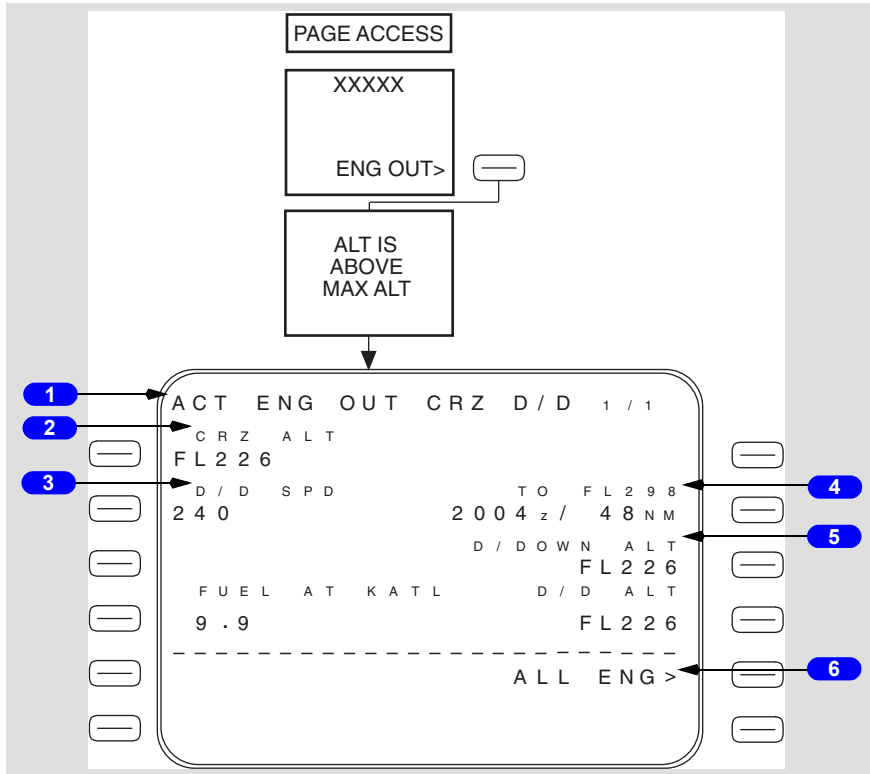
Selection changes cruise mode to ENG OUT CRZ.

- Commands engine out performance calculations.
- Changes cruise altitude if set above drift down altitude.
- Changes command speed to engine out speed.

12 Long Range Cruise (LRC)

Selection changes ECON SPD to LRC SPD.

Engine Out Cruise Descent



1 ACT ENG OUT CRZ DD Page 1/1

Used to evaluate or make an engine out drift down.

Displayed when computed DD altitude is below current altitude.

Thrust advanced to EPR limit (if VNAV is engaged).

SELECT MCT and CHECK ALT TGT displayed in scratch pad.

2 Cruise Altitude (CRZ ALT)

Displays drift down altitude if current altitude is above E/O MAX ALT.

Flight crew may enter lower altitude.

3 Engine Out Speed (DD SPD)

Displays AFMC computed minimum safe operating speed.

Cannot change.

4 TO FLXXX

Displays time and distance to the CRZ ALT at EO/UT SPD and MCT.

5 Drift Down Altitude (DD ALT)

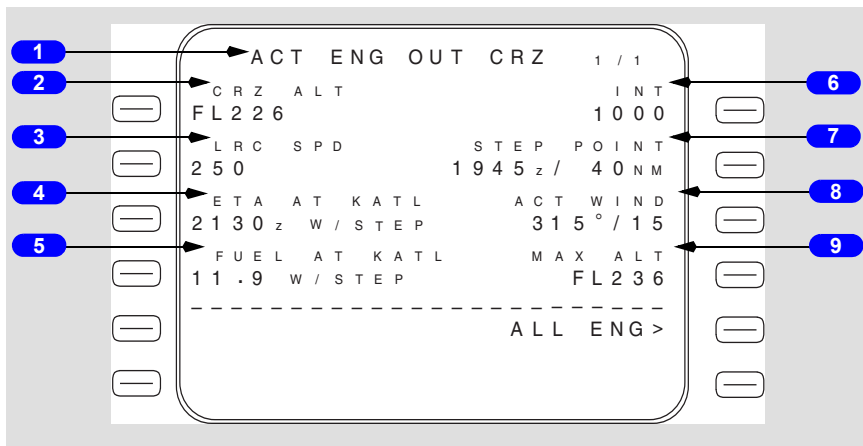
Displays maximum attainable altitude with one engine out, at MCT, EO DD speed at predicted weight at end of drift down.

Blank when current altitude is below drift down altitude.

6 All Engine Line Select Key (ALL ENG)

Selection changes mode to all engine speed and thrust schedule.

Engine Out Cruise Descent (Continued)



1	ACT ENG OUT CRZ	1 / 1	
2	CRZ ALT	INT	6
	FL 226	1000	
3	LRC SPD	STEP POINT	7
	250	1945 z / 40 NM	
4	ETA AT KATL	ACT WIND	8
	2130 z W / STEP	315° / 15	
5	FUEL AT KATL	MAX ALT	9
	11.9 W / STEP	FL 236	
	ALL ENG >		

1 ACT ENG OUT CRZ 1/1

Displayed when existing altitude is below the engine out (EO) maximum altitude.

2 CRZ ALT

Displays EO maximum altitude or a crew entered altitude that is no higher than the EO maximum altitude.

3 LRC SPD

Displays AFMC computed EO long range cruise speed.

4 ETA AT KATL

Displays the ETA and fuel at destination with the step.

With step, label will be missing if no step point is displayed.

Penalty will be displayed if the step climb will result in a fuel loss computation.

5 FUEL AT KATL

Displays the AFMC computed fuel at destination.

With step, label is missing if no step point is displayed.

6 INT

Displays step climb interval. The display defaults to 1,000 feet, but the crew may enter an altitude from 100 feet to 10,000 feet in 100 foot increments.

The field will be blank if the step climb interval cannot be reached prior to 200 nm from the TD.

If the field is blank, the data in 3L and 4L will be the same as those displayed on the PROG page.

7 STEP POINT

The distance to go and the ETA to the step point.

Display is blank. The step would incur a fuel penalty or the step interval cannot be achieved prior to 200 nm from the TD.

8 ACT WIND

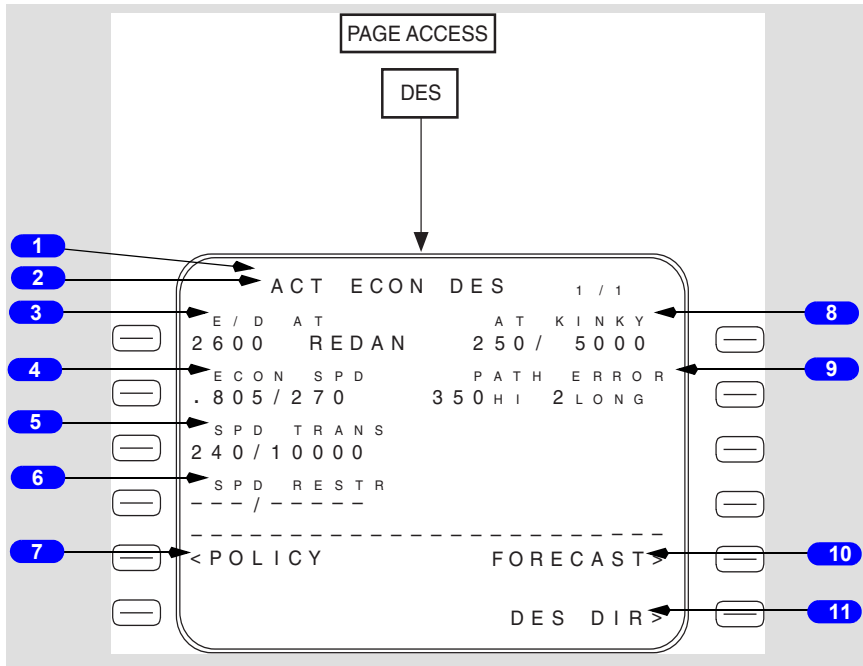
Displays AFMC computed wind.

EST WIND is displayed if the crew enters an estimated wind for the projected step climb altitude.

9 MAX ALT

Displays maximum altitude for single engine cruise.

Descent



The diagram shows a cockpit display page titled "ACT ECON DES" with a "1 / 1" indicator. Above the page is a "PAGE ACCESS" box with a "DES" button. The page contains several data fields and controls, numbered 1 through 11:

- 1**: Points to the "ACT ECON DES" title.
- 2**: Points to the "1 / 1" indicator.
- 3**: Points to the "E / D AT" field.
- 4**: Points to the "ECON SPD" field.
- 5**: Points to the "SPD TRANS" field.
- 6**: Points to the "SPD RESTR" field.
- 7**: Points to the "< POLICY" field.
- 8**: Points to the "AT KINKY" field.
- 9**: Points to the "PATH ERROR" field.
- 10**: Points to the "FORECAST" field.
- 11**: Points to the "DES DIR" field.

The data fields contain the following information:

- E / D AT**: 2600 REDAN
- AT KINKY**: 250 / 5000
- ECON SPD**: .805 / 270
- SPD TRANS**: 240 / 10000
- SPD RESTR**: --- / ---
- PATH ERROR**: 350 HI 2 LONG
- FORECAST**: ---
- DES DIR**: ---

1 ACT ECON DES Page 1/1

Display permits evaluating or revising the descent phase of the flight.

Available speed modes are ECON, SEL SPD, and POLICY (defaults to ECON).

Page is blank with DES as title if no waypoint constraints lower than CRZ ALT exist.

2 Page Title

Displays active descent mode.

- XXXKT if target is a fixed speed.
- M.XXX if target is a fixed Mach or ECON if target is economy speed based on cost index set on PERF INIT page.

LIM SPD is displayed if airplane is being controlled at a limit speed (e.g., flap placard).

ACT END OF DES is displayed when ED altitude is captured.

3 End Of Descent AT (ED AT)

Displays the lowest altitude constraint at a waypoint.

Propagated from the LEGS page.

4 SPEED

Displays command speed and Mach.

Label can show ECON SPD, or SEL SPD, or POLICY SPD.

Mach and/or speed can be entered. Valid Mach entry is .X, .XX, or .XXX. Label changes to SEL SPD.

When transitioning to a selected speed segment, label automatically changes to SEL SPD.

When SEL SPD or POLICY SPD is displayed, an ECON prompt is displayed on this page.

When flying ECON SPD, speed format changes from MACH to IAS upon transitioning through FL 270.

5 Speed Transition (SPD TRANS)

Displays 10 knots less than the database speed limit and the effective altitude for that speed limit. Associated with the destination airport.

Automatically displays 240/10000 if a different value is not in the database for destination.

Blank below SPD TRANS altitude.

Deleting causes the airplane to fly economy or selected speed if not limited by a waypoint constraint or speed restriction.

6 Speed Restriction (SPD RESTR)

Permits entry of a speed limit at an altitude higher than ED altitude.

When transitioning to the limiting speed, dashes are displayed.

7 Descent Mode (5L)

Displays ECON when the descent mode is not economy.

Displays POLICY when the descent mode is economy.

8 Waypoint Constraint (AT KINKY)

Displays the first waypoint speed/altitude constraint when constraints have been entered on a RTE LEGS page procedure or crew entry. After passing this constraint, the next one is automatically displayed.

Can be deleted here or on the RTE LEGS page.

The target speed is the constraint speed or the current performance speed, whichever is less.

Label can also be HOLD AT XXXXX (XXXXX is the holding fix), AT VECTORS OR AT (INTC).

9 PATH ERROR

Displays altitude discrepancy and distance with reference to the descent path.

Displayed when descent is active.

Blank if no error is predicted.

10 FORECAST

Selection displays Descent Forecasts page.

11 Descent (6R)

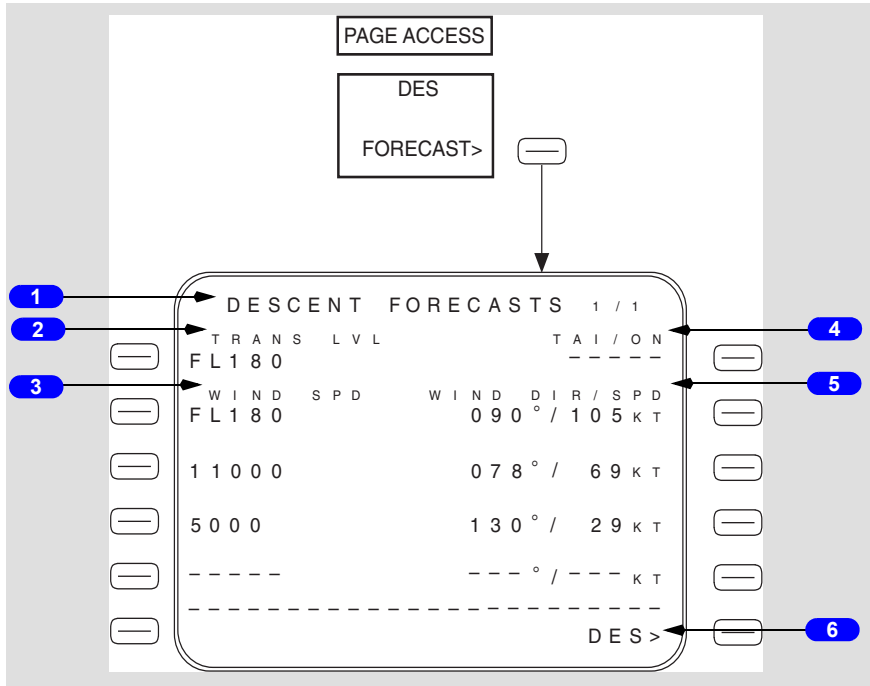
DES NOW displayed.

- Selection and execution begins descent of approximately 1,250 feet per minute using the active cruise speed schedule. If descent is initiated before reaching TD, displays error information with respect to the path and the first constrained waypoint. If descent is started at the TD, the aircraft will attempt to fly an idle descent path.

DES DIR displayed.

- Displays DES DIR when descent is active and a waypoint constraint exists between the current altitude and the ED.
- Selection of DES DIR deletes all waypoint constraints between the current altitude and the FGCP altitude preselect readout.

Descent Forecast



1 DESCENT FORECAST Page 1

Used to enter forecast winds and altitude where thermal anti-icing will be turned on to more accurately define the descent path.

2 Transition Level (TRANS LVL)

Automatically display FL180.

Can be changed by crew.

Changed automatically if an arrival procedure with a different transition level is selected.

Used to change descent MCDU displays between FL's and feet.

3 Wind Speed (WIND SPD)

Permits entry of altitudes where forecast winds are known.

4 Thermal Anti-Ice On (TAI/ON)

Permits entry of altitude where anti-ice will be turned on. This will change TD point calculation.

5 Wind Direction/Speed (WIND DIR/SPD)

Permits entry of forecast winds for the entered altitudes.

6 DESCENT (DES)

Selection displays descent page.

FMA Indications Associated with FMS Operations

Autothrottle Mode Annunciations

T	A	R	P
CLMP FMS			

VNAV engaged and throttles clamped in CRZ DES.

FMS EPR			

VNAV engaged and controlling throttles to a computed EPR command.

FMS IDLE			

VNAV engaged and throttles being controlled by FMS for idle setting.

FMS SPD			

VNAV engaged and controlling throttles to maintain a target airspeed.

OVRD XXX			

VNAV engaged and controlling pitch or autothrottles to maintain selected target airspeed.

OVRD LIM			

VNAV engaged and selected speed exceeds FMS computed limit speed.

ARM Mode Annunciations

	NAV		

Displayed when NAV mode is armed.

ROLL Mode Annunciations

		NAV CAP	

NAV engaged and capturing a new lateral course or when bank angles exceeding 10° are required.

		NAV TRK	

NAV engaged and has captured and is tracking desired course.

	NAV	NAV HLD	

NAV engaged and FMS is in an internal heading hold mode, e.g., in discontinuity and airplane on intercept track

PITCH Mode Annunciations

			VNAV CAP

VNAV engaged and in path capture mode.

			VNAV LVL

VNAV engaged in level flight.

			VNAV CLB

VNAV engaged in a climb mode.

			VNAV DES

VNAV engaged in a descent mode.

Flight Instruments, Displays

OAP Messages/Lights

Chapter 11

Section 30

OAP Messages/Lights

Amber Caution Messages

Note: The associated cue light is shown in parenthesis (XXX) following the message.

IRS 1/2 BATTERY FAIL - Indicates battery will not support respective IRU should normal power be lost.

IRS 1/2 NO AIR - Indicates loss of cooling air to respective IRU.

IRS 1/2 ON BATTERY - Indicates respective IRU is operating on battery power.

Blue Advisory Lights

IRS 1/2 ATT MODE - Indicates respective IRS is operating in the attitude mode.

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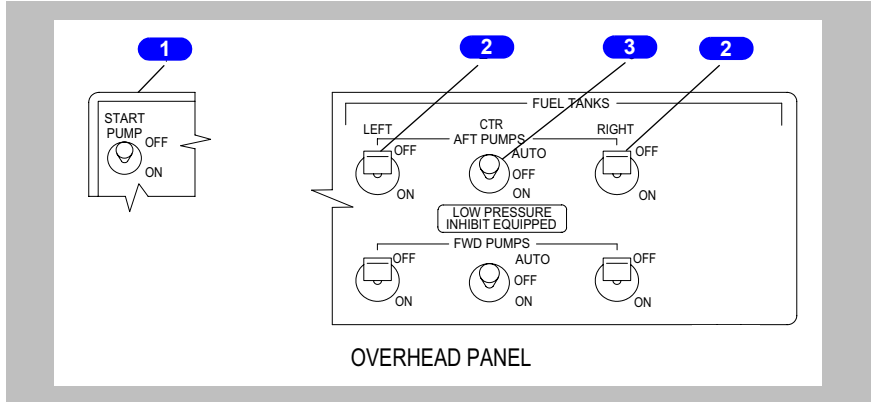
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Fuel Quantity	12.10.2
Fuel Temperature Display	12.10.3
Fuel X-Feed Lever and Fuel Lever	12.10.4
Fuel Load Selector Display and Control Panels	12.10.5
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Fuel Feed	12.20.1
Alternate Fuel Burn (AFB) System	12.20.2
Fuel Tank Quantity Indicating System	12.20.3
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Return To Tank (RTT) System	12.90.5

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Fuel Controls and Indicators

Chapter 12 Section 10

Fuel Control Panel



1

START PUMP Switch

ON - Supplies power from 28VDC transfer bus to power start pump.

OFF - Disconnects 28VDC power from start pump.

Note: Used for starting APU or an engine when AC power is not available.

2

AFT/FWD PUMPS Switch (LEFT/RIGHT)

ON - Turns respective aft/forward tank boost pump on.

OFF - Turns respective aft/forward tank boost pump off.

3

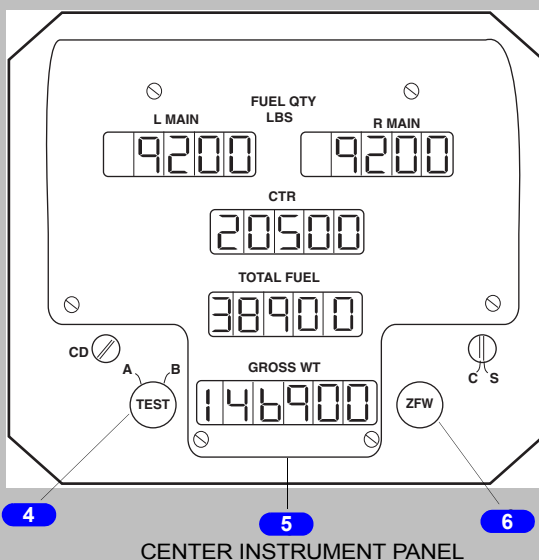
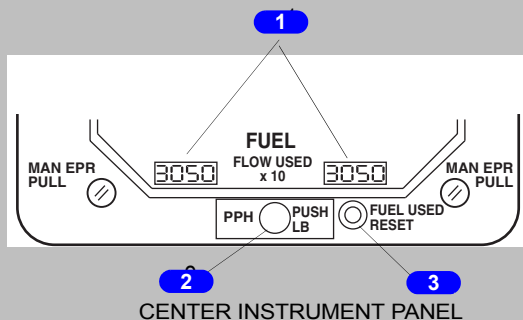
AFT/FWD PUMPS Switch (CTR)

AUTO - When both pump switches are in the AUTO position, the alternate fuel burn system (AFB) will be active. Turns on respective fuel boost pump dependent upon position of fuel level float switches in the center and main tanks.

ON - Turns respective aft/forward tank boost pump on.

OFF - Turns respective aft/forward tank boost pump off.

Fuel Quantity



1 FUEL FLOW/USED Readouts

Readouts indicate fuel flow rate delivered to engine. Fuel flow digits will flash during start if fuel flow exceeds normal starting parameters.

2 PPH Button

Push - Momentary display of fuel used, a blue light illuminates behind FUEL FLOW/USED legend.

3 FUEL USED Reset Button

Push - Resets FUEL FLOW/USED readout to "0". Button is recessed to prevent inadvertent reset.

4 TEST Knob

Position A selects channel A; position B selects channel B. Push to test selected channel. Each tank digital readout displays $3,000 \pm 100$. TOTAL FUEL displays 9,000. GROSS WT displays ZFW plus $9,000 \pm 300$.

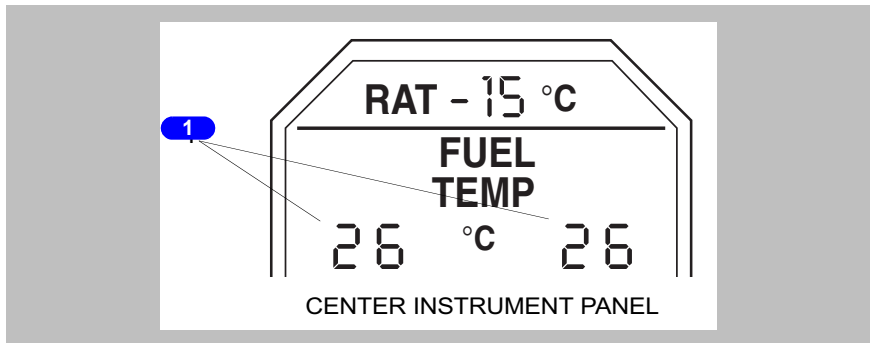
5 Digital FUEL QTY Display

Displays individual tank quantity, total fuel quantity, and aircraft gross weight. A blank window indicates a channel fault. All 9s displayed indicate a probe fault.

6 ZFW Set Knob

Calculated zero fuel weight (ZFW) is set by pushing in and rotating knob in required direction. Release knob and ZFW plus fuel quantity indicates gross weight. As fuel is used, quantity shown decreases to represent actual gross weight.

