MD-11

AIRPLANE CHARACTERISTICS
FOR AIRPORT PLANNING

OCTOBER 1990

To Whom It May Concern:

This document is intended for airport planning purposes. Specific aircraft performance and operational requirements are established by the airline that will use the airport under consideration.

Questions concerning the use of this document should be address to:

Boeing Commercial Airplanes
P.O. Box 3707
Seattle, Washington 98124-2207
U.S.A.

Attention: Manager, Airport Technology
Mail Code: 20-93
Email: AirportTechnology@boeing.com
Website: www.boeing.com/airports
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<tbody>
<tr>
<td>1.0 SCOPE</td>
<td>1-1</td>
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<tr>
<td>1.1 Purpose</td>
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<tr>
<td>1.2 Introduction</td>
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<tr>
<td>2.0 AIRPLANE DESCRIPTION</td>
<td>2-1</td>
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<tr>
<td>2.1 General Airplane Characteristics</td>
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<tr>
<td>2.2 General Airplane Dimensions</td>
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<tr>
<td>2.3 Ground Clearances</td>
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<td>4-10</td>
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<td>5.0 TERMINAL SERVICING</td>
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<td>5.1 Airplane Servicing Arrangement (Typical)</td>
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<td>5.2 Terminal Operations, Turnaround</td>
<td>5-4</td>
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<td>5.7 Preconditioned Airflow Requirements</td>
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<td>6.0 OPERATING CONDITIONS</td>
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<td>6.1 Jet Engine Exhaust Velocities and Temperatures</td>
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<td>6.2 Airport and Community Noise</td>
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## CONTENTS (CONTINUED)

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1.0 SCOPE

1.1 Purpose

1.2 Introduction
1.0 SCOPE

1.1 Purpose

This document provides, in a standardized format, airplane characteristics data for general airport planning. Since operational practices vary among airlines, specific data should be coordinated with the using airlines prior to facility design. Douglas Aircraft Company should be contacted for any additional information required.

Content of this document reflects the results of a coordinated effort by representatives of the following organizations:

- Aerospace Industries Association
- Airports Council International
- Air Transport Association of America
- International Air Transport Association

The airport planner may also want to consider the information presented in the “CTOL Transport Aircraft: Characteristics, Trends, and Growth Projections,” available from the US AIA, 1250 Eye St., Washington DC 20005, for long range planning needs. This document is updated periodically and represents the coordinated efforts of the following organizations regarding future aircraft growth trends:

- International Coordinating Council of Aerospace Industries Association
- Airports Council International
- Air Transport Association of America
- International Air Transport Association
1.2 Introduction

This document conforms to NAS 3601. It provides MD-11 characteristics for airport operators, airlines, and engineering consultant organizations. Since airplane changes and available options may alter the information, the data presented herein must be regarded as subject to change.

For further information contact:

Boeing Commercial Airplanes
P.O. Box 3707
Seattle, Washington 98124-2207
U.S.A.

Attention: Manager, Airport Technology
Mail Code: 20-93
Email: AirportTechnology@boeing.com
Website: www.boeing.com/airports
2.0 AIRPLANE DESCRIPTION

2.1 General Airplane Characteristics
2.2 General Airplane Dimensions
2.3 Ground Clearances
2.4 Interior Arrangements
2.5 Cabin Cross Section
2.6 Lower Compartment
2.7 Door Clearances
2.0 AIRPLANE DESCRIPTION

2.1 General Airplane Characteristics — MD-11

Maximum Design Taxi Weight (MTW). Maximum weight for ground maneuvering as limited by aircraft strength (MTOW plus taxi fuel).

Maximum Design Landing Weight (MLW). Maximum weight for landing as limited by aircraft strength and airworthiness requirements.

Maximum Design Takeoff Weight (MTOW). Maximum weight for takeoff as limited by aircraft strength and airworthiness requirements. (This is the maximum weight at the start of the takeoff run.)

Operating Empty Weight (OEW). Weight of structure, power plant, furnishing, systems, unusable fuel and other unusable propulsion agents, and other items of equipment that are considered part of a particular airplane configuration. OEW also includes certain standard items, personnel, equipment, and supplies necessary for full operations, excluding usable fuel and payload.

Maximum Design Zero Fuel Weight (MZFW). Maximum weight allowed before usable fuel and other specified usable agents must be loaded in defined sections of the aircraft as limited by strength and airworthiness requirements.

Maximum Payload. Maximum design zero fuel weight minus operational empty weight.

Maximum Seating Capacity. The maximum number of passengers certified or anticipated for certification.

Maximum Cargo Volume. The maximum space available for cargo.

Usable Fuel. Fuel available for aircraft propulsion.
## 2.0 AIRPLANE DESCRIPTION

### 2.1 GENERAL AIRPLANE CHARACTERISTICS

Model MD-11 GE Engine

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* OPTIONAL MTW: 608,500 LB (276,016 kg)
** OPTIONAL MLW (FREIGHTER ONLY): 491,500 LB (222,944 kg)
## 2.0 AIRPLANE DESCRIPTION

### 2.1 GENERAL AIRPLANE CHARACTERISTICS

MODEL MD-11 P&W ENGINE

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<td>323</td>
<td>214</td>
<td>21,530</td>
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<td>MAX</td>
<td>410</td>
<td>410</td>
<td>290</td>
<td>21,288</td>
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<td>5,288</td>
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<td>41,615</td>
<td>38,615</td>
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<td>157,529</td>
<td>146,173</td>
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<td>258,721</td>
<td>278,821</td>
<td>258,721</td>
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<tr>
<td>kg</td>
<td>117,356</td>
<td>126,470</td>
<td>117,356</td>
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<td></td>
</tr>
</tbody>
</table>

* OPTIONAL MTW: 608,500 LB (276,016 kg) 613,000 LB (278,057 kg) 621,000 LB (281,866 kg) 628,000 LB (284,861 kg) 633,000 LB (287,122 kg)
2.2 GENERAL AIRPLANE DIMENSIONS
MODEL MD-11

REV E
Maximum and minimum clearances of individual locations are given for combinations of airplane loading/unloading activities that produce the greatest variation at each location. Zero roll angle and level ground were assumed for analysis.

It is recommended that approximately ±3 inches (0.1 m) be allowed for vertical excursions due to varying strut and tire inflations, pavement unevenness, etc.

### Vertical Clearance

<table>
<thead>
<tr>
<th></th>
<th>Min Clearance Critical WT and CG</th>
<th>Max Clearance Critical WT and CG</th>
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<tr>
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<td>FT - IN.</td>
<td>METERS</td>
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<tr>
<td>A</td>
<td>28 – 7</td>
<td>8.71</td>
</tr>
<tr>
<td>B</td>
<td>27 – 1</td>
<td>8.27</td>
</tr>
<tr>
<td>C</td>
<td>15 – 9</td>
<td>4.81</td>
</tr>
<tr>
<td>D</td>
<td>7 – 4</td>
<td>2.23</td>
</tr>
<tr>
<td>E</td>
<td>15 – 8</td>
<td>4.78</td>
</tr>
<tr>
<td>F</td>
<td>9 – 2</td>
<td>2.80</td>
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<tr>
<td>G</td>
<td>15 – 7</td>
<td>4.75</td>
</tr>
<tr>
<td>H</td>
<td>8 – 10</td>
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<td>J</td>
<td>15 – 4</td>
<td>4.67</td>
</tr>
<tr>
<td>K</td>
<td>29 – 5</td>
<td>8.97</td>
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<tr>
<td>L</td>
<td>57 – 6</td>
<td>17.53</td>
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<tr>
<td>M</td>
<td>7 – 10</td>
<td>2.38</td>
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<tr>
<td>N *</td>
<td>3 – 2</td>
<td>0.96</td>
</tr>
<tr>
<td>O</td>
<td>9 – 8</td>
<td>2.93</td>
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<td>10 – 8</td>
<td>3.25</td>
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<td>3.77</td>
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<td>23 – 4</td>
<td>7.11</td>
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<tr>
<td>T</td>
<td>32 – 7</td>
<td>9.93</td>
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<td>U</td>
<td>37 – 3</td>
<td>11.35</td>
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<td>3.12</td>
</tr>
<tr>
<td>X</td>
<td>15 – 5</td>
<td>4.70</td>
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* = GE CF6–80C2 D1F
H = STANDARD CENTER CARGO DOOR
I = COMBI CENTER CARGO DOOR
J = COMBI MAINDECK DOOR
K = FREIGHTER

### 2.3 Ground Clearances

_Model MD-11_
323 SEATS, 34 FIRST CLASS — 6 ABREAST, 289 COACH — 9 ABREAST

2.4 INTERIOR ARRANGEMENTS
2.4.1 PASSENGERS – MIXED-CLASS SEATING
MODEL MD-11
2–7

2.4.2 PASSENGERS – ECONOMY SEATING
MODEL MD-11

379 SEATS — 9 ABREAST
410 SEATS — 10 ABREAST

2.4.3 PASSENGERS – HIGH-DENSITY SEATING
MODEL MD-11
214 SEATS, 34 FIRST CLASS — 6 ABREAST, 180 COACH — 9 ABREAST

MODEL MD-11 COMBI

GALLEY
CABINET
ATTENDANT SEAT
LA VATORY
CARGO DOOR
160 BY 102 IN.
(406 BY 259 cm)

