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777-9

Airplane Characteristics for Airport Planning

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Boeing Commercial Airplanes

All revisions to this document must be approved by the content owner before release.

Not Subject to US Export Administration Regulations (EAR), (15 C.F.R. Parts 730-774) or US International Traffic in Arms Regulations (ITAR), (22 C.F.R. Parts 120-130).



PRELIMINARY INFORMATION

Revision Record

Revision Letter	F
Revision Date	December 2024
Changes in This Revision	Section 7: Updated ACR Information.

Revision Letter	E
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Changes in This Revision	Minor edits.

Revision Letter	D
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Revision Letter	C
Revision Date	December 2021
Changes in This Revision	Section 2: Update Door Clearances Section 5: Update Service Connection Locations, Release preliminary Conditioned Air Requirements.

Revision Letter	B
Revision Date	October 2020
Changes in This Revision	Release preliminary data available in Section 2 and Section 5.

Revision Letter	A
Revision Date	March 2018
Changes in This Revision	Initial release of Folding Wing Tip (FWT) Concept of Operations

Revision Letter	NEW
Revision Date	April 2017
Changes in This Revision	Initial release of 777-9 data

PRELIMINARY INFORMATION

Table of Contents

1.0	SCOPE AND INTRODUCTION.....	1-1
1.1	SCOPE.....	1-1
1.2	INTRODUCTION.....	1-2
1.3	A BRIEF DESCRIPTION OF THE 777X FAMILY OF AIRPLANES.....	1-3
1.4	CONVERSION FACTORS.....	1-4
2.0	AIRPLANE DESCRIPTION.....	2-1
2.1	GENERAL CHARACTERISTICS.....	2-1
2.1.1	General Characteristics: Model 777-9.....	2-2
2.2	GENERAL DIMENSIONS.....	2-3
2.2.1	General Dimensions: Model 777-9.....	2-3
2.3	GROUND CLEARANCES.....	2-4
2.3.1	Ground Clearances: Model 777-9.....	2-4
2.4	INTERIOR ARRANGEMENTS.....	2-5
2.4.1	Interior Arrangements – Standard Two Class: Model 777-9.....	2-5
2.4.2	Interior Arrangements – Standard Three Class: Model 777-9.....	2-6
2.5	CABIN CROSS SECTIONS.....	2-7
2.5.1	Cabin Cross-Sections: Model 777-9 Seats.....	2-7
2.6	LOWER CARGO COMPARTMENTS.....	2-8
2.6.1	Lower Cargo Compartments: Model 777-9, Containers and Bulk Cargo.....	2-8
2.7	DOOR CLEARANCES.....	2-9
2.7.1	Door Clearances: Model 777-9, Door Locations.....	2-9
2.7.2	Door Clearances: Model 777-9, Main Entry Door No 1.....	2-10
2.7.3	Door Clearances: Model 777-9, Main Entry Door No 2, and No 3.....	2-11
2.7.4	Door Clearances: Model 777-9, Main Entry Door No 4.....	2-12
2.7.5	Door Clearances: Model 777-9, Optional Service Door.....	2-13
2.7.6	Door Clearances: Model 777-9, Large Forward Cargo Door.....	2-14
2.7.7	Door Clearances: Model 777-9, Small Aft Cargo Door.....	2-15
2.7.8	Door Clearances: Model 777-9, Bulk Cargo Door.....	2-16
3.0	AIRPLANE PERFORMANCE.....	3-1
3.1	GENERAL INFORMATION.....	3-1
3.2	PAYLOAD/RANGE FOR LONG RANGE CRUISE.....	3-2
3.2.1	Payload/Range for Long Range Cruise: Model 777-9.....	3-2
3.3	FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS.....	3-3
3.3.1	FAA/EASA Takeoff Runway Length Requirements: Model 777-9.....	3-3
3.4	FAA/EASA LANDING RUNWAY LENGTH REQUIREMENTS.....	3-4
3.4.1	FAA/EASA Landing Runway Length Requirements: Model 777-9	3-4