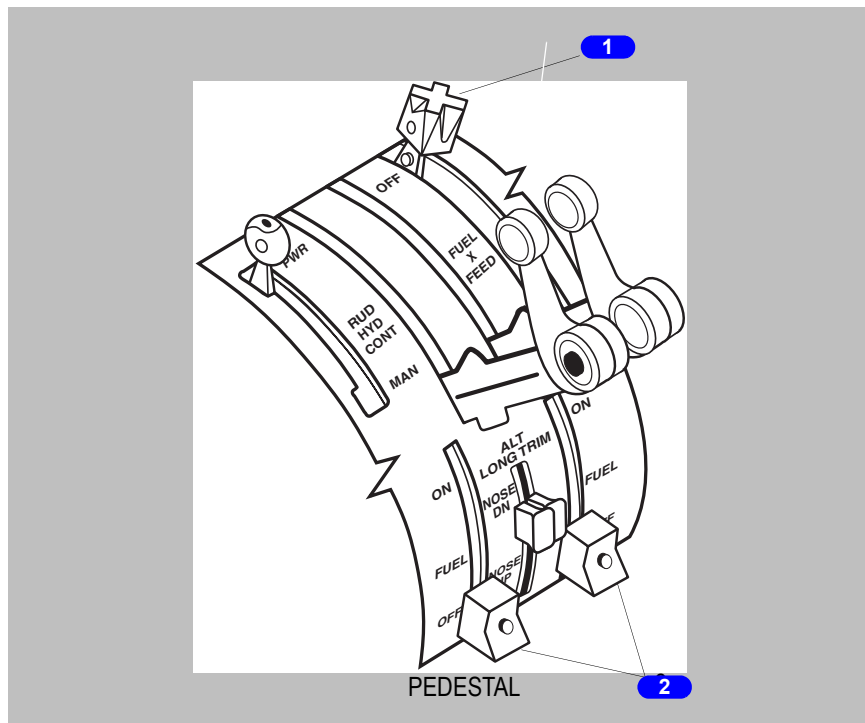
Fuel Temperature Display



1 FUEL TEMP Readout

Indicates temperature of fuel after it has flowed through the air/fuel heat exchanger.

Fuel X-Feed Lever and Fuel Lever



1 FUEL X-FEED Lever

Lever must be lifted to unlock prior to actuation to ON from OFF.

ON - Opens fuel crossfeed valve, allowing either or both main tanks to supply both engines and/or APU.

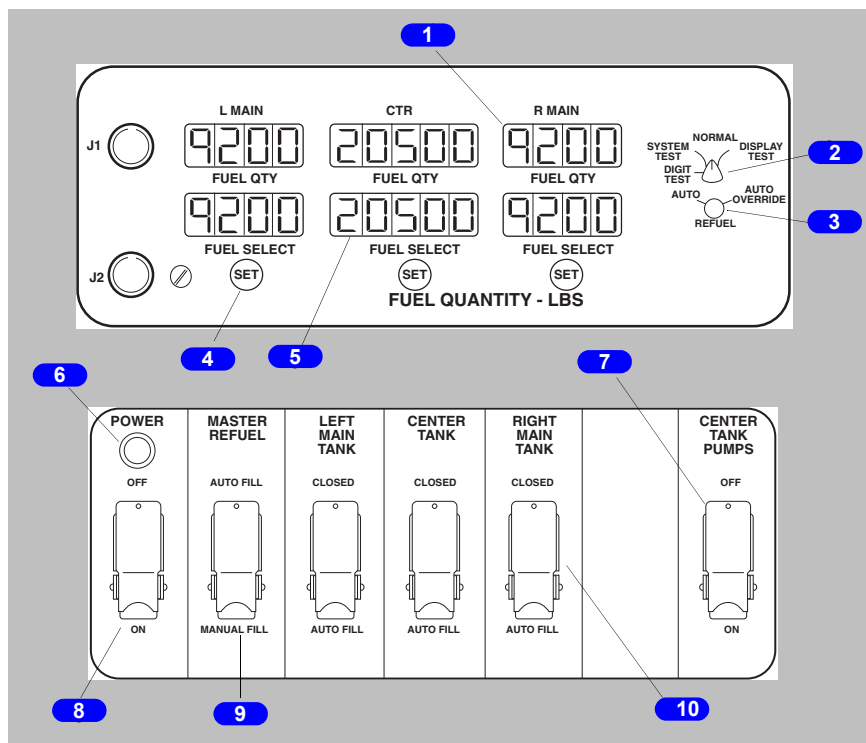
OFF - Fuel crossfeed valve is closed, causing left main fuel tank to supply left engine and right main fuel tank to supply right engine and APU.

2 FUEL Lever

ON - Fuel will flow into fuel control unit.

OFF - Shuts off fuel into fuel control unit.

Fuel Load Selector Display and Control Panels



1 FUEL QTY Digital Indicator (3)

Indicates fuel quantity in respective tank when FUNCTION knob is at NORMAL.

2 FUNCTION Knob

DIGIT TEST - All individual digit readouts display an 8. MASTER REFUEL switch must be at AUTO.

SYSTEM TEST - FUEL QTY digital readouts display 3000.

NORMAL - FUEL SELECT and FUEL QTY digital readouts display actual fuel quantity and/or fuel load selected.

DISPLAY TEST - FUEL QTY readouts display 3000

3 REFUEL Knob

AUTO - Turns on automatic fuel fill valve system.

AUTO OVERRIDE - Turns off automatic fuel-fill valve system and FUEL SELECT digital display. Fuel will flow into tank(s) until fuel level closes float switches (full tanks).

4 FUEL SELECT SET Knob

When the REFUEL selector knob is at AUTO, pulling out and rotating SET knob changes FUEL SELECT digital display. Pushing in the SET knob activates automatic refueling system by opening the fill valves permitting fuel flow until fuel level reaches quantity equal to FUEL SELECT numeric display when the fill valves automatically close.

5 FUEL SELECT Digital Indicator (3)

Digital display reflects the fuel quantity selected by the SET knob. FUNCTION knob must be at NORMAL and REFUEL knob must be at AUTO.

6 Fueling POWER Light

When light is illuminated, power is being supplied to ground refueling circuits.

7 CENTER TANK PUMPS Switch

ON - Supplies power to center tank boost pumps regardless of flight deck switch position as long as AC power is available. Enables fuel to transfer from center tank when defueling valve is opened and fill valve of selected tank is opened.

OFF - Boost pumps off.

8 Fueling POWER Switch

OFF - Removes power from fuel load selector display panel and fuel fill valve switches.

ON - Supplies power from battery or external power to fuel load selector display panel and fuel fill valve switches.

9 MASTER REFUEL Switch

AUTO - Provides electrical power to fuel fill valve actuating motors and float switches for automatic refueling.

MANUAL - Removes electrical power from fuel fill valve motors and float switches for manual refueling.

10 Fill Valve Switches

CLOSED - Electrically closes the tank fill valves.

AUTO FILL - Tank fill valves will close automatically when preset fuel quantity is reached in tanks.

Fuel System Description

Chapter 12 Section 20

General

The airplane fuel system is designed to provide an uninterrupted fuel flow under all normal conditions and flight attitudes. The system is also designed to permit fuel servicing activities from a single point.

Fuel Tanks

The airplane is equipped with three integral fuel tanks: a left main, a center, and a right main. Each main tank has a capacity of 9,250 pounds. The center tank has a capacity of 20,600 pounds. The total fuel weight of 39,100 pounds is based on a density of 6.7 pounds per gallon.

A sump drain is located at the lowest inboard point of each main tank. Two sump drains are located in the center tank. Four magnetic, dripless sticks (magna-sticks) are located in each main tank and one in the center tank. An inclinometer in the nosewheel well provides airplane ground attitude information for fuel gaging calibrations.

Fuel Feed

Each main fuel tank has two AC boost pumps installed in parallel. Either boost pump has adequate flow to supply both engines at take off power. An interconnect system and crossfeed valve between the fuel tank systems permits use of fuel from either main fuel tank to both engines.

The two AC center tank pumps are connected in series to provide pressure higher than that of the main tank pumps, and ensure usage of the center tank fuel even with both main tank pumps operating.

All six AC powered fuel boost pumps are protected by thermal switches that will remove all electrical power from a pump when an overheat condition is detected.

A DC start pump, operated by the START PUMP switch on the overhead panel, is installed in the right main tank and is used for APU or engine starting when AC power is not available. The start pump does not have overheat protection but is cooled by fuel in the right main tank. The start pump is powered by the DC transfer bus.

When the ground service bus is powered, the right aft fuel boost pump may be used for APU start and operation in lieu of using the DC start pump. However it is possible for air to be drawn from the center tank into the APU fuel line if main boost pumps are off, center boost pumps are on, and center tank fuel quantity is below 800 pounds. Air in the APU fuel line could cause APU flameout, thus preventing the APU from starting. Therefore, following APU start, if possible at least one main boost pump should be on.

When a fire handle is pulled, the fuel supply to the respective engine is shut off at the aft wing spar.

Low fuel pressure at the engine fuel inlets is indicated by the associated L/R INLET FUEL PRESS LOW message on the OAP. The R INLET FUEL PRESS LOW message can also indicate possible low fuel pressure at the APU fuel inlet.

Alternate Fuel Burn (AFB) System

The alternate fuel burn (AFB) system provides an automated means to burn a portion of the fuel in each main tank prior to emptying the center tank. The system is activated by moving both center tank fuel boost pump switches to the AUTO position. When in use, the AFB system energizes the center tank fuel boost pumps when the center tank fuel quantity is greater than the internal float switch level. Automatic switching to main tanks occurs when the center tank quantity decreases to approximately 10,000 pounds. The center tank fuel boost pumps are re-energized when either main tank fuel quantity is approximately 4,000 pounds. The float switch actuation point varies due to differences in fuel density and airplane attitude.

Float switches in both main tanks activate the FUEL LEVEL LOW message when either main tank reaches approximately 2,500 pounds. For aircraft modified to change the activation of the FUEL LEVEL LOW message from 2,500 to 2,000, the minimum fuel is 4,000. This message is independent of the fuel quantity indicating system and is susceptible to changes in fuel density and airplane pitch attitude.

A center fuel pressure low indicating system measures the differential pressure across each of the center tank fuel boost pumps. A CENTER FUEL PRESS LO message will be displayed on the OAP to indicate low pressure when either one of the fuel boost pumps is turned OFF or has failed. The CENTER FUEL PRESS LO message is inhibited when flaps are extended approximately 6 degrees or greater to prevent a nuisance message during takeoff or landing.

Fuel Tank Quantity Indicating System

A fuel quantity display (FUEL QTY), located on the center instrument panel, displays measured fuel quantity in each tank, total fuel quantity, and gross weight. The displayed gross weight is valid only after the pilot inputs the airplane's correct zero fuel weight.

A fuel load selector display panel, located in the leading edge of the right wing, displays fuel quantity (FUEL QTY) and load selection (FUEL SELECT). A fuel control panel, located adjacent to the fuel load selector display panel, controls the operation of the fill valves.

Fueling And Defueling

All fuel tanks can be fueled and defueled through a single-point adapter and manifold located in the right wing. The method and quantity of refueling is determined by selective operation of the fuel control panel and fuel load selector display panel. The control panels, fuel fill valves and defueling valve are located in the right wing leading edge and are behind access doors.

Fueling is accomplished by utilizing the Refueling POWER switch at the wing refueling panel. Without normal electrical power, the aircraft battery provides power. If battery power is not available for fueling operations, all fuel tank valves can be manually operated and fuel quantity measured using magna-sticks. Fuel tanks may be defueled using tank boost pumps or by suction defueling. A ground service interphone jack is located near the fuel load selector panel.

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OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

CENTER FUEL PRESS LO (ENG) - Indicates that one or both center fuel tank boost pumps has failed or has been shut off or tank is empty (inhibited when flaps are extended approximately 6 degrees or greater).

FUEL LEVEL LOW (ENG) - Indicates fuel quantity approximately 2500 pounds in either of the main tanks.

L/R INLET FUEL PRES LO (ENG) - Indicates respective fuel supply pressure at engine is low.

Blue Advisory Lights

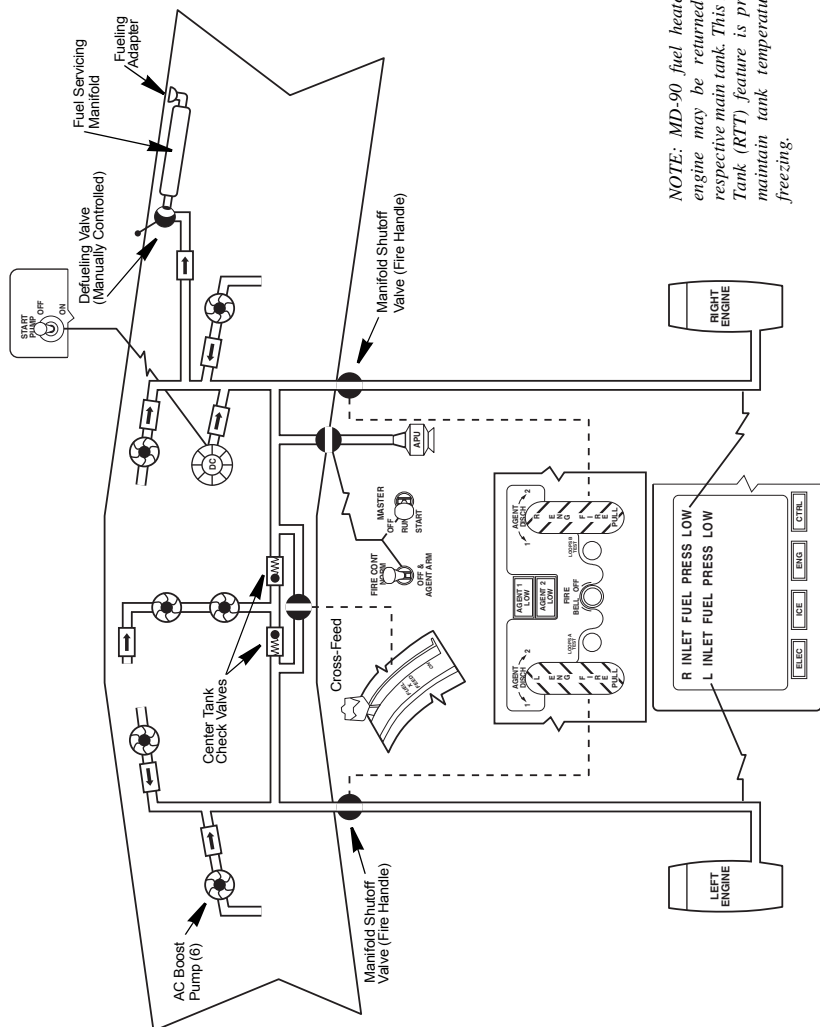
L/R FUEL HEAT ON - Indicates shutoff valve to the air/fuel exchanger is open.

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Fuel Functional Schematic

Chapter 12 Section 40

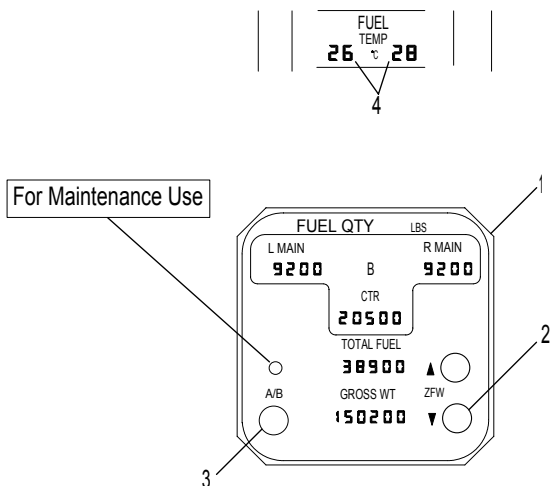
Fuel System Schematic



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Controls and Indicators

Fuel Quantity and Fuel Temperature Display



JB1-3-0143F

1. FUEL QTY Display

Displays individual tank quantity, total fuel quantity, and gross weight. When ANNUN/DIGITAL LTS TEST is actuated each digit displays a test pattern.

2. ZFW Set Buttons

Calculated zero fuel weight (ZFW is set by pushing in appropriate up or down ZFW Set button. Push and hold either button 2 seconds and the ZFW will begin to slew in the direction selected. The slew will be in steps of 100 pounds for five seconds, increasing to 1000 pounds per step.

The display will continue to show ZFW selected for two seconds after pushbutton is released.

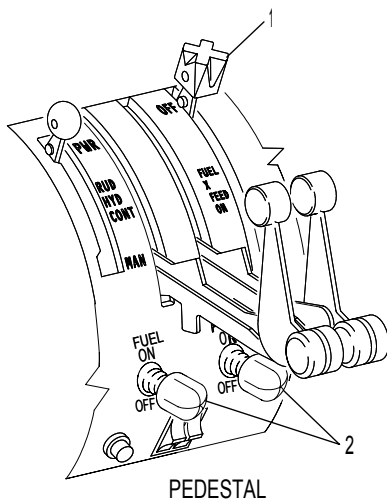
3. A/B Channel Button

Selects opposite channel. The “B” representing channel B is displayed above the center quantity when selected. Channel “A” is blank when selected.

4. FUEL TEMP Readouts

Displays left and right main fuel tank temperatures in degrees celsius.

Fuel X-Feed Lever and Fuel Switch



JB1-3-0884

1. FUEL X-FEED Lever

Lever must be lifted up to unlock prior to actuation to ON or OFF.

ON - Opens fuel crossfeed valve, allowing either or both main tanks to supply both engines and/or APU.

OFF - Fuel crossfeed valve is closed, causing left main fuel tank to supply left engine and right main fuel tank to supply right engine and APU.

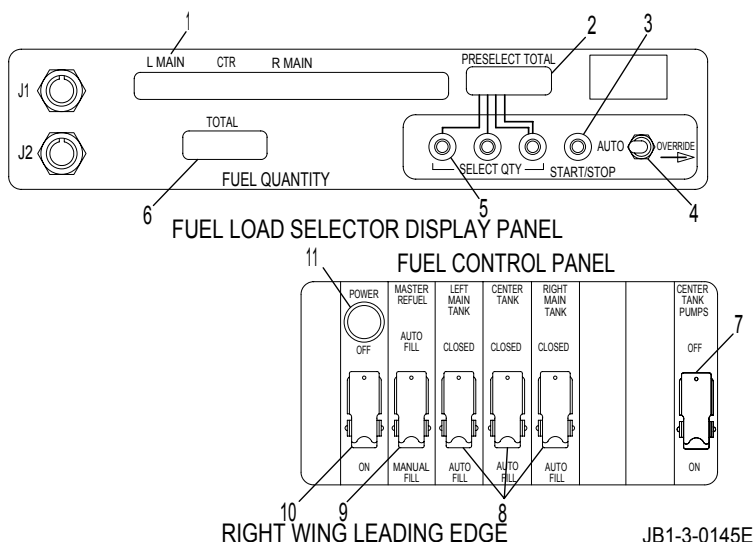
2. FUEL Switch

ON - Consent to EEC to deliver fuel to engine.

OFF - Closes fuel valve.

NOTE: A light is located in each switch. The light is illuminated if that engine's fire detection circuit detects a fire or if that engine's fire handle is pulled. The light remains illuminated until the respective switch is placed to OFF.

Fuel Load Selector Display and Control Panels



1. L/R MAIN, CTR Fuel Quantity Indicator

Indicates total fuel quantity in respective fuel tank.

2. PRESELECT TOTAL Window

When the refuel switch is in the AUTO position the window shows the total preselected fuel quantity. When the refuel switch is in the OVERRIDE position the window displays OVERRIDE.

3. START/STOP Button

After a number has been selected in the PRESELECT TOTAL window, pushing this button opens the appropriate fill valves. The aircraft will fill automatically to the desired fuel quantity. If desired, pushing the START/STOP button a second time will close all fill valves prior to reaching the preselected total.

4. AUTO/OVERRIDE Switch

AUTO - Turns on automatic fuel-fill valve system.

OVERRIDE - Turns off automatic fuel-fill valve system. Fuel will flow into tank(s) until fuel level closes fuel-lever float switches (full tanks).

5. SELECT QTY Buttons

When the AUTO/OVERRIDE switch is in the AUTO position, pushing these buttons changes the total preselected fuel quantity.

6. TOTAL Quantity Indicator

Indicates total fuel on the aircraft.

7. CENTER TANK PUMPS Switch

ON - Supplies power to center tank boost pumps if AC power is available. Enables fuel to transfer from center tank when defueling valve is opened and fill valve of selected tank is opened.

OFF - Center tank boost pumps off.

8. Fill Valve Switches (LEFT/RIGHT MAIN, CENTER TANK)

CLOSED - Electrically closes the tank fill valves.

AUTO FILL - Tank fill valves will close automatically when preset fuel quantity is reached in tanks.

9. MASTER REFUEL Switch

AUTO FILL - Supplies electrical power to fuel-fill valve actuating motors and float switches for automatic refueling.

MANUAL FILL - Removes electrical power from fuel-fill valve motors and float switches for manual refueling.

10. Fueling POWER Switch

ON - Supplies power from battery or external power to fuel load selector display panel and fuel fill valve switches.

OFF - Removes power from fuel load selector display panel and fuel fill valve switches.

11. Fueling POWER Light

When light is illuminated, power is being supplied to ground refueling circuits.

System Description

Alternate Fuel Burn (AFB) System

The alternate fuel burn (AFB) system provides an automated means to burn a portion of the fuel in each main tank prior to emptying the center tank. The system is activated by moving both center tank fuel boost pump switches to the AUTO position. When in use, the AFB system energizes the center tank fuel boost pumps when the center tank fuel quantity is greater than the internal float switch level. Automatic switching to main tanks occurs when the center tank quantity decreases to approximately 3000 pounds. The center tank fuel boost pumps are re-energized when either main tank fuel quantity is less than 4800 pounds to 3800 pounds. The float switch actuation point varies due to differences in fuel density and airplane attitude.

Return To Tank (RTT) System

The return to tank (RTT) system provides fuel lines which allow the engine heat management system to return fuel heated by the engine and generator fuel-oil heat exchangers to the main fuel tanks. The fuel return function is controlled by the engine electronic control (EEC). RTT reduces the likelihood of wing ice caused by cold-soaked fuel while improving the efficiency of the engine heat management system.

The fuel tank vents permit overflow from the main tanks into the center tank. This permits RTT flow even when the engines are supplied by the center tank and the main tanks are full.

If RTT is inoperative on one side, a fuel imbalance may result during AFB operations.

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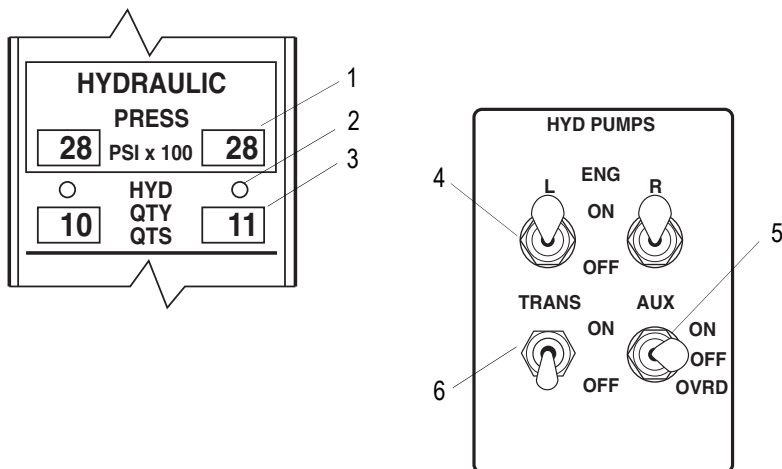
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System Display Panel And Hydraulic Switches



1. **HYDRAULIC PRESS Readouts**

Indicates respective system hydraulic pressure.

2. **HYD QTY Low Lights (amber)**

Indicates respective system quantity is below a set minimum level.

3. **HYD QTY Readouts**

Indicates the respective reservoir hydraulic fluid quantity.

4. **HYD PUMPS ENG (L/R) Switch**

NOTE: Engine pumps operate during electrical failure regardless of switch position.

ON - Pressurizes hydraulic system.

OFF - No pressure output to operate any hydraulic systems.

5. **HYD PUMP AUX Switch**

ON - Turns on electrical hydraulic auxiliary pump.

OFF - Turns off electrical hydraulic auxiliary pump.