GALLEY
ATTENDANT SEAT
ATTENDANT SEAT
ATTENDANT SEAT
ATTENDANT SEAT
CARGO DOOR
160 BY 102 IN.
(406 BY 259 cm)

2R ENTRY DOOR
42 BY 76 IN.
(106.7 BY 193.0 cm)

3R ENTRY DOOR
42 BY 76 IN.
(106.7 BY 193.0 cm)

3L ENTRY DOOR
42 BY 76 IN.
(106.7 BY 193.0 cm)

4R ENTRY DOOR
42 BY 76 IN.
(106.7 BY 193.0 cm)

4L ENTRY DOOR
42 BY 76 IN.
(106.7 BY 193.0 cm)

DEACTIVATED

214 SEATS, 34 FIRST CLASS — 6 ABREAST, 180 COACH — 9 ABREAST
2.4.6 PASSENGERS – HIGH-DENSITY SEATING
MODEL MD-11 COMBI

290 SEATS — 10 ABREAST
2.5 CABIN CROSS SECTION
2.5.1 FIRST CLASS
MODEL MD-11

REV E
2.5.2 BUSINESS CLASS
MODEL MD-11

REV E
2.5.4 HIGH-DENSITY
MODEL MD-11
2.5.5 CROSS SECTION – CARGO
MODEL MD-11F/CF

FREIGHTER
(26) 88- BY 125-IN. PALLETS = 14,542 FT³ (411.8 m³)
(26) 96- BY 125-IN. PALLETS = 15,514 FT³ (439.3 m³)
CF
(26) 88- BY 125-IN. PALLETS = 13,521 FT³ (382.9 m³)
(26) 96- BY 125-IN. PALLETS = 14,508 FT³ (410.8 m³)

MAIN CARGO LOADED COMPARTMENT
LENGTH = 144 FT 4 IN. (44.0 m)
FLAT FLOOR AREA = 2,614.5 FT² (242.9 m²)
BULK VOLUME = 22,048 FT³ * (624.3 m³)

* BULK VOLUME IS WATER VOLUME OF CABIN BETWEEN BARRIER NET AND AFT BULKHEAD

TYPICAL CARGO SECTION

97.5-IN. (247.7 cm)
STACK HEIGHT
FREIGHTER

88 BY 108 IN. (223.5 BY 274.3 cm)

88 BY 125 IN. (223.5 BY 317.5 cm)

96 BY 125 IN. (243.8 BY 317.5 cm)

LD5
LD7
LD9
LD11
LD21

LD3
LD6

BARRIER NET

DOOR

102-IN. (259.1 cm)

64 IN. (162.6 cm)
### 2.6 LOWER COMPARTMENT

#### 2.6.1 CARGO COMPARTMENTS – CONTAINERS

**MODEL MD-11**

<table>
<thead>
<tr>
<th>Container Type</th>
<th>GROSS Weight</th>
<th>TARE Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD3 Container</td>
<td>7,000 LB EACH (3,175.2 kg)</td>
<td>600 LB EACH (272.2 kg)</td>
</tr>
<tr>
<td>LD6 Container</td>
<td>3,500 LB EACH (1,587.6 kg)</td>
<td>320 LB EACH (145.2 kg)</td>
</tr>
</tbody>
</table>

**GROSS WEIGHT**
- 32 LD3 CONTAINERS: 5,056 FT³ (143.17 m³)
- 16 FULL WIDTH CONTAINERS: 5,120 FT³ (144.98 m³)
- BULK CARGO: 510 FT³ (14.44 m³)

**TARE WEIGHT**
- TOTAL: 5,566 FT³ (157.61 m³)

**Dimensions**
- **LD3 CONTAINER**
  - 160 IN. (406.4 cm)
  - 60.4 IN. (153.4 cm)
  - 44 IN. (111.76 cm)
  - 64 IN. (162.56 cm)
  - 79.0 IN. (200.7 cm)
  - 61.5 IN. (156.2 cm)

- **LD6 CONTAINER**
  - 104- BY 66-IN. (264.2 BY 167.6 cm)
  - CARGO DOOR RIGHT SIDE ONLY
  - 18 CONTAINERS

- **70- BY 66-IN. (177.8 BY 167.6 cm)
  - CARGO DOOR RIGHT SIDE ONLY
  - 14 CONTAINERS

- **BULK CARGO**
  - BULK CARGO DOOR
  - LEFT SIDE ONLY
  - 30 BY 36 IN. (76.2 BY 91.4 cm)

- **32 HALF WIDTH CONTAINERS**
  - EACH 158 FT³ (4.47 m³)
  - TOTAL: 5,056 FT³ (143.17 m³)

**REV E**

---

2-17
2.6.2 CARGO COMPARTMENTS – CONTAINERS/PALLETS

MODEL MD-11

GROSS WEIGHT
10,300 LB EACH (4,672.1 kg)

TARE WEIGHT
248 LB EACH (112.5 kg)

GROSS WEIGHT
3,500 LB EACH (1,587.6 kg)

TARE WEIGHT
320 LB EACH (145.2 kg)

14 HALF WIDTH CONTAINERS; (LD3)
EACH 158 FT³ (4.47 m³)
TOTAL 2,212 FT³ (62.58 m³)

LD3 CONTAINER
79.0 IN. (200.7 cm)
64 IN. (162.56 cm)
61.5 IN. (156.2 cm)
88 IN. (223.5 cm)
125 IN. (317.5 cm)

88 BY 125-IN. PALLETS (223.5 BY 317.5 cm)
OR

6–96 BY 125 PALLETS
2,667 FT³ (75.52 m³)
OR

6–88 BY 125 PALLETS
14 LD3 CONTAINERS
2,268 FT³ (64.20 m³)
BULK CARGO
510 FT³ (14.44 m³)
TOTAL 4,990 FT³ (141.22 m³)

BULK CARGO DOOR
LEFT SIDE ONLY
30 BY 36 IN. (76.2 BY 91.4 cm)

CARGO DOOR RIGHT SIDE ONLY
6 PALLETS
70– BY 66-IN. (177.8 BY 167.6 cm)
OPTIONAL 104– BY 66-IN. (264.2 BY 167.6 cm)
CARGO DOOR RIGHT SIDE ONLY
14 CONTAINERS

6–96 BY 125-IN. PALLETS
EACH 444 FT³ (12.57 m³)
TOTAL 2,664 FT³ (75.41 m³)

OR

6–88 x 125 PALLETS
EACH 378 FT³ (10.70 m³)
TOTAL 2,268 FT³ (64.2 m³)

CONTAINERS CENTER COMPARTMENT

PALLETs FWD COMPARTMENT

60.4 IN. (153.4 cm)
64 IN. (162.56 cm)
79.0 IN. (200.7 cm)
88 IN. (223.5 cm)
125 IN. (317.5 cm)

6–88 BY 125 IN. (264.2 BY 167.6 cm)
CARGO DOOR RIGHT SIDE ONLY

104– BY 66-IN. (264.2 BY 167.6 cm)
CARGO DOOR RIGHT SIDE ONLY

14 CONTAINERS

6–96 BY 125 PALLETS
2,667 FT³ (75.52 m³)
6–88 BY 125 PALLETS
2,268 FT³ (64.20 m³)
14 LD3 CONTAINERS
2,212 FT³ (62.58 m³)
BULK CARGO
510 FT³ (14.44 m³)
TOTAL 4,990 FT³ (141.22 m³)
2.7 DOOR CLEARANCES

2.7.1 CLEARANCES, PASSENGER LOADING DOORS, DOOR NO. 1
MODEL MD-11

REV E
2.7.1 CLEARANCES, PASSENGER LOADING DOORS, DOOR NO. 2
MODEL MD-11
2.7.1 CLEARANCES, PASSENGER LOADING DOORS, DOOR NO. 3
MODEL MD-11

2–21
2.7.1 CLEARANCES, PASSENGER LOADING DOORS, DOOR NO. 4
MODEL MD-11
2.7.2 CARGO LOADING DOORS – MAIN DECK
MODEL MD-11F/CF

SEE SEC. 2.3 FOR HEIGHT ABOVE GROUND

165 DEG POSITION
FULL OPEN

85 DEG POSITION

CONSTANT SECTION
DIA = 237 IN.
(602 cm)

97.5-IN. (248 cm) STACK HEIGHT FREIGHTER
92.0-IN. (234 cm) STACK HEIGHT CONVERTIBLE FREIGHTER

102-IN. (259 cm) DOOR

SECTION A-A
LOOKING AFT

DMC005–82

REV D

2–23
2.7.2 CARGO LOADING DOORS – MAINDECK
MODEL MD-11 COMBI

SEE SECTION 2.3 FOR HEIGHT ABOVE GROUND

SECTION A-A
LOOKING FORWARD

REV E
2.7.3 CARGO LOADING DOORS, LOWER DECK
FORWARD DOOR
MODEL MD-11

REVISION D

DMC005-94
2.7.3 CARGO LOADING DOORS, LOWER DECK
CENTER CARGO DOOR
MODEL MD-11

PLAN VIEW

AIRPLANE NOSE

144 FT 0 IN.
(43.9 m)

SECTION A-A
LOOKING FORWARD

DOOR ACTUATOR PANEL
SWITCH AND CONTROLS

WING FILLET

198.6 IN.
(504 cm)

158 DEG FULL OPEN

126.1 IN.
(320 cm)

60 IN. (152 cm)

113.2 IN.
(288 cm)

19.7 IN. (50 cm)
CRITICAL CLEARANCE LIMIT

SECTION A-A
LOOKING FORWARD

ELEVATION

SEE SECTION 2.3 FOR
GROUND CLEARANCE

19.7 IN. (50 cm)

44 IN. (112 cm)

70 IN.
(178 cm)

15.9 IN.
(40 cm)

66 IN.
(168 cm)

70 IN.
(178 cm)

60 IN. (152 cm)

175 DEG FULL OPEN

SECTION A-A
LOOKING FORWARD

CONSTANT SECTION DIA
= 237 IN. (602 cm)

