



MD-88/90 Flight Crew Training Manual FCTM Delta Air Lines, Inc.

REVIEWED BY:

Chris Manley

Chris Manley

MD-88/90 - Technical Manager

APPROVED BY:

Randall K. Flowers

Randall K. Flowers

MD-88/90 - Chief Line Check Pilot

APPROVED BY:

Jim Reese

Jim Reese

MD-88/90 - Fleet Captain

Revision Number: 5

Revision Date: June 2, 2008

©2008 Delta Air Lines, Inc.

Preface

Chapter PT

Table of Contents

Section 0

Flight Crew Training Manual.	Chapter
Preface	PT
Table of Contents	PT.0
Model Identification	PT.1
Introduction	PT.2
Abbreviations	PT.3
Revision Record / Highlights	PT.4
List of Effective Pages	PT.5
General Information	1
Taxi, Takeoff, Initial Climb	2
Climb, Cruise, and Descent	3
Holding, Approach, and Landing	4
Maneuvers	5
Non-Normal Operations	6

Intentionally
Blank

Preface
Model Identification

Chapter PT
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.

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

Airplane Number	Registry Number	Serial Number	Model Miscellaneous Data
0901	N901DL	49532	MD-88
0902	N902DL	49533	MD-88
0903	N903DL	49534	MD-88
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
0918	N918DL	49583	MD-88
0919	N919DL	49584	MD-88
0920	N920DL	49644	MD-88

Airplane Number	Registry Number	Serial Number	Model Miscellaneous Data
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
0946	N946DL	49819	MD-88
0947	N947DL	49878	MD-88
0948	N948DL	49879	MD-88

▲ Delta
MD-88/90 Flight Crew Training Manual

**Preface -
Model Identification**

Airplane Number	Registry Number	Serial Number	Model Miscellaneous Data
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
0974	N974DL	53242	MD-88
0975	N975DL	53243	MD-88
0976	N976DL	53257	MD-88

Airplane Number	Registry Number	Serial Number	Model Miscellaneous Data
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
9002	N902DE	53379	MD-88
9003	N903DE	53380	MD-88
9004	N904DE	53409	MD-88

▲ Delta
MD-88/90 Flight Crew Training Manual

**Preface -
Model Identification**

Airplane Number	Registry Number	Serial Number	Model Miscellaneous Data
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
9210	N910DN	53390	MD-90-30
9211	N911DA	53391	MD-90-30
9212	N912DN	53392	MD-90-30

Airplane Number	Registry Number	Serial Number	Model Miscellaneous Data
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 PT

Section 2

General

The Flight Crew Training Manual provides information and recommendations on maneuvers and techniques. The manual is divided into six chapters: General Information; Taxi, Takeoff and Initial Climb; Climb, Cruise and Descent; Holding, Approach, and Landing; Maneuvers; and Non-Normal Operations.

General Information covers procedures and techniques not associated with a particular maneuver. The Taxi, Takeoff, and Initial Climb chapter covers the procedures and techniques for taxi and takeoff through initial climb. The Climb, Cruise, and Descent chapter covers procedures and techniques for use during climb, cruise, and descent. The Holding, Approach, and Landing chapter covers holding, instrument and visual approaches and landings. The Maneuvers chapter covers maneuvers associated with climb, cruise, and descent, i.e., stall recovery and emergency descent. The Non-Normal Procedures chapter covers non-normal situations that may occur during any phase of flight. Each of the chapters has a preface which describes the chapter in more detail.

Manual Rights

The MD-88/90 Flight Crew Training Manual has been prepared for the exclusive use of Delta Air Lines, Inc. Flight Operations personnel under the direction and authority of Delta and shall, at all times, remain the property of Delta. The holder hereof acknowledges and agrees that this manual contains or may contain trade secrets, copyrighted material and commercial and proprietary information, privileged and confidential, to the interest of Delta, and the holder hereof further agrees that this manual may not be reproduced, distributed or copied, in whole or in part, without the express prior written consent of Delta Air Lines, Inc.

- In the event this MD-88/90 Flight Crew Training Manual is sold or distributed to any other party, no warranty or guarantee, expressed or implied, is made as to the accuracy, sufficiency or suitability of the materials contained herein or of any revision, supplement or bulletin hereto. It is understood and agreed to by such other party that it shall release indemnify and hold Delta Air Lines, Inc., its officers, employees and agents harmless against any and all claims or actions of whatever nature which may arise or claim to arise from the use hereof.

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://dalweb.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 Operation Manuals are 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, bulletins and normal checklist introduction.
- 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.

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 Flight Crew Training Manual uses a decimal page numbering system. While the other manuals use a three-field number system, the Flight Crew Training Manual page number is divided into two fields; chapter and page. An example of a page number for the HOLDING, APPROACH, LANDING chapter follows: chapter 4, page 3.

Example Page Number

Chapter (HOLDING,
APPROACH, LANDING)

4.3

Page Number

Warnings, Cautions, and Notes

The following levels of written advisories are used throughout the manual and are not to be confused with OAP messages, which are separately identified in the text.

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.

Intentionally
Blank

Preface

Abbreviations

Chapter PT

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

MD-88/90 Flight Crew Training Manual

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
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
C	

▲ DELTA
MD-88/90 Flight Crew Training Manual

**Preface -
Abbreviations**

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
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
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
F	
F	Fahrenheit
FAC	Final Approach Course

▲ DELTA
MD-88/90 Flight Crew Training Manual

**Preface -
Abbreviations**

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	GPS Landing System
GMT	Greenwich Mean Time
GND	Ground
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
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	Instrument Approach Navigation
IAS	Indicated Airspeed
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	Intergrated Standby Flight Display
ISLN	Isolation
J	
JAA	Joint Aviation Authority
K	
K or KTS	Knots
KCAS	Knots Calibrated Airspeed
KGS	Kilograms
KIAS	Knots Indicated Airspeed
L	
L	Left
LAT	Latitude

▲ DELTA
MD-88/90 Flight Crew Training Manual

**Preface -
Abbreviations**

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 DSWY or LWR DSWL	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
MLS	Microwave Landing System
MM	Middle Marker
MMO	Maximum Mach Operating Speed
MNPS	Minimum Navigation Performance Specification
MOCA	Minimum Obstruction Clearance Altitude
MOD	Modify

MD-88/90 Flight Crew Training Manual

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	
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
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
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	
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
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

▲ DELTA
MD-88/90 Flight Crew Training Manual

**Preface -
Abbreviations**

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
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
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 PT
Section 4

Revision Notification Transmittal Letter

To: All holders of Delta Air Lines, Inc. MD-88/90 Flight Crew Training Manual.

Subject: Flight Crew Training 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	October 16, 2006	
4	March 10, 2008	

No.	Revision Date	Date Filed
1	May 17, 2004	
3	November 27, 2006	
5	June 2, 2008	

General

Delta Air Lines issues operations manual revisions to provide new or revised procedures and information. Formal revisions also incorporate appropriate information from previously issued Flight Crew 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 (PT.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. Using the List of Effective Pages determines the correct content of the manual.

Revision Highlights

This section (PT.4) replaces the existing section 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 revision are identified only by a new page date.

Title Page

Front Cover - Changed Revision number and date.

Chapter PT - Preface

Section 4 - Revision Record

Revision Highlights

PT.4.1-4 - Explanations for each item identified by a change bar in the latest revision.

Section 5 - List of Effective Pages

List of Effective Pages

PT.5.1-2 - Reflects current pages for latest revision.

Chapter 1- General Information

Callouts

1.16 - Under Standard Phraseology, Normal Takeoff with level off below 2500' AFE without VNAV, removed Note to preset speed command bug to clean maneuver speed because it conflicted with guidance on page 1.10 to set the command speed to V2.

Chapter 3- Climb, Cruise, Descent

Table of Contents

3.TOC.0.1-.2 - Revised TOC to reflect content changes in this revision.

Climb

3.1 - Repagination.

3.2 - Under Low Altitude Level Off Without VNAV, revised "If ATL CAP occurs prior to selection of CLB thrust," statement for clarity.

3.2 - Under Low Altitude Level Off Without VNAV, revised setting the command speed bug from "desired speed" to "clean speed."

3.2 - Added new section, “Low Altitude Level Off With VNAV.”

3.3 - Repagination.

Chapter 4- Holding, Approach, Landing

Landing Configurations and Speeds

4.66 - Revised guidance to emphasize flaps 28 as the normal landing flap configuration.



MD-88/90 Flight Crew Training Manual

Preface

Chapter PT

List of Effective Pages - FAA Approved

Section 5

Page	Date
FCTM	
* Title Page	June 2, 2008
Preface (tab)	
PT.0.1-2	October 16, 2006
PT.1.1-6	April 01, 2004
PT.2.1-2	March 10, 2008
PT.2.3-4	April 01, 2004
PT.3.1-12	March 10, 2008
* PT.4.1-4	June 2, 2008
* PT.4.5-10	Deleted
* PT.5.1-2	June 2, 2008
1 General Information (tab)	
1.TOC.0.1-2	October 16, 2006
1.1	March 10, 2008
1.2-4	October 16, 2006
1.5-11	March 10, 2008
1.12-15	October 16, 2006
* 1.16	June 2, 2008
1.17-19	March 10, 2008
1.20-22	October 16, 2006
1.23	November 27, 2006
1.24	October 16, 2006
1.25	March 10, 2008
1.26	October 16, 2006
1.27	March 10, 2008
1.28	October 16, 2006

Page	Date
2 Taxi, Takeoff, Initial Climb (tab)	
2.TOC.0.1-4	March 10, 2008
2.1-6	March 10, 2008
2.7-11	October 16, 2006
2.12	March 10, 2008
2.13-16	October 16, 2006
2.17-42	March 10, 2008
3 Climb, Cruise, Descent (tab)	
* 3.TOC.0.1-2	June 2, 2008
* 3.1-3	June 2, 2008
3.4	March 10, 2008
3.5-7	October 16, 2006
3.8-21	March 10, 2008
3.22	October 16, 2006
3.23	March 10, 2008
3.24	October 16, 2006
3.25	March 10, 2008
3.26	October 16, 2006

* = Revised, Added, or Deleted



Page	Date	Page	Date
4 Holding, Approach, Landing (tab)		5 Maneuvers (tab)	
4.TOC.0.1-2	March 10, 2008	5.TOC.0.1-2	March 10, 2008
4.TOC.0.3-4	October 16, 2006	5.1-14	October 16, 2006
4.1-3	March 10, 2008	5.15	March 10, 2008
4.4-7	October 16, 2006	5.16-22	October 16, 2006
4.8	March 10, 2008	5.23	March 10, 2008
4.9-20	October 16, 2006	5.24-32	October 16, 2006
4.21	March 10, 2008	6 Non-Normal Operations (tab)	
4.22-25	October 16, 2006	6.TOC.0.1-4	October 16, 2006
4.26-27	March 10, 2008	6.1	April 01, 2004
4.28	October 16, 2006	6.2	October 16, 2006
4.29	March 10, 2008	6.3	March 10, 2008
4.30-38	October 16, 2006	6.4-6	October 16, 2006
4.39	March 10, 2008	6.7	March 10, 2008
4.40-54	October 16, 2006	6.8-12	October 16, 2006
4.55	March 10, 2008	6.13	March 10, 2008
4.56-59	October 16, 2006	6.14-16	October 16, 2006
4.60	March 10, 2008	6.17	March 10, 2008
4.61	October 16, 2006	6.18-19	October 16, 2006
4.62	March 10, 2008	6.20	March 10, 2008
4.63	October 16, 2006	6.21-32	October 16, 2006
4.64	March 10, 2008	6.33	March 10, 2008
4.65	October 16, 2006	6.34	October 16, 2006
* 4.66	June 2, 2008	Index (tab)	
4.67-77	October 16, 2006	Index.1-12	March 10, 2008
4.78	March 10, 2008		
4.79-89	October 16, 2006		
4.90	March 10, 2008		
4.91-96	October 16, 2006		

* = Revised, Added, or Deleted

General Information

Chapter 1

Table of Contents

Section 0

Preface	1.1
Operational Philosophy.....	1.1
Events Requiring Maintenance Inspection	1.2
Pilot Area of Responsibility	1.2
Training Objectives	1.2
Qualification Requirements (Checkride)	1.3
Evaluation	1.3
Crew Resource Management (CRM).....	1.3
Headsets/Boom Microphones	1.4
Flap Usage	1.5
Flap - Speed Schedule/Maneuvering Speeds	1.5
Limit Speeds	1.6
Flap Operation.....	1.7
Command Speed	1.8
Takeoff	1.8
Climb, Cruise and Descent	1.8
Approach.....	1.8
Landing	1.8
Non-Normal Conditions	1.9

Reference Bugs	1.10
Bug Setting (MASI)	1.10
Fast/Slow Display Use	1.11
Callouts	1.13
Standard Callouts	1.13
Standard Phraseology	1.14
Cold Temperature Altitude Corrections	1.20
Operation in Icing Conditions	1.21
Recommended Rudder Trim Technique	1.22
Drag Factors Due to Trim Technique	1.22
Primary Trim Procedure	1.22
Alternate Trim Technique	1.23
Flight Management Computer(s)/MCDUs	1.24
FMC Route Verification Techniques	1.24
FMC Performance Prediction - Non-Normal Configuration.	1.24
Weather Radar and Terrain Display Policy	1.25
DFGS Procedures	1.26
Autothrottle Use	1.26
Manual Flight	1.26
Automatic Flight	1.26
Turbulent Air Penetration	1.28

Preface

This chapter outlines Delta operational policies used during training. Recommended procedures for Crew Coordination, Flap/Speed Schedule, Thrust Management, Turbulent Air Penetration, and Crew Resource Management are covered. This provides a basis for standardization. Conditions beyond the control of the flight crew may preclude following a maneuver exactly. The maneuvers are not intended to replace good judgment and logic.

Operational Philosophy

The normal procedures are designed for use by trained flight crewmembers. The procedure sequence follows a definitive flow pattern. Each crewmember is assigned a flight deck area to initiate action in accordance with Normal and Supplementary Procedures. Non-normal procedural actions and actions outside the crewmember's area of responsibility are initiated at the direction of the Captain.

Non-normal checklists are provided to cope with or resolve non-normal situations on the ground or in flight.

Supplementary Procedures are accomplished as required rather than on each flight segment. They are not included in the Quick Reference Handbook (QRH).

Events Requiring Maintenance Inspection

During ground or flight operations, events may occur which require a maintenance inspection after flight. Most operators have established a procedure/policy to ensure that aircrews document these events so that proper maintenance can take place.

Chapter 5 of the Airplane Maintenance Manual refers to such events as “Unscheduled Maintenance Checks”. These include, but are not limited to:

- hard landing
- severe turbulence
- (landing gear, flap/slat, MMO/VMO) overspeed
- high-energy stop (Refer to the maintenance manual for guidance.)
- lightning strike
- engine surge or stall
- extreme dust
- tail strike
- overweight landing

Additional events, that are not listed in Airplane Maintenance Manual Chapter 5, but may require maintenance inspection, should also be reported. An example of such an event is an overly aggressive pitch up during a TCAS event or a Terrain Avoidance maneuver that could cause structural damage. The best course of action is; if in doubt, report it.

Pilot Area of Responsibility

Preflight and postflight crew duties are divided between the Captain and First Officer. Phase of flight duties are divided between the Pilot Flying (PF) and the Pilot Monitoring (PM). Phase of flight duties begin when the airplane starts moving under its own power and end when the airplane is parked at the gate.

Training Objectives

The flight-training program prepares the student for airplane qualification and/or the FAA rating checkride (or equivalent). Flight safety, passenger comfort and operational efficiency are emphasized.



Qualification Requirements (Checkride)

Following satisfactory completion of transition training and when recommended by an authorized instructor, each pilot must satisfactorily demonstrate the ability to perform maneuvers and procedures prescribed in FAA or other applicable governing regulations. Throughout the prescribed maneuvers, command ability and good judgment commensurate with a high level of safety must be demonstrated. In determining whether such judgment has been shown, the evaluator considers adherence to approved procedures, actions based on the analysis of situations, and care and prudence in selecting the course of action.

Evaluation

An evaluation will be given at the end of simulator training. The content of the evaluation varies with the capabilities of the simulator used and the requirements of the governing regulatory agency.

An evaluation in the airplane may be required if the training has not been accomplished under the prescribed requirements of FAA or other applicable governing regulations.

Crew Resource Management (CRM)

Crew resource management is the application of team management concepts and the effective use of all available resources to operate a flight safely. In addition to the aircrew, it includes all other groups routinely working with the aircrew who are involved in decisions required to operate a flight. These groups include, but are not limited to, aircraft dispatchers, flight attendants, maintenance personnel, and air traffic controllers.

Throughout this manual, techniques that will help build good CRM habit patterns on the flight deck are discussed. Situational awareness, or the ability to accurately perceive what is going on in the flight deck and outside the aircraft, requires on going questioning, crosschecking, communication and refinement of perception.

It is important that all flight deck crewmembers identify and communicate any situation that appears unsafe or out of the ordinary. Experience has proven that the most effective way to maintain safety of flight and resolve abnormal situations is to combine the skills and experience of all crewmembers in the decision making process to determine the safest course of action.



Headsets/Boom Microphones

In the airplane, headphones or boom microphones/headsets are required to be worn during operations below 18,000 feet (ref. FOM chapter 3), and are normally worn until the top of climb and from the start of descent throughout approach and landing. During cruise, flight deck speakers may be used. Speaker volume should be kept at the minimum usable level adequate to avoid interference with normal crew flight deck conversation, but still ensure reception of relevant communications.



MD-88/90 Flight Crew Training Manual

Flap Usage

For takeoffs, refer to Operations Manual Volume 1, Normal Procedures.

During maneuvering for an approach, when the situation dictates a speed reduction, the use of Flaps 11 or 15 with gear up is acceptable.

Flap - Speed Schedule/Maneuvering Speeds

Takeoff and Landing Speed Booklet

Note: Decision speed (V1), rotation speed (VR) and takeoff safety speed (V2) are available on AWABS and are not listed in the speed booklet. A Manual WDR is used when AWABS is unavailable. The procedure for Manual WDR computations is outlined in the FOM. Under this procedure flight crews must obtain stabilizer trim setting and V speeds from the ODM.

The speed booklet contains minimum maneuver and reference speeds for certain flap/slat configurations by aircraft weight in 2,500 pound increments. Use the closest weight for all reference speeds. The speed booklet maneuvering numbers are good for all altitudes and airspeeds. It is not necessary to reference the ODM for high altitude/hot temperature operations information.

Speed Booklet Analysis

Example Page	Description
	This is the minimum speed to safely retract the slats at this weight to maintain a safe stall margin. This speed is approximately 1.2 VS for a CLEAN wing.
	These are the maneuvering speeds for the associated configurations and represent approximately 1.4 to 1.5 VS.
	These are the reference speeds for approach and represent approximately 1.3 VS and assume minimum maneuvering is required after being established on final.
	This speed is approximately 1.25 VS for a Flaps 11 or 15 configuration and is the minimum climb safety speed for a go-around.

Minimum Maneuvering Speeds

The minimum maneuvering speed additives are approximately 1.4 to 1.5 Vs for each individual configuration. Minimum maneuvering speed additives for other flap configurations are shown below and in the speed booklet.

Configuration	Maneuvering Speed
Flaps 5	Flaps 15 Maneuvering + 20 knots
Flaps 11	Flaps 15 Maneuvering + 10 knots
Flaps 15	Flaps 15 Maneuvering
Flaps 23	Flaps 15 Maneuvering
Flaps 28 or 40	VREF + 10 knots

Note: For takeoff, do not exceed 15° of bank until at or above minimum maneuvering speed for the existing configuration. If maneuvering is a priority, delay the clean-up. V2 + 20 will provide a safe maneuvering speed for all takeoff flap settings. A maximum bank angle of 30 ° is permitted at V2 + 20 with takeoff flaps.

Limit Speeds

CAUTION: Operating close to the flap limit speed could cause inadvertent overspeed. Pilots are encouraged to operate the aircraft at least 10 knots below the placard speed.

Slat Limit Speeds

MD-88	MD-90
Mid position - 280 KIAS/.57Mach.	Mid position - 280 KIAS/.57Mach.
Full extend - 240 KIAS/.57Mach.	Full extend - 240 KIAS/.57Mach.

Flap Limit Speeds (KIAS)

Configuration	MD-88	MD-90
Flaps 11	280	280
Flaps 15	240	240
Flaps 23	220	220
Flaps 28	195	205
Flaps 40	195	200



Flap Operation

Acceleration Height - All Engines

The altitude selected for acceleration and flap retraction may be specified for each airport. Safety, obstruction clearance, airplane performance or noise abatement requirements are usually the determining factors. Delta has adopted a single climb profile for all of their operations based on the airport which requires the greatest height for level off to clear a close-in obstacle with an engine failure.

The minimum altitude for flap retraction during takeoff is 400 feet AGL. The standard flap retraction altitude for Delta flight operations is 1,000 feet AFE.

Acceleration Height - Engine Out

Acceleration height for a takeoff with an engine failure after V1 is based on accelerating to the recommended maneuvering speed ($V2 + 20$) and selecting maximum continuous thrust limits within five minutes (MD-90 ten minutes) after initiating takeoff. The takeoff flap setting is maintained for a subsequent climb to a pattern or vector altitude. If circumstances then require diversion to a takeoff alternate, clean up is as desired when time permits and in accordance with the flap retraction speed schedule published in the speed booklet.

Unless specified otherwise in Delta Special Pages, adequate performance exists to climb to 1000 feet AFE with an engine failure after V1.

Command Speed

Command speed may be set by the pilot through the FGCP, using the SPD/MACH select knob, or FMC and is displayed by the orange airspeed command bug on the airspeed indicator.

Refer to Vol. 2, Automatic Flight, System Description, Autothrottle/Speed Control for additional information.

Takeoff

Command speed remains set at V2 until changed by FMC or the pilot for acceleration and flap retraction.

Climb, Cruise and Descent

Command speed is set to the appropriate speed by the FMC during VNAV operation or manually on the FGCP. The white bugs are positioned to the appropriate airspeeds for approach and landing.

Approach

Command speed is set to the maneuvering speed for the selected flap position by the FMC during VNAV operation or manually using the FGCP.

Landing

When using the autothrottle, position the command speed, using the FGCP, to VREF + 5 knots. Sufficient wind and gust protection is available with the autothrottle engaged because the autothrottle adjusts the approach speed upward to account for the wind gusts actually encountered during the approach. Autothrottle can be used to touchdown only on an autoland. Autothrottle must be disconnected no later than 50 feet on a manual landing.

If the autothrottle is disengaged, or is planned to be disengaged prior to landing, the recommended method for approach speed correction is to add one half of the reported steady headwind component plus the full gust increment above the steady wind to the reference speed. One half of the reported steady headwind component can be estimated by using 50% for a direct headwind, 35% for a 45° crosswind, zero for a direct crosswind and interpolation in between.

When making adjustments for wind additives, the maximum command speed should not exceed VREF + 20 knots. The following table shows examples of wind additives with a runway heading of 360°. In all cases, the gust correction should be maintained to touchdown while the steady headwind correction may be bled off as the airplane initiates the landing flare.



MD-88/90 Flight Crew Training Manual

Reported Winds	Wind Additive	Approach Speed
360 at 16	8	VREF + 8 knots
Calm	0	VREF + 5 knots
360 at 20 Gust 30	10 + 10	VREF + 20 knots
060 at 24	6	VREF + 6 knots
090 at 15	0	VREF + 5 knots
090 at 15 Gust 25	0 + 10	VREF + 10 knots

Wind Component

Maximum gust velocity and least favorable direction will be used to compute the crosswind component.

Steady state wind velocity will be used to compute the headwind or tailwind component.

Non-Normal Conditions

Speed adjustments for non-normal conditions are contained in the appropriate non-normal checklist. Some non-normal checklists will instruct the flight crew to refer to the Non-normal Configuration Approach/Threshold Speeds chart in the QRH. The chart depicts minimum maneuver speeds for configuration not found in the speed booklet (Flaps 15°/Slats retract) and threshold speeds for various flap and slat configurations.

Note: Final approach speed is computed as VREF + wind additive. There is no automatic 5 knot additive.

Reference Bugs

The following figure shows the positioning of the reference bugs on the airspeed indicator for takeoff and approach.

Bug Setting (MASI)



Airspeed Command Bug (Orange)

Indicates airspeed set in the SPD/MACH readout window of the FGCP.

Airspeed Reference Bugs (4)

Movable pointers normally used to alert the pilot to specified airspeeds.

Takeoff

White movable reference airspeed bugs are set at V1, V2+20, slat retract, and flaps up (clean) maneuvering speed. Command speed should be set at V2 using the FGCP. V2 is the minimum takeoff safety speed and provides up to 30° bank capability (15° standard + 15° overshoot) for all takeoff flaps.

Landing

Position white reference airspeed bugs at clean maneuvering, flaps 0/slats extended, flaps 15 maneuvering, and go-around climb safety speed. Command speed should be set at final approach speed on the FGCP.

Note: If a non-normal event precludes using all four reference bugs for approach and landing, position the bugs as appropriate for situation.



Fast/Slow Display Use

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 landing configuration, 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).

The F/S display provides useful information for predicting the actions of the autothrottle system. The autothrottle can rapidly increase power from idle to the TRP thrust limit (throttle burst) when the airplane is allowed to enter a slow condition during the approach, as a result of high drag factor, lengthy engine spool-up time, speed command increase set by the pilot, or any combination of these. Conditions for throttle burst generally occur during approach when slowing and turning the aircraft. An indication of impending throttle burst is F/S pointer displacement well below the "on speed" diamond. Awareness of a throttle burst occurrence requires a pilot to monitor F/S pointer progress and aircraft speed to anticipate any delay of the engines to produce the required thrust. Manual throttle assistance can be used to prevent throttle burst when transitioning from a pitch-on-speed mode (IAS/CLMP) to a speed-on-throttle mode (V/S, ALT HLD). ILS Glideslope capture will "unclamp" the throttles and revert to a speed-on-throttle mode.

Smooth transition between speed changes can be accomplished through use of the F/S display. The autothrottle will provide immediate movement to meet selected command speeds.

In the speed-on-throttle mode, the EPR and LOW limits are the extremes. Use of a throttle setting between these limits may require disconnecting the autothrottle and manually inputting the desired thrust prior to selecting a new speed. Re-engage the autothrottle when the F/S is centered again to maintain the selected speed.

Continued on next page.



Subsequently, if the FMA shows the autothrottle is at the LOW Limit (the autothrottle system cannot reduce thrust at less than the LOW limit while the F/S pointer is centered on the "on speed" diamond) Consider IAS/CLMP (not available with ILS/Autoland), increasing drag, or simply disconnecting the autothrottle and maintaining speed with manual throttle movement.

See Operations Manual, Volume 2, Automatic Flight chapter, System Description section, Autothrottle/Speed Control for additional information.

**MD-88/90 Flight Crew Training Manual**

Callouts

Both crewmembers should be aware of altitude, airplane position and situation.

Avoid casual and nonessential conversation during critical phases of flight, particularly during taxi, takeoff, approach and landing. Unnecessary conversation reduces crew efficiency and alertness and is not permitted when below 10,000 feet MSL / FL100. At high altitude airports, adjust this altitude upward, as required.

The Pilot Monitoring (PM) makes callouts based on instrument indications or observations for the appropriate condition. The Pilot Flying (PF) should verify the condition/location from the flight instruments and acknowledge. If the PM does not make the required callout, the PF should make it.

One of the basic fundamentals of Crew Resource Management is that each crewmember must be able to supplement or act as a back-up for the other crewmember. Proper adherence to standard callouts is an essential element of a well-managed flight deck. These callouts provide both crewmembers required information about airplane systems and about the participation of the other crewmember. The absence of a standard callout at the appropriate time may indicate a malfunction of an airplane system or indication, or indicate the possibility of incapacitation of the other pilot.

The PF should acknowledge all GPWS voice callouts during approach except altitude callouts while below minimums. If the automatic electronic voice callout is not heard by the flight crew, the PM should make the callout.

Standard Callouts

Refer to Operations Manual Volume 1, Normal Procedures chapter, Introduction section for additional Standard Callout information.

Standard Phraseology

Complete details of the following maneuvers are found in the appropriate chapter of the Flight Crew Training Manual.

Recommended Callouts

Several examples of recommended, maneuver-related callouts appear below. Standard callouts and standard phraseology are combined to promote effective cockpit communication.

It may be necessary to alter altitudes listed here, as local area procedures may require the use of different altitudes. Reference the appropriate Airway Manual pages to determine special altitude requirements.

Normal Takeoff With VNAV

<u>PE</u>	<u>PM</u>
at approximately 1.4 EPR...	as indicated
“AUTOTHROTTLES ON”	“EPR XX”
	“CLAMP, 80 KNOTS, ENGINE INSTRUMENTS CHECKED”
	“V1, VR, V2, POSITIVE RATE”
“GEAR UP”	
when applicable...	
“HEADING SELECT”	
at 1000 feet AFE...	
“CLIMB POWER, FLAPS UP, VNAV”	
on schedule...	
“SLATS RETRACT”	
above2,500 feet AFE and maneuver speed...	
“BANK ANGLE 25, AFTER TAKEOFF CHECKLIST”	



MD-88/90 Flight Crew Training Manual

Normal Takeoff Without VNAV

<u>PF</u>	<u>PM</u>
at approximately 1.4 EPR...	as indicated
“AUTOTHROTTLES ON”	“EPR XX”
	“CLAMP, 80 KNOTS, ENGINE INSTRUMENTS CHECKED”
	“V1, VR, V2, POSITIVE RATE”
“GEAR UP”	
when applicable...	
“HEADING SELECT”	
at 1000 feet AFE...	
“CLIMB POWER, FLAPS UP, IAS CLEAN, SPEED COMMAND BUG CLEAN”	
on schedule...	
“SLATS RETRACT”	
above 2500 feet AFE and maneuver speed...	
“IAS 250, SPEED COMMAND BUG 250, BANK ANGLE 25, AFTER TAKEOFF CHECKLIST”	

Normal Takeoff with level off below 2500’ AFE without VNAV

<u>PF</u>	<u>PM</u>
at approximately 1.4 EPR...	as indicated
“AUTOTHROTTLES ON”	“EPR XX”
	“CLAMP, 80 KNOTS, ENGINE INSTRUMENTS CHECKED”
	“V1, VR, V2, POSITIVE RATE”
“GEAR UP”	
when applicable...	
“HEADING SELECT”	
at 1000 feet AFE...	
“CLIMB POWER, FLAPS UP, SPEED SELECT, SPEED COMMAND BUG CLEAN SPEED”	
on schedule...	
“SLATS RETRACT”	
above 2500 feet AFE and maneuver speed...	
“IAS 250, EPR LIMIT, SPEED COMMAND BUG 250, BANK ANGLE 25, AFTER TAKEOFF CHECKLIST”	



MD-88/90 Flight Crew Training Manual

Engine Failure after V1

<u>PF</u>	<u>PM</u>
at approximately 1.4 EPR...	as indicated
“AUTOTHROTTLES ON”	“EPR XX”
	“CLAMP, 80 KNOTS, ENGINE INSTRUMENTS CHECKED”
	“V1, ENGINE FAILURE, VR, V2, POSITIVE RATE”
“GEAR UP”	
recommended technique above 400 feet AFE...	
Declare an emergency. Comply with Airway Manual, Engine Out Departure Priorities.	
“SET SPEED COMMAND BUG TO V2 + 20”	
at 1000 feet AFE...	
“ALTITUDE HOLD, SET SPEED COMMAND BUG TO V2 + 20” (if not already set)	
at V2 + 20...	
“IAS, MCT, EPR LIMIT BANK ANGLE 25, AFTER TAKEOFF CHECKLIST, ENGINE FAILURE CHECKLIST”	
recommended technique...	
“AUTOPILOT ON”	

Missed Approach

Note: Preset missed approach bank angle, heading and altitude, when able.

<u>PF</u>	<u>PM</u>
“TOGA POWER, FLAPS 15”	as indicated
	“POSITIVE RATE”
“GEAR UP”	
recommended technique...	
“AUTOTHROTTLES ON, CHECK BANK ANGLE, HEADING AND ALTITUDE”	
above 400 feet AGL and at MAP...	
“HEADING SELECT” and “NAV” (if required)	
at 1000 feet AFE or acceleration height...	
“CLIMB POWER, SPEED COMMAND BUG 180”	
at MAP altitude and maneuver speed...	
“BANK ANGLE 25, AFTER TAKEOFF CHECKLIST”	



MD-88/90 Flight Crew Training Manual

Missed Approach - Single Engine

<u>PF</u>	<u>PM</u>
“TOGA POWER, FLAPS 11”	as indicated
	“POSITIVE RATE”
“GEAR UP”	
recommended technique...	
“CHECK BANK ANGLE, HEADING AND ALTITUDE”	
above 400 feet AGL and at MAP...	
“HEADING SELECT” and “NAV” (if required)	
at 1000 feet AFE or as specified...	
“ALTITUDE HOLD, SET SPEED COMMAND BUG TO FLAPS 11 MANEUVER SPEED”	
at flaps 11 maneuver speed (which is flaps 15 maneuver + 10 knots...	
“IAS, MCT, EPR LIMIT, BANK ANGLE 25, AFTER TAKEOFF CHECKLIST”	
recommended technique...	
“AUTOPILOT ON”	

Cold Temperature Altitude Corrections

If the outside air temperature (OAT) is different from standard atmospheric temperature (ISA), barometric altimeter errors result due to non-standard air density. Larger temperature differences from standard result in larger altimeter errors. When the temperature is warmer than ISA, true altitude is higher than indicated altitude. When the temperature is colder than ISA, true altitude is lower than indicated altitude. Extremely low temperatures create significant altimeter errors and greater potential for reduced terrain clearance. These errors increase with higher airplane altitudes above the altimeter source.

Generally, operators should consider altitude corrections when altimeter errors become appreciable, especially where high terrain and/or obstacles exist near airports in combination with very cold temperatures (-30°C/ -22°F or colder). Further, operators should also consider correcting en route minimum altitudes and/or flight levels where terrain clearance is a factor. In some cases corrections may be appropriate for temperatures between 0°C and -30°C.

Operators should coordinate with local and en route air traffic control facilities for each cold weather airport or route in their system. Coordination should include:

- confirmation that minimum assigned altitudes or flight levels provide adequate terrain clearance for the coldest expected temperatures
- cold weather altitude correction procedures to be used for published procedures, to include the table being used (refer to Airway Manual, Weather chapter)
- a determination of which procedures or routes, if any, that have been designed for cold temperatures and can be flown as published (without altitude corrections).

Pilots should note that for very cold temperatures, when flying published minimum altitudes significantly above the airport, altimeter errors can exceed 1000 feet, resulting in potentially unsafe terrain clearance if no corrections are made.



Operation in Icing Conditions

Boeing airplanes are certified to all applicable airworthiness regulations regarding flight in icing conditions. Operators are required to observe all operational procedures concerning flight in these conditions.

Although the process of certifying jet transport airplanes for operation in icing conditions involves many conservative practices, these practices have never been intended to validate operations of unlimited duration in severe icing conditions. The safest course of action is to avoid prolonged operation in moderate to severe icing conditions.

See FOM and Operations Manual Volume 1, Supplementary chapter, Adverse Weather section for additional information.

Recommended Rudder Trim Technique

This section describes two techniques for properly trimming the rudder. It is assumed that the airplane is properly rigged and in normal cruise. The primary technique uses rudder trim only to level the control wheel and is an acceptable and effective method for trimming the airplane. It is approximately equal to a minimum drag condition. This technique is usable for normal as well as many non-normal conditions. For some non-normal conditions, such as engine failure, this technique is the preferred method and provides near minimum drag.

The alternate technique may provide a more accurate trim condition when the roll is caused by a roll imbalance. In addition, this technique outlines the steps to be taken if the primary trim technique results in an unacceptable bank angle or excessive rudder trim. The alternate technique uses both rudder and aileron trim to neutralize a rolling condition using the bank pointer as reference.

Note: Large trim requirements should be documented for maintenance.

Drag Factors Due to Trim Technique

After setting cruise thrust, check lateral and directional trim. If crosstrim is suspected, check engine parameters for an indication of unequal thrust and check fuel balance. The following steps will assist in trimming the aircraft.

Note: Aileron trim may be required for significant fuel imbalance, airplane damage, or flight control system malfunctions.

Primary Trim Technique

It is recommended that the autopilot remain engaged while accomplishing the primary rudder trim technique (using rudder trim only). After completing this technique, if the autopilot is disconnected, the airplane should maintain a constant heading.

The following steps define the primary rudder trim technique:

- set symmetrical thrust
- balance fuel if required
- ensure the autopilot is engaged in HDG HLD and stabilized for at least 30 seconds

**MD-88/90 Flight Crew Training Manual**

- observe bank angle in HDG HLD mode.
- trim the rudder in the direction corresponding to the down (low) side of the control wheel until the control wheel indicates level. The indices on top of the control wheel should be used to ensure a level wheel condition. The airplane is properly trimmed when the control wheel is level, (zero index). As speed, gross weight, or altitude change, trim requirements may also change. In a proper trim condition, there may be a slight forward slip (slight bank angle indicated on the bank pointer) and a slight deflection of the slip/skid indicator, which is acceptable.

Alternate Rudder Trim Technique

The alternate rudder trim technique is used if the primary trim technique results in an unacceptable bank angle, excessive rudder trim, or if a more accurate dual axis trim is required.

The following steps define the alternate rudder trim technique:

- set symmetrical thrust
- balance fuel if required
- verify rudder trim is zero
- ensure the autopilot is engaged HDG HLD and stabilized for at least 30 seconds
- trim the rudder in the direction corresponding to the down (low) side of the control wheel until the bank indicates level (no bank angle indicated on the bank pointer). Apply rudder trim incrementally, allowing the bank to stabilize after each trim input. Large trim inputs are more difficult to coordinate. The airplane is properly trimmed when the bank angle on the bank pointer indicates zero. If the airplane is properly rigged, the control wheel should indicate approximately level. The resultant control wheel condition indicates the true aileron (roll) trim of the airplane being used by the autopilot.

After completing the alternate rudder trim technique, if the autopilot is disengaged the airplane may have a rolling tendency. Hold the wings level using the sky pointer as reference. Trim out any control wheel forces using the aileron trim wheel. If properly trimmed, the airplane holds a constant heading and the aileron trim reading on the wheel/column agrees with what was seen while the autopilot was engaged. Aileron trim inputs require additional time and should be accomplished prior to final approach.

Flight Management Computer(s)/MCDUs

The Flight Management System provides the crew with navigation and performance information which can result in a significant crew workload reduction. This workload reduction is fully realized when the system is operated as intended, including proper preflight and timely changes in flight. FMC guidance must always be monitored after any inflight changes. In the event flight plan changes occur at inopportune times or in areas of high traffic density, the crew should not hesitate to revert to modes other than NAV/VNAV.

During preflight, all flight plan or performance related FMC CDU entries made by one pilot must be verified by the other pilot. In flight the FMC CDU changes should be made by the PM and executed only after verification by the PF.

FMC Route Verification Techniques

After entering the route into the FMC, the crew should verify that the entered route is correct. There are several techniques that may be used to accomplish this. The crew should always compare:

- the filed flight plan with the airways and waypoints entered on the ROUTE pages
- the computer flight plan total distance and estimated fuel remaining with the FMC-calculated distance to destination and the calculated fuel remaining at destination on the PROGRESS page.

For longer flights and flights that are planned to transit oceanic airspace, the crew should cross-check each leg on the LEGS page with the computer flight plan to ensure that the waypoints, magnetic or true tracks, and distances between waypoints match.

If there is a discrepancy noted in any of the above, correct the LEGS page to match the filed flight plan legs. A cross check of the map display using the plan mode may also assist in verification of the flight plan.

See Operations Manual Volume 1, Normal Procedures chapter, Introduction section and Supplementary chapter, Flight Instruments, Displays section for additional autopilot flight director information.

FMC Performance Predictions - Non-Normal Configuration

FMC performance predictions are based on the airplane being in a normal configuration. These predictions include:

- climb and descent path predictions including top of climb and top of descent
- ECON, LRC, holding, and engine out speeds
- altitude capability
- step climb points



MD-88/90 Flight Crew Training Manual

-
- fuel remaining at waypoints and destination or alternate
 - estimated time of arrival at waypoints and destination or alternate
 - holding time available.

If operating in a non-normal configuration, such as gear down, flaps extended, spoilers extended, gear doors open, etc., these performance predictions are inaccurate. FMC predictions for the climb and descent path are not usable.

Do not use FMC fuel predictions. Cruise fuel predictions are based on a clean configuration. Fuel consumption may be significantly higher than predicted in other configurations.

An accurate estimated time of arrival is available if current speed or Mach is entered into the VNAV cruise page. Estimates of fuel remaining at waypoints or the destination may be computed by the crew based upon current fuel flow indications, but should be updated frequently. Performance information for gear down altitude capability and gear down cruise performance is available in the Abnormal section of the ODM.

Holding time available is accurate in the clean configuration provided the FMC holding speed is maintained.

Weather Radar and Terrain Display Policy

Whenever the possibility exists for adverse weather and terrain/obstacles near the intended flight path, one pilot should monitor the weather radar display and the other pilot should monitor the terrain display. The use of the terrain display during night or IMC operations, on departure and approach when in proximity to terrain/obstacles, and at all times in non-radar environments is recommended.

Note: It may be useful to show the terrain display at other times to enhance terrain/situational awareness.

DFGS Procedures

Crewmembers must coordinate their actions so that the airplane is operated safely and efficiently.

Autopilot engagement should only be attempted when the airplane is in trim, F/D commands (if the F/D is on) are essentially satisfied and the airplane flight path is under control. The autopilot is not certified or designed to correct a significant out of trim condition or to recover the airplane from an abnormal flight condition and/or unusual attitude.

Autothrottle Use

To simplify thrust setting procedures, autothrottle use is recommended during takeoff and climb in either automatic or manual flight. Make every effort to keep the engines synchronized for passenger comfort. Normally, the ENG SYNC selector is set to N1 for this purpose. If the autothrottle is not used, avoid excessive throttle lever adjustments. Use all engine parameters to maintain balanced thrust.

Manual Flight

The PM should make DFGS mode selections at the request of the PF. Heading and altitude changes from ATC clearances and speed selections associated with flap position changes may be made without specific directions. However, these selections should be announced, such as, “HEADING 170 SET”. The PF must be aware such changes are being made. This enhances overall safety by requiring that both pilots are aware of all selections, while still allowing one pilot to concentrate on flight path control.

Ensure the proper flight director modes are selected for the desired maneuver. If the flight director commands are not to be followed, the flight director should be turned off.

Automatic Flight

Autoflight systems can enhance operational capability, improve safety, and reduce workload. Automatic approach and landing, Category III operations, and fuel-efficient flight profiles are examples of some of the enhanced operational capabilities provided by autoflight systems. Maximum and minimum speed protection are among the features that can improve safety while NAV, VNAV, and instrument approaches using VNAV are some of the reduced workload features. Varied levels of automation are available. The pilot decides what level of automation to use to achieve these goals by selecting the level that provides the best increase in safety and reduced workload.

**MD-88/90 Flight Crew Training Manual**

Note: When the autopilot is in use, the PF makes DFGS mode selections. The PM may select new altitudes, but must ensure the PF is aware of any changes. Both pilots must monitor DFGS mode annunciations and the current FMC flight plan.

Automatic systems give excellent results in the vast majority of situations. When the automatic systems do not perform as expected, the pilot should reduce the level of automation until proper control of path and performance is achieved. For example, if the pilot failed to select the exit holding feature when cleared for the approach, the airplane will turn outbound in the holding pattern instead of initiating the approach. At this point, the pilot may select HEADING SELECT and continue the approach while using other automated features. A second example, if the airplane levels off unexpectedly during climb or descent with VNAV engaged, continue the climb or descent using the FGCP in the VERT SPD or IAS mode until the FMC can be programmed.

Early intervention prevents unsatisfactory airplane performance or degraded flight path. Reducing the level of automation as far as manual flight may be necessary to ensure proper control of the airplane is maintained. The pilot should attempt to restore higher levels of automation only after airplane control is assured. For example, if an immediate level-off in climb or descent is required, it may not be possible to comply quickly enough using the FGCP. The PF should disconnect the autopilot and level off the airplane manually at the desired altitude. After level off, set the desired altitude in the FGCP, select an appropriate pitch mode and re-engage the autopilot.

Note: In the event the flight crew overrides the autopilot, the autopilot should be disconnected as soon as practical. Continued flight overriding the autopilot is not recommended.

Recommended Pitch and Roll Modes

If the LEGS page and map display reflect the proper sequence and altitudes, NAV and VNAV are recommended. If NAV is not used, use an appropriate roll mode. When VNAV is not used, the following modes are recommended.

IAS is the preferred technique for altitude changes of 2,000 feet or more. V/S is preferred if the altitude change is less than 2,000 feet.

If unplanned speed or altitude restrictions are imposed during the arrival, the continued use of VNAV may induce an excessive workload. If this occurs, use IAS or V/S as appropriate.

Continued on next page.



Monitor the FMA closely at approximately 1,000 feet prior to the desired level off altitude to ensure the autopilot captures the altitude. Adjusting the pitch wheel may result in disengaging the altitude capture mode and the autopilot failing to level the aircraft at the desired altitude. Always verify the FMA progression nearing level off. The FMA will show ALT CAP, ALT HLD, VNAV CAP, or VNAV LVL.

Turbulent Air Penetration

Severe turbulence should be avoided if at all possible. However, if severe turbulence is encountered, refer to the SEVERE RAIN/ICE/TURBULENCE non-normal checklist in the QRH. Turbulent air penetration speeds provide high/low speed maneuver margins in severe turbulent air.

During manual flight, maintain wings level and smoothly control attitude. Use the attitude indicator as the primary instrument. In extreme updrafts or downdrafts, large altitude changes may occur. Do not use sudden or large control inputs. After establishing the trim setting for penetration speed, do not change pitch trim. Allow altitude and airspeed to vary and maintain attitude. However, do not allow the airspeed to decrease and remain below the turbulent air penetration speed because stall/buffet margin is reduced. Maneuver at bank angles below those normally used. Set thrust for penetration speed and avoid large thrust changes. Flap extension in an area of known turbulence should be delayed as long as possible because the airplane can withstand higher gust loads with the flaps up.

Normally, no changes to cruise altitude or airspeed are required when encountering moderate turbulence. If operating at cruise thrust limits, it may be difficult to maintain cruise speed. If this occurs, select a higher thrust limit (if available) or descend to a lower altitude.

See Operations Manual Volume 2, Automatic Flight chapter, for autopilot TURB mode information.

Note: An encounter with severe turbulence requires a log book entry and Special Aircraft Structural Inspection. Refer to FOM, Emergency/Irregular Operations.

Taxi, Takeoff, Initial Climb
Table of Contents

Chapter 2
Section 0

Preface	2.1
Departure Briefing	2.1
Pushback	2.2
Backing with Reverse Thrust	2.2
Taxi	2.3
Taxi General	2.3
Flight Deck Perspective	2.4
Thrust Use	2.4
Taxi Speed and Braking	2.5
Antiskid Inoperative	2.6
Nosewheel/Rudder Pedal Steering	2.6
Turning Radius and Gear Tracking	2.7
Visual Cues and Techniques for Turning while Taxiing	2.9
Turns of 180 Degrees	2.12
Taxi - Adverse Weather	2.16
Taxi - One Engine	2.17
Takeoff	2.18
Takeoff Profile	2.18
Special Takeoff Profile	2.19
Takeoff Briefing	2.20
Takeoff - General	2.20
Thrust Management	2.21
Initiating Takeoff Roll	2.21
Rotation and Liftoff - All Engines	2.24
Effect of Rotation Speed and Pitch Rate on Liftoff	2.25
Center-Of-Gravity (C.G.) Effects	2.25

Crosswind Takeoff	2.26
Takeoff Crosswind Guidelines	2.26
Directional Control	2.26
Rotation and Takeoff	2.26
Gusty Wind and Strong Crosswind Conditions	2.27
Reduced Thrust Takeoff	2.27
Assumed Temperature Method (ATM)	2.27
Improved Climb Performance Takeoff	2.28
Low Visibility Takeoff	2.28
Adverse Runway Conditions	2.28
Effect of Deicing/Anti-Icing Fluids on Takeoff	2.29
Federal Aviation Regulation (FAR) Takeoff Field Length	2.29
FAR Takeoff	2.30
Rejected Takeoff Decision	2.31
Rejected Takeoff Maneuver	2.31
Go/Stop Decision near V1	2.32
RTO Execution	2.33
Initial Climb - All Engines	2.33
Minimum Fuel Operation - Takeoff	2.33
Immediate Turn after Takeoff - All Engines	2.33
Roll Modes	2.34
Pitch Modes	2.34
Autopilot Engagement	2.35
Flap Retraction Schedule	2.35

Takeoff - Engine Failure	2.37
Takeoff Profile - Engine Failure	2.37
Takeoff Engine Failure - General	2.38
Engine Failure Recognition	2.38
Rotation - One Engine Inoperative	2.38
Liftoff Pitch Attitude - One Engine Inoperative	2.39
Initial Climb - One Engine Inoperative	2.40
Immediate Turn after Takeoff - One Engine Inoperative	2.42
Noise Abatement - One Engine Inoperative	2.42
Engine Failure During Reduced Thrust Takeoff	2.42

Intentionally
Blank

Taxi, Takeoff, Initial Climb

Chapter 2

Preface

This chapter outlines the recommended operating practices and techniques for taxi, takeoff, and initial climb. Rejected takeoff and loss of an engine during takeoff/initial climb is also addressed. The discussion portion of each illustration highlights important information.

The flight profile illustrations represent the recommended basic configuration during the accomplishment of the flight maneuvers, and provide a basis for standardization and crew coordination.

Departure Briefing

The departure briefing (WARTS) shall be accomplished prior to the Before Start checklist.

The departure briefing is a description of the departure flight path with emphasis on anticipated track and altitude restrictions. It assumes normal operating procedures are used. Therefore, it is not necessary to brief normal or standard takeoff procedures. Additional briefing items may be required when any elements of the takeoff and/or departure are different from those routinely use. These may include:

- adverse weather
- adverse runway conditions
- unique noise abatement requirements
- dispatch using the minimum equipment list
- special engine out departure procedures (if applicable)
- any other situation where it is necessary to review or define crew responsibilities.

Refer to the FOM for a detailed description of items to include in the departure briefing.

Pushback

Pushbacks present a serious hazard to ground personnel. There have been many accidents where personnel were run over by the airplane wheels during the pushback process.

Pushback or towing involves three phases:

- Positioning and connecting the tug and tow bar
- Moving the airplane
- Disconnecting the tow bar.

Proper training and good communication between the flight deck and ground personnel are essential for a safe pushback operation. Refer to the FOM Ramp Operations chapter for further guidance.

The headset operator, who is walking in the vicinity of the nose wheel, is usually the person injured or killed in the majority of the accidents. Procedures that do not have personnel in the vicinity of the nose wheels are key to reducing the possibility of these type accidents.

- The Captain should ensure that all appropriate checklist items are completed prior to airplane movement. All passengers should be in their seats, all doors closed and all ground equipment away from the airplane. Engine start may be accomplished during the pushback or delayed until the pushback is completed. Ground personnel should be on headset to observe and communicate to the flight crew any possible safety hazards.

Note: The aircraft should not be taxied away from a gate, or pushback position, unless the marshaller clears the airplane to taxi.

Backing with Reverse Thrust

Backing with reverse thrust is prohibited by Delta Operations Policies. Refer to the FOM Ramp Operations chapter for further guidance.

 DELTA
MD-88/90 Flight Crew Training Manual

Taxi

Taxi General

An airport diagram should be kept in a location readily available to both crewmembers during taxi. The following guidelines aid in conducting safe and efficient taxi operations.

Prior to Taxi

- Both pilots verify the correct alignment coordinates are entered into the FMC.
- Brief applicable items from airport taxi diagrams and related charts.
- Ensure both crewmembers understand the expected taxi route.
- Write down the taxi clearance when received.

During Taxi

CAUTION: If flaps are up for taxi, delay completing the TAXI and BEFORE TAKEOFF checklists until the flaps are properly positioned and a control check has been accomplished.

- Progressively follow taxi position on the airport diagram.
- During low visibility conditions, call out all signs to verify position.
- If unfamiliar with the airport consider requesting a FOLLOW ME vehicle or progressive taxi instructions.
- Use standard radio phraseology.
- Read back all clearances. If any crewmember is in doubt regarding the clearance, verify taxi routing with the written clearance or with ATC. Stop the airplane if the clearance is in doubt.
- When ground/obstruction clearance is in doubt, stop the airplane and obtain a wing-walker.
- Avoid distractions during critical taxi phases; plan ahead for checklist accomplishment and company communications.
- Consider delaying checklist accomplishment until stopped during low visibility operations.
- Do not allow ATC or anyone else to rush you.
- Be constantly aware of the equipment, structures, and aircraft behind the airplane when the engines are above idle thrust.
- Use the taxi light in accordance with the FOM, Chapter 3, Exterior Lights Usage.
- At night use all appropriate airplane lighting.

Runway Safety

- When crossing or entering any runway:
 - verify the runway is clear in both directions
 - ensure taxi clearance compliance in accordance with the FOM, Chapter 3, Clearance Awareness
 - ensure the appropriate exterior lights are illuminated in accordance with the FOM, Chapter 3, Exterior Lights Usage
 - confirm aircraft location utilizing an outside source such as runway signage, painted runway number markings, and/or aircraft heading.

Prior to Landing

- Plan/brief the expected taxiway exit and route to parking.

After Landing

- Ensure taxi instructions are clearly understood, especially when crossing closely spaced parallel runways.
- Delay company communications until clear of all runways.

Flight Deck Perspective

There is a large area near the airplane where personnel, obstacles or guidelines on the ground cannot be seen, particularly in the oblique view across the flight deck. Special care must be exercised in the parking area and while taxiing. When parked, the pilot should rely on ground crew communications to a greater extent to ensure a safe, coordinated operation.

The pilot's seat should be adjusted for optimum eye position. The rudder pedals should be adjusted so that it is possible to apply maximum braking with full rudder deflection.

During taxiing, the pilot's heels should be on the floor, sliding the feet up on the rudder pedals only when required to apply brakes to slow the taxi speed, or when maneuvering in close quarters on the parking ramp.

Thrust Use

Thrust use during ground operation demands sound judgment and technique. Even at relatively low thrust the air blast effects from the large, high bypass engines can be destructive and cause injury. Airplane response to throttle movement is slow, particularly at high gross weights. Engine noise level in the flight deck is low and not indicative of thrust output. Idle thrust is adequate for taxiing under most conditions. A slightly higher thrust setting is required to begin taxiing. Allow time for airplane response before increasing thrust further.

Taxi Speed and Braking

To begin taxi, release brakes, smoothly increase thrust to minimum required for the airplane to roll forward (For an average weight airplane [125,000 lbs]: approximately 65% N1/1.1EPR [MD-88], 40-45% N1/1.2EPR [MD-90]), then reduce thrust to idle. A turn should not be started until sufficient forward speed has been attained to carry the airplane through the turn at idle thrust.

The airplane may appear to be moving slower than it actually is due to the flight deck height above the ground. Consequently, the tendency may be to taxi faster than desired. This is especially true during runway turnoff after landing. The ground speed display on the flight instruments may be used to determine actual taxi speed. The appropriate taxi speed depends on turn radius and surface condition.

Taxi speed should be closely monitored during taxi out, particularly when the active runway is some distance from the departure gate. Normal taxi speed is approximately 20 knots, adjusted for conditions. On long straight taxi routes, speeds up to 30 knots are acceptable, however at speeds greater than 20 knots use caution when using the nose wheel steering tiller to avoid overcontrolling the nose wheels. When approaching a turn, speed should be slowed to an appropriate speed for conditions. On a dry surface, use approximately 10 knots for turn angles greater than those typically required for high speed runway turnoffs. Taxi speeds, between 10 and 20 knots can cause an increase in airplane vibration, especially on rough taxiways. A slight increase or decrease in speed may reduce or eliminate the vibration and increase passenger comfort.

Note: High taxi speed combined with heavy gross weight and a long taxi distance can result in tire sidewall overheating.

Avoid prolonged braking application to control taxi speed as this causes high brake temperatures and increased wear of brakes. If taxi speed is too high, reduce speed with a steady brake application and then release the brakes to allow them to cool. Braking to approximately 10 knots and subsequent release of the brakes results in less heat build-up in the tires and brakes than when the brakes are constantly applied.

Under normal conditions, differential braking and braking while turning should be avoided. Allow for decreased braking effectiveness on slick surfaces.

Avoid following other aircraft too closely. Jet blast is a major cause of foreign object damage.

During taxi, or on landing rollout below 60 knots, the use of reverse thrust above reverse idle is not recommended due to the possibility of foreign object damage and/or engine surge. Idle reverse thrust may be necessary on slippery surfaces to control speed while taxiing. Use caution as autobrakes will apply if armed.

Antiskid Inoperative

With antiskid inoperative, tire damage or blowouts can occur if moderate to heavy braking is used. With this condition, it is recommended that taxi speed be adjusted to allow for very light braking.

Note: Dispatch with antiskid inoperative is not authorized.