OVRD - (Momentary - must be held in OVRD) Bypasses thermal protective circuit. Activates pump.

NOTE: The electrically driven pump is protected from overheat damage by a thermal protective circuit that automatically shuts off pump when exceeding normal operating temperature. OVRD position bypasses protective circuit to permit continuous pump operation when needed.

6. HYD PUMPS TRANS Switch

ON - Opens shutoff valve on each side of transfer pump.

OFF - Closes shutoff valve on each side of transfer pump.

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Hydraulics

System Description

Chapter 13

Section 20

General

The airplane has two independent (left and right) hydraulic systems utilizing fire-resistant hydraulic fluid. Each system has a reservoir and is normally pressurized by a single engine-driven pump. An alternate means of pressurizing the hydraulic systems would be an electrically driven auxiliary pump and transfer pump. Ground service provisions for each system are located in the main gear wheel wells. These include a ground service connection panel, a hand pump for ground maintenance operations, and a spoiler shutoff and system bypass valve.

Hydraulic Pumps

The left and right hydraulic systems are each pressurized by a hydraulic pump mounted on their respective engine. Pump operation is controlled by the respective engine (L/R) hydraulic pump (ENG) switch located on the First Officer's instrument panel. Each pump is capable of providing pressure of 3000 psi. Fluid supply to an engine driven hydraulic pump stops when the respective ENG FIRE handle on the upper instrument panel is pulled. The L or R HYD PRESS LOW message is displayed on the OAP whenever the respective system pressure is low.

An auxiliary pump, in the right system, provides an additional source of hydraulic pressure. Pump operation is controlled by the auxiliary pump (AUX) switch. The auxiliary pump is protected by a thermal switch that automatically shuts the pump off if the normal operating temperature range is exceeded. The OVRD position operates the pump while bypassing the thermal switch. The auxiliary pump is electrically powered by the left generator bus and is designed for continuous operation at 3000 psi.

A hydraulic transfer pump mechanically connects left and right hydraulic systems and enables hydraulic pressure to be transferred from the highest to the lowest side (the high pressure side operates as a motor and the low pressure side operates as a pump). A single motor operating two shutoff valves, one in each hydraulic system, controls the transfer pump. The transfer pump switch (HYD PUMPS TRANS) is located on the First Officer's instrument panel. The shutoff valves automatically close if either system reservoir quantity falls below a minimum level. If one system is inoperative, airplane systems that normally receive pressure from both hydraulic systems operate at a reduced rate.

Hydraulic Reservoir

The left and right hydraulic system reservoirs are located in the respective left and right main gear wheel wells. Each reservoir supplies fluid to its own system.

A fluid quantity transmitter, located at each reservoir, transmits fluid quantity information to the hydraulic quantity (HYD QTY) indicators on the system display panel (center instrument panel).

The amber HYD QTY low lights on the system display panel illuminate when left quantity is less than 8 quarts or the right quantity is less than 9 quarts. After engine start, if either systems quantity is below 4, the applicable low light illuminates.

A L/R HYD TEMP HIGH message on the OAP indicates above normal hydraulic fluid temperature.

Spoiler Shutoff and System Bypass Valve

Each hydraulic system has a spoiler shutoff and system bypass valve located in the respective wheel well. The spoiler shutoff and system bypass valve is a three position valve. The three positions are ON, OFF and SYSTEM BYPASS. In the ON position the hydraulic system operates normally. In the spoiler OFF position, the right valve shuts off hydraulics to the outboard flight spoilers and the left valve will shut off hydraulics to the inboard flight spoilers. The SYSTEM BYPASS position will depressurize the respective hydraulic system.

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

AUTO BRAKE FAIL (HYD) - Indicates ABS malfunction. System will automatically disarm and AUTO BRAKE ARM/DISARM switch will drop to DISARM position. MASTER CAUTION and ABS glareshield lights illuminate.

(L/R) HYD PRESS LOW (HYD) - The hydraulic pressure in the (left/right) spoiler supply system is below normal. MASTER CAUTION lights illuminate.

(L/R) HYD TEMP HIGH (HYD) - The hydraulic fluid temperature in the (left/right) reservoir is above normal. MASTER CAUTION lights illuminate.

(L/R) INBD ANTI-SKID (HYD) - Applicable annunciation indicates malfunction of anti-skid protection for specific wheel. All annunciations will be illuminated if arming switch is OFF or system malfunctions.

(L/R) OUTBD ANTI-SKID (HYD) - Applicable annunciation indicates malfunction of anti-skid protection for specific wheel. All annunciations will be illuminated if arming switch is OFF or system malfunctions.

(L/R) REVERSER ACCUM LOW (HYD) - Indicates hydraulic pressure at reverser accumulator is low.

NO HYD FAULTS (HYD) - When HYD cue light is pushed, indicates no hydraulic faults exist.

PARKING BRAKES ON (HYD) - Indicates the parking brakes are set. When parking brakes are not set and annunciator is illuminated, an anti-skid malfunction is indicated.

RUDDER CONTROL MAN (HYD) - Indicates there is no hydraulic power to the rudder.

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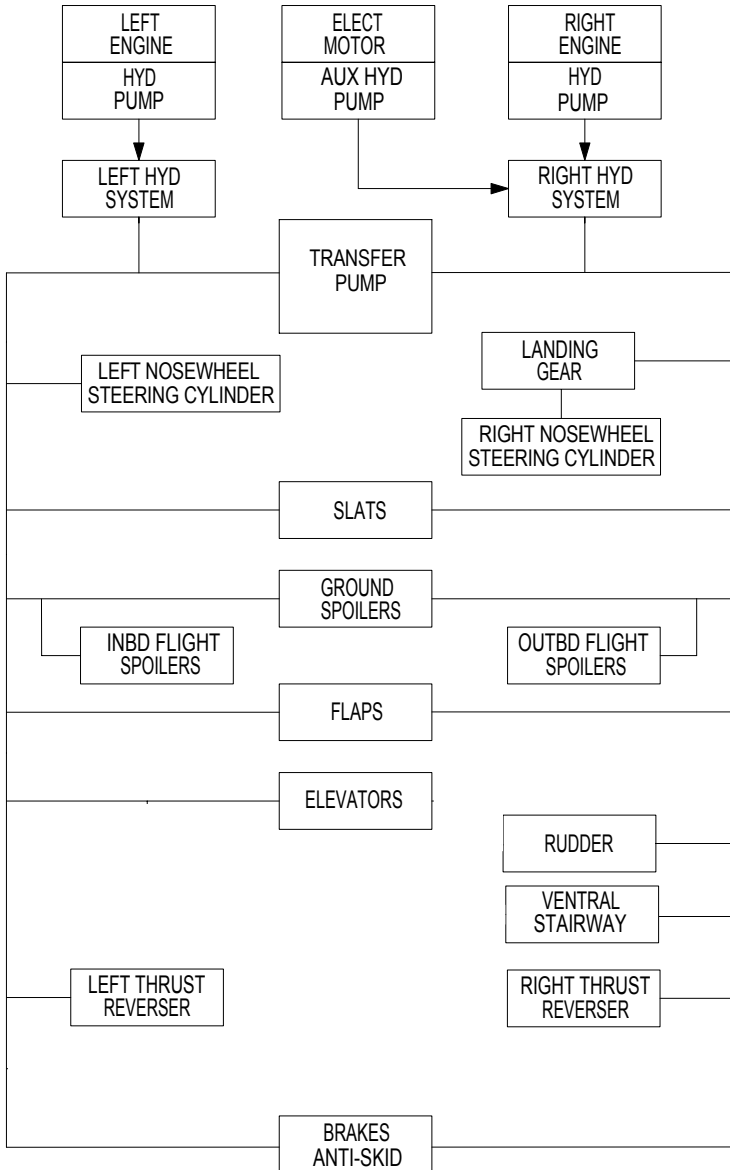
Hydraulics

Functional Schematic

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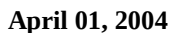
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MD-88 Block Diagram



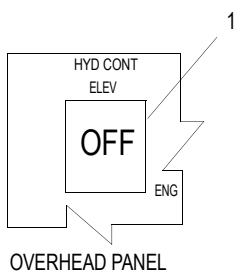
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Controls and Indicators

System Display Panel And Hydraulic Switches



1. HYD CONT ELEV Switch - amber

(Momentary) Push to remove or restore hydraulic power to the elevator.

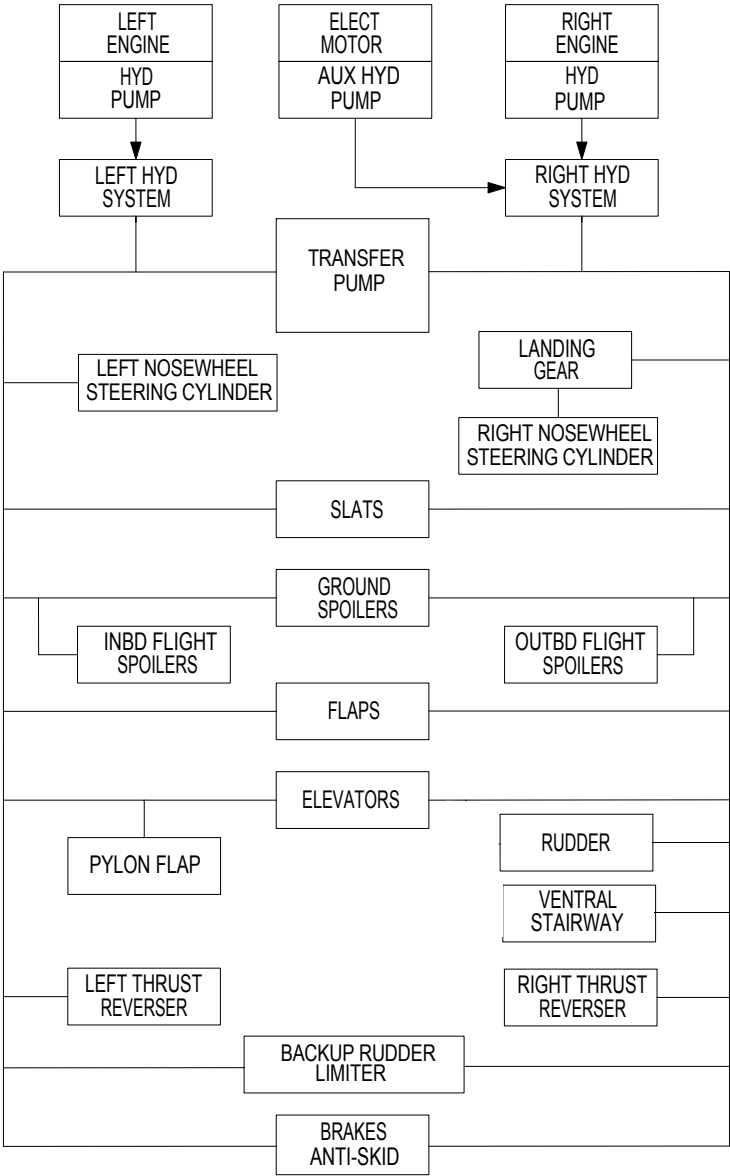
System Description

Hydraulic Systems

Before engine start, the amber low quantity on the system display panel illuminates when left quantity is less than 9 quarts or the right quantity is less than 10 quarts. After start, if either system's quantity is below 6 quarts, the applicable low light illuminates.

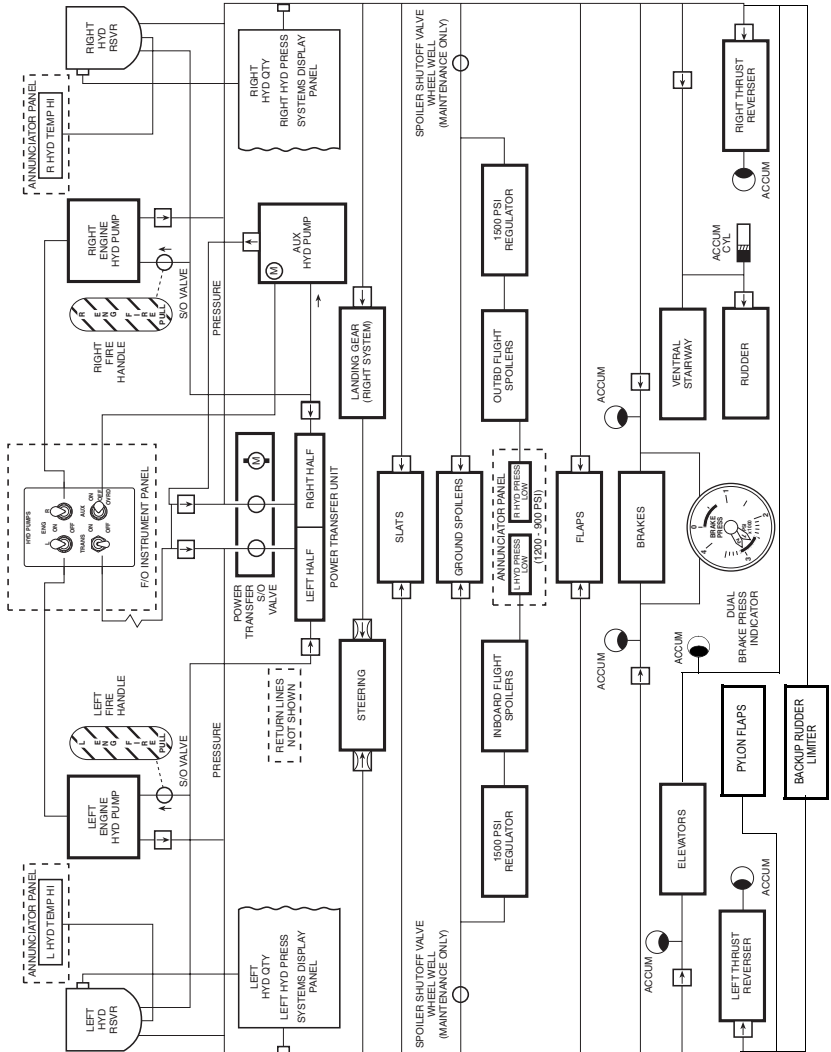
Functional Schematic

MD-90 Block Diagram



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MD-90 Hydraulic Functional Schematic



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Landing Gear
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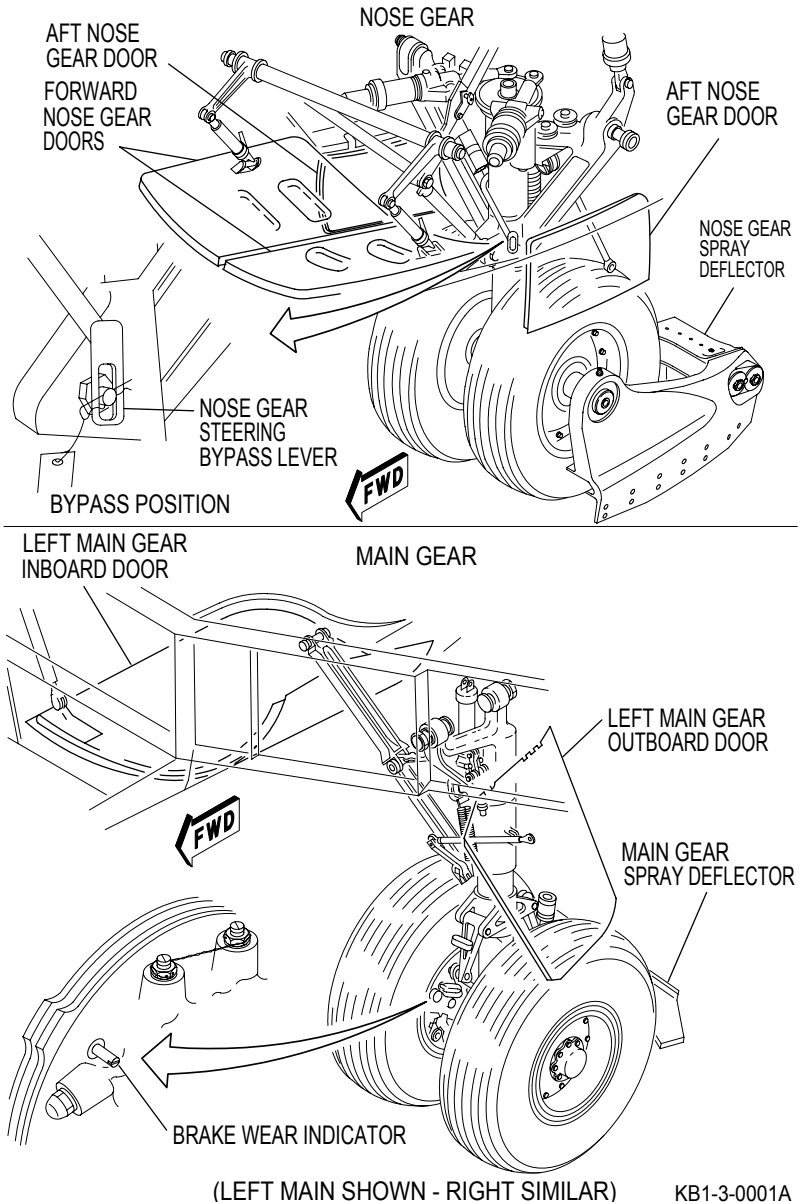
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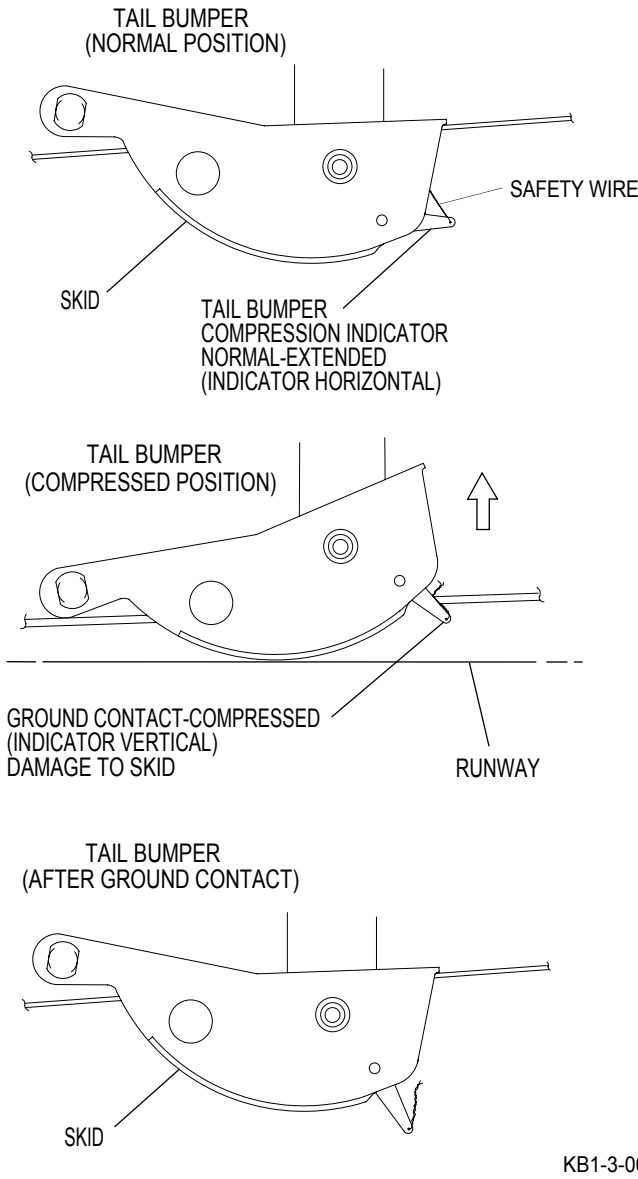
Landing Gear Controls and Indicators

Chapter 14 Section 10

Major Component Locations

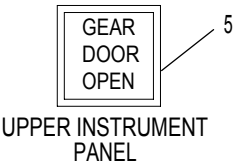
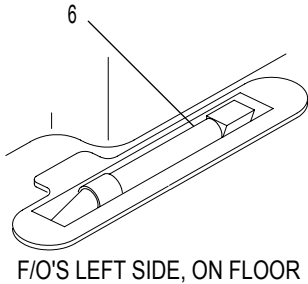
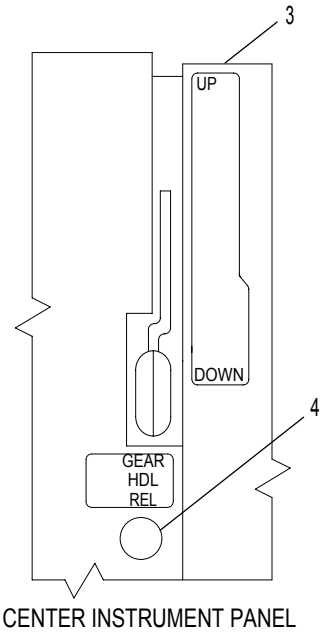
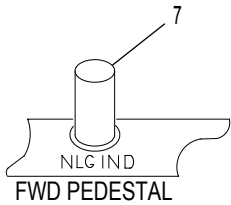
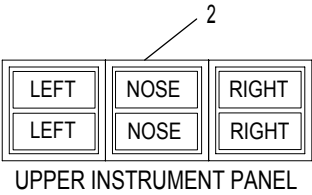
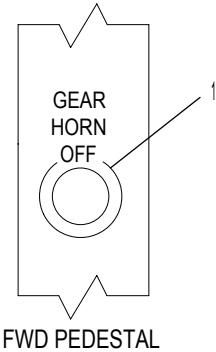


Tail Bumper and Compression Indicator



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Gear Handle/Indicators



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1. GEAR HORN OFF Button

Pushing button will silence landing gear warning horn and vocal warning under all conditions of descent and approach except when gear is not down and flaps are extended beyond approximately 26 degrees; gear must then be down and locked to silence warning system.

2. Gear Lights (LEFT, NOSE, RIGHT)

Green - Indicates gear handle down and landing gear down and locked; gear down and locked with emergency gear extension lever raised regardless of gear handle position.

Red - Indicates landing gear not down and locked and handle is down; any unsafe gear condition; landing gear in transit or not in agreement with gear handle; gear up and locked and either one or both throttles retarded to idle.

Off - When gear handle is up and gear up and locked.

3. Gear Handle

UP - Positions control valve to hydraulically retract gear. Activates gear warning system until gear is fully retracted.

DOWN - Positions control valve to hydraulically unlock, extend, and lock gear. Activates gear warning system until the gear is fully extended and locked.

NOTE: Gear handle must be pulled out of a detent at UP and DOWN before it can be moved. To prevent inadvertent retraction, handle is locked in DOWN position until nose gear strut extends and moves ground shift mechanism.

4. GEAR HDL REL Button

Bypasses anti-retraction release mechanism to allow landing gear handle to be raised in event of ground shift system malfunction after takeoff.

5. GEAR DOOR OPEN Light (amber)

Indicates either main gear door not closed.

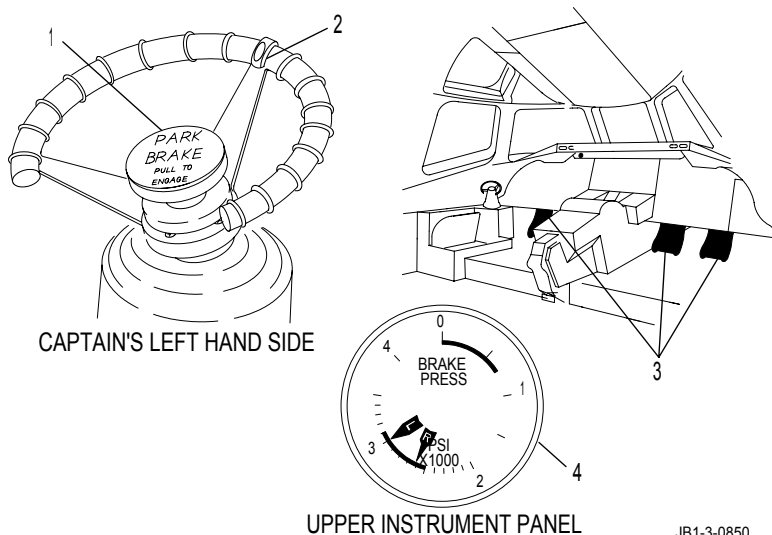
6. Emergency Gear Extension Lever

Mechanically releases main gear door latches, nose gear over-center lock and places gear hydraulic system in bypass condition, allowing gear to free-fall and lock into position.