144 FT 0 IN.
(43.9 m)

SEE SECTION 2.3 FOR
GROUND CLEARANCE

WING FILLET
2.7.3 CARGO LOADING DOORS, LOWER DECK
CENTER CARGO DOOR (OPTIONAL FOR OTHER MODELS)
MODEL MD-11 COMBI

PLAN VIEW

AIRPLANE NOSE

139 FT 7 IN. (42.55 m)

SECTION A-A

SEE SECTION 2.3 FOR GROUND CLEARANCE

ELEVATION

WING FILLET
DOOR ACTUATOR
PANEL SWITCH
AND CONTROL

66 IN. (168 cm)

44 IN. (112 cm)

104 IN. (264 cm)

SECTION A-A
LOOKING FORWARD

116 IN. (295 cm)

158 DEG FULL OPEN

113.2 IN. (288 cm)

19.7 IN. (50 cm)

CRITICAL CLEARANCE LIMIT

FILLET AT FWD DOOR JAMB

198.6 IN. (504 cm)

126.1 IN. (320 cm)

60 IN. (152 cm)
2.7.3 CARGO LOADING DOORS, LOWER DECK
AFT BULK CARGO DOOR
MODEL MD-11

PLAN VIEW

AIRPLANE NOSE

VENT DOOR HANDLE
DOOR CONTROL PANEL

160 FT 6 IN. (48.92 m)

ELEVATION

18 IN. (46 cm)

SEE SECTION 2.3 FOR GROUND CLEARANCE

152 DEG FULL OPEN

CRITICAL CLEARANCE LIMIT

SECTION A-A LOOKING FORWARD

23.8 IN. (60 cm)

70.5 IN. (179 cm)

93.5 IN. (237 cm)

119 IN. (302 cm)

158.3 IN. (402 cm)

77 IN. (196 cm)
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3.0 AIRPLANE PERFORMANCE

3.1 General Information
3.2 Payload-Range
3.3 FAR Takeoff Runway Length Requirements
3.4 FAR Landing Runway Length Requirements
3.0 AIRPLANE PERFORMANCE

3.1 General Information

Figures 3.2.1 through 3.2.8 present payload-range information for a specific Mach number cruise at the fuel reserve condition shown.

Figures 3.3.1 through 3.4.2 represent FAR takeoff and landing field length requirements for FAA certification.

Standard day temperatures for the altitudes shown are tabulated below:

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<th>ELEVATION</th>
<th>STANDARD DAY TEMPERATURE</th>
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<td>0</td>
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<tr>
<td>2,000</td>
<td>610</td>
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<tr>
<td>4,000</td>
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<td>6,000</td>
<td>1,829</td>
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<tr>
<td>8,000</td>
<td>2,438</td>
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</table>

Note: These data are provided for information only and are not to be used for flight planning purposes.

For specific performance data/analysis, contact the using airline or the Airport Technology Group at (425) 237-0126 or:

Boeing Commercial Airplane Group
P.O. Box 3707
Seattle, Washington  98124-2207
USA

Attn:  Manager, Airport Technology
Mail Code 67-KR
3.2 PAYLOAD-RANGE
3.2.1 GE ENGINE
MODEL MD-11 PASSENGER
3.2 PAYLOAD-RANGE
3.2.3 GE ENGINE
MODEL MD-11 COMBI
3.2 PAYLOAD-RANGE
3.2.4 PW ENGINE
MODEL MD-11 COMBI
3.2 PAYLOAD-RANGE
3.2.5 GE ENGINE
MODEL MD-11 CONVERTIBLE FREIGHTER
3.2 PAYLOAD-RANGE
3.2.6 PW ENGINE
MODEL MD-11 CONVERTIBLE FREIGHTER
3.2 PAYLOAD-RANGE
3.2.7 GE ENGINE
MODEL MD-11 FREIGHTER
3.2 PAYLOAD-RANGE
3.2.8 PW ENGINE
MODEL MD-11 FREIGHTER
3.3 FAR TAKEOFF FIELD LENGTH REQUIREMENTS
3.3.1 STANDARD DAY
MODEL MD-11 GE ENGINE
3.3 FAR TAKEOFF FIELD LENGTH REQUIREMENTS
3.3.2 STANDARD DAY + 27F (15C)
MODEL MD-11 GE ENGINE
3.3 FAR TAKEOFF FIELD LENGTH REQUIREMENTS
3.3.3 STANDARD DAY + 36F (20C)
MODEL MD-11 GE ENGINE
3.3 FAR TAKEOFF FIELD LENGTH REQUIREMENTS
3.3.4 STANDARD DAY
MODEL MD-11 PW ENGINE
3.3 FAR TAKEOFF FIELD LENGTH REQUIREMENTS
3.3.5 STANDARD DAY + 27F (15C)
MODEL MD-11 PW ENGINE
3.3 FAR TAKEOFF FIELD LENGTH REQUIREMENTS
3.3.6 STANDARD DAY + 36F (20C)
MODEL MD-11 PW ENGINE
3.4 FAR LANDING RUNWAY LENGTH REQUIREMENTS
3.4.1 FLAPS 35 DEGREES
MODEL MD-11

NOTES:
- STANDARD DAY
- ZERO RUNWAY GRADIENT
- $V_{REF} = 1.3 V_S$
- NO REVERSE THRUST

AIRPORT ALTITUDE (FT)
10,000
8,000
6,000
4,000
2,000
SEA LEVEL

FAR RUNWAY LENGTH (1,000 ft)
5
6
7
8
9
10
11
12
13

Landing Weight (1,000 lb)
280
320
360
400
440
480
520

WET RUNWAY
DRY RUNWAY

Landing Weight (1,000 kg)
120
130
140
150
160
170
180
190
200
210
220

REV D
3.4 FAR LANDING RUNWAY LENGTH REQUIREMENTS
3.4.2 FLAPS 50 DEGREES
MODEL MD-11
4.0 GROUND MANEUVERING

4.1 General Information
4.2 Turning Radii, No Slip Angle
4.3 Minimum Turning Radii
4.4 Visibility from Cockpit
4.5 Runway and Taxiway Turn Paths
4.6 Runway Holding Bay (Apron)
4.0 GROUND MANEUVERING

4.1 General Information

This section provides airplane turning capability and maneuvering characteristics.

For ease of presentation, these data have been determined from the theoretical limits imposed by the geometry of the aircraft, and where noted, provide for a normal allowance for tire slippage. As such, they reflect the turning capability of the aircraft in favorable operating circumstances. The data should only be used as guidelines for determining such parameters and to obtain the maneuvering characteristics of this aircraft type.

In the ground operating mode, varying airline practices may demand that more conservative turning procedures be adopted. Airline operating techniques will vary in level of performance over a wide range of circumstances throughout the world. Variations from standard aircraft operating patterns may be necessary to satisfy physical constraints within the maneuvering area, such as adverse grades, limited space, or high risk of jet blast damage. For these reasons, ground maneuvering requirements should be coordinated with the using airlines prior to layout planning.
4.2 TURNING RADII, NO SLIP ANGLE
MODEL MD-11

NOTE: ACTUAL OPERATING DATA MAY BE GREATER THAN VALUES SHOWN SINCE TIRE SLIPPING IS NOT CONSIDERED IN THESE CALCULATIONS. CONSULT AIRLINE FOR OPERATING PROCEDURES. R3 MEASURED FROM OUTSIDE FACE OF TIRE.

<table>
<thead>
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<th>STEERING ANGLE (DEG)</th>
<th>R–1</th>
<th>R–2</th>
<th>R–3</th>
<th>R–4</th>
<th>R–5</th>
<th>R–6</th>
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<tbody>
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<td></td>
<td>FT</td>
<td>m</td>
<td>FT</td>
<td>m</td>
<td>FT</td>
<td>m</td>
</tr>
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<td>25</td>
<td>153.7</td>
<td>46.8</td>
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<td>128.2</td>
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<td>35.5</td>
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<td>32.9</td>
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<td>77.5</td>
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<td>100.9</td>
<td>30.8</td>
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<td>65</td>
<td>17.3</td>
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<tr>
<td>70 MAXIMUM</td>
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<td>15.3</td>
<td>88.2</td>
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</table>
4.3 MINIMUM TURNING RADII
MODEL MD-11

NORMAL TURNS
SYMMETRICAL THRUST AND NO DIFFERENTIAL BRAKING. SLOW CONTINUOUS TURN. AFT CENTER OF GRAVITY AT MAX RAMP WEIGHT

LIGHTLY BRAKED TURN
UNSYPETICAL THRUST AND LIGHT DIFFERENTIAL BRAKING. SLOW CONTINUOUS TURN. AFT CENTER OF GRAVITY AT MAX RAMP WEIGHT