Nosewheel/Rudder Pedal Steering

The Captain's position is equipped with a handwheel steering control. The handwheel is used to turn the nosewheel through the full range of travel at low taxi speeds. Maintain positive pressure on the handwheel at all times during a turn to prevent the nose wheel from abruptly returning to center. Rudder pedal steering turns the nose wheel through a limited range of travel (17°). Straight ahead steering and large radius turns may be accomplished with rudder pedal steering.

Note: The airplane is very sensitive to inputs from the handwheel. Smooth turns can be made by leading turns with rudder pedal steering, then adding handwheel steering.

If nose wheel "scrubbing" occurs while turning, reduce steering angle and/or taxi speed. Avoid stopping the airplane in a turn as excessive thrust is required to start taxiing again.

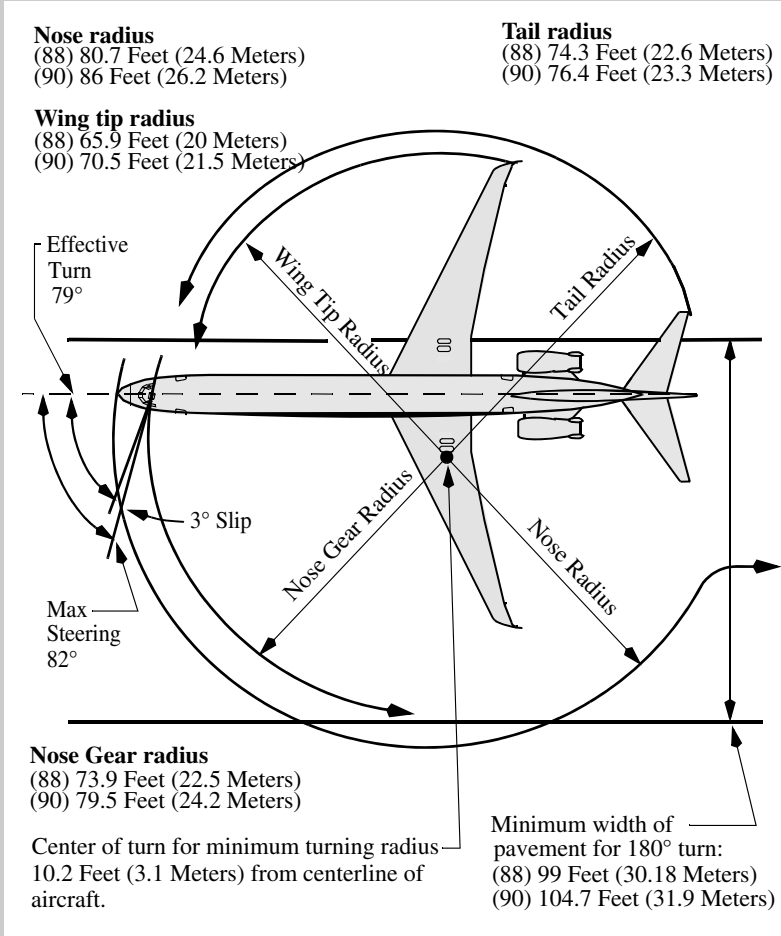
Differential thrust may be required at high weights during tight turns. This should only be used as required to maintain the desired speed in the turn. After completing a turn, center the nose wheel and allow the airplane to roll straight ahead. This relieves stresses in the main and nose gear structure prior to stopping.

MD-88/90 Flight Crew Training Manual

Turning Radius and Gear Tracking

Turning Radius

The nose swings the largest arc while turning and determines the minimum obstruction clearance path. All other portions of the airplane remain within this arc. The tail swings a larger arc than the wingtip, therefore, wingtip clearance does not guarantee tail clearance.

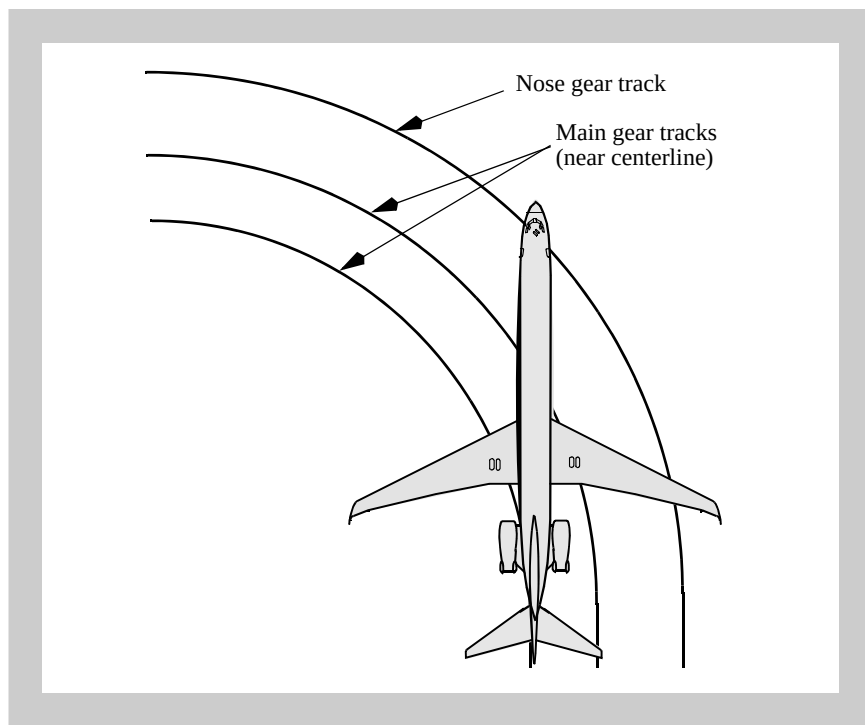


Note: While both the MD-88 and MD-90 are capable turning 180° on smaller pavement widths, attempting a 180° turn on a pavement dimension less than 125 feet is not recommended.

Gear Tracking

During all turning maneuvers, crews should be aware of their position relative to nose and main landing gear. The nose and main gear position is depicted in the tables in this chapter.

As the following diagram illustrates, while the airplane is turning, the main gear tracks inside the nose gear. The smaller the radius of the turn, the greater the distance that the main gear tracks inside the nose gear and the greater the need to steer the nose gear outside of the taxi path (oversteer).



 DELTA
MD-88/90 Flight Crew Training Manual

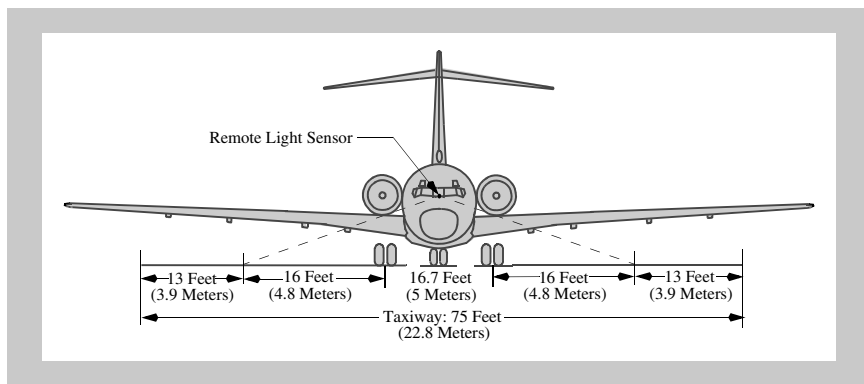
Visual Cues and Techniques for Turning while Taxiing

The following visual cues assume the pilot's seat is adjusted for proper eye position. The following techniques also assume a typical taxiway width (75 feet). Since there are many combinations of turn angles, taxiway widths, fillet sizes and taxiway surface conditions, pilot judgment must dictate the point of turn initiation and the amount of nose wheel steering wheel required for each turn. The Captain and First Officer must work as a team to ensure proper obstacle clearance. Except for turns less than approximately 30°, speed should be 10 knots or less prior to turn entry. The nose wheel is located directly underneath the throttles. For all turns, keep in mind the main gear are located well behind the nose wheels, which causes them to track inside the nose wheels during turns. The pilot position forward of the main gear for each airplane is depicted in the table below.

Model	Pilot Seat Position (forward of main gear feet (meters))
MD-88	72.4. (22)
MD-90	77.2 (23.5)

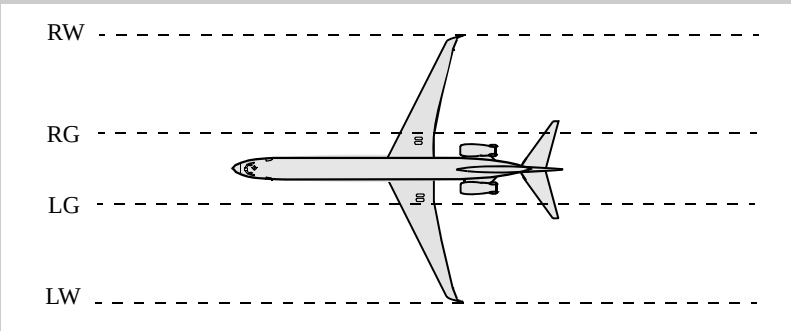
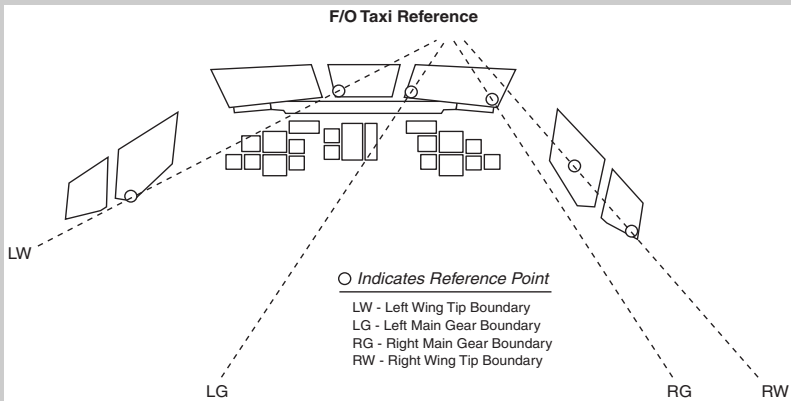
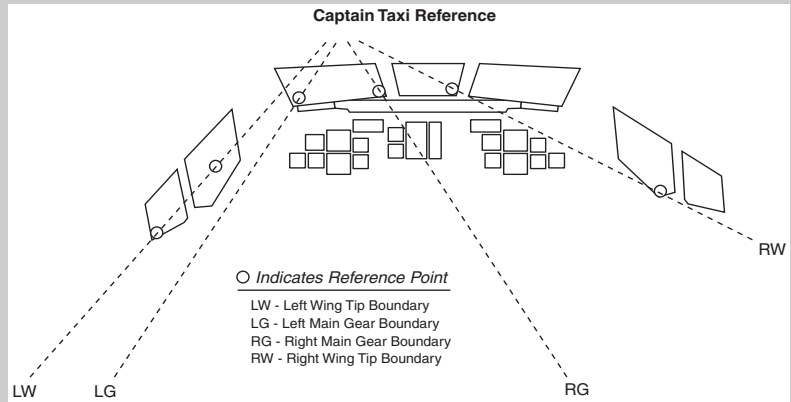
Peripheral Awareness

With the airplane centered on a typical taxiway, envision an imaginary line over the left shoulder through the very bottom of the left clearview (sliding) window, and down to the pavement. The point where this imaginary line intersects the pavement is approximately 16 feet outboard of the left main gear track; that point is approximately 13 feet from the edge of the pavement. When looking over the Remote Light Sensor (RLS) (located on the glare shield at the base of the center windshield) and down to the pavement, the same distances can be determined for the opposite side of the airplane.



Flight Deck References During Straight-Line Taxi

Certain flight deck references can be utilized to indicate the track of the main landing gear and wing tips while taxiing in a straight line.





Flight Deck References During Turns

For all turns, overshoot the centerline of the taxiway you intend to turn onto before beginning the turn. For a left turn, keep the edge of the taxiway above the bottom of the sliding window. The main gear will be 8 to 10 feet from the edge of the taxiway. For a right turn, drag the RLS over the edge of the taxiway. The main gear will have the same 8 to 10 feet clearance. These references work well for arcing turns also.

Turns less than 90 degrees

Use a technique similar to other large airplanes: steer the nose wheels far enough beyond the centerline of the turn to keep the main gear close to the centerline.

Turns of 90 degrees or more

Initiate the turn after overshooting the intersecting taxiway centerline (or intended exit point) and the nose gear is approaching the edge of the taxiway. Initially use approximately full handwheel steering wheel displacement. Adjust the handwheel input as the airplane turns to keep the nose wheels outside of the taxiway centerline, near the outside radius of the turn. Nearing turn completion, when the main gear are clear of the inside radius, gradually release the steering wheel input as the airplane lines up with the intersecting taxiway centerline or intended taxi path.

Turns of 180 Degrees

If the available taxi surface is narrow, coordination with ATC and ground support personnel may be required to complete the operation safely. Reference special aerodrome operating instructions, if available. In some cases (e.g. heavy weight, pilot uncertainty of runway and/or taxiway pavement edge locations and related safety margins, nearby construction, vehicles, potential FOD damage, etc.), towing the airplane to the desired location may be the safest option.

If a minimum radius 180° turn is necessary, consider using the ground crew to monitor the wheel path and provide relevant information as the turn progresses. The ground crew should be warned of the risk associated with jet blast and position themselves to avoid the hazard. Also ensure that obstacle clearance requirements are met. Since more than idle thrust is required, the flight crew must be aware of buildings or other objects in the area being swept by jet blast during the turn.

Note: Monitor the nose gear track closely, as it will leave the pavement in the turn before the main gear.

Approach the edge of the taxi surface at a shallow angle until the outboard side of the main gear wheels are near the edge. See Flight Deck Reference During Straight-Line Taxi, this chapter.

Note: Painted runway markings are slippery when wet and may cause skidding of the nose gear during the turn.

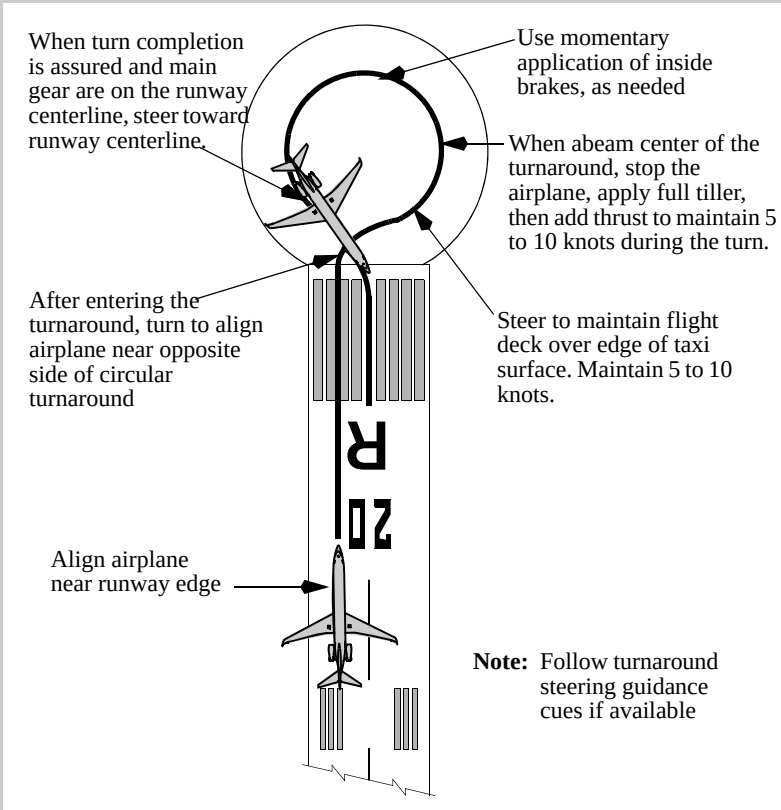
Turning radius can be reduced by following a few specific taxi techniques. Taxi the airplane so that the main gear tires are close to the runway edge. This provides more runway surface to make the turn. Stop the airplane completely with the thrust at idle. Hold the nose wheel steering wheel to the maximum steering angle, release the brakes, then add thrust on the outboard engine. Only use the engine on the outboard side of the turn and maintain 5 to 10 knots during the turn to minimize turn radius. Light intermittent braking on the inside main gear helps decrease turn radius. Stopping the airplane in a turn is not recommended unless required to reduce the turn radius. As the airplane passes through 90° of turn, steer to place the main gear approximately on the runway centerline, then gradually reduce the nose wheel steering wheel input as required to align the airplane with the new direction of taxi. These actions result in a low speed turn and less runway being used. Wind, slope, runway or taxiway surface conditions, and center of gravity may also affect the turning radius.

Continued on next page

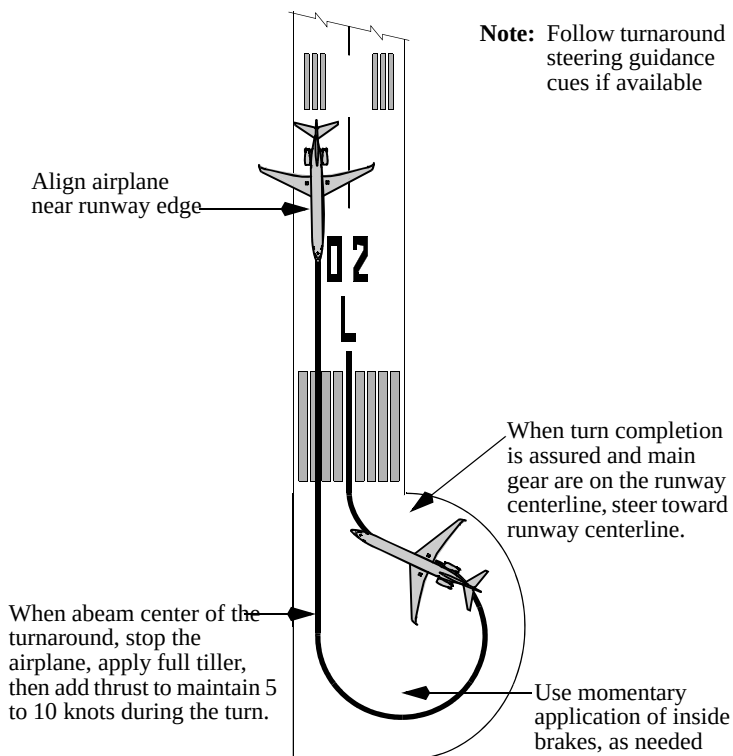
MD-88/90 Flight Crew Training Manual

The following diagrams show suggested airplane ground tracks for minimum radius 180° turns with various runway turnaround configurations. These ground tracks provide the best maneuver capability while providing the maximum runway length available for takeoff at the completion of the turn. However, this type of maneuvering is normally not required unless operating on runways less than 148 feet (45m) in width.

Techniques when using a Circular Turnaround

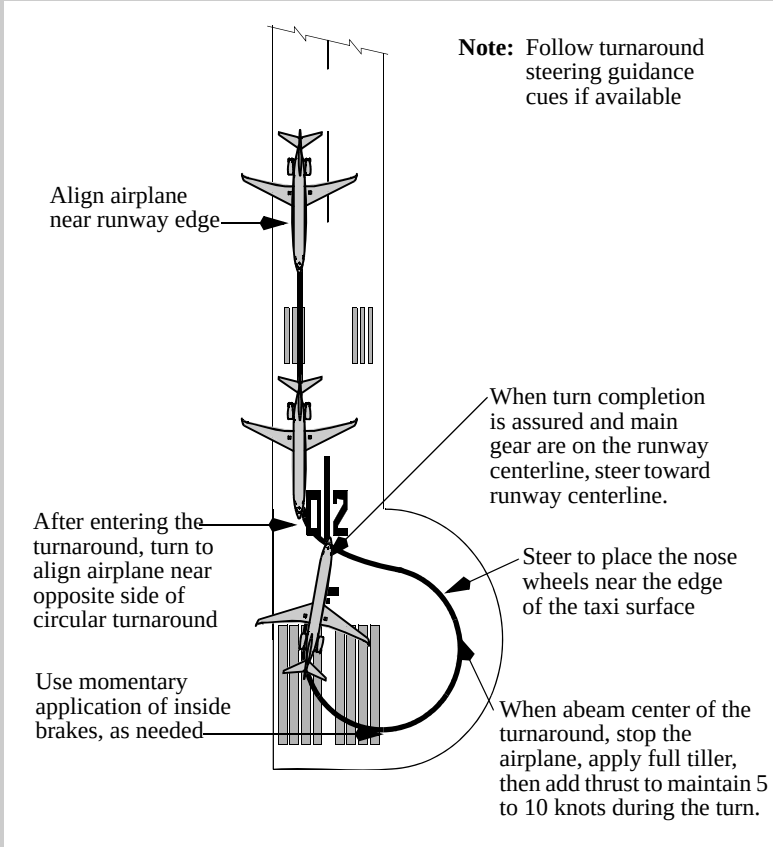


Techniques when using a Hammerhead Turnaround



Continued on next page

DELTA
MD-88/90 Flight Crew Training Manual

Techniques when using a Hammerhead Turnaround

Taxi - Adverse Weather

Taxi under adverse weather conditions requires more awareness of surface conditions.

When taxiing on a slippery or contaminated surface, particularly with strong crosswinds, use reduced speeds. Use of differential engine thrust assists in maintaining airplane momentum through the turn. Avoid using large nose wheel steering inputs to correct for skidding. Differential braking may be more effective than nose wheel steering on slippery or contaminated surfaces. If speed is excessive, reduce speed prior to initiating a turn. If no reaction to nose wheel steering occurs while taxiing on a slippery surface, the nose wheel is skidding. Center the nose wheel to prevent nose gear damage that could occur if surface traction is regained.

Note: A slippery surface is any surface where the braking capability is less than that on a dry surface. Therefore, a surface is considered “slippery” when it is wet or contaminated with ice, standing water, slush, snow or any other deposit that results in reduced braking capability. Be alert that painted areas on taxiways, ramps and runways are much more slippery than unpainted areas.

During cold weather operations, nose gear steering should be exercised in both directions during taxi. This circulates warm hydraulic fluid through the steering cylinders and minimizes the steering lag caused by low temperatures. If icing conditions are present, engine anti-ice switches should be turned on immediately after engine start.

During prolonged ground operation, periodic engine run-up should be accomplished to minimize ice build-up. These engine run-ups should be performed as defined in the Operations Manual Volume 1, Chapter SP, Section 16, Adverse Weather.

Engine exhaust may form ice on the ramp and takeoff areas of the runway, or blow snow or slush which may freeze on airplane surfaces. If the taxi route is through slush or standing water in low temperatures, or if precipitation is falling with temperatures below freezing, taxi with flaps up.

To reduce the possibility of flap damage after making an approach in icing conditions or landing on a runway covered with snow or slush, do not retract the flaps until the flap area has been checked free of debris by maintenance.

 DELTA
MD-88/90 Flight Crew Training Manual

Low Visibility

Pilots need a working knowledge of airport surface lighting, markings, and signs for low visibility taxi operations. Understanding the functions and procedures to be used with stop bar lights, ILS critical area markings, holding points, and low visibility taxi routes is essential to conducting safe operations. Many airports have special procedures for low visibility operations. For example, airports operating under FAA Surface Movement Guidance and Control System (SMGCS) criteria with takeoff and landing minimums below 1,200ft (350m) RVR are required to have a low visibility taxi plan. (See Airway Manual, chapter for additional information.)

Taxi - One Engine

Because of additional procedural requirements and crew workload, taxiing out for flight with an engine shut down requires a high degree of crew awareness. High bypass engines require warm up prior to applying takeoff thrust and cool down prior to shutting down. (MD-90) If the engine has been shut down for several hours, it is desirable to operate at as low a thrust setting as practical for several minutes prior to takeoff.

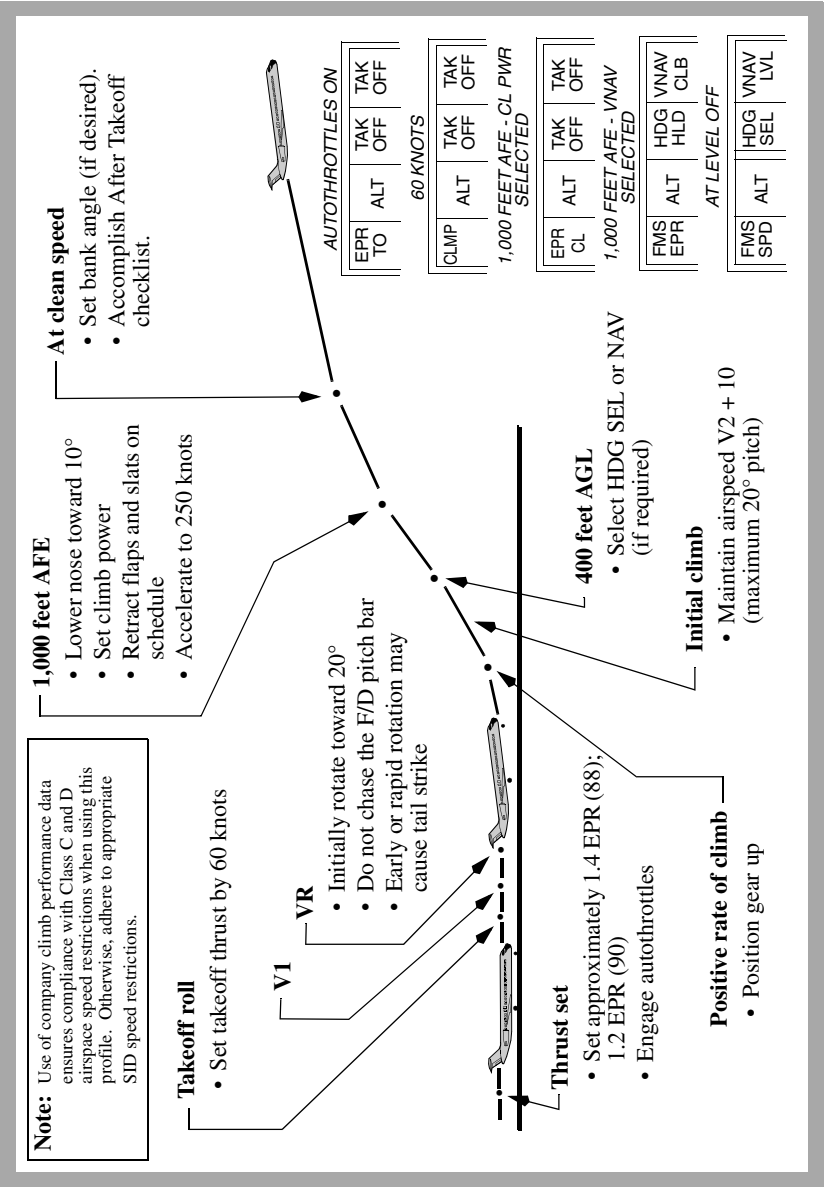
Note: When accomplishing delayed start procedure, start second engine in sufficient time (five minutes minimum when possible if engine has been shut down more than two hours) to achieve two minutes at idle prior to takeoff. This timely starting of the engines also provides adequate time for the orderly accomplishment of required checklists.

If taxiing after landing with an engine shut down, the crew must be aware of systems requirements, i.e., hydraulics, brakes, electrical. If possible, make minimum radius turns in a direction that puts the operating engine on the outside of the turn. In operational environments such as uphill slope, soft asphalt, high gross weights, congested ramp areas, and wet/slippery ramps and taxiways, taxi with both engines operating.

Takeoff

Normal Takeoff Profile (Distant/ICAO NADP 2)

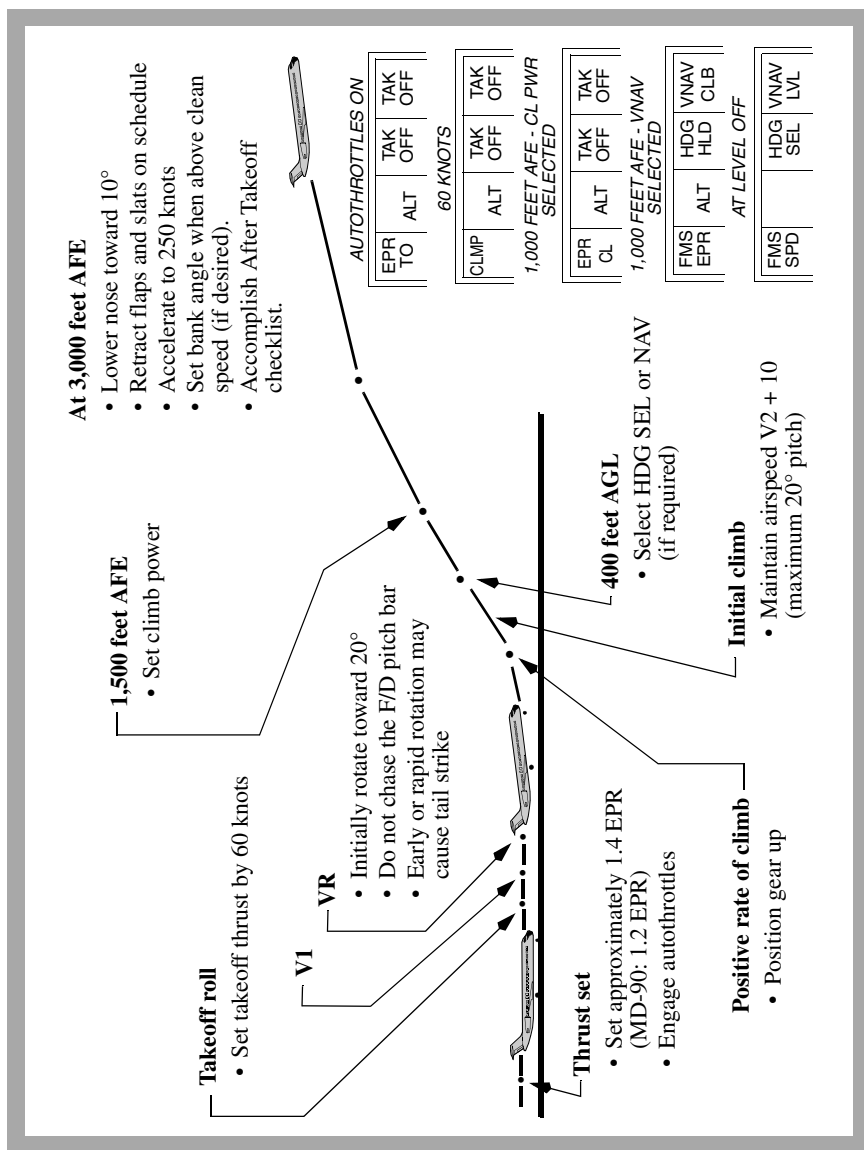
The following profile satisfies typical vertical noise abatement requirements.



MD-88/90 Flight Crew Training Manual

Special Takeoff Profile (Close-In /ICAO NADP 1)

The following profile satisfies noise abatement requirements for noise sensitive areas in close proximity to the departure end of an airport runway.



Takeoff Briefing

The takeoff briefing shall be accomplished prior to application of takeoff power. Refer to the FOM for a detailed description of items (e.g., HAA) to include in the takeoff briefing.

Takeoff - General

Normal takeoff procedures satisfy typical noise abatement requirements. Some airports may have special procedures which require modification of the takeoff profile.

Maintain $V_2 + 10$ until the noise abatement profile is satisfied, until clear of obstacles or above any minimum crossing altitude.

MD-90 procedures may require use of the FMS auto-thrust cutback function (ACB). Consult the airport special pages in the Delta Airways Manual for cutback EPR and altitude settings.

Note: Specific local airport procedures should be followed and are contained in Delta's Special Pages.

As part of the before start procedure, review the TAKEOFF REF page to ensure the entries are correct and the preflight is complete. Ensure V_2 is set on the FGCP. The map display, map range and LEGS page sequence should be consistent with the departure procedure.

Review the LEGS page for any climb constraints. Ensure the CLB page contains the appropriate altitude and airspeed restriction consistent with the departure procedure.

To reduce heads down activity, climb constraint modification immediately after takeoff should normally be accomplished on the flight guidance control panel. Modify the CLB page when workload permits.

Thrust Management

The autothrottle function of the Digital Flight Guidance Control System provides a full flight regime automatic throttle system that can control airspeed, Mach number, and engine thrust from takeoff through landing. Having the autothrottles functioning does not relieve pilots from monitoring the engine parameters and verifying proper thrust is obtained.

(90) The Electronic Engine Control (EEC) simplifies thrust management procedures. Having the EEC functioning does not relieve the pilots from monitoring the engine parameters and verifying proper thrust is obtained.

High thrust settings from jet engine blast over unpaved surfaces or thin asphalt pavement intended only to support occasional aircraft movements can cause structural blast damage from loose rocks, dislodged asphalt pieces, and other foreign objects. Ensure run ups and takeoff operations are only conducted over well maintained paved surfaces and runways.

Initiating Takeoff Roll

Autothrottle and flight director use is recommended for all takeoffs. However, do not follow F/D commands until after liftoff.

CAUTION: Rolling takeoffs are not permitted in icing or low visibility conditions. Refer to Normal Procedures, Introduction and Supplementary, Adverse Weather sections for additional guidance.

A rolling takeoff procedure is recommended for setting takeoff thrust. It expedites takeoff and reduces risk of foreign object damage or engine surge/stall due to a tailwind or crosswind. Flight test and analysis prove that the change in takeoff roll due to the Rolling Takeoff procedure is negligible when compared to a Static or Standing Takeoff.

A Rolling Takeoff is accomplished by:

- maintaining normal taxi speed when cleared for takeoff prior to, or while entering the assigned runway. When the airplane is aligned with the runway centerline, apply takeoff thrust by advancing the throttles to approximately 1.4 EPR (88), 1.2 EPR (90). Allow the engines to stabilize momentarily then promptly advance the throttles to takeoff thrust or engage autothrottles. There is no need to stop the airplane prior to adding thrust.

Note: When conditions permit, request takeoff clearance when approaching the hold short line so as to minimize the need to stop.

A Static Takeoff is accomplished by:

- holding in position on the assigned runway. When cleared for takeoff, ensure the nose wheel steering handwheel is released, release brakes, then apply takeoff thrust as described above. This method satisfies the criteria for Takeoff Minima in low visibility. Reference Airway Manual, Procedures (Ops. Specs.), Takeoff Minima.

Note: Brakes are not normally held with thrust above idle unless a Standing Takeoff is required in icing conditions.

A Standing Takeoff is accomplished by:

- holding the brakes while in position on the assigned runway until the engines are stabilized at approximately 1.4 EPR (88), 1.2 EPR (90). Ensure the nose wheel steering wheel is released, then release the brakes and promptly advance the throttles to takeoff thrust or engage autothrottles.

Note: Allowing the engines to stabilize provides uniform engine acceleration to takeoff thrust and minimizes directional control problems. This is particularly important if crosswinds exist or the runway surface is slippery. The exact initial setting is not as important as setting symmetrical thrust

When accomplishing a standing takeoff, taxi the aircraft onto the runway so as to leave as much of the runway available for the takeoff as possible. Align the aircraft with the runway centerline and come to a complete stop prior to commencing the takeoff. When holding in position at night, line up a few feet to the left or right of centerline to better enable a landing aircraft to visually differentiate the holding aircraft from the runway lighting.

Acceleration time from idle to the initial thrust setting can vary among engines because of differences in engine bleed configuration or fuel control acceleration schedules. Variations of up to three seconds are considered acceptable.

Note: During tailwind conditions, slight EPR fluctuations may occur on some engines prior to 5 knots forward airspeed.

During takeoff, if an engine exceedance occurs after thrust is set and the decision is made to continue the takeoff, do not retard the throttle in an attempt to control the exceedance. Retarding the throttles after thrust is set invalidates takeoff performance. When the PF judges that altitude (minimum 400 feet AGL) and airspeed are acceptable, the throttle should be retarded until the exceedance is within limits and the appropriate NNC accomplished.

The PM should monitor engine instruments and both primary and standby airspeed indications during the takeoff roll and announce any abnormalities. The PM should verify that takeoff thrust has been set and the autothrottle system clamp mode (CLMP) is engaged. The PM should also announce passing 80 knots, and the PF should verify that his airspeed indicator is in agreement.



MD-88/90 Flight Crew Training Manual

A pitot system blocked by protective covers or foreign objects can result in no airspeed indication, or airspeed indications that vary between instruments. It is important that aircrews ensure airspeed indicators are functioning and reasonable at the 80 knot callout. If there are any questions, another source of speed information is the ground speed indication. Early recognition of a malfunction is important in making a sound go/stop decision. Refer to the unreliable airspeed section in chapter 6 for an expanded discussion of this subject.

Note: Once CLMP annunciates, the A/T cannot change throttle position, but throttles can be positioned manually. Takeoff into headwind of 20 knots or greater may result in CLMP before the autothrottle can make final thrust adjustments.

The CLMP mode protects against throttle movement if a system fault occurs. Lack of the CLMP annunciation means the protective feature may not be active. If CLMP annunciation does not appear, no crew action is required unless a subsequent system fault causes unwanted throttle movement. As with any autothrottle malfunction, the autothrottles should then be disconnected and desired thrust set manually.

If full thrust is desired when CLMP mode is displayed, the throttles must be manually advanced.

After the airplane is in the air, pushing a TO/GA switch advances the thrust to maximum available thrust and TO/GA is annunciated.

Rotation and Liftoff - All Engines

Takeoff speeds are established based on minimum control speed, stall speed, and tail clearance margins. Shorter airplanes are normally governed by stall speed margin while longer bodied airplanes are normally limited by tail clearance margin. When a smooth continuous rotation is initiated at VR, tail clearance margin is assured because computed takeoff speeds depicted in the ODM, airport analysis, or FMC, are adjusted to provide adequate tail clearance.

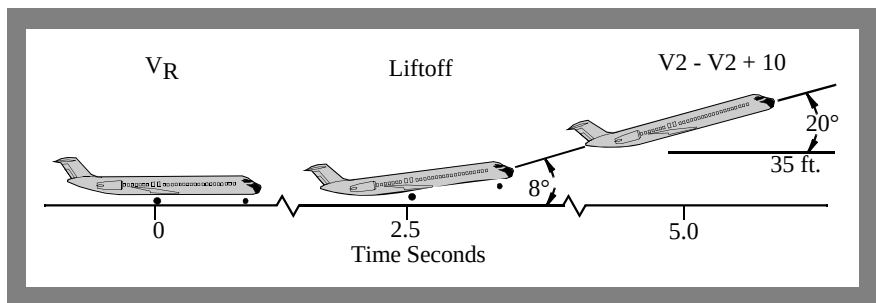
Above 80 knots, relax the forward control column pressure to the neutral position. At VR, commence a smooth, continuous rotation (approximately 3 degrees per second) to attain a speed of $V_2 + 10$ knot minimum, limiting pitch to 20 degrees. Slow or fast rotation will seriously degrade takeoff performance.

After lift-off use the flight director as the primary pitch reference cross checking indicated airspeed and other flight instruments.

Note: The flight director pitch command is not used for rotation.

Typical Rotation, All Engines

The following figure shows typical rotation with all engines operating.



Retract the landing gear after a positive rate of climb is indicated on the barometric altimeter.

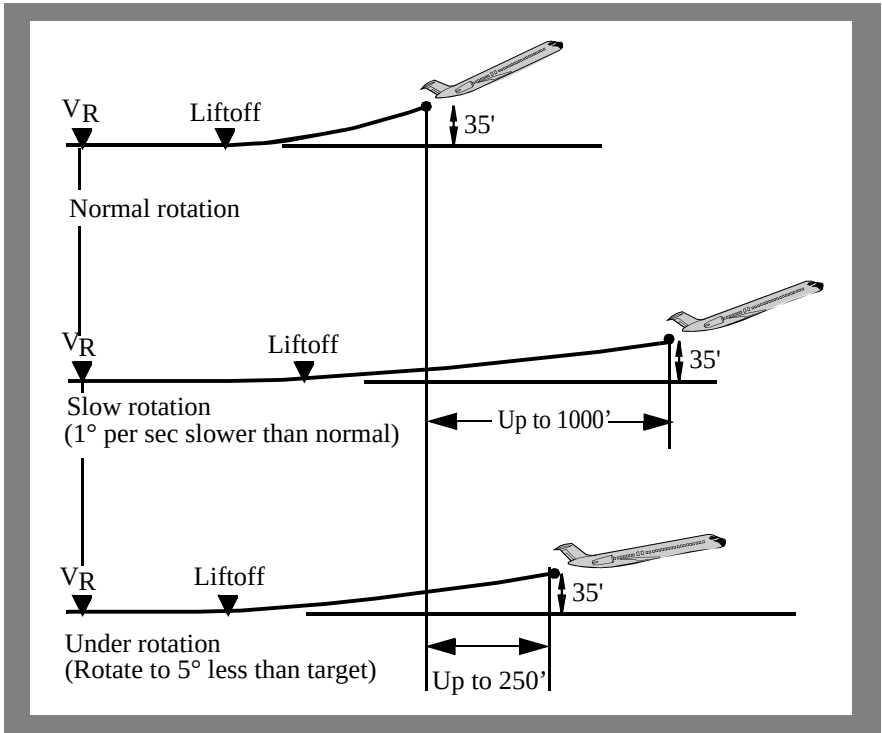
Retract the flaps in accordance with the technique described in this chapter.

Effect of Rotation Speed and Pitch Rate on Liftoff

Takeoff and initial climb performance depend on rotating at the correct airspeed and proper rate to the rotation target attitude. Early or rapid rotation may cause a tail strike. Late, slow, or under-rotation increases takeoff ground roll. Any improper rotation decreases initial climb flight path.

The following diagram shows how a slow or under rotation during takeoff increases the distance to a height of 35 feet compared to a normal rotation.

Slow or Under Rotation (Typical)



Center-Of-Gravity (C.G.) Effects

When taking off at light weight and with an aft C.G., the combination of full thrust, rapid thrust application, and sudden brake release may tend to pitch the nose up, reducing nosewheel steering effectiveness. With C.G. at or near the aft limit, maintain forward pressure on the control column until 80 knots to increase nosewheel steering effectiveness. Above 80 knots, relax the forward control column pressure to the neutral position. At light weight and aft C.G., use of reduced thrust and rolling takeoff technique is recommended whenever possible. The rudder becomes effective between 40 and 60 knots.

Crosswind Takeoff

Crosswind guidelines were derived through flight test data and engineering analysis.

Note: Engine surge can occur with a strong crosswind component if takeoff thrust is set prior to brake release. Therefore, the rolling takeoff procedure is strongly advised when crosswinds exceed 20 knots.

Takeoff Crosswind Guidelines

Crosswind guidelines are not considered limitations.

Takeoff crosswind guidelines are based upon the most adverse airplane loading (light weight and aft center of gravity) and assume an engine out RTO. On slippery runways, crosswind guidelines are a function of runway surface condition, and assume proper pilot technique.

Refer to Operations Manual Volume 1, Supplementary Procedures, Adverse Weather section, Guidelines for Contaminated Runways.

Directional Control

Initial runway alignment and smooth symmetrical thrust application result in good crosswind control capability during takeoff. Light forward pressure on the control column during the initial phase of takeoff roll (below approximately 80 knots) increases nose wheel steering effectiveness. Any deviation from the centerline during thrust application should be countered with immediate smooth and positive control inputs. Smooth rudder control inputs combined with small control wheel inputs result in a normal takeoff with no overcontrolling.

Note: During wet or slippery runway conditions, and or high crosswind the PM should give special attention to assuring the engines have symmetrically balanced thrust indications.

Rotation and Takeoff

Maintain wings level throughout the takeoff roll by applying control wheel displacement into the wind. During rotation continue to apply control wheel in the displaced position to keep the wings level during liftoff. The airplane is in a sideslip with crossed controls at this point. A slow, smooth recovery from this sideslip is accomplished after liftoff by slowly neutralizing the control wheel and rudder pedals.

 DELTA
MD-88/90 Flight Crew Training Manual

Gusty Wind and Strong Crosswind Conditions

For takeoff in gusty or strong crosswind conditions, use of a higher thrust setting than the minimum required is recommended. When the prevailing wind is at or near 90° to the runway, the possibility of wind shifts resulting in gusty tailwind components during rotation or liftoff increases. During this condition, consider normal takeoff thrust. The use of a higher takeoff thrust setting reduces the required runway length and minimizes the airplane exposure to gusty conditions during rotation, liftoff, and initial climb.

Avoid rotation during a gust. If a gust is experienced near VR, as indicated by stagnant airspeed or rapid airspeed acceleration, momentarily delay rotation. This slight delay allows the airplane additional time to accelerate through the gust and the resulting additional airspeed improves the tail clearance margin. Do not rotate early or use a higher than normal rotation rate in an attempt to clear the ground and reduce the gust effect because this reduces tail clearance margins. Limit control wheel input to that required to keep the wings level. All of these factors provide maximum energy to accelerate through gusts while maintaining tail clearance margins at liftoff. The airplane is in a sideslip with crossed controls at this point. A slow, smooth recovery from this sideslip is accomplished after liftoff by slowly neutralizing the control wheel and rudder pedals.

Reduced Thrust Takeoff

Delta performs reduced thrust takeoffs whenever performance limits and noise abatement procedures permit. The reduced thrust takeoff lowers EGT and extends engine life. Some or all reduced thrust settings may not be available on colder days. Higher assumed temperatures result in takeoff EPR less than Max Climb EPR. The MD-88 automation will not set a Flex EPR less than Climb EPR.

Assumed Temperature Method (ATM)

This method achieves a takeoff thrust less than the full rated takeoff thrust by using an assumed temperature that is higher than the actual temperature. The maximum thrust reduction authorized by most regulatory agencies is 25% below any certified rating. Use the takeoff speeds provided by AWABS.

The thrust setting parameter (EPR/N1) is not considered a limitation. If conditions are encountered during the takeoff where additional thrust is desired, such as windshear or temperature inversion, the crew should not hesitate to manually advance throttles to maximum rated thrust.

Improved Climb Performance Takeoff

When not field length limited, an increased climb limit weight is achieved by using the excess field length to accelerate to higher takeoff and climb speeds. This improves the climb gradient, thereby raising the climb limit weight. V1, VR and V2 are increased to maintain consistent performance relationships. V1, VR and V2 must be obtained from dispatch or a runway analysis.

Low Visibility Takeoff

Low visibility takeoff operations, below landing minima, may require a takeoff alternate. When selecting a takeoff alternate, consideration should be given to unexpected events such as an engine failure or other non-normal situation that could affect landing minima at the takeoff alternate.

With proper crew training and appropriate runway lighting, takeoffs with visibility as low as 500ft/150m RVR may be authorized (FAA). Regulatory agencies may impose takeoff crosswind limits specifically for low visibility takeoffs.

All RVR readings must be equal to or greater than required takeoff minima. If the touchdown or rollout RVR system is inoperative, the mid RVR may be substituted for the inoperative system.

Adverse Runway Conditions

Slush, standing water, or deep snow reduces the airplane takeoff performance because of increased rolling resistance and the reduction in tire-to-ground friction.

Delta specifies weight reductions to the AFM field length and/or obstacle limited takeoff weight based upon the depth of powdery snow, slush, wet snow or standing water and a maximum depth where the takeoff should not be attempted.

Note: The flight crew must ensure the actual takeoff weight is less than or equal to the PERF LIMIT weight for the selected runway and condition.

Slush or standing water may cause damage to the airplane. The maximum runway depth for slush, standing water, or wet snow is 0.5 inch (12.7 mm). For dry snow the maximum depth is 4 inches (102 mm).

A slippery runway (wet, compact snow, ice) also increases stopping distance during a rejected takeoff. Takeoff performance and critical takeoff data are adjusted to fit the existing conditions. Check the AWABS or ODM for takeoff performance changes with adverse runway conditions

Note: If there is an element of uncertainty concerning the safety of an operation with adverse runway conditions, do not takeoff until the element of uncertainty is removed.

MD-88/90 Flight Crew Training Manual

During wet runway or slippery conditions, the PM must give special attention to assuring that the thrust on the engines advances symmetrically. Any tendency to deviate from the runway centerline must immediately be countered with steering action and, if required, slight differential thrust.

Forward pressure on the control column during the initial portion of the takeoff roll (below approximately 80 knots) increases nose wheel steering effectiveness.

During takeoffs on icy runways, lag in rudder pedal steering and possible nose wheel skidding must be anticipated. Keep the airplane on the centerline with rudder pedal steering and rudder. The rudder becomes effective between 40 - 60 knots. If deviations from the centerline cannot be controlled either during the start of the takeoff roll or until the rudder becomes effective, immediately reject the takeoff.

Effect of Deicing/Anti-Icing Fluids on Takeoff

Testing of undiluted Type II and Type IV fluids has shown that some of the fluid remains on the wing during takeoff rotation and during initial climb out. The residual fluid causes a temporary decrease in lift and increase in drag. These effects are more significant at lower ambient temperatures where the fluid tends to stay on the wing longer. Operators must comply with the lowest operational use temperatures provided by the fluid manufacturer to ensure a relatively clean wing.

No performance adjustments are required for the application of deicing/anti-icing fluids. Takeoff operations with reduced thrust based on derates and/or the assumed temperature method are permitted. Use normal rotation rates.

Federal Aviation Regulation (FAR) Takeoff Field Length

The FAR takeoff field length is the longest of the following:

- The distance required to accelerate with all engines, experience an engine failure 1 second prior to V₁, continue the takeoff and reach a point 35 feet above the runway at V₂ speed. (Accelerate-Go Distance).
- The distance required to accelerate with all engines, experience an event 1 second prior to V₁, recognize the event, initiate the stopping maneuver and stop within the confines of the runway (Accelerate-Stop Distance).
- 1.15 times the all engine takeoff distance required to reach a point 35 feet above the runway.

Stopping distance includes the distance traveled while initiating the stop and is based on the measured stopping capability as demonstrated during certification flight test.

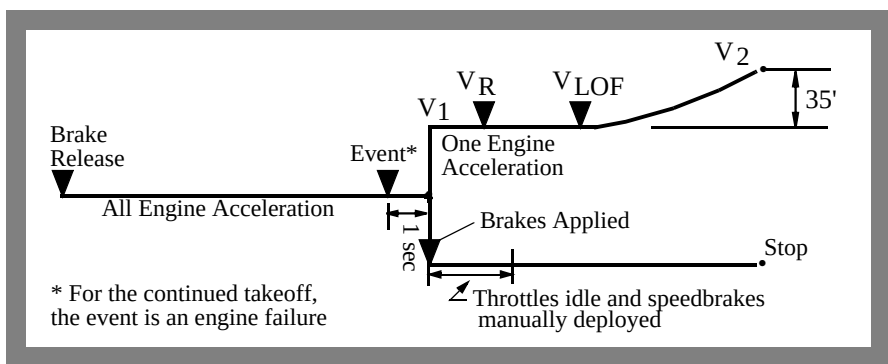
During certification maximum manual braking and speedbrakes are used. Thrust reversers are not used. Although reverse thrust and autobrakes are not used in determining the FAR accelerate-stop distance, thrust reversers should be used during any operational rejected takeoff.

Calculating a V_1 speed that equates accelerate-go and accelerate-stop distances allows the maximum takeoff weight for dispatch from a given runway length. This is known as a “balanced field length.” The associated V_1 speed is called the “balanced V_1 ” and is the V_1 speed listed in the ODM and the Flight Management Computer. The V_1 speeds depicted for derated takeoffs are also “balanced V_1 ” speeds.

When using reduced thrust for takeoff, the “assumed temperature” for a given runway (either the field limit weight or climb limit weight) dictates the maximum weight or assumed temperature to be used. When using derated thrust for takeoff, the derate must also take performance calculations into account. The resulting assumed temperature V_1 is the equivalent “balanced V_1 ” for that particular takeoff.

Takeoff gross weight must not exceed the climb limit weight, field limit weight, obstacle limit weight, tire speed limit, or brake energy limit.

FAR Takeoff



MD-88/90 Flight Crew Training Manual

Rejected Takeoff Decision

The total energy that must be dissipated during an RTO is proportional to the square of the airplane velocity. At low speeds (up to approximately 80 knots), the energy level is low. Therefore, the airplane should be stopped if an event occurs that would be considered undesirable for continued takeoff roll or flight. Examples include Master Caution, unusual vibrations or tire failure.

Note: Refer to the QRH, NNM.1, Non-Normal Maneuvers section for guidance concerning the decision to reject a takeoff below and above 80 knots.

As the airspeed approaches V1 during a balanced field length takeoff, the effort required to stop can approach the airplane maximum stopping capability. Therefore, the decision to abort must be initiated prior to V1.

Historically, rejecting a takeoff near V1 has often resulted in the airplane stopping beyond the end of the runway. Common causes include initiating the RTO after V1 and failure to use maximum stopping capability (improper procedures/techniques). The maximum braking effort associated with an RTO is a more severe level of braking than most pilots experience in normal service.

Rejecting the takeoff after V1 is not recommended unless the captain judges the airplane incapable of flight. Even if excess runway remains after V1, there is no assurance that the brakes have the capacity to stop the airplane prior to the end of the runway.

Rejected Takeoff Maneuver

The rejected takeoff (RTO) maneuver is initiated during the takeoff roll to expeditiously stop the airplane on the runway. The PM should closely monitor essential instruments throughout the takeoff roll and immediately announce abnormalities, such as “ENGINE FIRE”, “ENGINE FAILURE”, or any adverse condition significantly affecting safety of flight. The decision to reject the takeoff is the responsibility of the Captain, and must be made prior to V1 speed. If the Captain is the PM, he/she should initiate the RTO and announce the abnormality simultaneously.

Note: If the decision is made to reject, the flight crew should accomplish the procedure in the NNM chapter of the QRH.

If rejecting due to fire, in windy conditions consider positioning the aircraft so the fire is on the downwind side. After an RTO, comply with brake cooling requirements before attempting a subsequent takeoff.

Go/Stop Decision near V1

It was determined when the aviation industry produced the Takeoff Safety Training Aid in 1992 that the existing definition of V1 might have caused confusion because they did not make it clear that V1 is the maximum speed at which the flight crew must take the first action to reject a takeoff. The U.S. National Transportation Safety Board (NTSB) also noted in their 1990 study of rejected takeoff accidents, that the late initiation of rejected takeoffs was the leading cause of runway overrun accidents. As a result, the FAA has changed the definition of V1 in FAR Part 1 to read as follows:

- V1 means the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance; and,
- V1 also means the minimum speed in the takeoff, following a failure of the critical engine, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.

Pilots know that V1 is fundamental to making the Go/Stop decision. Under runway limited conditions, if the reject procedure is initiated at V1, the airplane can be stopped prior to reaching the end of the runway.

When the takeoff performance in the Airplane Flight Manual is produced, it assumes an engine failure or event one-second before V1. In a runway limited situation, this means the airplane reaches a height of 35 feet over the end of the runway if the decision is to continue the takeoff.

Within reasonable limits even if the engine failure occurs earlier than the assumed one second before V1, a decision to continue the takeoff will mean that the airplane is lower than 35 feet at the end of the runway, but it is still flying. For instance if the engine fails two seconds prior to V1 and the decision is made to go, the airplane will reach a height of 15 to 20 feet at the end of the runway.

Although training has historically centered on engine failures as the primary reason to reject, statistics show engine thrust loss was involved in approximately one quarter of the accidents, and wheel or tire problems have caused almost as many accidents and incidents as have engine events. Other reasons that rejects occurred were for configuration, indication or light, crew coordination problems, bird strikes or ATC problems.

What's important to note here is that the majority of past RTO accidents were not engine failure events. Full takeoff power from all engines was available. With normal takeoff power, the airplane should easily reach a height of one hundred fifty feet over the end of the runway and the pilot has the full length of the runway to stop the airplane if an air turnback is required.

**MD-88/90 Flight Crew Training Manual**

Making the Go/Stop decision starts long before V1. A thorough brief, early detection, good crew coordination and quick reaction are the keys to a successful takeoff or stop.

RTO Execution

A successful rejected takeoff at or near V1 is dependent upon the Captain making timely decisions and using the proper procedures found in the Quick Reference Handbook, Non-Normal Maneuvers chapter, Non-Normal Maneuvers section, Rejected Takeoff Procedure.

Initial Climb - All Engines

After liftoff use the flight director as the primary pitch reference cross checking indicated airspeed and other flight instruments. If the flight director is not used, indicated airspeed and attitude become the primary pitch references.

After liftoff, the flight director commands pitch to maintain an airspeed of V2 + 10 knots until another pitch mode is engaged.

V2 + 10 is the optimum climb speed with takeoff flaps. It results in the maximum altitude gain in the shortest distance from takeoff. Acceleration to higher speeds reduces the altitude gain. If airspeed exceeds V2 + 10 during initial climb, stop the acceleration by increasing pitch to a maximum of 20 degrees, but do not attempt to reduce airspeed to V2 + 10. A speed slightly higher than V2 + 10 will not significantly affect the climb profile. Crosscheck indicated airspeed for proper initial climb speed.

Retract the landing gear after a positive rate of climb is indicated on the barometric altimeter. Do not apply brakes after becoming airborne. Braking is automatically applied when the landing gear lever is placed in the up position. After gear and flaps are retracted, the PM should verify the gear and flaps indications are normal.

Minimum Fuel Operation - Takeoff

The minimum fuel recommended for takeoff is trip fuel plus reserves and is listed on the flight plan. Contact dispatch if an adjustment to the minimum fuel is required. On very short flights this fuel quantity may not be enough to prevent forward fuel pump low pressure lights from illuminating after takeoff.

Immediate Turn after Takeoff - All Engines

Obstacle clearance, noise abatement, or departure procedures may require an immediate turn after takeoff. Initiate the turn at the appropriate altitude (normally at least 400 feet AGL) and limit bank angle to 15 degrees maximum until maneuver speed for the takeoff configuration is attained.