7. Nose Gear Down Lock Indicator

Appears when the nose gear is fully extended and nose gear links are locked over-center.

Brakes and Nosewheel Steering



1. **PARK BRAKE Control**

To set parking brakes, depress brake pedals, lift PARK BRAKE control, then release brakes. When set, parking brakes are released by depressing either set of brake pedals.

If throttles are advanced with parking brakes set, an intermittent takeoff warning horn and vocal warning "BRAKES" are sounded.

2. **Nose Gear Steering Wheel**

Overrides rudder pedal steering and provides control of nosewheel steering thru an arc approximately 82 degrees left or right, during ground operations. An index on the wheel rim indicates the relative position of the nose wheel.

3. **Rudder/Brake Pedals**

Nosewheel Steering Function - Provides control of nosewheel steering through an arc approximately 17 degrees left or right, during ground operation.

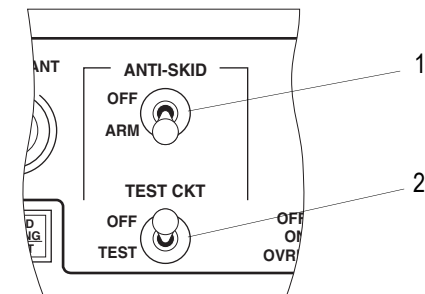
Brakes Function - Depressing top of pedal applies brake pressure.

4. **BRAKE PRESS Gauge**

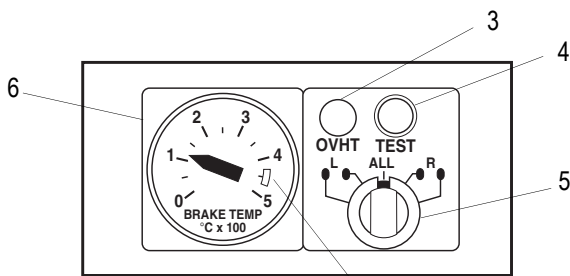
Respective pointer indicates L or R brake system hydraulic pressure.

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Anti-Skid Controls and Brake Temperature Indication



FORWARD OVERHEAD PANEL



TEST BAND

FIRST OFFICER'S INSTRUMENT PANEL

1. ANTI-SKID Switch

OFF - Anti-skid system disarmed and all ANTI-SKID messages (except ANTI-SKID FAULT) are displayed on the OAP. Foot pressure on brake pedal controls hydraulic pressure to the brakes.

ARM - After main wheel spinup the anti-skid system will reduce applied brake pressure if necessary to prevent tire skidding and to obtain maximum available braking. The system is active down to approximately 10 knots.

2. TEST CKT Switch

OFF - Test circuit off.

TEST - (Momentary) All ANTI-SKID messages are displayed on the OAP provided ANTI-SKID switch is in the ARM position and landing gear handle is DOWN. All messages are removed when switch is released.

3. OVHT Light (amber)

Illuminates when brake temperature exceeds 305°C and extinguishes when brakes cool to 260°C.

4. **Brake Temp TEST Button**

Tests brake temperature sensors and OVHT light. BRAKE TEMP gauge drives to test band and OVHT light illuminates. The OVHT light flashes if faulty temperature sensor is detected during test.

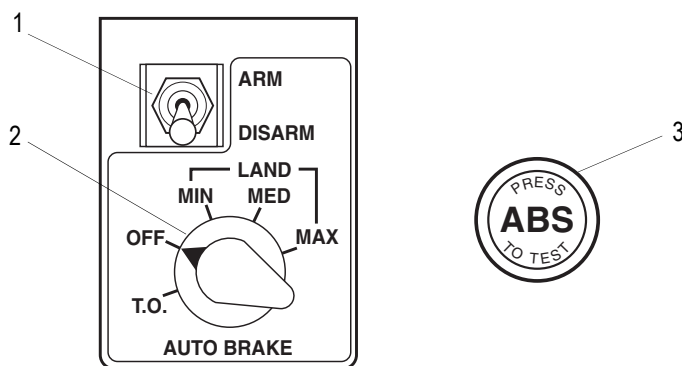
5. **Brake Temp Selector**

When ALL is selected, BRAKE TEMP gauge displays temperature of hottest brake. When rotated from ALL, selects individual brake temperature.

6. **BRAKE TEMP Gauge**

Indicates hottest or selected brake temperature depending on the position of the Brake Temp selector.

Auto Brake Controls



1. AUTO BRAKE ARM/DISARM Switch

ARM - Arms ABS to apply brakes automatically when SPD BRK lever moves full aft during takeoff or landing. Switch is electrically held in ARM position.

NOTE: With autobrakes armed, takeoff warning horn and vocal warning “AUTO SPOILERS” will sound during takeoff if throttles are advanced and auto-ground spoilers are not armed.

DISARM - ABS disarmed. Normal anti-skid braking available.

2. AUTO BRAKE Selector

T.O. - During rejected takeoff with SPD BRK lever full aft, minimum automatic braking is provided if the airplane speed is less than 70 knots. If the airplane speed is above 70 knots, maximum automatic braking is provided.

OFF - ABS is not available. Manual braking available.

LAND MIN - With SPD BRK lever full aft after landing, brakes are automatically applied with a minimum force.

LAND MED - With SPD BRK lever full aft after landing, brakes are automatically applied with a medium force.

LAND MAX - With SPD BRK lever full aft after landing, brakes are automatically applied with maximum force.

3. ABS Disarm Light (amber)

Illuminates when the landing gear handle is down, AUTO BRAKE selector is moved out of the OFF position and AUTO BRAKE ARM/DISARM switch is in DISARM.

Landing Gear System Description

Chapter 14 Section 20

General

The gear is normally actuated by a landing gear handle and may be raised or lowered by pressure from the right hydraulic system. When retracted, the gear is fully enclosed by doors. If the right hydraulic system fails, the gear can be mechanically released to free-fall to the extended and locked position. Dual, hydraulic powered multi-disc brakes with anti-skid control is provided on the main gear. An electrical visual/aural indicating and warning system provides gear and brake system status.

Spray and debris deflectors on both main gear and nose gear assemblies direct water and debris away from the engines during takeoff and landing.

A tail skid assembly, mounted on the bottom of the fuselage aft of the pressure bulkhead, prevents structural damage if the aft fuselage contacts the runway. A compression indicator provides evidence of contact by means of a visual inspection.

Nose Gear

The nose gear assembly is locked in both the extended and retracted positions by an overcenter linkage. During normal operation, the overcenter linkage is released hydraulically to permit gear extension and retraction. If hydraulic pressure is not available, the overcenter links can be released mechanically by the emergency gear extension lever.

A ground shift mechanism, mounted on the nose gear, is operated by the compression and extension of the nose gear strut. When the strut is fully extended, the ground shift mechanism disengages the rudder pedal nosewheel steering mechanism, hydraulically centers the nosewheel for retraction, and retracts the landing gear handle release button. The ground shift mechanism also actuates ground control relays that establish the ground or flight modes of operation.

Nose Gear Doors

The nose gear wheel well enclosure consists of two forward doors and two strut doors. The doors are mechanically operated by movement of the nose gear during extension and retraction. The forward doors may be opened for ground maintenance operations.

Nosewheel Steering

Nosewheel steering is hydraulically operated by the steering wheel or rudder pedals.

The nosewheel steering system consists of two independent actuating cylinders (left and right). Each steering cylinder receives pressure from its respective hydraulic system. Nosewheel steering, with only one hydraulic system operating, will function normally except for a restriction in the maximum steering angle on the side toward the operating system to approximately 55 degrees. Rate of turn will also be decreased in both directions.

While the steering system is in the neutral position, the cylinders function as shimmy dampers. For towing, a manually operated bypass valve, located on the nose strut, is provided to deactivate the steering system permitting manual turning of the nose gear.

Normally the steering wheel provides control of the nosewheel steering through an arc of approximately 82 degrees left or right. The rudder pedals provide control of nosewheel steering through an arc of approximately 17 degrees left or right.

Main Gear

The airplane has two main gear assemblies consisting of dual wheels mounted on a strut. When extended, each main gear assembly is locked in the extended position by overcenter linkage. When retracted, the main gear assemblies are held up by hydraulic pressure. If right hydraulic pressure is not available, the gear is held up by the doors. For manual gear extension, the main gear door latches can be released by the emergency gear extension lever.

Main Gear Door

Each main gear wheel well enclosure consists of a hydraulically operated main gear door and a mechanically operated strut door. The main gear doors are mechanically latched when closed and are designed to support the main gear during flight if the right hydraulic system fails. The main gear doors cycle to the closed position after the main gear is extended. The main gear doors can also be mechanically released and opened on the ground.

Visual/Aural Indicating and Warning System

Landing gear lights (LEFT, NOSE, RIGHT) illuminate green to indicate that the landing gear and landing gear handle are in the down-and-locked position. The lights will illuminate red for the following conditions:

- Landing gear position not in agreement with gear handle position.
- Landing gear is not down and locked and either throttle is approximately at idle.

The GEAR DOOR OPEN light will illuminate anytime either one or both main gear doors are not closed.

The takeoff warning horn and vocal warning will sound when both throttles are advanced and the parking brakes are set.

The landing gear warning horn and vocal warning will sound in the following conditions:

- Landing gear is not down and locked with flaps extended beyond 26 degrees. (not silencable)
- Landing gear is not down and locked, either throttle is approximately at idle, airspeed is less than 210 KIAS and radio altitude is less than 1,500 feet. (silencable)

The aural/vocal warning can be silenced by pressing the GEAR HORN OFF button on the pedestal except when the landing gear handle is not down and the flaps are extended beyond 26 degrees. Once silenced, the warning is reactivated when either throttle is advanced then retarded to idle.

Reference markings on each main gear overcenter link may be viewed with the periscope from inside the airplane to confirm gear is fully extended and locked. Nose gear verification is provided by an indicator on the pedestal.

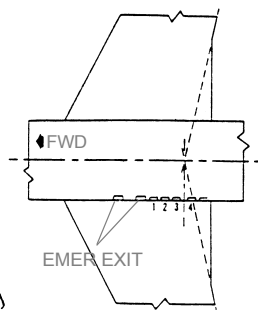
To visually check main gear overcenter linkage, depressurize the aircraft, raise carpet over periscope, remove cover and dust cap, and turn on wheel well lights (switch located adjacent to periscope). Align periscope with index mark to view desired gear, rotate approximately 180° and align other index mark to view opposite gear. Periscope may be removed to clean mirror.

GEAR DOWN - Orange strip
on black background.

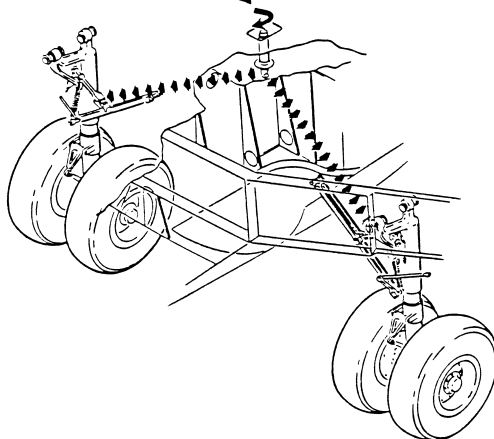


MAIN GEAR
(right gear shown,
left gear opposite)

 FWD



PERISCOPE MAY BE LOCATED AS BEING
BETWEEN 3RD AND 4TH WINDOWS AFT
OF EMERGENCY EXITS OR ABEAM THE
LEADING EDGE OF THE INBOARD FLAPS.



 FWD

Note: The periscope is located under the left aisle seat on the MD-88 and in the aisle on the MD-90.

Brakes and Anti-Skid

When either set of brake pedals are depressed, hydraulic pressure from both the left and right hydraulic brake system is applied to the main wheel brakes. The anti-skid system reduces hydraulic pressure as necessary to prevent tire skidding. The anti-skid system is electrically controlled. The anti-skid system is operational when the following conditions are met:

- Switch in ARM position
- Gear handle down or alt gear handle pulled
- Parking brakes released
- Wheel speed greater than 10 knots.

When the system is deactivated, braking action is directly controlled by pilot input at the pedals.

Each main gear wheel is equipped with disc type brakes actuated by two independent sets of pistons. Each set is powered by one of the hydraulic systems. In addition, each system has an accumulator that will supply reserve brake pressure in the event of normal hydraulic pressure failure. A brake pressure (BRAKE PRESS) gauge provides visual indication of hydraulic pressure in each system.

A brake temperature (BRAKE TEMP) gauge and an overheat (OVHT) light provide visual indications of brake temperature. If the wheels become too hot, fuse plugs in the wheel will melt, releasing the tire pressure. Each brake assembly is equipped with wear indicators so that visual checks can be made of brake wear. Maximum allowable wear is indicated when the wear indicators are flush to the surrounding brake surface, with the parking brakes set.

The parking brakes are set by depressing the brake pedals, pulling up on the parking brake (PARK BRAKE) control knob, and releasing the brake pedals. This mechanically latches the brake pedal, trapping pressure in the wheel brake system. When the PARK BRAKE knob is raised, the PARKING BRAKE ON message is displayed on the OAP. If throttles are advanced with the parking brake set, the aural/vocal warning system will be activated.

Automatic Brake System

The automatic brake system (ABS) takeoff mode is armed by selecting T.O. on the AUTO BRAKE selector switch and placing the ARM-DISARM switch in the ARM position. The spoiler/speedbrake lever must be retracted and flaps must be less than 26 degrees. The takeoff aural warning will sound if either auto spoilers or ABS is armed and the other system is disarmed. The ABS takeoff mode is activated during a rejected takeoff upon spoiler handle extension.

Note: If spoiler handle fails to deploy automatically, manual spoiler handle deployment will activate ABS.

If a rejected takeoff is initiated below 70 knots, the ABS reverts to landing mode operation and MIN braking is provided. At speeds greater than 70 knots, maximum dual-system automatic braking is applied immediately without any time delay. Disarming can be initiated by advancing either throttle or by depressing brake pedals. Either condition will cause the ABS to disarm, the ARM-DISARM switch will revert to the DISARM position and the ABS lights will illuminate.

An ABS malfunction will cause the system to automatically disarm. The ARM-DISARM switch will revert to the DISARM position, and the ABS lights illuminate. To rearm the ABS system after it has automatically disarmed, the AUTO BRAKE selector must be placed to the OFF position and then back to the appropriate setting and the ARM-DISARM switch must be placed to the ARM position. If the fault has cleared, the system will rearm.

The ABS landing mode is armed prior to landing, after the landing gear handle is down and flaps are greater than 26 degrees, by selecting MIN, MED, or MAX by the AUTO BRAKE selector and placing the AUTO BRAKE ARM/DISARM switch to ARM. The anti-skid system must be armed and operational as a condition for ABS operation. ABS landing mode is activated when the spoiler handle is deployed either automatically or manually with throttles retarded and brake pedals released. Automatic braking is delayed after spoiler deployment for approximately 1 second in MAX position and approximately 3 seconds in MIN or MED positions. ABS landing mode is inhibited if the throttles are not retarded towards idle. Disarming can be initiated at anytime by manually placing the ARM/DISARM switch into the DISARM position, or by rotating the auto brake selector to OFF, or by depressing either or both brake pedals. ABS automatically disarms (during landing) when either or both throttles are advanced or by raising the gear handle (ABS light inhibited with gear handle raised). When the system is disarmed, the ABS disarm lights located on the glareshield will illuminate. During landing, the ABS will also disarm and the ABS lights will illuminate if flaps are raised to less than 26 degrees. Stowing the spoiler handle will release brake pressure without disarming the ABS. The ABS lights will remain extinguished and automatic braking will again be available if the spoiler handle is re-deployed.

OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

AUTO SPOILER FAIL (CONT) - Indicates auto spoiler failure.

PARKING BRAKES ON (HYD) - Indicates parking brakes are set. When parking brakes are not set, indicates an anti-skid malfunction.

L/R INBD/OUTBD ANTI-SKID (HYD) - Applicable message will be displayed to indicate malfunction of anti-skid protection for specific wheel. All messages will be displayed, with ANTI-SKID switch OFF or system malfunctions.

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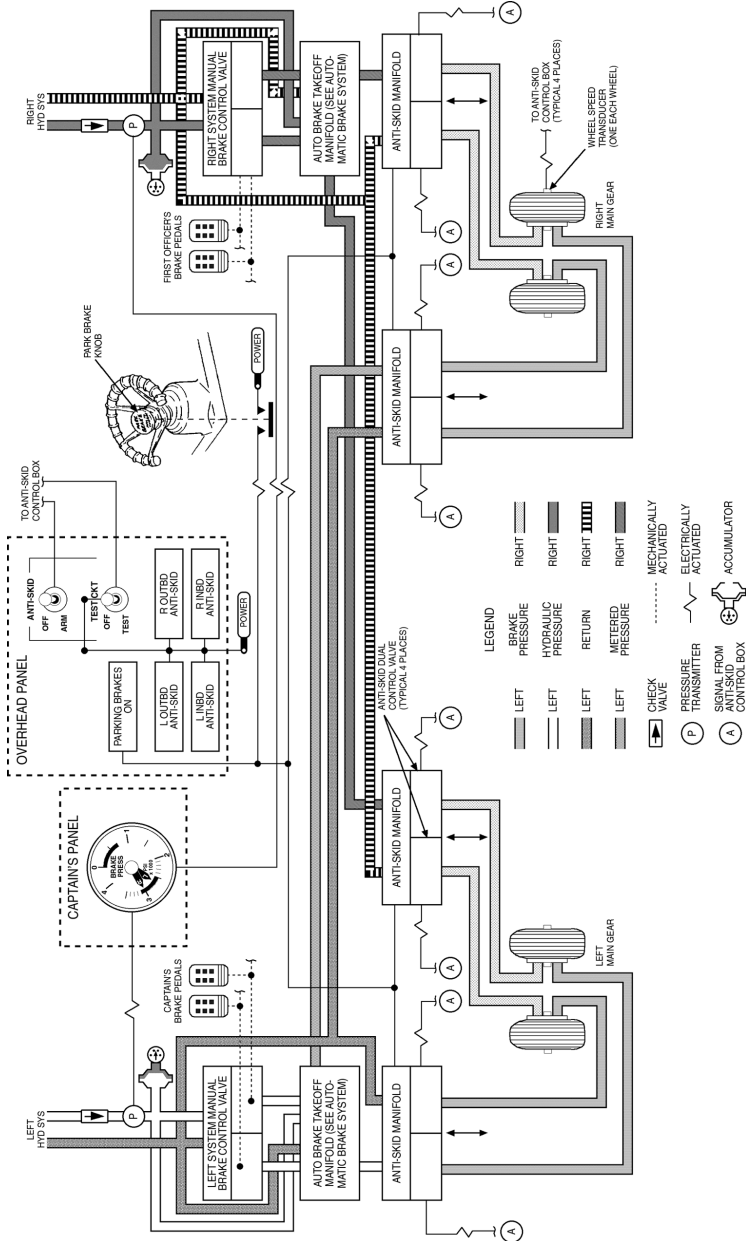
Landing Gear

Functional Schematic

Chapter 14

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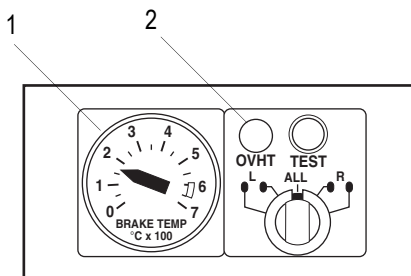
MD-88 Landing Gear Schematic



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Controls and Indicators

Anti-Skid Controls and Brake Temperature Indication



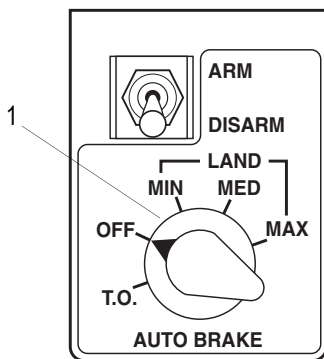
1. BRAKE TEMP Gauge

Indicates hottest or selected brake temperature.

2. OVHT Light (amber)

Illuminates when brake temperature exceeds 540°C and extinguishes when brakes cool to 425°C.

Auto Brake Controls



1. AUTO BRAKE Selector

T.O. - During rejected takeoff with spoiler handle full aft, minimum automatic braking is provided if the airspeed is less than 90 knots. If the airspeed is above 90 knots, maximum automatic braking is provided.

System Description

Automatic Brake System

If a rejected takeoff is initiated below 90 knots, MIN dual-system braking is provided. At speeds greater than 90 knots, MAX dual-system automatic braking is applied immediately without any time delay.

An automatic brake system (ABS) malfunction will cause the system to automatically disarm. The ARM-DISARM switch will revert to the DISARM position, and the ABS lights illuminate. AUTO BRAKE FAIL message on the OAP, and the MASTER CAUTION lights will illuminate.

Automatic braking is delayed after spoiler handle deployment for approximately 1 second in MAX , MED or MIN positions.

OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

ANTI-SKID FAULT (HYD) - Indicates a detected fault could result in a reduction in or a loss of system redundancy.

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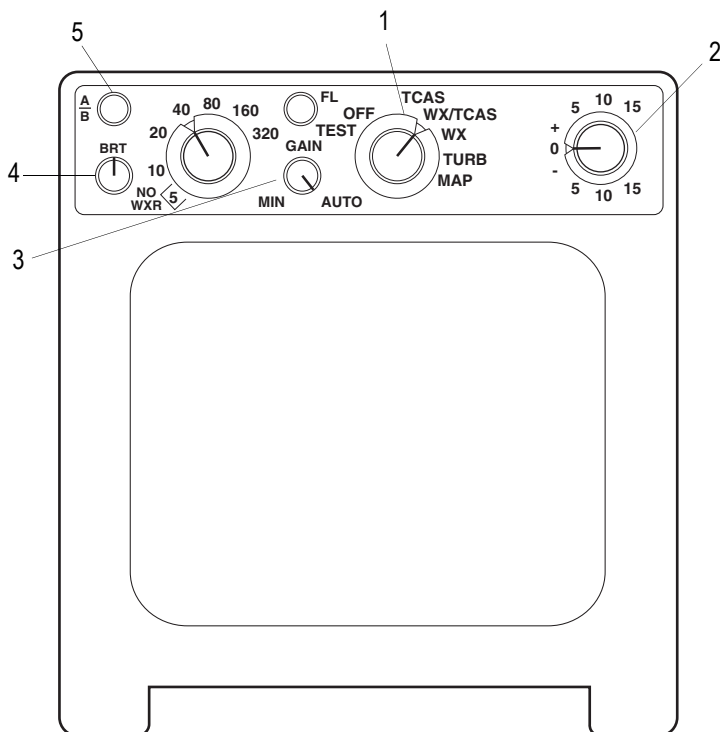
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Weather Radar



1. Mode Selector

OFF - De-energizes system.

TEST - Displays test pattern. If an LRU fault exists, message(s) will be displayed on radar indicator to indicate component failure.