MINIMUM RECOMMENDED RADIUS TO AVOID EXCESSIVE TIRE WEAR. LIMITED BY 8-DEG MAIN GEAR TIRE SCRUB

<table>
<thead>
<tr>
<th>TYPE TURN</th>
<th>EFFECTIVE TURN ANGLE</th>
<th>TIRE SLIP ANGLE</th>
<th>X FT/m</th>
<th>Y FT/m</th>
<th>A FT/m</th>
<th>R3 FT/m</th>
<th>R4 FT/m</th>
<th>R5 FT/m</th>
<th>R6 FT/m</th>
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<tr>
<td>2</td>
<td>72.0 DEG</td>
<td>-2.0 DEG</td>
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<td>-</td>
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<td>81.2</td>
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<td>93.1</td>
<td>133.4</td>
<td>116.9</td>
<td>109.8</td>
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</table>

4-3
4.4 VISIBILITY FROM COCKPIT IN STATIC POSITION

MODEL MD-11

NOT TO BE USED FOR LANDING APPROACH VISIBILITY

PILOT’S EYE POSITION

36 DEG
20 FT 8 IN. (6.3 m)

20 DEG

20 FT 11 IN. (6.4 m)
27 FT 10 IN. (8.5 m)

50 FT 4 IN. (15.3 m)

6 FT 11 IN. (2.1 m) (REF)

135 DEG
MAXIMUM AFT VISION WITH HEAD ROTATED ABOUT SPINAL COLUMN

PILOT’S EYE POSITION

40 DEG
21 IN. (53.3 cm)

31 DEG

31 DEG

45 DEG

40 DEG

45 DEG

WITH HEAD MOVED 14 IN. OUTBOARD (35.6 cm)

DMC005-42
4.5 RUNWAY AND TAXIWAY TURN PATHS
4.5.1 MORE THAN 90-DEG TURN – RUNWAY TO TAXIWAY
MANEUVERING METHOD – COCKPIT OVER CENTERLINE
MODEL MD-11

NOTE: THE MINIMUM MAIN GEAR TIRE-TO-TAXIWAY
PAVEMENT EDGE CLEARANCE SHOWN IS APPROXIMATELY
15 FT (4.57 m)
4.5.2 MORE THAN 90-DEGREE TURN – RUNWAY TO TAXIWAY
MANEUVERING METHOD — JUDGMENTAL OVERSTEERING
MODEL MD–11

NOTE:
1. EFFECTIVE STEERING ANGLE-APPROX 30 DEG
   (33-DEG STEERING, 3-DEG NOSE GEAR SLIP)
2. THE MINIMUM MAIN GEAR TIRE-TO-TAXIWAY
   PAVEMENT EDGE CLEARANCE SHOWN IS APPROXIMATELY
   15 FT (4.57 m)
4.5.3 90-DEGREE TURN – TAXIWAY TO TAXIWAY MANEUVERING METHOD — COCKPIT OVER CENTERLINE
MODEL MD-11
4.5.4 90-DEGREE TURN – TAXIWAY TO TAXIWAY
MANEUVERING METHOD – JUDGMENTAL OVERSTEERING
MODEL MD-II

NOTES:
1. THE INTERSECTION FILLET IS DETERMINED FROM THE GEOMETRY OF THE CRITICAL AIRCRAFT AND THE STEERING PROCEDURE THAT WILL BE USED.
2. 33-DEGREE STEERING ANGLE, 3-DEGREE NOSE GEAR SLIP (30-DEGREE EFFECTIVE STEERING ANGLE)
3. THE MINIMUM MAIN GEAR TIRE-TO-TAXIWAY PAVEMENT EDGE CLEARANCE SHOWN IS APPROXIMATELY 15 FT (4.57 m)
4.5.5 90-DEGREE TURN – RUNWAY TO TAXIWAY
MANEUVERING METHOD – COCKPIT OVER CENTERLINE
MODEL MD–11
4.6 RUNWAY HOLDING BAY (APRON)  
MODEL MD-11

NOTE: THE MINIMUM MAIN GEAR TIRE-TO-PAVEMENT EDGE CLEARANCE SHOWN IS APPROXIMATELY 15 FT (4.57 m)
5.0 TERMINAL SERVICING

5.1 Airplane Servicing Arrangement (Typical)
5.2 Terminal Operations, Turnaround Station
5.3 Terminal Operations, En Route Station
5.4 Ground Service Connections
5.5 Engine Starting Pneumatic Requirements
5.6 Ground Pneumatic Power Requirements
5.7 Preconditioned Airflow Requirements
5.8 Ground Towing Requirements
5.0 TERMINAL SERVICING

5.1 AIRPLANE SERVICING ARRANGEMENT (TYPICAL)

5.1.1 AIRPLANE SERVICING ARRANGEMENT — TYPICAL TURNAROUND
MODEL MD-11

NOTE: THE AIRCRAFT AUXILIARY POWER UNIT SUPPLIES ELECTRICAL, PNEUMATIC AIR, AND PRECONDITIONED AIR.
5.0 TERMINAL SERVICING
5.1.2 AIRPLANE SERVICING ARRANGEMENT — TYPICAL TURNAROUND
MODEL MD-11 COMBI

NOTE: THE AIRCRAFT AUXILIARY POWER UNIT SUPPLIES ELECTRICAL, PNEUMATIC AIR, AND PRECONDITIONED AIR.
5.0 TERMINAL SERVICING
5.1.3 AIRLINE SERVICING ARRANGEMENT – TYPICAL TURNAROUND
MODEL MD-11F/CF

NOTE: THE AIRCRAFT AUXILIARY POWER UNIT SUPPLIES ELECTRICAL,
PNEUMATIC, AND PRECONDITIONED AIR
### 5.2 TERMINAL OPERATIONS, TURNAROUND

#### 5.2.1 TURNAROUND

**MODEL MD-11**

<table>
<thead>
<tr>
<th>DUTIES</th>
<th>MINUTES</th>
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<tr>
<td><strong>ENGINE RUNDOWN</strong></td>
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<tr>
<td><strong>CHECK LOGBOOK</strong></td>
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<tr>
<td><strong>CHECK LOGBOOK</strong></td>
<td>9.0</td>
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<tr>
<td><strong>CHECK LOGBOOK</strong></td>
<td>1.5</td>
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<tr>
<td><strong>ENGINE RUNDOWN</strong></td>
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<tr>
<td><strong>ENGINE RUNDOWN</strong></td>
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<tr>
<td><strong>WALKAROUND INSPECTION</strong></td>
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<tr>
<td><strong>POSITION PASSENGER BRIDGE</strong></td>
<td>5.6</td>
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<tr>
<td><strong>DEPLANE PASSENGERS</strong></td>
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<tr>
<td><strong>SERVICE FORWARD AND MID GALLEY</strong></td>
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<td><strong>SERVICE AFT GALLEY</strong></td>
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<td><strong>POSITION PASSENGER BRIDGE</strong></td>
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<td><strong>DEPLANE PASSENGERS</strong></td>
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<td><strong>SERVICE AFT GALLEY</strong></td>
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<tr>
<td><strong>ENPLANING BRIDGE</strong></td>
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<td><strong>CLEAR FOR DEPARTURE</strong></td>
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<tr>
<td><strong>CLEAR FOR DEPARTURE</strong></td>
<td>51.4</td>
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</tbody>
</table>

**NOTES:**

1. CRITICAL TIME PATH
2. 1,562-GPM REFUELING RATE USING TWO HYDRANT VEHICLES
3. ESTIMATES BASED ON 34 FIRST CLASS AND 289 COACH
4. UPPER GALLEY CLOSED OFF DURING PART OF PASSENGER ENPLANEMENT
5. AFT GALLEY CLOSED OFF DURING PART OF PASSENGER ENPLANEMENT
6. DEPLANING AND ENPLANING THROUGH DOORS NO. 1 AND 2
### 5.3 TERMINAL OPERATIONS, ENROUTE STATION
#### MODEL MD-II

<table>
<thead>
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<td>CABIN SERVICING (2-MAN CREW)</td>
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<td>ENPLANE PASSENGERS</td>
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<td>REMOVE PASSENGER BRIDGE</td>
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<td>LAVATORY SERVICE</td>
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<tr>
<td>POTABLE WATER SERVICE</td>
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</tbody>
</table>

**NOTES:**
1. CRITICAL TIME PATH
2. 55 PERCENT LOAD FACTOR, 17 FIRST CLASS AND 160 COACH
3. DEPLANING THROUGH DOORS NO. 1 AND 2
4. ENPLANING FIRST CLASS PSGRS THROUGH NO. 1 DOOR AND COACH PSGRS THROUGH NO. 2 DOOR
5. 962-GPM REFIUELING RATE USING TWO TRUCKS
6. UPPER GALLEY CONFIGURATION WITH FWD, MD, AND AFT GALLEYS
7. AFT GALLEY CLOSED OFF DURING PART OF PASSENGER ENPLANEMENT
5.4 GROUND SERVICE CONNECTIONS
MODEL MD–11
5.4 GROUND SERVICE CONNECTION DATA

MODEL MD-11

5.4.1 HYDRAULIC SYSTEM
TWO SERVICE CONNECTIONS:
A. SERVICE PANEL CONTAINING PRESSURE AND TEST STAND CONNECTIONS, 3,000 PSI (21 MPa) AT 50 GPM (189 lPM) MAXIMUM
B. RESERVOIR FILL CONNECTIONS, 60 PSI (414 kPA)