PRELIMINARY INFORMATION

4.0	GROUND MANEUVERING	4-1
4.1	GENERAL INFORMATION.....	4-1
4.2	TURNING RADII	4-3
4.2.1	Turning Radii – No Slip Angle: Model 777-9	4-3
4.3	CLEARANCE RADII	4-4
4.3.1	Clearance Radii – Model 777-9	4-4
4.4	VISIBILITY FROM COCKPIT IN STATIC POSITION: MODEL 777-9 4-5	
4.5	RUNWAY AND TAXIWAY TURN PATHS	4-6
4.5.1	Runway and Taxiway Turn Paths - Runway-to-Taxiway, More Than 90 Degree Turn: Model 777-9	4-6
4.5.2	Runway and Taxiway Turn Paths - Runway-to-Taxiway, 90 Degree Turn: Model 777-9.....	4-7
4.5.3	Runway and Taxiway Turn Paths - Taxiway-to-Taxiway, 90 Degree Turn: Model 777-9.....	4-8
4.6	RUNWAY HOLDING BAY: MODEL 777-9.....	4-9
5.0	TERMINAL SERVICING	5-1
5.1	AIRPLANE SERVICING ARRANGEMENT - TYPICAL TURNAROUND	5-2
5.1.1	Airplane Servicing Arrangement - Typical Turnaround: Model 777-9	5-2
5.2	TERMINAL OPERATIONS - TURNAROUND STATION	5-3
5.2.1	Terminal Operations - Turnaround Station: Model 777-9	5-3
5.3	TERMINAL OPERATIONS - EN ROUTE STATION.....	5-4
5.3.1	Terminal Operations - En Route Station: Model 777-9.....	5-4
5.4	GROUND SERVICING CONNECTIONS.....	5-5
5.4.1	Ground Service Connections: Locations: Model 777-9.....	5-5
5.4.2	Ground Servicing Connections and Capacities: Model 777-9.....	5-6
5.5	ENGINE STARTING PNEUMATIC REQUIREMENTS	5-7
5.5.1	Engine Start Pneumatic Requirements - Sea Level: Model 777-9.....	5-7
5.6	GROUND PNEUMATIC POWER REQUIREMENTS	5-8
5.6.1	Ground Conditioned Air Requirements – Heating, Pull-Up: Model 777-9	5-8
5.6.2	Ground Conditioned Air Requirements – Cooling, Pull-Down: Model 777-9.....	5-9
5.7	CONDITIONED AIR REQUIREMENTS.....	5-10
5.7.1	Conditioned Air Flow Requirements - Steady State Airflow, Hot Day Operation: Model 777-9	5-10
5.7.2	Conditioned Air Flow Requirements - Steady State Airflow, Cold Day Operation: Model 777-9	5-11
5.7.3	Air Conditioning Gauge Pressure Requirements - Steady State Airflow: Model 777-9	5-12

D6-86073

PRELIMINARY INFORMATION

5.7.4	Conditioned Air Cooling Requirements - Steady State BTU's: Model 777-9	5-13
5.7.5	Conditioned Air Heating Requirements - Steady State BTU's: Model 777-9	5-14
5.8	GROUND TOWING REQUIREMENTS	5-15
5.8.1	Ground Towing Requirements - Metric Units: Model 777-9	5-15
6.0	JET ENGINE WAKE AND NOISE DATA	6-1
6.1	JET ENGINE EXHAUST VELOCITIES AND TEMPERATURES	6-1
6.1.1	Jet Engine Exhaust Velocity Contours - Idle Thrust: Model 777-9.....	6-2
6.1.2	Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 0% Slope / Both Engines / MTW: Model 777-9	6-3
6.1.3	Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 1% Slope / Both Engines / MTW: Model 777-9	6-4
6.1.4	Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 0% Slope / Single Engine / MTW: Model 777-9	6-5
6.1.5	Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 0% Slope / Single Engine / MLW: Model 777-9	6-6
6.1.6	Jet Engine Exhaust Velocity Contours - Takeoff Thrust: Model 777-9	6-7
6.1.7	Jet Engine Exhaust Temperature Contours - Idle/Breakaway Thrust: Model 777-9	6-8
6.1.8	Jet Engine Exhaust Temperature Contours - Takeoff Thrust: Model 777-9	6-9
6.1.9	Inlet Hazard Areas: All Models	6-10
6.2	AIRPORT AND COMMUNITY NOISE.....	6-11
7.0	PAVEMENT DATA	7-1
7.1	GENERAL INFORMATION.....	7-1
7.2	LANDING GEAR FOOTPRINT	7-4
7.2.1	Landing Gear Footprint: Model 777-9.....	7-4
7.3	MAXIMUM PAVEMENT LOADS.....	7-5
7.3.1	Maximum Pavement Loads: Model 777-9.....	7-5
7.4	LANDING GEAR LOADING ON PAVEMENT	7-6
7.4.1	Landing Gear Loading on Pavement: Model 777-9.....	7-6
7.5	FLEXIBLE PAVEMENT REQUIREMENTS - FAA DESIGN METHOD	7-7
7.6	FLEXIBLE PAVEMENT REQUIREMENTS - LCN CONVERSION.....	7-8
7.7	RIGID PAVEMENT REQUIREMENTS - PORTLAND CEMENT ASSOCIATION DESIGN METHOD.....	7-9
7.8	RIGID PAVEMENT REQUIREMENTS - LCN CONVERSION	7-10
7.9	RIGID PAVEMENT REQUIREMENTS - FAA DESIGN METHOD	7-11
7.10	ACN/PCN REPORTING SYSTEM - FLEXIBLE AND RIGID PAVEMENTS	7-12