WX - Displays areas of high density (red), lower density (amber), and light precipitation (green).

TURB - Overlays turbulence (magenta) on WX mode when turbulence exists. Available to 40 nm.

MAP - Displays local terrain features.

2. Antenna Tilt Selector

Varies vertical plane of antenna scanning. Tilt limits are +/- 15 degrees of fuselage reference plane.

3. **GAIN Selector**

MIN - Minimum receiver sensitivity.

AUTO - Automatically controls receiver sensitivity.

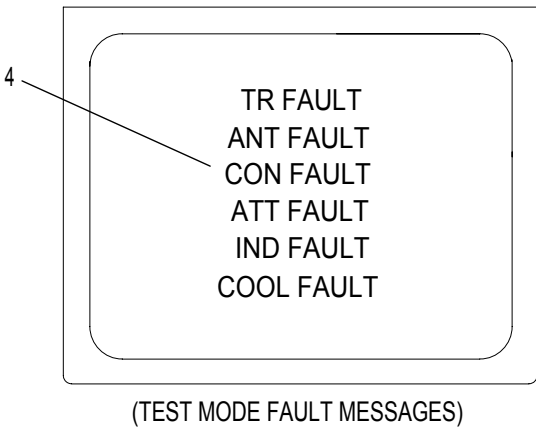
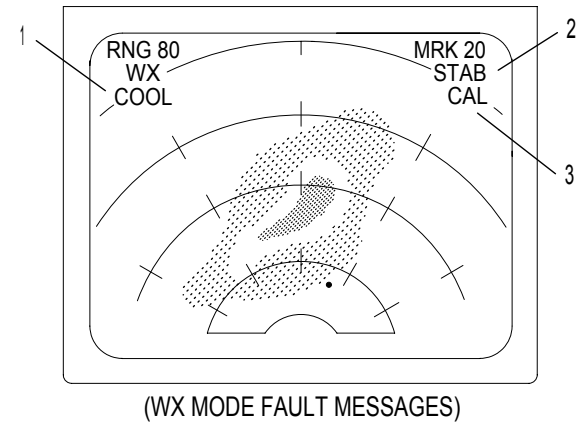
4. **BRT Knob**

Adjusts intensity of display.

5. **Range Selector**

Selects desired range and respective range marks.

Pedestal Weather Radar Messages



NOTE

The indicator will display a detected attitude, indicator, or calibration fault as an LRU fault only in TEST mode.

1. COOL (amber)

Transmitter/Receiver cooling fault.

2. **STAB (amber)**

Stabilization fault.

3. **CAL (amber or blue)**

Amber - Radar receiver gain is out of calibration.

Blue - GAIN knob is not set to AUTO.

4. **LRU Fault Messages**

TR FAULT - Transmitter/Receiver fault.

ANT FAULT - Antenna fault.

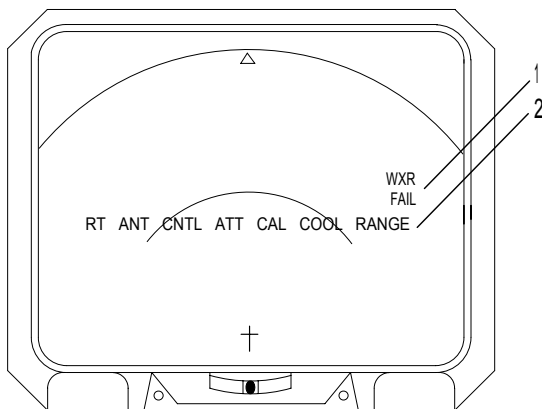
CON FAULT - Control fault.

ATT FAULT - Radar antenna attitude fault.

IND FAULT - Radar indicator fault.

COOL FAULT - T/R cooling fault.

ND Weather Radar Messages (Typical)



JB1-3-0816

1. WXR Status Messages

WXR OFF - Weather radar is off.

NO WX - Weather radar imagery has been removed due to overheat condition.

WXR FAIL - Receiver/transmitter fault, antenna fault, or control fault which results in removal of weather radar imagery.

WXR RANGE - Computed range is not equal to selected range which results in removal of weather radar imagery.

The following messages indicate operating modes of R/T unit:

WX - Weather radar displayed without turbulence.

MAP - Ground mapping displayed.

TURB - Turbulence displayed only.

REAC - Indicates R/T units inability to look behind intervening rainfall.

STBY - Weather radar in standby mode.

The following messages have the prefix XXXX. This represents any one of the operating modes that may appear directly above the message:

XXXX VAR - Weather radar input sensitivity is not calibrated to any precipitation rate.

XXXX CAL - Loss of calibration.

XXXX ATT - Attitude input fault.

XXXX STAB - Stabilization is off.

2. LRU Fault Messages

If a failure exists in test mode, TEST will be replaced by FAIL and one or more fault messages.

RT - Receiver/Transmitter fault.

ANT - Antenna fault.

CNTL - Control fault.

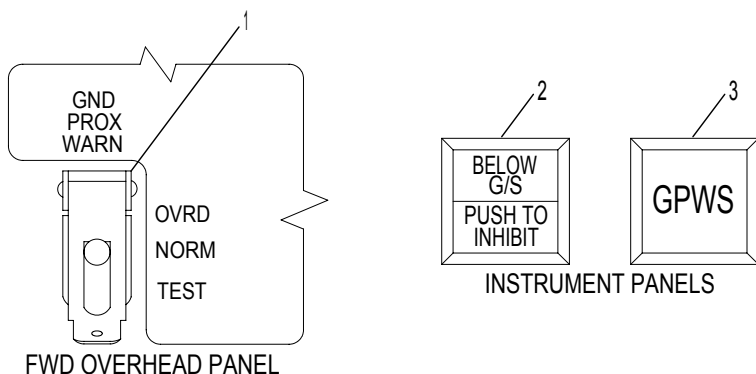
ATT - Attitude fault.

CAL - Calibration fault.

RANGE - Range fault (MSP fault).

COOL - R/T unit cooling fault.

Ground Proximity Warning System



JB1-3-0820

1. **GND PROX WARN Switch**

OVRD - Inhibits "TOO LOW FLAPS" warning when landing is made with less than normal landing flap configuration.

NORM - System annunciates dangerous situations while remaining silent during normal flight operations.

TEST - (Momentary) Initiates system test.

2. **BELOW G/S Switch-Light (amber)**

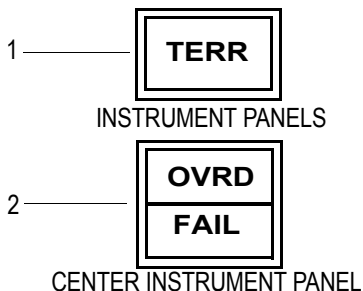
Illuminated - Indicates excessive deviation below glide slope. Light is accompanied by voice warning "GLIDE SLOPE".

Pushing switch-light, when the airplane is below 1000 feet radio altitude, will inhibit or cancel the warning.

3. **GPWS Warning Light (red)**

Illuminated - Indicates corrective action is required due to airplane proximity to the ground or not in proper configuration for descent. Light is accompanied by appropriate aural/voice warning. Light has a push-to-test feature and is connected to the instrument panel light dimming circuit.

EGPWS Controls and Indicators



1. EGPWS Terrain Switchlight (white)

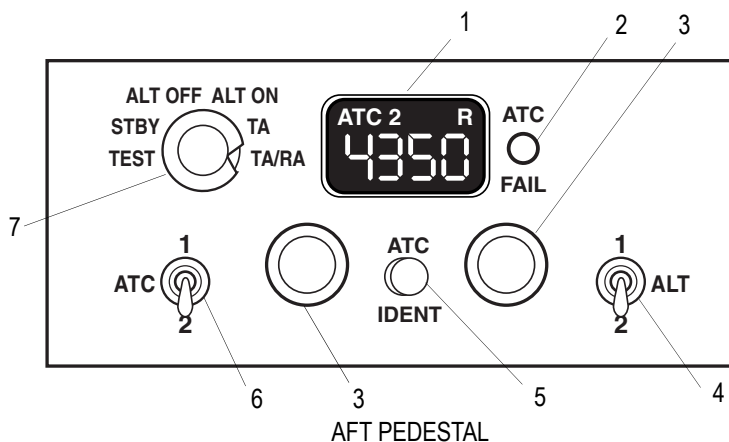
Light illuminates when depressed. Enables terrain to be displayed on pilot's ND.

2. GPWS Terrain Switchlight

OVRD (white) - Illuminates when depressed. Inhibits the look-ahead terrain alerts and terrain display.

FAIL (amber) - Illuminates when look-ahead terrain alerts and terrain display functions are inoperative.

TCAS/Transponder Control Panel



1. Code Indicator Display Window

Displays code selected with code selectors. Also indicates which of the transponders is currently active and if it is in reply mode.

2. ATC FAIL Light

Indicates failure of selected transponder.

3. Code Selector Knobs (2)

Selects transponder code. Consists of a large knob and a small knob. Each controls one digit of the code.

4. ALT Switch

1/2 - Selects respective source of altitude information.

5. ATC/IDENT Button

Press for positive identification on controllers radar scope.

6. ATC Switch

1/2 - Activates respective transponder. Other transponder is in standby.

7. TCAS/Transponder Function Selector

TEST - (Spring-loaded) Initiates system self test. Transponder will reply to interrogation during test.

STBY - Transponder and TCAS are in standby.

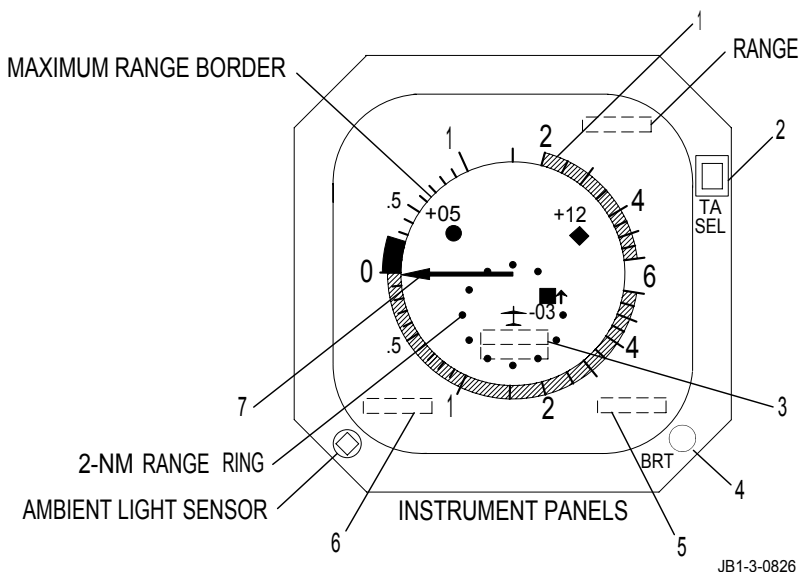
ALT OFF - Activates transponder without altitude reporting. TCAS is in standby.

ALT ON - Activates transponder altitude reporting. TCAS is in standby.

TA - Selects traffic advisory mode. Presents traffic location on TA display. Inhibits RA mode.

TA/RA - Selects both traffic advisory and resolution advisory modes. Presents traffic location on displays and issues audio and visual resolution advisories for traffic determined to be a threat.

TA/VSI Indicator



1. Typical Display of Resolution Advisories

Red areas represent vertical speed “restricted”. Green areas represent requirement of pitch adjustment and are referred to as “Fly To” areas. Remaining arc identifies vertical rates which provide safe altitude separation.

2. TA SEL Pushbutton

Active while TCAS display is present. Push to cancel traffic display.

3. Intruder Without Bearing Message

An RA or TA with relative altitude and trend arrow are displayed respectively in red or amber.

4. BRT Knob

Adjusts intensity of display.

5. VSI Message (amber)

Indicates a loss or invalid vertical speed data. Vertical speed pointer is removed.

6. TCAS Mode/Failure Message

TCAS STBY - (blue) TCAS is in standby.

TEST - (amber) TCAS is in test mode.

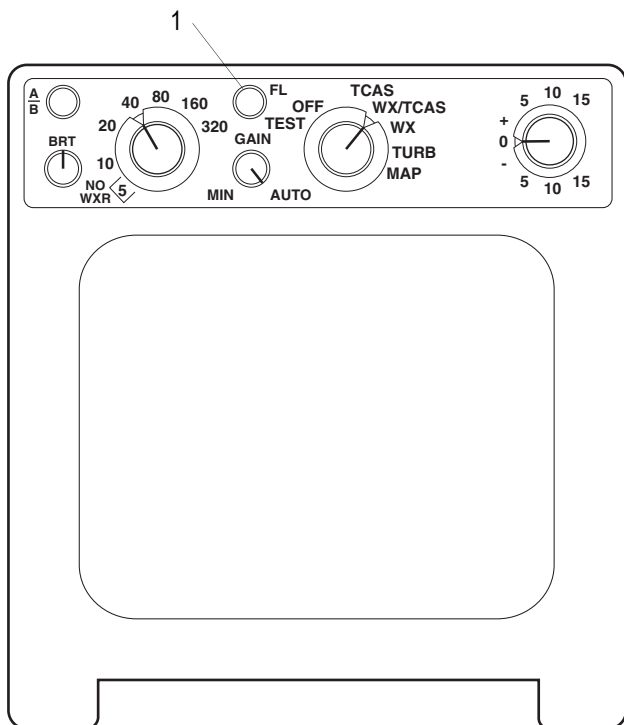
TA ONLY - (blue) Traffic advisory mode.

TCAS - (amber) TCAS failure.

7. Vertical Speed Pointer

Indicates present airplane vertical speed.

Radar TCAS Control Panel

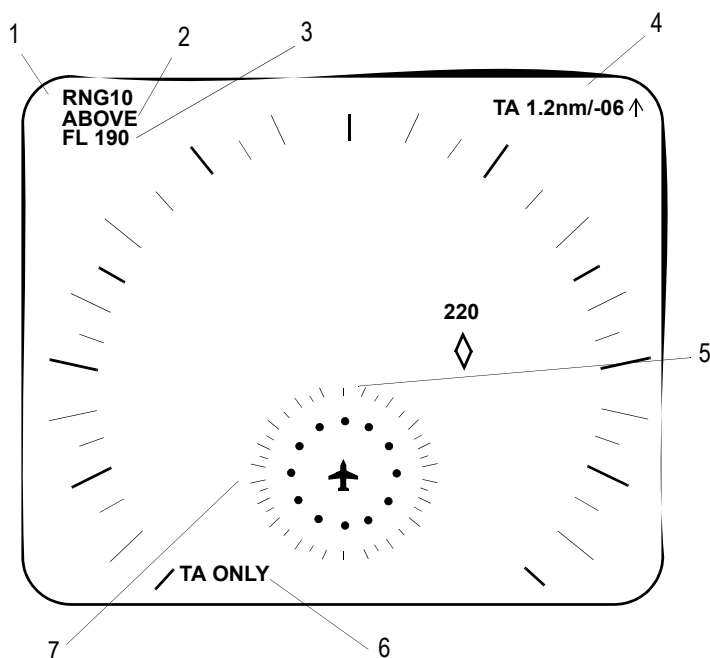


1. **FL Pushbutton**

Push - Replaces intruder airplane relative altitude with flight level altitude for 15 seconds. Airplane flight level altitude is also displayed. If a new RA or TA is detected, flight level display will be replaced by relative altitude.

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Pedestal Radar - TCAS Display



1. **Operating Range**
RNG XX readout.
2. **Displayed Altitude Band**
ABOVE/BELOW
Blank if NORMAL band.
3. **Absolute Altitude**
FL XXX readout.
Only when FL mode selected.
If not available - FL _ _ _.
4. **NO Bearing**
Yellow (TA) - 1.2 nm/-06.
Red (RA) - 1.2 nm/-06.
5. **TCAS Fault Annunciation (Center of Display)**
Identifies the reason for loss of TCAS capability.

6. TCAS Status/Mode

TA/RA.

TA ONLY.

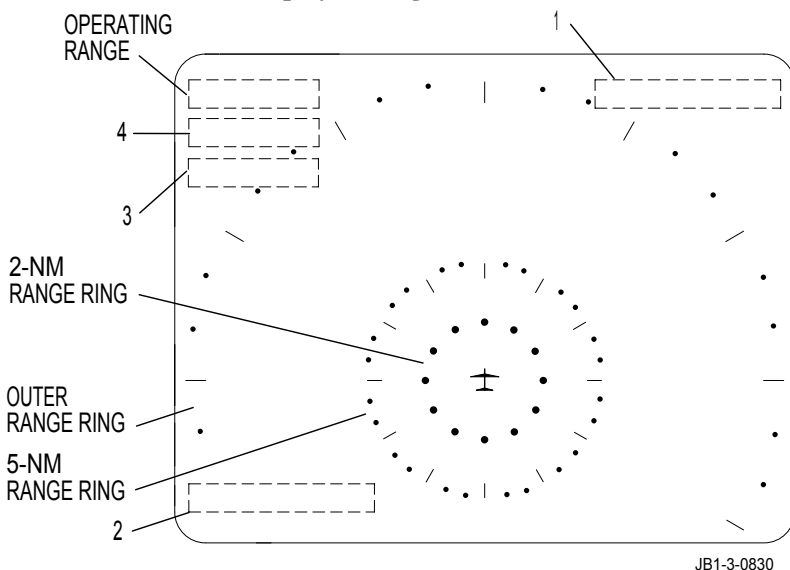
TEST.

7. Radar Indicator in TCAS Mode

RANGE	RANGE MARKS (In Nautical Miles)
5	2 & 5
10	2, 5 & 10
20	5, 10 & 20
40	10, 20 & 40
80	10, 20 & 40
160	20 & 40
320	40

NOTE: Max range for traffic display is approximately 40 nm.

Pedestal Radar - TCAS Display Messages



1. Intruder Without Bearing Message

An RA or TA with distance, altitude and trend arrow are displayed respectively in red or amber.

2. TCAS Mode Status

TA/RA - Traffic advisory and resolution advisory displays selected.

TA ONLY - Traffic advisory display selected.

TEST - System test selected.

NO TCAS - TCAS not operational.

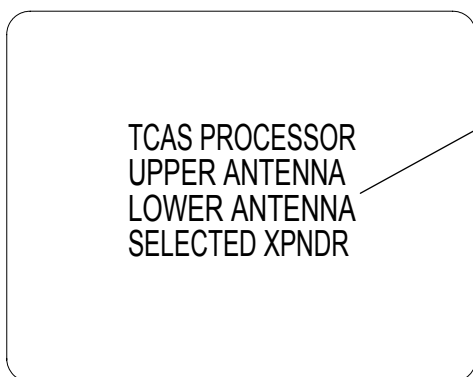
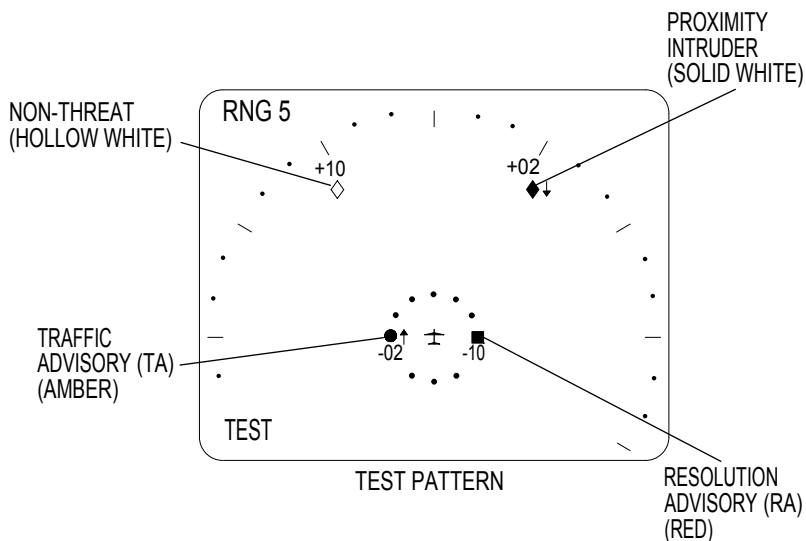
3. Flight Level

Airplane flight level is displayed for 15 seconds when the FL pushbutton is pushed.

4. ABOVE/BELOW

ABOVE or BELOW is displayed when the A/B pushbutton is pushed.

Pedestal Radar - TCAS Test Display



FAULT MESSAGES IN TEST MODE

FAULT MESSAGES

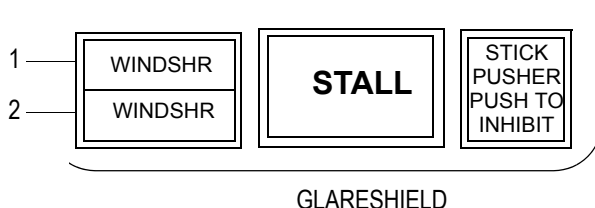
TCAS PROCESSOR
UPPER ANTENNA
LOWER ANTENNA
SELECTED XPNDR
RADIO ALT # 1
RADIO ALT # 2
RADIO ALT # 1 and # 2
1 XPNDR DATA BUS
2 XPNDR DATA BUS
TRAFFIC DISPLAY
RA DISPLAY # 1
RA DISPLAY # 2
RA DISPLAY # 1 and # 2
SELECTED XPNDR
XPNDR TOP ANT
XPNDR LOWER ANT
XPNDR TCAS DATA
XPNDR CONTROL DATA
XPNDR ALT # 1 and # 2
1 XPNDR ALT DATA
2 XPNDR ALT DATA
ALTITUDE
HEADING
NO TCAS (NO DATA)
TD FAIL
TCAS FAIL

NOTE

At the conclusion of self-test, the TCAS processor outputs the synthesized voice message, "TCAS System Test OK."

JB1-3-0832

Windshear Annunciator(s)



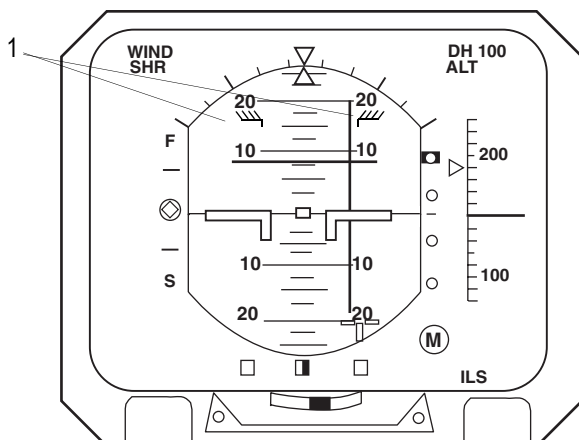
1. **WINDSHR (red)**

Upper Red - Indicates detection of decreasing performance shear.

2. **WINDSHR (amber)**

Lower Amber - Indicates detection of an increasing performance shear.

Pitch Limit Indicator (PLI)



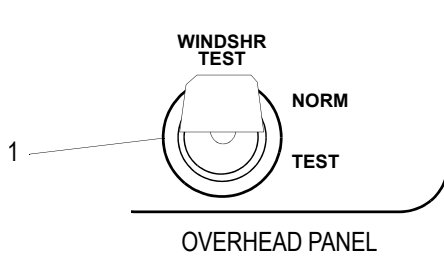
1. **Pitch Limit Indicator (PLI) (white)**

Appears when airplane reaches 60 KIAS and the airplane is at or below 1,500 AGL.

If the slats are extended, the PLI will be displayed at any altitude.

PLI indicates relationship of airplane angle of attack to stick shaker angle of attack.

WINDSHR TEST Switch



1. NORM

Windshear system is armed.

2. TEST (Momentary)

Windshear system undergoes eight second self test if airplane on ground and airspeed less than 30 knots.