5.4.2 ELECTRICAL SYSTEM
TWO SERVICE CONNECTIONS, 90 KV A, EA. 115 VOL T, 400 H Z, 3 PHASE

5.4.3 OXYGEN — INDEPENDENT AIRCREW AND PASSENGER SYSTEMS
AIRCREW OXYGEN SYSTEM
PASSENGER OXYGEN SYSTEM

5.4.4 FUEL SYSTEM
TWO PRESSURE SERVICE POINTS IN EACH WING LEADING EDGE
1,250 GPM (4,731 lPM) THROUGH 2 POINTS — 1,600 GPM (6,056 lPM) THROUGH 4 POINTS AT 50 PSIG (345 kPA)
TOTAL USABLE CAPACITY
38,652 U.S. GALLONS (146,296 l)
6,075 U.S. GALLONS (22,945 l) EACH WING TANK 1 AND 2
9,767.9 U.S. GALLONS (36,968 l) NUMBER 2 TANK
13,001 U.S. GALLONS (49,208 l) CTR WING AUX TANK UP PER
1,643 U.S. GALLONS (6,217 l) UNDER WING AUX TANK LOWER
2,000 U.S. GALLONS (7,570 l) TAIL AUX TANK
RIGHT WING SERVICE RECEPT ACLES
LEFT WING SERVICE RECEPT ACLES
124 – 3 37.87 58 – 4 17.78
FUEL VENT WING LEFT
124 – 3 37.87 58 – 4 17.78
TAIL AUX TANK VENT
179 – 9 54.79 15 – 8 4.78

5.4.5 PNEUMATIC SYSTEM
TWO 3-IN. SERVICE CONNECTIONS FOR ENGINE START AND AIR CONDITIONING

5.4.6 PRECONDITIONED AIR
TWO 8-IN. CONNECTIONS FOR AIR CONDITIONING

5.4.7 POTABLE WATER SYSTEM
ONE SER VICE CONNECTION FOUR-TANK SYSTEM
64 U.S. GALLONS EACH (242 l) — TOTAL SYSTEM CAPACITY 256 GAL (959 LITERS)

5.4.8 LAB A TORY SYSTEM
NUMBER OF TOILETS SER VICE LOCATION
1 (1) FREIGHTER — 1 TOILET FORWARD LOCATION
UP TO 12 49.89
SER VICE CAPACITIES
WASTE HOLDING 260 U.S. GALLONS (984 l)

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<th>DISTANCE FROM AIRPLANE CENTERLINE</th>
<th>HEIGHT ABOVE GROUND</th>
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<td>LEFT SIDE</td>
<td>MINIMUM</td>
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<td>5.4.1 HYDRAULIC SYSTEM</td>
<td>5.4.2 ELECTRICAL SYSTEM</td>
<td>5.4.3 OXYGEN — INDEPENDENT AIRCREW AND PASSENGER SYSTEMS</td>
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</table>

**5.4 GROUND SERVICE CONNECTION DATA**

MODEL MD-11
5.5 ENGINE STARTING PNEUMATIC REQUIREMENTS
MODEL MD-11 GE ENGINE

* THERE IS NO SATISFACTORY DEFINITION FOR "REQUIRED PRESSURE AT GROUND CONNECTOR" SO THAT A SINGLE LINE CAN BE DEPICTED. THE LINE DEPICTED IS FOR A 46-SECOND START TIME, WHICH IS AN ARBITRARY VALUE.
5.5 ENGINE STARTING PNEUMATIC REQUIREMENTS
MODEL MD-11 P&W ENGINE
5.6 GROUND PNEUMATIC POWER REQUIREMENTS
MODEL MD-11

- INITIAL CABIN TEMPERATURE –25°F (–32°C)
- OUTSIDE AIR TEMPERATURE –40°F (–40°C)
- MAX TEMPERATURE AT GROUND CONN 440°F (227°C)
- MIN TEMPERATURE NOT LESS THAN 200°F (93°C)
- ABOVE O.A.T
- DOORS CLOSED

- DULL DAY
- NO CABIN OCCUPANTS OR ELECTRICAL LOAD
- MAX ALLOWABLE SUPPLY PRESSURE 45 PSIG
- BOTH GROUND CONNECTIONS USED
- THREE-PACK OPERATION

- INITIAL CABIN TEMPERATURE 115°F (46°C)
- OUTSIDE AIR TEMPERATURE 103°F (40°C) REL HUM 42%
- MAX TEMPERATURE AT GROUND CONN 440°F (227°C)
- MIN TEMPERATURE NOT LESS THAN 200°F (93°C)
- ABOVE O.A.T
- DOORS CLOSED

- BRIGHT DAY
- NO CABIN OCCUPANTS OR ELECTRICAL LOAD
- MAX ALLOWABLE SUPPLY PRESSURE 45 PSIG
- BOTH GROUND CONNECTIONS USED
- THREE-PACK OPERATION
5.7 PRECONDITIONED AIRFLOW REQUIREMENTS
MODEL MD-11

CONDITIONED AIR GROUND CART REQUIREMENTS USING BOTH CONNECTORS

CONDITIONED AIR GROUND CART REQUIREMENTS USING ONE CONNECTOR

MAXIMUM ALLOWABLE TEMPERATURE
190°F (88°C)

MAXIMUM ALLOWABLE PRESSURE AT GROUND CONNECTION (25 INCHES WATER)
5.8 GROUND TOWING REQUIREMENTS
MODEL MD-11

- UNUSUAL BREAKAWAY CONDITIONS NOT REFLECTED
- ESTIMATED FOR TOW VEHICLES WITH RUBBER TIRES
- COEFFICIENTS OF FRICTION (\(m\)) — APPROXIMATE
6.0 OPERATING CONDITIONS

6.1 Jet Engine Exhaust Velocities and Temperatures

6.2 Airport and Community Noise
6.0 OPERATING CONDITIONS
6.1 JET ENGINE EXHAUST VELOCITIES AND TEMPERATURES
6.1.1 JET ENGINE EXHAUST VELOCITY CONTOURS, IDLE POWER (ESTIMATED)
MODEL MD-11 GE ENGINE

NOTES:
1. ENGINE CF6-80C2
2. THESE CONTOURS ARE TO BE USED AS GUIDELINES ONLY SINCE THE OPERATIONAL ENVIRONMENT VARIES GREATLY — OPERATIONAL SAFETY ASPECTS ARE THE RESPONSIBILITY OF THE USER OR PLANNER
3. ALL VELOCITY VALUES ARE STATUTE MILES PER HOUR
4. CROSSWINDS WILL HAVE CONSIDERABLE EFFECT ON CONTOURS
5. SEA LEVEL STATIC — STANDARD DAY
6. ALL ENGINES AT SAME THRUST

CONVERSION FACTOR
1 MPH = 1.6 km PER HOUR
6.1.1 JET ENGINE EXHAUST VELOCITY CONTOURS, IDLE POWER (ESTIMATED)
MODEL MD-11 P&W ENGINE

NOTES:
1. ENGINE PW4460
2. THESE CONTOURS ARE TO BE USED AS GUIDELINES ONLY SINCE THE OPERATIONAL ENVIRONMENT VARIES GREATLY — OPERATIONAL SAFETY ASPECTS ARE THE RESPONSIBILITY OF THE USER OR PLANNER
3. ALL VELOCITY VALUES ARE STATUTE MILES PER HOUR
4. CROSSWINDS WILL HAVE CONSIDERABLE EFFECT ON CONTOURS
5. SEA LEVEL STATIC — STANDARD DAY
6. ALL ENGINES AT SAME THRUST

CONVERSION FACTOR
1 MPH = 1.6 km PER HOUR
6.1.2 JET ENGINE EXHAUST VELOCITY CONTOURS, BREAKAWAY POWER (ESTIMATED) MODEL MD-11 GE ENGINE
6.1.2 JET ENGINE EXHAUST VELOCITY CONTOURS, BREAKAWAY POWER (ESTIMATED)
MODEL MD-11 P&W ENGINE

NOTES:
1. ENGINE PW4000
2. THESE CONTOURS ARE TO BE USED AS GUIDELINES ONLY SINCE THE
   OPERATIONAL ENVIRONMENT VARIES GREATLY—OPERATIONAL SAFETY
   ASPECTS ARE THE RESPONSIBILITY OF THE USER OR PLANNER
3. ALL VELOCITY VALUES ARE STATUTE MILES PER HOUR
4. CROSSWINDS WILL HAVE CONSIDERABLE EFFECT ON CONTOURS
5. RAMP GRADIENT WILL AFFECT REQUIRED TAXI AND BREAKAWAY THRUST
6. SEA LEVEL STATIC — STANDARD DAY
7. ALL ENGINES AT SAME THRUST
8. 605,500 LB GROSS WEIGHT

CONVERSION FACTOR
1 MPH = 1.6 km PER HOUR
6.1.3 JET ENGINE EXHAUST VELOCITY CONTOURS, TAKEOFF POWER (ESTIMATED)
MODEL MD-11 GE ENGINE

NOTES:
1. ENGINE CF6-80C2D1F
2. THESE CONTOURS ARE TO BE USED AS GUIDELINES ONLY SINCE THE OPERATIONAL ENVIRONMENT VARIES GREATLY — OPERATIONAL SAFETY ASPECTS ARE THE RESPONSIBILITY OF THE USER OR PLANNER.
3. ALL VELOCITY VALUES ARE STATUTE MILES PER HOUR.
4. CROSSWINDS WILL HAVE CONSIDERABLE EFFECT ON CONTOURS
5. SEA LEVEL STATIC — STANDARD DAY
6. ALL ENGINES AT SAME THRUST