Note: A maximum bank angle of 30° is permitted at V2 + 20 knots with takeoff flaps.

Climb performance is slightly reduced while turning but is accounted for in the airport analysis.

After completing the turn, and at or above flap retraction altitude, accelerate and retract flaps while climbing.

Note: The possibility of an engine failure along the departure track must be considered. Special engine out procedures, if available, are preferable to a takeoff weight reduction to ensure all obstacles are cleared.

Roll Modes

After takeoff and climb is stabilized, select NAV, or HDG SEL, on the FGCP after passing 400 feet AGL. NAV (lateral guidance) outputs from the FMC are normally great circle courses between the waypoints making up the active route. However, when a procedure stored in the FMC database is entered into the active route, the FMC can supply commands to fly a constant heading, track, or follow a DME arc.

NAV 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.

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 degrees of bank. However, the bank angle limit is 15 degrees if NAV is engaged, the slats are extended, and the airspeed is less than an FMC computed minimum speed.

If the departure procedure or route does not begin at the end of the runway, it may be necessary to use the HDG SEL mode at 400 feet AGL to intercept the desired track for NAV capture. When the departure procedure is not a part of the active flight plan, use HDG SEL or HDG HOLD mode. When an immediate turn after takeoff is necessary, the desired heading may be preset before takeoff.

Nav aids and appropriate radials required for use during the departure may be displayed on the navigation display using the FIX page feature and/or VOR/ADF. Use of the MAP declutter buttons on the EFIS mode selector panel provides additional information on the navigation display.

Pitch Modes

Normally, VNAV is engaged at 1000 feet AGL. The use of VNAV for climb is the preferred method of managing the FMS. This provides the VNAV profile and acceleration schedule compatible with the planned departure.

Autopilot Engagement

The airplane should be in trim, and the flight director commands should be satisfied prior to autopilot engagement. This prevents unwanted changes from the desired flight path during autopilot engagement.

Flap Retraction Schedule

1,000 feet AFE is normally used for acceleration height to initiate thrust reduction and flap retraction. For noise abatement considerations during line operations, thrust reduction typically occurs at approximately 1,000 feet AFE and acceleration typically occurs between 1,000 and 3,000 feet AFE, or as specified by individual airport noise abatement procedures (See Delta 10-0 [green] page in the Airway Manual).

At thrust reduction altitude, select or verify climb thrust is set. At acceleration height, set flaps up maneuvering (clean) speed by briefly lowering pitch to approximately 10 degrees and retract flaps on the Flap Retraction Schedule.

The 10 degree pitch attitude will allow the aircraft to rapidly accelerate to clean speed while climbing. The goal is to accelerate to the clean speed as soon as practical, but as a technique, also keep the aircraft climbing. If the 10 degree pitch attitude generates something significantly less than 1,000 fpm, the pilot should increase the pitch attitude to obtain a higher climb rate and accept the slower acceleration to clean speed. If the 10 degree pitch attitude generates a climb in excess of 1,000 fpm, maintain the 10 degree pitch and accept the added performance.

Retract flaps and slats on schedule.

Accelerate to clean maneuvering speed:

- If using FMS, select VNAV.
- If not using the FMS, or VNAV, select IAS on the FGCP and rotate pitch wheel to clean speed.

Climb to 2,500 feet AFE at minimum maneuvering clean speed.

At 2,500 feet AFE, accelerate to 250 knots (unless special procedures dictate otherwise.):

- If using VNAV, observe programmed acceleration.
- If using DFSGS, select 250 knots on the pitch wheel.
- (MD-90) If rate of climb falls below 1000 fpm, select next higher CL thrust.

Reset bank angle selector as desired when above clean speed.

Note: Do not move the FLAP TAKEOFF selector unless the FLAP/SLAT handle is in the UP RET position as the mechanism may cause binding/jamming of the FLAP/SLAT handle.

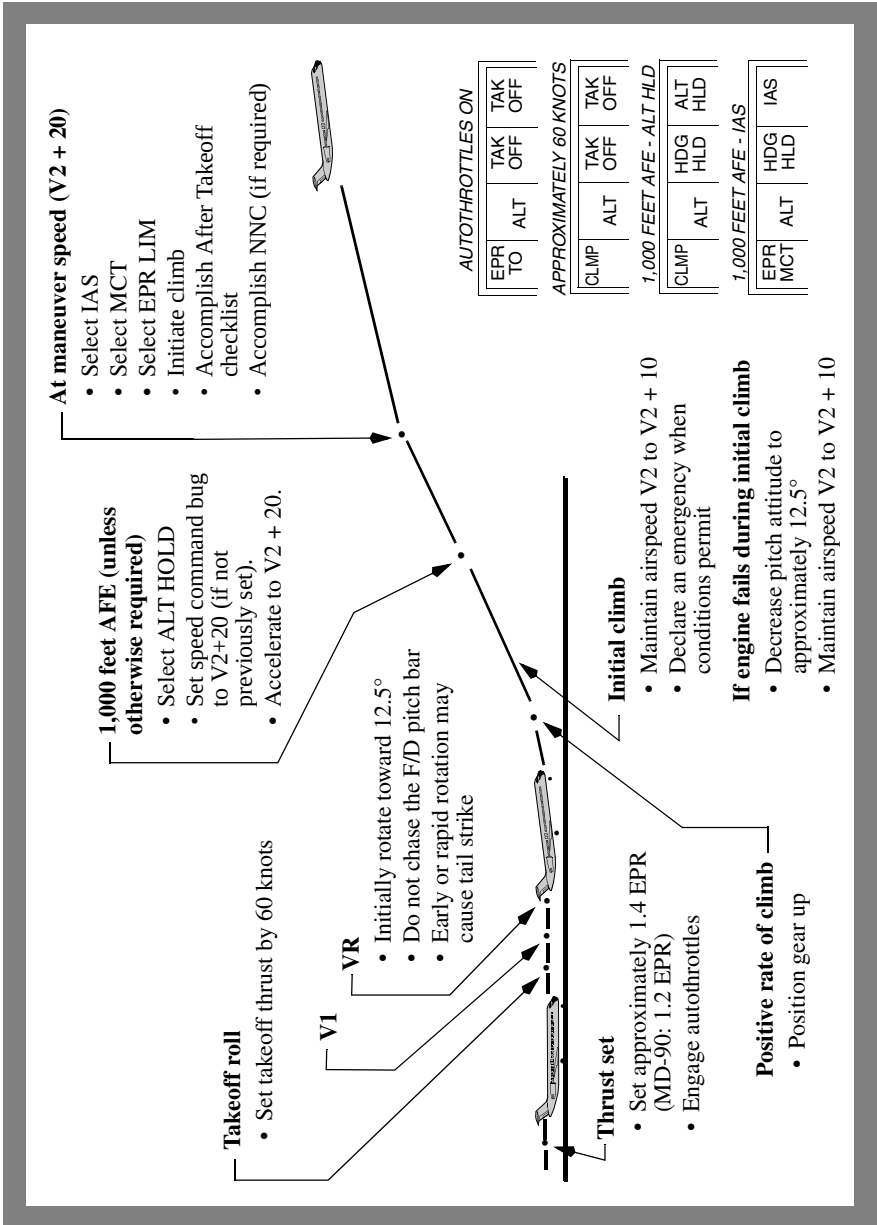
Takeoff Flap Retraction Speed Schedule

Configuration	Flap Retraction Speed
Flaps 1-13	V2 + 5 knots
Flaps 15-24	V2 + 15 knots

 DELTA
 MD-88/90 Flight Crew Training Manual

Takeoff - Engine Failure

Takeoff Profile - Engine Failure



Takeoff Engine Failure - General

One engine out controllability is excellent during takeoff roll and after liftoff. Minimum control speed in the air (VMCAs) are below VR and VREF.

Engine Failure Recognition

An engine failure at or after V1 initially affects yaw much like a crosswind effect. Vibration and noise from the affected engine may be apparent and the onset of yaw may be rapid.

The airplane heading is the best indicator of the correct rudder pedal input. To counter the thrust asymmetry due to an engine failure, stop the yaw with rudder. At V1 approximately 1/3 to 1/2 rudder pedal deflection is required to provide directional control with nosewheel still in contact with the runway. Under some conditions failure may not be immediately felt and should be identified or confirmed by engine instruments.

Rotation - One Engine Inoperative

If an engine fails at or after V1, the takeoff should be continued.

Maintain directional control by smoothly applying rudder proportionate with thrust decay. Aileron should not be required due to the effect of engine failure alone.

- The PM will verbally announce the engine failure upon recognition.
- Normally, the PF will continue to fly the aircraft.
- The PF should maintain runway centerline or a line parallel to the runway centerline using rudder inputs.

At V/R, smoothly rotate to no less than 12.5 degrees nose high. Do not follow the pitch steering bar.

Anticipate the need for additional rudder as the nosewheel comes off the ground due to loss of rudder pedal steering. Once airborne, maintain rudder inputs and use ailerons as the primary directional control.

Note: At nosewheel liftoff, the aircraft's heading, not the runway heading, will be commanded by the F/D bank steering bar in the TAK OFF roll mode.

CLMP	ALT	TAK OFF	TAK OFF

**MD-88/90 Flight Crew Training Manual**

If the engine failure occurs at or after liftoff apply rudder and aileron to control heading and keep the wings level. In-flight, adjust rudder trim to center the control wheel. Use white markings on other pilot's control wheel as a reference for centering. Centering the control wheel results in coordinated flight and a minimum drag configuration.

Liftoff Pitch Attitude - One Engine Inoperative

Liftoff attitude should be achieved in approximately 5 seconds. Adjust pitch attitude, as required, to maintain desired airspeed of V_2 to V_2+10 .

The attitude is held until the automation catches up with the fact that an engine has failed. Maintain a pitch attitude of 12.5 degrees until the pitch steering bar decreases from 20 degrees to the 12-15 degree range. At this point the reference pitch attitude is transferred to the F/D pitch bar and followed to 1,000 feet AFE. The visual cue for this is when the Fast/Slow display is centered, or at least active in the range of centered to +10 kts. Following the Pitch Bar to 1,000 feet AFE should ensure the airspeed remains within the maneuver standards.

Initial Climb - One Engine Inoperative

If the engine failure occurs after V1 but before V2, maintain V2; if failure occurs after V2 but before V2 + 10 knots, maintain that speed; and if failure occurs when the speed is greater than V2 + 10, increase pitch to attain V2 + 10.

Once a climb has been established, the flight director will provide proper pitch guidance. Cross check indicated airspeed, vertical speed and other flight instruments. The flight director commands a minimum of V2, or the existing speed up to a maximum of V2 + 10. Avoid rapid pitch changes - establish an attitude and check speed trend.

If the flight director is not used, indicated airspeed and attitude become the primary pitch references. The flight director roll mode commands wings level after liftoff until another roll mode is selected. If ground track is not consistent with desired flight path, use HDG SEL to achieve the desired track.

From the standpoint of directional control, the upwind engine is usually the most critical since both the asymmetrical thrust and crosswind component are forces acting in the same direction.

- Apply rudder and/or rudder trim to level the control wheel. Initial climb may require approximately full rudder trim.
- Declare an emergency.
- Comply with Delta Airway Manual 10-0 page engine failure instructions (if applicable).
- 15 degree angle of bank maximum until achieving V2 + 20.

Prior to 400 Feet:

- Do not make any thrust changes or take other action requiring the input of the PF, except trim adjustments, until 400 feet AFE.
- Do not initiate communications below 400 feet unless called by an ATC facility.

Note: Derated thrust takeoffs meet all performance requirements.

At 1,000 Feet AFE (unless otherwise required)

- Maintain configuration (flaps and slats extended).
- Select ALT HOLD and follow the FD pitch bar to leveloff.

 DELTA
MD-88/90 Flight Crew Training Manual

CLMP

ALT

HDG
HLDALT
HLD

- Accelerate to at least minimum maneuver speed for existing flaps. ($V_2 + 20$ is a minimum maneuver speed for all T/O flap settings and weights).

At Maneuver Speed (Minimum)

- Select IAS.
- Select MCT.
- Select EPR LIM if using autothrottles. The throttles may have retarded to maintain maneuver speed. Selecting EPR LIM will advance them to EPR MCT.

EPR
MCT

ALT

HDG
HLD

IAS

- Initiate a climb to pattern or vector altitude.
- After establishing the climb, engage the autopilot if desired. Adjust rudder trim to level the control wheel.

At A Safe Altitude And When Time Permits

Call for AFTER TAKEOFF checklist:

- It is not necessary to complete this check in its entirety.
- Confirm gear is UP.
- Select ignition OFF.
- Disarm spoilers.
- Select autobrakes OFF.

Call for the ENGINE FAILURE/SHUTDOWN procedure (if applicable).

- The NO MODE light remains illuminated on the TRP and the air-conditioning packs will not operate until the AIR COND AUTO SHUTOFF switch is placed in OVRD.

Plan for return to field or diversion to takeoff alternate. If circumstances require diverting to at takeoff alternate:

- Clean up as desired when time permits and above all obstructions.
- Climb to cruise altitude at single engine climb speed (slat retract speed + 20 knots).

Note: Slat retract speed + 20 knots is not a maneuvering speed. Do not use bank angles greater than 15 degrees. Use of NAV may result in turns greater than 15 degrees of bank.

Indications of an engine fire, impending engine breakup or approaching or exceeding engine limits, should be dealt with as soon as possible. Accomplish the appropriate recall checklist items as soon as the airplane is under control, the gear has been retracted and a safe altitude (typically 400 feet AGL or above) has been attained. Accomplish the reference checklist items when conditions permit.

Immediate Turn after Takeoff - One Engine Inoperative

Obstacle clearance or departure procedures may require an immediate turn after takeoff. Initiate the turn at the appropriate altitude (normally at least 400 feet AGL). Climb performance is slightly reduced while turning but is accounted for in the airport analysis.

Note: Limit bank angle to 15° until $V_2 + 20$ knots. Bank angles up to 30° are permitted at $V_2 + 20$ knots with takeoff flaps.

Noise Abatement - One Engine Inoperative

When an engine failure occurs after takeoff, noise abatement is no longer a requirement.

Engine Failure During Reduced Thrust Takeoff

Takeoff thrust reduction is based on a minimum climb gradient that clears all obstructions with an engine failure after V_1 . If reduced thrust is used and an engine failure occurs, based on performance, it is not necessary to set maximum thrust on the remaining engine. However, if maximum thrust is desired, thrust on the operating engine may be increased. The preferred technique is to press either T.O. or GA buttons on the TRP (when above 400 feet AFE). This action will cause the EPR chevrons to move to reference the appropriate EPR setting and allow the PM to set the new thrust manually.

For reduced thrust takeoffs, resetting the operating engine to full thrust provides additional performance margin. This additional performance margin is not a requirement of the reduced thrust takeoff certification and its use is at the discretion of the flight crew. It should be noted the assumed temperature method of computing reduced thrust takeoff performance is always conservative and provides performance equal to or better than the performance obtained if actually operating at the assumed temperature.

Climb, Cruise, Descent
Table of Contents

Chapter 3
Section 0

Preface	3.1
Climb.....	3.1
Climb Thrust	3.1
Reduced Thrust Climb	3.1
Climb Constraints	3.1
Low Altitude Level Off Without VNAV	3.2
Low Altitude Level Off With VNAV	3.2
Transition to Climb	3.2
Climb Speed Determination	3.2
Engine Icing During Climb	3.3
Economy Climb	3.3
Economy Climb Schedule - FMC Data Unavailable	3.3
Maximum Rate Climb	3.3
Maximum Angle Climb	3.4
Engine Inoperative Climb	3.4
Intermediate Level Off	3.6
10,000' Level Off	3.6
Cruise	3.7
Autopilot Level Off	3.7
Maximum Altitude	3.7
Optimum Altitude	3.8
Cruise Speed Determination	3.9
Step Climb	3.9
Cruise Performance Economy	3.10
Engine Inoperative Cruise/Driftdown	3.11
High Altitude High Speed Flight	3.16
Low Speed at Altitude	3.16

Descent	3.17
Methods of Descending.....	3.17
VNAV	3.17
Descent Speed Determination	3.18
Descent Path	3.18
Descent Constraints.....	3.18
Speed Intervention.....	3.19
IAS/MACH	3.19
Vertical Speed	3.20
Manual.....	3.20
Standard Descent Profile (Non VNAV).....	3.20
Descent Planning	3.23
Descent Rates	3.23
Speedbrakes.....	3.24
Flaps and Landing Gear.....	3.25
Speed Restrictions.....	3.25
Engine Icing During Descent	3.25
Throttle Technique.....	3.26

Climb, Cruise, Descent**Chapter 3**

Preface

This chapter outlines recommended operating practices and techniques used during climb, cruise and descent. Loss of an engine during climb or cruise and engine inoperative cruise/driftdown is also addressed. The recommended operating practices and techniques discussed in this chapter improve crew coordination, enhance safety and provide a basis for standardization.

Climb**Climb Thrust**

Once climb thrust is set, the thrust rating computer (TRC/MD-88), electronic engine control (EEC/MD-90), automatically compensates for changes in environmental conditions during climb and maintains climb thrust.

Reduced Thrust Climb

Engine service life may be extended by operating the engines at less than full climb rated thrust.

The MD-90 has two reduced thrust climb selections on the TRP.

- CLB 1 is approximately 12% derate of climb thrust
- CLB 2 is approximately 18% derate of climb thrust

Climb Constraints

When ATC issues a climb clearance which contains altitude crossing restrictions, the crew should verify that all altitude constraints have been properly entered in the route, set the final altitude clearance limit in the DFGC altitude selector, engage VNAV, and monitor the climb or descent to ensure compliance with all altitude restrictions.

For additional altitude alerting and automation redundancy, the crew can elect to set all mandatory altitude restrictions, including “at or below” constraints in the DFGC altitude window. In this case, the next altitude may be set when the restriction has been satisfied, or further clearance has been received.

If a climb is being accomplished using IAS or Vertical Speed, all altitude restrictions must be entered in the DFGC altitude window until that crossing restriction has been assured.

Low Altitude Level Off Without VNAV

Occasionally a level off below 2,500 feet AFE is required after takeoff.

In the event of a level off at a low altitude during the initial climb, it is important to know the relationship between the selection of CLB thrust on the TRP and the operation of the autothrottles. If ALT CAP occurs prior to selection of CLB thrust, as long as the TRP remains in a takeoff mode, the autothrottles will remain clamped and no overspeed protection is available. If this occurs:

- Select CLB thrust. This will restore the ATS overspeed protection logic.
- Set the command speed bug to clean speed.
- Press SPD SEL on the FGCP, or
- Disconnect the autothrottles and retard the throttles manually so as not to exceed limit speeds.

Low Altitude Level Off With VNAV

When taking off with an initial level off below 2,500 ft. AFE and using VNAV accomplish one of the following steps:

- Enter the clean speed at 2,500 AFE on the Climb Page. The speed restriction will automatically be deleted when the aircraft climbs above 2,500 ft.
- If the restriction cannot be entered on the Climb Page before takeoff, use FMS OVRD after 1,000 ft. to select clean speed. Deselect FMS OVRD when above 2,500 ft.

Transition to Climb

Maintain flaps up maneuvering speed until clear of obstacles or above minimum crossing altitudes. If there are no altitude or airspeed restrictions, accelerate to the desired climb speed schedule. The sooner the airplane can be accelerated to the climb speed schedule, the more time and fuel efficient the flight.

Climb Speed Determination

Enroute climb speed is automatically computed by the FMC and displayed on the CLB and PROGRESS pages, as well as by the command speed bug on the airspeed display when VNAV is engaged. Below the speed transition altitude the FMC targets the transition speed limit stored in the navigation data base for the departure airport (250 knots in the USA), or flaps up maneuvering speed, whichever is higher. The FMC applies waypoint-related speed restrictions displayed on the LEGS pages, and altitude-related speed restrictions displayed on the CLIMB page.

The FMC provides optimum climb speed modes for economy (ECON) operation and engine out (ENG OUT) operation. These optimum speeds can be changed before or during the climb. Reference speeds are also provided for maximum angle climb (MAX ANGLE) operation.

The ECON climb speed is a constant speed/constant Mach schedule optimized to obtain the minimum airplane operating cost. The constant Mach value is set equal to the economy cruise Mach calculated for the cruise altitude entered in the FMC.



MD-88/90 Flight Crew Training Manual

For very low cruise altitudes the economy climb speed is increased above normal values to match the economy cruise speed at the entered cruise altitude. For ECON climb, the speed is a function of gross weight (predicted weight at top of climb), predicted top of climb wind, predicted top of climb temperature deviation from ISA, and cost index.

Engine Icing During Climb

Engine icing may form when not expected and may occur when there is no evidence of icing on the windshield or other parts of the airplane. Once ice starts to form, accumulation can build very rapidly. Although one bank of clouds may not cause icing, another bank, which is similar, may cause icing.

CAUTION: The engine anti-icing system should be ON whenever icing conditions exist or are anticipated. Failure to follow the recommended anti-ice procedures can result in engine stall, overtemperature or engine damage.

Economy Climb

If using FMS, climb at ECON speed as displayed on the MCDU CLB page.

The normal economy climb speed schedule of the FMC minimizes trip cost. It varies with gross weight and is influenced by cost index. The FMC generates a fixed speed schedule as a function of cost index and weight.

Economy climb speed normally exceeds 250 knots for all gross weights. FMC climb speed is limited to 250 knots or flaps up maneuvering speed, whichever is greater, below 10,000 feet (FAA Airspace).

If ATC permits the use of a higher speed below 10,000 feet, the use of ECON speed may provide additional fuel savings.

Economy Climb Schedule - FMC Data Unavailable

- Below 10,000 feet - 250 knots/Clean speed, whichever is higher.
- Above 10,000 feet - Climb at 310 knots until transitioning to flight planned cruise Mach (approximately 27,000 feet). Transition to flight planned cruise Mach at this time by reselecting the IAS/MACH select button on the FGCP.

Maximum Rate Climb

A maximum rate climb provides both high climb rates and minimum time to cruise altitude. Maximum rate climb can be approximated by using 225 KIAS.

Note: The FMC does not provide maximum rate climb speeds.

Note: Maximum rate climb is not intended for normal operations. It is discussed here for informational purposes only. Maintain ECON climb speed schedule.

Maximum Angle Climb

The FMC provides maximum angle climb speeds. Maximum angle climb speed is normally used for obstacle clearance, minimum crossing altitude or to reach a specified altitude in a minimum distance. It varies with gross weight and provides approximately the same climb gradient as flaps up maneuvering speed.

Engine Inoperative Climb

The engine inoperative climb speed is approximately maximum angle climb speed and varies with gross weight and altitude. Engine inoperative climb speed is the FMC default used during climb when ENG OUT CLIMB is selected. Select ENG OUT CLIMB after flap retraction, all obstructions are cleared, and time permits.

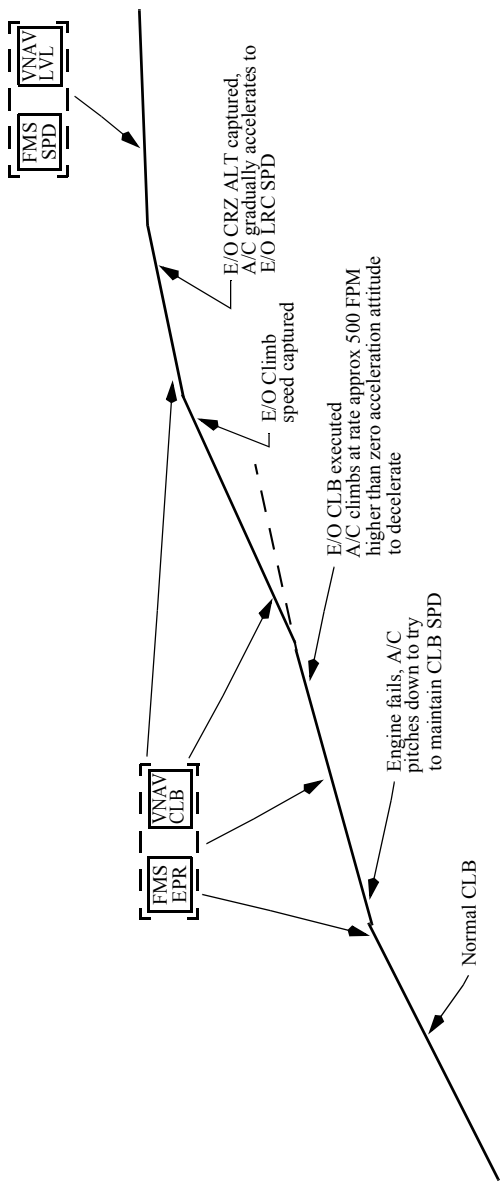
Note: Selection of the engine out mode is approved for coupled VNAV operation; however, the performance predictions are advisory only.

If a thrust loss occurs at other than takeoff thrust, set maximum continuous thrust on the operative engine and lower the nose slowly to maintain airspeed as the thrust loss occurs.

Note: Selecting MCT on the TRP moves the N1/EPR bug to maximum continuous thrust until another mode is selected or automatically engaged. The SELECT MCT message will alert the pilot to select MCT if it has not already been selected. The speed will then change to the engine inoperative climb speed and the aircraft will continue the climb while decelerating to the engine inoperative climb speed. If cleared, the SELECT MCT message is reissued every 30 seconds or until MCT is selected. This message is redisplayed regardless of the VNAV engagement status.

In the clean configuration, select engine out mode on the MCDU climb page. The engine out mode provides VNAV commands to climb at engine out climb speed to cruise altitude, or maximum engine out altitude, whichever is lower. If the airplane is currently above the engine out maximum altitude, driftdown information is available. The aircraft will level off and maintain thrust at the EPR limit. The CHECK ALT TGT message will be displayed when the cruise altitude is below the aircraft and the FGCP altitude window is set above the aircraft altitude. Upon reaching level off altitude the command speed will change to the engine out LRC. Leave thrust set at maximum continuous thrust until airspeed increases to the commanded value.

Note: If computed climb speeds are not available, use SLAT RET speed + 20 knots and maximum continuous thrust.



Engine Out in Climb Below Engine Out Cruise Altitude

Intermediate Level Off

If the climb profile in the FMS includes an altitude climb restraint, the aircraft will level-off in FMS SPD and VNAV LVL until the restraint has been satisfied, and then initiate a VNAV climb to the FGCP altitude or the cruise altitude entered into the FMS, whichever is lower.

If the aircraft will be at the intermediate altitude for an extended period or if the intermediate altitude has been assigned as the final cruise altitude:

- Select the CRZ page.
- Enter new cruise altitude.
- Engage VNAV on FGCP.

10,000' Level Off

In VNAV, the autothrottle system will increase engine thrust slowly when starting a climb. Use of other pitch modes, such as IAS or VERT SPD, in conjunction with EPR LIM can increase engine thrust more rapidly. However, the rate of throttle movement in VNAV depends on the amount of speed change commanded. In VNAV LVL, a speed increase of 20 knots will result in the autothrottle system applying a rapid thrust increase.

During the initial climb to 10,000 feet, and using VNAV, the FMS will command 250 knots through VNAV CAP. At VNAV LVL, the FMS will command an increase to the calculated climb speed. The increase in speed from 250 knots to climb speed, while the airplane is still in level flight at 10,000 feet, results in a throttle burst situation.

Note: Maximum speed is limited to 250 knots or clean maneuvering speed, whichever is greater, below 10,000 feet (FAA Airspace).

Note: If FMS override is used for extended periods of time, the FMS will not give accurate ETAs since it is still referencing the programmed speeds on the Climb, Cruise and Descent pages.

CAUTION: Selecting VNAV while accelerating in a DFSGS IAS climb mode at slightly below FMS climb speed can cause an over speed warning to occur because of slow pull-up rate of the FMS in the VNAV mode.

**MD-88/90 Flight Crew Training Manual**

Cruise

This section furnishes general guidance for the cruise portion of the flight for maximum passenger comfort and economy.

Autopilot Level Off

As the aircraft begins to level at the FMS programmed cruise altitude, the following will occur:

- The pitch mode will change from VNAV CLB to VNAV CAP to VNAV LVL.
- The FMS will control the autothrottles to automatically maintain the programmed cruise Speed/Mach displayed on the ACT ECON CRZ page.

Maximum Altitude

Maximum altitude is the highest altitude at which the airplane can be operated. It is determined by three basic characteristics, which are unique to each airplane model. The FMC predicted maximum altitude is the lowest of:

- maximum certified altitude - determined during certification and is usually set by the pressure load limits on the fuselage. The maximum certified altitude may not be exceeded.
- thrust limited altitude - the altitude at which sufficient thrust is available to provide a specific rate of climb. (Reference the Long Range Cruise Maximum Operating Altitude table in the ODM). Depending on the thrust rating of the engines, the thrust limited altitude may be above or below the maneuver limited altitude capability.
- maneuver limited altitude - the altitude at which a specific maneuver margin exists prior to buffet onset (minimum 0.2g for FAA). These specific margins provide 33° of bank angle protection to buffet.

Although each of these limits are checked by the FMC, thrust limitations may limit the ability to accomplish anything other than relatively minor maneuvering. When at or near the FMC maximum altitude, it is possible for NAV inputs to exceed the capability of the airplane. This could result in loss of altitude or airspeed.

Optimum Altitude

Optimum altitude is the cruise altitude for minimum cost when operating in the ECON mode, and for minimum fuel burn when in the LRC or pilot-selected speed modes. In ECON mode, optimum altitude increases as either airplane weight or cost index decreases. In LRC or selected speed modes, optimum altitude increases as either airplane weight or speed decreases. On each flight, optimum altitude continues to increase as weight decreases during the flight.

For shorter trips, optimum altitude as defined above may not be achievable since the TOD (top of descent) point occurs prior to completing the climb to optimum altitude.

- Cruise altitude, as defined on the FMC PERF INIT page, further constrains optimum altitude by reducing the altitude for short trips until minimum cruise segment time is satisfied. This cruise time is typically one minute, but is operator selectable in the FMC by maintenance action. For short trips, operation at cruise altitude results in the minimum fuel/cost while also satisfying the minimum cruise time requirement.
- The requested/accepted initial cruise altitude should be compared to the thrust limited or the maneuver margin limited altitudes. Remember, a cruise thrust limited altitude is dependent upon the cruise level temperature. If the cruise level temperature increases above the chart value for gross weight, maximum cruise thrust will not maintain desired cruise speed.

The selected cruise altitude should normally be as close to optimum as possible. Optimum altitude is the altitude that gives the minimum trip cost for a given trip length, cost index, and gross weight. As deviation from optimum cruise altitude increases, performance economy deteriorates.

Some loss of thrust limited maneuver margin can be expected above optimum altitude. The higher the airplane flies above optimum altitude, the more the thrust margin is reduced. Before accepting an altitude above optimum, determine that it will continue to be acceptable as the flight progresses under projected conditions of temperature and turbulence.

On airplanes with higher thrust engines, the altitude selection is most likely limited by maneuver margin to initial buffet. Projected temperature and turbulence conditions along the route of flight should be reviewed when requesting/accepting initial cruise altitude as well as subsequent step climbs.

CAUTION: Operating above the FMS calculated optimum cruise altitude can result in airspeed decay and eventual stall. Do not input any number less than the actual zero fuel weight or fuel on-board to obtain a higher optimum altitude.



Cruise Speed Determination

Cruise speed is automatically computed by the FMC and displayed on the CRZ and PROGRESS pages. It is also displayed by the command air speed when VNAV is engaged. The default cruise speed mode is economy (ECON) cruise. The pilot can also select long range cruise (LRC), engine out modes, or overwrite fixed Mach or IAS values on the CRZ page target speed line.

ECON cruise is a variable speed schedule that is a function of gross weight, cruise altitude, cost index, and headwind component. It is calculated to provide minimum operating cost for the entered cost index. Entry of zero for cost index results in maximum range cruise (fuel flow is optimized to minimize cost). The cost index allows the manipulation of ECON speeds to take into account the cost of airline time.

Headwinds increase the ECON CRZ speed. Tailwinds decrease ECON speed, but not below the zero wind maximum range cruise airspeed.

LRC is a variable speed schedule providing fuel mileage one percent less than the maximum available. No wind corrections are applied to LRC.

Step Climb

Step altitudes can be planned as step ups or step downs. Optimum step points are a function of the route length, flight conditions, speed mode, present aircraft altitude, STEP TO altitude and the gross weight.

The FMC does not compute an optimum step point. The crew must enter a STEP TO altitude. The FMC then computes the ETA and distance to step climb point based upon gross weight. A fuel savings or penalty to destination is computed assuming the step climb is performed. Initiate a cruise climb to the new altitude as close as practical to the step climb point.

Fuel for Enroute Climb

The additional fuel required for a 4,000 foot enroute climb varies from 500 to 1,000 lbs (225 to 450 kgs) depending on the airplane gross weight and air temperature. Additional fuel burn is offset by fuel savings in the descent. It is usually beneficial to climb to a higher altitude if recommended by the FMC or the flight plan, provided the wind information used is reliable.

Cruise Performance Economy

The dispatch computed fuel burn from departure to destination is based on certain assumed conditions. These include takeoff gross weight, cruise altitude, route of flight, temperature, wind enroute, and cruise speed.

Actual fuel burn should be compared with the flight plan fuel burn throughout the flight.

The planned fuel burn can increase due to:

- temperature above planned
- a lower cruise altitude than planned
- cruise altitude more than 2,000 feet above optimum altitude
- speed faster than planned or appreciably slower than long range cruise speed when long-range cruise was planned
- stronger headwind component
- fuel imbalance
- improperly trimmed airplane
- excessive thrust lever adjustments.

Cruise fuel penalties include:

- ISA + 10° C: 1% increase in trip fuel
- 2,000 feet above optimum altitude: 1% to 2% increase in trip fuel
- 4,000 feet below optimum altitude: 4% to 5% increase in trip fuel
- 8,000 feet below optimum altitude: 12% to 14% increase in trip fuel
- cruise speed M.01 above scheduled: 1% to 2% increase in trip fuel.

For cruise within 2,000 feet of optimum, long range cruise speed can be approximated by M.76. Long range cruise also provides best buffet margin at all cruise altitudes.

Note: If a discrepancy is discovered between actual fuel burn and flight plan fuel burn that cannot be explained by one of the items above, a fuel leak should be considered. Accomplish the applicable non-normal checklist.



Engine Inoperative Cruise/Driftdown

The loss of an engine enroute may entail driftdown to altitudes which present hazardous terrain clearance conditions thus affecting your selection of nearest suitable airport. All areas affected are depicted on Low Altitude Charts for the Western U.S. or High/Low Level (Canada/Mexico) Chart. Your flight plan will note if driftdown terrain clearance is a factor for your current route. If it is, in the event of an engine loss your selection of the nearest suitable airport will be based on the appropriate Jeppesen Chart and flight plan

If an engine fails during cruise:

- Set MCT and allow aircraft to decelerate to driftdown speed (FMS or ODM) as applicable.
- Check the appropriate Jeppesen Chart to ascertain if aircraft is in a brown outlined driftdown sector.
 - If you are inside a brown sector, identify its name and obtain suitable airports from the chart legend fold or flight plan.
 - If you are not inside a brown sector, do not proceed into a brown sector unless you are able to maintain an altitude above MEA on an airway. Suitable airports should be selected using the above information.

The FMS is capable of providing guidance for the aircraft during engine-out (E/O) conditions if the appropriate E/O performances mode is selected on the MCDU.

Driftdown Using VNAV

Note: The FGCP altitude must be reset to a lower altitude in order for the FMS to start a driftdown. A stall may result if the FGCP altitude is not reset.

On the MCDU ACT CRZ page, select ENG OUT. This will display the ENG OUT CRZ D/D page if the current altitude is above the FMS computed E/O CRZ altitude.

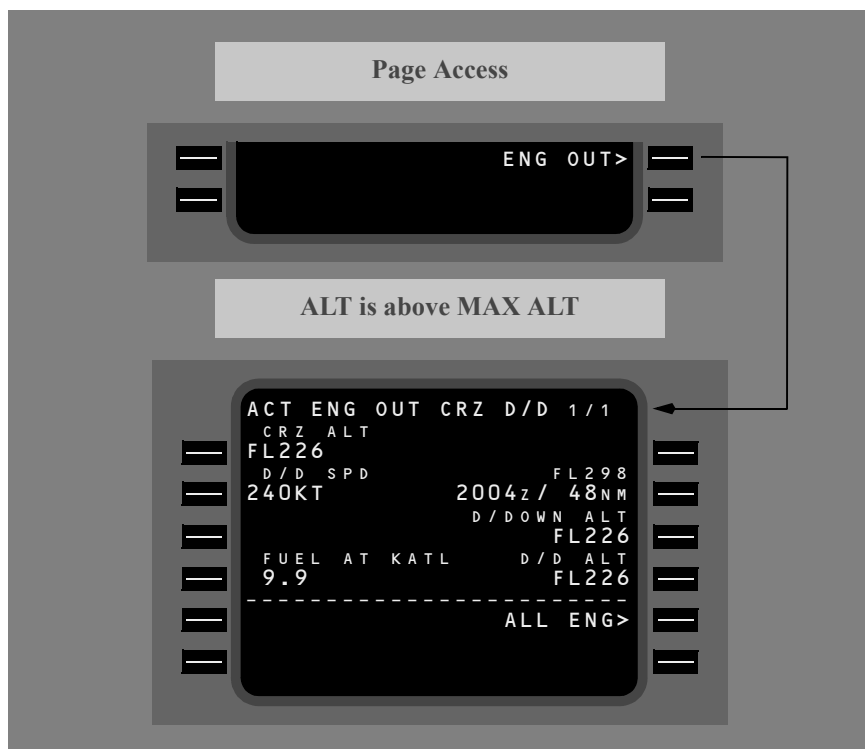
When the Engine (E/O) mode is executed in cruise, and the aircraft is above the maximum E/O altitude, thrust will automatically advance to the EPR limit, then the following messages will appear on the MCDU:

- CHECK ALT TGT
- SELECT MCT.

These messages alert the pilot to select MCT on the TRP, and to reset the FGCP altitude.



MD-88/90 Flight Crew Training Manual



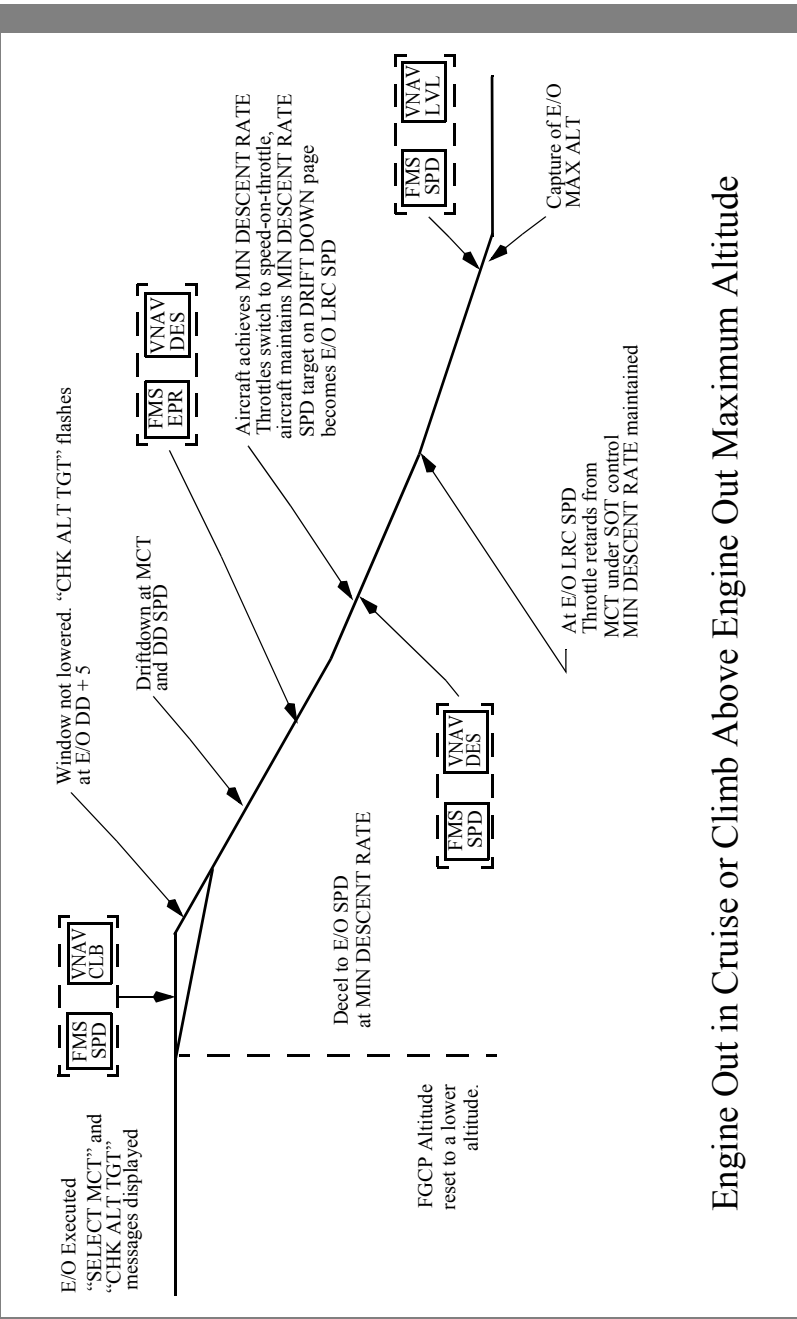
If the pilot clears the CHECK ALT TGT message, and does not reset the FGCP altitude, the FMS will maintain level flight while decelerating to the E/O speed (E/O D/D speed or E/O LRC speed). At E/O speed + 5 knots, the CHECK ALT TGT message will be issued once again. This message, along with the “MCDU MSG” annunciation on both PFDs, and the FMA Pitch and Throttle windows will flash once a second. This condition will continue until the FGCP altitude is reset to a lower altitude or VNAV is disengaged.

If the FGCP altitude is reset to a lower altitude, the aircraft will perform a driftdown with thrust set at MCT (limited by the TRP), using speed on pitch to maintain the E/O D/D speed. When the aircraft can maintain a 100 FPM rate of descent, or the aircraft's altitude is within 750 feet of the E/O maximum altitude, the speed target will change from E/O D/D speed to E/O LRC speed. The thrust mode changes from FMS EPR (speed on pitch) to FMS SPD (speed on throttle), and the minimum descent rate is maintained (100 FPM).

**MD-88/90 Flight Crew Training Manual**

Should the aircraft become slow after this transition (below E/O LRC - 5 knots), the speed target will revert back to the E/O D/D speed and controlled to a speed-on-pitch condition. When the E/O LRC speed is captured, the throttles will retard to maintain speed and the minimum descent rate (100 FPM). This will continue until the E/O maximum altitude is captured. When this occurs, the FMS sequences onto VNAV LVL.

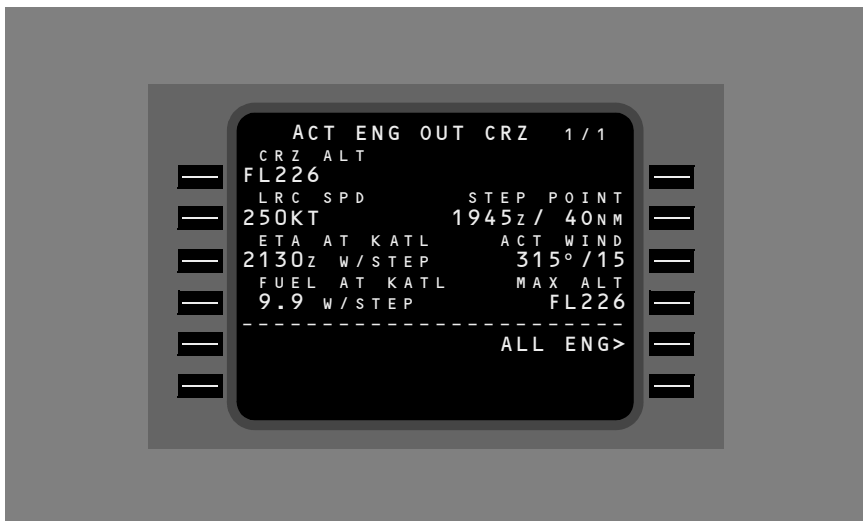
Should the E/O maximum altitude decrease to below E/O CRZ ALT at any time during E/O CLB, CRZ or D/D (e.g., Anti-Ice is selected), a message CHECK MAX ALT will alert the pilot of this condition.



Engine Out in Cruise or Climb Above Engine Out Maximum Altitude

MD-88/90 Flight Crew Training Manual

The following E/O CRZ page format represents the data displayed at the E/O maximum altitude:



Driftdown Without VNAV

- Select MCT on remaining engine.
- Reset FGCP altitude.
- Decelerate to driftdown speed.
- Descend using Vertical Speed or IAS mode.
- After level-off, accelerate to E/O LRC.

Note: If the airplane is at or below maximum EO altitude when an engine becomes inoperative, select and execute the EO CRZ page and maintain engine out cruise speed.

If required to cruise at maximum altitude, set MCT and establish a climb, decelerating slowly to EO CLB speed. At level off select EO LRC for best fuel economy.

Definitions:

- E/O Climb and E/O Driftdown (D/D) speed is defined as the limited maximum L/D speed. It is computed as the higher of 1.33 V_{stall} or 1.5 Gs to buffet.
- E/O LRC speed is defined as the zero Cost Index Long Range Cruise speed for single-engine operation.
- E/O Driftdown/Maximum Altitude is defined as the altitude where aircraft can maintain a 100 FPM rate of climb at E/O LRC speed and MCT.

High Altitude High Speed Flight

Mach buffet and Mach tuck are associated with the formation of shock waves on the airfoil during transonic flight. Small, weak shock waves are formed on the wing at Mach 0.75. Although shock waves form much earlier, noticeable buffeting does not occur on the MD-88/90 until approaching MMO. At this Mach number, shock waves become quite large and strong, and move rapidly for and aft on the wing, causing a gentle high frequency buffet.

Pressure distributions are affected when these shock waves occur, and this in turn affects the aircraft's lift, drag and pitching characteristics. Mach tuck will become noticeable at Mach 0.80; and, the pull force required to maintain level flight increases linearly up to Mach 0.85, then remains constant. It is for this reason that Mach trim compensation is needed above Mach 0.80.

Note: Maximum airspeed with malfunctioning or inoperative Mach Trim Compensator (MTC) is 0.78 Mach (MD-88), 0.80 Mach (MD-90).

Low Speed at Altitude

MD-88/90s have experienced events where speed falls below intended cruise mach. If aircraft speed gets slow enough it cannot be recovered without descending.

Onset scenarios are:

- Inappropriate use of VERT SPD in the climb or over aggressive "zoom" maneuver.
- Lack of awareness of performance penalty associated with engine bleeds or failure to recognize PT2 probe icing. Engine anti-ice is required in accordance with Limitations in Vol. 1, including temperatures below -40°C SAT.
- Lack of understanding of the limitations of holding in VNAV or selecting an inappropriately low holding speed.

Contributing factors include:

- Allowing the aircraft to approach the back side of the power curve.
- Not crosschecking EPR with other engine instruments, especially N1.
- Lack of vigilance in cruise, especially immediately after TOC.

Climb and cruise procedures include steps to bring focus to aircraft performance (determine maximum altitude and minimum speed).

- During climb:
 - Ensure FMS PERF data is accurate.
 - Use VNAV if available.
 - Recall FMC OPT/MAX altitudes do not take into account the use of engine bleeds.

**MD-88/90 Flight Crew Training Manual**

- Consider possibility for turbulence and in-flight maneuvering.
- During cruise:
 - Perform the Cruise Procedure immediately after TOC.
 - Leave CL selected in the TRP.
 - Limit bank angle to 15°, if operationally feasible.
 - Fly the FMC-generated cruise speed.
 - Determine a minimum cruise airspeed by adding 10 knots to clean speed. Do not allow airspeed to fall below this speed in cruise, including holding.
 - Monitor engine performance, especially N1.

Descent

Methods of Descending

The MD-88/90 offers four methods of descent.

- VNAV.
- IAS/Mach.
- Vertical speed.
- Manual.

The pilot may use any of the last three methods or combination thereof to achieve the standard descent profile. VNAV computes a geographically fixed descent path based on idle thrust, which may differ slightly from the standard descent profile.

During any descent, the pilot must consider other factors in computing the descent path, such as wind, ATC restrictions, direction of traffic and length of traffic pattern.

VNAV

To execute a VNAV descent, program an end of descent point (E/D) into the vertical profile. The E/D enables the FMS to calculate a top of descent point.

Define the E/D by any of the following methods.

- Select a STAR from the FMS data base that includes an altitude constraint.
- Use the descent planning information on the flight plan. Insert the appropriate altitude constraint on the LEGS or DIR INTC page.
- If appropriate, and considering the destination airport landing runway, calculate an altitude constraint based on the standard descent profile. Define a point 30 miles from the airport and insert it into the route of flight if necessary. Insert an altitude constraint to cross this point at 250 knots and 10,000 feet AFE for the destination airport.

Once the FMS has calculated a top of descent point, the aircraft will begin to descend automatically at that point provided a lower altitude is in the altitude preselect readout and VNAV is the active pitch mode. The throttles will retard to idle and the FMS will fly the programmed descent.

If a more gradual transition to the descent profile is desired:

- Reset FGCP altitude window to lower altitude.
- Select and execute the DES NOW prompt on the DES page at a point 10 miles prior to the top of descent point.
- Press VNAV on the FGCP.

The throttles will retard slightly and the aircraft will begin a 1,000-1,500 fpm descent. It will maintain this descent until intercepting the computed profile, at which time the throttles will retard to idle and the aircraft will fly the calculated descent path.

Throughout the descent, the FMS will attempt to stay on the descent through use of throttle position followed by an increase in airspeed and a notification to the pilot if drag is required. Because of the many variables involved such as wind, use of anti-icing, etc., the VNAV function of the FMS may not be able to make a crossing restriction and must be closely monitored.

Descent Speed Determination

The default FMC descent speed schedule is an economy (ECON) descent from cruise altitude to the airport speed transition altitude followed by a descent at ten knots less than this speed. The speed schedule is adjusted to accommodate waypoint speed/altitude constraints displayed on the LEGS pages, and speed/altitude constraints displayed on the DES page. If desired, the ECON speed schedule can be modified by alternate Mach, Mach/IAS, or IAS values on the DES page target speed line.

Descent Path

An FMC path descent is the most economical descent method. At least one waypoint-related altitude constraint below cruise altitude on a LEGS page generates a descent guidance path. The path is built from the lowest constraint upward, assuming idle thrust, or approach idle below the anti-ice altitude entered on the DESCENT FORECAST page.

The path is based on the descent speed schedule, any entered speed/altitude constraints or forecast use of anti-ice. The path reflects descent wind values entered on the DESCENT FORECAST page.

Descent Constraints

Descent constraints may be automatically entered in the route when selecting an arrival procedure, or manually entered through the MCDU.



MD-88/90 Flight Crew Training Manual

When ATC issues a descent clearance which contains altitude crossing restrictions, the crew should verify that all altitude constraints have been properly entered in the route, set the final altitude clearance limit in the DFGC altitude selector, engage VNAV, and monitor the climb or descent to ensure compliance with all altitude restrictions.

For additional altitude alerting and automation redundancy, the crew can elect to set all mandatory altitude restrictions, including “at or above” constraints in the DFGC altitude window. In this case, the next altitude may be set when the restriction has been satisfied, or further clearance has been received.

If a descent is being accomplished using IAS or Vertical Speed, all altitude restrictions must be entered in the DFGC altitude window until that crossing restriction has been assured.

Note: Use of DES DIR deletes constraints from the LEGS page.

Shallow vertical path segments may result in the autothrottle supplying partial power to maintain the target speed. Vertical path segments steeper than an idle descent may require the use of speedbrakes. Deceleration requirements below cruise altitude (such as at 10,000 MSL) are accomplished based on a rate of descent of approximately 500 fpm. When a deceleration is required at top of descent, it is performed in level flight.

Speed Intervention

VNAV speed intervention can be used to respond to ATC speed change requirements.

IAS/MACH

IAS/MACH mode is normally used for large changes in altitude (more than 2,000 feet). It will provide a rate of climb or descent based upon thrust setting and will command a pitch attitude to acquire and maintain the selected IAS/MACH.

- Select a higher or lower altitude in the FGCP altitude window.
- Start the aircraft tracking in the proper direction by actuating the pitch wheel. This will place the autopilot in the vertical speed mode.

CAUTION: Do not actuate the pitch wheel when nearing altitude capture. This will disable the ALT CAP mode and result in an altitude deviation. Confirm all FGCP changes are annunciated on the FMA.

- Select IAS/MACH on the FGCP.
- Rotate the pitch wheel to the desired airspeed or mach.
- If descending, retard the throttles manually to achieve the desired rate of descent.
- If climbing, select EPR limit to achieve the appropriate climb setting.

Vertical Speed

Vertical speed (V/S) mode is normally used for small changes in altitude (approximately 2,000 feet or less) and non-precision approaches. It will provide a constant rate climb or descent.

- Select a higher or lower altitude in the FGCP altitude window.
- Push the vertical speed button (this is only necessary if operating in the IAS/Mach mode).
- Rotate the pitch control wheel to the desired rate of descent.
- The autothrottles will retard only to the ATS low limit. Further throttle reduction must be accomplished manually.

CAUTION: In V/S mode, no stall or overspeed protection is provided. Therefore, V/S is not normally used to climb.

CAUTION: Do not actuate the pitch wheel when nearing altitude capture. This will disable the ALT CAP mode and result in an altitude deviation. Confirm all FGCP changes are annunciated on the FMA.

CAUTION: Changing the barometric altimeter setting while in the ALT CAP mode causes the autopilot to level the airplane above or below the selected altitude. However, resetting the barometric altimeter while in VNAV CAP will not interfere with level off at selected altitude.

Manual

The airplane may be flown manually, with reference to the basic flight instruments, with or without the flight director or autothrottle, using the following procedure.

- Select a higher or lower altitude in the FGCP altitude window.
- Adjust thrust as necessary to maintain the desired airspeed.
- Adjust the pitch attitude as necessary.

Standard Descent Profile (Non VNAV)

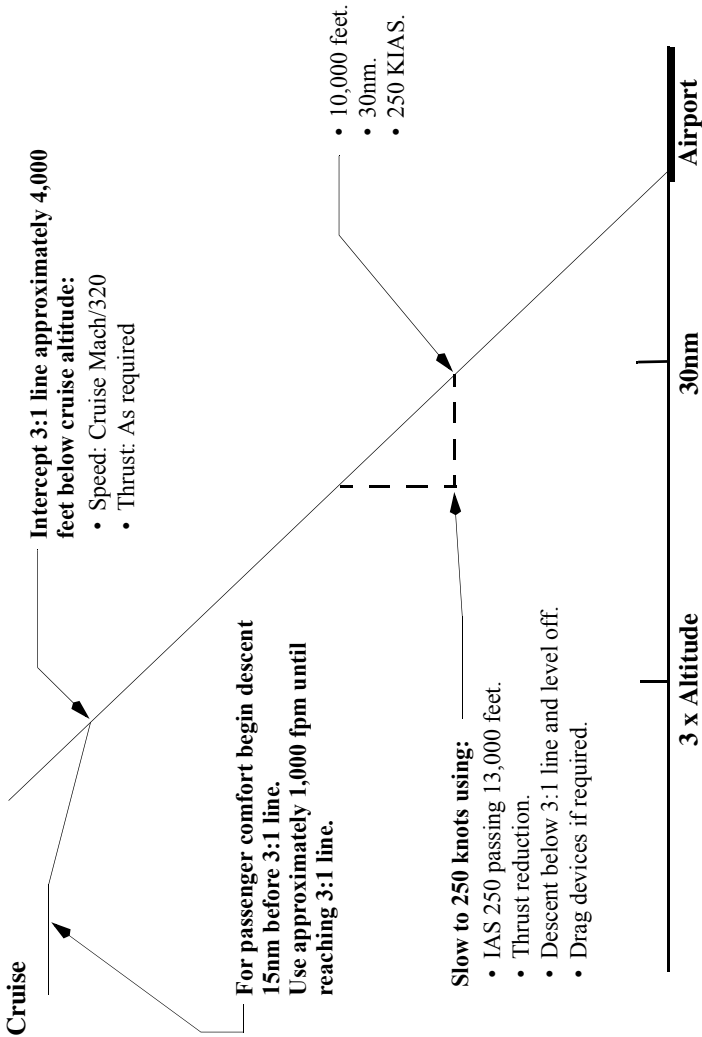
The standard descent profile is based on using a descent path equating to 300 feet per mile, or a 3° glide path. Using this profile provides the best compromise between passenger comfort and fuel efficiency.

To transition smoothly to this glide path from cruise altitude, the profile begins with a 1,000 fpm descent rate until intercepting the 3:1 line approximately 4,000 feet below cruise altitude.

**MD-88/90 Flight Crew Training Manual**

Procedures are as follows.

- Determine top-of-descent point (T/D):
$$T/D = (\text{cruise altitude} - \text{bottom-of-descent altitude}) \times 3 + 15.$$
- Begin a 1,000 fpm descent at T/D.
- Plan to intercept the 3:1 line approximately 4,000 feet below cruise altitude, however, another altitude or airspeed may be more appropriate depending on arrival geometry and other factors.
- Maintain 3:1 line with an airspeed of 320 knots and thrust as required.
- Plan to arrive at a point 30 nm from the airport at 10,000 feet AFE for the destination airport and at approximately 250 knots.
- Descend from 10,000 feet to the traffic pattern at or below 250 knots.
- If turbulence is encountered, adjust descent speed to 280 ± 5 KIAS/.75-.79M. Below 10,000 feet, 250 KIAS provides adequate stall margin at all weights.