PRELIMINARY INFORMATION

7.10.1	Aircraft Classification Number - Flexible Pavement: Model 777-9	7-13
7.10.2	Aircraft Classification Number - Rigid Pavement: Model 777-9	7-14
7.11	ACR/PCR REPORTING SYSTEM - FLEXIBLE AND RIGID PAVEMENTS	7-15
7.11.1	Aircraft Classification Rating - Flexible Pavement: Model 777-9	7-16
7.11.2	Aircraft Classification Rating - Rigid Pavement: Model 777-9.....	7-17
8.0	FUTURE 777 DERIVATIVE AIRPLANES.....	8-1
9.0	SCALED 777 DRAWINGS	9-1
9.1	MODEL 777-9.....	9-2
9.1.1	Scaled Drawings – 1:500: Model 777-9.....	9-2
10.0	APPENDICES	10-1
10.1	APPENDIX A – 777-9 FOLDING WING TIP CONCEPT OF NORMAL OPERATIONS (FWT CONOPS).....	10-1
10.1.1	LIST OF ACRONYMS.....	10-1
10.1.2	INTRODUCTION.....	10-2
10.1.3	NORMAL FWT OPERATIONS OVERVIEW.....	10-3
10.1.4	FWT OPERATIONS BEFORE TAKEOFF	10-4
10.1.5	FWT OPERATIONS AFTER LANDING.....	10-6
10.1.6	OTHER DESIGN CONSIDERATIONS	10-9
10.2	APPENDIX B – 777-9 FOLDING WING TIP CONCEPT OF NON-NORMAL OPERATIONS - FWT OPERATIONS PLAN	10-11
10.2.1	LIST OF ACRONYMS.....	10-11
10.2.2	INTRODUCTION.....	10-12
10.2.3	NORMAL FWT OPERATIONS: BACKGROUND, TAKEOFF AND LANDING	10-13
10.2.4	FWT NON-NORMAL OPERATIONS BEFORE TAKEOFF	10-14
10.2.5	FWT NON-NORMAL OPERATIONS AFTER LANDING	10-15
10.2.6	NON-NORMAL FWT TAXIWAY OPERATIONS	10-16
10.2.7	TAXILANE AND APRON OPERATIONS	10-22

PRELIMINARY INFORMATION

1.0 SCOPE AND INTRODUCTION

1.1 SCOPE

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. Boeing Commercial Airplanes should be contacted for any additional information required.

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

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

The airport planner may also want to consider the information presented in the "Commercial Aircraft Design Characteristics - Trends and Growth Projections," for long range planning needs and can be accessed via the following website:

<http://www.boeing.com/airports>

The document is updated periodically and represents the coordinated efforts of the following organizations regarding future aircraft growth trends.

- International Coordinating Council of Aerospace Industries Associations
- Airports Council International - North American and World Organizations
- Air Transport Association of America
- International Air Transport Association

PRELIMINARY INFORMATION

1.2 INTRODUCTION

This document conforms to NAS 3601. It provides characteristics of the Boeing 777X family of airplanes for airport planners and operators, airlines, architectural and engineering consultant organizations, and other interested industry agencies. Airplane changes and available options may alter model characteristics. The data presented herein reflects the 777X family. Data used is generic in scope and not customer-specific.

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PRELIMINARY INFORMATION

1.3 A BRIEF DESCRIPTION OF THE 777X FAMILY OF AIRPLANES

777X Family

The 777X is the latest series of derivative airplanes in the 777 family of airplanes. The 777X family includes the 777-8 and 777-9. The 777-9 will be the first airplane model in the 777X series to enter into service. The remaining models will be added to this document in the future.

Proven technologies from the 777 and 787, combined with new technologies, bring a balanced design focused on efficiency. New composite wings and new engines reduce fuel burn and community noise. The new interior has a wider cabin to improve airline customer and passenger appeal.

Main Gear Aft Axle Steering

The main gear axle steering is automatically engaged based on the nose gear steering angle. This allows for less tire scrubbing and easier maneuvering into gates with limited parking clearances.

Engines

The 777X features new engines from General Electric for improved fuel burn and noise. The new GE9X-105B1A has a 134-inch fan diameter and 105,000 lb Boeing equivalent thrust (BET).

Wings

A folding wing tip design on the 777X results in substantial aerodynamic benefits in flight with the wing tip extended, while maintaining Code E wing span on the ground for taxiway and gate compatibility.