CONVERSION FACTOR
1 MPH = 1.6 km PER HOUR
6.1.3 JET ENGINE EXHAUST VELOCITY CONTOURS, TAKEOFF POWER (ESTIMATED)
MODEL MD-11 P&W ENGINE

NOTES:
1. ENGINE PW4460
2. THESE CONTOURS ARE TO BE USED AS GUIDELINES ONLY SINCE THE OPERATIONAL ENVIRONMENT VARIES GREATLY — OPERATIONAL SAFETY ASPECTS ARE THE RESPONSIBILITY OF THE USER OR PLANNER
3. ALL VELOCITY VALUES ARE STATUTE MILES PER HOUR
4. CROSSWINDS WILL HAVE CONSIDERABLE EFFECT ON CONTOURS
5. SEA LEVEL STATIC — STANDARD DAY
6. ALL ENGINES AT SAME THRUST

CONVERSION FACTOR
1 MPH = 1.6 km PER HOUR
6.1.4 Jet Engine Exhaust Temperature (MD-11, All Engine Models)

Jet engine exhaust temperature contour lines have not been presented because the adverse effects of exhaust temperature at any given position behind the aircraft fitted with these high-bypass engines are considerably less than the effects of exhaust velocity.
6.2 Airport and Community Noise

Airport noise is of major concern to the airport and community planner. The airport is a major element of the community’s transportation system and, as such, is vital to its growth. However, the airport must also be a good neighbor, and this can be accomplished only with proper planning. Since aircraft noise extends beyond the boundaries of the airport, it is vital to consider the impact on surrounding communities. Many means have been devised to provide the planner with a tool to estimate the impact of airport operations. Too often they oversimplify noise to the point where the results become erroneous. Noise is not a simple subject; therefore, there are no simple answers.

The cumulative noise contour is an effective tool. However, care must be exercised to ensure that the contours, used correctly, estimate the noise resulting from aircraft operations conducted at an airport.

The size and shape of the single-event contours, which are inputs into the cumulative noise contours, are dependent upon numerous factors. They include:

1. Operational Factors
   
   (a) Aircraft Weight — Aircraft weight is dependent on distance to be traveled, en route winds, payload, and anticipated aircraft delay upon reaching the destination.

   (b) Engine Power Settings — The rates of ascent and descent and the noise levels emitted at the source are influenced by the power setting used.

   (c) Airport Altitude — Higher airport altitude will affect engine performance and thus can influence noise.

2. Atmospheric Conditions — Sound Propagation

   (a) Wind — With stronger headwinds, the aircraft can take off and climb more rapidly relative to the ground. Also, winds can influence the distribution of noise in surrounding communities.

   (b) Temperature and Relative Humidity — The absorption of noise in the atmosphere along the transmission path between the aircraft and the ground observer varies with both temperature and relative humidity.

3. Surface Condition — Shielding, Extra Ground Attenuation (EGA)

   Terrain — If the ground slopes down after takeoff or up before landing, noise will be reduced since the aircraft will be at a higher altitude above the ground. Additionally, hills, shrubs, trees, and large buildings can act as sound buffers.
All of these factors can alter the shape and size of the contours appreciably. To demonstrate the effect of some of these factors, estimated noise level contours for two different operating conditions are shown below. These contours reflect a given noise level upon a ground level plane at runway elevation.

As indicated by these data, the contour size varies substantially with operating and atmospheric conditions. Most aircraft operations are, of course, conducted at less than maximum gross weights because average flight distances are much shorter than maximum aircraft range capability and average load factors are less than 100 percent. Therefore, in developing cumulative contours for planning purposes, it is recommended that the airlines serving a particular city be contacted to provide operational information.

In addition, there are no universally accepted methods for developing aircraft noise contours or for relating the acceptability of specific noise zones to specific land uses. It is therefore expected that noise contour data for particular aircraft and the impact assessment methodology will be changing. To ensure that currently available information of this type is used in any planning study, it is recommended that it be obtained directly from the Office of Environmental Quality in the Federal Aviation Administration in Washington, D.C.

It should be noted that the contours are shown here only to illustrate the impact of operating and atmospheric conditions and do not represent the single-event contour of the family of aircraft described in this document. It is expected that the cumulative contours will be developed as required by planners using the data and methodology applicable to their specific study.

REV E
7.0 PAVEMENT DATA

7.1 General Information
7.2 Footprint
7.3 Maximum Pavement Loads
7.4 Landing Gear Loading on Pavement
7.5 Flexible Pavement Requirements
7.6 Flexible Pavement Requirements, LCN Conversion
7.7 Rigid Pavement Requirements
7.8 Rigid Pavement Requirements, LCN Conversion
7.9 ACN-PCN Reporting System; Flexible and Rigid Pavements
7.0 PAVEMENT DATA

7.1 General Information

A brief description of the pavement charts that follow will help in their use for airport planning. Each airplane configuration is shown with a minimum range of four loads imposed on the main landing gear to aid in interpolation between the discrete values shown. All curves are plotted at constant specified tire pressure at the highest certified weight for each model.

Section 7.2 presents basic data on the landing gear footprint configuration, maximum design taxi loads, and tire sizes and pressures.

Maximum pavement loads for certain critical conditions at the tire-to-ground interface are shown in Section 7.3, with the tires having equal loads on the struts.

Pavement requirements for commercial airplanes are customarily derived from the static analysis of loads imposed on the main landing gear struts. The chart in Section 7.4 is provided in order to determine these loads throughout the stability limits of the airplane at rest on the pavement. These main landing gear loads are used as the point of entry to the pavement design charts, interpolating load values where necessary.

The flexible pavement design curves (Section 7.5) are based on procedures set forth in Instruction Report No. S-77-1, "Procedures for Development of CBR Design Curves," dated June 1977, and as modified according to the methods described in ICAO Aerodrome Design Manual, Part 3, Pavements, 2nd Edition, 1983, Section 1.1 (The ACN-PCN Method), and utilizing the alpha factors approved by ICAO in October 2007. Instruction Report No. S-77-1 was prepared by the U.S. Army Corps of Engineers Waterways Experiment Station, Soils and Pavements Laboratory, Vicksburg, Mississippi.

The following procedure is used to develop the curves, such as shown in Section 7.5:

1. Having established the scale for pavement depth at the bottom and the scale for CBR at the top, an arbitrary line is drawn representing 6,000 annual departures.

2. Values of the aircraft gross weight are then plotted.

3. Additional annual departure lines are drawn based on the load lines of the aircraft gross weights already established.

4. An additional line representing 10,000 coverages (used to calculate the flexible-pavement Aircraft Classification Number) is also placed.

Subsection 7.6 provides LCN conversion curves for flexible pavements. These curves have been plotted using procedures and curves in the Internation Civil Aviation Organization (ICAO) Aerodrome Design Manual, Part 3 – Pavements, Document 9157-AN/901, 1977.
Subsection 7.7 provides rigid pavement design curves prepared with the use of the Westergaard equations in general accord with the relationships outlined in the 1955 edition of Design of Concrete Airport Pavement, published by the Portland Cement Association, 33 W. Grand Ave., Chicago, Illinois, but modified to the new format described in the 1968 Portland Cement Association publication, Computer Program for Airport Pavement Design by Robert G. Packard. The following procedure is used to develop the rigid pavement design curves.

1. Having established the scale for pavement thickness to the left and the scale for allowable working stress to the right, an arbitrary load line is drawn representing the main landing gear maximum weight to be shown.

2. All values of the subgrade modulus (K-values) are then plotted using the maximum load line, as shown.

3. Additional load lines for the incremental value of weight on the main landing gear are then established on the basis of the curve for K = 300 lb/in.\(^3\) already established.

Subsection 7.8 presents LCN conversion curves for rigid pavements. These curves have been plotted using procedures and curves in the ICAO Aerodrome Design Manual, Part 3 — Pavements, Document 9157-AN/901, 1977. The same charts include plots of equivalent single-wheel load versus radius of relative stiffness. The LCN requirements are based on the condition of center-of-slab loading. Radii of relative stiffness values are obtained from Subsection 7.8.1.

Subsection 7.9 provides ACN data prepared according to the ACN-PCN system described in Aerodromes, Annex 14 to the Convention on International Civil Aviation. ACN is the Aircraft Classification Number and PCN is the corresponding Pavement Classification Number.