Descent Planning

Flight deck workload typically increases as the airplane descends into the terminal area. Distractions must be minimized and administrative and nonessential duties completed before descent or postponed until after landing. The earlier that essential duties can be performed, the more time will be available for the critical approach and landing phases.

Operational factors and/or terminal area procedures may not permit following the optimum descent schedule. Terminal area requirements can be incorporated into basic flight planning but ATC, weather, icing and other traffic may require adjustments to meet the requirements.

Descent Rates

Normally, descend with idle thrust and in clean configuration (no speedbrakes). Maintain cruise altitude until the proper distance or time out for the planned descent and then hold the selected airspeed schedule during descent. Deviations from this schedule may result in arriving too high at destination and require circling to descend, or arriving too low and far out requiring extra time and fuel to reach destination.

The speedbrake may be used to correct the descent profile if arriving too high or too fast. The Descent checklist is normally accomplished at 18,000 feet or top of descent whichever is lower. The Approach checklist is normally accomplished during descent and should be completed passing approximately 10,000 feet AFE for the destination airport or transition level, whichever is lower.

Plan the descent to arrive at traffic pattern altitude at flaps up maneuvering speed approximately 10 miles from the runway when proceeding straight-in or about 8 miles out when making an abeam approach. A good crosscheck is to be at 10,000 feet AFE, 30 miles from the airport, at 250 knots. However, use of a different altitude or airspeed may be more appropriate depending on arrival geometry and other factors.

Reducing airspeed during the descent can be challenging. Plan for approximately 60 seconds and 7 NM to decelerate from 320 to 250 knots in level flight without the use of speedbrakes. An additional 25 seconds and 2 NM is required to decelerate to flaps up maneuvering speed at average gross weights. Using speedbrakes to aid in deceleration reduces these times and distances by approximately 50%.

Maintaining the desired descent profile and using the map mode to maintain awareness of position ensures a more efficient operation. Maintain an awareness of the destination weather and traffic conditions, and consider the requirements of a potential diversion. Review the airport approach charts and discuss the plan for the approach and landing. Complete the approach briefing as soon as practical, preferably before arriving at top of descent. This allows the crew to give full attention to aircraft control.

Speedbrakes

The pilot flying should keep a hand on the speedbrake lever when speedbrakes are used in-flight. This precludes leaving the speedbrakes extended inadvertently. Use of speedbrakes does not appreciably affect aircraft roll rates. While using the speedbrakes in descent, allow sufficient altitude and airspeed margin to level off smoothly. Retract speedbrakes before adding thrust.

There is no maximum airspeed restriction for extension. Deployment of the speedbrakes will produce some buffeting and a pitch down tendency. Retracting the speedbrakes will result in pitch up. In either case, anticipation of the effect and proper use of the spoiler/speedbrake lever will result in a smooth transition between configurations.

Normally, descend in the clean configuration to pattern or instrument approach altitude. Use speedbrakes if necessary. Increased descent rates at intermediate altitudes may be accomplished using extended slats and flaps.

Note: Speedbrakes must not be used with flaps extended in flight. Do not extend landing gear with speedbrakes deployed. Speedbrakes may be used with or without slats extended. Do not move spoiler/speedbrake lever to ground spoiler position in flight.

When descending with the autopilot engaged and the speedbrakes extended at speeds near VMO/MMO, the airspeed may momentarily increase to above VMO/MMO if the speedbrakes are retracted quickly. To avoid this condition, smoothly and slowly retract the speedbrakes to allow the autopilot sufficient time to adjust the pitch attitude to maintain the airspeed within limits.

When the speedbrakes are retracted during altitude capture near VMO/MMO, a momentary overspeed condition may occur. This is because the autopilot captures the selected altitude smoothly by maintaining a fixed path while the thrust is at or near idle. To avoid this condition, it may be necessary to reduce the selected speed and or descent rate prior to altitude capture or reduce selected speed and delay speedbrake retraction until after level off is complete.



Flaps and Landing Gear

Normal descents are made in the clean configuration to pattern or instrument approach altitude. If greater descent rates are desired, extend the speedbrakes. When thrust requirements for anti-icing result in less than normal descent rates or if higher than normal descent rates are required by ATC clearance, additional drag may be used in accordance with aircraft limitations (e.g., gear, speedbrakes, flaps).

Note: Avoid using the landing gear for increased drag. This minimizes passenger discomfort and increases gear door life.

Speed Restrictions

Speed restrictions below specific altitudes/flight levels and in the vicinity of airports are common. At high gross weights, minimum maneuvering speed may exceed these limits. Consider extending the flaps to attain a lower maneuvering speed or obtain clearance for a higher airspeed from ATC.

Other speeds may be assigned by ATC. Pilots complying with speed adjustments are expected to maintain the speed within plus or minus 10 knots.

Engine Icing During Descent

The use of anti-ice and the increased thrust required increases the descent distance. Therefore, proper descent planning is necessary to arrive at the initial approach fix at the correct altitude, speed, and configuration. The anticipated anti-ice use altitude should be entered on the DESCENT FORECASTS page to assist the FMC in computing a more accurate descent profile.

Engine icing may form when not expected and may occur when there is no evidence of icing on the windshield or other parts of the airplane. Once ice starts to form, accumulation can build very rapidly. Although one bank of clouds may not cause icing, another bank, which is similar, may induce icing.

Note: The engine anti-icing system should be turned ON whenever icing conditions exist or are anticipated. During all phases of flight, wing anti-ice should be used if icing conditions exist.

CAUTION: Failure to follow the recommended anti-ice procedures can result in engine stall, overtemperature, engine damage, or engine failure.



Throttle Technique

The LOW LIMIT setting on the autothrottles may not allow the aircraft to decelerate and/or descend at adequate rates when at low altitudes and slow airspeeds. This occurs when a deceleration or descent is initiated with the speed select knob or the pitch control wheel. In this instance, the throttles stop at LOW LIM and the aircraft does not decelerate or the airspeed increases during descent. Since the MD-88/90 engines exhibit a relatively high residual thrust (even with the throttles below the LOW LIM), initiate terminal area descents with the pitch control wheel (vertical speed) for a smooth entry, then select IAS mode and retard the throttles to idle. Rate of descent can be adjusted with power and desired airspeed will be maintained. Just before level off, increase the power setting to shallow out the descent (move the throttles forward until the red gear warning lights extinguish). This will provide for a smooth power application by the autothrottles to acquire and maintain level off speed.

When hand flying with manual throttles, the following target EPR settings work for most approach and terminal area weights:

Speed	Configuration	Power (MD-88)	Power (MD-90)
250	CLEAN	1.25	1.07
210	SLATS	1.25	1.07
180	FLAPS 11	1.25	1.07
160	FLAPS 15	1.30	1.10
FINAL	FLAPS 28	1.15	1.00
FINAL	FLAPS 40	1.25	1.07

Holding, Approach, Landing

Table of Contents

Chapter 4

Section 0

Preface	4.1
Holding	4.1
Holding Speeds	4.2
ICAO and FAA Holding Airspeeds (Maximum)	4.2
Holding Pattern Entry	4.2
Approach	4.3
Instrument Approaches	4.3
Approach Briefing	4.4
Approach Category	4.5
Approach Clearance	4.6
Procedure Turn	4.6
Stabilized Approach Requirements	4.6
Mandatory Missed Approach	4.7
Landing Minima	4.7
Radio Altimeter (RA)	4.7
Missed Approach Points (MAP)	4.8
Determination of a MAP	4.8
Timing During Approaches	4.8
Instrument Landing System (ILS)	4.8
Localizer	4.8
Other Non-ILS Approaches	4.8
ILS Approach	4.10
ILS Approach Profile	4.10
ILS Approach - General	4.11
Procedure Turn and Initial Approach	4.11

Approach	4.11
Decision Altitude/Height - DA(H)	4.13
Raw Data - (No Flight Director)	4.14
DFGS Autoland Capabilities.	4.15
ILS Approach/Landing Geometry.	4.15
Low Visibility Approaches	4.20
DFGS System Configuration.	4.21
ILS Autoland Approach Profile.	4.24
ILS Autoland Approach	4.25
ILS Approach Profile - One Engine Inoperative.	4.28
Non-Normal Operations (ILS)	4.29
Engine Failure On Final Approach	4.30
Non - ILS Instrument Approaches	4.31
Non - ILS Instrument Approaches - General	4.31
Instrument Approach Using V/S Profile (CANPA)	4.36
Use of Vertical Speed	4.37
Navigation Display (ND) Settings for Non-ILS Approaches	4.38
Instrument Approach Using V/S (CANPA)	4.40
Instrument Approach Using V/S Profile (CANPA) - One Engine Inoperative.	4.44
Instrument Approach Using V/S (CANPA) - One Engine Inoperative.	4.45
Circling Approach	4.46
Circling Approach Profile	4.46
Circling Approach - General	4.47
Obstruction Clearance	4.48
Circling Approach Profile - One Engine Inoperative	4.50
Circling Approach - One Engine Inoperative	4.51
Missed Approach - Circling	4.52

Visual Traffic Patterns	4.54
Visual Traffic Pattern Profile	4.54
Visual Approach - General	4.55
Thrust	4.55
Downwind and Base Leg	4.55
Final Approach	4.55
Visual Traffic Pattern Profile - One Engine Inoperative.	4.58
Engine Failure On Final Approach.	4.59
 Missed Approach/Go-Around	 4.60
Missed Approach/Go-Around Profile - All Approaches	4.60
Missed Approach/Go-Around - General.	4.61
Missed Approach/Go-Around Profile - One Engine Inoperative ..	4.64
Missed Approach/Go-Around - One Engine Inoperative.	4.65
Engine Failure During Missed Approach/Go-Around	4.65
 Landing Configurations and Speeds	 4.66
Maneuver Margin	4.66
Non-Normal Landing Configurations and Speeds	4.66
Non-Normal Landing Distance.	4.66
 Visual Approach Slope Indicator (VASI/T - VASI)	 4.67
Three Bar VASI/T - VASI.	4.67
VASI Landing Geometry	4.68
 Precision Approach Path Indicator (PAPI).....	 4.70
PAPI Landing Geometry.	4.70
 Landing Geometry.	 4.72
Visual Aim Point.	4.72
Landing Runway Markings (Typical).	4.73
Threshold Height	4.74

Recommended Callouts from 100 Feet	4.74
Flare and Touchdown	4.75
Landing Flare Profile.	4.77
Bounced Landing Recovery	4.78
Rejected Landing.	4.78
Pitch and Roll Limit Conditions	4.79
Landing Roll	4.80
Spoilers	4.80
Directional Control and Braking after Touchdown.	4.81
Factors Affecting Landing Distance	4.81
Slippery Runway Landing Performance	4.82
Landing on Slippery Runways	4.84
Wheel Brakes.	4.85
Reverse Thrust Operation	4.88
Crosswind Landings.	4.92
Crosswind Landing Techniques	4.92
Overweight Landing	4.94
Overweight Autolands Policy	4.94

Holding, Approach, Landing

Chapter 4

Preface

This chapter outlines the Delta recommended operating practices and techniques for holding, approach, and landing. Flight profile illustrations represent the Delta recommended basic configuration for normal and non-normal flight maneuvers and provide a basis for standardization and crew coordination.

The maneuvers are normally accomplished as illustrated. However, due to conflicting traffic at training airports, ATC traffic separation requirements, and radar vector advisories, modifications may be necessary. Conditions beyond the control of the flight crew may preclude following an illustrated maneuver exactly. The maneuver profiles are not intended to replace good judgment and logic.

Holding

Start reducing to holding airspeed three minutes before arrival time at the holding fix so that the airplane crosses the fix, initially, at or below the maximum holding airspeed. Establish holding airspeed based on altitude and aircraft configuration. Normally, hold in a clean configuration. Obtain holding speed from the MCDU hold page, the Takeoff and Landing Data Speed Booklet or the Holding/Descent section of the ODM.

Note: The holding speed displayed on the MCDU HOLD page is a minimum speed for straight-and-level flight and normally increases when starting a turn. However, it is recommended that crews hold at a minimum of clean speed plus 10 knots to reduce the chance of experiencing buffet in a turn.

Note: Delta recommends not holding in VNAV.

Note: These speeds do not take into account the ICAO or FAA maximum holding speeds.

If the recommended holding speed exceeds the ICAO or FAA maximum holding speed for a given altitude, request clearance to hold at the higher speed. Holding speeds in the FMS provide an optimum holding speed based upon fuel burn and speed capability. The holding speed target is the IAS value that corresponds to 1.3g buffet minimum speed or the 1.5 V_{stall} speed (whichever is higher) for clean configuration. Holding speeds are also defined for flaps-up/slats extend, and the target speed is 1.5 V_{stall} for this configuration.

Holding Speeds (KIAS)

Pressure Altitude (1000 ft.)	Gross Weight (1000 lbs)						
	90	100	110	120	130	140	150
2 thru 25	194	205	215	224	233	242	251
30	194	205	215	224	233	242	Buffet Limited
33	194	205	215	224	233		
35	194	205	215	224			
37	197	206	215				

Note: These speeds do not take into account the FAA maximum holding speeds which are found in the Delta Airway Manual.

CAUTION: Holding at altitudes above FL250 may be Buffet Limited. If the aircraft configuration falls within the Buffet Limited (grey shaded) area, holding is not authorized.

ICAO and FAA Holding Airspeeds (Maximum)

Refer to the Delta Airway Manual, Chapter 3 for ICAO, F.A.A. maximum holding speeds information.

Holding Pattern Entry

Pattern displayed will vary directly with groundspeed not to exceed FAA or ICAO airspace.

If the pilot selects NAV prior to passing the holding fix, the FMS will execute standard holding pattern entry methods (parallel, teardrop or direct entry) with some differences.

NAV will direct the aircraft to remain within FAA (or ICAO, as appropriate) protected airspace.

Approach

Instrument Approaches

All safe instrument approaches have certain basic factors in common. These include good descent planning, careful review of the approach procedure, accurate flying, and good crew coordination. Thorough planning is the key to a safe, unhurried, professional approach.

Ensure the waypoint sequence on the LEGS page, altitude restrictions, and the map display reflect the air traffic clearance. Last-minute air traffic changes or constraints may be managed by appropriate use of the FGCP heading and altitude selectors. Updating the waypoint sequence on the LEGS page should be accomplished only as time permits.

The Approach Checklist is normally accomplished during descent and should be completed passing approximately 10,000 feet AFE for the destination airport or transition level, whichever is lower.

CAUTION: Building approaches not in the FMS data base is discouraged when operating below 10,000 feet.

Complete the approach preparations before arrival in the terminal area.

- Normally the PM should obtain the ATIS at the destination prior to top of descent.
- After determining the approach, Both pilots should review the approach plate prior to the approach briefing. It is a good technique to have the PM set-up the approach prior to the briefing.

The PM can accomplish the following:

- Select the proper approach from the FMS data base if not previously accomplished.
- Identify and set up all required radio nav aids (ILS, LOC/BC, marker beacons, NDBs, DMEs, etc.).
- Set the radio and barometric altimeter bugs to the published decision altitude/height (DA(H)), derived decision altitude DDA or minimum descent altitude/height MDA(H).
- Set the airspeed bugs.
- Advise the PF upon completion.

Do not completely abandon enroute navigation procedures even though ATC is providing radar vectors to the initial or final approach fix. Use all suitable electronic and visual systems for assistance. Check ADF/VOR selector set to the proper position. Verify ILS, VOR and ADF are tuned and identified if required for the approach. Confirm the published approach inbound course is set or displayed. Check that the marker beacon is selected on the audio panel, as desired.

Crosscheck full or expanded ILS or VOR displays. When on vectors, extend the runway centerline from the IAF (initial approach fix), FAF (final approach fix), FF (final fix), or CF (course fix), as appropriate.

Crosscheck flight director commands versus vertical speed, glideslope, pitch attitude and thrust.

The course and glideslope signals are reliable only when their warning flags are not displayed, localizer and glideslope pointers are in view, and the identifier is received.

Do not use radio navigation aid facilities that are out of service, even though flight deck indications appear normal. Radio navigation aids that are out of service may have erroneous transmissions that are not detected by airplane receivers and no flight deck warning is provided to the crew.

The PM should immediately bring any deviation from the published approach to the attention of the PF.

The PM should closely monitor the airspeed, vertical speed, altitude, glideslope, throttle position, and call out any significant deviations from normal.

Approach Briefing

Prior to the start of an instrument approach, the PF should brief the other pilot as to intentions in conducting the approach. Both pilots should review the approach procedure. All pertinent approach information, including minimums and missed approach procedures, should be reviewed and alternate courses of action considered.

The crew should accomplish the approach briefing as early as possible so they may devote maximum attention to descent planning and meeting any assigned ATC restrictions.

- The Captain will determine if aircraft control should be transferred during the approach briefing after considering the complexity of the approach and time required to conduct the brief.
- The PF should accomplish the following.
 - Review the applicable approach plate.
 - Set barometric and radio altimeter bugs.
 - Set airspeed bugs.
 - Verify or complete FMS programming.

Refer to the FOM for a detailed description of items (e.g., NATS) to include in the approach briefing.

 DELTA
MD-88/90 Flight Crew Training Manual

While not specific briefing items, it is useful to include the following:

- Review the approach lighting system in the Delta Airway Manual to assist in runway identification.
- Brief the final approach flap setting and use or non-use of the autobrake system.
- For Non-Precision approaches determine descent rate, descent point, and DDA if necessary.
- Brief the expected landing environment visual picture including runway lighting.
- Brief when to set missed approach altitude.

Approach Category

FAA Category	Speed
C	121 knots or more but less than 141 knots
D	141 knots or more but less than 166 knots
Speed - based upon a factor of 1.3 or 1.23 (see note) times stall speed in the landing configuration at maximum certificated landing weight.	

Note: Factor is dependant upon airplane type certification basis.

ICAO Category	Vat	Range of Speeds for Initial Approach	Range of Speeds for Final Approach	Max Speeds for Visual Maneuvering (Circling)	Max Speeds for Missed Approach	
					Inter-mediate	Final
C	121/140	160/240	115/160	180	160	240
D	141/165	185/250	130/185	205	185	265
Vat - Speed at threshold based upon a factor of 1.3 or 1.23 (see note) times stall speed in the landing configuration at maximum certified landing mass.						

Note: Factor is dependant upon airplane type certification basis.

For instrument approaches, the MD-88 is classified as a category “C”, and the MD-90 is classified as a category “D”. The MD-88 and the MD-90 are both category “D” aircraft for circling approaches.

Approach Clearance

When cleared for an approach and on a published segment of that approach, the pilot is authorized to descend to the minimum altitude for that segment. When cleared for an approach and not on a published segment of the approach, maintain assigned altitude until crossing the initial approach fix or established on a published segment of that approach. If established in a holding pattern at the final approach fix, the pilot is authorized to descend to the procedure turn altitude when cleared for the approach.

If using a VNAV profile, all altitude and speed constraints must be entered either manually, by selecting a published arrival, or by a combination of both. When properly entered, the VNAV profile complies with all altitude constraints. Crossing altitudes may be higher than the minimum altitudes for that segment because the VNAV path is designed to optimize descent profiles.

When conducting an instrument approach from the holding pattern, continue on the same pattern as holding, extend flaps to fifteen on the outbound track parallel to final approach course. Turn inbound on the procedure turn heading. This type of approach is also referred to as a race track approach.

Procedure Turn

On most approaches the procedure turn must be completed within specified limits, such as within 10 NM of the procedure turn fix or beacon. The FMC depicted procedure turn, or holding pattern in lieu of procedure turn, complies with airspace limits. The published procedure turn altitudes are normally minimum altitudes.

The procedure turn size is determined by the ground speed at the IAF. Refer to Airway Manual section 3, Procedures (Ops Specs), Instrument Approach Procedures (IAP) , Procedure Turns for procedures and airspeed Constraints.

Adjust time outbound for airspeed, wind effects, and location of the procedure turn fix. If the procedure turn fix is crossed at an excessively high ground speed, the procedure turn protected airspace may be exceeded. The procedure turn should be monitored using the map to assure the airplane remains within protected airspace.

Stabilized Approach Requirements

Refer to Volume 1, Normal Procedures, Flight Patterns, for Stabilized Approach Requirements.

Mandatory Missed Approach

On all instrument approaches, execute an immediate missed approach:

- if a navigation radio or flight instrument failure occurs which affects the ability to safely complete the approach in instrument conditions
- when on ILS final approach, in instrument conditions, and either the localizer and/or glideslope indicator shows full deflection
- when the navigation instruments show significant disagreement and visual contact with the runway has not been made

Refer to Operations Manual Volume 1, Normal Procedures, Flight Patterns, Missed Approach/Rejected Landing.

Landing Minima

Most regulatory agencies require visibility for landing minima. Ceilings are not required. There are limits on how far an aircraft can descend without visual contact with the runway environment when making an approach. Descent limits are based on a decision altitude/height DA(H) for approaches using a glide slope, or a MDA(H) for approaches that do not use vertical guidance, or where a DA(H) is not authorized for use.

Approach charts use the abbreviation DA(H) or MDA(H). DA(H) applies to Category I, II, and certain fail passive Category III operations. A decision altitude “DA” or minimum descent altitude “MDA” is referenced to MSL and the parenthetical height “(H)” is referenced to Touchdown Zone Elevation (TDZE) or threshold elevation. Example: A DA(H) of 1,440’ (200’) is a DA of 1,440’ with a corresponding height above the touchdown zone of 200’.

When RVR is reported for the landing runway, it is used in lieu of the reported meteorological visibility.

Radio Altimeter (RA)

A radio altimeter is used to determine DH when a DA(H) is specified for category II or category III approaches. Procedures at airports with irregular terrain may use a marker beacon instead of a DH to determine the missed approach point. The radio altimeter may also be used to cross check the primary altimeter over known terrain in the terminal area. The radio altimeter is not used for determining Category I DA(H)/MDA(H) on instrument approaches. It should also not be used for approaches where use of the radio altimeter is not authorized (RA NOT AUTHORIZED).

Missed Approach Points (MAP)

A missed approach point is a point where a missed approach must be initiated if suitable visual references are not available to make a safe landing or the airplane is not in a position to make a safe landing.

Determination of a MAP

For approaches such as ILS, the DA(H) in conjunction with the glide slope is used to determine the MAP. For all types of non-ILS approaches, the MAP is defined as published on the approach procedure. All types of non-ILS approaches require that the MAP be identified by some means of raw data.

Timing During Approaches

- Delta requires the use of timing for approaches if other applicable raw data is not available (e.g., ILS DME, VOR DME). The timing table on the published approach procedure, when included, shows the distance from the final approach fix to the MAP.

Instrument Landing System (ILS)

Arrival at the MAP is determined by reference to an altimeter. DA is determined by reference to the barometric altimeter. For CAT II & III approaches, DH is determined by reference to the radio altimeter.

Localizer

The MAP for a localizer approach is not the same as for the corresponding ILS approach. For most approaches the MAP distance is to the threshold of the runway. The common method of determining the MAP is by timing from the final approach fix, though other methods may be used, such as DME or middle marker.

Other Non-ILS Approaches

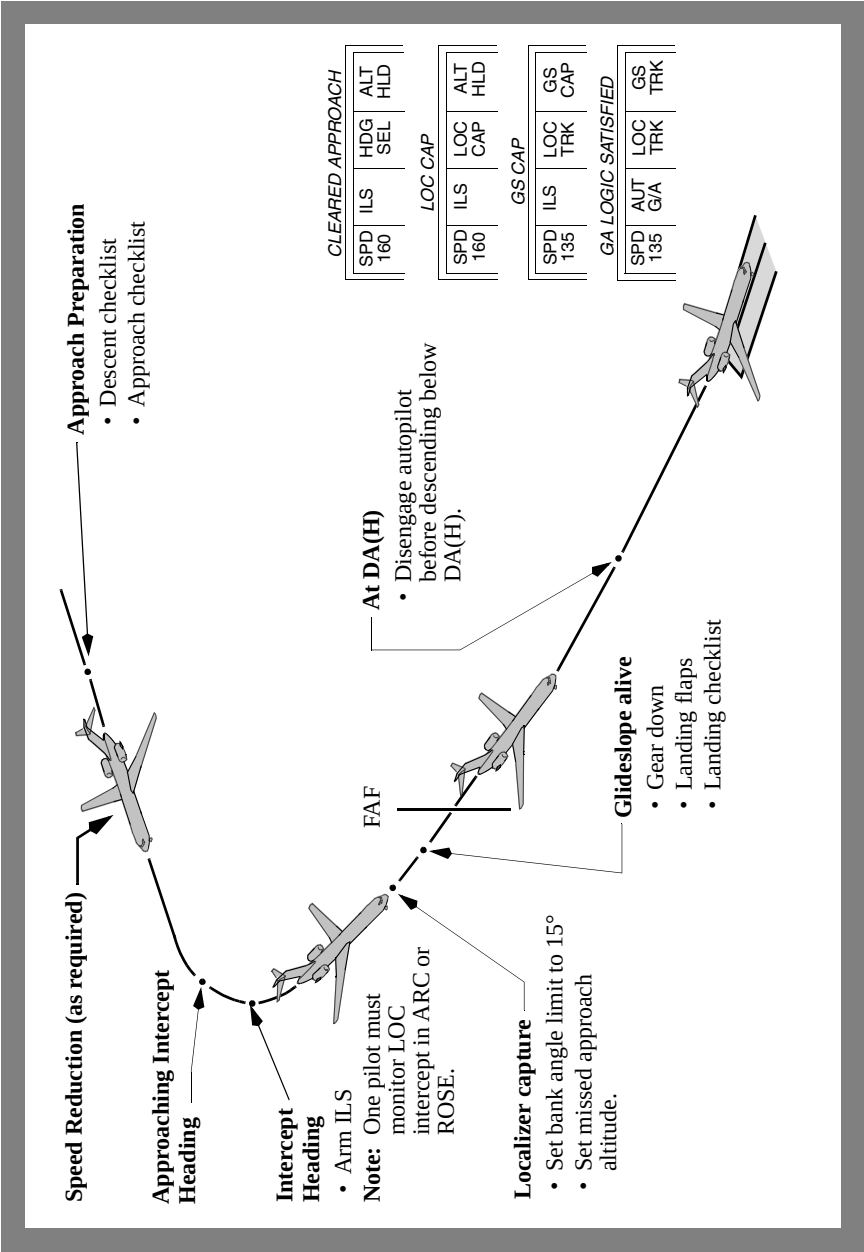
The MAP for all other non-ILS approaches is depicted on the approach chart. If the procedure has a final approach fix, the MAP may be short of the runway threshold, at the runway threshold, or located over a radio facility on the field. For on airport facilities (VOR or NDB) which do not have a final approach fix, the facility itself is the MAP and in most cases is beyond the runway threshold.

 DELTA
MD-88/90 Flight Crew Training Manual

Intentionally
Blank

ILS Approach

ILS Approach Profile



ILS Approach - General

The ILS approach illustrated assumes all preparations for the approach such as review of approach procedure and setting of minima and radios are complete. It focuses on crew actions and avionic systems information. It also includes unique considerations during low weather minima operations. The pattern may be modified to suit local traffic and ATC requirements.

Procedure Turn and Initial Approach

Cross the IAF at flaps 15 and a minimum of flaps 15 maneuvering airspeed and monitor the procedure turn using the map to assure the airplane remains within protected airspace. The depicted procedure turn, or holding pattern in lieu of procedure turn, complies with approach airspace limits.

If a complete arrival procedure to the localizer and glideslope capture point has been selected via the MCDU, the initial approach phase may be completed using NAV.

Approach

Both pilots should not be “heads-down” during the approach. In some cases, such as high density traffic, busy ATC environment, or when an arrival procedure is desired for reference, revising the FMS flight plan may not be appropriate.

If displaying the arrival procedure is not desired, perform a “DIRECT TO” or “INTERCEPT COURSE TO” the FAF, OM, or appropriate fix, to simplify the navigation display. This provides:

- a display of distance remaining to the FAF, OM, or appropriate fix
- a depiction of lateral displacement from the final approach course
- NAV capability during the missed approach procedure.

The approach procedure may be flown using HDG SEL, VOR/LOC or NAV for lateral tracking of V/S or IAS for altitude changes. For small altitude changes, V/S permits a more appropriate descent rate.

When operating in speed intervention or the autothrottle SPD mode, timely speed selections minimize throttle lever movement during the approach. This reduces cabin noise levels and increases fuel efficiency. When flaps are extended, select the minimum maneuver speed as the additional configuration drag takes effect.

Delaying the speed selection causes an increase in thrust, while selecting the lower speed too quickly causes thrust to decrease, then increase.

During the approach, adjust the map display and range to provide a scaled plan view of the area. When on intercept heading and cleared for the approach, select the desired autopilot and flight director mode and observe the arm mode annunciation on the FMA (ILS, LND).

ILS or AUTOLAND should not be selected until:

- the ILS is tuned and identified
- the airplane is on an inbound intercept heading
- both localizer and glideslope pointers appear on the PFD and ND in the proper position
- clearance for the approach has been received.

The glideslope may be captured from either above or below, however, glideslope will not capture unless localizer has previously been captured. To avoid unwanted glideslope capture, LOC mode may be selected initially, followed by the ILS or AUTOLAND mode.

Final Approach

The pilots should monitor the quality of the approach, flare, landing and rollout, including spoiler deployment and autobrake application.

For normal localizer intercept angles, very little overshoot occurs. The maximum bank angle during capture is 28 ± 2 degrees and is not affected by the position of the bank angle selector. For large intercept angles some overshoot can be expected. One pilot must be in the ARC or ROSE mode to monitor the LOC intercept.

Use the map display to maintain awareness of distance to go to the final approach fix. When the glideslope pointer begins to move (glideslope alive), extend the landing gear, select landing flaps and VREF + 5 or VREF + wind correction if landing manually, and complete the Landing checklist. When using the autothrottle to touchdown, no additional wind correction is required to the final approach speed. The PM should continue standard callouts during final approach and the PF should acknowledge callouts. Observe the flight mode annunciations for correct modes.

Check for correct crossing altitude and begin timing, if required, when crossing the final approach fix (FAF or OM).

There have been incidents where airplanes have captured false glideslope signals and maintained continuous on-glideslope indications as a result of an ILS ground transmitter erroneously left in the test mode. False glideslope signals can be detected by crosschecking the final approach fix crossing altitude. A normal pitch attitude and descent rate should also be indicated on final approach after glideslope capture. Normal pitch attitude for descending at approximately 700 fpm with Flaps 40 selected on final approach is 2.5 degrees nose up. Further, if a glideslope anomaly is suspected, an abnormal altitude range-distance relationship may exist. This can be identified by crosschecking distance to the runway with altitude or crosschecking the airplane position with waypoints indicated on the navigation display. The altitude should be approximately 300 feet HAT per NM of distance to the runway for a three-degree glide slope.

 DELTA
MD-88/90 Flight Crew Training Manual

If a false glideslope capture is suspected, perform a missed approach if visual conditions cannot be maintained.

If the AUTOLAND mode is engaged, and the dual-input logic is satisfied, the FMA will annunciate AUT LND in the roll and pitch windows below 1,500 feet radio altitude. As the lowest weather minimums are directly related to the system status, ensure correct FMA annunciations are observed.

If an autoland annunciation changes or system fault occurs that requires higher weather minimums, do not continue the approach below these higher minimums unless suitable visual reference with the runway environment is established.

During an autoland with crosswind conditions, the runway alignment maneuver uses forward slip to reduce the crab angle of the airplane at touchdown. Alignment begins at 150 feet radio altitude. The maneuver is accomplished primarily by the rudder axis using the parallel rudder servo with primary guidance for the rudder axis alignment derived from runway heading (CRS) error. The airplane is aligned to within 1.5 degrees upwind of the runway heading for touchdown with a bank angle to oppose the turning moment generated by the rudder displacement (cross control). Both the aileron and rudder control systems receive localizer commands during the ALIGN mode to maintain the runway centerline. Roll control for the forward slip maneuver is limited to 5 ± 1 degrees at touchdown.

The autobrakes should remain engaged until a safe stop is assured and adequate visibility exists to control the airplane using visual references.

Delayed Flap Approach (Noise Abatement, Fuel Conservation)

If the approach is not being conducted in icing or other adverse conditions, the final flap selection may be delayed to conserve fuel or to accommodate speed requests by ATC.

Intercept the glideslope with gear down and flaps appropriate to maintain maneuverability for the airspeed. The thrust required to descend on the glideslope may be near idle. Approaching 1,000 feet AFE, select landing flaps, allow the speed to bleed off to the final approach speed, then adjust thrust to maintain it. Complete the Landing checklist. Comply with stabilized approach requirements.

Decision Altitude/Height - DA(H)

A Decision Altitude/Height is a specified altitude or height in a precision approach where a missed approach must be initiated if the required visual reference to continue the approach has not been established. The "Altitude" value is typically measured by a barometric altimeter and is the determining factor for minima for Category I approaches.

For Category II approaches, the Decision Height is the controlling minima and the barometric altitude value specified is advisory. A Decision Height is usually based on a specified radio altitude above the terrain on the final approach or touchdown zone.

During a CAT I approach the PM should expand the instrument scan to include outside visual cues when approaching DA. Do not continue the approach below DA(H) unless the Airway Manual Descent Below DA(H)/MDA criteria are satisfied. Upon arrival at DA(H), or any time thereafter, any of the above requirements are not met, immediately execute the missed approach procedure. When visual contact with the runway is established, maintain the glide path to the flare. Do not descend below the glide path.

Raw Data - (No Flight Director)

ILS deviation is displayed on the PFD. ILS deviation may also be displayed on the ND by selecting ARC or ROSE mode on the EFIS Mode selector. Set VOR/ADF to display appropriate pointers on the ND. Continue to crosscheck the map display against the PFD raw data. Begin the turn to the inbound localizer heading at the first movement of the course deviation bar.

After course intercept, the track line and read-out on the navigation display may be used to assist in applying proper drift correction and maintaining desired course. Bank as necessary to keep the course deviation bar centered and the track line over the course. This method automatically corrects for wind drift with very little reference to actual heading required.

Large bank angles are rarely required while tracking inbound on the localizer. Use 5° to 10° of bank angle.

When the glideslope deviation indicator begins to move (glideslope alive), lower the landing gear, extend flaps and establish the final approach speed. On final approach, maintain appropriate airspeed. Check altitude and time crossing the FAF. To stabilize on the final approach speed as early as possible, it is necessary to exercise precise speed control during the glideslope intercept phase of the approach. The rate of descent varies with the glideslope angle and groundspeed. Expeditious and smooth corrections should be made based on the ILS course and glideslope indications. Apply corrections at approximately the same rate and amount as the flight path deviations.

The missed approach procedure is the same as a normal missed approach. Flight Director guidance appears if TO/GA is selected. Refer to Missed Approach/Go-Around - All Approaches, this chapter.

DFGS Autoland Capabilities

Refer to the applicable Airplane Flight Manual for a description of demonstrated autoland capabilities.

Note: Autoland requires use of flaps 28 or 40.

Note: Autoland should not be attempted unless the localizer beam is aligned with the runway centerline. If the localizer beam is offset from the centerline the DFGS may cause the airplane to depart the runway.

ILS Performance

Most ILS installations are subject to signal interference by either surface vehicles or aircraft. To prevent this interference, ILS critical areas are established near each localizer and glideslope antenna. In the United States, these areas are restricted from all vehicle or aircraft operation any time the weather is reported less than 800 foot ceiling and/or visibility is less than 2 miles.

When the weather is less than 200 foot ceiling and/or RVR 2,000, vehicle or aircraft operations in or over these critical areas are not authorized when an arriving aircraft is inside the Middle Marker (MM).

During category III operations, the entire length of the preceding aircraft must be 250 feet clear of the runway centerline before an aircraft on an ILS approach reaches the Middle Marker or 200 feet AGL.

Flight inspections of the ILS approaches do not include analysis of the performance inside the runway threshold or along the runway unless the ILS is used for Category II or III approaches. For this reason, the ILS beam quality may vary at these locations and autolands performed at these facilities should be closely monitored.

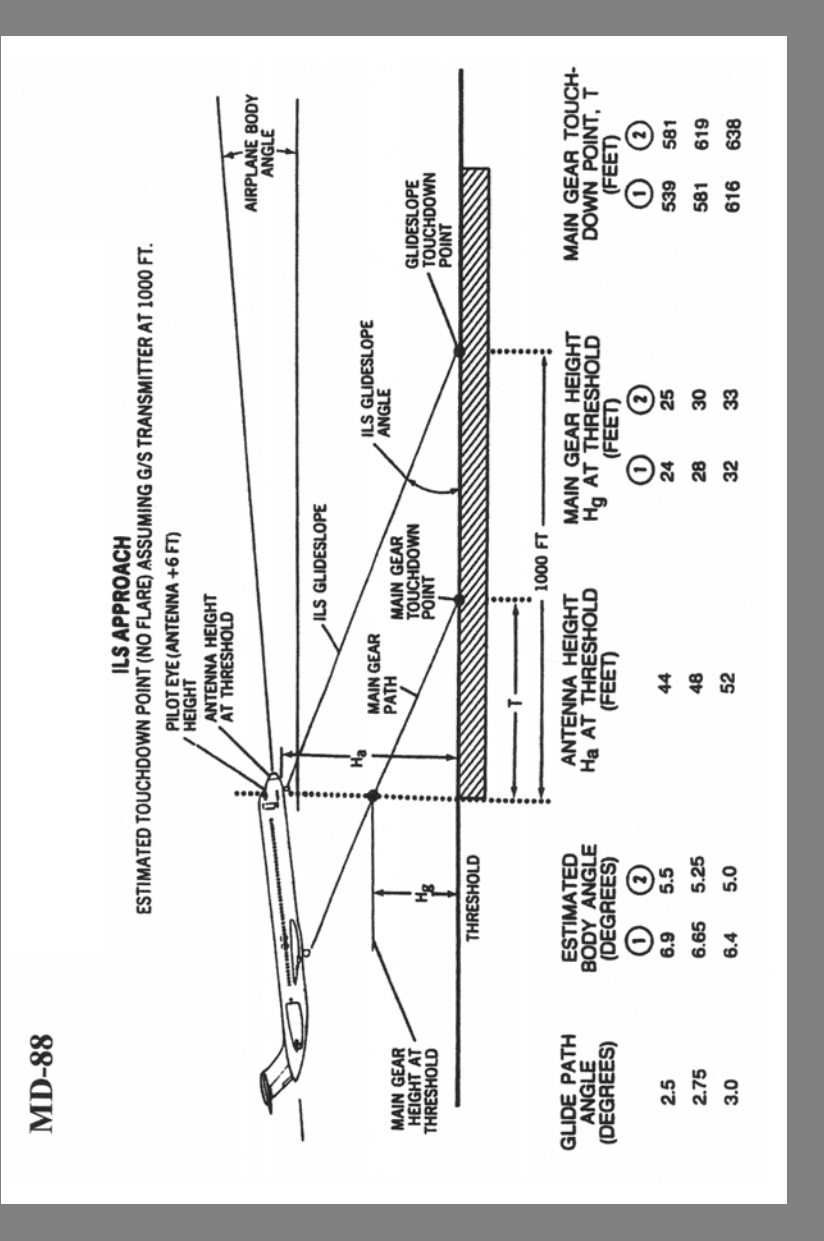
Flight crews must remember that the ILS critical areas are not usually protected when the weather is above 800 foot ceiling and/or 2 mile visibility. As a result, ILS beam bends may occur because of vehicle or aircraft interference. Sudden and unexpected flight control movements may occur at a very low altitude or during the landing and rollout when the autopilot attempts to follow the beam bends. At ILS facilities where critical areas are not protected, flight crews should be alert for this possibility and guard the flight controls (control wheel, rudder pedals and throttles) throughout all automatic approaches and landings. Be prepared to disengage the autopilot and manually land or go-around.

ILS Approach/Landing Geometry

The following diagrams use these conditions:

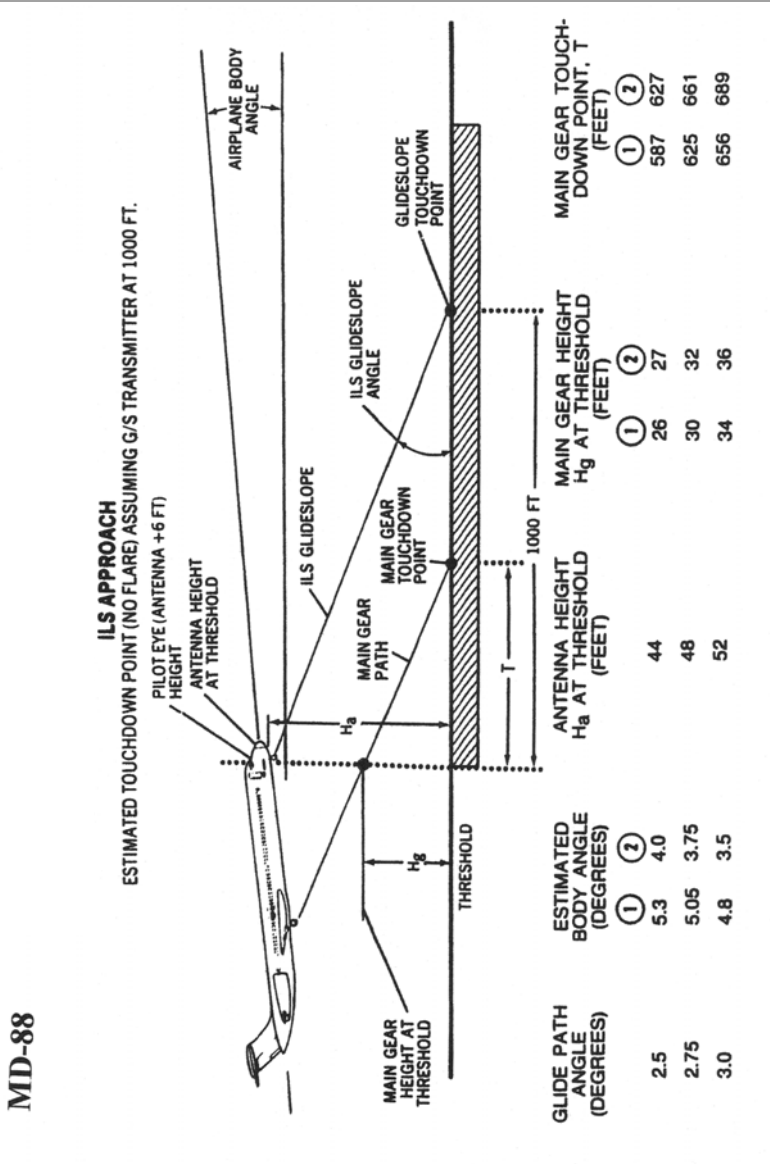
- airplane body attitudes are based on Flaps 28 and 40.
- pilot eye height measured at point when main gear crosses threshold

MD-88 Pilot Eye Orientation
Approach and Landing - Flaps 28 (1.3 Vs)



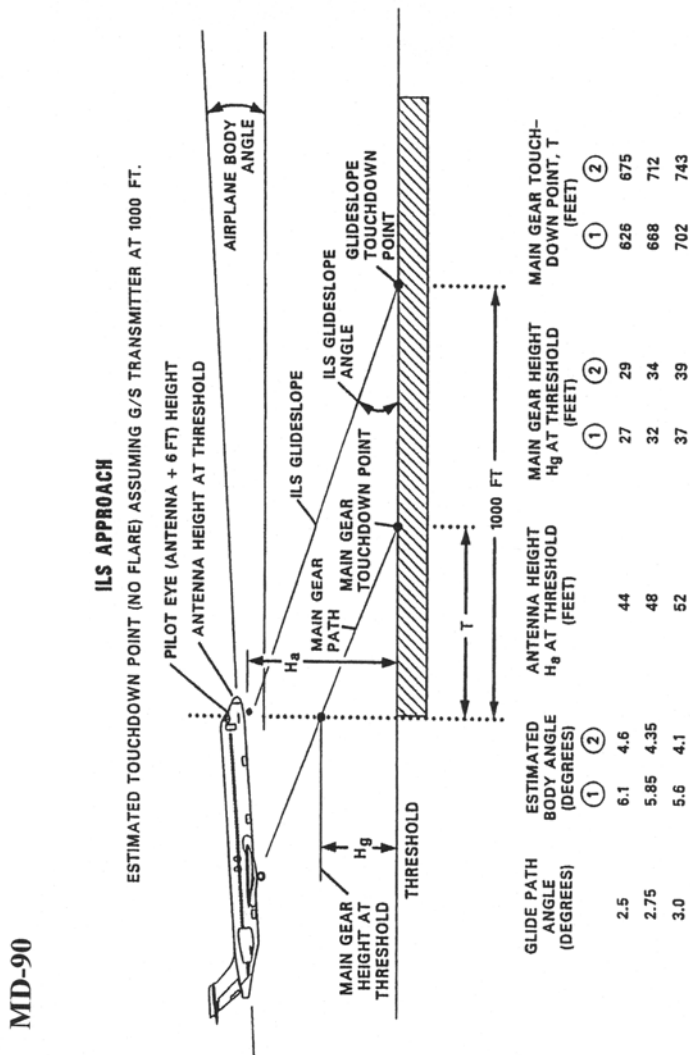
MD-88 Pilot Eye Orientation

Approach and Landing - Flaps 40 (1.3 Vs)



MD-90 Pilot Eye Orientation

Approach and Landing - Flaps 28 (1.3 Vs)

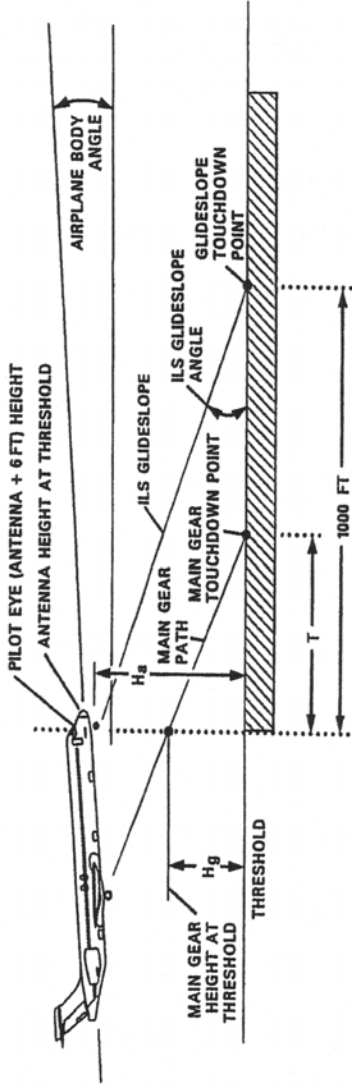


MD-90 Pilot Eye Orientation
Approach and Landing - Flaps 40 (1.3 Vs)

MD-90

ILS APPROACH

ESTIMATED TOUCHDOWN POINT (NO FLARE) ASSUMING G/S TRANSMITTER AT 1000 FT.



GLIDE PATH ANGLE (DEGREES)	ESTIMATED BODY ANGLE (DEGREES)		ANTENNA HEIGHT H_a AT THRESHOLD (FEET)	MAIN GEAR HEIGHT H_g AT THRESHOLD (FEET)		MAIN GEAR TOUCHDOWN POINT, T (FEET)	
	(1)	(2)		(1)	(2)	(1)	(2)
2.5	6.1	4.6	44	27	29	626	675
2.75	5.85	4.35	48	32	34	668	712
3.0	5.6	4.1	52	37	39	702	743

Low Visibility Approaches

A working knowledge of approach lighting systems and regulations as they apply to the required visual references is essential to safe and successful approaches. Touchdown RVR is normally controlling for Category I, II, and III approaches. For Category I and II approaches, mid and rollout RVR are normally advisory. For Category III operations mid RVR is controlling. In some countries, visibility is used instead of RVR. Approval from the regulatory agency is required to use visibility rather than RVR. See Airway Manual, Procedures chapter, for visibility and RVR requirements.

During Category I approaches, visual reference requirements specify that either the approach lights or other aids be clearly visible to continue below DA(H). During Category I and II approaches, descent below 100 ft. above touchdown zone elevation requires the red terminating bars or red side row bars (ALSF or Calvert lighting systems, or ICAO equivalent, if installed) to be distinctly visible. If actual touchdown RVR is at or above the RVR required for the approach, the runway environment (threshold, threshold lights and markings, touchdown zone, touchdown lights and markings) should become clearly visible resulting in a successful approach. After acquiring the red terminating bars or red side row bars, if the runway environment does not become distinctly visible execute an immediate missed approach.

A review of the approach and runway lighting systems available during the approach briefing is recommended as the pilot has only a few seconds to identify the lights required to continue the approach. For all low visibility approaches, a review of the airport diagram, expected runway exit, runway remaining lighting and expected taxi route during the approach briefing is recommended.

DFGS System Configuration

The system configurations listed in this section do not include all of the systems and equipment required for each type of operation. See Operations Manual, Volume 1, Normal Procedures chapter, Introduction section, Airborne ILS Equipment Chart and Airway Manual, Procedures chapter, for specific system and equipment information.

More detailed information concerning Category II and Category III operational requirements can be found in the Procedures chapter of the Airway Manual.

Category II Operations

These approaches are based on an approach to touchdown using the automatic landing system (similar to CAT III). Normal operations should not require pilot intervention. However, pilot intervention should be anticipated in the event inadequate airplane performance is suspected, or when an automatic landing cannot be safely accomplished in the touchdown zone. Guard the controls on approach through the landing roll and be prepared to take over manually. Flight may be continued to landing if runway is in sight.

If the autopilot is disengaged on the approach and a manual landing planned, the autothrottles must be disengaged by 50 feet AGL.

Refer to Operations Manual Volume 1, Normal Procedures chapter, Flight Patterns section specific approach requirements and considerations.

Category III Operations

Category III operations are based on an approach to touchdown using the automatic landing system. Normal operations should not require pilot intervention. However, pilot intervention should be anticipated in the event inadequate airplane performance is suspected, or when an automatic landing cannot be safely accomplished in the touchdown zone. Guard the controls on approach through the landing roll and be prepared to take over manually. If required to take over manually, execute a missed approach (unless touchdown is already achieved).

Refer to Operations Manual Volume 1, Normal Procedures chapter, Flight Patterns section specific approach requirements and considerations.

Category III/Autoland

Prior to approach, the Captain and First Officer must adjust their seats to optimum eye level position to provide the maximum slant range visibility at the 50 feet DH. A higher pitch angle or lower than optimum seat position will result in less runway being visible (see pilot eye orientation diagram this section).

Throughout the approach, touchdown and landing, the First Officer's primary duty is to monitor the instruments and advise the Captain as to approach progress.

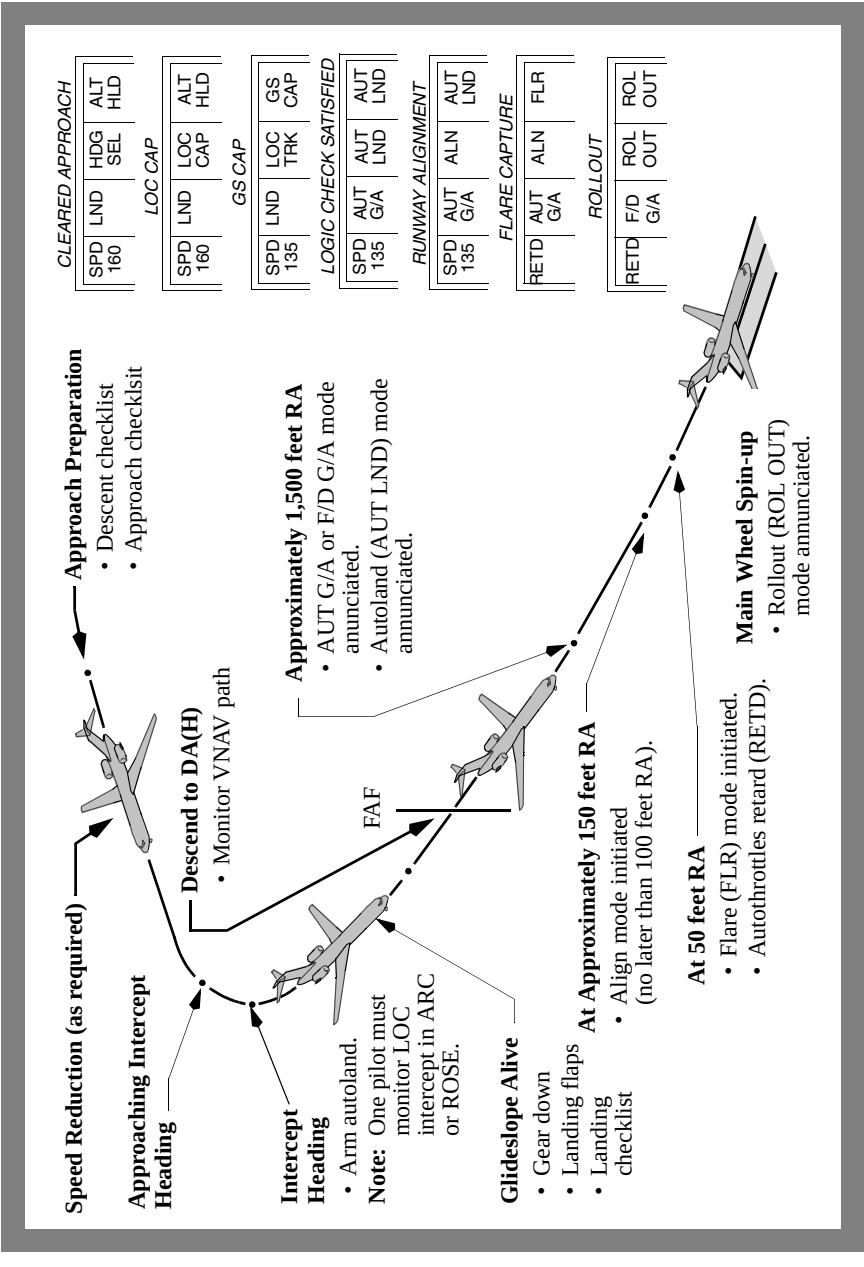
The Captain is primarily responsible for acquiring the runway visually and must have visual contact with the touchdown zone or TDZ lights to continue below DH.

Since Category III approaches are predicated on the use of autoland, the autopilot must not be disconnected until after touchdown. Should the autopilot disengage for any reason, execute a missed approach.

 DELTA
MD-88/90 Flight Crew Training Manual

Intentionally
Blank

ILS Autoland Approach Profile



ILS Autoland Approach

Procedures for Category II and Category III approaches are similar, except, in event sequencing and missed approach execution criteria. The sequence between approaching minimums, minimums, and runway alignment will vary according to published minimums.

When Cleared For Approach

- Arm autoland instead of ILS.
- Ensure LND appears in the FMA arm window.

SPD 160	LND	HGD SEL	ALT HLD

At 1,500 Feet AGL (RA)

When the logic check is complete:

- If the system fails the logic check, LND will flash in the arm window.
- Ensure AUT G/A or F/D G/A appears in the FMA arm window.
 - If automatic go-around logic is not satisfied, the FMA arm window will annunciate F/D G/A instead of AUT G/A.
 - The approach may continue with either AUT G/A or F/D G/A annunciated in the arm window.
- Ensure AUT LND appears in the FMA roll and pitch windows.

SPD 135	AUT G/A	AUT LND	AUT LND

At Approximately 150 Feet AGL (RA)

- Ensure FMA roll window displays ALN.

SPD 135	AUT G/A	ALN	AUT LND

- Align mode is annunciated at approximately 150' AGL and must be annunciated by 100' AGL.

Prior To Decision Height

Execute a missed approach if:

- Any controlling RVR goes below minimums (Category III only).
- Any required airborne or ground systems fail.
- Any amber FMA legend light illuminates during the final approach segment, except the AP TRIM light.

- The AP TRIM light is illuminated in excess of 3 seconds after the aircraft is stabilized and tracking the glideslope.
- The crosswind component on the landing runway is expected to be greater than 15 knots.

At Decision Height

- Decision height will be made by reference to the radio altimeter only.
- If autoland is not armed, the pilot must disengage the autopilot no later than DH.
- The Captain will call “RUNWAY IN SIGHT” or “MISSED APPROACH” at DH.

Note: The First Officer will acknowledge the Captain.

- Ensure RETD appears in the FMA throttle window.
- Ensure FLAR appears in the FMA pitch window.



- Execute a missed approach if:
 - At minimums, the pilot has not established visual reference with the TDZ lights or TDZ.
 - An automatic landing cannot be safely accomplished within the touchdown zone.
 - At any time the crosswind component on the landing runway is expected to be greater than 15 knots.

Note: A go-around executed at D(H) may result in the aircraft touching down on the runway. Continue the go-around if this occurs.

Note: Selecting TO/GA with F/D G/A annunciated on the FMA will result in the autopilot disengaging. The missed approach must be flown manually.

At Or Below Decision Height

F/O should monitor localizer/runway symbol on PFD for deviations from centerline.

 DELTA
MD-88/90 Flight Crew Training Manual

After Touchdown

- The AUT G/A mode is disarmed, and F/D G/A is armed and available for 20 seconds.
- Autopilot rudder control will maintain runway track for 5 seconds after nosewheel touchdown, then the autopilot will automatically disengage.
- Autothrottles disengage when reverse thrust is applied.