Cargo Handling

The lower lobe cargo compartments can accommodate a variety of containers and pallets now in use.

PRELIMINARY INFORMATION

1.4 CONVERSION FACTORS

The data in this manual is provided in both English and Metric units. Unless otherwise stated, the conversions listed below are used throughout this manual.

MULTIPLY	BY	TO OBTAIN
Pounds	0.45359237	Kilograms
U.S. Gallons	3.78541180	Liters
Inches	2.54000000	Centimeters
Feet	0.30480000	Meters

When totals or summations are required the English values are summed separately from the Metric values. Differences may occur when comparing the English total with metric totals due to rounding.

All metric values are converted from English values. When using the conversion factors in this manual, all resultants will be rounded except when the value is a weight limitation. For minimum or maximum weight limitations the resultant metric values will be rounded up or truncated, whichever is more conservative.

PRELIMINARY INFORMATION

2.0 AIRPLANE DESCRIPTION

2.1 GENERAL CHARACTERISTICS

Maximum Design Taxi Weight (MTW). Maximum weight for ground maneuver as limited by aircraft strength and airworthiness requirements. (It includes weight of taxi and run-up fuel.)

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

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

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.

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

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

Seating Capacity. The number of passengers in a typical seating arrangement.

Maximum Cargo Volume. The maximum space available for cargo.

Usable Fuel. Fuel available for aircraft propulsion.

PRELIMINARY INFORMATION

2.1.1 General Characteristics: Model 777-9

CHARACTERISTICS	UNITS	777-9
MAX DESIGN TAXI WEIGHT	POUNDS	777,000
	KILOGRAMS	352,441
MAX DESIGN TAKEOFF WEIGHT	POUNDS	775,000
	KILOGRAMS	351,534
MAX DESIGN LANDING WEIGHT	POUNDS	587,000
	KILOGRAMS	266,258
MAX DESIGN ZERO FUEL WEIGHT	POUNDS	562,000
	KILOGRAMS	254,918
TYPICAL SEATING CAPACITY	TWO CLASS	414 [1]
	THREE CLASS	349 [2]
MAX CARGO --LOWER DECK	CUBIC FEET	7,815 [4]
	CUBIC METERS	221.3 [4]
MAX CARGO --LOWER DECK [3]	CUBIC FEET	8,131 [5]
	CUBIC METERS	230.2 [5]
USABLE FUEL [6]	U.S. GALLONS	52,136
	LITERS	197,356
	POUNDS	349,311
	KILOGRAMS	158,477

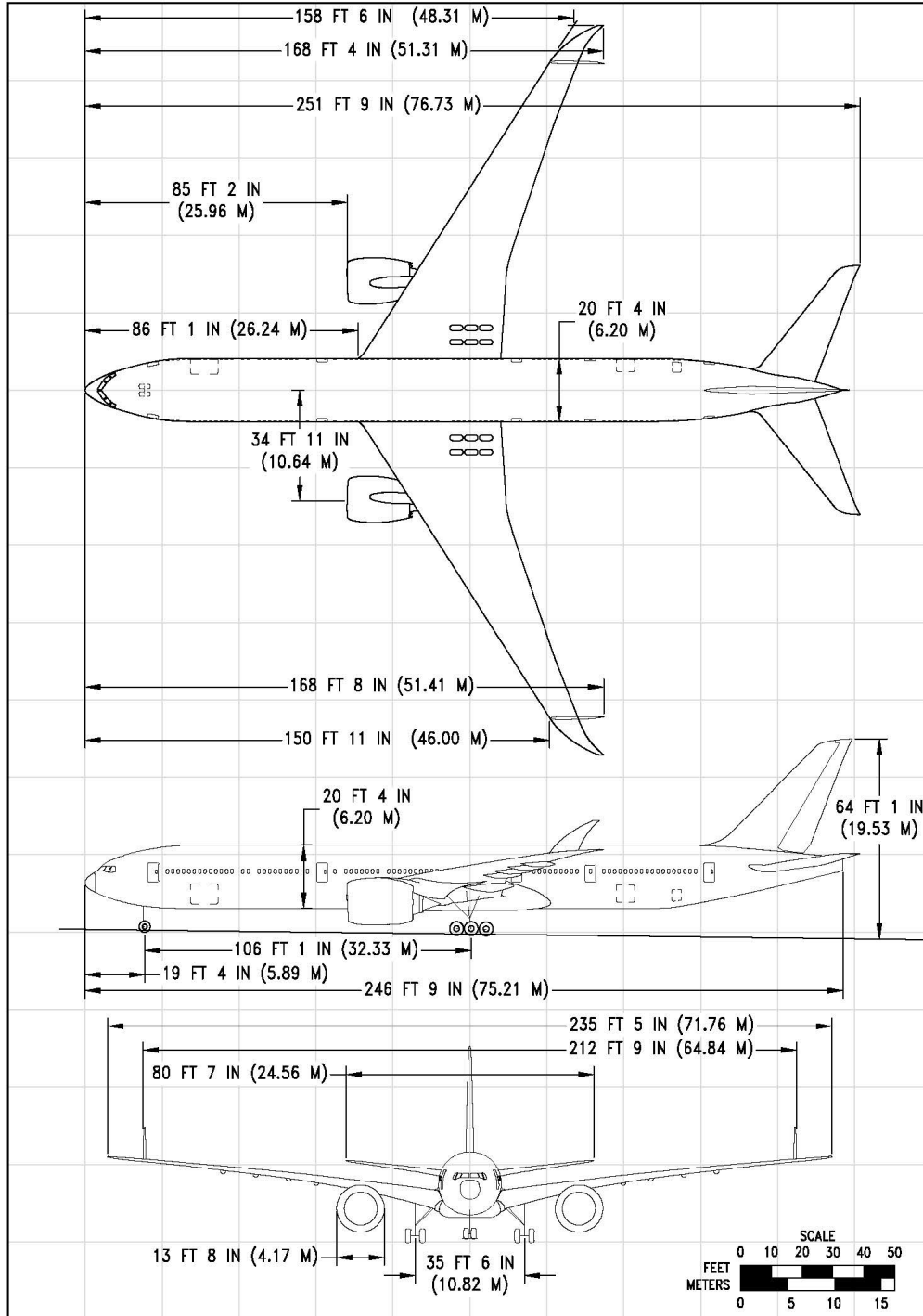
NOTES:

- 42 BUSINESS CLASS AND 372 ECONOMY CLASS
- 8 FIRST CLASS, 49 BUSINESS CLASS AND 292 ECONOMY CLASS
- OPTIONAL AFT LARGE CARGO DOOR
- FWD CARGO = (26) LD-3 CONTAINERS AT 158 CU FT EACH
AFT CARGO = (20) LD-3 CONTAINERS AT 158 CU FT EACH
BULK CARGO = 547 CU FT
SEE SEC 2.6 FOR OTHER LOADING COMBINATIONS.
- FWD CARGO = (26) LD-3 CONTAINERS AT 158 CU FT EACH
AFT CARGO = (22) LD-3 CONTAINERS AT 158 CU FT EACH
BULK CARGO = 547 CU FT
SEE SEC 2.6 FOR OTHER LOADING COMBINATIONS.
- FUEL DENSITY = 6.7 LBS/US GAL

PRELIMINARY INFORMATION

2.2 GENERAL DIMENSIONS

2.2.1 General Dimensions: Model 777-9



D6-86073

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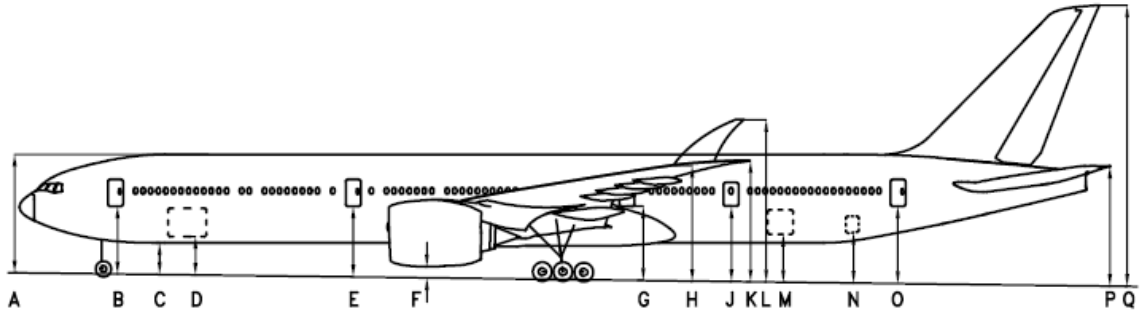
2-3

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PRELIMINARY INFORMATION

2.3 GROUND CLEARANCES

2.3.1 Ground Clearances: Model 777-9



Dimension	MINIMUM*		MAXIMUM*	
	FT - IN	M	FT - IN	M
A	27-9	8.46	28-10	8.79
B	15-8	4.78	16-10	5.13
C	7-0	2.13	8-6	2.59
D	9-5	2.87	10-5	3.18
E	16-4	4.98	17-2	5.23
F	2-9	0.86	2-10	0.87
G	16-11	5.16	17-8	5.38
H (UNDERSIDE FOLDED WING TIP)	26-2	7.97	26-10	8.17
J (OPTIONAL EXIT DOOR)	16-11	5.16	17-11	5.46
K (EXTENDED WING TIP)	25-10	7.87	26-8	8.12
L (FOLDED WING TIP)	36-8	11.12	37-4	11.38
M	10-5	3.18	11-6	3.51
N	10-10	3.3	11-7	3.53
O	17-0	5.18	18-2	5.54
P	26-4	8.03	27-10	8.48
Q	63-3	19.28	64-9	19.74