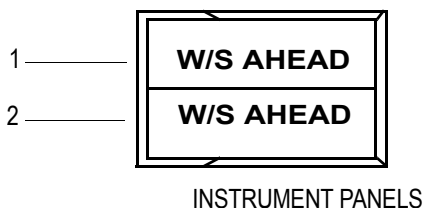
PWS INOP Light



1. PWS INOP Light (amber)

Indicates the PWS function is inoperative. The amber PWS INOP light will illuminate on the center instrument panel and NO W/S will appear in the upper left corner of the radar display. Other means of windshear avoidance should be used.

Predictive Windshear Annunciator(s)



1. Windshear Caution Annunciator (amber)

Illuminates for PWS windshear caution.

2. Windshear Warning Annunciator (red)

Illuminates for PWS windshear warning.

Warning and Caution Systems

The warning and caution systems provide aural, visual, and/or tactile (stall) indications to warn of potentially unsafe operating conditions or airplane configurations and system malfunctions. Indications are generated by a central aural warning system (CAWS), a master warning and caution system, a tactile stall warning system, or a ground proximity warning system (GPWS). See applicable systems for more detailed description.

Central Aural Warning Systems

NOTE: Horn, “C” chord tone, chime, and bell sounds are classified as aural warnings. Electronically generated “words” are classified as vocal warnings.

Aural warnings generated by a central control unit provide warning discrimination by means of vocal and aural signals. Additional information regarding the operation and testing of Central Aural Warning Systems (CAWS) generated signals is provided in the AURAL/VOCAL WARNING AND CAUTION SYSTEM section of this chapter and in applicable systems chapter.

Master Warning And Caution System

Master warning and caution indications are provided by red annunciator lights and some amber OAP messages. The red MASTER WARNING lights indicate a condition that requires immediate attention. The amber MASTER CAUTION lights indicate a condition that requires less than immediate attention. MASTER WARNING and MASTER CAUTION lights illuminate concurrently with their associated individual warning lights and caution messages and can be reset by pushing on the light lens for subsequent indications. Individual warning lights or caution messages remain illuminated until the condition has been corrected. Certain individual caution messages are considered advisory and do not cause the MASTER CAUTION lights to illuminate.

Stall Warning System

An artificial stall warning device (a stick shaker on each control column) is used to provide a warning of an impending stall. This warning begins at approximately 110 percent of VS by vibrating both control columns. A complete description of this system is contained in the FLIGHT CONTROL section.

In addition to the STALL warning lights, the dual stall warning system actuates a stick shaker to warn of an impending stall. Refer to Flight Controls chapter for detailed description.

APU Fire Warning Horn

In addition to CAWS generated warnings, an additional aural warning for an APU fire is provided by an exterior horn located adjacent to the APU ground control panel in the tailcone. Refer to Fire Protection chapter for detailed description.

Aural/Vocal Warning and Caution Systems

Refer to the following table for Aural/Vocal Warning and Caution Systems.

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Warning	Aural/Vocal	Visual	Condition	Correction	Test
ALTITUDE ALERT is inhibited when: 1. Flaps are more than 26° extended and/or 2. Glide slope is captured.	'C' chord tone at 750 feet above or below capture.	Altimeter altitude advisory light on steady.	Within threshold of selected altitude (within 750 to 250 feet of selected altitude).	Capture selected altitude (within 250 feet of selected altitude) or select new altitude.	Select altitude above field elevation and rotate BARO set knob to 750 feet and 250 feet of selected altitude.
	'C' chord continues until condition corrected or warning deactivated. "ALTITUDE"	Altimeter altitude advisory light on flashing.	Deviation of more than 750 feet from selected altitude after entering the threshold and prior to capturing selected altitude.	Re-enter the threshold, select new altitude.	
	'C' chord continues until condition corrected or warning deactivated. "ALTITUDE"	Altimeter altitude advisory light on flashing.	Deviation of more than 250 feet from selected altitude after capturing selected altitude.	Recapture selected altitude or select new altitude.	

Warning	Aural/Vocal	Visual	Condition	Correction	Test
APU FIRE	Continuous extremely loud exterior horn. Cockpit indication is an intermittent horn sound which automatically cancels after (3) cycles. “APU FIRE”	APU FIRE and DETECTOR LOOP message. MASTER WARNING/CAUTION lights. APU LOOP A and B lights, and APU FIRE light (on external APU ground control panel).	Fire or overheat in APU compartment.	MASTER WARNING/CAUTION lights are reset by pushing light caps. The APU FIRE, FIRE DETECTOR LOOP, and APU loop lights and external fire warning horn sounds until fire is extinguished.	LOOPS TEST buttons (A and B). (APU cockpit aural not tested.)
AUTO-PILOT	“AUTO-PILOT”	Flashing red AP light on flight mode annunciators.	Autopilot disengaged.	Press AP release button on either control wheel or engage AP.	None.
CABIN ALTITUDE	Modulating horn. “CABIN ALTITUDE”	CABIN ALT light and MASTER WARNING lights.	Cabin altitude has exceeded allowable limit of 10,000 feet.	Reduce cabin altitude to 10,000 feet or below. Light resets when cabin altitude is 10,000 feet or below. Horn silences after 5 seconds.	None.

Warning	Aural/Vocal	Visual	Condition	Correction	Test
ENGINE FIRE	Continuous bell sound until condition corrected or warning deactivated. “FIRE LEFT ENGINE” “FIRE RIGHT ENGINE”	L or R ENG FIRE handle(s); respective LOOP A & B lights; FIRE DETECTOR LOOP message, and MASTER CAUTION lights.	Fire or overheat in engine nacelle.	Aural warning silenced by pushing FIRE BELL OFF button or pulling the fire handle out. Visual indications remain illuminated until fire is extinguished.	LOOPS TEST buttons (A and B).
GROUND PROXIMITY WARNING is inhibited below 50 feet ($\pm$ 15 feet).	“SINK RATE, SINK RATE” “WHOOOP WHOOOP- PULL UP”	Red GPWS light.	Excessive sink rate.	Recover from condition indicated.	GND PROX WARN TEST switch.

Warning	Aural/Vocal	Visual	Condition	Correction	Test
GROUND PROXIMITY WARNING is inhibited below 50 feet (± 15 feet). (Continued)	“TERRAIN- TERRAIN” “WHOOP WHOOP- PULL UP”	Red GPWS light.	Excessive terrain closure rate - airplane not in landing configuration.	Recover from condition indicated.	None.
	“DON’T SINK, DON’T SINK”	Red GPWS light.	Altitude loss after takeoff.		None.
	“TOO LOW GEAR” “TOO LOW TERRAIN”	Red GPWS light.	Terrain clearance - descending in wrong configuration - gear up.		None.
	“TOO LOW FLAP” “TOO LOW TERRAIN”	Red GPWS light.	Terrain clearance - descending in wrong configuration - gear down, flaps not in landing position.		None.

Warning	Aura/Vocal	Visual	Condition	Correction	Test
GROUND PROXIMITY WARNING is inhibited below 50 feet (± 15 feet). (Continued)	“GLIDESLOPE”	Amber BELOW G/S light.	Descent below glide slope.	Recover from condition indicated.	GRND PROX WARN switch.
	“MINIMUMS”	None.	Descent below decision height setting.	None.	None.
ENHANCED GROUND PROX WARNING	“TERRAIN-TERRAIN, PULL UP”	Solid red terrain on NAV displays.	20 to 30 seconds from projected impact with terrain shown solid red on the NDs.	Recover from condition indicated.	GRND PROX WARN switch.
			GPWS terrain switch in OVRD inhibits the alert.		

Warning	Aural/Vocal	Visual	Condition	Correction	Test
ENHANCED GROUND PROX WARNING (Continued)	“CAUTION TERRAIN”	Solid amber terrain on NAV displays.	40 to 60 seconds from projected impact with terrain shown amber on the NDs.		GRND PROX WARN switch.
			GPWS terrain switch in OVRD inhibits the alert.		
LANDING GEAR	Steady horn continues until condition corrected or warning deactivated. “LANDING GEAR”	Gear handle not down.	1. Gear handle not down and flaps extended beyond 26°.	Extend gear or retract flaps to less than 26°.	Landing gear handle pulled down and out.
			2. Gear handle not down. Any throttle fully retarded, with an airspeed less than 210 kts. and altitude less than 1500 RA.	Aural warning silenced by pushing GEAR HORN OFF button, provided flaps are less than 26°.	

Warning	Aura/Vocal	Visual	Condition	Correction	Test
OVERSPEED	Clacker. “OVERSPEED”	None.	VMO/MMO exceeded.	Correct overspeed condition.	MAX SPD WARN TEST switch.
	“SLAT OVERSPEED”	None.	280 KIAS (MACH 0.57) exceeded with slats extended.	Correct overspeed condition or retract slats.	None.
SPOILERS/ FLAPS EXTENDED	Modulating horn “SPEED BRAKE”	SPOILER/FLAP EXTEND message and MASTER CAUTION lights.	Spoilers extended with flaps extended beyond 6 degrees.	Set speedbrake/spoiler handle full forward (RET or ARM) or retract flaps.	None.
STABILIZER IN MOTION	Momentary horn. “STABILIZER MOTION” (only with AP trimming after 30 seconds).	None. (Stabilizer LONG TRIM indicator may be crosschecked).	Horizontal stabilizer in motion.	Warning silenced when stabilizer is stopped.	Operate longitudinal trim controls to test horn only.

Warning	Aural/Vocal	Visual	Condition	Correction	Test
STALL WARNING	Stall warning horn sounds.	Red STALL warning lights.	Airspeed approaching stall condition for flap/slat configuration.	Correct stall condition.	STALL TEST switch.
	Tactile warning by stick shaker. Both columns vibrate simultaneously.				
TAKEOFF WARNING	Modulating horn continuous until condition corrected.		Airplane on ground, either throttle advanced, and:	Retard throttle and/or (one of following actions):	Advance throttles with at least one subsystem not configured.
	“BRAKES”	PARKING BRAKES ON message.	Parking brake is set.	Release parking brake.	
	“FLAPS”	Flap lever position does not agree with selected position in TO condition computer window.	Flaps not set for takeoff.	Set flaps for takeoff.	

Warning	Aural/Vocal	Visual	Condition	Correction	Test
TAKEOFF WARNING (Continued)	“SLATS”	SLAT TAKEOFF blue light not illuminated.	Slats not set for takeoff.	Set slats for takeoff.	Advance throttles with at least one subsystem not configured.
	“SPOILERS”	None.	Speedbrake handle not in the full forward (RET or ARM) position.	Set speedbrake/spoiler handle at RET or ARM.	
	“STABILIZER”	Stabilizer setting not in agreement with TO condition computer readout (green band).	Stabilizer not set for takeoff.	Set stabilizer to match TO condition computer readout or indicator. (green band)	
	“AUTO BRAKE”	AUTO BRAKE selector not in T.O.	1. Autobrake system not in T.O. with auto spoilers armed. 2. ABS malfunction. (disarmed system)	Select T.O. or disarm spoilers.	

Warning	Aural/Vocal	Visual	Condition	Correction	Test
TAKEOFF WARNING (Continued)	"AUTO SPOILER"	Auto spoilers not armed with autobrake system selected to T.O.	Auto spoilers not armed.	Arm auto spoilers or turn off ABS.	Advance throttles with at least one subsystem not configured.
WINDSHEAR WARNING	Inhibited.	Amber WND SHR annunciation on both PFDs and amber WND SHR lights on glareshield illuminate.	Increasing performance windshear encounter.	Fly out of windshear condition.	WINDSHEAR TEST switch.
	Inhibited during the takeoff roll. Tone followed by vocal "WINDSHEAR" (3 times).	Red WND SHR annunciation on both PFDs and red WND SHR lights on glareshield illuminate.	Decreasing performance windshear encounter.		

Warning	Aural/Vocal	Visual	Condition	Correction	Test
PREDICTIVE WINDSHEAR WARNING	“WINDSHEAR AHEAD”	Red W/S AHEAD annunciators located on each pilot’s instrument panel. Red and black windshear symbol with amber radial lines on the radar display.	Windshear close to and directly ahead of the airplane detected by the weather radar. Enabled during takeoff, below 1,200 feet RA. Predictive windshear symbol on the radar display shows windshear position.	See Flight Crew Training Manual for procedures.	RADAR SYSTEM TEST Switch.

Warning	Aural/Vocal	Visual	Condition	Correction	Test
PREDICTIVE WINDSHEAR WARNING (Continued)	“GO AROUND, WINDSHEAR AHEAD”	Red W/S AHEAD annunciators located on each pilot's instrument panel. Red and black windshear symbol with amber radial lines on the radar display.	Windshear within 1.5 miles and directly ahead of the airplane detected by the weather radar. Enabled during landing, below 1,200 feet RA. Predictive windshear symbol on the radar display shows windshear position.	See Flight Crew Training Manual for procedures.	RADAR SYSTEM TEST Switch.

Warning	Aural/Vocal	Visual	Condition	Correction	Test
PREDICTIVE WINDSHEAR CAUTION	“MONITOR RADAR DISPLAY”	Amber W/S AHEAD annunciators located on each pilot’s instrument panel. Red and black windshear symbol with amber radial lines on the radar display.	Windshear within 3 miles and directly ahead of the airplane detected by the weather radar. Enabled during Takeoff and approach, below 1,200 feet RA. Predictive windshear symbol on the radar display shows windshear position.	See Flight Crew Training Manual for procedures.	RADAR SYSTEM TEST switch.

Overhead Annunciator Panel

The overhead annunciator panel (OAP) provides a centrally located alerting system for aircraft system operation on two overhead panels. The OAP also displays system status not otherwise displayed in the cockpit. An accompanying MASTER CAUTION light illuminates with designated messages.

In the event of a requirement for system annunciation, messages will be presented on the OAP starting at the top of the left panel in order of occurrence. No priority is given to any message. When the left panel contains 6 messages, the next message appears at the top of the right panel.

Each panel can present 6 messages for a maximum of 12 at any time. If an additional message is presented, it appears on the right panel at the bottom. All messages move up and the oldest message moves off the top of the left screen. Scroll buttons are located adjacent to the right screen to provide a means to review messages not shown on the screens. The appropriate scroll button illuminates to indicate one or more messages are stored off screen.

Individual messages are automatically removed from the screen when the condition causing the message no longer exists.

Cue Lights

Seven systems cue lights are located below the annunciator panels. When a message first appears on the screen, the associated system's cue light flashes four times to draw attention to the screen. If a system message has been moved off screen, the associated cue light illuminates steadily. Each cue light can be pressed to present the messages associated with the system.

When a system fault exists in the OAP, the MON cue light illuminates. This indicates a discrepancy between the two OAP channels that continuously monitor each other.

Warning and Advisory Lights (Fixed)

The OAP also displays system status not otherwise displayed in the cockpit. The right side of the OAP contains "fixed" warning and advisory lights with a specific message imprinted on each light. When a red light illuminates on this panel, it is accompanied by both MASTER WARNING lights. The blue advisory lights indicate specific systems status.

Traffic Collision Avoidance System

Traffic Collision Avoidance System (TCAS) is an aircraft proximity warning system that identifies nearby transponder equipped aircraft and provides vertical guidance to ensure altitude separation from aircraft equipped with altitude reporting transponders. The system can display up to 30 aircraft and simultaneously coordinate a resolution advisory for up to three threat aircraft. This independent means of ensuring safe aircraft separation is intended to supplement the ground based Air Traffic Control system and the “see and avoid” concept.

The purpose of TCAS is to prevent mid-air collisions, increase traffic awareness, and assist in establishing visual contact with other aircraft. TCAS does not alleviate a pilot’s responsibility of maintaining safe visual separation from other aircraft.

Normally a Traffic Advisory (TA) will be issued prior to a RA, but in situations where aircraft are turning or initiating climbs or descents, the first alert may be a RA.

Traffic causing a Resolution Advisory (RA) on the TA/VSI constitutes a significant threat. During a RA, lighted red arcs presented on the TA/VSI display indicate restricted vertical speeds. A lighted green arc presented on the TA/VSI display indicates the commanded (fly-to) vertical speed that should be flown. Pilots should accurately adhere to the TCAS vertical speed commands to minimize altitude excursions and potential disruptions to ATC.

Because TCAS tracks numerous aircraft and can coordinate multiple RAs, pilots should be aware that an aircraft that has been acquired visually may not necessarily be the aircraft causing the RA or may not be the only aircraft to which TCAS is responding.

Glossary Of Terms

Mode S Transponder:

A transponder that has a data link channel for use by TCAS in addition to the aircraft identification capability of a mode A transponder and altitude reporting capability of a mode C transponder.

Relative Altitude:

The difference in altitude between two aircraft. TCAS calculates relative altitude as the difference between your aircraft’s pressure altitude and the encoded pressure altitude of the intruder aircraft.

Surveillance Volume:

The airspace which TCAS scans. TCAS can scan up to 40 nm horizontally in front of the aircraft. In high traffic density airspace, TCAS will automatically reduce the distance scanned to a minimum of 7.5 nm. TCAS can scan vertically 8,700 feet above and below the aircraft. The vertical scan may be adjusted by use of the TCAS above/below selector.

Traffic:

Aircraft with an operating transponder capable of being tracked by a TCAS equipped aircraft. Categories of traffic are:

- **Non-Threatening Traffic:** Any target within the TCAS surveillance volume.
- **Non-Threatening Proximity Traffic:** A target within 1,200 feet relative altitude and 6 nm range.
- **Traffic Advisory (Potential Conflict):** A target identified as a potential conflict and requiring a traffic advisory.
- **Resolution Advisory (Immediate Threat):** A target identified as a collision threat and requiring a resolution advisory. The closest point of approach is less than 35 seconds.

Traffic Advisory/Vertical Speed Indicator (TA/VSI):

A flight instrument that provides standard VSI information, position of nearby transponder equipped traffic, RA climb and descent commands, and TCAS messages and status. Maximum display range is 6.5 nm.

TCAS Advisories

A Traffic Advisory (TA) identifies traffic which is projected to pass at less than IFR separation standards and presents a potential conflict. An aural alert, "TRAFFIC, TRAFFIC", calls attention to a display of a solid yellow circle presented on the TA/VSI.

A Resolution Advisory (RA) identifies traffic which is an immediate threat. In addition to a solid red square on the traffic display, colored arcs are added on the TA/VSI. These arcs identify the desired vertical rates which will satisfy altitude separation standards. Resolution advisories attempt to ensure approximately 500 foot separation. There are four categories of RAs:

- **Preventive RA:** An RA that requires the pilot to maintain an existing vertical speed or to avoid certain vertical speeds.
- **Corrective RA:** An RA that requires a pilot to modify the aircraft's existing vertical speed. A crossing RA is a corrective RA that directs a pilot to cross through the threat aircraft's altitude in order to achieve safe vertical separation.

- **Updated RA:** An RA that is issued after an initial corrective RA which requires additional climb or descent rate to achieve safe vertical separation.
- **Reversal RA:** An RA that requires a reverse in direction from the initial corrective RA to achieve safe vertical separation (such as a corrective “Descend, Descend Now” RA reverses a climb RA).

A RA may change categories as the range and closure rate of the threat aircraft changes or other aircraft become a threat. For example, a corrective RA Climb may update to an increase climb and then update again to monitor vertical speed and safely clear of conflict.

Cockpit Warning System Conflicts

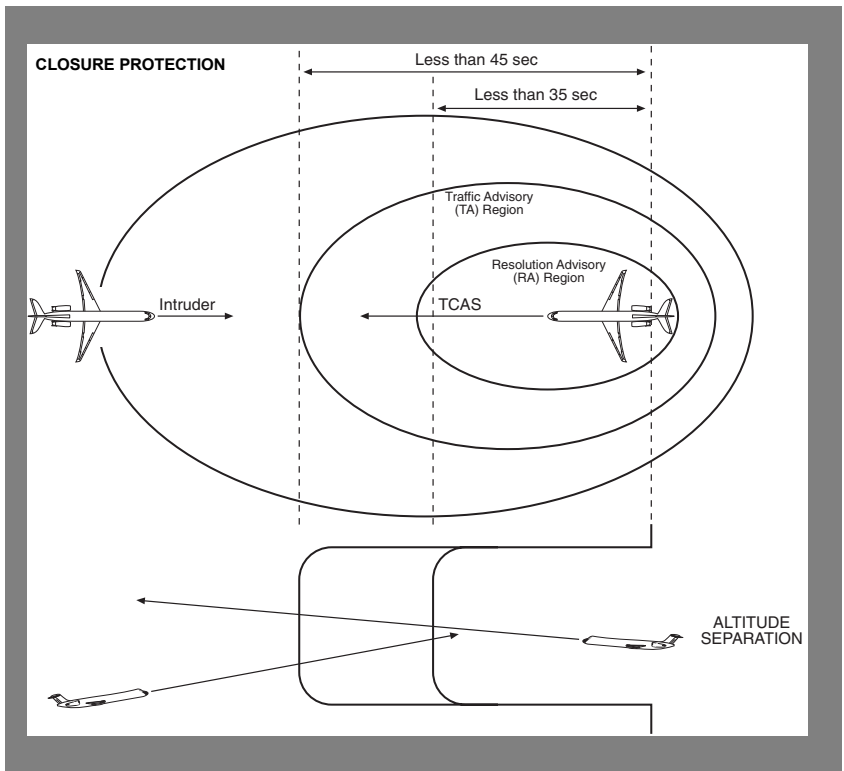
Critical cockpit warnings, such as stall warning, windshear, or GPWS, have priority over a RA. A windshear or GPWS warning will automatically place TCAS in TA ONLY mode, and the TA/VSI will show TA ONLY in yellow if a TCAS alert is simultaneously activated. TCAS will automatically return to TA/RA mode when priority warnings have ceased.

Protection Envelopes

TCAS provides two envelopes of protection around the aircraft.

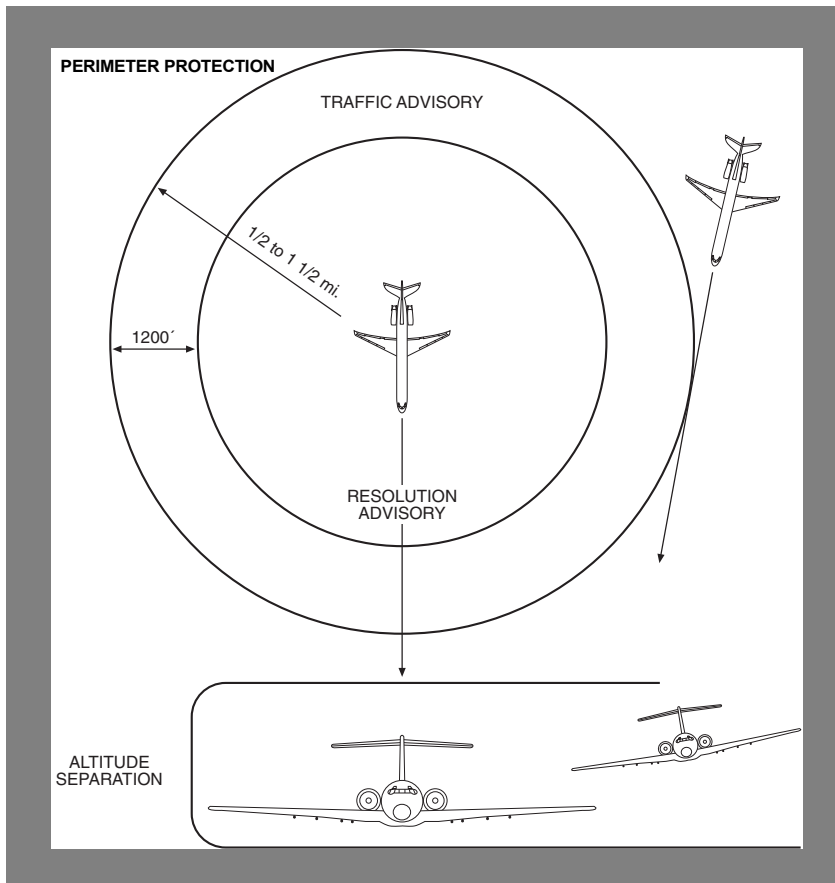
Closure Protection (time-based protection envelope).