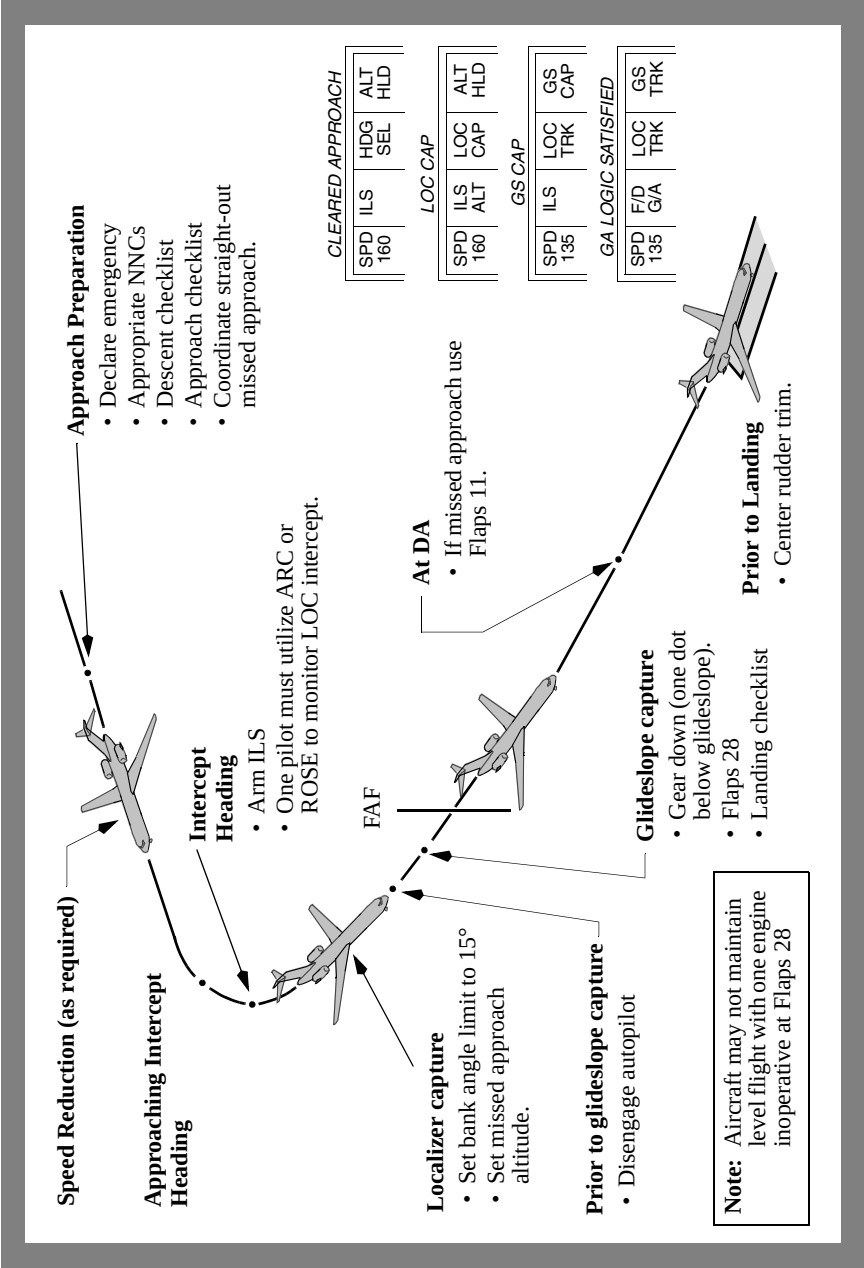


- After the autopilot disengages, the roll and pitch windows will revert to HDG HLD and ALT HLD.



- On rollout, F/O will give guidance reference to runway centerline using the PFD expanded localizer.
- Runway lighting.
 - 3,000 feet remaining - centerline lights alternate red and white.
 - 2,000 feet remaining - runway edge lights become amber.
 - 1,000 feet remaining - centerline lights become all red.
- After landing, the F/O should assist the Captain in taxiway identification using a SMGCS chart if appropriate.
- Maintain a safe taxi speed.

ILS Approach Profile - One Engine Inoperative



Non-Normal Operations (ILS)

This section describes pilot techniques associated with engine inoperative ILS approaches. Techniques discussed minimize workload, improve crew coordination, and enhance flight safety. However, a thorough review of applicable Non-Normal Checklists associated with engine inoperative flight is a prerequisite to understanding this section.

Note: Procedures for an engine out CAT I approach are the same as those for a two engine approach except for the procedures described below.

Requirements

- CAT I is the lowest authorized approach.
- For inoperative equipment, refer to Operations Manual Volume 1, Normal Procedures, Introduction section, ILS Airborne Equipment Requirement Chart.

Note: Failure to apply adequate rudder trim may result in an uncommanded heading excursion and/or an autopilot disconnect.

On Downwind

- Declare an emergency if not previously accomplished.
- Use of autopilot is recommended while in the pattern.
- Use autothrottles as desired.
- Ensure appropriate checklists and procedures are complete.
 - AFTER TAKEOFF checklist.
 - ENGINE FAILURE/SHUTDOWN or ENGINE FIRE OR SEVERE DAMAGE procedure as appropriate.
 - DESCENT checklist.
 - APPROACH checklist.
- Additional Briefing items.
 - Request straight out missed approach if desired and terrain permits.
 - Use flaps 28 for landing.
 - Use flaps 11 for go-around.
 - Have PM zero rudder trim no later than touchdown.
 - Engine out coupled ILS approaches are not permitted.

Prior To Glideslope Capture

Disengage the autopilot prior to glideslope capture. Engine out coupled ILS approaches are not permitted. Lower the gear when approximately one dot deflection below glideslope.

After The Gear Is Down And Locked

- Select flaps 28.
- Set command airspeed bug to VREF + 5 or VREF + appropriate wind additive, whichever is higher.
- Complete LANDING checklist.

Not Later Than Touchdown

The PM zeroes the rudder trim as briefed by the PF. Failure to center the rudder trim may create directional control problems during the rollout.

After Nosewheel Is On The Ground

- Position both throttles to idle reverse and apply as necessary.
- Be prepared to apply rudder to offset asymmetrical reverse thrust.

Engine Failure On Final Approach

If an engine failure should occur on final approach with flaps 40, the decision to continue the approach or execute a go around should be made immediately. If the approach is continued, change the configuration from flaps 40 to flaps 28 and adjust speed accordingly.

If a go around is required, follow the engine out go around procedures.

Non-ILS Instrument Approaches

Non-ILS approaches are defined as:

- VOR, VOR DME
- NDB or Locator
- LOC, LOC DME, LOC Back Course
- LDA, LDA DME, LOC

Non-ILS approaches are normally flown using vertical speed mode to achieve a pre-computed descent rate. This method results in a “constant angle non-precision approach” (CANPA) during the final approach segment. The constant rate non-precision approach provides a profile very similar to a VNAV approach and will approximate an ILS-type final approach segment. There is no level off during the approach so large pitch and power changes are not required. VDP calculations are also not required. Recommended roll modes are provided in the applicable procedures discussed in this chapter.

Non - ILS Instrument Approaches - General

A typical non-precision instrument approach, as illustrated, assumes all preparations for the approach; such as review of the approach procedure and setting of minima and radio tuning have been completed. The procedures illustrated focus generally on crew actions and avionics systems information. The flight pattern may be modified to suit local traffic and ATC requirements.

Use of the Autopilot during Approaches

Automatic flight is the preferred method of flying non-precision approaches. If the visibility is less than RVR 4,000 (3/4 mile), the autopilot and flight director must be used (if operable). Automatic flight minimizes flight crew workload and facilitates monitoring the procedure and flight path. Manually flying non-precision approaches in IMC conditions increases workload without a significant increase in efficiency and protection provided by the automatic systems. However, to maintain flight crew proficiency, pilots may elect to use the flight director without the autopilot when in VMC conditions.

Note: In all cases, the autopilot must be disconnected no later than 50 feet below the published MDA (100 feet below DDA).

Raw Data Monitoring Requirements

Use all suitable electronic and visual systems for assistance. Checking raw data for correct navigation prior to commencing the approach may be accomplished by:

- selecting ARC or ROSE on the EFIS mode selector panel and comparing the displayed raw data with the navaid symbols on the map.
- displaying the VOR and/or ADF pointers on the map display and using them to verify your position relative to the map display.

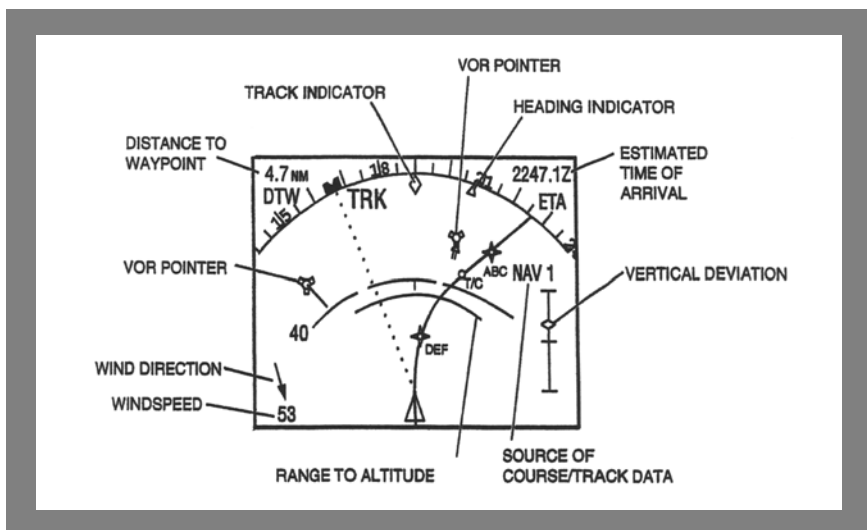
When outside the FAF, the pilot must use raw data to identify the final approach course. As long as MAP indications are normal, the pilot may use the FMS to identify step down fixes.

When at or inside the FAF, the pilot must use raw data to identify course and any step down fixes.

It is not necessary for both pilots to display raw data. See nav display set ups in this chapter for each type of non-precision approach.

Typical Navigation Display

The following diagram represents a typical navigation display with the MAP display selected.



MAP Displays and Raw Data

The MAP display provides a plan view of the approach, including final approach and missed approach routing. The map increases crew awareness of progress and position in the approach.

The map is particularly useful when the inbound course does not align with runway centerline and allows the pilot to clearly determine the type of alignment maneuver required. The map can be used to integrate weather radar returns, terrain or traffic information within the approach path and airport area.

Note: When appropriate, compare airplane position on the map with ILS, VOR, DME, and ADF systems to detect possible map shift errors.

Use of MAP Display

To use the MAP display for approaches, a proper series of legs/waypoints that describe the approach route (and missed approach) must appear on the LEGS page. There are two methods of loading these waypoints:

- Database Selection

An approach procedure selected through the FMC ARRIVALS page provides the simplest method of selecting proper waypoints. Procedures in the database comply with obstruction clearance criteria for non-precision approaches.

If the approach to be flown is not in the database, another approach having the same plan view may be selected. For example, an ILS procedure might be selected if the plan view (route) is identical to an NDB approach. In this case, waypoint altitudes must be checked and modified as required.

- Manual Waypoint Entry

When no procedure is available from the FMC ARRIVALS page, manual entry of a series of waypoints may be accomplished to define the approach routing. The waypoints may be conveniently defined by using names of waypoints or nav aids in the database, bearing/distance from such fixes, intersections of radials or latitude/longitude information.

Procedure turns and DME arcs cannot usually be manually entered (unless they can be defined by a series of waypoints). Deviation from the defined route may require use of “DIRECT TO” or “INTERCEPT LEG TO/INTERCEPT COURSE TO” when intercepting the inbound course. Constant monitoring of raw data during the approach is required.

Note: Procedure turns and DME arcs may require use of HDG SEL.

A navaid/waypoint and the appropriate radial may be inserted on the FIX page to create a “course” line on the map that helps to improve situational awareness.

These methods should only be used when there is no opportunity to use an approach selected from the navigation database and should therefore be considered only when normal means of displaying approaches are not available. Pilots should be aware that the displayed course is an FMC calculated course and is not raw data information.

Note: HDG SEL should be used to fly the approach ground track on NDB and LOC B/C approaches.

If the approach is not available in the NAV database, select the landing runway from the FMC ARRIVALS page. The runway and associated extended centerline then displays on the map to aid in maintaining position awareness.

Pilots should not become involved in excessive “heads down” FMC manipulation to build map displays while at low altitude. Raw data VOR, ILS, and ADF displays should be used to avoid distractions during higher workload phases of flight. Map building should be avoided below 10,000 feet AFE.

Procedure Turn and Initial Approach

The FMC constructs the procedure turn path based upon predicted winds, a 170 knot airspeed and the “do not exceed” distance in the nav database for the procedure.

Cross the IAF at flaps 15 and a minimum of flaps 15 maneuvering airspeed and monitor the procedure turn using the map to assure the airplane remains within protected airspace. The depicted procedure turn, or holding pattern in lieu of procedure turn, complies with approach airspace limits.

Note: If the fix is crossed at an excessively high ground speed, the procedure turn protected airspace may be exceeded. Do not exceed 200 knots.

If a complete arrival procedure has been selected via the MCDU, the initial approach phase may be completed using NAV and IAS or V/S. Ensure the LEGS page sequences, altitude restrictions and map display reflects the ATC clearance. Last minute ATC changes or constraints may be managed by appropriate use of the FGCP heading and altitude selectors. Updating the LEGS page sequencing should be accomplished only as time permits.

Approach

Both pilots should not be “heads-down” during the approach. In some cases, such as high density traffic, or when an arrival procedure is used only for reference, revising the FMS flight plan may not be appropriate.

 DELTA
MD-88/90 Flight Crew Training Manual

If displaying the arrival procedure is not desired, perform a “DIRECT TO” or “INTERCEPT LEG TO/INTERCEPT COURSE TO” the FAF, OM, or appropriate fix, to simplify the navigation display. This provides:

- a display of distance remaining to the FAF, OM, or appropriate fix
- a depiction of cross track error from the final approach course
- NAV capability during the missed approach procedure.

If being vectored to intercept the final approach course, decelerate and extend flaps as appropriate for maneuvering speed.

When operating in speed select or the autothrottle SPD mode, timely speed selections minimize throttle lever movement during the approach. This reduces cabin noise levels and increases fuel efficiency. When flaps are extended, select the next lower speed just as the additional configuration drag takes effect.

During the approach, adjust the map display and range to provide a scaled plan view of the area. When on an intercept heading and cleared for the approach, select the appropriate mode, and observe that the LOC or VOR mode annunciation is armed.

Transition to a Circling Approach

The following non-precision instrument approach discussions assume a straight-in instrument approach is being flown. A circling approach may be flown provided the FGCP altitude is set in accordance with the circling approach procedure. Refer to Operations Manual Volume 1, Normal Procedures, Flight Patterns section, and the Circling Approach information in this chapter for circling approach procedures.

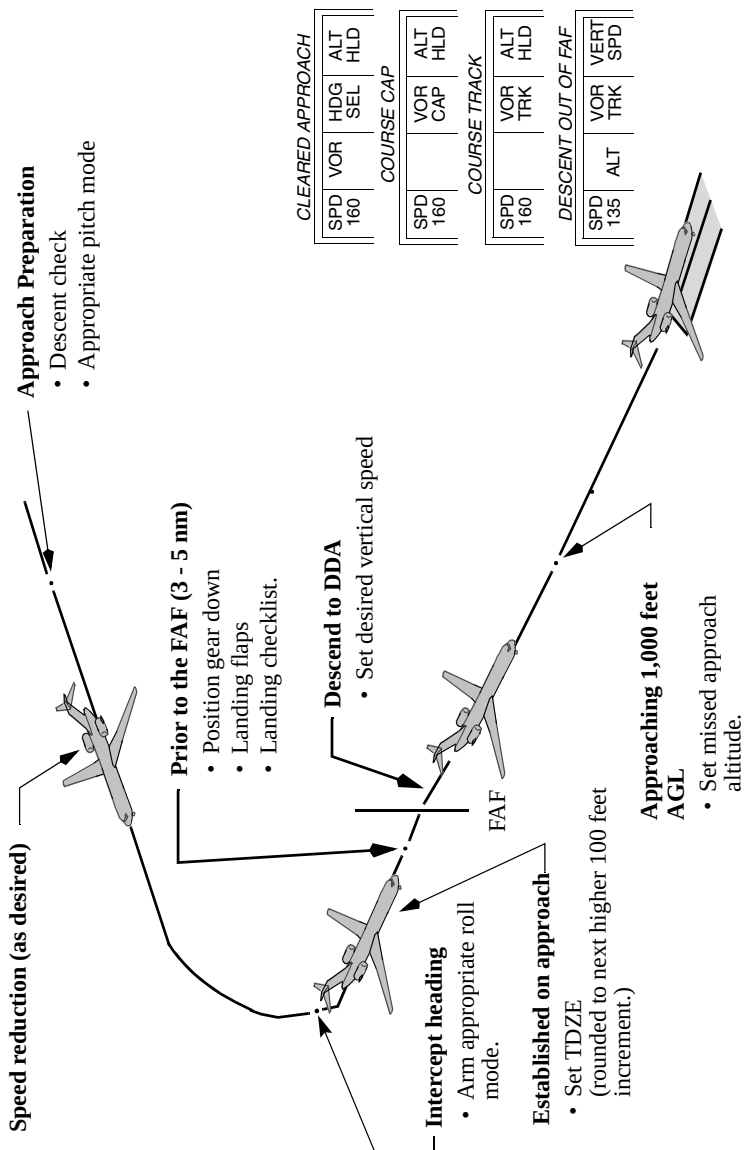
Determination of Approach Minimums

Non-ILS approaches may be flown to a DDA, or MDA. Prior to the Approach Check, the crew must determine the appropriate approach value and type.

A DDA is calculated by adding 50 feet to the approach MDA.

Circling approaches must use an MDA as specified in the Delta Airway Manual (Ops Specs).

Instrument Approach Using V/S Profile (CANPA)



Use of Vertical Speed

Constant Angle Non-Precision Approach (CANPA)

The goal of a constant rate non-precision approach is to maintain a constant rate of descent throughout the final approach segment. Descent rates approximating a 3 degree glidepath are published on most Jeppesen approach plates. In addition to the stabilized rate, an artificial "decision point" will be created by adding 50' to the MDA. The new decision point is called the DDA (derived decision altitude) and will be treated like a DA. Upon reaching the DDA, make the decision to continue to a landing, or start a missed approach.

Note: There is no reason to calculate a VDP as the aircraft is on an approximate 3 degree glidepath from the descent point to touchdown.

There is no level off at the DDA. After the DDA, you must utilize all visual clues if continuing to land. You may need to adjust your descent rate in order to fly a normal glide path and land in the touchdown zone. In order to maintain a stabilized approach throughout, do not exceed a sustained descent rate of 1000 fpm after passing the FAF.

If you reach the DDA and do not see the runway environment or are not in a position from which a safe approach and landing can be made, execute a missed approach and start to climb to the missed approach altitude. Also, if you reach the MAP prior to the DDA and do not see the runway environment or are not in a position from which a safe approach and landing can be made, execute a missed approach. During any missed approach, delay any turns until reaching the Missed Approach Point (MAP) to ensure proper obstacle clearance. Do not descend below the published MDA.

Descent Rates

On most Jeppesen approach plates, a descent angle will be indicated from the FAF to the missed approach point (MAP). An approach flown on that angle allows for a landing in the touchdown zone after crossing the threshold at approximately 50 feet. A corresponding conversion table in the block below the profile view provides a recommended rate of descent based on ground speed.

If no descent angle or vertical speed is depicted, use a target rate of 800 FPM and do not exceed a sustained rate of 1000 FPM after passing the FAF.

Approaches With A Step Down Fix

Although most approaches start the descent at the FAF, there may be a depicted descent point inside the FAF. Such approaches depict a stabilized descent at an approximate 3 degree approach angle from this point to the runway.

If there is a depicted descent point inside the FAF that you can identify with raw data, fly the depicted vertical track. This descent point is designed to keep you above the step-down fix. If you can not identify or find a depicted descent point after the FAF, utilize a rate of descent that assures the aircraft will remain above the step-down fix altitude.

If you are unable to identify the descent point inside the FAF, begin the descent at the FAF at a target rate of 800 fpm. Remain above any step-down fix altitude.

Note: For approaches with stepdown fixes inside the FAF, set TDZE rounded up to next 100 feet increment in the FGCP window, not the stepdown fix altitude.

Approaches With No FAF

Some approaches have no FAF. On these approaches, initiation of the descent from the procedure turn altitude should be made so as to stay on a 3:1 approach path to the runway (300 feet per NM). In other words, if the procedure turn altitude is 1500' AFE, you should start your final descent 5 NM from the runway. This will allow you to cross the DDA on a 3:1 glideslope.

Digital Flight Guidance Control Panel

The barometric altimeter bug will be set at DDA.

When established inbound to the FAF, at the FAF altitude with "ALT HOLD" displayed, set TDZE rounded up to the nearest 100 feet increment.

At approximately 1,000 feet AGL set missed approach altitude.

Missed Approach

During any missed approach, delay any turns until reaching the missed approach point (MAP) to ensure proper obstacle clearance. Do not descend below the published MDA. Refer to Missed Approach/Go Around - All Approaches, this chapter.

Navigation Display (ND) Settings for Non-ILS Approaches

Refer to Operations Manual Volume 1, Normal Procedures, Flight Patterns section, Non - Precision Approach for specific Nav Display Set-up information.

Data displayed in the MAP mode can be unreliable at low altitudes. Pilots should monitor raw data using the following techniques:

Localizer And ILS (G/S OUT) Approaches

Select the VOR/ LOC mode on the FGCP. The FD and autopilot (if engaged) will provide course guidance. Observe raw data during the approach by selecting either the ARC, or ROSE mode and expanded localizer display on the PFD. Both pilots may be in MAP mode throughout the approach except during localizer capture. One EFIS NAV display must be in the ARC or ROSE mode during localizer capture in order to crosscheck FMS operation with navigation radio data.

LDA Approach

Select VOR/LOC to track inbound course. One pilot must be in ARC or ROSE to verify capture of correct LOC course, then may return to ND map display. Use vertical speed or glide slope to control descent. One EFIS NAV display must be in the ARC or ROSE mode during localizer capture in order to crosscheck FMS operation with navigation radio data.

VOR Approach

Set appropriate VOR frequency and course. Select the VOR/ LOC mode on the FGCP. The FD and autopilot (if engaged) will provide course guidance. A pilot must observe raw data information for the VOR approach by using either the ARC, or ROSE mode with the RDMI selector in VOR. One pilot may use the MAP display as a monitor for situational awareness if desired.

NDB Approach

Select ADF to ON on the EFIS control panel. This will display the ADF needle on the ND in the ARC, ROSE and MAP modes. Select the RDMI selector switch to ADF to display raw data on the RDMI. It is recommended that the PF set NDB course in the ILS/VOR window on the FGCP and compare ADF blue needle with CDI course needle in either the ARC or ROSE display. Use HDG SEL or NAV to track inbound course. If NAV is used, it must be manually disengaged by the FAF.

Consider selecting approach in the FMS that resembles the NDB approach (i.e. ILS) or extending the runway for situational awareness. See the Use of MAP Display information in this chapter.

LOC Back Course Approach

Observe raw data, during the LOC Back Course, by using either the ARC or ROSE mode.

Ignore any glide slope information as the glide slope signal will be unreliable. Be aware that the expanded localizer on the PFD is not directional.

CAUTION: Automatic flight guidance and autopilot tracking of the back course are not available. Do not arm the localizer function of the DFGS during a back course approach.

Instrument Approach Using V/S (CANPA)

The procedures outlined below are typical for all types of Non-ILS approaches.

Prior To Passing The IAF (Or When Speed Reduction Desired)

- Flaps/slats as required
- Airspeed: not less than minimum maneuvering for the existing configuration.

Procedure Turn Outbound

- Configuration: normally slats extend/flaps 15.
- Airspeed: minimum maneuvering to 200 knots as required.

On Intercept Heading And Cleared For Approach

- Confirm proper navaid selection.
- Arm appropriate mode on the FGCP.
 - For VOR:

SPD 160	VOR	HDG SEL	ALT HLD

- For LOC or LDA:

SPD 160	LOC	HDG SEL	ALT HLD

- For NDB or LOC BC approaches, the DFGS does not provide course guidance. The PF will normally use HDG SEL when controlling the aircraft through the autopilot.

SPD 160		HDG SEL	ALT HLD

Course Capture

- Observe proper annunciations in the FMA arm and roll windows.
 - For VOR:

SPD 160		VOR CAP	ALT HLD

 DELTA
MD-88/90 Flight Crew Training Manual

SPD 160		VOR TRK	ALT HLD

- For LOC or LDA:

SPD 160		LOC CAP	ALT HLD

SPD 160		LOC TRK	ALT HLD

- For NDB or LOC BC approaches, there is no change.
- Maximum bank angle during autopilot localizer capture is approximately 28° and is not affected by the position of the bank angle selector.
- Set the bank angle selector to 15 to provide bank angle protection in the event of a missed approach.
- The pilot may set the heading select cursor to the missed approach heading when no longer using HDG SEL for course guidance.
- Update the altitude preselect readout
 - Set the TDZE in the altitude preselect readout after established at the FAF altitude and ALT HLD appears in the FMA pitch window.
 - If the TDZE is not a hundred foot increment, set the next higher altitude to nearest 100 feet (e.g., if TDZE is 610 feet, set 700 feet in the altitude preselect readout).

Approaching The FAF

- At approximately 5 miles prior to the FAF, extend the landing gear.
- After the gear is down and locked:
 - Set final flaps. Flaps 40 helps maintain final approach speed during descent, and provides better visibility of the runway environment due to deck angle.
 - Update the speed command bug to final approach speed.

SPD 135	ALT	VOR TRK	ALT HLD

- Complete LANDING checklist.

At The FAF or Depicted Descent Point

- Begin descent at the determined descent rate or a target rate of 800 FPM if it is not published.

Note: Do not exceed a sustained descent rate of 1,000 FPM. Some approaches require a descent at a point inside the FAF.

SPD		VOR	VERT
135	ALT	TRK	SPD

- PNF will begin timing from the FAF if applicable.

At approximately 1,000 feet AGL

- Set missed approach altitude in the DFGC panel.

At The DDA (MDA + 50)

- Execute a missed approach if:
 - The runway environment is not in sight, or
 - The aircraft is not in a position from which a safe approach and landing can be made.
- If the runway environment is in sight, adjust the rate of descent if necessary so as to land in the touchdown zone.
- Disengage the autopilot no later than 50 feet below the MDA.

Note: When executing a published missed approach procedure, the vertical portion may be initiated at, or prior to, the MAP; however, the lateral portion cannot be begun until reaching the MAP.

Note: The PF must be in the MAP mode prior to arming NAV to track the MAP.

Minimum Descent Altitude (MDA) (Circling Approach)

When reaching the MDA [as specified in Airway Manual (Ops Specs)]:

- If the runway environment is in sight, continue the approach per Circling Approach - General.
- If a normal approach to the runway of intended landing cannot be made or suitable visual reference cannot be maintained, execute a missed approach.

Additional Information during the approach

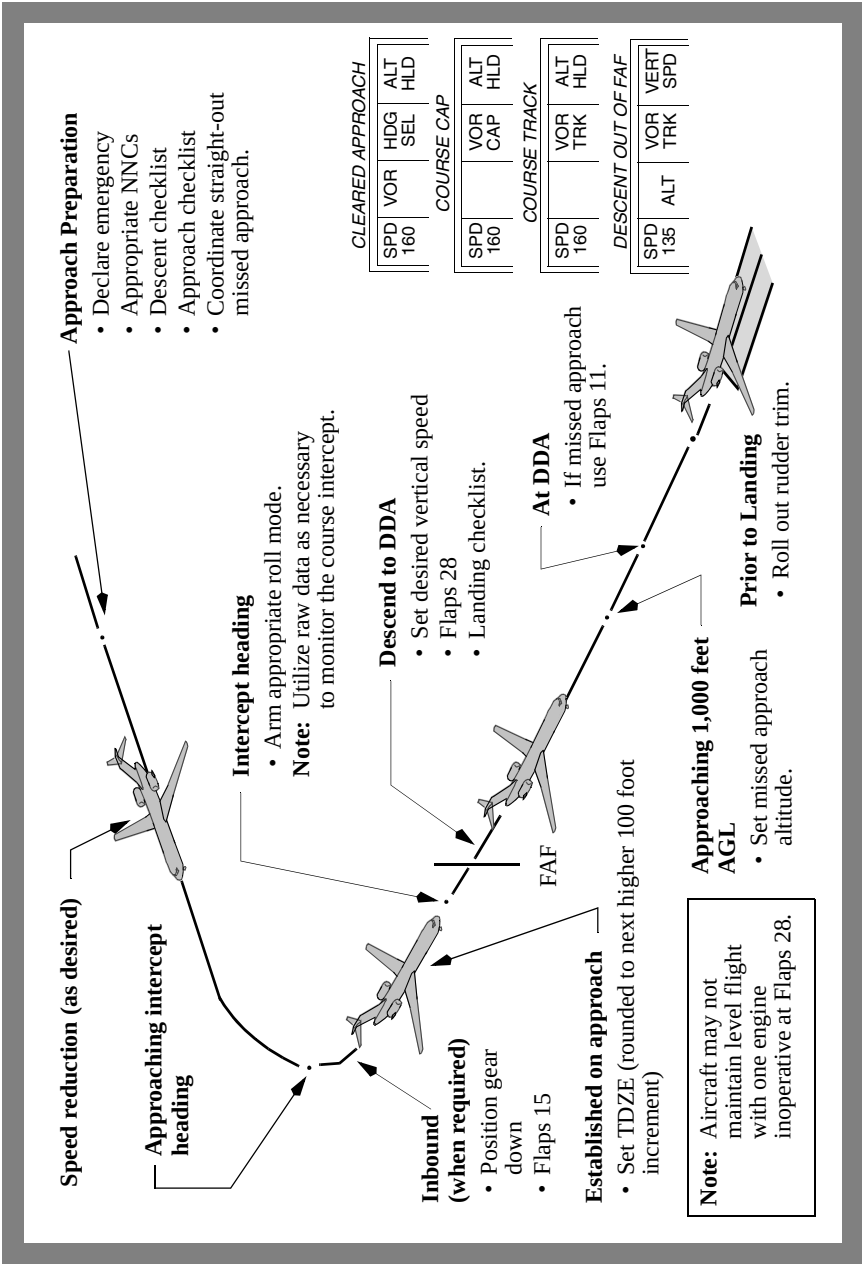
A/P is highly recommended but not required.

When the DFGP ALT is reset to desired missed approach altitude, ensure that the DFGP knob is rolled continuously through any altitude near the aircraft's current altitude to avoid VERT SPD being replaced by ALT CAP.

 DELTA
MD-88/90 Flight Crew Training Manual

Intentionally
Blank

Instrument Approach Using V/S Profile (CANPA) -
One Engine Inoperative



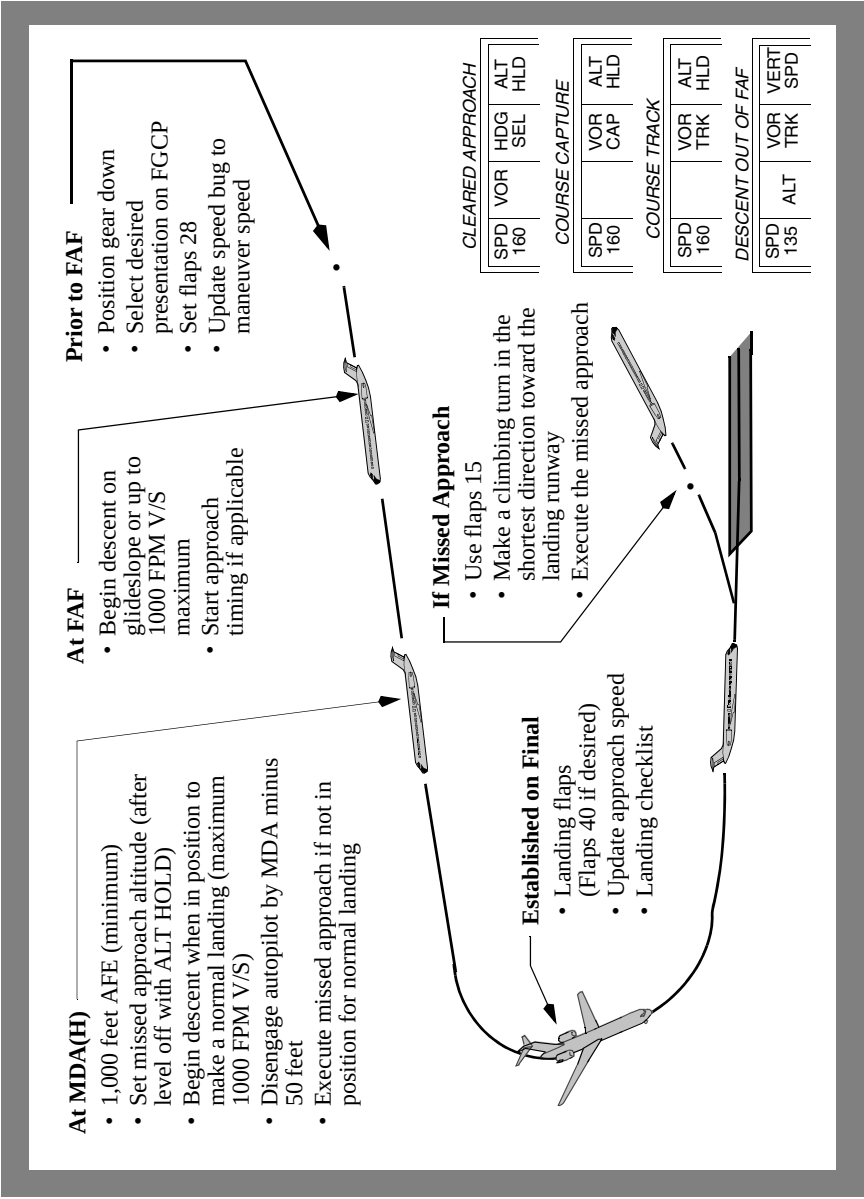
Instrument Approach Using V/S (CANPA) - One Engine Inoperative

Engine out maneuvering prior to and after the final approach fix with one engine inoperative is the same as an all engine non-ILS approach. However, attempt to maintain Flaps 15 until starting final descent to avoid high power settings on the good engine.

Request straight out missed approach (if desired and terrain permits). The final flap setting is Flaps 28. Final target speed is $V_{REF} + 5$ or $V_{REF} + \text{wind additive}$, (whichever is higher). Use Flaps 11 for go around.

Circling Approach

Circling Approach Profile



Circling Approach - General

The circling approach is a visual approach. Maintain visual conditions at all times, or execute a missed approach.

Circling minimums are just that. Nothing prevents you from flying higher, if the ceiling allows it, to give a more normal perspective.

Category D minima are used. The higher of published category D visibility or 3 miles determines the minimum required visibility. The higher of published MDA or 1000 feet AFE determines the MDA.

If no category D circling minima are published, the approach is not authorized. CANPA procedures do not apply to circling approaches except for the restriction to descend from the FAF at no greater than 1000 FPM. CANPA procedures apply to straight-in approaches only.

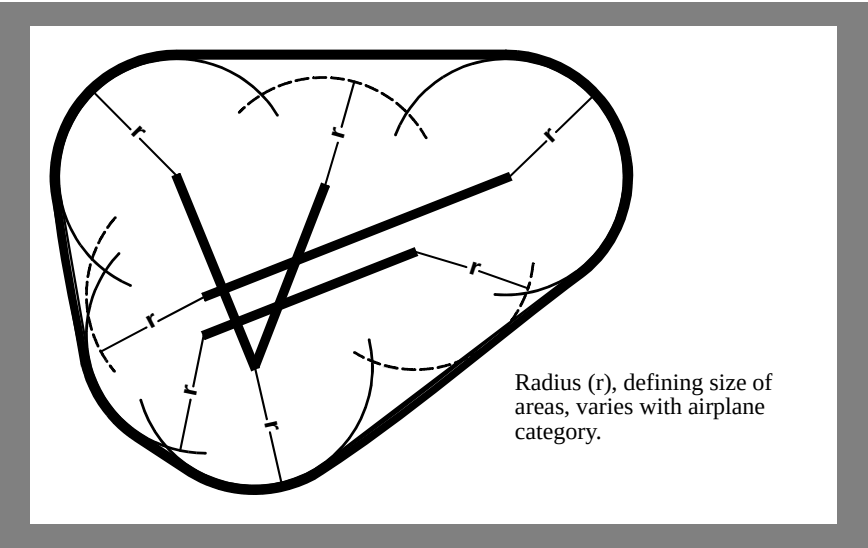
Use circling minima for the approach flown, not the landing runway. Configuration is gear, flaps 28 (preferred) or flaps 40. Descend at no greater than 1000 FPM. Maintain maneuver airspeed until established on final approach. Autopilot/ATS use is optional, but encouraged. Disconnect autopilot no later than 50 feet below the MDA.

Plan turn to final in order to achieve stabilized approach criteria by 500 feet AFE. Remain at or above circling MDA until the aircraft is continuously in a position from which a descent to a landing on the intended runway can be made using normal descent rate and maneuvering.

Example clearance: "Delta 502, circle north for a left base for 18R, cleared to land Runway 18R."

Obstruction Clearance

Obstruction clearance areas during the circling approach are depicted in the following figure. Distances are determined by aircraft approach category. Adjust airplane heading and timing so that the airplane ground track does not exceed the obstruction clearance radius distance at any time during the circling approach.

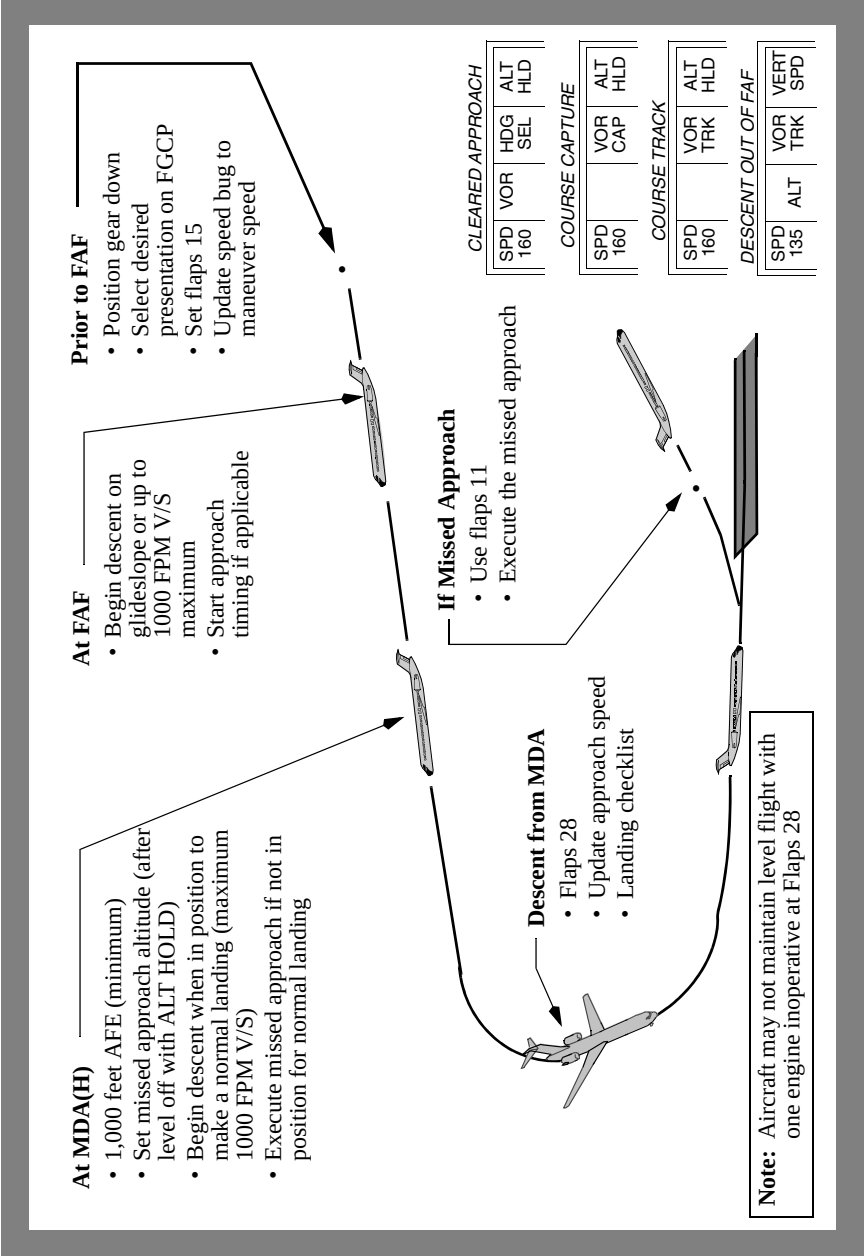


Aircraft Category	FAA Obstruction Clearance Radius (r)	ICAO Obstruction Clearance Radius (r)
C	1.7 NM	4.2 NM
D	2.3 NM	5.28 NM

 DELTA
MD-88/90 Flight Crew Training Manual

Intentionally
Blank

Circling Approach Profile - One Engine Inoperative



Circling Approach - One Engine Inoperative

The Captain must consider whether it is preferable to perform a circling approach vs. diverting to a more suitable airport.

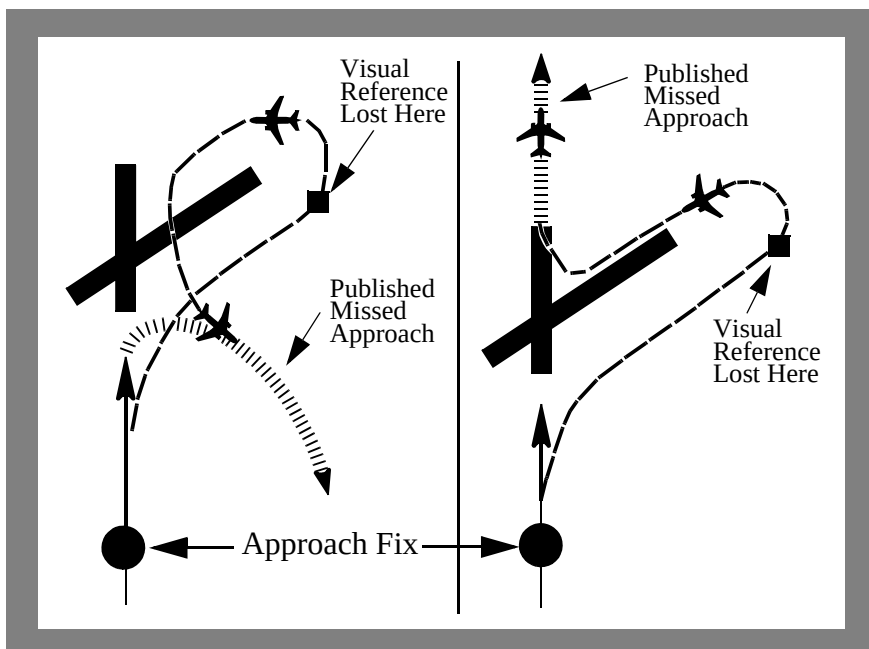
Fly approach at flaps 15 at appropriate maneuver airspeed. Select flaps 28 when starting descent from MDA and adjust speed.

Coordinate a straight out missed approach or execute the appropriate single engine procedure for the landing runway

Missed Approach - Circling

If a missed approach is required at any time while circling, make a climbing turn toward the landing runway to reach the missed approach heading even if the turn is more than 180° and not in the shortest direction. Maintain the missed approach flap setting until close-in maneuvering is completed.

Different patterns may be required to become established on the prescribed missed approach course. This depends on airplane position at the time the missed approach is started. The following figure illustrates the maneuvering that may be required. This ensures the airplane remains within the circling and missed approach obstruction clearance areas.



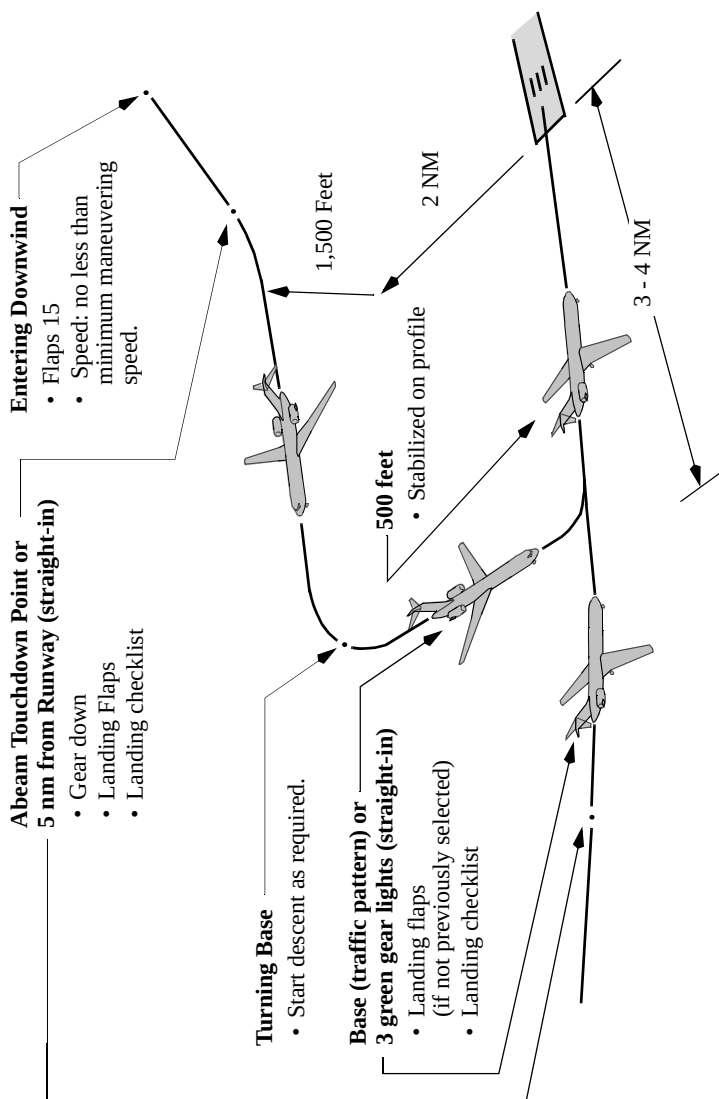
In the event that a missed approach must be accomplished from below the MDA(H), consideration should be given to selecting a flight path which assures safe obstacle clearance until reaching an appropriate altitude on the specified missed approach path.

Refer to Missed Approach/Go-Around - All Approaches, this chapter.

Intentionally
Blank

Visual Traffic Patterns

Visual Traffic Pattern Profile



Visual Approach - General

The recommended landing approach path is approximately 2 1/2° to 3°. Once the final approach is established, the airplane configuration remains fixed and only small adjustments to the glide path, approach speed, and trim are necessary. This results in the same approach profile under all conditions.

Thrust

Engine thrust and elevators are the primary means to control attitude and rate of descent. Adjust thrust slowly using small increments. Sudden large thrust changes make airplane control more difficult and are indicative of an unstable approach. No large changes should be necessary except when performing a go-around. Large thrust changes are not required when extending landing gear or flaps on downwind and base leg. A thrust increase may be required when stabilizing on speed on final approach.

Downwind and Base Leg

Fly at an altitude of 1500 feet above field elevation and enter downwind with flaps 15 at flaps 15 maneuvering speed and slats extended. Maintain a track parallel to the landing runway approximately 2 NM abeam.

Prior to turning base leg, extend the landing gear and select flaps 28/40 and slow to maneuvering speed (VREF + 10 minimum) or approach speed plus wind correction. If the approach pattern must be extended, delay lowering the gear and selecting flaps until approaching the normal visual approach profile. Turning base leg, adjust thrust as required while descending at 300-400 fpm.

Extend landing flaps prior to turning final. Allow the speed to decrease to the proper final approach speed and trim the airplane. Complete the Landing checklist. Descent using a VASI should not be initiated until the aircraft is aligned with the runway centerline.

Final Approach

Roll out of the turn to final on the extended runway centerline and maintain the appropriate approach speed. An altitude of approximately 300 feet above airport elevation for each mile from the runway provides a normal approach profile

At 1,000 feet AGL and on final, the aircraft must be configured for landing. Maintain at or above the glide slope until the middle marker (if using an ILS backup).

Initiate a go-around if:

- Airspeed, descent rate, and runway alignment are not established by 500 feet AFE.
- The aircraft is not in a position to make a normal landing in the touchdown zone using normal maneuvering.

Note: If using the FMS, the ND will display the distance from the runway when the runway is the active waypoint. This can be used in conjunction with the radio altimeter to assist in glidepath awareness.

Attempt to keep thrust changes small to avoid large trim changes. Stabilize the airplane on the selected approach airspeed with an approximate rate of descent between 700 and 900 feet per minute on the desired glide path, in trim. Stabilize on the profile by 500 feet above touchdown.

Note: Descent rates greater than 1,000 fpm should be avoided.

Attempt to be at 250-300 feet AFE as the closest approach light disappears from view. Disengage autothrottle no later than the flare.

A runway aiming point slightly beyond the 1,000 foot mark should result in main gear touchdown point between 1,000 and 1,500 feet. Main landing gear should cross the runway threshold at approximately 50 feet.

Note: The touchdown zone is defined as the first 3,000 feet or first third of the runway, whichever is less.

With one engine inoperative, the rudder trim should be centered prior to landing. This allows most of the rudder pedal pressure to be removed when the thrust of the operating engine is retarded to idle at touchdown.

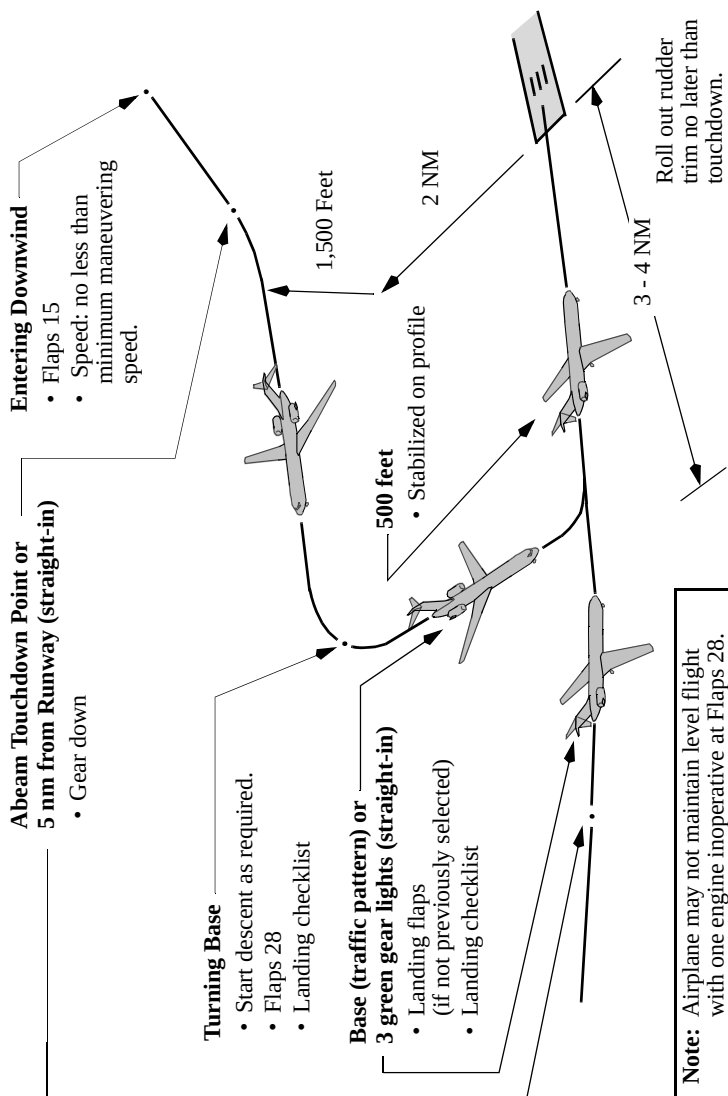
Full rudder authority and rudder pedal steering capability are not affected by rudder trim. If touchdown occurs with the rudder still trimmed for the approach, be prepared for the higher rudder pedal forces required to track the centerline on rollout.

The Operations Manual, Volume 1, notes that the autopilot and autothrottle should be disconnected when intercepting the landing profile. The specific location along the flight path is left to the discretion of the pilot. In all cases the autopilot and autothrottle should be disconnected prior to the flare.

 DELTA
MD-88/90 Flight Crew Training Manual

Intentionally
Blank

Visual Traffic Pattern Profile - One Engine Inoperative

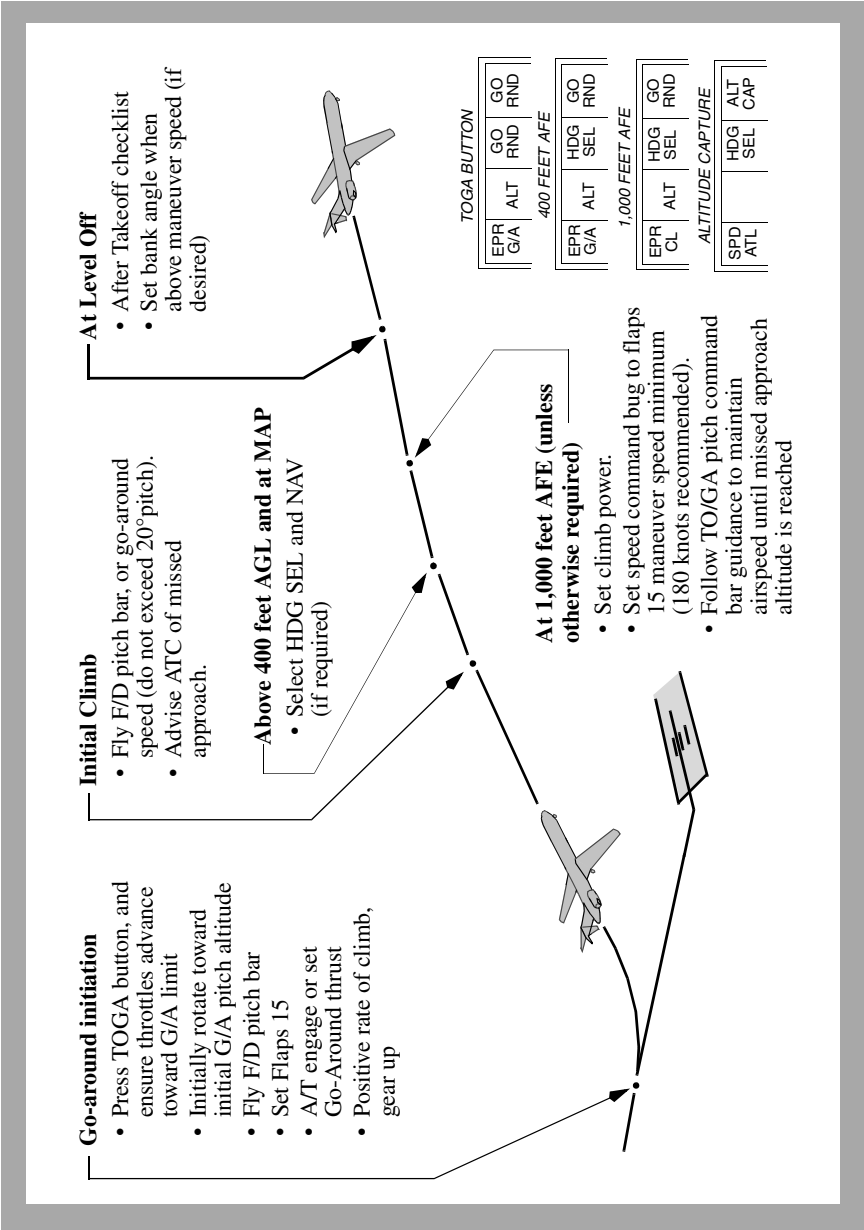


Engine Failure On Final Approach

In case of engine failure on visual final approach, use the procedure described in the ILS approach section, this chapter.

Missed Approach/Go-Around

Missed Approach/Go-Around Profile - All Approaches



Missed Approach/Go-Around - General

The missed approach/go-around is generally performed in the same manner whether an instrument or visual approach was flown. The missed approach/go-around is flown using the go-around procedure described in Volume 1, Normal Procedures. The discussion in this section supplements those procedures.

Missed Approach/Go-Around - All Engines Operating

Go-around Initiation

The Captain announces the intention to go-around by stating “MISSED APPROACH.” The PF should accomplish the following steps simultaneously.

- Apply TO/GA power.
 - Press the TO/GA buttons.

Note: The recommended technique to select TO/GA power is to use the heel of the hand to select the TO/GA buttons on both throttles while simultaneously pushing the throttles forward.

- If using the autopilot and ATS, pressing the TO/GA buttons will command automatic pitch and power changes.
- If hand flying, pressing the TO/GA buttons will select pitch and roll guidance on the FD. If the ATS is not in use, the PM will refine the go-around thrust setting.
- The FD will command pitch to maintain a safe margin above stall speed and existing magnetic heading.
 - Verify that the FMA annunciates the following



- Smoothly and positively commence rotation toward go-around attitude (maximum of 20° pitch).
- Retract flaps to 15.
 - When a positive rate of climb is confirmed:
 - The PM calls “POSITIVE RATE”.
 - The PF confirms the positive rate of climb and calls “GEAR UP”.
 - PM raises landing gear
 - PM reports missed approach to ATC.