NOTES:

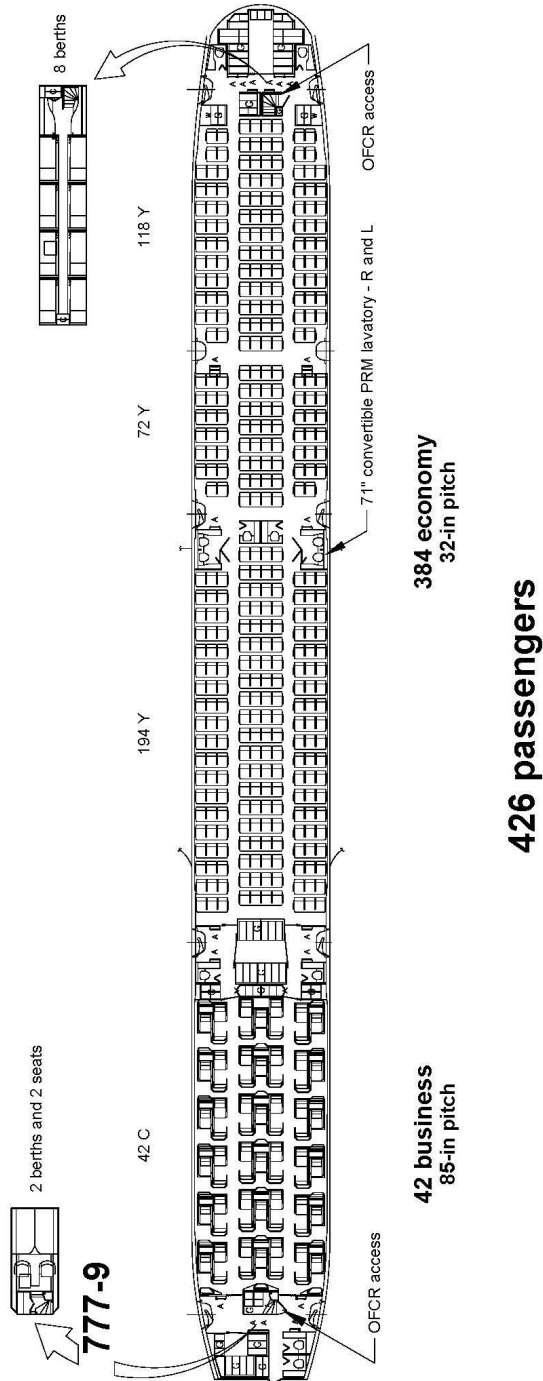
1. VERTICAL CLEARANCES SHOWN OCCUR DURING MAXIMUM VARIATIONS OF AIRPLANE ATTITUDE. COMBINATIONS OF AIRPLANE LOADING AND UNLOADING ACTIVITIES THAT PRODUCE THE GREATEST POSSIBLE VARIATION IN ATTITUDE WERE USED TO ESTABLISH THE VARIATIONS SHOWN.
2. DURING ROUTINE SERVICING, THE AIRPLANE REMAINS RELATIVELY STABLE, PITCH AND ELEVATION CHANGES OCCURRING SLOWLY.