ACN-PCN provides a standardized international airplane/pavement rating system replacing the various S, T, TT, LCN, AUW, ISWL, etc., rating systems used throughout the world. An aircraft having an ACN equal to or less than the PCN can operate without restriction on the pavement. Numerically, the ACN is two times the derived single-wheel load expressed in thousands of kilograms, where the load is on a single tire inflated to 1.25 MPa (181 psi) that would have the same pavement requirements as the aircraft. Computationally, the ACN-PCN system uses PCA program PDILB for rigid pavements and S-77-1 for flexible pavements to calculate ACN values. The method of pavement evaluation is the responsibility of the airport, with the results of its evaluation presented as follows:
<table>
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<tr>
<th>PCN</th>
<th>PAVEMENT CLASSIFICATION NUMBER</th>
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<tr>
<td>(s)</td>
<td>(BEARING STRENGTH FOR UNRESTRICTED OPERATIONS)</td>
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<table>
<thead>
<tr>
<th>CODE</th>
<th>PAVEMENT TYPE</th>
<th>SUBGRADE CATEGORY</th>
<th>TIRE PRESSURE CATEGORY</th>
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<td>R</td>
<td>RIGID</td>
<td>HIGH</td>
<td>W</td>
</tr>
<tr>
<td>F</td>
<td>FLEXIBLE</td>
<td>(K = 150 MN/M²)</td>
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<td></td>
<td>(OR CBR = 15%)</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>MEDIUM</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(K = 80 MN/M²)</td>
<td>(LIMITED TO 1.75 MPa)</td>
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<td></td>
<td>(OR CBR = 10%)</td>
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</tr>
<tr>
<td>B</td>
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<td>LOW</td>
<td>Y</td>
</tr>
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<td>ULTRA LOW</td>
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<td>(OR CBR = 3%)</td>
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**REPORT EXAMPLE:** PCN 80/R/B/W/T
<table>
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<th><strong>MAXIMUM RAMP WEIGHT</strong></th>
<th>633,000 LB (287,129 kg)</th>
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<tr>
<td><strong>PERCENT OF WEIGHT ON MAIN GEAR</strong></td>
<td>SEE SECTION 7.4</td>
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<tr>
<td><strong>NOSE TIRE SIZE</strong></td>
<td>40 x 15.5 — 16</td>
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<tr>
<td><strong>NOSE TIRE PRESSURE</strong></td>
<td>180 PSI (12.7 kg/cm²)</td>
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<tr>
<td><strong>WING AND CENTER GEAR TIRE SIZE</strong></td>
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<tr>
<td><strong>WING GEAR TIRE PRESSURE</strong></td>
<td>206 PSI (14.4 kg/cm²)</td>
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<tr>
<td><strong>CENTER GEAR TIRE PRESSURE</strong></td>
<td>180 PSI (12.7 kg/cm²)</td>
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</table>

### 7.2 FOOTPRINT MODEL MD-11

- **25 IN. (64 cm)**
- **54 IN. (137 cm)**
- **30 IN. (76 cm)**
- **80 FT 9 IN. (24.61 m)**
- **35 FT (10.67 m)**
- **41 FT 3 IN. (12.57 m)**
- **37.5 IN. (95 cm)**
- **64 IN. (163 cm)**
### 7.3 Maximum Pavement Loads
**Model MD-11**

**Ramp Weight**

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<th>RAMP WEIGHT</th>
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<tr>
<td></td>
<td>LB</td>
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<tr>
<td>MD-11</td>
<td>633,000</td>
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</table>

**Pavement Loads for Critical Combinations of Weight and CG Positions**

- \( V_N \): Vertical Nose Gear Ground Load per Strut
- \( V_W \): Vertical Wing Gear Ground Load per Strut
- \( V_C \): Vertical Center Gear Ground Load per Strut
- \( H_W \): Horizontal Wing Gear Ground Load per Strut from Braking
- \( H_C \): Horizontal Center Gear Ground Load per Strut from Braking

**Values**

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<tr>
<th>MODEL MD-11</th>
<th>RAMP WEIGHT</th>
<th>NOSE GEAR (1) FORWARD CG</th>
<th>WING GEAR (2) AFT CG</th>
<th>CENTER GEAR (1) AFT CG</th>
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<tr>
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<td>V_N</td>
<td>V_N</td>
<td>V_W</td>
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<td>kg</td>
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* Aircraft deceleration = 10 ft/sec\(^2\). \( H_W \) and \( H_C \) assume deceleration from braking only.

**Instantaneous Braking**

**Coefficient of friction = 0.8**
7.4 Landing Gear Loading on Pavement

7.4.1 Loads on the Main Landing Gear Group

For the MD-11, the main gear group consists of two wing gears plus one center gear.

In the example for the MD-11, the gross weight is 470,000 pounds, the percent of weight on the main gears is 94.33 percent, and the total weight on the three main gears is 443,351 pounds.
7.4 LANDING GEAR LOADING ON PAVEMENT
MODEL MD-11
7.5 Flexible Pavement Requirements — U.S. Army Corps of Engineers Method (S-77-1)

To determine the airplane weight that can be accommodated on a particular flexible pavement, the thickness of the pavement, the subgrade CBR, and the annual departure level must be known.

In the example shown for the MD-11, for a CBR of 7.0, an annual departure level of 6,000, and a flexible pavement thickness of 36 inches, the main gear group loading is 450,000 pounds.

The line showing 10,000 coverages is used for ACN calculations, which are shown in another subsection.
7.5 FLEXIBLE PAVEMENT REQUIREMENTS
U.S. ARMY CORPS OF ENGINEERS/FAA DESIGN METHOD
MODEL MD-11

REV E
7.6 Flexible Pavement Requirements, LCN Conversion

To determine the airplane weight that can be accommodated on a particular flexible airport pavement, both the LCN of the pavement and the thickness (h) of the pavement must be known.

In the example for the MD-11, the flexible pavement thickness is 30 inches, the LCN is 76, and the main landing gear group weight is 350,000 pounds.
7.6 FLEXIBLE PAVEMENT REQUIREMENTS – LCN CONVERSION
MODEL MD-11

NOTE: EQUIVALENT SINGLE-WHEEL LOADS ARE DERIVED BY METHODS SHOWN IN ICAO AERODROME MANUAL, PART 2, PAR. 4.1.3
7.7 Rigid Pavement Requirements, Portland Cement Association Design Method

To determine the airplane weight that can be accommodated on a particular rigid pavement, the thickness of the pavement, the subgrade modulus (k), and the allowable working stress must be known.

In the example for the MD-11, the rigid pavement thickness is 13.7 inches, the subgrade modulus is 150, and the allowable working stress is 400 psi. For these conditions, the weight on the landing gear group is 450,000 pounds.
NOTE: THE VALUES OBTAINED BY USING THE MAX LOAD REFERENCE LINE AND ANY VALUES OF K ARE EXACT.
FOR LOADS LESS THAN MAX, THE CURVES ARE EXACT FOR K = 300, BUT DEVIATE SLIGHTLY FOR
OTHER VALUES OF K.

REF: DESIGN OF CONCRETE AIRPORT PAVEMENT, 1968 PORTLAND CEMENT ASSOCIATION
COMPUTER PROGRAM

7.7 RIGID PAVEMENT REQUIREMENTS,
PORTLAND CEMENT ASSOCIATION DESIGN METHOD
MODEL MD-11

REV E
7.8 Rigid Pavement Requirements, LCN Conversion

To determine the airplane weight that can be accommodated on a particular rigid airport pavement, both the LCN of the pavement and the radius of relative stiffness must be known.

In the example for the MD-11, the rigid pavement radius of relative stiffness is 40 inches and the LCN is 78. For these conditions, the weight on the main landing gear group is 400,000 pounds.

The LCN charts use $\ell$-values based on Young’s Modulus (E) of 4 million psi and Poisson’s ratio (m) of 0.15. For convenience in finding $\ell$-values based on other values of E and m, the curves in chart 7.8.2 are included. For example, to find an $\ell$-value based on an E of 3 million psi, the E-factor of 0.931 is multiplied by the $\ell$-value found in Chart 7.8.1. The effect of variations in m on the $\ell$-value is treated in a similar manner.

Note: If the resulting aircraft LCN is not more than 10 percent above the published pavement LCN, the United Kingdom, which originated the LCN method, considers that the bearing strength of the pavement is sufficient for unlimited use by the airplane. The figure of 10 percent has been chosen as representing the lowest degree of variation in LCN which is significant. (Reference: ICAO Aerodrome Design Manual, Part 3 — Pavements, Document 9157-AN/901, 1977 Edition.)
7.8.1 RIGID PAVEMENT REQUIREMENTS, LCN CONVERSION
MODEL MD-11

NOTE: EQUIVALENT SINGLE-WHEEL LOADS ARE DERIVED BY METHODS SHOWN IN ICAO AERODROME
MANUAL, PART 2, PAR. 4.1.3

REV E
RADIUS OF RELATIVE STIFFNESS \( (L) \)

VALUES IN INCHES

\[
L = \sqrt[4]{\frac{Ed^3}{12(1-\mu^2)k}} = 24.1652 \sqrt[4]{\frac{d^3}{k}}
\]

WHERE:
- \( E = \) YOUNG'S MODULUS = \( 4 \times 10^6 \) PSI
- \( k = \) SUBGRADE MODULUS, LB/IN.\(^3\)
- \( d = \) RIGID-PAVEMENT THICKNESS, IN.
- \( \mu = \) POISSON'S RATIO = 0.15

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<td>54.89</td>
<td>51.91</td>
<td>50.69</td>
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<td>86.24</td>
<td>80.26</td>
<td>72.52</td>
<td>67.49</td>
<td>63.83</td>
<td>60.98</td>
<td>58.68</td>
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<td>53.67</td>
<td>52.41</td>
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<td>89.04</td>
<td>82.86</td>
<td>74.87</td>
<td>69.68</td>
<td>65.90</td>
<td>62.96</td>
<td>60.58</td>
<td>58.89</td>
<td>55.41</td>
<td>54.11</td>
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<tr>
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<td>85.44</td>
<td>77.20</td>
<td>71.84</td>
<td>67.95</td>
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<td>62.46</td>
<td>60.41</td>
<td>57.14</td>
<td>55.79</td>
<td></td>
</tr>
</tbody>
</table>

REFERENCE: PORTLAND CEMENT ASSOCIATION

7.8.2 RADIUS OF RELATIVE STIFFNESS

7–16
7.8.3 EFFECT OF E AND \( \mu \) ON \( \ell \)-VALUES

NOTE: BOTH CURVES ON THIS PAGE ARE USED TO ADJUST THE \( \ell \)-VALUES OF TABLE 7.8.2

EFFECT OF E ON \( \ell \)-VALUES

\[ E \text{ FACTOR} \]

EFFECT OF \( \mu \) ON \( \ell \)-VALUES

\[ \mu \text{ FACTOR} \]
7.9 ACN –PCN REPORTING SYSTEM: FLEXIBLE AND RIGID PAVEMENTS

To determine the ACN of an aircraft on flexible or rigid pavement, both the aircraft gross weight and the subgrade strength category must be known. The examples show that for an aircraft gross weight of 440,000 lb and low subgrade strength, the ACN for flexible pavement is 47.7 and the ACN for rigid pavement for the same gross weight is 50.