During an automatic go-around initiated at 50 feet, approximately 30 feet of altitude is lost. If touchdown occurs after a go-around is initiated, the go-around continues. Observe that the autothrottles apply go-around thrust or manually apply go-around thrust as the airplane rotates to the go-around attitude.

Note: An automatic go-around cannot be initiated after touchdown.

Initial Climb

- Fly the flight director bars if available. If the F/D bars are not available, fly a minimum of speed book go-around. Do not exceed 20° nose high.
- Autothrottle commands EPR LIM for go-around.
- If not previously accomplished, set:
 - Missed approach altitude.
 - Bank angle 15°.

Above 400 Feet AGL

Select HDG SEL and NAV, if required.

Preferred techniques:

- At the turn point, the PF should call for “HEADING SELECT,” and, if not previously accomplished, request the PM to set the bank angle limiter to 15°.
- When on an intercept to the missed approach course, select NAV. The aircraft must be above 400 feet, and the PF’s ND must be in MAP prior to selection of NAV.

Note: The roll mode on the FMA must be out of GA in order to arm NAV (i.e., HDG SEL).



If Remaining In The Area

At 1,000 feet AFE:

- Select climb power.
- Maintain flaps 15° if desired.
- Set airspeed command bug to maneuvering speed for the existing configuration.
- Follow TO/GA pitch command guidance and maintain airspeed until missed approach altitude is reached.

▲ DELTA
MD-88/90 Flight Crew Training Manual

EPR G/A	NAV ALT	HDG SEL	G/A

At Leveloff

- Maintain a minimum of maneuver speed.

SPD 180		HDG SEL	ALT HLD

- Complete AFTER TAKEOFF checklist.

If Departing The Area

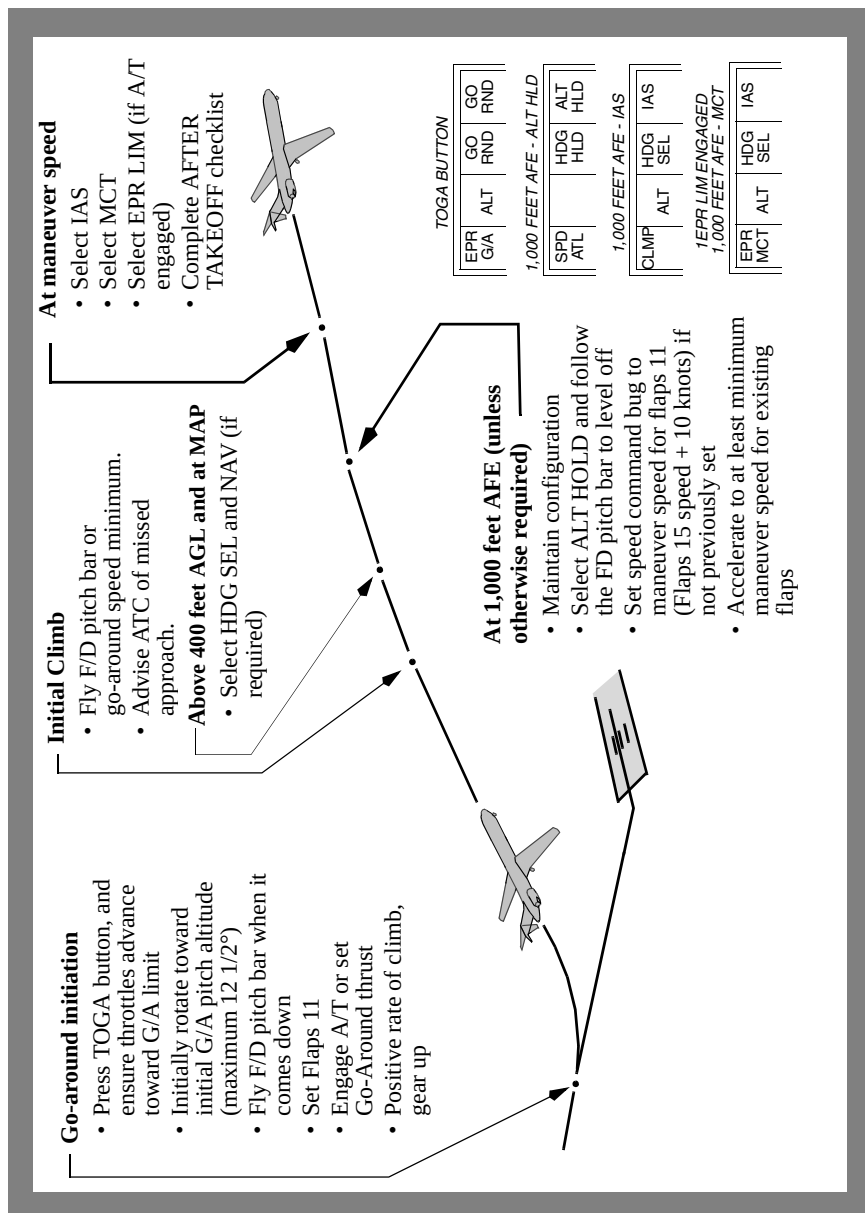
Continue climbout as in a normal takeoff. Delay use of VNAV until appropriate FMC entries are completed.

Note: FMC cruise speeds may not comply with speed/altitude restrictions when using VNAV at low altitudes.

At 2,500 Feet AFE

- Complete AFTER TAKEOFF checklist.
- Accelerate to 250 knots.

Missed Approach/Go-Around Profile - One Engine Inoperative



Missed Approach/Go-Around - One Engine Inoperative

The missed approach with an engine inoperative should be accomplished in the same manner as a normal missed approach, except use Flaps 11 for the go-around flap setting and accelerate to maneuvering speed at 1,000 feet AFE, or in accordance with single engine procedure in 10-0 pages (green pages). The pilot must control yaw with rudder and trim. Some rudder pedal pressure may be required even with full rudder trim.

Engine Failure During Missed Approach/Go-Around

If an engine fails during go-around, perform normal go-around procedures. Verify maximum go-around thrust is set. Maintain flaps 15, VREF + wind correction (5 knots minimum) speed until initial maneuvering is complete and a safe altitude is reached. Accelerate to flap retraction speed by repositioning the command speed to the maneuvering speed for the desired flap setting. Retract flaps on the normal flap/speed schedule.

Landing Configurations and Speeds

Landing flap positions are flaps 28 and 40. Flaps 28 is the normal flap setting. Landing with flaps 28 helps conserve fuel by reducing drag and provides a smoother approach. Flaps 28 will also provide better control response in gusty wind conditions. Runway length, runway condition, and other considerations may dictate flaps 40 for landing. A flaps 40 landing may be appropriate when:

- The runway is contaminated or if available landing distance is a factor.
- The approach is steeper than normal due to ATC requirements.
- Using engine and airfoil anti-ice, which require higher than normal engine power.
- Other conditions warrant use of flaps 40.

The speed for a flaps 28 landing is 5 knots higher than flaps 40 with an increased landing distance of approximately 500 feet.

Maneuver Margin

Flight profiles should be flown at, or slightly above, the recommended maneuvering speed for the existing flap configuration. These speeds approximate maximum fuel economy and allow full maneuvering capability (25° bank with a 15° overshoot for turbulent flight conditions.)

Full maneuver margin exists for all normal and non-normal landing procedures and during all go-arounds whenever speed is at or above the maneuver speed for the current flap setting.

Airspeeds recommended for non-normal flight profiles are intended to restore near normal maneuvering margins and/or aerodynamic control response.

The configuration changes are based on maintaining full maneuvering and/or maximum performance unless specified differently in individual procedures. It is necessary to apply wind correction to the VREF speeds. See the Command Speed section in chapter 1 for an explanation of wind corrections.

Non-Normal Landing Configurations and Speeds

The Abnormal Configuration Actual Landing Distance and Approach Speeds in the Abnormal section of the ODM shows speeds and landing distances for various non-normal landing configurations and runway conditions. The target speed for the approach is the appropriate approach VREF plus the wind and gust additives.

Non-Normal Landing Distance

Because of higher approach speeds associated with the non-normal landing condition the actual landing distance is increased. The flight crew should review the non-normal landing distance information in the ODM.

Visual Approach Slope Indicator (VASI/T - VASI)

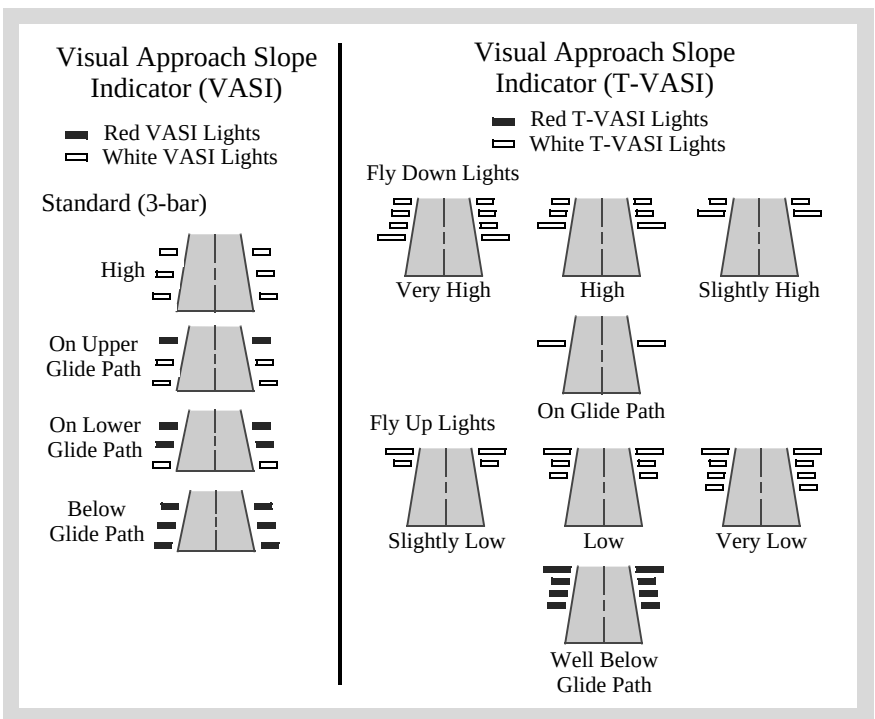
The VASI is a system of lights arranged to provide visual descent guidance information during the approach. All VASI systems are visual projections of the approach path normally aligned to intersect the runway at a point 1,000 or 1,800 feet beyond the threshold. Flying the VASI glideslope to touchdown is the same as selecting a visual aim point on the runway adjacent to the VASI installation.

When using a two-bar VASI, the difference between the eye reference path and the gear path results in a normal approach and threshold height. It provides useful information in alerting the crew to low profile situations.

Some airports have three-bar VASI which provides two visual glide paths. The additional light bar is located upwind from a standard two-bar installation. When the airplane is on the glide path, the pilot sees the one white bar and two red bars. Three-bar VASI may be safely used with respect to threshold height, but may result in landing further down the runway.

For a T-VASI, flying the approach with one additional white fly down light visible provides additional wheel clearance.

Three Bar VASI/T-VASI



VASI Landing Geometry

Two-bar VASI installations provide one visual glide path which is normally set at 3° . Three-bar VASI installations provide two visual glide paths. The lower glide path is provided by the near and middle bars and is normally set at 3° while the upper glide path, provided by the middle and far bars, is normally $1/4^\circ$ higher (3.25°). This higher glide path is intended for use only by high cockpit airplanes to provide a sufficient threshold crossing height.

Two Bar VASI Landing Geometry

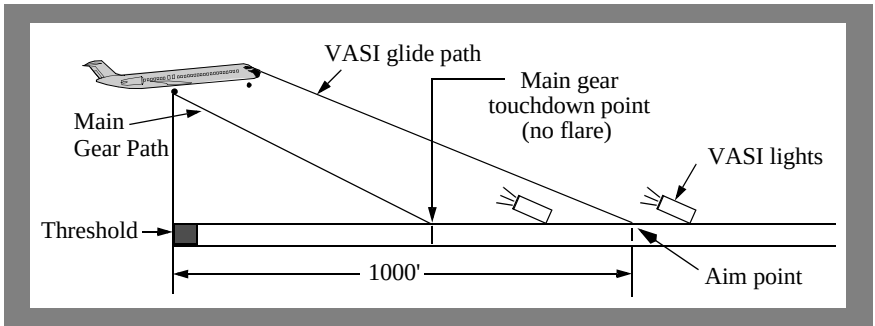
The following diagrams use these conditions:

- data is based upon typical landing weight
- airplane body attitudes are based on Flaps 40, VREF $40 + 5$ and should be
- d by 1° for each 5 knots above this speed.
- eye height is calculated at the moment the main gear is over the threshold.

MD-88/90 Flight Crew Training Manual

Two Bar VASI Landing Geometry

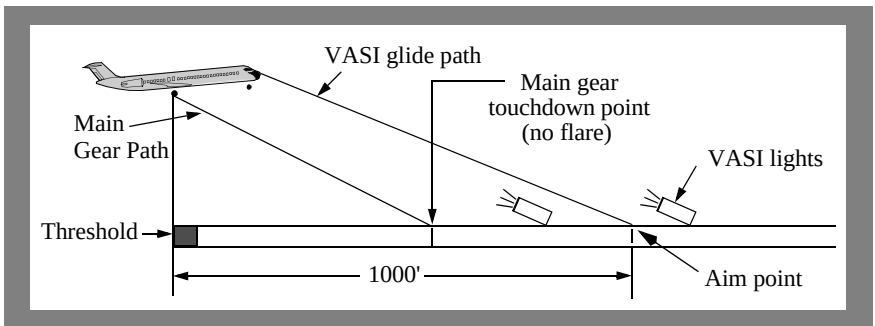
MD-88



Flaps 40			AIM Point at 1,000 Feet		
Airplane Model	Visual Glide Path (degrees)	Airplane Body Attitude (degrees)	Threshold Height		Main Gear Touchdown Point - no flare (feet)
			Pilot Eye Height (feet)	Main Gear Height (feet)	
MD-88	3.0	4.2	52	29.5	561

Two Bar VASI Landing Geometry

MD-90



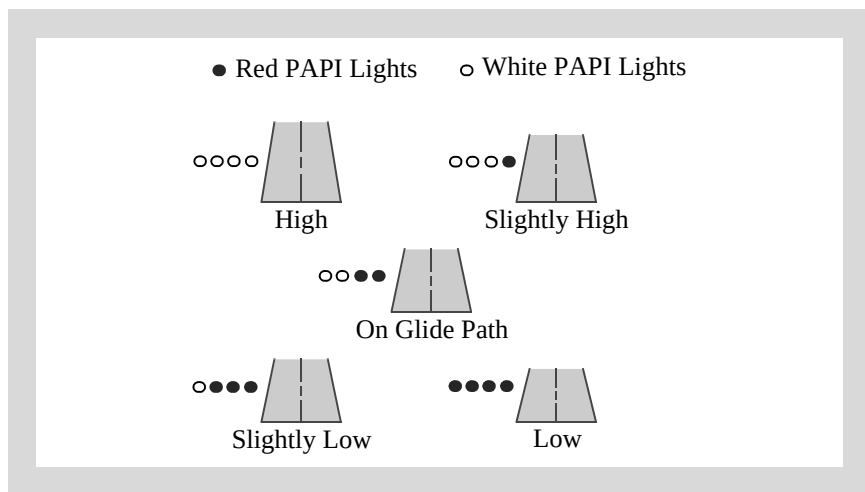
Flaps 40			AIM Point at 1,000 Feet		
Airplane Model	Visual Glide Path (degrees)	Airplane Body Attitude (degrees)	Threshold Height		Main Gear Touchdown Point - no flare (feet)
			Pilot Eye Height (feet)	Main Gear Height (feet)	
MD-90	3.0	3.7	52	33	635

Precision Approach Path Indicator (PAPI)

The PAPI uses lights which are normally on the left side of the runway. They are similar to the VASI, but are installed in a single row of light units.

When the airplane is on a normal 3° glide path, the pilot sees two white lights on the left and two red lights on the right. The PAPI may be safely used with respect to threshold height, but may result in landing further down the runway. The PAPI is normally aligned to intersect the runway 1,000 to 1,500 feet down the runway.

PAPI Landing Geometry



 DELTA
MD-88/90 Flight Crew Training Manual

Intentionally
Blank

Landing Geometry

Visual Aim Point

During visual approaches many techniques and methods are used to ensure main landing gear touchdown at the desired point on the runway. One of the most common methods used is to aim at the desired gear touchdown point on the runway, then adjust the final approach glide path until the selected point appears stationary in relation to the airplane (the point does not move up or down in the pilot's field of view during the approach).

In first generation jet transports, this method is acceptable because of the small difference between landing gear path and eye level path. Flare distance accounts for the small difference in paths. Gear touchdown occurs very near the visual aim point. However, in today's larger aircraft, the difference in gear path and eye-level path has increased because of the longer wheel base and the increased flight deck height. Consequently, the main gear do not touchdown on the runway at the selected visual aim point.

Visual aim points versus gear touchdown point differences increase as glide path angle decreases as in a flat approach. For a particular visual approach, the difference between gear path and eye level path must be accounted for by the pilot.

Threshold Height

Threshold height is a function of glide path angle and landing gear touchdown target. Threshold height for main gear and pilot eye level is shown in the Two Bar VASI Landing Geometry tables. Special attention must be given to establishing a final approach that assures safe threshold clearance and gear touchdown at least 1,000 feet down the runway. Recommended callouts assist the pilot in determining a proper profile.

Recommended Callouts from 100 Feet

If automatic callouts are not available, the radio altimeter should be used to assist the pilot in judging terrain clearance, threshold height and flare initiation height.

If requested, the PM may call out radio altitude to aid in developing an awareness of eye height at touchdown.

Flare and Touchdown

These techniques discussed are applicable to all landings including crosswind landings and slippery runway conditions. Unless an unexpected or sudden event occurs, such as windshear or collision avoidance situation, it is not appropriate to use sudden, violent or abrupt control inputs during landing. Begin with a stabilized approach on speed, in trim and on glide path.

CAUTION: To avoid a touchdown short of the threshold, avoid approaches on a shallow visual glidepath (less than 2.5 degrees) and using runway aiming points less than the 1,000 feet mark.

Configure to landing flaps so as to center the pointer on the F/S indicator by 1000' AFE (3 miles from touchdown). To arrive at 1000'/3 miles on speed, it takes about 3 miles to slow from 160 knots/flaps 15 configuration. It cannot be overemphasized that the FAST/SOW indicator is of prime importance during approach and landing. At lighter weights, the autothrottles may cause your speed to increase due to the inability of the autothrottle system to retard the power past the LOW LIM setting.

Use the electronic or VASI glideslope. If not available, put the touchdown zone in the center of the windscreen (may be slightly below center depending on gross weight or seat height). Use 700-800 FPM descent. Avoid using runway aim points less than the 1000' mark. If the touchdown zone moves up relative to the center of the windscreen, the aircraft is going below glidepath; if the touchdown zone moves down relative to the center of the windscreen, the aircraft is going above glidepath. Make corrections early. Keep the F/S indicator centered.

Pitch attitude VREF 40 + 5 is about 2.5 degrees. Stab trim usage should be kept to a minimum after approach attitude and speed are established.

The ailerons are controlled by tabs and tend to lose effectiveness at slow speeds and high angles of attack. The spoilers are hydraulically controlled and always operative. This combination of aileron and spoiler make roll control non-linear. The airplane has a very slow roll response for the first 5 degrees of yoke travel, which increases rapidly as the yoke is rotated further and the spoilers deploy. This can cause over controlling when lining up with the runway centerline.

Comply with Stabilized Approach Requirements as specified in Volume 1, NP.30, Normal Procedures, Flight Patterns.

As final approach speed and descent rate are established, trim the aircraft to maintain slight nose up pressure. As the MD-88 has a very wide "in trim" feel at landing airspeeds, this will help provide more elevator effectiveness in the flare.

At 250' AFE, ALSF-I/II approach lights should disappear under the nose. If the aircraft is high, the lights will disappear at a higher AFE altitude, and the opposite is true if the aircraft is below glidepath.

Do Not:

- allow speed to decrease below VREF-5.
- use too much stabilizer trim prior to or during landing flare.
- hold airplane off in an attempt to make an extremely smooth landing.
- touchdown with an increasing pitch rate - maintain attitude to touchdown.

Initiate flare at approximately 20 feet wheel height with a gentle rotation of 2 to 3 degrees to slow sink rate. As ground effect increases, there is a slight pitch down tendency. Maintain the same attitude with slight increased back pressure to touchdown. Ground effect is equal to approximately 200-300 FPM decrease in rate of descent. Elevators are sensitive - harsh inputs may result in ballooning.

Look down the runway to help reduce tendency to rock the wings and assist in the controlling the pitch attitude during the flare maneuver.

Reduce power to idle. Fly the aircraft onto the runway. Ideally, main gear touchdown should occur with throttles reaching idle. Stop nose-up rotation at touchdown. Do not allow pitch attitude to reach or exceed eight degrees. Prolonged "hold off" is strongly discouraged as is excessive speed due to the increase in landing distance.

Note: Large aft stabilizer trim settings (10° - 12°) during landing reduces elevator authority during flare. In this circumstance, delay reducing power to idle until arresting the descent in the flare.

Ten knots above computed approach speed will increase the minimum landing distance approximately 20%.

CAUTION: The tail skid will touch the runway at a body angle of approximately 11 degrees nose up.

Desired speed:

- before flare: VREF +5
- flare initiation: VREF to VREF + 5
- after flare: VREF to VREF -5

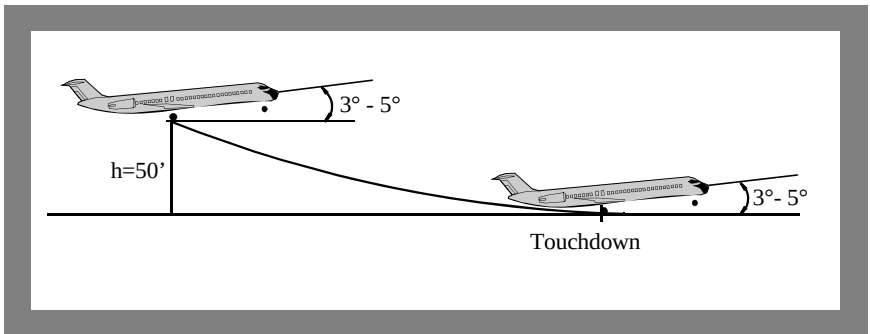
If a greater than desired sink rate develops during the flare, or if the pitch inputs are not flaring the aircraft as you desire, the MD-88/90 generally requires a power addition rather than more pitch up input to decrease the sink rate.

Gently fly the nose to the runway.

Landing Flare Profile

The following diagrams use these conditions:

- 3° approach glide path
- flare distance is approximately 1,000 to 2,000 feet beyond the threshold
- typical landing flare times range from 4 to 8 seconds and are a function of approach speed
- airplane body attitudes are based upon typical landing weights, flaps 40, VREF 40 + 5 (approach) and VREF 40 + 0 (landing), and should be reduced by 1° for each 5 knots above this speed.



Typically, the pitch attitude increases slightly during the actual landing, but avoid over-rotating. Do not increase the pitch attitude after touchdown; this could lead to a tail strike.

Shifting the visual sighting point down the runway assists in controlling the pitch attitude during the flare. A smooth power reduction to idle also assists in controlling the natural nose down pitch change associated with thrust reduction. Hold sufficient back pressure on the control column to keep the pitch attitude constant.

Avoid rapid control column movements during the flare. Do not use pitch trim during flare or after touchdown. Such actions are likely to cause the pitch attitude to increase at touchdown and increase the potential for a tailstrike. Do not allow the airplane to float; fly the airplane onto the runway. Do not attempt to extend the flare by increasing pitch attitude in an attempt to achieve a perfectly smooth touchdown. Do not attempt to hold the nose wheel off the runway.

Bounced Landing Recovery

If the airplane should bounce, hold or reestablish a normal landing attitude and add thrust as necessary to control the rate of descent. Avoid rapid pitch rates in establishing a normal landing attitude.

CAUTION: Tail strikes or nosewheel structural damage can occur if large forward or aft control column movements are made prior to touchdown.

If a high, hard bounce occurs, consider initiating a go-around by use of normal go-around procedures. Do not retract the landing gear until a positive rate of climb is established because a second touchdown may occur during the go-around.

Rejected Landing

The rejected landing procedure is identical to the go-around procedure. Press TO/GA and ensure go-around thrust is set or manually apply go-around thrust and select flaps 15 while rotating to go-around attitude. Retract the landing gear after a positive rate of climb is established. Set command speed to maneuvering speed for existing configuration, or other speed as desired. Maintain flaps 15 if remaining in the area.

WARNING: After reverse thrust is initiated, a full stop landing must be made.

Factors dictating this are:

- five seconds are required for a reverser to transition to the forward thrust position
- a possibility exists that a reverser may not stow in the forward thrust position.

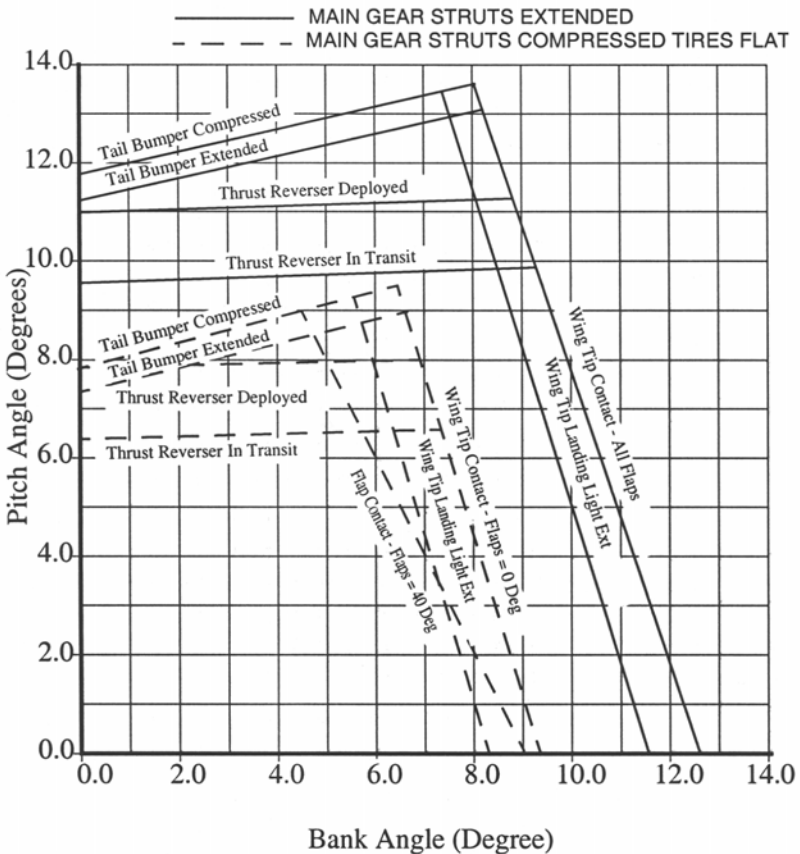
 DELTA
MD-88/90 Flight Crew Training Manual

Pitch and Roll Limit Conditions

Bank Angle Limitations for Various Pitch Attitudes - Landing figure illustrates body roll angle/pitch angles at which the airplane structure contacts the runway. Prolonged flare increases the body pitch attitude 2° to 3° . When prolonged flare is coupled with a misjudged height above the runway aft body contact is possible.

Fly the airplane onto the runway at the desired touchdown point and at the desired airspeed. Do not hold it off and risk the possibility of a tailstrike.

Note: A smooth touchdown is not the criterion for a safe landing.



| Landing Roll

Avoid touching down with thrust above idle to ensure auto spoiler actuation.

After main gear touchdown, initiate the landing roll procedure. If the spoilers do not extend automatically move the spoiler handle to the AFT and latched position (up) without delay. Fly the nosewheel onto the runway smoothly by relaxing aft control column pressure. Control column movement forward of neutral should not be required. Do not attempt to hold the nosewheel off the runway. Holding the nose up after touchdown for aerodynamic braking is not an effective braking technique.

CAUTION: Pitch rates sufficient to cause airplane structural damage can occur if large nose down control column movement is made prior to nose wheel touchdown.

To avoid the risk of tailstrike, do not allow the pitch attitude to increase after touchdown. However, applying excessive nose down elevator during landing can result in substantial forward fuselage damage. Do not use full down elevator. Use an appropriate autobrake setting or manually apply wheel brakes smoothly with steadily increasing pedal pressure as required for runway condition and runway length available. Maintain deceleration rate with constant or increasing brake pressure as required until stopped or desired taxi speed is reached.

Spoilers

The spoiler system is controlled with the SPOILER handle. The spoiler system consists of individual spoiler panels which the pilot can extend and retract by moving the SPOILER handle.

The spoilers can be fully raised after touchdown while the nose wheel is lowered to the runway, with no adverse pitch effects. The spoilers spoil the lift from the wings, which places the airplane weight on the main landing gear, providing excellent brake effectiveness.

Unless spoilers are raised after touchdown, braking effectiveness may be reduced initially as much as 60%, since very little weight is on the wheels and brake application may cause rapid anti-skid modulation. In addition, the autobrakes, if selected, will not function.

Normally, spoilers are armed to extend automatically. Because the autospoiler actuator cycles every landing, regardless of the position of the handle, the spoiler handle must be visually confirmed to be in the aft and latched position. The visual confirmation is crucial because spoilers may not extend automatically due to a bounced landing, throttles being forward of the idle position at touchdown or other unexpected system malfunction.

 DELTA
MD-88/90 Flight Crew Training Manual

CAUTION: If throttles are forward of the idle position during main wheel spin-up, the auto spoilers may not function. In this case the spoilers must be extended manually.

The position of the spoilers must be announced during the landing phase by the PM. This improves the crew's situational awareness of the position of the spoilers during landing and builds good habit patterns which can prevent failure to observe a malfunctioned or disarmed spoiler system.

Directional Control and Braking after Touchdown

If the nose wheel is not promptly lowered to the runway, braking and steering capability are significantly degraded and no drag benefit is gained. Rudder control is effective to approximately 60 knots. Rudder pedal steering is sufficient for maintaining directional control during the rollout. Do not use the nose wheel steering wheel until reaching taxi speed. In a crosswind, displace the control wheel into the wind to maintain wings level which aids directional control.

Stopping distance varies with wind conditions and any deviation from recommended approach speeds.

Factors Affecting Landing Distance

The field length requirements are contained in the Operational Data Manual (ODM) - Approach/Landing section. Factors that affect stopping distance include: height and speed over the threshold, glideslope angle, landing flare, lowering the nose to the runway, use of reverse thrust, spoilers, wheel brakes and surface conditions of the runway.

Note: Reverse thrust and spoiler drag are most effective during the high speed portion of the landing. Deploy the spoiler handle and activate reverse thrust with as little time delay as possible.

CAUTION: The nose wheel must be on the runway prior to deploying reverse thrust.

Note: Spoilers fully deployed, in conjunction with maximum reverse thrust and maximum manual anti-skid braking provides the minimum stopping distance.

Floating above the runway before touchdown must be avoided because it uses a large portion of the available runway. The airplane should be landed as near the normal touchdown point as possible. Deceleration rate on the runway is approximately three times greater than in the air.

Height of the airplane over the runway threshold also has a significant effect on total landing distance. For example, on a 3° glide path, passing over the runway threshold at 100 feet altitude rather than 50 feet could increase the total landing distance by approximately 950 feet. This is due to the length of runway used up before the airplane actually touches down.

Glide path angle also affects total landing distance. As the approach path becomes flatter, even while maintaining proper height over the end of the runway, total landing distance is increased.

Slippery Runway Landing Performance

| General Considerations

When landing on slippery runways contaminated with ice, snow, slush or standing water, the reported braking action must be considered. Boeing performance data are provided for reported braking actions of dry, good, fair and poor in the ODM. The performance level associated with good is representative of a wet runway. The performance level associated with poor is representative of a wet ice covered runway. Pilots should use extreme caution to ensure adequate runway length is available when poor braking action is reported.

Pilots should keep in mind slippery/contaminated runway performance data is based on an assumption of uniform conditions over the entire runway. This means a uniform depth for slush/standing water for a contaminated runway or a fixed braking coefficient for a slippery runway. The data cannot cover all possible slippery/contaminated runway combinations and does not consider factors such as rubber deposits or heavily painted surfaces.

| Friction Measurements

One of the commonly used runway descriptors is coefficient of friction. Ground friction measuring vehicles typically measure this coefficient of friction. Much work has been done in the aviation industry to correlate the friction reading from these ground friction measuring vehicles to airplane performance. Use of ground friction vehicles raises the following concerns:

- the measured coefficient of friction depends on the type of ground friction measuring vehicle used. There is not a method, accepted worldwide, for correlating the friction measurements from the different friction measuring vehicles to each other, or to the airplane's braking capability.
- all testing to date, which compares ground friction vehicle performance to airplane performance, has been done at relatively low speeds (100 knots or less). The critical part of the airplane's deceleration characteristics is typically at higher speeds (120 to 150 knots).

 DELTA
MD-88/90 Flight Crew Training Manual

- ground friction vehicles often provide unreliable readings when measurements are taken with standing water, slush or snow on the runway. Ground friction vehicles might not hydroplane (aquaplane) when taking a measurement while the airplane may hydroplane (aquaplane). In this case, the ground friction vehicles would provide an optimistic reading of the runway's friction capability. The other possibility is the ground friction vehicles might hydroplane (aquaplane) when the airplane would not, this would provide an overly pessimistic reading of the runway's friction capability. Accordingly, friction readings from the ground friction vehicles may not be representative of the airplane's capability in hydroplaning conditions.
- ground friction vehicles measure the friction of the runway at a specific time and location. The actual runway coefficient of friction may change with changing atmospheric conditions such as temperature variations, precipitation etc. Also, the runway condition changes as more operations are performed.

The friction readings from ground friction measuring vehicles do supply an additional piece of information for the pilot to evaluate when considering runway conditions for landing. Crews should evaluate these readings in conjunction with the PIREPS (pilot reports) and the physical description of the runway (snow, slush, ice etc.) when planning the landing. Special care should be taken in evaluating all the information available when braking action is reported as POOR or if slush/standing water is present on the runway.

Ground Friction Measurement System Limitations

Hydroplaning and landing gear drag effects increase as the depth of loose contaminants increases, therefore numerical friction measurements should not be relied upon under the following conditions:

- When water on a pavement surface exceeds .04 inch (1 mm);
- When water is present on top of an ice layer on the pavement surface, and its depth exceeds .04 inch (1 mm);
- When there is slush present on the pavement exceeding 1/8 inch (3 mm);
- When there is slush or wet snow on ice or compacted snow exceeding 1/8 inch (3 mm); or
- When the depth of dry snow on the pavement surface exceeds 1 inch (2.5 cm).

Braking Action Reports

When tower controllers receive runway braking action reports from pilots or airport management which include the terms "poor" or "nil", or whenever weather conditions are conducive to deteriorating or rapidly changing runway braking conditions, the ATIS broadcast will include the statement "BRAKING ACTION ADVISORIES ARE IN EFFECT."

Under these conditions, ATC should issue the latest braking action reports for the runway in use to each arriving or departing aircraft. Pilots should be prepared for deteriorating braking conditions and should request current runway condition information if not volunteered by controllers.

Landing on Wet or Slippery Runways

Wet Runway

The airplane should be flown firmly onto the runway even if speed is excessive. A firm touchdown will improve wheel spin-up.

If an unsatisfactory approach is likely to cause touchdown beyond the touchdown zone, execute a missed approach.

Consider the following actions to maximize the rollout performance on wet runways.

- Use 40° flaps.
- Manually extend spoilers if they do not deploy on touchdown.
- Immediately lower the nose wheel after main gear touchdown.
- Maintain forward control pressure to improve directional control. For maximum stopping capability, avoid excessive forward pressure as this action shifts weight from the main gear to the nose gear and reduces braking effectiveness.
- Use the automatic brake system. If autobrakes are inoperative, smoothly apply the needed brake pedal pressure and hold until decelerating to taxi speed.
- Avoid large abrupt steering inputs.
- Consider leaving engines in idle reverse until ability to stop, or clear the runway, is assured.

Slippery Runway

During landing rollout on a slippery runway with a crosswind, directional control problems may develop. Apply reverse thrust cautiously when landing on slick surfaces.

- Allow engines to spool up at a low power setting, then apply reverse thrust slowly and symmetrically.
- For increased directional control, exert forward control wheel pressure in order to maintain positive nose wheel traction. Avoid excessive pressure.
- If a skid condition develops, return both reverse levers to the IDLE detent.
- If the airplane starts to weathervane into the wind:
 - Reduce reverse thrust to reverse idle.
 - Disconnect the autopilot, if engaged.
 - Release the brakes.

 DELTA
MD-88/90 Flight Crew Training Manual

- Use rudder pedal steering and differential braking to correct back to runway track. It is not necessary to immediately correct to runway centerline as this may delay deceleration efforts and aggravate skid conditions.
- When re-established on runway track, apply maximum braking and symmetrical reverse thrust to stop the airplane.
- Consider leaving engines in idle reverse until ability to stop, or clear the runway, is assured.

CAUTION: Reverse thrust above 1.3 EPR may blank the rudder and degrade directional control effectiveness. However, as long as the aircraft is aligned with runway track, reverse thrust may be used as necessary (up to maximum), to stop the aircraft.

- Do not attempt to turn off from a slippery runway until speed is reduced to a safe level.

CAUTION: Anticipate low friction when approaching touchdown zone at far end of runway due to heavy rubber and oil deposits.

Wheel Brakes

Braking force is proportional to the force of the tires on the runway and the coefficient of friction between the tires and the runway. The contact area normally changes little during the braking cycle. The perpendicular force comes from airplane weight and any downward aerodynamic force such as speedbrakes.

The coefficient of friction depends on the tire condition and runway surface, e.g., concrete, asphalt, dry, wet or icy.

Automatic Brakes

Boeing recommends that whenever runway limited, using higher than normal approach speeds, landing on slippery runways, or landing in a crosswind, the autobrake system be used.

For normal operation of the autobrake system select a deceleration setting.

Settings include:

- MIN: Not recommended. Experience has shown that MIN brakes generate high brake temperatures contributing to excessive brake wear, and provide minimal braking capability.
- MED: Use for wet or slippery runways, when landing rollout distance is limited, reverser capability is reduced, or landing speed is higher than normal. (With combinations of these conditions, use MAX brakes). In the MED position, the ABS provides a three second delay after spoiler deployment until brake application.

- **MAX:** Use on cluttered, snow covered or icy runways, or when a minimum stop distance is required. In the MAX position, the ABS provides a one second delay after spoiler deployment until brake application.

Note: Do not delay lowering the nose gear to the runway after landing with MAX selected.

Flight crew/airline experience with airplane characteristics relative to the various runway conditions routinely encountered provide initial guidance as to the desirable level of deceleration selected.

Immediate initiation of reverse thrust at nose gear touchdown and full reverse thrust allow the autobrake system to reduce brake pressure to the minimum level. Since the autobrake system senses deceleration and modulates brake pressure accordingly, the proper application of reverse thrust results in reduced braking for a large portion of the landing roll.

The importance of establishing the desired reverse thrust level as soon as possible after touchdown cannot be overemphasized. This minimizes brake temperatures and tire and brake wear and reduces stopping distance on very slippery runways.

The use of minimum reverse thrust almost doubles the brake energy requirements and can result in brake temperatures much higher than normal.

During the landing roll, use manual braking if the deceleration is not suitable for the desired stopping distance.

The autobrakes may be reduced by selecting a lower level or manually overridden by depressing either or both brake pedals more than 25% of travel (MD-90: 90% of travel when above 90 knots). Monitor autobrake operation and apply brakes manually if necessary.

Disarming the autobrakes before coming out of reverse thrust provides a smooth transition to manual braking.

All crewmembers should be alert for autobrake disarm annunciations during the landing roll so that manual braking can be initiated if required.

The airplane speed at which the transition from autobrakes to manual braking is made varies with airplane deceleration and stopping requirements. For runway conditions that produce good deceleration, the transition from autobrakes to manual brakes should be made at about 60 knots. The transition speed should be closer to a safe taxi speed on very slippery runways or when runway length is limited.

Manual Braking

The following technique for manual braking provides optimum braking for all runway conditions:

 DELTA
MD-88/90 Flight Crew Training Manual

The pilot's seat and rudder pedals should be adjusted so that it is possible to apply maximum braking with full rudder deflection.

Immediately after main gear touchdown, smoothly apply a constant brake pedal pressure for the desired braking. For short or slippery runways, use full brake pedal pressure.

- Do not attempt to modulate, pump or improve the braking by any other special techniques
- Do not release the brake pedal pressure until the airplane speed has been reduced to a safe taxi speed
- The antiskid system stops the airplane for all runway conditions in a shorter distance than is possible with either antiskid off or brake pedal modulation.

The antiskid system adapts pilot applied brake pressure to runway conditions by sensing an impending skid condition and adjusting the brake pressure to each individual wheel for maximum braking effort. When brakes are applied on a slippery runway, several skid cycles occur before the antiskid system establishes the right amount of brake pressure for the most effective braking.

If the pilot modulates the brake pedals, the antiskid system is forced to readjust the brake pressure to establish optimum braking. During this readjustment time, braking efficiency is lost.

Low available braking coefficient of friction on extremely slippery runways at high speeds may be interpreted as a total antiskid failure. Pumping the brakes or turning off the antiskid degrades braking effectiveness. Maintain steadily increasing brake pressure, allowing the antiskid system to function at its optimum.

Although immediate braking is desired, manual braking techniques normally involve a four to five second delay between main gear touchdown and brake pedal application even when actual conditions reflect the need for a more rapid initiation of braking. This delayed braking can result in the loss of 800 to 1,000 feet of runway. Directional control requirements for crosswind conditions and low visibility may further increase the delays. Distractions arising from a malfunctioning reverser system can also result in delayed manual braking application.

Braking with Antiskid Inoperative

When the antiskid system is inoperative, the following techniques apply:

- Ensure that the nose wheel is on the ground and the spoilers extended before applying the brakes
- Initiate wheel braking using very light pedal pressure and increase pressure as ground speed decreases

- Apply steady pressure and DO NOT PUMP the pedals.

Note: Do not dispatch with an inoperative antiskid system.

Flight testing has demonstrated that braking effectiveness on a wet grooved runway is similar to that of a dry runway. Caution however, must be exercised when braking on any wet, ungrooved portions of the runway with antiskid inoperative to avoid blown tires.

Brake Cooling

A series of taxi-back or stop and go landings without additional in-flight brake cooling can cause excessive brake temperatures. The energy absorbed by the brakes from each landing is cumulative.

Extending the gear a few minutes early in the approach normally provides sufficient cooling for a landing.

To minimize brake temperature build-up, if the last ground time plus present flight time is less than 90 minutes, extend the landing gear 5 minutes early or 7 minutes prior to landing.

Close adherence to recommended landing rollout procedures ensures minimum brake temperature build up.

Reverse Thrust Operation

Awareness of the position of the forward and reverse thrust levers must be maintained during the landing phase. Improper seat position as well as long sleeved apparel may cause inadvertent advancement of the throttles, preventing movement of the reverse thrust levers.

The position of the hand should be comfortable, permit easy access to the autothrottle disconnect switch, and allow control of all thrust levers, forward and reverse, through full range of motion.

Note: Reverse thrust always reduces the “brake only” stopping distance, brake and tire wear. Reverse thrust is most effective at high speeds.

Landing performance of the aircraft is certified without the use of reverse thrust; however, proper use of reverse thrust will add to the margin of safety, enhance passenger comfort, and significantly reduce brake and tire wear.

After touchdown, smoothly lower the nose wheel onto the runway, then move the reversers aft to the reverse thrust position.

CAUTION: Ensure the nose wheel is on the runway before applying reverse thrust.

 DELTA
MD-88/90 Flight Crew Training Manual

When ENG REVERSE UNLOCK and ENG REVERSE THRUST lights illuminate, increase reverse thrust as required.

Note: (88) Normal reverse thrust target is 1.3 EPR.

Note: (90) Normal reverse thrust target is 1.1-1.2 EPR.

CAUTION: (90) A 17 pound pull past the last stop will activate emergency reverse thrust.

Note: (90) Activation of emergency reverse thrust results in an ENG SYS FAIL message and requires an extensive thrust reverser maintenance inspection.

Note: (90) Carbon brakes wear equally whether the pilot uses idle reverse or more than idle reverse. Consequently, the combination of idle reverse and normal braking comprises the most efficient and economic stopping capability on a normal, dry runway.

Approaching 80 knots, start reducing reverse thrust so as to achieve reverse idle by 60 knots.

The PM should monitor the engine operating limits and call out any engine operational limits being approached, exceeded, or any other abnormalities.

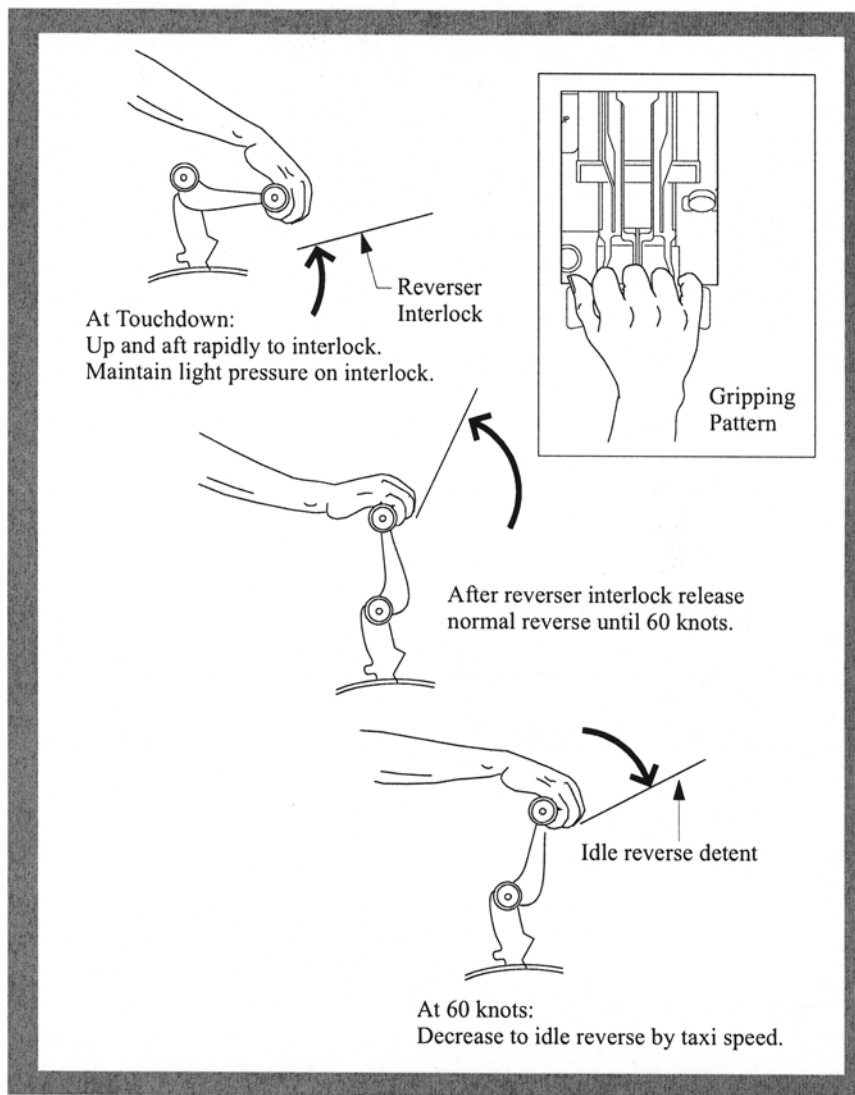
Consider the following when deciding on the amount of reverse thrust to use:

- Runway length and condition.
- Landing weight and touchdown speed.

Reduce the reverse thrust so that the reverse thrust levers are moving down at a rate commensurate with the deceleration rate of the airplane. The reverse thrust levers should be positioned to reverse idle by 60 knots, then to full down after the engines have decelerated to idle, the airplane is stopping, and nosewheel steering is assured. The PM should call out any inadvertent selection of forward thrust as reverse thrust is cancelled. If an engine surges during reverse thrust operation, quickly select reverse idle on all engines.

CAUTION: Do not use more than reverse idle thrust below approximately 60 knots (unless required for adverse conditions) due to possible surging and foreign object ingestion.

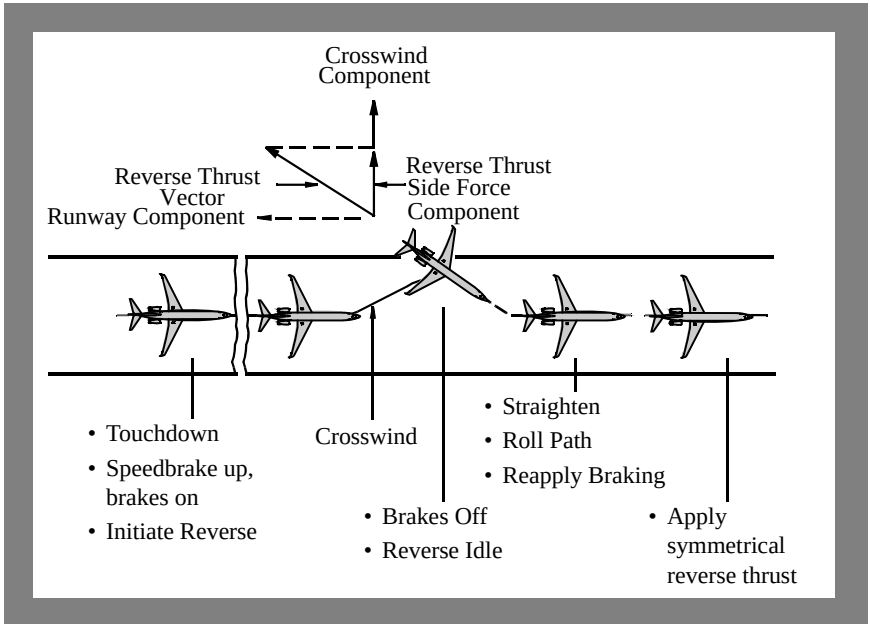
Reverse Thrust Operations



Reverse Thrust - Engine Inoperative

Asymmetrical reverse thrust may be used with one engine inoperative. Use normal reverse thrust procedures and techniques with the operating engine. Be prepared to apply rudder to offset asymmetrical reverse thrust. If directional control becomes a problem during deceleration, return throttle lever to reverse idle detent.

Reverse Thrust and Crosswind (All Engines)



This figure shows a directional control problem during a landing rollout on a slippery runway with a crosswind. As the airplane starts to weathervane into the wind, the reverse thrust side force component adds to the crosswind component and drifts the airplane to the downwind side of the runway. Main gear tire cornering forces available to counteract this drift are at a minimum when the antiskid system is operating at maximum braking effectiveness for the existing conditions.

To correct back to the centerline, reduce reverse thrust to reverse idle and release the brakes. This minimizes the reverse thrust side force component without the requirement to go through a full reverser actuation cycle, and improve tire cornering forces for realignment with the runway centerline. Use rudder pedal steering and differential braking as required, to prevent over correcting past the runway centerline. When re-established near the runway centerline, apply maximum braking and symmetrical reverse thrust to stop the airplane.

Crosswind Landings

The crosswind guidelines were derived through flight test data, engineering analysis and piloted simulation evaluations. These crosswind guidelines are based on steady wind (no gust) conditions and include all engines operating and engine inoperative. Gust effects were evaluated and tend to increase pilot workload without significantly affecting the recommended guidelines.

Crosswind Landing Techniques

Two methods of performing crosswind landings are presented. They are the de-crab technique (with removal of crab in flare), and the sideslip technique. Whenever a crab is maintained during a crosswind approach, offset the flight deck on the upwind side of centerline so that the main gear touches down in the center of the runway.

De-Crab During Flare

The objective of this technique is to maintain wings level throughout the approach, flare, and touchdown. On final approach, a crab angle is established with wings level to maintain the desired track. Just prior to touchdown while flaring the airplane, downwind rudder is applied to eliminate the crab and align the airplane with the runway centerline.

As rudder is applied, the upwind wing sweeps forward developing roll. Hold wings level with simultaneous application of aileron control into the wind. The touchdown is made with cross controls and both gear touching down simultaneously. Throughout the touchdown phase upwind aileron application is utilized to keep the wings level.

Sideslip (Wing Low)

The initial phase of the approach to landing is flown using the crab method to correct for drift. Prior to the flare the airplane centerline is aligned on or parallel to the runway centerline. Downwind rudder is used to align the longitudinal axis to the desired track as aileron is used to lower the wing into the wind to prevent drift. A steady sideslip is established with opposite rudder and low wing into the wind to hold the desired course.

The sideslip crosswind technique aligns the aircraft with the extended runway centerline so that main gear touchdown occurs on the runway centerline.

Touchdown is accomplished with the upwind wheels touching just before the downwind wheels. Overcontrolling the roll axis must be avoided because overbanking could cause the outboard wing flap to contact the runway. (See Ground Clearance Angles - Normal Landing charts, this chapter.)

 DELTA
MD-88/90 Flight Crew Training Manual

Properly coordinated, this maneuver results in nearly fixed rudder and aileron control positions during the final phase of the approach, touchdown, and beginning of the landing roll. However, since turbulence is often associated with crosswinds, it is often difficult to maintain the cross control coordination through the final phase of the approach to touchdown.

If the crew elects to fly the sideslip to touchdown, it may be necessary to add a crab during strong crosswinds. (See the landing crosswind guidelines table, this chapter). Main gear touchdown is made with the upwind wing low and crab angle applied. As the upwind gear touches first, a slight increase in downwind rudder is applied to align the airplane with the runway centerline. At touchdown, increased application of upwind aileron should be applied to maintain wings level. The approach will require more thrust than usual due to the increase drag caused by the crosscontrolling.

Overweight Landing

Overweight landings may be safely accomplished by using normal landing procedures and techniques. There are no adverse handling characteristics associated with overweight landings. Landing distance is normally less than takeoff distance for flaps 28 or 40 landings at all gross weights. However, wet or slippery runway field length requirements should be verified from the landing distance charts in the Approach/Landing section of the ODM. Brake energy limits will not be exceeded for flaps 28 or 40 landing at all gross weights.

If stopping distance is a concern, reduce the landing weight as much as possible. At the captain's discretion, reduce weight by holding at low altitude with a high drag configuration (gear down) to achieve maximum fuel burn-off.

Observe flap placard speeds during flap extension and on final approach. In the holding and approach patterns, maneuvers should be flown at the normal maneuver speeds.

Use the longest available runway, and consider wind and slope effects. Where possible avoid landing in tailwinds, on runways with negative slope, or on runways with less than normal braking conditions. Do not carry excess airspeed on final. This is especially important when landing during an engine inoperative or other non-normal condition.

Fly a normal profile. Ensure that a higher than normal rate of descent does not develop. Do not hold the airplane off waiting for a smooth landing. Fly the airplane onto the runway at the normal touchdown point. If a long landing is likely to occur, go-around. After touchdown, immediately apply maximum reverse thrust using all of the available runway for stopping to minimize brake temperatures. Do not attempt to make an early runway turnoff.

Overweight Autolands Policy

Boeing does not recommend overweight autolands. Autopilots on Boeing airplanes are not certified for automatic landings above maximum landing weight. At higher than normal speeds and weights, the performance of these systems may not be satisfactory and has not been thoroughly tested. An automatic approach may be attempted, however the pilot should disengage the autopilot prior to flare height and accomplish a manual landing.

In an emergency, should the pilot determine that an overweight autoland is the safest course of action, the approach and landing should be closely monitored by the pilot and the following factors considered:

- touchdown may be beyond the normal touchdown zone; allow for additional landing distance.
- touchdown at higher than normal sink rates may result in exceeding structural limits.



MD-88/90 Flight Crew Training Manual

- plan for a go-around or manual landing if autoland performance is unsatisfactory; automatic go-arounds can be initiated until just prior to touchdown, and can be continued even if the airplane touches down after initiation of the go-around.

Intentionally
Blank

Manuevers

Chapter 5

Table of Contents

Section 0

Preface	5.1
Acceleration to and Deceleration from VMO	5.1
Engine Out Familiarization	5.3
Rudder and Lateral Control	5.3
Thrust and Airspeed	5.4
High Altitude Maneuvering, “G” Buffet	5.5
Mach Buffet	5.5
Mach Tuck	5.5
Dutch Roll	5.6
Mach Trim Compensator (MTC), Mach Buffet, Dutch Roll Demonstrations	5.6
Rapid Descent	5.7
Autopilot Entry and Level Off	5.8
Manual Entry and Level Off	5.9
After Level Off	5.9
Maneuvers Training	5.10
Flight Control Effectiveness	5.10
Delta Maneuvers Training	5.11
Autospoiler/Autobrake Demonstration	5.13
Stall Recovery	5.15
Approach to Stall Recovery	5.15
Recovery from a Fully Developed Stall	5.19

Steep Turns	5.21
Entry	5.21
During Turn	5.21
Vertical Speed Indicator	5.21
Altimeter	5.21
Airspeed	5.22
Rollout	5.22
Summary	5.22
Terrain Avoidance	5.23
Traffic Alert and Collision Avoidance System (TCAS)	5.23
Use of TA/RA, TA Only Modes	5.23
Traffic Advisory (TA)	5.23
Resolution Advisory (RA)	5.24
Unusual Attitude Recovery Procedures	5.25
Upset Recovery	5.25
General	5.25
Upset Recovery Techniques	5.29
Windshear	5.30
General	5.30
Airplane Performance in Windshear	5.30
Avoidance, Precautions and Recovery	5.31

Maneuvers

Chapter 5

Preface

This chapter provides a quick reference summary of operating procedures and training maneuvers. The discussion portion of each illustration highlights important information. The flight profile illustrations represent the Boeing recommended basic configuration during the accomplishment of the flight maneuvers, and provides a basis for standardization and crew coordination.