* NOMINAL DIMENSIONS ROUNDED TO NEAREST INCH AND NEAREST CENTIMETER

PRELIMINARY INFORMATION

2.4 INTERIOR ARRANGEMENTS

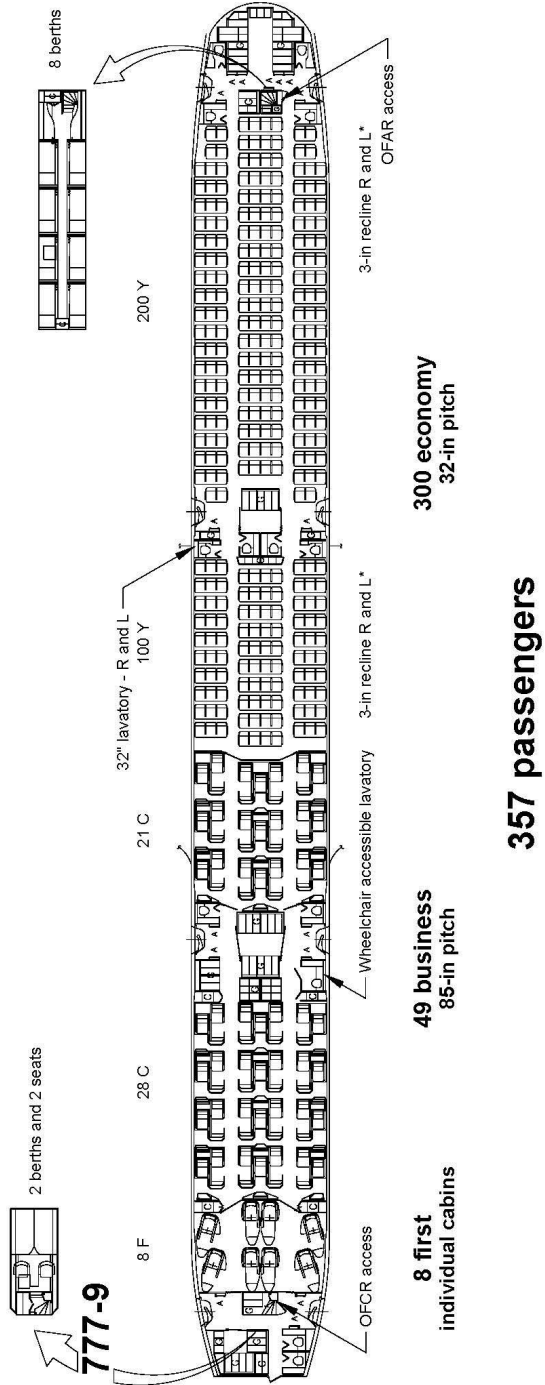
2.4.1 Interior Arrangements – Standard Two Class: Model 777-9



D6-86073

PRELIMINARY INFORMATION

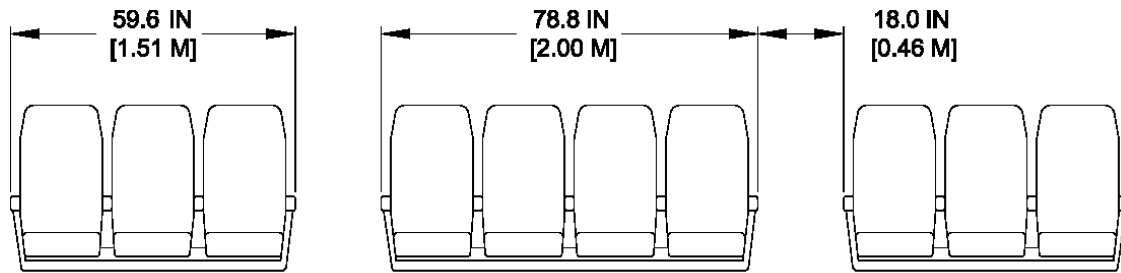
2.4.2 Interior Arrangements – Standard Three Class: Model 777-9