- TCAS projects closure rate and future altitude separation based on bearing, range, and altitude information from other altitude reporting aircraft.
- A TA is issued if IFR separation will be compromised and time of closure is less than 45 seconds.
- A RA will be issued when the conflicting aircraft is less than 35 seconds away and the conflicting traffic is determined to be a threat.



Perimeter Protection (distance-based protection envelope)

- The radius of the outer perimeter varies from approximately one half mile at low altitude to one and one half miles at high altitude. A TA is issued when this perimeter is penetrated and an altitude separation is compromised.
- The radius of the inner perimeter is 1,200 feet less than the outer perimeter. A RA is issued when this perimeter is penetrated and an altitude separation is compromised.



TCAS Voice Alerts

The TCAS voice alert **TRAFFIC**, **TRAFFIC** sounds once when TCAS first predicts a new traffic advisory.

When TCAS first predicts a new resolution advisory, one of the following TCAS voice alerts sounds once:

MONITOR VERTICAL SPEED

MAINTAIN VERTICAL SPEED, MAINTAIN

MAINTAIN VERTICAL SPEED, CROSSING MAINTAIN

CLIMB, CLIMB

CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB

DESCEND, DESCEND

DESCEND, CROSSING DESCEND, DESCEND, CROSSING DESCEND.

The crossing alerts tell the flight crew that the airplane will fly through the altitude of the other airplane when following the TCAS vertical guidance on the VSI.

If TCAS requires an increase or decrease in the vertical rate of climb, then one of the following TCAS voice alerts sounds once:

INCREASE CLIMB, INCREASE CLIMB

INCREASE DESCENT, INCREASE DESCENT

ADJUST VERTICAL SPEED, ADJUST.

If TCAS requires a change in vertical direction from either an existing climb to a descent, or an existing descent to a climb, then one of the following TCAS voice alerts sounds once:

- **DESCEND, DESCEND NOW..... DESCEND, DESCEND NOW**
- **CLIMB, CLIMB NOW..... CLIMB, CLIMB NOW.**

When separation from the other airplane is increasing and TCAS predicts there will be no resolution advisory, the TCAS voice alert **CLEAR OF CONFLICT** sounds once. However, the alert will not sound if the resolution advisory can no longer be calculated because TCAS cannot predict the track of the other airplane.

The following are the available TCAS voice alerts:

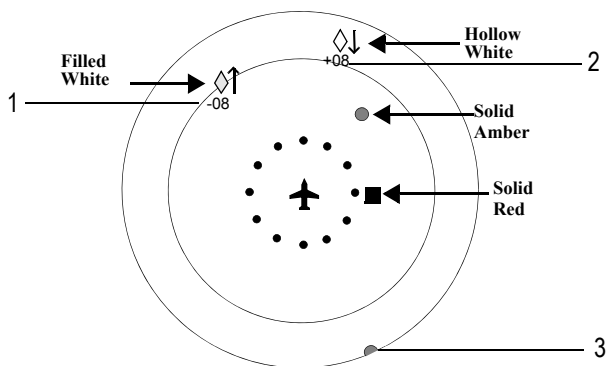
Voice Alert	Type	Response
TRAFFIC, TRAFFIC	TA	Attempt to visually locate the traffic.
MONITOR VERTICAL SPEED	RA	Present pitch attitude is outside the TCAS VSI vertical guidance pitch command. Keep pitch attitude away from the red pitch command.
MAINTAIN VERTICAL SPEED, MAINTAIN	RA	Present pitch attitude is outside the TCAS VSI vertical guidance pitch command. Continue to keep pitch attitude away from the red pitch command.
MAINTAIN VERTICAL SPEED CROSSING, MAINTAIN	RA	Present pitch attitude is outside the TCAS VSI vertical guidance pitch command. Continue to keep pitch attitude away from the red pitch command. Airplane will pass through the altitude of the traffic.
CLIMB, CLIMB	RA	Climb as directed by TCAS VSI vertical guidance.
CLIMB, CROSSING CLIMB, CLIMB, CROSSING CLIMB	RA	Climb as directed by TCAS VSI vertical guidance. Airplane will climb through the altitude of the traffic.
DESCEND, DESCEND	RA	Descend as directed by TCAS VSI vertical guidance.
DESCEND, CROSSING DESCEND, DESCEND, CROSSING DESCEND	RA	Descend as directed by TCAS VSI vertical guidance. Airplane will descend through the altitude of the traffic.
INCREASE CLIMB, INCREASE CLIMB	RA	Present pitch attitude is within TCAS VSI vertical guidance pitch command. Keep pitch attitude out of red pitch command.
INCREASE DESCENT, INCREASE DESCENT	RA	
ADJUST VERTICAL SPEED, ADJUST	RA	Present pitch attitude is outside TCAS VSI vertical guidance pitch command. Keep pitch attitude out of red pitch command.
DESCEND, DESCEND NOW, DESCEND, DESCEND NOW	RA	Descend as directed by TCAS VSI vertical guidance. Previous TCAS vertical guidance was to climb.
CLIMB, CLIMB NOW, CLIMB, CLIMB NOW	RA	Climb as directed by TCAS VSI vertical guidance. Previous TCAS vertical guidance was to descend.
CLEAR OF CONFLICT	RA	Separation is increasing and the RA will not occur. Vertical guidance is removed from the VSIs and traffic changes to a TA symbol.

TCAS Display Symbology

TCAS SYMBOLOGY			
THREAT LEVEL	CAUSE	SYMBOL	COLOR
RESOLUTION ADVISORY (RA)	Intruding traffic approximately 25 seconds from closest point of approach.	■	Red
TRAFFIC ADVISORY (TA)	Intruding traffic approximately 40 seconds from closest point of approach.	●	Amber
PROXIMATE TRAFFIC	Any traffic within 6 nautical miles and ± 1200 feet vertical.	◆	Cyan or White (Solid)
OTHER TRAFFIC	Any traffic within TCAS range limit and ± 2700 feet vertical.	◇	Cyan or White (Hollow)

DISPLAY THREAT LEVELS AND DATA TAG			
THREAT LEVEL	CAUSE	SYMBOL	COLOR
RESOLUTION ADVISORY (RA)	Intruding traffic is above by 100 feet and descending at least 500 feet per minute.	+01 ■↓	Red
TRAFFIC ADVISORY (TA)	Intruding traffic, same altitude. It could be descending or climbing less than 500 feet per minute.	+00 ●	Amber
PROXIMATE TRAFFIC	Traffic 1200 feet below and climbing at least 500 feet per minute.	◆↑ -12	Cyan or White (Solid)
OTHER TRAFFIC	Traffic 2700 feet above and descending at least 500 feet per minute.	+27 ◇↓	Cyan or White (Hollow)

TCAS Data Tags



1. Traffic advisory eight hundred feet below your altitude and climbing at greater than 500 fpm.
2. Traffic advisory eight hundred feet above your altitude and descending at greater than 500 fpm.
3. Traffic causing a TA or RA while outside the range displayed will be shown as half the appropriate symbol at the edge of the display area

As the traffic comes into range of the display, the full symbol will come into view.

Altitude of displayed traffic (relative altitude) is shown as the difference between your altitude and that of the traffic. TCAS calculates relative altitude as the difference between your aircraft's pressure altitude and the encoded pressure altitude of the intruder aircraft. This relative altitude is represented as a two digit number indicating hundreds of feet. (i.e., 05 represents 500 feet.) A plus or minus sign and the placement of the altitude information are both used to indicate whether displayed traffic is above or below your aircraft's altitude. Symbols displayed without altitude information indicate no altitude received. Yellow circles with no altitude information may be a significant hazard, yet TCAS is unable to provide RA's without altitude information.

Aircraft that are climbing or descending in excess of 500 feet per minute will be displayed with a data tag which includes an arrow pointing in the appropriate direction.

TCAS Inhibits

INCREASE DESCENT RAs are inhibited below approximately 1,450 feet radio altitude.

DESCEND RAs are inhibited below approximately 1,100 feet radio altitude.

RAs are inhibited below approximately 1,000 feet radio altitude. Below approximately 1,000 feet when the TA/RA mode is selected on the transponder panel, TA only mode is enabled automatically.

All TCAS voice annunciations are inhibited below approximately 500 feet radio altitude.

All TCAS alerts are inhibited by GPWS or windshear warnings.

TCAS Limitations

TCAS is unable to detect any aircraft without an operating transponder.

If the traffic's transponder is not reporting altitude, TCAS will issue a TA, but will not generate a RA.

The TCAS processor is not programmed with all aircraft performance parameters. There are situations, such as high density altitude or an engine inoperative operation, where the aircraft does not have the performance reserve to attain the RA commanded climb rates. The pilot must always respect the performance envelope of the aircraft. Power and configuration should be adjusted, if necessary, to achieve the desired vertical speed.

TCAS Components

The TCAS is composed of:

- A TCAS processor.
- Two TA/VSIs.
- A combined weather radar and TCAS traffic display.
- A combined transponder and TCAS control panel.
- Two fuselage mounted TCAS antennas (top and bottom).
- Two mode S transponders.
- Aural warning.

A combined control panel is used to operate both the mode S transponder and the TCAS. The TCAS processor and mode S transponder work together to interrogate other aircraft transponders and identify potential conflicts. When potential conflicts exist, the processor activates TCAS displays and provides aural alerts. The system issues maneuver commands providing separation from altitude reporting aircraft. The mode S transponder provides the capability to communicate with and coordinate avoidance maneuvers with other TCAS equipped aircraft.

During a TCAS advisory, the inside of the TA/VSI becomes a traffic display. During a RA, colored arcs are displayed on the TA/VSI vertical speed scale

In addition, weather radar indicators provide full-time display of either traffic, weather, or a combined weather and TCAS traffic display when WX/TCAS [WXR/TCAS] is selected.

The TCAS is interfaced with the following aircraft systems:

- Radio altimeter.
- Air data computer.
- IRS.
- Air/ground sensor.
- Gear position.
- GPWS.
- Windshear system.
- Aural warning system.

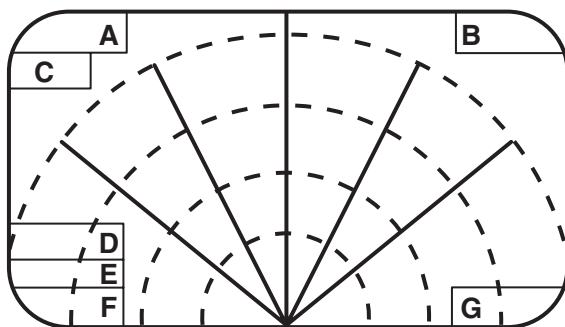
TCAS only on Radar Display

TCAS mode will have an aircraft symbol displayed near the center of the display so that traffic approaching from behind may be shown. Range is adjustable, although the ability to display traffic beyond forty miles is limited.

Weather and TCAS on Radar Display (WX/TCAS)

This combined operating mode allows display of both weather radar information and TCAS traffic. The information is presented on the standard weather display format with aircraft position at the bottom of the display. TCAS traffic will overlay any weather displayed.

All ranges may be selected. TCAS may display traffic at a distance of up to 40 nm. At higher ranges, TCAS information will be compacted in the lower display area. The five mile range, while clearly displaying TCAS traffic, will not display weather, and the weather radar will display a blue NO WXR.



A. Operating Range

RANGE XX.

B. Range Mark Interval

MRK XX.

When no bearing is available for a target, no bearing information will be provided.

C. Weather Display Status

Blank if weather will be displayed.

If 5 or 10 nm - NO WXR.

D. Altitude

FL XXX.

Blank if relative altitude mode, FL - - - if selected and not available.

E. Displayed Altitude Band

ABOVE/BELOW.

Blank if NORMAL band.

F. TCAS Status Mode

TA/RA.

TA ONLY.

TEST.

NO TCAS.

G. Traffic Behind

TA BEHIND.

RA BEHIND.

Traffic Advisory/Vertical Speed Indicator

The TA/VSI is a combined VSI and traffic display. The traffic display uses both color and shape to show other aircraft and to differentiate conflicting traffic. The traffic display will be operational whenever TCAS is turned on or whenever system power is lost and regained. If the standard VSI display is selected and an advisory causes the traffic display to pop up, the TA SELECT button must be pressed to return to the standard VSI display. The traffic display will not automatically return to the standard VSI display after the advisory has terminated.

The display is fixed in range, showing traffic 6.5 miles in front of an aircraft symbol representing current position. A two mile range ring surrounds the aircraft symbol. Ranges to the side and behind are to scale.

Each instrument has two bezel mounted controls. Display lighting is normally controlled by an ambient light sensor; minor pilot adjustment can be made with the BRT knob. The TA SEL push button is provided for manual cancellation of the TCAS traffic display.

[illegible]

- If TCAS is momentarily unable to obtain bearing information, a traffic symbol will not be displayed. Instead, data will be shown in the lower portion of the display to indicate range, relative altitude, vertical rate arrow, and whether this traffic is causing a TA or RA (1.2 nm/-06 is traffic 1.2 nm away and 600 feet below). If yellow, a TA is indicated. If red, a RA is indicated.

TA/VSI Resolution Advisory Indications

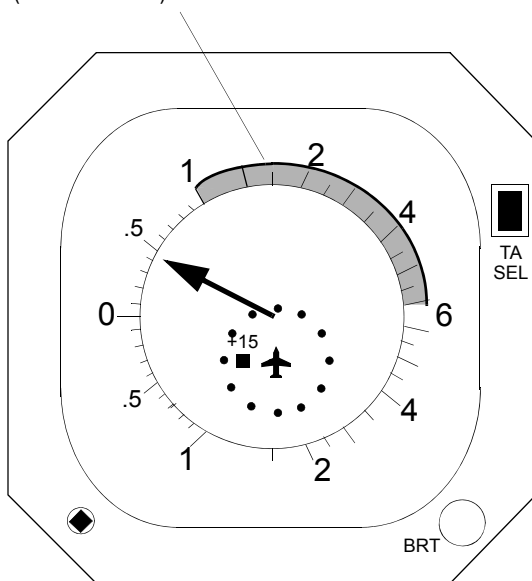
RAs provide vertical rate information to ensure approximately 500 feet vertical separation from all altitude reporting transponder equipped aircraft. Colored bands are presented outside the TA/VSI vertical rate scale. These arcs identify vertical rates which provide safe altitude separation.

Vertical Speed Restricted RA Indication (With Traffic Above)

Red Vertical Speed Arc - A preventive RA will restrict an area of vertical rate. In this situation, TCAS has computed the altitude separation from conflicting traffic to be less than IFR requirements but not within near miss criteria. TCAS will display a red arc on the TA/VSI restricting vertical rate. Vertical rates not restricted by red arcs or green arcs may be flown and separation will be adequate.

“MONITOR VERTICAL SPEED”

RED (RESTRICTED) VERTICAL SPEED ARC

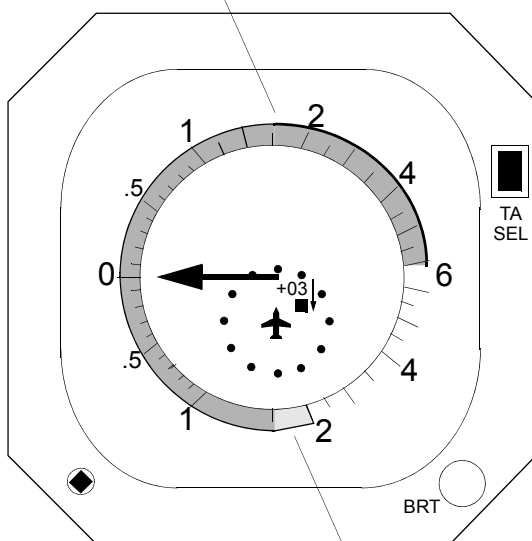


Descend RA Indication (With Traffic Above Descending)

When a RA requires pilot action, a small green arc referred to as a (fly-to) area is displayed along with the red arc. This is known as a corrective RA. The green arc identifies the vertical rate to be flown. Pilots should respond with prompt and positive control inputs to attain the commanded vertical rate within five seconds.

“DESCEND, DESCEND”

RED (RESTRICTED) VERTICAL SPEED ARC



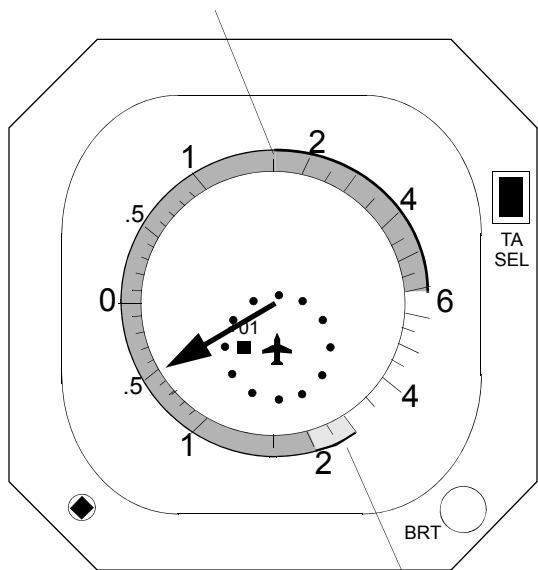
GREEN (FLY-TO) ARC

Increase Descent RA Indication (With Traffic Above)

TCAS can increase, decrease, or reverse direction of the recommended vertical speed. TCAS updates RA information during a traffic conflict. Red arcs are capable throughout the entire vertical speed range. Green (fly-to) arcs can be displayed as high as 3,000 fpm climb or as low as 3,000 fpm descent. Any update of the displayed RA will be accompanied by an aural advisory. TCAS expects prompt adjustment of pitch attitude to keep aircraft vertical rate in the updated green (fly-to) region on the outer ring of the TA/VSI vertical rate scale.

“INCREASE DESCENT”

RED (RESTRICTED) VERTICAL SPEED ARC

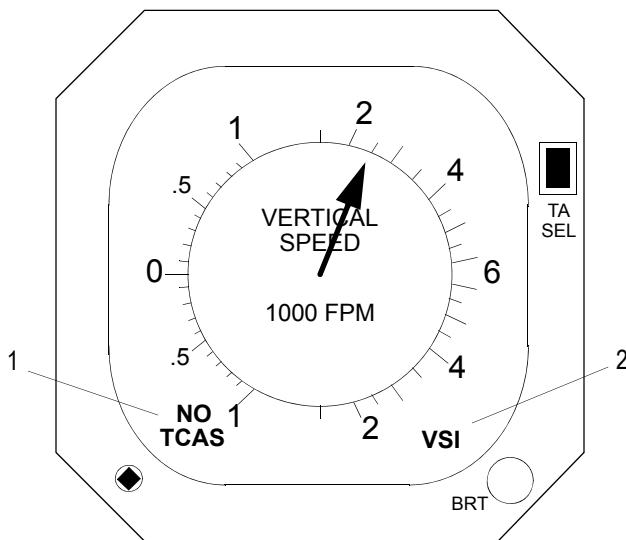


GREEN (FLY-TO) ARC

TCAS Failure

If the TCAS fails, the annunciation NO TCAS in yellow will appear in the lower left corner of the TA/VSI. If the TCAS has been disabled because switch position or an individual TA/VSI will not display TCAS information, NO TCAS is annunciated in blue.

“MONITOR VERTICAL SPEED”



1. TCAS Annunciation Area - Left corner

NO TCAS

- Blue - TCAS mode not selected or individual TA/VSI malfunction.
- Yellow - TCAS failure.

TA only

- Blue - Transponder in TA position.
- Yellow - Traffic advisory in progress. No resolution advisory possible.

2. VSI Annunciation Area - Right corner

VSI

- Yellow - Vertical speed has failed.

Ground Proximity Warning System

The ground proximity warning system (GPWS) interfaces with the radio altimeter, CADC, landing gear switch, VOR/LOC/GS receiver, and flap position switch. The system utilizes radio altitude, vertical speed, Mach, DH, and glide slope deviation information to determine adverse proximity to the ground.

The GPWS alerts the crew when any one of the following occurs:

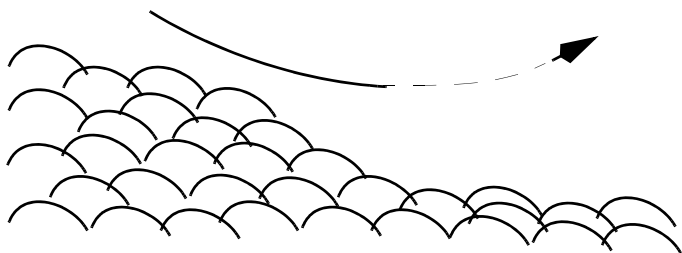
- Excessive descent rate.
- Excessive terrain closure rate.
- Altitude loss after takeoff or go-around.
- Unsafe altitude while not in the landing configuration.
- Descent below glide slope.

The GPWS computer provides a vocal annunciation, "MINIMUMS-MINIMUMS", whenever the airplane passes through the selected DH as set by the Captain's DH "bug" (between 1,000 feet to 50 feet). To help prevent high sink rates at low altitudes and aid pilots with runway closure rate, advisory altitude callouts are also heard every 10 feet from 50 feet RA through 10 feet RA (not installed on all aircraft).

Descent below decision altitude. BELOW G/S warning lights, located on the Captain's and First Officer's instrument panels, illuminate accompanied by aural/vocal annunciation to advise the crew of adverse proximity to the ground.

***NOTE:** The "MINIMUMS, MINIMUMS" vocal is inhibited below 50 ±15 feet. Consequently, when the DH is set to 50 feet, the "MINIMUMS" vocal may be heard only once or not at all. This has no effect on the DH light which has a much closer tolerance.*

Mode - 1 Excessive Descent Rate

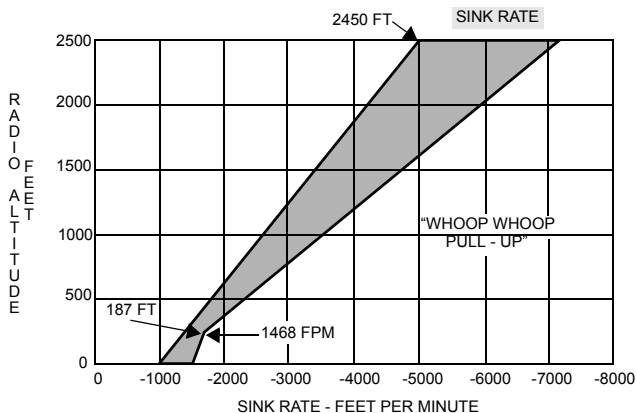


Visual Indication

- GPWS light illuminated.

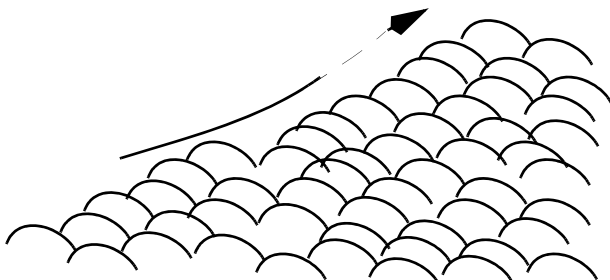
Aural/vocal annunciation:

- "SINK RATE, SINK RATE".
- "WHOOOP WHOOOP - PULL UP" (continuous).