Note: An aircraft with an ACN equal to or less than the reported PCN can operate on the pavement subject to any limitations on the tire pressure.
7.9.1 Development of ACN Charts

The ACN charts for flexible and rigid pavements were developed by methods referenced in the ICAO Aerodrome Manual, Part 3 — Pavements, Document 9157-AN/901, 1983 Edition. The procedures used in developing these charts are described below.

The following procedure was used to develop the flexible-pavement ACN charts already shown in this subsection.

1. Determine the percentage of weight on the main gear to be used below in Steps 2, 3, and 4, below. The maximum aft center-of-gravity position yields the critical loading on the critical gear (see Subsection 7.4). This center-of-gravity position is used to determine main gear loads at all gross weights of the model being considered.

2. Establish a flexible-pavement requirements chart using the S-77-1 design method, such as shown on the right side of Figure 7.9.3. Use standard subgrade strengths of CBR 3, 6, 10, and 15 percent and 10,000 coverages. This chart provides the same thickness values as those of Subsection 7.5, but is presented here in a different format.

3. Determine reference thickness values from the pavement requirements chart of Step 2 for each standard subgrade strength and gear loading.

4. Enter the reference thickness values into the ACN flexible-pavement conversion chart shown on the left side of Figure 7.9.3 to determine ACN. This chart was developed using the S-77-1 design method with a single tire inflated to 1.25 MPa (181 psi) pressure and 10,000 coverages. The ACN is two times the derived single-wheel load expressed in thousands of kilograms. These values of ACN were plotted as functions of aircraft gross weight, as already shown.

The following procedure was used to develop the rigid-pavement ACN charts already shown in this subsection.

1. Determine the percentage of weight on the main gear to be used in Steps 2, 3, and 4, below. The maximum aft center-of-gravity position yields the critical loading on the critical gear (see Subsection 7.4). This center-of-gravity position is used to determine main gear loads at all gross weights of the model being considered.

2. Establish a rigid-pavement requirements chart using the PCA computer program PDILB, such as shown on the right side of Figure 7.9.4. Use standard subgrade strengths of k = 75, 150, 300, and 550 lb/in.³ (nominal values for k = 20, 40, 80, and 150 MN/m³). This chart provides the same thickness values as those of Subsection 7.7.

3. Determine reference thickness values from the pavement requirements chart of Step 2 for each standard subgrade strength and gear loading at 400 psi working stress (nominal value for 2.75 MPa working stress).
4. Enter the reference thickness values into the ACN rigid-pavement conversion chart shown on the left side of Figure 7.9.4 to determine ACN. This chart was developed using the PCA computer program PDILB with a single tire inflated to 1.25 MPa (181 psi) pressure and a working stress of 2.75 MPa (400 psi.) The ACN is two times the derived single-wheel load expressed in thousands of kilograms. These values of ACN were plotted as functions of aircraft gross weight, as already shown in this subsection.
7.9.1 AIRCRAFT CLASSIFICATION NUMBER – FLEXIBLE PAVEMENT

MODEL MD-11

NOTES:

1. TO DETERMINE MAIN LANDING GEAR LOADING
   SEE SECTION 7.4
2. PERCENT WEIGHT ON MAIN GEARS 94.33

CODE D = CBR 3 (ULTRA LOW)
CODE C = CBR 6 (LOW)
CODE B = CBR 10 (MEDIUM)
CODE A = CBR 15 (HIGH)

AIRCRAFT GROSS WEIGHT

1,000 LB

1,000 KG

AIRCRAFT GROSS WEIGHT
7.9.2 AIRCRAFT CLASSIFICATION NUMBER – RIGID PAVEMENT
MODEL MD-11

SUBGRADE STRENGTH
ULTRA LOW - 20 MN/m³ (75 LB/IN³)
LOW - 40 MN/m³ (150 LB/IN³)
MEDIUM - 80 MN/m³ (300 LB/IN³)
HIGH - 150 MN/m³ (550 LB/IN³)

H54 x 21.0-24 TIRES
TIRE PRESSURE CONSTANT
AT 206 PSI (14.5 kg/cm²)
PERCENT WEIGHT ON
MAIN GEARS 94.35

AIRCRAFT GROSS WEIGHT

7–22
7.9.3 DEVELOPMENT OF AIRCRAFT CLASSIFICATION NUMBER (ACN) – FLEXIBLE PAVEMENT MODEL MD-II
7.9.4 DEVELOPMENT OF AIRCRAFT CLASSIFICATION NUMBER (ACN) – RIGID PAVEMENT
MODEL MD-11
8.0 POSSIBLE MD-11 DERIVATIVE AIRPLANES
8.0 POSSIBLE MD-11 DERIVATIVE AIRPLANES

No additional versions of the MD-11 are currently planned.
9.0 MD-11 SCALE DRAWINGS
9.0 SCALE DRAWINGS

9.1 1 INCH EQUALS 32 FEET

MODEL MD-11
LEGEND:

A (2)  AIR CONDITIONING (2 CONN)  MC  MAIN DECK CARGO DOOR
B  BULK CARGO DOOR  MLG  MAIN LANDING GEAR
C  LOWER DECK CARGO DOOR  NG  NOSE GEAR
CLG  CENTER LANDING GEAR  P (2)  PNEUMATIC (2 CONNECTIONS)
E (2)  ELECTRICAL (2 CONNECTIONS)  V  FUEL VENT
F (2)  FUEL (2 CONNECTIONS)  X  PASSENGER DOOR
H₂O  POTABLE WATER  +  TURNING RADIUS POINTS:
L  LAVATORY

68 DEG, 65 DEG, 55 DEG, 50 DEG,
45 DEG, 40 DEG, 35 DEG, 30 DEG

9.0 SCALE DRAWINGS
9.2 1 INCH EQUALS 50 FEET
MODEL MD-11
LEGEND:
A (2)  AIR CONDITIONING (2 CONN)
B      BULK CARGO DOOR
C      LOWER DECK CARGO DOOR
CLG    CENTER LANDING GEAR
E (2)  ELECTRICAL (2 CONNECTIONS)
F (2)  FUEL (2 CONNECTIONS)
H₂O    POTABLE WATER
L      LAVATORY

MC      MAIN DECK CARGO DOOR
MLG     MAIN LANDING GEAR
NG      NOSE GEAR
P (2)   PNEUMATIC (2 CONNECTIONS)
V       FUEL VENT
X       PASSENGER DOOR

+ TURNING RADIUS POINTS:
   68 DEG, 60 DEG, 55 DEG, 50 DEG,
   45 DEG, 40 DEG, 35 DEG, 30 DEG
9.0 SCALE DRAWINGS
9.4 1 TO 500
MODEL MD-11

LEGEND:
A (2)  AIR CONDITIONING (2 CONN)
B      BULK CARGO DOOR
C      LOWER DECK CARGO DOOR
CLG    CENTER LANDING GEAR
E (2)  ELECTRICAL (2 CONNECTIONS)
F (2)  FUEL (2 CONNECTIONS)
H2O    POTABLE WATER
L      LAVATORY

MC      MAIN DECK CARGO DOOR
MLG     MAIN LANDING GEAR
NG      NOSE GEAR
P (2)   PNEUMATIC (2 CONNECTIONS)
V       FUEL VENT
X       PASSENGER DOOR

+ TURNING RADIUS POINTS: 68 DEG, 60 DEG, 55 DEG, 50 DEG, 45 DEG, 40 DEG, 35 DEG, 30 DEG

68 DEG
60 DEG
55 DEG
50 DEG
45 DEG
40 DEG
35 DEG
30 DEG

WING SPAN: 51.97 METERS
WING SPAN: 51.97 METERS

LEGEND:
A (2) AIR CONDITIONING (2 CONN)       MC MAIN DECK CARGO DOOR
B BULK CARGO DOOR                      MLG MAIN LANDING GEAR
C LOWER DECK CARGO DOOR                NG NOSE GEAR
CLG CENTER LANDING GEAR                P (2) PNEUMATIC (2 CONNECTIONS)
E (2) ELECTRICAL (2 CONNECTIONS)       V FUEL VENT
F (2) FUEL (2 CONNECTIONS)             X PASSENGER DOOR
H₂O POTABLE WATER                      + TURNING RADIUS POINTS:
L LAVATORY                              68 DEG, 60 DEG, 55 DEG, 50 DEG,
                                        45 DEG, 40 DEG, 35 DEG, 30 DEG

9.0 SCALE DRAWINGS
9.5 1 TO 1,000
MODEL MD-11

DMC005-87