The procedures recommended are based on minimizing crew workload, crew coordination and operational safety and provide a basis for standardization.

Acceleration to and Deceleration from VMO

Acceleration to and deceleration from VMO demonstrates performance capabilities and response to speed, thrust, and configuration changes throughout the medium altitude speed range of the airplane. This maneuver can be performed in a full flight simulator and is used for demonstration purposes only. It is normally performed at 10,000 to 15,000 feet, simulating slowdown to 250 knots due to speed restrictions.

VMO is a structural limitation and is the maximum operating indicated airspeed. It is a constant airspeed from sea level to the altitude where VMO and MMO coincide. MMO is the structural limitation above this altitude. Sufficient thrust is available to exceed VMO in level flight at lower altitudes. Failure to reduce to cruise thrust in level flight can result in excessive airspeed.

Begin the maneuver at existing cruise speed with the autothrottle connected and the autopilot disconnected. Set command speed to VMO. As speed increases observe:

- nose down trim required to keep airplane in trim and maintain level flight
- handling qualities during acceleration
- autothrottle protection at VMO.

At a stabilized speed just below VMO execute turns at high speed while maintaining altitude. Next, accelerate above VMO by disconnecting the autothrottle and increasing thrust.

When the overspeed warning occurs reduce thrust levers to idle, set command speed to 250 knots, and decelerate to command speed. Since the airplane is aerodynamically clean, any residual thrust results in a longer deceleration time. As airspeed decreases observe that nose up trim is required to keep airplane in trim and maintain level flight. During deceleration note the distance traveled from the time the overspeed warning stops until reaching 250 knots.

This maneuver may be repeated using speedbrakes to compare deceleration times and distances. Deploying the speedbrakes produces some buffeting and a pitch down tendency. Retraction of the speedbrakes results in a pitch up.

▲ **DELTA**
MD-88/90 Flight Crew Training Manual

Engine Out Familiarization

The exercises shown in the following table can be performed in a full flight simulator to develop proficiency in handling the airplane with one engine inoperative and gain familiarization with rudder control requirements.

	Condition One	Condition Two
Airspeed	Flaps up maneuvering speed	V2
Landing Gear	Up	Down
Flaps	Up	11
Thrust	As Required	MCT
When In Trim - Retard one throttle lever to idle Controls - Apply to maintain heading, wings level Rudder - Apply to center control wheel Airspeed - Maintain with thrust (Condition One) Pitch (Condition Two) Trim - As required to relieve control forces		

One engine out controllability is excellent during takeoff roll and after lift-off. Minimum control speed in the air (VMCA) is below VR and VREF.

Rudder and Lateral Control

This familiarization can be performed in a full flight simulator to develop proficiency in handling the airplane with an engine inoperative. It also helps to gain insight into rudder control requirements.

Under instrument conditions the instrument scan is centered around the attitude indicator. Roll is usually the first indication of an asymmetric condition. Roll control (ailerons) should be used to hold the wings level or maintain the desired bank angle. Stop the yaw by smoothly applying rudder at the same rate that thrust changes. When the rudder input is correct, very little control wheel displacement is necessary. Refine the rudder input as required and trim the rudder so the control wheel remains approximately level.

When the rudder is trimmed to level the control wheel, the airplane maintains heading. A small amount of bank toward the operating engine may be noticeable on the bank indicator. The slip/skid indicator is displaced slightly toward the operating engine.

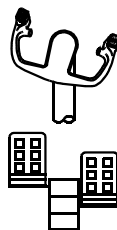
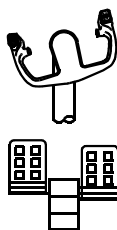
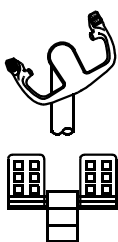
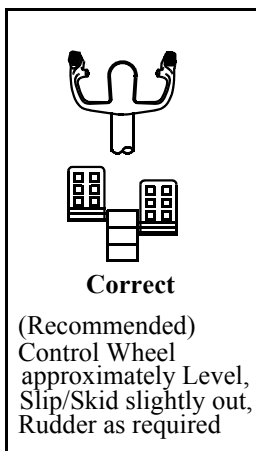
If the airplane is trimmed with too much control wheel displacement, full lateral control is not available and spoilers on one wing may be raised, increasing drag.

Make turns at a constant airspeed and hold the rudder displacement constant. Do not attempt to coordinate rudder and lateral control in turns. Rudder pedal inputs produce roll due to yaw and induce the pilot to counter rudder oscillations with opposite control wheel.

The following figure shows correct and incorrect use of the rudder.

If an engine failure occurs with the autopilot engaged, manually position the rudder to approximately center the control wheel and add thrust. Trim the rudder to relieve rudder pedal pressure.

Any engine failure should trigger the same thought: Establish or maintain control of flight path and airspeed. In other words, “fly the airplane.”



Condition: Engine out right side.

Thrust and Airspeed

If not thrust limited, apply additional thrust, if required, to control the airspeed. The EPR settings for fuel flow existing at the time of engine failure may be used initially to establish a thrust setting at low altitude. If performance limited (high altitude), adjust airplane attitude to maintain airspeed while setting maximum continuous thrust.

High Altitude Maneuvering, “G” Buffet

Airplane buffet reached as a result of aircraft maneuvering is commonly referred to as “g” buffet. During turbulent flight conditions, it is possible to experience high altitude “g” buffet at speeds less than MMO. In training with a full flight simulator, buffet may induced to demonstrate the airplane's response to control inputs during flight in buffet.

Establish an airspeed of Mach .80. Induce “g” buffet by smoothly increasing the bank angle until the buffet is noticeable. Increase the rate of descent while increasing the bank angle to maintain airspeed. Do not exceed 45 degrees of bank. If buffet does not occur by 45 degrees of bank, increase control column back pressure until buffet occurs. When buffet is felt, relax back pressure and smoothly roll out to straight and level. Notice that the controls are fully effective at all times.

Mach Buffet

As altitude and airspeed increase, a flight condition will eventually be reached where the localized airflow becomes supersonic (Mach 1.0) on top of the wing and weak shock waves begin to form. This condition occurs well below an actual aircraft Mach number of 1.0 and varies with flight level and aircraft weight. Although small, weak shock waves form on the wing at Mach 0.75, noticeable buffeting does not occur on the MD-88/90 until approaching MMO. At this Mach number, shock waves become quite large and strong, and move rapidly fore and aft on the wing, causing a gentle high frequency buffet. Buffet intensity will be significantly increased by making a turn, or by applying a slight back pressure to the control column. If the aircraft is accelerated beyond MMO, or if excessive G loading is applied, buffet intensity can increase enough to pose structural integrity problems.

Mach Tuck

In normal subsonic flight, the center of pressure (lift) on the wing is near the 1/4 chord point of the wing (approximately 25% of the way back on the wing from the leading edge). Although the airfoil center of pressure moves aft in the subsonic speed range as speed is increased, other factors, primarily the pitching moment created by the horizontal stabilizer, create a net pitch up tendency. This tendency is desirable, since any increase in speed will be naturally opposed by the aircraft. In the transonic range, however, due to shock wave formation and the associated loss of downwash on the horizontal stabilizer, and the rapidly increased aft movement of the wing center of pressure, a new pitch down moment results. Mach tuck will become noticeable at Mach 0.80; and the pull force required to maintain level flight increases linearly up to Mach 0.85, then remains constant. The tuck effect is automatically zeroed by Mach trim compensation.

Dutch Roll

Dihedral is considered to be positive when the wing tips are higher than the roots. The effect of dihedral is to produce a rolling moment tending to return the airplane to a balanced flight condition if sideslip occurs. Sweepback increases the dihedral stability of an aircraft, which to the pilot means the ability to pick up a wing by using opposite rudder. The dihedral stability is low for a sweptback-wing aircraft in the approach/landing configuration and also at very high Mach numbers.

An increase in wing sweepback normally degrades lateral-directional dynamic stability, better known as "Dutch Roll". Dutch Roll is a combination of roll and yaw oscillations that are coupled together. As with most large, high speed aircraft, there is a lateral directional oscillation present that may be excited by turbulence or rough use of the controls. With the yaw damper operative, all Dutch Roll oscillations are promptly dampened. If the yaw damper should become inoperative, Dutch Roll may be easily dampened with the primary flight controls. Recommended procedure is to use aileron to stop the roll. The oscillations have a relatively long period and the pilot should experience no difficulty in timing control inputs to dampen the oscillation.

Mach Trim Compensator (MTC), Mach Buffet, Dutch Roll Demonstrations

These maneuvers can be performed in the full flight simulator and are used for demonstration purposes only.

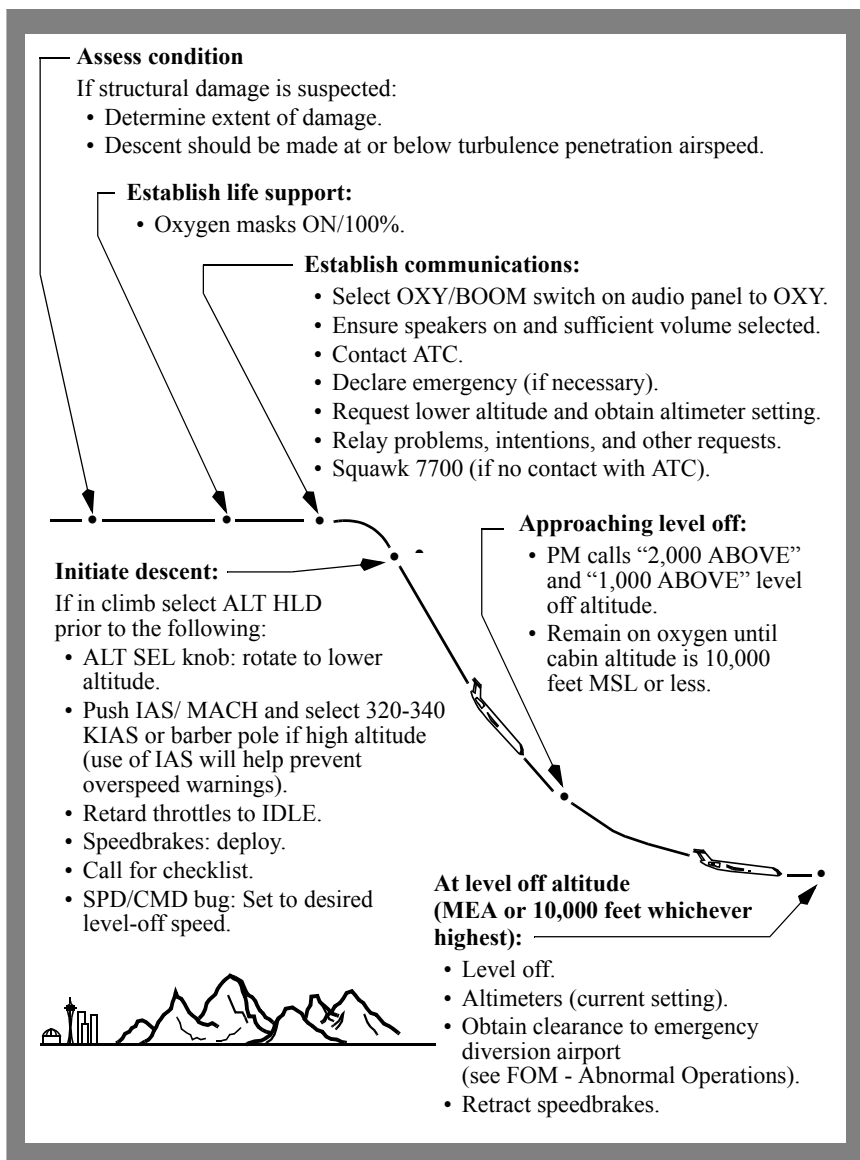
Set MCT power, lower nose of aircraft and accelerate until buffet. Note movement of the MTC indicator rod (MD-88), longitudinal trim indicator (MD-90). Reduce speed to 0.82 Mach. Place MTC switch to OVRD (MD-88), OFF (MD-90). Note force required to maintain that speed. Allow aircraft to return to level flight. Place MTC switch to NORM. With speed at 0.72-0.74 Mach, Yaw Damper OFF, and wings level, place aircraft in shallow climb. Apply rudder pressure sufficient to displace slip indicator with maximum bank angle of 15°. Recover to wings level by opposing rising wing. Keep rudder centered. Neutralize ailerons when wings are level. Apply aileron correction at the same rate as Dutch Roll oscillations. Repeat entry procedure. Move Yaw Damper switch to ON and note reduced oscillations.

▲ **DELTA**
MD-88/90 Flight Crew Training Manual

Rapid Descent

This maneuver is designed to bring the airplane down smoothly to a safe altitude, in the minimum time, with the least possible passenger discomfort.

Note: Use of the autopilot is recommended.



If the descent is performed because of a rapid loss of cabin pressure, crew members should place oxygen masks on and establish communication at the first indication of a loss of cabin pressurization. Verify cabin pressure is uncontrollable, and if so begin descent. If structural damage exists or is suspected, limit airspeed to current speed or less. Avoid high maneuvering loads.

Perform the procedure deliberately and methodically. Do not be distracted from flying the airplane. If icing conditions are entered, use engine anti-ice and thrust as required.

Note: Rapid descent is made with the landing gear up.

The pilot monitoring checks the lowest safe altitude, notifies ATC, and obtains an altimeter setting (QNH). Both pilots should verify that all recall items have been accomplished and call out any items not completed. The pilot monitoring calls out 2,000 feet and 1,000 feet above the level off altitude.

Level off at the lowest safe altitude or 10,000 feet, whichever is higher. Lowest safe altitude is the Minimum Enroute Altitude (MEA), Minimum Off Route Altitude (MORA), or any other altitude based on terrain clearance, navigation aid reception, or other appropriate criteria.

If turbulent air is encountered or expected, reduce to turbulent air penetration speed.

Autopilot Entry and Level Off

Because of airspeed and altitude protection and reduced crew workload, use of the autopilot with IAS mode is the recommended technique for rapid descents.

First set a lower altitude in the altitude window. Select IAS, retard the throttles and extend the speedbrakes. Fly straight ahead or initiate a turn using HDG SEL. Leave autothrottles engaged. The airplane will pitch down smoothly while the throttles retard to idle. Adjust the speed as necessary and ensure the altitude window is correctly set for the level off. During descent, the IAS/MACH speed window does not automatically change from MACH to IAS. The use of IAS (not MACH) will help prevent overspeed warnings.

When approaching the target altitude, ensure the altitude is set in the FGCP altitude select window. Altitude capture engages automatically. Adjusting the command speed prior to level-off aids in smoothly transitioning to level flight. Do not adjust the pitch wheel during altitude capture. The pitch mode then controls altitude and the throttles increase to hold the selected speed. Smoothly retract the speedbrakes during the level off maneuver.

Manual Entry and Level Off

The entry may be accomplished on heading or a turn may be made to clear the airway.

To manually fly the maneuver, disconnect the autothrottles and retard throttles to idle. Smoothly extend the speedbrakes, disconnect the autopilot and smoothly lower the nose to initial descent attitude (approximately 10 degrees nose down).

About 10 knots before reaching target speed, slowly raise the pitch attitude to maintain target speed. Keep the airplane in trim at all times. If MMO/VMO is inadvertently exceeded, change pitch smoothly to decrease speed.

Approaching level off altitude, smoothly adjust pitch attitude to reduce the rate of descent. The speedbrakes lever should be retracted when approaching the desired level off altitude.

After Level Off

Recheck the pressurization system and evaluate the situation. Do not remove the crew oxygen masks if cabin altitude remains above 10,000 feet. Determine the new course of action based on weather, oxygen, fuel remaining, medical condition of crew and passengers, and available airports. Obtain a new ATC clearance.

Maneuvers Training

Flight Control Effectiveness

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. The ailerons and elevators are normally operated mechanically. The ailerons have hydraulically assisted flight spoilers for roll control. The rudder is normally hydraulically powered. In the event of a total hydraulic power loss, the primary flight controls are fully operational.

Ailerons

The ailerons are bussed together by cables and driven aerodynamically by control tabs. The control tabs are connected by cable to the control wheel. The ailerons are not powered in any way. However, rolling forces induced by aileron inputs are supplemented by hydraulically actuated spoilers on each wing surface. Movement of the control wheel beyond approximately 5 degrees will cause the spoilers to extend.

Horizontal Stabilizer and Elevators

Longitudinal trim is accomplished by changing the angle of incidence of the horizontal stabilizer. It is effective throughout the entire center of gravity range and speed envelope of the aircraft. As the stabilizer is moved, the elevator forces must be relaxed to maintain the same attitude. Aerodynamic response induced by movement of the horizontal stabilizer is about 2 1/2 times greater than that induced by elevator movement through the same angular deflection. Primary pitch control is obtained by movement of the elevators.

Rudder

Normally the rudder will be operated at all times in the power mode. Rudder effectiveness is more than adequate under all flight conditions including single-engine operation and autoland operation with rudder power on. With rudder power off (manual rudder or restricted rudder), during single-engine operation, the VMCA may be as high as 135 KIAS.

Strakes

Fuselage strakes are added at the nose to enhance directional control (rudder) during high angle of attack flight. Engine strakes are added to the engine nacelles to enhance longitudinal (elevator) control for post stall recovery.

Vortilons

The vortilons (Vortex-Generating Pylons) serve a dual purpose. First, because of their size, shape, and location, there is a significant effect on the tail surfaces at high angles of attack. This action enhances aerodynamic response from the tail surfaces below the stalling speed of the aircraft (the tail is still flying after the aircraft initially stalls). The secondary purpose is to act as an aerodynamic fence, which contributes to a positive and stable restoring moment in stall recovery. During development of the original DC-9, wind tunnel tests indicated that spanwise flow on the wing caused the outboard portion of the wing to begin stalling early resulting in some minor pitch up at stall. The solution was the vortilon. The device is shaped such that the wing stagnation point in the normal flight envelope is ahead of the vortilon leading edge and no vortex drag penalty is induced at these conditions. At angles of attack approaching stall, the stagnation point moves aft of the intersection and a strong vortex is created over the top of the wing. This energizes the outer panel boundary layer and delays outer panel stall. The vortex then continues aft, rotating in a manner that creates an upwash field at the tail that adds to the pitch down forces at, and substantially beyond stall.

Delta Maneuvers Training (DMT)

These maneuvers are performed in the full flight simulator and are for demonstration purposes only.

Proper airplane flight dynamics and handling qualities are a function of timely, appropriate and coordinated flight control inputs. Whether teaching recoveries from stall, CFIT, windshear or upsets the expected norm is coordinated flight to the maximum extent possible. In order to establish a base line for coordinated flight, Delta presents three demonstrations to the initial qualification pilot. These are one time demo/practice and intended to show the power of the flight control (i.e. handling quality) and aerodynamic response (i.e. flight dynamic) of the aircraft. These demos are accomplished at approach airspeeds representative of typical maneuver energy states and intermediate wing angle of attack. These maneuvers are:

- Rudder effectiveness demo
- Aileron effectiveness demo
- Loaded/Unloaded roll demo

Rudder Effectiveness

This maneuver is accomplished with hands off (hands placed behind the control column, allowing pitch inputs only) the control yoke using rudder inputs only to induce a roll to 45 degree of bank and return to wings level. The emphasis is on smooth, incremental application of rudder. Focus should be on rate of application and magnitude of rudder input. Properly done (slow, incremental) the aircraft will roll to dihedral effect with minimal adverse yaw. Improperly done (fast, large amplitude) the aircraft will display adverse yaw and roll coupling. Only a small amount of rudder input is needed (to induce a roll). Too much rudder applied too quickly or held too long may result in loss of lateral and directional control. Rudder is never the preferred initial response to induce a roll in a transport category aircraft.

Aileron Effectiveness

In like manner, the aileron effectiveness demo is accomplished in one axis (aileron roll only with feet off rudder pedals) at approach energy states and angle of attack. The pilot will smoothly roll to 60 degree bank and then roll back to wings level using full throw aileron authority. The instructional intent is to allow the pilot to observe full throw aileron position, authority and the generated roll rate and roll overshoots (roll out lead points change) as the wings approach level. Additionally, any asymmetric tendencies caused by differential aileron and/or spoiler deployment will be evident.

This demonstration accomplishes three objectives. First, it demonstrates the aircraft will not depart controlled flight from full throw aileron applications. Secondly, it establishes a baseline in the students mind for roll rate capability at an approach energy state. Thirdly, it demonstrates roll overshoot tendencies inherent with large aileron deflection rolls. This level of roll demand would only be required when responding to an unanticipated departure of the aircraft in roll (i.e. wake turbulence, partial flap failure, asymmetric loss of flap structure, etc.).

Loaded/Unloaded Roll

The previous maneuvers are tied together in a coordinated training event utilizing all three axis. This exercise will also demonstrate the effectiveness of a slight release of backpressure to activate the roll mode using aileron. The pilot will smoothly roll to 60 degrees (approximately) of bank, then pull (smoothly) to stick shaker. Recover in the following three manners:

- Roll ailerons only without the use of rudder and no release of backpressure. The result will be a slow roll to wings level.
- Roll with ailerons and small release of back pressure. No use of rudder. The result will be improved roll rate to wings level.
- Roll using aileron and small release of back pressure and coordinated input of rudder. The result will be improved roll rate to wings level with yaw coordination.

▲ DELTA
MD-88/90 Flight Crew Training Manual

By the conclusion of this exercise the pilot should be proficient with the main tasking of DMT:

- Recognition
- Protect the aircraft from the stall
- Maneuver to orient the lift vector
- Stabilize post recovery.

Autospoiler/Autobrake Demonstration

This maneuver is performed in the full flight simulator and is for demonstration purposes only. The objective is to demonstrate Autospoiler and Autobrake operation and show methods in which they may be disarmed. A series of three landings is performed, each landing commencing from short final. The PF will fly the aircraft to touchdown and smoothly lower the nose to the runway and will not apply manual braking and will not pull thrust reverse thrust. The pilot monitoring will manipulate the spoilers, flaps and throttles. Autobrakes will be set to MAX for best effect.

- After the first landing and the nosewheel on the runway, feel the Autobrakes engage in MAX. Pilot monitoring will place the flaps to 15. Note the disarming on the autobrakes (yellow ABS light) and feel the brakes release.
- Reposition to final with Autobrakes and Autospoilers failed simulating an autospoiler failure or a severe hydroplaning condition. After the nosewheel is on the runway, the pilot monitoring deploys the spoilers by pulling the handle straight back. Then, with the spoiler handle locked back, the pilot monitoring advances the right throttle until the Autobrakes disarm (yellow ABS light) and the brakes release. When this occurs the pilot monitoring will pull the right throttle to idle and then will advance the left throttle slowly until the Autospoilers disarm.
- Reposition to final with Autobrakes armed and Autospoilers disarmed. The PF lands again in the same manner. After the nosewheel is on the runway, the pilot monitoring deploys the spoilers manually (up back and up). After the Autobrakes have activated, the pilot monitoring will disarm the spoilers. Note the brake pressure releases but the autobrakes do not disarm (yellow ABS light does not come on). Redeploy the spoilers and note the brakes reapply. Repeat as necessary until fully stopped.

- After fully stopped, arm the spoiler handle. The pilot monitoring pulls the reverse thrust levers up and the spoilers deploy. Disarm the spoilers and deploy them manually, only this time after pulling up and back about 1-2 inches, push the handle down and continue to pull back (the pilot monitoring will have to hold the handle back as the spoilers are deployed but in the disarm channel and not full up in the locking position). Release the handle and watch it return to the stowed position. Repeat the exercise and pull the handle full up after it is full back thus locking the handle full aft. The purpose of this demonstration is to show the two channels the ground spoilers may operate in during deployment and the reason for the up back and up technique to manually deploy and lock the spoilers.

Stall Recovery

The objective of these maneuvers is to familiarize the pilot with stall warning and the correct recovery technique for conditions that are approaching stall, both with and without the autopilot.

Approach to Stall Recovery

Over the recent years, several situations have occurred involving ground contact after takeoff or during approach. While other distractions were usually a factor, the probability of a successful recovery would have been increased if near maximum aircraft performance had been achieved immediately upon recognition of the flight path problem.

The traditional stall recovery techniques that lower the nose to trade altitude for airspeed may be acceptable at high altitudes, but at low altitude these methods do not approach the maximum aircraft performance that may be required to avoid ground contact.

Command Speed

As the airplane is decelerated to the desired initial condition for the approach to stall, set command speed to the maneuver speed for each selected flap setting. For the approach to stall in the landing configuration, set command speed to VREF 40 + 5 knots.

Initial Buffet-Stall Warning-Stall Buffet

During initial stages of stall, local airflow separation results in buffeting (initial buffet), giving natural warning of an approach to stall. A stall warning is considered to be any warning readily identifiable by the pilot, either artificial (stick shaker, auto slat extended) or initial buffet. Recovery from an approach to stall is initiated at the earliest recognizable stall warning, initial buffet or stick shaker.

The FAA requires a warning for the pilot of an impending stall. Natural stall buffet does not provide adequate warning in all configurations for the MD-88/90. Therefore, an artificial stick shaker system and a visual and aural stall warning system were installed.

The stick shaker, the visual and aural warnings, the buffet and the actual stall are all tied directly to specific angles of attack. Because there is a fixed angle of attack relationship between stall and stick shaker, the stick shaker can provide the pilot with a stall margin reference. This may be necessary in some critical situations.

Natural buffet may occur prior to the stick shaker in some situations. Although this stall buffet may be hard to detect in turbulent conditions, be alert for this warning.

If stick shaker or buffet is encountered, respond with a slight change of control pressure to stop the stall warning, and then continue smoothly working the nose toward the desired pitch attitude. If control pressure is aircraft nose up, any conscious effort to actually lower the pitch attitude will result in greater altitude loss.

If ground contact should become imminent, increase pitch attitude gradually, in small increments, to control the descent while continuing to respect any stall warnings.

If the situation continues to deteriorate, intermittent stall warning may provide the only available reference to fly the aircraft near the maximum acceptable angle of attack. The higher pitch attitude and the lower airspeed must be accepted until ground contact is avoided. If absolutely necessary, increase pitch attitude to stop descent, even if doing so causes a steady stick shaker.

Lateral and Directional Control

Lateral control is maintained with ailerons. Rudder control should not be used because it causes yaw and the resultant roll is undesirable.

Effect of Flaps

Flaps are used to increase low speed performance capability. The leading edge devices ensure that the inboard wing stalls prior to the outboard wing. This causes the nose of the airplane to pitch down at the onset of the stall.

Effect of Speedbrakes

For any airspeed, the angle of attack is higher with speedbrakes up. This increases initial buffet speed and stick shaker speed but has a lesser effect on actual stall speed.

Entry

To save time, throttles may be closed to allow a more rapid deceleration. The airplane is maintained in trim while decelerating.

Landing Gear

If the entry has been made with the landing gear extended, do not retract it until after the recovery.

Flaps

Do not retract flaps during the recovery. Retracting the flaps from the landing position, especially when near the ground, causes an altitude loss during the recovery.

 DELTA
MD-88/90 Flight Crew Training Manual

Recovery

Recover from approach to a stall with one of the following recommended recovery techniques.

Ground Contact Not a Factor

Note: If altitude is above 1,000 feet AGL, ground contact may not be a factor and normal takeoff/go around power could be used at the pilot's discretion.

Aggressive thrust application is still appropriate but:

- Try to avoid exceeding engine limitations, if possible. Reduce to TO/GA power if appropriate.

Adjust target pitch attitude as appropriate for the conditions.

- 10° nose up is suitable at most altitudes. 5° may be needed at higher altitudes.

Appropriate configuration changes may be made as desired.

- If in clean configuration, extend slats (280 KIAS/.57 Mach limit).

Accelerate back to normal speed.

- Minimize altitude loss during acceleration.

Ground Contact a Factor

Apply maximum available thrust.

- Aggressively push throttle full forward - firewall. This includes through the overrated thrust gate (ORT) on the MD-90.
- Disconnect ATS.

Pitch - rotate toward 15°, wings level.

- Disengage autopilot.
- Simultaneously with thrust application, rotate at approximately 1° per second toward an initial target pitch attitude of 15°.
- Roll wings level if possible.

Respect any stall warnings.

- Stop rotation if stick shaker or buffet is encountered.
- Use intermittent stick shaker as the upper control pressure limit and continue to try to move toward the target pitch.

Note: If ground contact becomes imminent, increase pitch attitude to stop descent, even if doing so causes a steady stick shaker.

Control flight path with pitch.

- Use 15° nose up as the target pitch attitude throughout the recovery unless ground contact becomes imminent.
- If ground contact becomes imminent, increase pitch attitude gradually to control the descent and continue to respect any stall warnings.

-
- Retain positive control of the aircraft.
 - The pilot monitoring should call out vertical speed/airspeed, altitude and/or radio altitude as appropriate.

Maintain configuration.

- Do not change configuration until ground contact is no longer a factor.

Autopilot Engaged

If an approach to a stall is encountered with the autopilot engaged, apply limit thrust and allow the airplane to return to the normal speed. At high altitude, it may be necessary to initiate a descent to regain maneuvering speed. If autopilot response is not acceptable, it should be disengaged.

Maintain Configuration

The slats are very effective in changing the stall speed of the MD-88/90. If a stall warning occurs while the aircraft is in the clean configuration, after appropriate thrust and target pitch is established, the slats should be extended if below slat limit.

If ground contact is a factor, minimize changes to gear or flap positions during the recovery. All attention should be focused toward flying the aircraft and avoiding ground contact. If the recovery is to be simple and effective, configuration changes must be held to a minimum.

If the aircraft is in a landing configuration, selecting go-around flaps may be beneficial to reduce drag but pitch and thrust control are far more important. Raising the gear will briefly increase the drag.

When ground contact is not a factor appropriate configuration changes may be made.

Instructor Pilot Responsibilities

Approaches to stall will be performed in the clean, takeoff, and landing configurations. The maneuvers are designed to be performed in the simulator to provide experience in the normal low speed capabilities of the aircraft and in the recommended recovery if an approach to stall warning is encountered. The Flight Instructor will direct all preparation and entry procedures. The pilot will be expected to initiate the recovery when the initial stall indication is observed.

Recovery from a Fully Developed Stall

An airplane may be stalled in any attitude (nose high, nose low, high angle of bank) or any airspeed (turning, accelerated stall). It is not always intuitively obvious that the airplane is stalled.

In common with most other T-tail aircraft, the airplane is subject to a characteristic known as the “deep stall”. This term refers to an angle-of-attack range beyond the normal stall region in which the tail enters the turbulent wakes of the wing and nacelles. This causes a loss in tail effectiveness and a tendency to pitch up until the aircraft stabilizes at some very high angle-of-attack. Entry into the deep stall may not be readily apparent to the pilot since the increase in angle-of-attack may be accompanied by increasing sink rate and flight path angle so that pitch attitudes remain low.

An airplane stall is characterized by one (or a combination) of the following conditions:

- buffeting, which could be heavy
- lack of pitch authority
- lack of roll control
- inability to arrest descent rate.

These conditions are usually accompanied by a continuous stall warning. A stall must not be confused with the stall warning that alerts the pilot to an approaching stall. Recovery from an approach to a stall is not the same as recovery from an actual stall. An approach to a stall is a controlled flight maneuver; a stall is an out-of-control, but recoverable, condition.

Note: Anytime the airplane enters a fully developed stall, the autopilot and autothrottle should be disconnected.

To recover from a stall, angle of attack must be reduced below the stalling angle. Nose down pitch control must be applied and maintained until the wings are unstalled. Application of forward control column (as much as full forward may be required) and the use of some nose-down stabilizer should provide sufficient elevator control to produce a nose-down pitch rate. It may be difficult to know how much stabilizer trim to use, and care must be taken to avoid using too much trim. Pilots should not fly the airplane using stabilizer trim, and should stop trimming nose down when they feel the g force on the airplane lessen or the required elevator force lessen.

Once the wing is unstalled, upset recovery actions may be taken and thrust reapplied as necessary.

If normal pitch control inputs do not stop an increasing pitch rate in a nose high situation, rolling the airplane to a bank angle that starts the nose down may be effective. Bank angles of about 45 degrees, up to a maximum of 60 degrees, could be needed. Normal roll controls up to full deflection of ailerons and spoilers may be used. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack as low as possible, making the normal roll controls as effective as possible.

Finally, if normal pitch control then roll control is ineffective, careful rudder input in the direction of the desired roll may be required to initiate a rolling maneuver recovery.

WARNING: Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control.

Steep Turns

The objective of the turn maneuver is to familiarize the pilot with airplane handling characteristics and improve the instrument cross check.

During training, 45 degrees of bank is used. It is not intended that the pilot should bank greater than 25 to 30 degrees for normal, or non-normal procedures.

Entry

Stabilize the aircraft at the chosen altitude and airspeed of 250 kts by utilizing the autopilot and autothrottles. Select a cardinal heading, and set the course selector on this or the reciprocal heading (rose mode on the EFIS ND) and rotate the heading bug to the reciprocal heading. Note the EPR setting on the engines and the pitch in degrees (approximately 2.5). Turn off the flight director and the autothrottles. When ready, turn off the autopilot and ensure the aircraft simulator is in trim. Slowly roll into a 45 degree bank. Maintain the bank angle, airspeed, and altitude for 180 degrees of turn. When bank angle increases above 30 degrees, add power to maintain airspeed, and increase airplane pitch 3.0 to 4.0 degrees.

During Turn

Pitch and thrust control are the same as for a normal turn; however, larger pitch adjustments are required for a given altitude deviation. Varying the angle of bank while turning makes pitch control more difficult. If altitude loss becomes excessive, reduce the angle of bank as necessary to regain positive pitch control.

Smooth and positive control is required. A rapid instrument scan is required to detect deviations early enough to be corrected by small adjustments.

Keep bank angle at 45 degrees plus or minus 5 degrees.

Vertical Speed Indicator

The VSI is not an instantaneous display. Under rapidly changing conditions, the VSI may lag actual aircraft performance by as much as four seconds.

Altimeter

Check altitude. If increasing, reduce thrust slightly and if decreasing, add a small amount of thrust to maintain the airspeed within plus or minus 10 knots. Continue to glance at the altimeter to comply with the tolerance of plus or minus 100 feet.

Airspeed

Anticipate thrust changes and apply them at the first indication of change on the FAST/SLOW indicator. An increase in thrust is required as bank angle increases. Adjust the throttles to maintain the fast slow indicator on the center dot, crosscheck altitude and vertical speed indicator (VSI) and make proper adjustments. If altitude is constant add or subtract a small amount of power to return the fast slow indicator to center.

Rollout

Roll out on the required heading within plus or minus 10 degrees. Lead the rollout by approximately 15 - 20 degrees. The pilot monitoring should be briefed to call out lead point to assist in rolling out on the proper heading. It should be stressed that the roll rate should be constant going in and out of the turn and the pilot should perform a rapid crosscheck of the PFD, VSI, altimeter and compass rose.

Summary

- Establish aircraft in level flight on a cardinal heading at 250 knots with A/T, FD, and AP off.
- Roll smoothly into 45 degrees of bank, increasing thrust and pitch slightly passing through 30 degrees of bank. Pitch attitude will be approximately 4.0 degrees.
- Maintain entry altitude and 250 knots for 180 degrees of turn.
- Fast/Slow Indicator and scale on PFD may assist for airspeed trends.
- Lead the rollout by 15 - 20 degrees and reduce the thrust as the wings become level.
- A 180 degree steep turn in the opposite direction is required to complete the maneuver.

Terrain Avoidance

The Ground Proximity Warning System (GPWS) PULL UP Warning occurs when an unsafe distance or closure rate is detected with terrain below the airplane. The Look-ahead terrain alerting also provides an aural warning when an unsafe distance is detected from terrain ahead of the airplane. Immediately accomplish the Terrain Avoidance maneuver found in the non-normal maneuvers section of the QRH.

Traffic Alert and Collision Avoidance System (TCAS)

TCAS is designed to enhance crew awareness of nearby traffic and issue advisories for timely visual acquisition or appropriate vertical flight path maneuvers to avoid potential collisions. It is intended as a backup to visual collision avoidance, application of right-of-way rules and ATC separation.

Use of TA/RA and TA Only Modes

Transponder operation using TA/RA mode should be initiated at Pushback and continued until arrival Shutdown. Refer to Vol. 1, Amplified Procedures, Pushback/Start Procedure for additional guidance. Operations in the Traffic Advisory (TA) Only mode are permitted only when directed by procedure (i.e. ENGINE FAILURE).

The responsibility for avoiding collisions still remains with the flight crew and ATC. Pilots should not become preoccupied with TCAS advisories and displays at the expense of basic airplane control, normal visual lookout and other crew duties.

Traffic Advisory (TA)

A Traffic Advisory (TA) occurs when nearby traffic meets system minimum separation criteria, and is indicated aurally and visually on the TCAS traffic display. If a TA is received, immediately accomplish the Traffic Avoidance maneuver in the QRH, Non-Normal Maneuvers section.

Resolution Advisory (RA)

When TCAS determines that separation from approaching traffic may not be sufficient, TCAS issues a Resolution Advisory (RA) aural warning and a pitch command. Maneuvering is required if the existing vertical speed is in the red band (RA VSI). Flight crews will follow RA commands using established procedures unless doing so would jeopardize the safe operation of the airplane. If an RA is received, immediately accomplish the Traffic Avoidance maneuver in the QRH.

RA maneuvers require only small pitch attitude changes which should be accomplished smoothly and without delay. Properly executed, the RA maneuver is mild and does not require large or abrupt control movements. Remember that the passengers and flight attendants may not all be seated during this maneuver. The flight director is not affected by TCAS guidance. Therefore, when complying with an RA, flight director commands may be followed only if they result in a vertical speed that satisfies the RA command.

During the RA procedure, the aircrew attempts to establish visual contact with the target. However, visual perception of the encounter can be misleading. The traffic acquired visually may not be the same traffic causing the RA.

Pilots should maintain situational awareness since TCAS may issue RAs in conflict with terrain considerations, such as during approaches into rising terrain or during an obstacle limited climb. Continue to follow the planned lateral flight path unless visual contact with the conflicting traffic requires other action. Windshear, GPWS, and stall warnings take precedence over TCAS advisories. Stick shaker must be respected at all times. Complying with RAs may result in brief exceedance of altitude and/or placard limits. However, even at the limits of the operating envelope, in most cases sufficient performance is available to safely maneuver the airplane. Smoothly and expeditiously return to appropriate altitudes and speeds when clear of conflict. Maneuvering opposite to an RA command is not recommended since TCAS may be coordinating maneuvers with other airplanes.

Unusual Attitude Recovery Procedures

The pilot monitoring should back up recovery process, and assist with appropriate callouts (VSI, airspeed and altitudes).

Nose low recovery.

- Reduce thrust.
- Extend speedbrakes (if required to control airspeed).
- Roll wings level in nearest direction to the horizon, then
- Return the airplane to level flight by increasing pitch as necessary.

Nose high recovery.

- TO/GA thrust.
- Pitch the nose to level flight attitude, and simultaneously
- Roll wings level.

Return to ATC assigned heading and altitude.

Upset Recovery

An upset can generally be defined as unintentionally exceeding the following conditions:

- pitch attitude greater than 25 degrees nose up, or
- pitch attitude greater than 10 degrees nose down, or
- bank angle greater than 45 degrees, or
- within above parameters but flying at airspeeds inappropriate for the conditions.

General

Though flight crews in line operation rarely, if ever, encounter an upset situation, understanding how to apply aerodynamic fundamentals in such a situation helps them control the airplane. Several techniques are available for recovering from an upset. In most situations, if a technique is effective, it is not recommended that pilots use additional techniques. Several of these techniques are discussed in the example scenarios below:

- stall recovery
- nose high, wings level
- nose low, wings level
- high bank angles
- nose high, high bank angles
- nose low, high bank angles

Stall Recovery

In all upset situations, it is necessary to recover from a stall before applying any other recovery actions. A stall may exist at any attitude and may be recognized by continuous stick shaker activation accompanied by one or more of the following:

- buffeting which could be heavy at times
- lack of pitch authority and/or roll control
- inability to arrest descent rate.

If the airplane is stalled, recovery from the stall must be accomplished first by applying and maintaining nose down elevator until stall recovery is complete and stick shaker activation ceases. Once stall recovery is complete, upset recovery actions may be taken and thrust reapplied as needed.

Nose High, Wings Level

A nose high, wings level situation is defined by an airplane pitch attitude that is unintentionally more than 25 degrees nose high and increasing, and airspeed decreasing rapidly. As airspeed decreases, the pilot's ability to maneuver the airplane also decreases. If the stabilizer trim setting is nose up, as for slow-speed flight, it partially reduces the nose-down authority of the elevator. At full thrust settings and very low airspeeds, the elevator - working in opposition to the stabilizer - will have limited control to reduce the pitch attitude.

In this situation the pilot should trade altitude for airspeed, and maneuver the airplane's flight path back toward the horizon. This is accomplished by the input of up to full nose-down elevator and the use of some nose-down stabilizer trim. These actions should provide sufficient elevator control power to produce a nose-down pitch rate. It may be difficult to know how much stabilizer trim to use, and care must be taken to avoid using too much trim. Pilots should not fly the airplane using stabilizer trim, and should stop trimming nose down when they feel the g force on the airplane lessen or the required elevator force lessen. This use of stabilizer trim may correct an out-of-trim airplane and solve a less-critical problem before the pilot must apply further recovery measures. Because a large nose-down pitch rate results in a condition of less than 1 g, at this point the pitch rate should be controlled by modifying control inputs to maintain between 0 to 1 g. If altitude permits, flight tests have determined that an effective way to achieve a nose-down pitch rate is to reduce some thrust.

▲ DELTA
MD-88/90 Flight Crew Training Manual

If normal pitch control inputs do not stop an increasing pitch rate, rolling the airplane to a bank angle that starts the nose down should work. Bank angles of about 45 degrees, up to a maximum of 60 degrees, could be needed. Unloading the wing by maintaining continuous nose-down elevator pressure keeps the wing angle of attack as low as possible, making the normal roll controls as effective as possible. With airspeed as low as stick shaker onset, normal roll controls - up to full deflection of ailerons and spoilers - may be used. The rolling maneuver changes the pitch rate into a turning maneuver, allowing the pitch to decrease. Finally, if normal pitch control then roll control is ineffective, careful rudder input in the direction of the desired roll may be required to induce a rolling maneuver for recovery.

CAUTION: Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control. Because of the low energy condition, pilots should exercise caution when applying rudder.

The reduced pitch attitude allows airspeed to increase, thereby improving elevator and aileron control effectiveness. After the pitch attitude and airspeed return to a desired range the pilot can reduce angle of bank with normal lateral flight controls and return the airplane to normal flight.

Nose Low, Wings Level

A nose low, wings level situation is defined by an airplane pitch attitude that is unintentionally more than 10 degrees nose low and going lower, and airspeed increasing rapidly. A pilot would likely reduce thrust and extend the speedbrakes. Thrust reduction causes an additional nose-down pitching moment. Speedbrake extension causes a nose-down pitching moment, an increase in drag, and a decrease in lift for the same angle of attack. At airspeeds well above VMO/MMO, the ability to command a nose-up pitch rate with elevator may be reduced because of the extreme aerodynamic loads on the elevator.

Again, it is necessary to maneuver the airplane's flight path back toward the horizon. At moderate pitch attitudes, applying nose-up elevator - and reducing thrust and extending speedbrakes, if necessary - will change the pitch attitude to a desired range. At extremely low pitch attitudes and high airspeeds (well above VMO/MMO), nose-up elevator and nose-up trim may be required to establish a nose-up pitch rate.

High Bank Angles

A high bank angle is one beyond that necessary for normal flight. Though the bank angle for an upset has been defined as unintentionally more than 45 degrees, it is possible to experience bank angles greater than 90 degrees.

Any time the airplane is not in “zero-angle-of-bank” flight, lift created by the wings is not being fully applied against gravity, and more than 1 g is required for level flight. At bank angles greater than 67 degrees, level flight cannot be maintained within flight manual limits for a 2.5 g load factor. In high bank angle increasing airspeed situations, the primary objective is to maneuver the lift of the airplane to directly oppose the force of gravity by rolling (in the shortest direction) to wings level. Applying nose-up elevator at bank angles above 60 degrees causes no appreciable change in pitch attitude and may exceed normal structure load limits as well as the wing angle of attack for stall. The closer the lift vector is to vertical (wings level), the more effective the applied g is in recovering the airplane.

A smooth application of up to full lateral control should provide enough roll control power to establish a very positive recovery roll rate. If full roll control application is not satisfactory, it may even be necessary to apply some rudder in the direction of the desired roll.

CAUTION: Only a small amount of rudder is needed. Too much rudder applied too quickly or held too long may result in loss of lateral and directional control or structural failure.

Nose High, High Bank Angles

A nose high, high angle of bank upset requires deliberate flight control inputs. A large bank angle is helpful in reducing excessively high pitch attitudes. The pilot must apply nose-down elevator and adjust the bank angle to achieve the desired rate of pitch reduction while considering energy management. Once the pitch attitude has been reduced to the desired level, it is necessary only to reduce the bank angle, ensure that sufficient airspeed has been achieved, and return the airplane to level flight.

Nose Low, High Bank Angles

The nose low, high angle of bank upset requires prompt action by the pilot as altitude is rapidly being exchanged for airspeed. Even if the airplane is at a high enough altitude that ground impact is not an immediate concern, airspeed can rapidly increase beyond airplane design limits. Simultaneous application of roll and adjustment of thrust may be necessary. It may be necessary to apply nose-down elevator to limit the amount of lift, which will be acting toward the ground if the bank angle exceeds 90 degrees. This also reduces wing angle of attack to improve roll capability. Full aileron and spoiler input should be used if necessary to smoothly establish a recovery roll rate toward the nearest horizon. It is important to not increase g force or use nose-up elevator or stabilizer until approaching wings level. The pilot should also extend the speedbrakes as necessary.

Upset Recovery Techniques

It is possible to consolidate and incorporate recovery techniques into two basic scenarios, nose high and nose low, and to acknowledge the potential for high bank angles in each scenario described above. Other crew actions such as recognizing the upset, reducing automation, and completing the recovery are included in these techniques. The recommended techniques provide a logical progression for recovering an airplane.

If an upset situation is recognized, immediately accomplish the Upset Recovery maneuver in the non-normal maneuvers section of the QRH.

Windshear

General

Improper or ineffective vertical flight path control has been one of the primary factors in many cases of flight into terrain. Low altitude windshear encounters are especially significant because windshear can place the crew in a situation which requires the maximum performance capability of the airplane. Windshear encounters near the ground are the most threatening because there is very little time or altitude to respond to and recover from an encounter.

Airplane Performance in Windshear

Knowledge of how windshear affects airplane performance can be essential to the successful application of the proper vertical flight path control techniques during a windshear encounter.

The wind component is mostly horizontal at altitudes below 500 feet. Horizontal windshear may improve or degrade vertical flight path performance. Windshear that improves performance is first indicated in the flight deck by an increasing airspeed. This type of windshear may be a precursor of a shear that decreases airspeed and degrades vertical flight path performance.

Airspeed decreases if the tailwind increases, or headwind decreases, faster than the airplane is accelerating. As the airspeed decreases, the airplane normally tends to pitch down to maintain or regain the in-trim speed. The magnitude of pitch change is a function of the encountered airspeed change. If the pilot attempts to regain lost airspeed by lowering the nose, the combination of decreasing airspeed and decreasing pitch attitude produces a high rate of descent. Unless this is countered by the pilot, a critical flight path control situation may develop very rapidly. As little as 5 seconds may be available to recognize and react to a degrading vertical flight path.

In critical low altitude situations, trade airspeed for altitude, if possible. An increase in pitch attitude, even though the airspeed may be decreasing, increases the lifting force and improves the flight path angle. Proper pitch control, combined with maximum available thrust, utilizes the total airplane performance capability.

The crew must be aware of the normal values of airspeed, altitude, rate of climb, pitch attitude and control column forces. Unusual control column force may be required to maintain or increase pitch attitude when airspeed is below the in-trim speed. If significant changes in airspeed occur and unusual control forces are required, the crew should be alerted to a possible windshear encounter and be prepared to take action.

Avoidance, Precautions and Recovery

Crew actions are divided into three areas: Avoidance, Precautions and Recovery. For more information on avoidance and precautions, see the Windshear Supplementary Procedure in Volume 1 of the Operations Manual. For specific crew actions for recovery, see the non-normal maneuvers section in the QRH.

Intentionally
Blank

Non-Normal Operations
Table of Contents

Chapter 6
Section 0

Preface	6.1
Non-Normal Situation Guidelines	6.1
Landing at the Nearest Suitable Airport	6.2
Diverting to an Alternate Airport - One Engine Inoperative	6.3
Ditching.....	6.4
General	6.4
Send Distress Signals	6.4
Advise Crew and Passengers	6.4
Fuel Burn-Off	6.4
Passenger Cabin Preparation.....	6.4
Ditching Final	6.4
Initiate Evacuation	6.4
Electrical.....	6.5
Approach and Landing on Emergency Power	6.5
Engines, APU	6.7
Engine Failure vs. Engine Fire After Takeoff.....	6.7
Loss of Engine Thrust Control	6.7
Dual Engine Failure	6.7
Engine Fire On the Ground.....	6.8
Engine Severe Damage Accompanied by High Vibration	6.8
Recommended Technique for an In-Flight Engine Shutdown	6.9

Evacuation	6.10
Method of Evacuation	6.10
Flight Controls	6.12
No Flap/No Slat Approach Profile	6.12
Leading Edge or Trailing Edge Device Malfunctions	6.13
Jammed or Restricted Flight Controls	6.15
Inoperative Stabilizer	6.17
Runaway Stabilizer	6.17
Flight Instruments, Displays	6.18
Airspeed Unreliable	6.18
Fuel	6.20
Fuel Balance	6.20
Fuel Leak	6.20
Low Fuel	6.20
Hydraulics	6.22
Hydraulic System(s) Inoperative - Landing	6.22
Landing Gear	6.22
Landing on a Flat Tire	6.22
Partial or Gear Up Landing	6.22
Overspeed	6.25
Tail Strike	6.25
Takeoff Risk Factors	6.25
Landing Risk Factors	6.25

Brake Overheat	6.28
Windows	6.28
Window Damage.	6.28
Flight with the Side Window(s) Open	6.28
Situations Beyond the Scope of Non-Normal Checklists	6.29
Basic Aerodynamics and Systems Knowledge.	6.29
Flight Path Control	6.30
Recall Checklists.	6.31
Communications	6.31
Damage Assessment and Airplane Handling Evaluation	6.32

Intentionally
Blank

Non-Normal Operations

Chapter 6

Preface

This chapter describes pilot techniques associated with accomplishing selected non-normal checklists. Aircrews are expected to accomplish checklists listed in the QRH. These checklists ensure maximum safety until appropriate actions are completed and a safe landing is accomplished. Techniques discussed in this chapter minimize workload, improve crew coordination, enhance safety, and provide a basis for standardization. A thorough review of the QRH, Cl.2, Checklist Introduction, Non-Normal Checklist is an important prerequisite to understanding this chapter.

Non-Normal Situation Guidelines

When a non-normal situation occurs, the following guidelines apply:

- **NON-NORMAL RECOGNITION:** The crew member recognizing the malfunction calls it out clearly and precisely
- **MAINTAIN AIRPLANE CONTROL:** It is mandatory for one pilot to fly the airplane while the non-flying pilot accomplishes the non-normal checklist. Maximum use of the autoflight system is recommended to reduce crew workload
- **ANALYZE THE SITUATION:** Non-normal checklists should be accomplished only after the malfunctioning system has been positively identified

Note: Pilots should don oxygen masks and establish communications anytime oxygen deprivation or air contamination is suspected, even though an associated warning has not occurred.

- **TAKE THE PROPER ACTION:** Although many in-flight non-normal situations require immediate corrective action, difficulties can be compounded by the rate the pilot flying issues commands and speed of execution by the non-flying pilot. Commands must be clear and concise, allowing time for acknowledgment of each command prior to issuing further instructions. The pilot flying must exercise positive control by allowing time for acknowledgment and execution. The other crew members must be certain their reports to the pilot flying are clear and concise, neither exaggerating nor understating the nature of the non-normal situation. This eliminates confusion and ensures efficient, effective, and expeditious handling of the non-normal situation
- **EVALUATE THE NEED TO LAND:** If the NNC directs the crew to land at the nearest suitable airport, diversion to the nearest airport where a safe landing can be accomplished is required. If the NNC does not direct landing at the nearest suitable airport, the pilot must determine if continued flight to destination is a compromise to safety.

Landing at the Nearest Suitable Airport

“Plan to land at the nearest suitable airport” is a phrase used in the QRH. This section explains the basis for that statement and how it is applied.

In a non-normal situation, the pilot-in-command, having the authority and responsibility for operation and safety of the flight, must make the decision to continue the flight as planned or divert. In an emergency situation, this authority may include necessary deviations from any rule to meet the emergency. In all cases the pilot-in-command is expected to take a safe course of action.

The QRH assists flight crews in the decision making process by indicating those situations where “landing at the nearest suitable airport” is required. These situations are described in the Checklist Introduction or the individual NNC.

The regulations regarding an engine failure are specific. The FARs specify that the pilot-in-command of a twin engine airplane that has an engine failure or engine shutdown shall land at the nearest suitable airport at which a safe landing can be made.

Note: If the pilot-in-command lands at an airport other than the nearest suitable airport, in point of time, the FARs require a written report from the airline stating the reasons for determining that the selection of an airport, other than the nearest suitable airport, was as safe a course of action as landing at the nearest suitable airport.

A suitable airport is defined by the operating authority for the operator by guidance material, but in general must have adequate facilities and meet certain minimum weather and field conditions. If required to divert to the nearest suitable airport (twin engine airplane with engine failure), the guidance material also typically specifies the pilot should select the nearest suitable airport “in point of time” or “in terms of time.” In selecting the nearest suitable airport, the pilot-in-command should consider the suitability of nearby airports in terms of facilities and weather and their proximity to the airplane position. The pilot-in-command may determine, based on the nature of the situation and an examination of the relevant factors, that the safest course of action is to divert to a more distant airport than the nearest airport. For example, there is not necessarily a requirement to spiral down to the airport nearest the airplane's present position if, in the judgment of the pilot-in-command, it would require equal or less time to continue to another nearby airport.

For persistent smoke or a fire which cannot positively be confirmed to be completely extinguished, the safest course of action typically requires the earliest possible descent, landing and passenger evacuation. This may dictate landing at the nearest airport appropriate for the airplane type, rather than the nearest suitable airport normally used for the route segment where the incident occurs.



Diverting to an Alternate Airport - One Engine Inoperative

Consider heading, airspeed, and altitude in your decision-making.

Heading

If circumstances require diversion, obtain clearance from ATC and turn toward the alternate airport. Adjust bank angle limiter based on the aircraft speed. V2+20 is a maneuvering airspeed; slat retract (SR)+20 is not. Use heading select to turn. Using NAV may result in bank angles greater than 15 degrees. Coordinate the diversion with the flight dispatcher and Flight Leader when time and workload permit.

Altitude

At 1000' AFE or as stipulated in the 10-0 green pages, accelerate to V2+20.

Coordinate a pattern or intermediate safe altitude (MSA, MVA, MEA, etc.) with ATC. You will be at or climbing to this altitude when you make the divert decision.

Determine your single engine cruise altitude using the FMS or ODM. The dispatcher may have provided takeoff alternate information, including altitude, prior to takeoff.

Coordinate your altitude request with ATC.

Airspeed

You will be operating initially at V2+20. Once on-course to the alternate airport, accelerate to SR+20. Select IAS, MCT, EPR limit. Update the IAS window to SR+20. Update the speed command window to single engine cruise speed minimum. Because SR+20 is not a maneuvering speed, the FMA may indicate "speed low" when operating at SR+20.

The FMS provides an equivalent profile after selecting ENG OUT on either the CLIMB page, or CRUISE page. VNAV can then be used if the autothrottles are re-engaged during the accomplishment of a non-normal checklist.

Retract flaps and slats as appropriate.

You may continue to climb at SR+20 until reaching single engine cruise altitude (most fuel efficient) or you may accelerate to a higher speed after evaluating fuel remaining and distance to the alternate airport. Consult the FMS/ODM to determine best single engine cruise speed.

During the diversion

Adjust the rudder trim as necessary throughout the diversion and closely monitor fuel distribution to avoid an imbalance condition.

Ditching

General

When the decision has been made to ditch, review the crew duties summary located in the Quick Reference Handbook (QRH), Checklist Introduction chapter Non-Normal Checklist section, and complete the Ditching/Crash Landing Non-Normal Checklist.

Send Distress Signals

Transmit Mayday, establish position, course, speed, altitude, situation, intention, time and position of intended touchdown, and type of aircraft using existing air-to-ground frequency. Set transponder code 7700 and, if practical, determine the course to the nearest ship or landfall.