This mode indicates the rate of descent for a given altitude is excessive, and the condition should be corrected. Any excessive rate (barometric altitude) below 2,450 feet radio altitude actuates an aural/vocal annunciation. The mode is independent of aircraft configuration and is functional to within 50 feet of terrain.

Mode - 2 Excessive Terrain Closure Rate



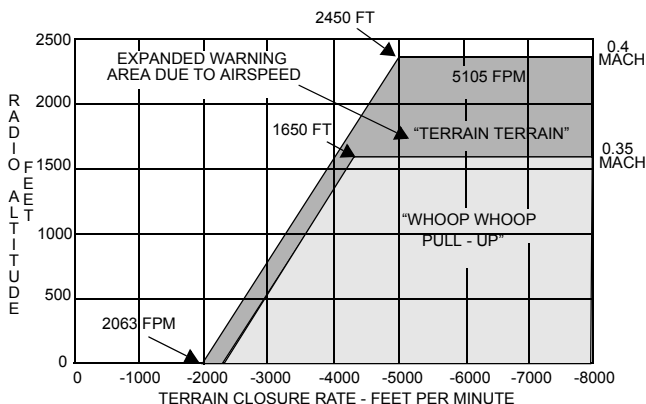
Visual Indication

- GPWS light illuminated.

Aural/vocal annunciation:

- “TERRAIN - TERRAIN” (Rapid succession).
- “WHOOH WHOOP - PULL UP”.
- “TERRAIN - TERRAIN” will be activated first. If rate of descent continues or increases, “WHOOH”

Aircraft no in Landing Configuration



After closure continuation ceases, “PULL UP” vocal has stopped, a barometric altitude gain of 300 feet is required before the “TERRAIN” vocal (repeated in 0.75 second cycle) is shut off. During an approach, when gear or flaps are extended, the altitude gain function is inhibited, and the “PULL UP” vocal is replaced by “TERRAIN”.

Mode - 3 Altitude Loss After Takeoff

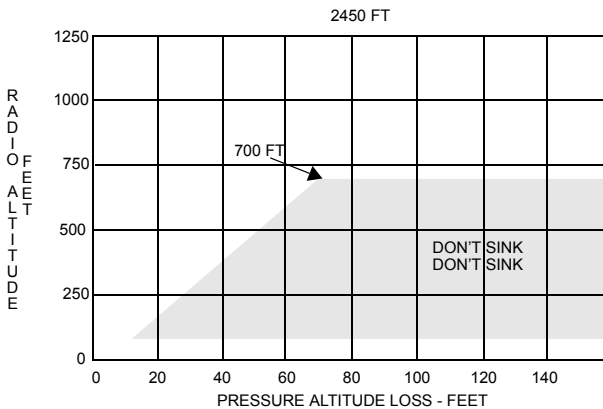


Visual Indication

- GPWS light illuminated.

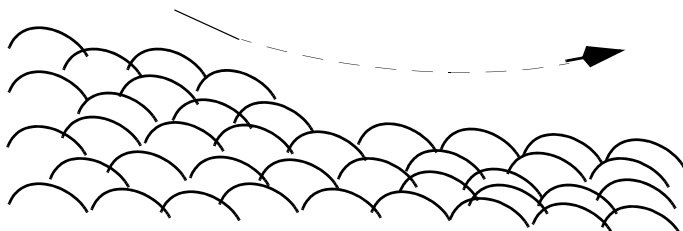
Aural/vocal annunciation:

- **DON'T SINK, DON'T SINK"**
 (repeated until positive rate of climb is established.)
- **"DON'T SINK"** vocal repeats until positive rate of climb established. At that point, the warning stops but GPWS computer continues to compare aircraft barometric altitude to the altitude of initial descent.



If aircraft should descend again before climbing to initial altitude, another warning will be generated based on original altitude. The warning threshold is when 10% (approx.) of the initial descent altitude has been lost. This mode is active from 50 feet to 700 feet AGL during takeoff or when either flaps or gear is raised during a missed approach from below 500 feet AGL. Above 700 feet, the GPWS computer automatically switches to TERRAIN CLEARANCE mode.

Mode - 4A Terrain Clearance (Descent In Wrong Configuration - Gear Up)

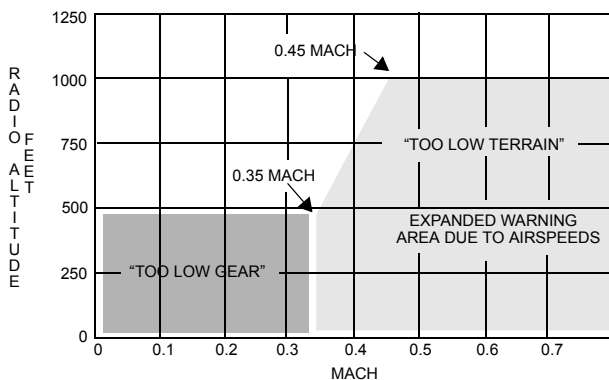


Visual Indication

- GPWS light illuminated.

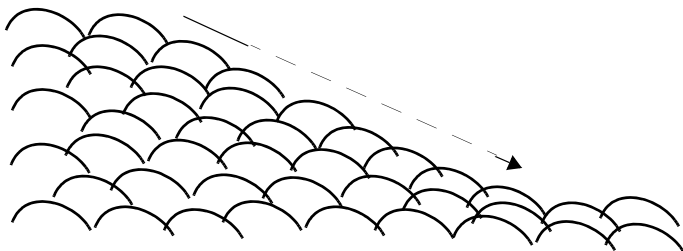
Aural/vocal annunciation:

- "TOO LOW GEAR" (repeated).
- "TOO LOW TERRAIN" (repeated).



This mode is activated upon clearing 700 feet AGL after takeoff. Below 0.35 Mach, "TOO LOW GEAR" is announced. Above 0.35 Mach, "TOO LOW TERRAIN" is announced. Warning is inhibited below 50 feet and reverts to mode 3 (with both gear and flaps down).

Mode - 4B Terrain Clearance (Descent in Wrong Configuration - Gear Down, Flaps Not in Landing Configuration).



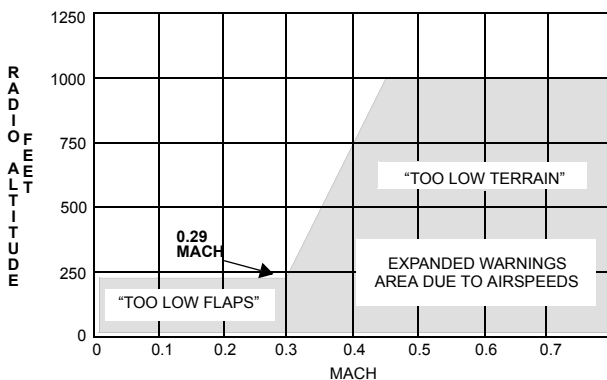
Visual Indication

- GPWS light illuminated.

Aural/vocal annunciation:

- "TOO LOW FLAPS" (repeated).
- "TOO LOW TERRAIN" (repeated).

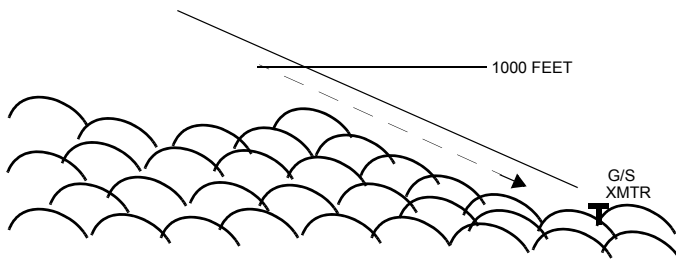
Proximity to Terrain - Flaps Up



This mode is activated upon clearing 700 feet AGL after takeoff. Below 0.29 Mach, with the flaps not extended for landing, "TOO LOW FLAPS" is annunciated.

Above 0.29 Mach, "TOO LOW TERRAIN" is announced. If gear is extended and then retracted, "TOO LOW GEAR" will be announced at 200 feet AGL if still retracted. Warning is inhibited below 50 feet and reverts to Mode 3 (with both gear and flaps down).

Mode - 5 Descent Below Glide Slope



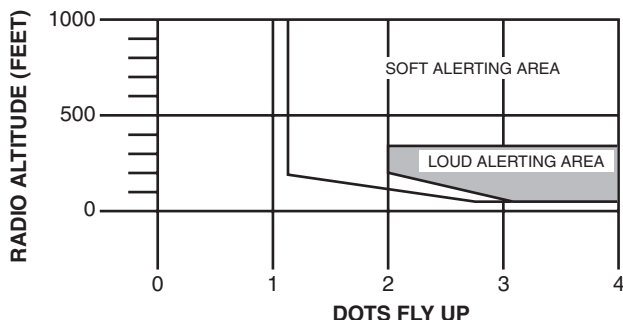
Visual Indication

- BELOW G/S light illuminated.

Aural/vocal annunciation:

- "GLIDESLOPE"

This mode warns of excessive low ILS glide slope deviation when the aircraft is below 1,000 feet radio altitude and a valid ILS frequency is received.



When the glide slope advisory region is penetrated, a soft warning is given by illumination of the BELOW G/S light and voice annunciation "GLIDE SLOPE". As the altitude is decreased and the DOTS "FLY UP" glide slope deviation is increased, the glide slope voice warning audio output level and repeat rate will increase.

Mode 6 - Descent Below Decision Height

To help prevent high sink rates at low altitudes and aid pilots with runway closure rate, advisory altitude callouts are also heard every 10 feet from 50 feet RA through 10 feet RA (not installed on all aircraft)

This mode warns of descent below DH (between radio altitude 1,000 feet and 50 feet), landing gear down. "MINIMUMS, MINIMUMS" sounded.

NOTE: NOTE: The "MINIMUMS, MINIMUMS" vocal is inhibited below 50 ± 15 feet. Consequently, when the DH is set to 50 feet, the "MINIMUMS" vocal may be heard only once or not at all. This has no effect on the DH light which has a much closer tolerance.

Enhanced Ground Proximity Warning System (Look-ahead Terrain Alerting)

The EGPWS terrain database contains detailed terrain data near major airports, and data in lesser detail for areas between airports. Terrain within 2,000 feet of airplane barometric altitude show on the navigation display. The terrain data is not designed to be an independent navigation aid.

NOTE: The EGPWS terrain database, look-ahead alerting, and terrain display do not account for man-made obstructions.

The terrain display is generated from a database contained in the EGPWS computer and correlated to FMS position.

NOTE: FMS position error may compromise terrain display and separation.

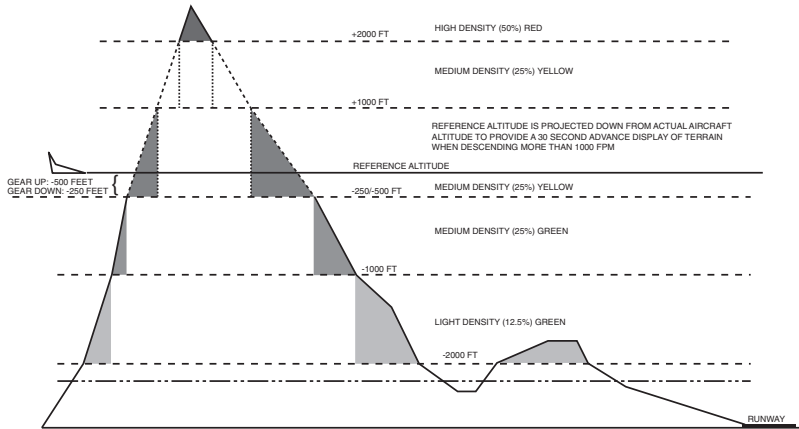
Color and density vary based on terrain height vs. airplane altitude.

- Magenta - No terrain data available.
- Dotted Green - Terrain from 2,000 feet below to 500 feet below (250 feet with gear down) the airplane's current altitude.
- Dotted Amber - Terrain 500 feet below (250 feet with gear down) to 2,000 feet above airplane's current altitude.
- Dotted Red - Terrain more than 2,000 feet above airplane's current altitude.
- Solid Amber - Caution terrain (approximately 60 seconds from impact).
- Solid Red - Warning terrain (approximately 30 seconds from impact).

This terrain display automatically shows when a look ahead terrain alert occurs, and neither pilot has the terrain display selected. The terrain display updates with a display sweep, similar to the weather radar display.

In areas without terrain data, look ahead terrain alerting and display functions are not available. Radio altitude based terrain alerts will function normally. Terrain more than 2,000 feet below airplane altitude or within 400 feet of the nearest airport runway elevation is not displayed.

Terrain Display



Reactive Windshear System

General

The aircraft must enter an actual windshear area before the system can provide any windshear alerts. The windshear alerting and guidance system provides detection, alerting, and guidance through hazardous windshear. The windshear computer receives attitude, acceleration, and other data from the DFGC, CADC, FD and stall warning computers. The windshear computer also interfaces with the central aural warning system (CAWS) for aural/vocal windshear alerts.

Indications

When the windshear computer detects a windshear condition, it provides both aural and visual cockpit alerts. A red windshear warning (decreasing performance), or an amber windshear caution (increasing performance), is displayed on both the glareshield and PFD. The FMA will display windshear annunciations. During a decreasing performance windshear the windshear computer also enables the CAWS to generate a warning tone and the vocal warning "WINDSHEAR".

During windshear guidance, the PFD fast/slow (F/S) display indicates relative angle of attack (Alpha). The center mark represents the DFGC determined Alpha equivalent of either the takeoff or go-around reference speeds, the F denotes $V_{ref} + 20$, while the S denotes stickshaker.

Under certain specific conditions, the post stall recovery system (stick pusher), ground proximity warning system (GPWS), and the traffic alert and collision avoidance system (TCAS) will be inhibited during windshear guidance.

Guidance

The F/D will provide guidance commands on the PFD for windshear encounters during takeoff (after nose strut extension), approach, and go-around. The pitch limit indicator (PLI) provides a visual indication of energy by showing the difference between the aircraft angle of attack and the stick shaker angle of attack. The PLI will be displayed on the PFD anytime the slats are extended or the aircraft is at or below 1500 feet AGL. The PLI display intensity will increase after windshear detection.

When a decreasing performance windshear is detected, and sufficient energy is available, the F/D provides pitch guidance to achieve and maintain a positive energy conserving flight path of 1.5 degrees. Above 450 feet radio altitude, a zero or slightly descending flight path may be commanded to conserve energy. Below 450 feet radio altimeter, and unable to maintain a positive flight path, the windshear computer will command up to stick shaker angle of attack. A loss of altitude will occur as necessary in order to prevent a stall.

When an increasing performance windshear is detected and guidance is active, the windshear computer provides an energy absorbing positive flight path. The windshear computer will command a flight path of 1.5 degrees until the aircraft reaches an energy level of $V_2 + 30$ KIAS on takeoff or $V_{ref} + 20$ KIAS on the go-around.

Windshear During Takeoff Roll

Indications

Windshear indications are inhibited until nose gear extension.

Guidance

Windshear guidance is inhibited until nose gear extension.

Autothrottles

Autothrottles remain in CLMP until nose gear extension, then disengage immediately after the windshear computer guidance is activated.

Windshear During Takeoff After Nose Gear Extension

Indications

Increasing Performance - Windshear alerts display amber "WINDSHEAR" on both the PFD and glareshield. There is NO aural warning.

Decreasing performance - Windshear alerts display red "WINDSHEAR" on both the PFD and glareshield. The CAWS activates an aural warning tone and three cycles of "WINDSHEAR".

Guidance

Increasing performance - When "WIND SHR" is displayed on the FMA pitch window, pitch guidance is available through the autopilot and/or F/D. "WIND SHR" will flash five times on the FMA and then become steady. The roll window will remain unchanged.

Decreasing performance - When "WIND SHR" is displayed on the FMA pitch window, pitch guidance is available through the autopilot and/or F/D. "WIND SHR" will flash five times on the FMA and then become steady. In addition, windshear roll guidance (wings level) will be provided on the F/D and "HDG HLD" will be displayed on the FMA.

Autothrottles

Increasing and Decreasing performance - Immediately after the windshear computer guidance is activated the autothrottles will disconnect and the Automatic Reserve Thrust (ART), if armed, will fire. For a FLEX takeoff, the autothrottles will disconnect and the EPR bugs will move to maximum takeoff.

Windshear On Approach Or Landing

Indications

Increasing Performance - Windshear alerts display amber "WINDSHEAR" on both the PFD and glareshield. There is NO aural warning.

Decreasing performance - Windshear alerts display red "WINDSHEAR" on both the PFD and glareshield. The CAWS activates an aural warning tone and three cycles of "WINDSHEAR".

Guidance

Increasing performance - Guidance is not activated during the approach mode unless the TOGA button is pressed or either engine EPR is within 95% of the maximum go-around EPR limit. With TOGA selected, or power at 95% of the maximum go-around EPR limit, windshear guidance is available through the autopilot and/or F/D.

When "WIND SHR" is displayed on the FMA pitch window, pitch guidance is available through the autopilot and/or F/D. "WIND SHR" will flash five times on the FMA and then become steady. The roll window will remain unchanged.

Decreasing performance - Guidance is not activated during the approach mode unless the TOGA button is pressed or either engine EPR is within 95% of the maximum go-around EPR limit. With TOGA selected, or power at 95% of the maximum go-around EPR limit, windshear guidance is available through the autopilot and/or F/D.

When "WIND SHR" is displayed on the FMA pitch window, pitch guidance is available through the autopilot and/or F/D. "WIND SHR" will flash five times on the FMA and then become steady. Windshear roll guidance (wings level) will be provided on the F/D and "HDG HLD" will be displayed on the FMA.

Autothrottles

Increasing and Decreasing performance - Immediately after the windshear computer guidance is activated the autothrottles will disconnect.

Windshear Guidance Reversion

When the windshear condition no longer exists all windshear detection annunciation cease. Windshear pitch and roll guidance will continue until safe conditions exist. Pitch and roll guidance will revert to the original FMA mode when safe conditions are received for 15 seconds with normal guidance and 30 seconds with pop-up guidance. Safe conditions are defined as a minimum rate of climb of 750 fpm, and airspeed greater than $V_{ref} - 5$.

During windshear guidance, the pilot may remove guidance commands by selecting a non-TO/GA pitch mode on the Digital Flight Guidance Control Panel. Windshear guidance may be reselected by pressing either TO/GA switch.

Windshear Pop-up Guidance

During takeoff, approach, and go-around if the windshear computer detects a windshear with the flight directors selected off, windshear guidance is still available by either pushing TOGA, or by advancing throttles to at least 95% of go-around thrust.

Windshear Test

The windshear test is initiated by moving the WNDSHR TEST switch to TEST.

Windshear Fail Light

The windshear computer is continuously self-monitoring. When failures are detected by the windshear computer that will prevent detection or guidance, W/S FAIL is presented on the PFD and WINDSHEAR INOP is annunciated on the overhead annunciator panel.

Predictive Windshear System

General

The weather radar uses radar imaging to detect disturbed air prior to entering a windshear.

***NOTE:** The weather radar provides windshear alerts for windshear events containing some level of moisture or particulate matter.*

***NOTE:** The weather radar detects microbursts and other windshears with similar characteristics. The weather radar does not provide alerting for all types of windshear. The flight crew must continue to rely on traditional windshear avoidance methods.*

The PWS automatically begins scanning for windshear on the ground when:

- The right throttle is set for takeoff.

***CAUTION:** Advancement of the right throttle beyond 2 1/8 units (approximately 80% N1) will activate PWS on the ground.*

- One engine is running.

The PWS automatically begins scanning for windshear in the air when:

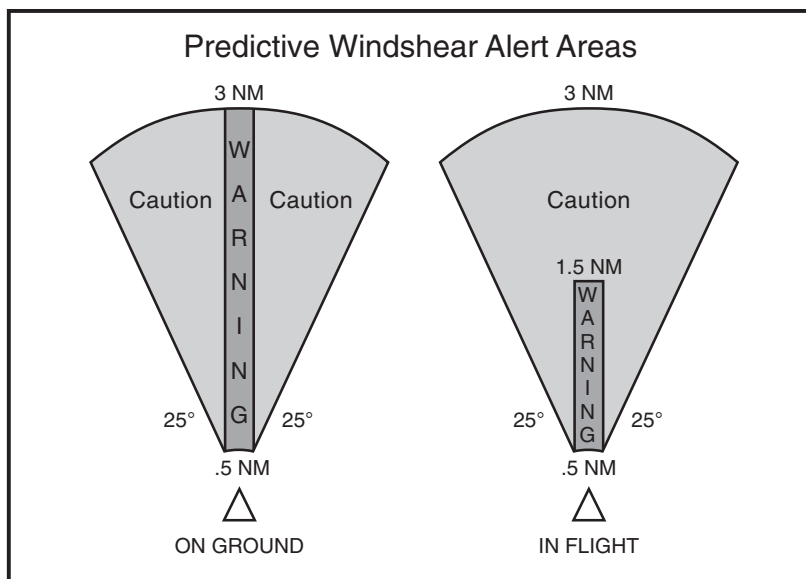
- Below 2,300 feet RA (predictive windshear alerts are issued below 1,200 feet RA).

Alerts are available approximately 12 seconds after the weather radar begins scanning for windshear. Below 2,300 feet RA windshear operations use an alternate scan technique for radar and windshear detection. Windshear operation is transparent to the crew unless an alert is issued, however crews may notice that the radar update rate could be delayed by as much as 12 seconds due to sharing of processing between windshear and radar.

***NOTE:** If radar is in a non weather mode (OFF or TCAS only mode), the reaction time is greatly reduced.*

PWS is active regardless of weather radar switch position on the Weather Radar Indicator. The crew is alerted by way of annunciation and audio announcement.

There are two different types of Predictive Windshear Alerts: CAUTIONS and WARNINGS. The determination of the alert level given depends simply on the position of the detected windshear relative to the aircraft position. A PWS CAUTION does not imply a lower-intensity windshear than a WARNING, rather that the windshear is in an area that is not an immediate threat to the aircraft flight path thus allowing more time for the flight crews to respond.



Predictive Windshear Alert Inhibits

During takeoff and landing, new predictive windshear caution alerts are inhibited between 80 knots and 400 feet RA, and new warning alerts between 100 knots and 50 feet RA. These inhibits do not remove existing predictive windshear alerts.

Predictive Windshear System Test

The PWS system test is incorporated with the radar system test. It is initiated by moving the mode selector on the radar system control panel to TEST. The PWS system test is inhibited in the air.

Intentionally
Blank

OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

CAWS FAIL (MISC) - Indicates central aural warning system has failed.

GPWS FAIL (MISC) - Indicates ground proximity warning system is inoperative.

STALL IND FAILURE (MISC) - Indicates any system channel is inoperative or malfunctioning or post stall pusher system is shut off by pushing stick pusher PUSH TO INHIBIT light or by reduction in G forces.

WINDSHEAR INOP (MISC) - Indicates windshear detection and guidance not available and PFD-PLI not displayed.

Intentionally
Blank

System Description

Windshear

Predictive Windshear not installed.

OAP Messages/Lights

Amber Caution Messages

NOTE: The associated cue light is shown in parenthesis (XXX) following the message.

MWCC FAULT (MISC) - Indicates overhead annunciator panel internal fault.

TAKEOFF WARNING FAIL (MISC) - Indicates takeoff warning not available when both throttles advanced for takeoff and FLAP/SLAT handle not in agreement with value set in flap/CG windows or HORIZ STAB not set in green band or slats not extended or spoiler handle not in RETRACT detent or parking brake is set, or autobrakes and autospoilers not both armed or disarmed.

Intentionally
Blank