Advise Crew and Passengers

Alert the crew and the passengers to prepare for ditching. Assign life raft positions (as installed) and order all loose equipment in aircraft secured. Put on life vests, shoulder harness, and seat belts. Do not inflate life vest until after exiting the airplane.

Fuel Burn-Off

Consider burning off fuel prior to ditching, if the situation permits. This provides greater buoyancy and a lower approach speed. However, do not reduce fuel to a critical amount, as ditching with engine power available improves ability to properly control touchdown.

Passenger Cabin Preparation

Confer with cabin personnel either by interphone or by personally reporting to the flight deck to assure passenger cabin preparations for ditching are complete.

Ditching Final

Transmit final position. Extend flaps 28°. On final approach announce ditching is imminent, advise crew and passengers to brace for impact. Plan to touchdown on the windward side and parallel to the waves or swells, if possible. Contact at minimum forward and sink speeds but do not stall prior to touchdown.

Initiate Evacuation

After the airplane has come to rest, proceed to assigned ditching stations and evacuate as soon as possible, assuring all passengers are out of the airplane.

Deploy slides/rafts. Be careful not to rip or puncture the slides/rafts. Avoid drifting into or under parts of the airplane. Remain clear of fuel saturated water.



Electrical

Approach and Landing on Emergency Power

The probability of a total and unrecoverable AC power failure is remote. During training, or in the unlikely event that a landing must be made on emergency power, the following guidelines should be considered:

- Plan
 - Avoid IMC
 - Land at Nearest Suitable Airport
 - Review major items available when reduced to operating on battery only (Emergency Power Switch ON).
- Aviate
 - Manual pressurization/manual temperature control
 - No stabilizer trim
 - No ATS
 - No Autopilot
 - No Ice protection (engine anti-ice may stay on if it was on at time of the failure).
- Navigate
 - Captain's VHF Nav and primary flight instruments
 - No DME
 - Heading and course readout on Captain's ND only (DFGC displays Captain's VHF Nav frequency only).
- Communicate
 - Captain's VHF and cockpit speaker
 - Flight Interphone
 - PA
- Instrument Approach Capability
 - Raw data ILS
 - Raw data Localizer
 - VOR
- Landing
 - Gear and Slat operation is normal.
 - Refer to QRH for Flap/Slat configuration (no indication and mid-seal stats only).
 - Manual Spoilers
 - Manual Brakes, no Anti-Skid
 - Thrust Reversers (no indication).



- Compute Approach Reference speed if required. Depending on where stabilizer is stuck, yoke pressure can be heavy. Speed additive is due to the elevator not being big enough to compensate for the stuck stabilizer.

Note: Refer to Volume 1, SP.6, Supplementary Procedures, Electrical, for a complete list of equipment powered by battery.

| Fly the approach on speed. Anti-skid is not available, so excess approach speed is undesirable. Do not reduce thrust until landing flare has been initiated and sink **|** rate has been reduced. Brake with caution.

The Captain may require verbal assistance with glidepath, rate of descent and **|** airspeed from the pilot monitoring.



Engines, APU

Engine Failure vs Engine Fire After Takeoff

In case of an engine fire, when the airplane is under control, the gear has been retracted, and a safe altitude has been attained (minimum 400 feet AGL) accomplish the non-normal checklist recall action items. Due to asymmetric thrust considerations, Boeing recommends that the PF retard the throttle after the pilot monitoring confirms that the PF has the correct engine.

Loss of Engine Thrust Control

All turbo fan engines are susceptible to this malfunction whether engine control is hydro-mechanical, hydro-mechanical with supervisory electronics or Full Authority Digital Engine Control (FADEC).

Note: FADEC only applicable to the MD-90.

Engine response to a loss of control varies from engine to engine. Malfunctions have occurred in-flight and on the ground. The major challenge to the flight crew when responding to this malfunction is recognizing the condition and determining which engine has malfunctioned. This condition can occur during any phase of flight.

Failure of engine or fuel control system components, or loss of throttle position feedback has caused loss of engine thrust control. Control loss may not be immediately evident since many engines fail to some fixed RPM or throttle condition. This fixed RPM or throttle condition may be very near the commanded thrust level and therefore difficult to recognize until the flight crew attempts to change thrust with the throttle. Other engine responses include: shutdown, and operation at low RPM.

Since engine failure recognition may be difficult, if a loss of engine control is suspected, the flight crew should continue the takeoff or remain airborne until the non-normal checklist can be accomplished. This helps with directional control and may preclude an inadvertent shutdown of the wrong engine. In some conditions such as during low speed ground operations, immediate engine shutdown may be necessary to maintain directional control.

Dual Engine Failure

Dual engine failure is a situation that demands prompt action regardless of altitude or airspeed. Initiate the ALL ENGINES FLAMEOUT non-normal checklist and establish the appropriate airspeed to immediately attempt windmill restart. There is a higher probability that a windmill start will succeed if the restart attempt is made as early as possible (or immediately after recognizing engine failure) to take advantage of high engine RPM. Use of higher airspeeds and altitudes below 30,000 feet improves the probability of a restart. Loss of thrust at higher altitudes may require driftdown to lower altitude to improve windmill starting capability.

The inflight start envelope defines the region where windmill starts were demonstrated during certification. It should be noted that this envelope does not define the only areas where a windmill start may be successful. The DUAL ENGINE FAILURE non-normal checklist is written to ensure flight crews take advantage of the high RPM at engine failure regardless of altitude or airspeed. A subsequent APU start may be initiated as soon as practical for electrical power and starter assist (MD-90) start attempt if the rapid restart does not succeed.

A hung or stalled in-flight start is normally indicated by stagnant RPM and/or increasing EGT. During start, engines may accelerate to idle slowly but action should not be taken if RPM is increasing and EGT is not near or rapidly approaching the limit.

Note: When electrical power is restored, do not confuse the establishment of APU generator power with airplane engine generator power at idle RPM and advance the thrust lever prematurely.

Engine Fire On the Ground

Stop the airplane. Initiate recall items and refer to the QRH non-normal checklist for Engine Fire or Severe Damage.

In windy conditions, consider positioning the airplane so the fire is on the downwind side. After the airplane is completely stopped, consider passenger evacuation.

Engine Severe Damage Accompanied by High Vibration

Certain engine failures, such as fan blade separation can cause high levels of airframe vibration. Although the airframe vibration may seem severe to the flight crew, it is extremely unlikely that the vibration will damage the airplane structure or critical systems. However, the vibration should be reduced as soon as possible by reducing airspeed and descending. As altitude and airspeed change, the airplane may transition through various levels of vibration. In general, vibration levels decrease as airspeed decreases; however, at a given altitude vibration may temporarily increase or decrease as airspeed changes.

If vibration remains unacceptable, descending to a lower altitude (terrain permitting) allows a lower airspeed and thus lower vibration levels. Vibration will likely become imperceptible as airspeed is further reduced during approach.

The impact of a vibrating environment on human performance is dependent on a number of factors, including the orientation of the vibration relative to the body. People working in a vibrating environment may find relief by leaning forward or backwards, standing, or otherwise changing their body position.

Once airframe vibration has been reduced to acceptable levels, the crew must evaluate the situation and determine a new course of action based on weather, fuel remaining, and available airports.



Recommended Technique for an In-Flight Engine Shutdown

Any time an engine shutdown is required in flight, good crew coordination is essential. Airplane incidents have turned into airplane accidents as a result of a crew shutting down an incorrect engine.

When the flight path is under complete control, the crew should proceed with a deliberate, systematic process that identifies the correct engine and ensures that the incorrect engine is not shut down. Do not rush through the shutdown procedure, even for a fire indication.

Reference QRH Checklist Introduction Section, for Engine Shutdown Precautions.

Evacuation

If the evacuation is planned and time permits, a thorough briefing and preparation of the crew and passengers will increase the chances of a successful evacuation. Flight deck preparations should include a review of pertinent checklists and any other actions to be accomplished. Appropriate use of autobrakes should be discussed. If evacuating due to fire in windy conditions, consider positioning the airplane so the fire is on the downwind side.

Notify cabin crew of possible adverse conditions at affected exits. The availability of various exits may differ for each situation. Crewmembers must make the decision as to which exits are usable for the prevailing circumstances.

For unplanned evacuations, the captain needs to analyze the situation carefully before initiating an evacuation order. Quick actions in a calm and methodical manner will improve the chances for a successful passenger evacuation.

Method of Evacuation

When there is a need to evacuate passengers and crew, the Captain has to choose between commanding an emergency evacuation using the emergency escape slides or less urgent means such as deplaning using stairs, jetways, or other means. All available sources of information should be used to determine the safest course of action including reports from the cabin crew, other aircraft, and air traffic control. The captain must then determine the best means of passenger evacuation by carefully considering all factors. These include, but are not limited to:

- the urgency of the situation including the possibility of significant injury or loss of life if a significant delay occurs
- the type of threat to the airplane, to include structural damage, fire, reported bomb on board, etc.
- the possibility of fire spreading rapidly from spilled fuel or other flammable materials
- the extent of damage to the airplane
- the possibility of passenger injury during an emergency evacuation using the escape slides.

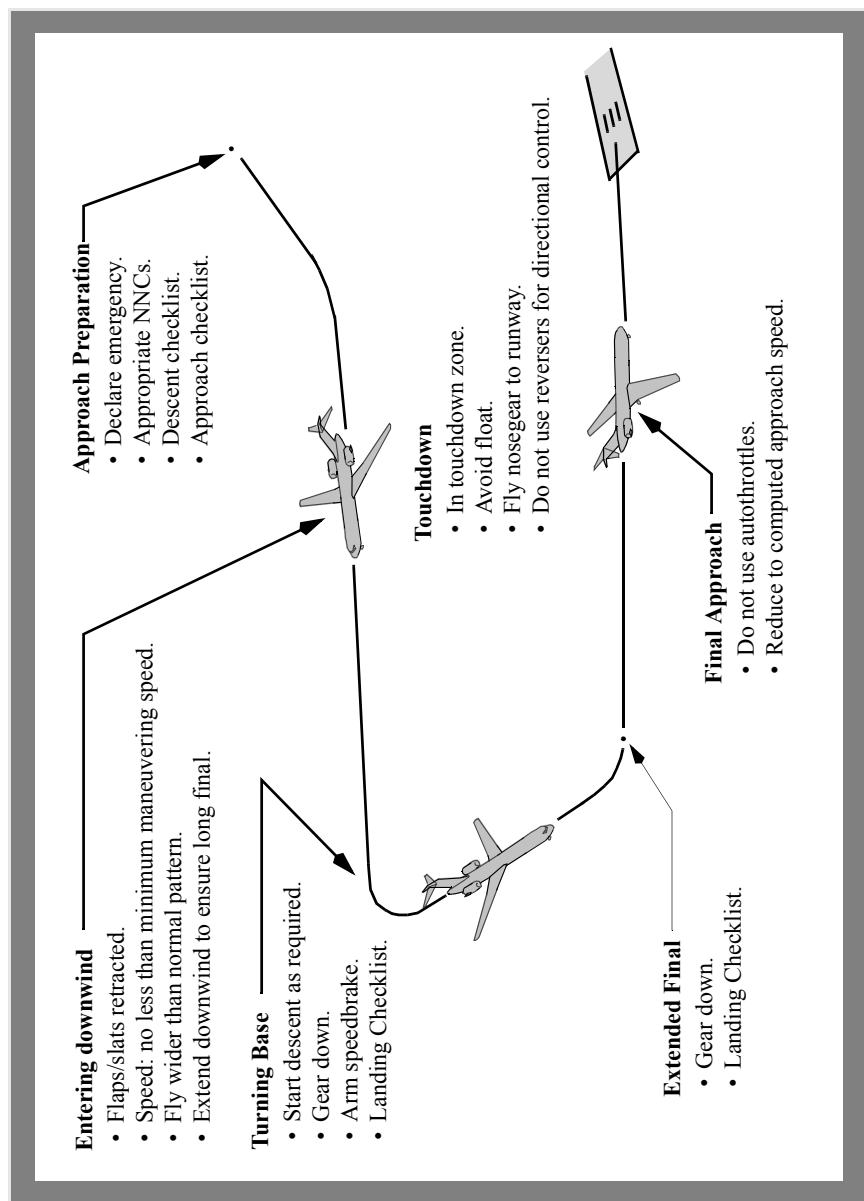
If in doubt about these factors, the crew should consider an emergency evacuation using the escape slides.



Intentionally
Blank

Flight Controls

No Flap / No Slat Approach Profile





Leading Edge or Trailing Edge Device Malfunctions

Leading edge or trailing edge device malfunctions can occur during extension or retraction. This section discusses all flaps up and partial or asymmetrical leading/trailing edge device malfunctions for landings.

No Flap/No Slat Landing

The probability of both leading and trailing edge devices failing to extend is remote. If a flaps up landing situation were to be encountered in service, the pilot should consider the following techniques. Training to this condition should be limited to the flight simulator.

Consider the following when accomplishing a No Flap/No Slat approach and landing:

- Declare an emergency.
- Determine appropriate NON-NORMAL procedure:
 - NO FLAP/NO SLAT LANDING (WITH HYDRAULIC PRESSURE) Ref. QRH, Chapter NNC, Section 9, Flight Controls.
 - LOSS OF BOTH HYDRAULIC SYSTEMS/LANDING WITH NO HYDRAULIC PRESSURE. Ref. QRH, Chapter NNC, Section 13, Hydraulics.
- Plan approach to allow time to accomplish appropriate procedure, fuel permitting.
- Determine whether or not you will be able to exit runway.
- Plan for a 10-15 mile final to allow time to extend the landing gear, complete required checklists, and stabilize at calculated final approach airspeed.

Final Approach

Use an ILS glidepath if available. Do not reduce the airspeed to the final approach speed until aligned with the final approach.

Disconnect autothrottles. Autothrottles will not allow aircraft to slow to final approach speed. Prior to intercepting descent profile, decrease airspeed to final approach speed and maintain this speed until landing is assured.

The rate of descent on final is approximately 900 fpm due to the higher ground speed. Final approach body angle is 4° to 5° ANU for a 2.5 degree gradient. Do not fly less than 2.5 degree glidepath (shallow glidepath angle) or aim for the threshold of the runway.

Plan touchdown at the 1,000 foot point.

Engines will be at low idle speed due to no flap extension. When engines are near idle RPM, time required for engines to accelerate is longer than normal.

Landing

Fly the airplane onto the runway for a positive touchdown to avoid float. Normal landing flare may cause airplane to balloon. Floating just above the runway surface to deplete additional speed wastes available runway and increases the possibility of a tail strike. Do not risk touchdown beyond the normal touchdown zone in an effort to achieve a smooth landing. If landing is anticipated beyond the normal touchdown zone, go around.

Slight forward pressure on the control column may be required to achieve touchdown at the desired point and to lower the nosewheel to the runway. After lowering the nosewheel to the runway, hold forward control column pressure and expeditiously accomplish the landing roll procedure.

Use normal reverse thrust procedures (reverse thrust is more effective at high speeds). Autobrakes are inoperative. Smoothly apply manual brakes to full pedal deflection. Be alert for excessive brake temperatures after landing.

Asymmetrical or No Slat - Landing

If a slat asymmetry/no slat malfunction occurs, the adjusted VREF provides 15° bank angle maneuvering capability.

Do not hold the airplane off during landing flare. Floating just above the runway surface to deplete the additional threshold speed wastes available runway and increases the possibility of a tail strike.

Note: If the gear is retracted during a go-around and flaps are extended beyond approximately 26°, a landing gear configuration warning horn sounds.

Asymmetrical Trailing Edge Flaps - Landing

If flaps fail to extend or retract to selected position, consider burning off fuel to reduce landing weight and lower approach speed. Check actual landing distance in the ODM abnormal section.

Fly accurate airspeeds in the landing pattern. At lesser flap settings excess airspeed is difficult to dissipate, especially when descending on final approach. Pitch attitude and rate of descent on final is higher than for a normal landing. During flare, airspeed does not bleed off as rapidly as normal.

Fly the airplane onto the runway at the recommended touchdown point. Flare only enough to achieve acceptable reduction in the rate of descent. Do not allow the airplane to float. Floating just above the runway surface to deplete additional speed wastes available runway and increases the possibility of a tail strike. Do not risk touchdown beyond the normal touchdown zone in an effort to achieve a smooth landing. Autobrakes are inoperative if flaps are less than 26°.

Note: If the gear is retracted during a go-around and flaps are extended beyond approximately 26°, a landing gear configuration warning horn sounds.



Jammed or Restricted Flight Controls

Although rare, jamming of the flight control system has occurred on commercial airplanes. A jammed flight control can result from ice accumulation due to water leaks onto cables or components, dirt accumulation, component failure such as cable break or worn parts, improper lubrication, or foreign objects.

A flight control jam may be difficult to recognize, especially in a properly trimmed airplane. A jam in the pitch axis may be more difficult to recognize than a jam in other axes. In the case of the elevator, the jammed control can be masked by trim. Some indications of a jam are:

- unexplained autopilot disconnect
- autopilot that will not engage
- undershoot or overshoot of an altitude during autopilot leveloff
- higher than normal control forces required during speed or configuration changes

If any jammed flight control condition exists, both pilots should apply force to try to either clear the jam or activate the override feature. There should be no concern about damaging the flight control mechanism by applying too much force to either clear a jammed flight control or activate an override feature. Maximum force may result in some flight control surface movement with a jammed flight control. If the jam clears, both pilot's flight controls are available.

Note: If a control is jammed due to ice accumulation, the jam may clear when moving to a warmer temperature.

Some flight controls are linked together through override features. If the jam does not clear, activation of an override feature allows a flight control surface to be moved independently of the jammed control. Applying force to the non-jammed flight control activates the override feature. When enough force is supplied, the jammed control is overridden allowing the non-jammed control to operate. To identify the non-jammed flight control, apply force to each flight control individually. The flight control that results in the greatest aircraft control is the non-jammed control.

The non-jammed control will require a normal force, plus an additional override force to move the flight control surface. For example, if a force of 10 lbs (4 kg) is normally required to move the surface, and 50 lbs (23 kg) of force is required to activate the override, a total force of 60 lbs (27 kg) is required to move the control surface while in override. Response will be slower than normal with a jammed flight control; however, sufficient response is available for aircraft control and landing.

For those controls without override features, limited flight control surface deflection occurs when considerable force is applied to the flight control. This response is due to cable stretch and structural bending. This response may be sufficient for aircraft control and landing.

Trim Inputs

If a jammed flight control condition exists, use manual inputs from other control surfaces to counter pressures and maintain a neutral flight control condition. The following table provides trim inputs that may be used to counter jammed flight control conditions.

Jammed Control Surface	Manual Trim Inputs
Elevator	Stabilizer
Aileron	Rudder*
Rudder	Aileron*
*Asymmetric engine thrust may aid roll and directional control.	

Approach and Landing

Attempt to select a runway with minimum crosswind. Complete approach preparations early. Recheck flight control surface operation prior to landing to determine if the malfunction still exists. Do not make abrupt thrust, speedbrake, or configuration changes. Make small bank angle changes. On final approach, do not reduce thrust to idle until after touchdown. Asymmetrical braking and asymmetrical thrust reverser deployment may aid directional control on the runway.

Note: In the event of an elevator jam, control forces will be significantly greater than normal and control response will be slower than normal to flare the airplane.

Go Around Procedure

If the elevator is known or suspected to be jammed, a go-around should be avoided if at all possible. To execute a go-around with a jammed elevator, smoothly advance throttles while maintaining pitch control with stabilizer and any available elevator. If a go-around is required, the go-around procedure is handled in the same manner as a normal go-around.



Inoperative Stabilizer

A stabilizer may jam as a result of dirt or ice on the jackscrew or due to mechanical failure. Regardless of the stabilizer position, the pilot still has sufficient elevator control to land the airplane. However, elevator authority is limited. The QRH specifies an adjusted approach speed and landing configuration that ensures adequate elevator control is available for the remainder of the flight. Use normal piloting techniques for landing.

Runaway Stabilizer

Hold control column firmly to maintain desired pitch attitude. If uncommanded trim motion continues, the stabilizer trim commands are interrupted when the control wheel trim switches are displaced in the opposite direction of runaway. Accomplish the RUNAWAY STABILIZER NNC. Avoid manual pitch inputs until autopilot is disconnected.

Flight Instruments, Displays

Airspeed Unreliable

Unreliable airspeed indications can result from blocking or freezing of the pitot/static system or a severely damaged or missing radome. When the ram air inlet to the pitot head is blocked, pressure in the probe is released through the drain holes and the airspeed slowly drops to zero. If the ram air inlet and the probe drain holes are both blocked, trapped pressure within the system reacts unpredictably. The pressure may increase through expansion, decrease through contraction, or remain constant. In each case, the airspeed indications would be abnormal. This could mean increasing indicated airspeed in climb, decreasing indicated speeds in descent, or unpredictable indicated speeds in cruise.

If the flight crew is aware of the problem, flight without the benefit of valid airspeed information can be safely conducted and should present little difficulty. Early recognition of erroneous airspeed indications require familiarity with the interrelationship of attitude, thrust setting, and airspeed. A delay in recognition could result in loss of aircraft control.

The flight crew should be familiar with the approximate pitch attitude for each flight maneuver. For example, climb performance is based on maintaining a particular airspeed or Mach number. This results in a specific body attitude that varies slightly with gross weight and altitude. Any significant change from this body attitude required to maintain a desired airspeed should alert the flight crew to a potential problem.

When the abnormal airspeed is recognized, immediately return the airplane to the target attitude and thrust setting for the flight regime. If continued flight without valid airspeed indications is necessary, consult the Operation Without Airspeed Indication table in the abnormal section of the ODM for the correct attitude, thrust settings, and V/S for actual airplane gross weight and altitude.

Ground speed information is available from the FMC and on the instrument displays. These indications can be used as a cross check. Many air traffic control radars can also measure ground speed.

Descent

Idle thrust descents can be made to 10,000 feet by flying body attitude and checking rate of descent from the ODM tables. At 2,000 feet above the selected level off altitude, reduce rate of descent to 1,000 FPM. On reaching selected altitude, establish attitude and thrust for the airplane configuration. If possible, allow the airplane to stabilize before changing configuration and altitude.

**MD-88/90 Flight Crew Training Manual**

Approach

If available, accomplish an ILS approach. Establish landing configuration early on final approach. At glideslope intercept or beginning of descent, set thrust and attitude per tables and control the rate of descent with thrust.

Landing

Control the final approach so as to touch down approximately 1,000 feet to 1,500 feet beyond the threshold. Fly the airplane on to the runway, do not hold it off or let it “float” to touchdown.

Use autobraking if available. If manual braking is used, maintain adequate brake pedal pressure until a safe stop is assured. Immediately after touchdown, expeditiously accomplish the landing roll procedure.

Fuel

Fuel Balance

The primary purpose for fuel balance limitations/alerts on Boeing airplanes is for structural life of the airframe and not due to controllability limitations. A reduction in structural life of the airframe or landing gear can be caused by frequently operating with out-of-limit fuel balance conditions. Lateral control is not significantly affected when operating with fuel beyond normal balance limits.

There is a common misconception among flight crews that the fuel crossfeed valve should be opened immediately after an in-flight engine shutdown to prevent fuel imbalance. This practice is contrary to Boeing recommended procedures and could aggravate a fuel imbalance. This practice is especially significant if an engine failure occurs and a fuel leak is present. Arbitrarily opening the crossfeed valve and starting fuel balancing procedures without following the checklist can result in pumping usable fuel overboard.

The misconception may be further reinforced during simulator training. The fuel pumps in simulators are modeled with equal output pressure on all pumps so opening the crossfeed valve appears to maintain a fuel balance. However, the fuel pumps in the airplane have allowable variations in output pressure. If there is a sufficient difference in pump output pressures and the crossfeed valve is opened, fuel feeds to the operating engine from the fuel tank with the highest pump output pressure. This may result in fuel coming unexpectedly from the tank with the lowest quantity.

Fuel Leak

Any time an unexpected fuel quantity indication, FMC or OAP fuel message, or imbalance condition is experienced, a fuel leak should be considered as a possible cause. Maintaining a fuel log and comparing it to the flight plan can help the pilot recognize a fuel leak.

Significant fuel leaks, although fairly rare, are difficult to detect. There is no specific fuel leak annunciation on the flight deck. A leak must be detected by discrepancies in the fuel log, by visual confirmation, or by some annunciation that can occur because of a leak. Any unexpected change in fuel quantity or fuel balance should alert the crew to the possibility of a leak. If a leak is suspected, it is imperative to follow the Non-Normal checklist.

Low Fuel

An OAP FUEL LEVEL LOW message illuminates when indicated fuel quantity is 2,500 pounds of fuel or less in either main tank. For modified aircraft, this message illuminates at 2,000 pounds of fuel or less in either main tank.

**MD-88/90 Flight Crew Training Manual**

Approach and Landing

With a low fuel quantity, the clean configuration should be maintained as long as possible during the descent and approach to conserve fuel. However, initiate configuration change early enough to provide a smooth, slow deceleration to final approach speed to prevent fuel running forward in the tanks.

A normal landing configuration and appropriate airspeed for the wind conditions are recommended.

Runway conditions permitting, heavy braking and high levels of reverse thrust should be avoided to prevent uncovering all fuel pumps and possible engine flameout during landing roll.

Go-Around

If a go-around is necessary, apply thrust slowly and smoothly and maintain the minimum nose-up body attitude required for a safe climb gradient. If any wing tank fuel pump low pressure message illuminates, do not turn off fuel pump switches.

Hydraulics

Proper planning of the approach is important. Consideration should be given to the effect the inoperative system(s) has on crosswind capabilities, autoflight, configuration changes, reverse thrust, stopping distance, directional control/taxi, go-around configuration and performance required to reach an alternate airfield.

Hydraulic System(s) Inoperative - Landing

If the landing gear is extended using the alternate gear extension, the gear cannot be raised. Flaps can be extended or retracted using a single hydraulic system. However, the rate of flap/slat travel is reduced.

Landing Gear

Landing on a Flat Tire

Boeing airplanes are designed so that the landing gear and remaining tire(s) have adequate strength to accommodate a flat nose gear tire or main gear tire. When the pilot is aware of a flat tire prior to landing, use normal landing techniques, avoid landing overweight and use the center of the runway.

In the case of a flat nose wheel tire, slowly and gently lower the nose wheel to the runway while braking lightly. Runway length permitting, use idle reverse thrust. Autobrakes may be used at the lower settings. Once the nose gear is down, vibration levels may be affected by increasing or decreasing control column back pressure. Maintain nose gear contact with the runway. Use differential braking as required to help with directional control.

Flat main gear tire(s) cause a general loss of braking effectiveness and a yawing moment toward the flat tire with light or no braking and a yawing moment away from the flat tire if the brakes are applied harder. Maximum use of reverse thrust is recommended. Do not use autobrakes.

If uncertain whether a nose tire or main tire has failed, slowly and gently lower the nose wheel to the runway and do not use autobrakes. Differential braking may be required to help steer the airplane. Use idle or higher reverse thrust as required to stop the airplane.

Partial or Gear Up Landing

General

In all cases, reduce weight as much as possible by burning off fuel to provide the slowest possible touchdown speed. Less damage occurs if the airplane is kept on a paved landing area.



Landing Runway

Consideration should be given to landing at the most suitable airport with adequate runway and fire fighting capability. Foaming the runway is not a Delta procedure.

Prior to Approach

At the captain's command, advise the crew and the passengers of the situation, as necessary. Coordinate with all ground emergency facilities. For example, the fire trucks normally operate on a common VHF frequency with the airplane and can advise the crew of airplane condition during the landing. Advise cabin crew to perform emergency landing procedures and to brief passengers on evacuation procedures.

Landing Techniques

Plan a normal approach, extending maximum flaps with a normal landing and a normal rate of descent. Use the normal speeds plus estimated headwind component and gust factor corrections. Attempt to keep the airplane on the runway to help passenger evacuation and minimize damage.

Both Main Gear Extended (Nose Gear Up)

Establish approach speed early and maintain normal rate of descent. After touchdown at the normal 1,000 foot point, manually extend the spoilers if necessary. Use idle reverse thrust with caution. Actuate trim control to nose up to assist in holding nose off runway. Hold nose off until approximately 80 KIAS then lower the nose gently before losing elevator effectiveness. Upon nose contact, use maximum braking (within limits of directional control) to stop aircraft.

Nose Gear Only Extended

Establish a normal approach with maximum flaps (for configuration). Land in the center of the runway. Use normal approach and flare attitude maintaining back pressure on the control column until ground contact. Do not use spoilers during landing.

All Gear Up or Partially Extended

Use a normal approach and flare attitude.

One Main Gear Only Extended

Consideration should be given to selecting the widest runway available for landing due to the possibility of severe directional control difficulties.

Land the airplane on the side of the runway that corresponds to the extended main gear down. Do not arm the spoilers. This gives maximum lateral control. At touchdown maintain wings level as long as possible. Use rudder and nose wheel steering to keep airplane rolling straight.



One Main Gear Extended and Nose Gear Extended

Fly a normal approach and flare profile. The landing gear absorbs the initial shock . Do not use spoilers during landing. At touchdown, use rudder and nose wheel steering for directional control. Braking on the side opposite the unsupported wing should be used as required to keep the airplane rolling straight. Maintain the wings level as long as possible.

After Stop

Accomplish passenger evacuation, if required.



Overspeed

V_{mo}/M_{mo} is a maximum operating speed limit on the airplane and should not be exceeded. However, momentary exceedance sometimes occurs due to atmospheric effects and airplane anomalies. If encountered, smoothly reduce thrust and, if required, adjust attitude to reduce airspeed to less than V_{mo}/M_{mo}. This can be accomplished using the autoflight system or manual flight.

Airplanes have been flight tested beyond V_{mo}/M_{mo} to ensure smooth pilot inputs will return the airplane safely to the normal flight envelope. Anytime V_{mo}/M_{mo} is exceeded, the maximum airspeed should be noted in the flight log.

Tail Strike

Tail strike occurs when the lower aft fuselage contacts the runway during takeoff or landing. A significant factor that appears to be common is the lack of flight crew experience in the model being flown. Understanding the factors that contribute to a tail strike can reduce the possibility of a tail strike occurrence.

Takeoff Risk Factors

Any one of the following takeoff risk factors may precede a tail strike:

Mistrimmed Stabilizer

This usually results from using erroneous takeoff data, e.g., the wrong weights, or an incorrect center of gravity (CG). In addition, sometimes accurate information is entered incorrectly either in the flight management system (FMS) or set incorrectly on the stabilizer.

Rotation at Improper Speed

This situation can result in a tail strike and is usually caused by early rotation due to some unusual situation, or rotation at too low an airspeed for the weight and/or flap setting.

Improper Use of the Flight Director

The flight director provides accurate pitch guidance only after the airplane is airborne. However, an aggressive rotation into the pitch bar at takeoff is not appropriate and can cause a tail strike.

Landing Risk Factors

A tail strike on landing tends to cause more serious damage than the same event during takeoff and is usually more expensive and time consuming to repair. In the worst case, the tail can strike the runway before the landing gear, thus absorbing large amounts of energy for which it is not designed.

Any one of the following landing risk factors may precede a tail strike:

Unstabilized Approach

An unstabilized approach is the biggest single cause of tail strike. Flight crews should stabilize all approach variables in accordance with the Stabilized Approach Requirements criteria located in Operations Manual Volume 1, Normal Procedures, Flight Patterns section. Under normal conditions, if the airplane descends through 1,000 feet AGL (IMC), or 500 feet AGL (VMC), with these approach variables not stabilized, a go-around should be considered.

Flight recorder data show that flight crews who continue with an unstabilized condition below 500 feet seldom stabilize the approach. When the airplane arrives in the flare, it often has either excessive or insufficient airspeed. The result is a tendency toward large power and pitch corrections in the flare, often culminating in a vigorous pitch change at touchdown resulting in tail strike shortly thereafter. If the pitch is increased rapidly when touchdown occurs as ground spoilers deploy, the spoilers add additional nose up pitch force, reducing pitch authority, which increases the possibility of tail strike. Conversely, if the airplane is slow, increasing the pitch attitude in the flare does not effectively reduce the sink rate; and in some cases, may increase it.

A firm touchdown on the main gear is often preferable to a soft touchdown with the nose rising rapidly. In this case, the momentary addition of power may aid in preventing the tail strike. In addition, unstabilized approaches can result in landing long or a runway over run.

Holding Off in the Flare

The second most common cause of a landing tail strike is an extended flare, with a loss in airspeed that results in a rapid loss of altitude, (a dropped-in touchdown). This condition is often precipitated by a desire to achieve an extremely smooth/soft landing. A very smooth/soft touchdown is not essential, nor even desired, particularly if the runway is wet.

Trimming in the Flare

Trimming the stabilizer in the flare may contribute to a tail strike. The pilot flying may easily lose the feel of the elevator while the trim is running. Too much trim can raise the nose, even when this reaction is not desired. The pitch up can cause a balloon, followed either by dropping in or pitching over and landing in a three-point attitude. Flight crews should trim the airplane during the approach, but not in the flare.

Mishandling of Crosswinds

When the airplane is placed in a forward slip attitude to compensate for the wind effects, this cross-control maneuver reduces lift, increases drag, and may increase the rate of descent. If the airplane then descends into a turbulent surface layer, particularly if the wind is shifting toward the tail, the stage is set for tail strike.

**MD-88/90 Flight Crew Training Manual**

The combined effects of high closure rate, shifting winds with the potential for a quartering tail wind, can result in a sudden drop in wind velocity commonly found below 100 feet. Combining this with turbulence can make the timing of the flare very difficult. The pilot flying can best handle the situation by using additional thrust, if required, and by using an appropriate pitch change to keep the descent rate stable until initiation of the flare. Flight crews should clearly understand the criteria for initiating a go-around and plan to use this time-honored avoidance maneuver when needed.

Over-Rotation during Go-Around

Go-arounds initiated very late in the approach, such as during the landing flare or after touching down, are a common cause of tail strikes. When the go-around mode is initiated, the flight director immediately commands a go-around pitch attitude. If the pilot flying abruptly rotates up to the pitch command bar, a tail strike can occur before the airplane responds and begins climbing. During a go-around, an increase in thrust as well as a positive pitch attitude is needed. If the thrust increase is not adequate for the increased pitch attitude, the resulting speed decay will likely result in a tail strike. Another contributing factor in tail strikes may be a strong desire by the flight crew to avoid landing gear contact after initiating a late go-around when the airplane is still over the runway. In general, this concern is not warranted because a brief landing gear touchdown during a late go-around is acceptable. This had been demonstrated during autoland and go-around certification programs.

Brake Overheat

Prompt execution of the BRAKE OVERHEAT non-normal checklist following a BRAKE OVHT light is important for timely gear extension. Landing gear speed limitations should be observed during this procedure.

Max extend speed = 300 KIAS/0.70 Mach

Max retract speed = 250 KIAS.

If brake temperature is above 305 (MD-88) or 540 (MD-90), or BRAKE OVHT light remains illuminated, the brakes and tires require maintenance inspection before the next flight. If brake temperature exceeds gauge limits, loss of braking may occur.

Windows

Window Damage

If both forward windows delaminate or forward vision is unsatisfactory, accomplish an autoland, if the ILS facility is satisfactory.

Flight with the Side Window(s) Open

The inadvertent opening of an unlatched flight deck window by air loads during the takeoff roll is not considered an event that warrants a high speed RTO. Although the resulting noise levels may interfere with crew communications, the crew should consider continuing the takeoff and close the window after becoming airborne and the flight path is under control.

If required, the windows may be opened in-flight, at or below holding speeds, after depressurizing the airplane. It is recommended that the airplane be slowed since the noise levels increase at higher airspeed. Intentions should be briefed and ATC notified prior to opening the window as the noise level is high, even at slow speeds. Because of airplane design, there is an area of relatively calm air over the open window. Forward visibility can be maintained by looking out of the open window using care to stay clear of the airstream.



Situations Beyond the Scope of Non-Normal Checklists

It is rare to encounter in-flight events which are beyond the scope of the Delta recommended non-normal checklists. These events can arise as a result of unusual occurrences such as a midair collision, bomb explosion or other major malfunction. In these situations the flight crew may be required to accomplish multiple non-normal checklists, selected elements of several different checklists applied as necessary to fit the situation, or be faced with little or no specific guidance except their own judgement and experience. Because of the highly infrequent nature of these occurrences, it is not practical or possible to create definitive flight crew checklists to cover all events.

The following guidelines may aid the flight crew in determining the proper course of action should an in-flight event of this type be encountered. Although these guidelines represent what might be called “conventional wisdom”, circumstances determine the course of action which the crew perceives will conclude the flight in the safest manner.

Basic Aerodynamics and Systems Knowledge

Knowledge of basic aerodynamic principles and airplane handling characteristics and a comprehensive understanding of airplane systems can be key factors in situations of this type.

Basic aerodynamic principles are known and understood by all pilots. Although not a complete and comprehensive list, following are a brief review of some basic aerodynamic principles and airplane systems information relevant to such situations:

- if aileron control is affected, rudder inputs can assist in countering unwanted roll tendencies. The reverse is also true if rudder control is affected
- if both aileron and rudder control are affected, the use of asymmetrical engine thrust may aid roll and directional control

- if elevator control is affected, stabilizer trim, bank angle and thrust can be used to control pitch attitude. To do this effectively, engine thrust and airspeed must be coordinated with stabilizer trim inputs. The airplane continues to pitch up if thrust is increased and positive corrective action is not taken by re-trimming the stabilizer. Flight crews should be aware of the airplane's natural tendency to oscillate in the pitch axis if the stable pitch attitude is upset. These oscillations are normally self damping in Boeing airplanes, but to ensure proper control, it may be desirable to use thrust and/or stabilizer trim to hasten damping and return to a stable condition. The airplane exhibits a pitch up when thrust is increased and a pitch down when thrust is decreased when operating in any flight control mode other than normal. Use caution when attempting to dampen pitch oscillations by use of engine thrust so that applications of thrust are timed correctly, and diverging pitch oscillations do not develop
- a flight control break-out feature is designed into all Boeing airplanes. If a jammed flight control exists, both pilots can apply force to either clear the jam or activate the break-out feature. There should be no concern about damaging the mechanism by applying too much force. In certain cases, clearing the jam may permit one of the control columns to operate the flight controls with portions of a control axis jammed. It may be necessary to apply break-out forces for the remainder of the flight on the affected control axis
- stall margin decreases with angle of bank and increasing load factors. Therefore, it is prudent to limit bank angle to 15 degrees in the event maneuvering capability is in question. Increasing the normal flap/speed maneuvering schedule while staying within flap placard limits provides extra stall margin where greater bank angles are necessary
- all Boeing airplanes have the capability to land using any flap position, including flaps up. Use proper maneuvering and final approach speeds and ensure adequate runway is available to stop the airplane after landing.

Flight Path Control

When encountering an event of the type described above, the flight crew's first consideration should be to maintain or regain full control of the airplane and establish an acceptable flight path. This may require use of unusual techniques such as the application of full aileron or rudder or in an asymmetrical thrust situation, reduction of power on the operating engine(s) to regain lateral control. This may also require trading altitude for airspeed or vice versa. The objective is to take whatever action is necessary to control the airplane and maintain a safe flight path. Even in a worst case condition where it is not possible to keep the airplane flying and ground contact is imminent, a "controlled crash" is a far better alternative than uncontrolled flight into terrain.

**MD-88/90 Flight Crew Training Manual**

If the operation of flaps is in doubt, leading and trailing edge flap position should not be changed unless it appears that airplane performance immediately requires such action. Consideration should be given to the possible effects of an asymmetrical flap condition on airplane control, if flap position is changed. If no flap damage exists, wing flaps should be operated as directed in the associated non-normal checklist. Anytime an increasing rolling moment is experienced during flap transition, return the flap handle to the previous position.

Recall Checklists

After flight path control has been established, accomplish the recall steps of appropriate non-normal checklists. The emphasis at this point should be on containment of the problem. Execution of non-normal checklist actions commences when the airplane flight path and configuration are properly established.

Accomplish all applicable non-normal checklists prior to commencing final approach. Exercise common sense and caution when accomplishing multiple checklists with differing direction. The intended course of action should be consistent with the damage assessment and handling evaluation.

Communications

Establish flight deck communications as soon as possible. This may require use of the flight deck interphone system or, in extreme cases of high noise levels, hand signals and gestures in order to communicate effectively.

Declare an emergency with Air Traffic Control (ATC) to assure priority handling and emergency services upon landing. Formulate an initial plan of action and inform ATC. If possible, request a discrete radio frequency to minimize distractions and frequency changes. If unable to establish radio communication with ATC, squawk 7700 and proceed as circumstances dictate.

Communications with the cabin crew and with company ground stations are important, but should be accomplished as time permits. If an immediate landing is required, inform the cabin crew as soon as possible.

Damage Assessment and Airplane Handling Evaluation

Unless circumstances such as imminent airplane breakup or loss of control dictate otherwise, the crew should take time to assess the effects of the damage and/or conditions before attempting to land. Use caution when reducing air speed to lower flaps. Make configuration and airspeed changes slowly until a damage and controllability assessment has been accomplished. If possible, conduct this assessment and handling evaluation at an altitude that provides a safe margin for recovery should flight path control be inadvertently compromised. It is necessary for the flight crew to use good judgement in consideration of the existing conditions and circumstances to determine an appropriate altitude for this evaluation.

The assessment should start with an examination of flight deck indications to assess damage. Consideration should be given to the potential cumulative effect of the damage. A thorough understanding of airplane systems operation can greatly facilitate this task.

If structural damage is suspected, attempt to assess the magnitude of the damage by direct visual observation from the flight deck and/or passenger cabin. While only a small portion of the airplane is visible to the flight crew from the flight deck, any visual observation data could be used to gain maximum knowledge of airplane configuration and status and could be valuable in determining subsequent actions.

The flight crew should consider contacting the company to both inform them of the situation and as a potential source of useful information. In addition to current and forecast weather, and airfield conditions, it may be possible to obtain technical information and recommendations from expert sources.

If controllability is in question, consider performing a check of the airplane handling characteristics. The purpose of this check is to determine minimum safe speeds and appropriate configuration for landing. Limit bank to 15 degrees and avoid rapid thrust and airspeed changes which might adversely affect controllability. If flap damage has occurred, prior to accomplishing this check, consider the possible effects on airplane control should an asymmetrical condition occur if flap position is changed. Accomplish this check by slowly and methodically reducing speed and lowering the flaps; lower the gear only if available thrust permits.

As a starting point, use the flap/speed schedule as directed in the appropriate non-normal checklist. If stick shaker or initial stall buffet are encountered at or before reaching the associated flap speed, or if a rapid increase in wheel deflection and full rudder deflection are necessary to maintain wings level, increase speed to a safe level and consider this speed to be the minimum approach speed for the established configuration.

**MD-88/90 Flight Crew Training Manual**

If airplane performance is a concern, use of the alternate flap or gear extension systems may dictate that the configuration portion of this check be accomplished in conjunction with the actual approach. Configuration changes made by the alternate systems is not reversible. The crew must exercise extreme caution on final approach with special emphasis on minimum safe speeds and proper airplane configuration.

After the damage assessment and handling characteristics are evaluated, the crew should formulate a sequential plan for the completion of the flight.

Approach and Landing

The following items should be considered when selecting an airport for landing:

- weather conditions (VMC preferred)
- enroute time
- length of runway available (longest possible runway preferred, wind permitting)
- emergency services available
- flight crew familiarity
- other factors dictated by the specific situation.

Plan an extended straight-in approach with time allotted for the completion of any lengthy non-normal checklists such as the use of alternate flap or landing gear extension systems. Arm autobrakes and autospoilers unless precluded by the checklist.

If possible fly a normal approach profile, and attempt to land in the normal touchdown zone. If asymmetrical thrust is being used for roll control or pitch authority is limited, maintain thrust on until touchdown. After landing, use available deceleration measures to bring the airplane to a complete stop on the runway. Circumstances dictate the requirement for an airplane evacuation or if the airplane can be taxied off the runway.

Intentionally
Blank

Index

10,000' Level Off	3.6
A	
Acceleration to and Deceleration from VMO	5.1
Adverse Runway Conditions	2.28
Advise Crew and Passengers	6.4
After Level Off	5.9
Airport Specific Takeoff and Departure Procedures	2.30
Airplane Performance in Windshear	5.30
Airspeed	5.22
Airspeed Unreliable	6.18
Alternate Trim Technique	1.23
Altimeter	5.21
Approach	1.8, 4.3, 4.11
Approach and Landing on Emergency Power	6.5
Approach Briefing	4.4
Approach Category	4.5
Approach Clearance	4.6
Approach to Stall Recovery	5.15
Antiskid Inoperative	2.6
Assumed Temperature Method (ATM)	2.27
Avoidance, Precautions and Recovery	5.31
Automatic Flight	1.26
Autopilot Engagement	2.35
Autopilot Entry and Level Off	5.8
Autopilot Level Off	3.7
Autospoiler/Autobrake Demonstration	5.13
Autothrottle Use	1.26
B	
Backing with Reverse Thrust	2.2
Basic Aerodynamics and Systems Knowledge	6.29
Bounced Landing Recovery	4.78
Brake Overheat	6.28

▲ DELTA
MD-88/90 Flight Crew Training Manual

C	
Callouts	1.13
Center of Gravity (C.G.) Effects	2.25
Circling Approach.	4.46
Circling Approach - General.	4.47
Circling Approach Profile.	4.46
Circling Approach - One Engine Inoperative	4.51
Circling Approach Profile - One Engine Inoperative	4.50
Cold Temperature Altitude Corrections	1.20
Command Speed	1.8
Communications	6.31
Climb.	3.1
Climb Constraints	3.1
Climb, Cruise and Descent	1.8
Climb Speed Determination	3.2
Climb Thrust	3.1
Crew Resource Management	1.3
Crosswind Landings	4.92
Crosswind Landing Techniques	4.92
Crosswind Takeoff	2.26
Cruise	3.7
Cruise Performance Economy	3.10
Cruise Speed Determination	3.9
D	
Damage Assessment and Airplane Handling Evaluation	6.32
Decision Altitude/Height - DA(H)	4.13
Delta Maneuvers Training.	5.11
Departure Briefing	2.1
Descent	3.17
Descent Constraints.	3.18
Descent Path	3.18
Descent Planing.	3.23
Descent Rates	3.23
Descent Speed Determination.	3.18

▲ DELTA
MD-88/90 Flight Crew Training Manual

Determination of a MAP	4.8
DFGS Autoland Capabilities	4.15
DFGS Procedures	1.26
DFGS System Configuration	4.21
Directional Control	2.26
Directional Control and Braking after Touchdown	4.81
Ditching	6.4
Ditching Final	6.4
Diverting to an Alternate Airport - One Engine Inoperative	6.3
Downwind and Base Leg	4.55
Dual Engine Failure	6.7
During Turn	5.21
Dutch Roll	5.6
E	
Economy Climb	3.3
Economy Climb Schedule - FMC Data Unavailable	3.3
Effect of Deicing/Anti-Icing Fluids on Takeoff	2.29
Effect of Rotation Speed and Pitch Rate on Liftoff	2.25
Electrical	6.5
Engine Failure During	
Thrust Takeoff	2.42
Engine Failure On Final Approach	4.30, 4.59
Engine Failure Recognition	2.38
Engine Failure vs Engine Fire After Takeoff	6.7
Engine Fire On the Ground	6.8
Engine Icing During Climb	3.3
Engine Icing During Descent	3.25
Engine Inoperative Climb	3.4
Engine Inoperative Cruise/Driftdown	3.11
Engine Out Familiarization	5.3
Engines, APU	6.7
Engine Severe Damage Accompanied by High Vibration	6.8
Entry	5.21
Events Requiring Maintenance Inspection	1.2

▲ DELTA
MD-88/90 Flight Crew Training Manual

Evacuation	6.10
Evaluation	1.3
F	
Factors Affecting Landing Distance	4.81
FAR Takeoff	2.30
Fast/Slow Display Use	1.11
Federal Aviation Regulation (FAR) Takeoff Field Length	2.29
Final Approach	4.55
Flap Operation.	1.7
Flap Retraction Schedule	2.35
Flap - Speed Schedule/Maneuvering Speeds	1.5
Flap Usage.	1.5
Flaps and Landing Gear	3.25
Flare and Touchdown	4.75
Flight Control Effectiveness	5.10
Flight Controls	6.12
Flight Deck Perspective	2.4
Flight Instruments, Displays	6.18
Flight Management Computer(s)/MCDUs	1.24
Flight Path Control	6.30
Flight with the Side Window(s) Open.	6.28
FMC Route Verification Techniques.	1.24
Fuel	6.20
Fuel Balance	6.20
Fuel Burn-Off	6.4
Fuel Leak.	6.20
G	
Go/Stop Decision near V1	2.32
Gusty Winds and Strong Crosswind Conditions.	2.27
H	
Headsets/Boom Microphones	1.4
High Altitude High Speed Flight	3.16
High Altitude Maneuvering, “G” Buffet.	5.5

▲ DELTA
MD-88/90 Flight Crew Training Manual

Holding	4.1
Holding Speeds	4.2
Holding Pattern Entry	4.2
Hydraulics	6.22
Hydraulic System(s) Inoperative - Landing	6.22
I	
IAS/MACH	3.19
ICAO and FAA Holding Airspeeds (Maximum)	4.2
ILS Approach	4.10
ILS Approach - General	4.11
ILS Approach/Landing Geometry	4.15
ILS Approach Profile - One Engine Inoperative	4.28
ILS Approach Profile	4.10
ILS Autoland Approach	4.25
ILS Autoland Approach Profile	4.24
Intermediate Level Off	3.6
Immediate Turn after Takeoff - All Engines	2.33
Immediate Turn after Takeoff - One Engine Inoperative	2.42
Improved Climb Performance Takeoff	2.28
Initial Climb - All Engines	2.33
Initial Climb - One Engine Inoperative	2.40
Initiate Evacuation	6.4
Initiating Takeoff Roll	2.21
Inoperative Stabilizer	6.17
Instrument Approach Using V/S (CANPA)	4.40
Instrument Approach Using V/S Profile (CANPA)	4.36
Instrument Approach Using V/S Profile (CANPA) - One Engine Inoperative	4.44
Instrument Approach Using V/S (CANPA) - One Engine Inoperative	4.45
Instrument Approaches	4.3
Instrument Landing System (ILS)	4.8
J	
Jammed or Restricted Flight Controls	6.15

▲ DELTA
MD-88/90 Flight Crew Training Manual

L	
Landing	1.8
Landing at the Nearest Suitable Airport	6.2
Landing Configurations and Speeds	4.66
Landing Flare Profile	4.77
Landing Gear	6.22
Landing Geometry	4.72
Landing Minima	4.7
Landing on a Flat Tire	6.22
Landing on Wet or Slippery Runways	4.84
Landing Risk Factors	6.25
Landing Roll	4.80
Landing Runway Markings (Typical)	4.73
Leading Edge or Trailing Edge Device Malfunctions	6.13
Liftoff Pitch Attitude - One Engine Inoperative	2.39
Limit Speeds	1.6
Localizer	4.8
Loss of Engine Thrust Control	6.7
Low Altitude Level Off Without VNAV	3.1
Low Fuel	6.20
Low Speed at Altitude	3.16
Low Visibility Approaches	4.20
Low Visibility Takeoff	2.28
M	
Mach Buffet	5.5
Mach Trim Compensator (MTC), Mach Buffet, Dutch Roll Demonstrations	5.6
Mach Tuck	5.5
Mandatory Missed Approach	4.7
Maneuver Margin	4.66
Maneuvers Training	5.10
Manual (Descent)	3.21
Manual Entry and Level Off	5.9
Manual Flight	1.26

▲ DELTA
MD-88/90 Flight Crew Training Manual

Maximum Altitude	3.7
Maximum Angle Climb	3.3
Maximum Rate Climb	3.3
Methods of Descending	3.17
Method of Evacuation	6.10
Minimum Fuel Operation - Takeoff	2.33
Missed Approach - Circling	4.52
Missed Approach/Go-Around	4.60
Missed Approach/Go-Around Profile - All Approaches	4.60
Missed Approach/Go-Around - General	4.61
Missed Approach/Go-Around Profile - One Engine Inoperative	4.64
Missed Approach/Go-Around - One Engine Inoperative	4.65
Engine Failure During Missed Approach/Go-Around	4.65
Missed Approach Points (MAP)	4.8
N	
Navigation Display (ND) Settings for Non-ILS Approaches	4.38
No Flap/No Slat Approach Profile	6.12
Noise Abatement	2.20
Noise Abatement - One Engine Inoperative	2.42
Non-ILS Instrument Approaches	4.31
Non-ILS Instrument Approaches - General	4.31
Non-Normal Conditions	1.9
Non-Normal Landing Configurations and Speeds	4.66
Non-Normal Landing Distance	4.66
Non-Normal Operations (ILS)	4.29
Non-Normal Situation Guidelines	6.1
Nosewheel/Rudder Pedal Steering	2.6
O	
Obstruction Clearance	4.48
Operation in Icing Conditions	1.21
Operational Philosophy	1.1
Optimum Altitude	3.8
Other Non-ILS Approaches	4.8
Overspeed	6.25

▲ DELTA
MD-88/90 Flight Crew Training Manual

Overweight Autolands Policy	4.94
Overweight Landing	4.94
P	
Partial or Gear Up Landing	6.22
Passenger Cabin Preparation (Ditching)	6.4
PAPI Landing Geometry	4.70
Pilot Area of Responsibility	1.2
Pitch and Roll Limit Conditions	4.79
Pitch Modes	2.34
Precautions (Windshear)	5.31
Precision Approach Path Indicator (PAPI)	4.70
Primary Trim Technique	1.22
Procedure Turn	4.6
Procedure Turn and Initial Approach	4.11
Pushback	2.2
Q	
Qualification Requirements (Checkride)	1.3
R	
Radio Altimeter (RA)	4.7
Rapid Descent	5.7
Raw Data - (No Flight Director)	4.14
Recall Checklists	6.31
Recommended Callouts from 100 Feet	4.74
Recommended Rudder Trim Technique	1.22
Recommended Technique for an In-Flight Engine Shutdown	6.9
Recovery from a Fully Developed Stall	5.19
Reduced Thrust Climb	3.1
Reduced Thrust Takeoff	2.27
Rejected Landing	4.78
Rejected Takeoff Decision	2.31
Rejected Takeoff Maneuver	2.31
Resolution Advisory (RA)	5.24
Reverse Thrust Operation	4.88
Roll Modes	2.34

▲ DELTA
MD-88/90 Flight Crew Training Manual

Rollout	5.22
Rotation and Liftoff - All Engines	2.24
Rotation and Takeoff	2.26
Rotation - One Engine Inoperative	2.38
RTO Execution	2.33
Rudder and Lateral Control	5.3
Runaway Stabilizer	6.17
S	
Send Distress Signals	6.4
Situations Beyond the Scope of Non-Normal Checklists	6.29
Slippery Runway Landing Performance	4.82
Special Takeoff Profile	2.19
Speedbrakes	3.24
Speed Intervention	3.19
Speed Restrictions	3.25
Spoilers	4.80
Stabilized Approach Requirements	4.6
Stall Recovery	5.15
Standard Callouts	1.13
Standard Descent Profile (Non VNAV)	3.20
Standard Phraseology	1.14
Steep Turns	5.21
Step Climb	3.9
T	
Tail Strike	6.25
Takeoff	1.8, 2.18
Takeoff Crosswind Guidelines	2.26
Takeoff - Engine Failure	2.37
Takeoff Engine Failure - General	2.38
Takeoff General	2.20
Takeoff Profile	2.18
Takeoff Profile - Engine Failure	2.37
Takeoff Risk Factors	6.25
Taxi	2.3

▲ DELTA
MD-88/90 Flight Crew Training Manual

Taxi - Adverse Weather	2.16
Taxi - General	2.3
Taxi - One Engine	2.17
Taxi Speed and Braking	2.5
Terrain Avoidance	5.23
Three Bar VASI/T-VASI	4.67
Threshold Height	4.74
Throttle Technique	3.26
Thrust	4.55
Thrust and Airspeed	5.4
Thrust Management	2.21
Thrust Use	2.4
Timing During Approaches	4.8
Traffic Advisory (TA)	5.23
Traffic Alert and Collision Avoidance System (TCAS)	5.23
Training Objectives	1.2
Transition to Climb	3.2
Turbulent Air Penetration	1.28
Turns of 180 Degrees	2.12
Turning Radius and Gear Tracking	2.7
U	
Unusual Attitude Recovery Procedures	5.25
Upset Recovery	5.25
Upset Recovery Techniques	5.29
Use of TA/RA, TA Only Modes	5.23
Use of Vertical Speed	4.37
V	
VASI Landing Geometry	4.68
Vertical Speed	3.20
Vertical Speed Indicator	5.21
Visual Cues and Techniques for Turning while Taxiing	2.9
Visual Aim Point	4.72
Visual Approach - General	4.55
Visual Approach Slope Indicator (VASI/T - VASI)	4.67

▲ DELTA
MD-88/90 Flight Crew Training Manual

Visual Traffic Patterns	4.54
Visual Traffic Pattern Profile	4.54
Visual Traffic Pattern Profile - One Engine Inoperative	4.58
VNAV	3.18
W	
Weather Radar and Terrain Display Policy	1.25
Wheel Brakes	4.85
Window Damage	6.28
Windows	6.28
Windshear	5.30

Intentionally
Blank