PRELIMINARY INFORMATION

2.5 CABIN CROSS SECTIONS

2.5.1 Cabin Cross-Sections: Model 777-9 Seats

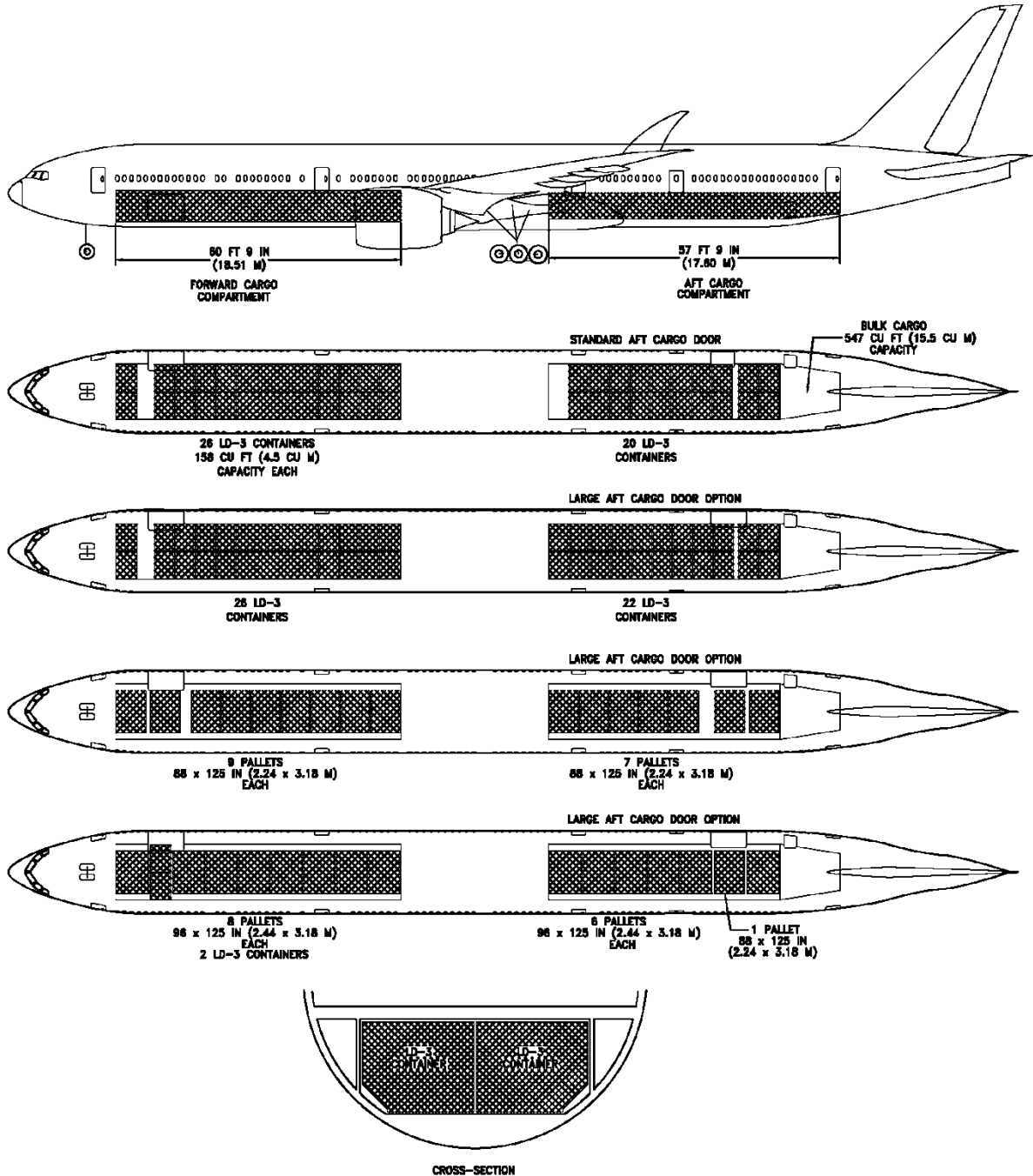


ECONOMY CLASS SEATING
10 - ABREAST

PRELIMINARY INFORMATION

2.6 LOWER CARGO COMPARTMENTS

2.6.1 Lower Cargo Compartments: Model 777-9, Containers and Bulk Cargo

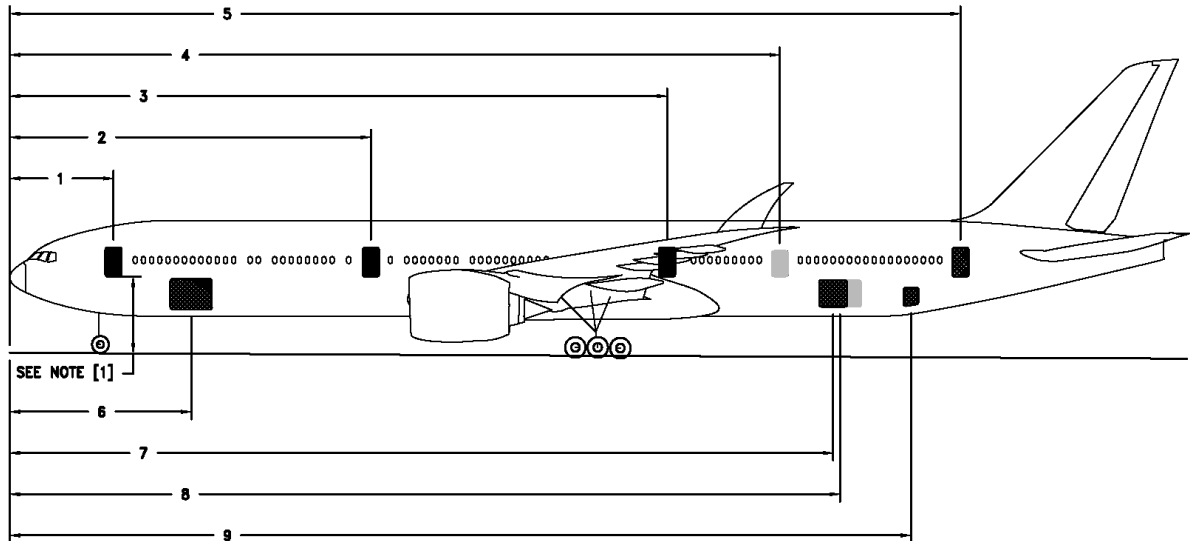


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PRELIMINARY INFORMATION

2.7 DOOR CLEARANCES

2.7.1 Door Clearances: Model 777-9, Door Locations



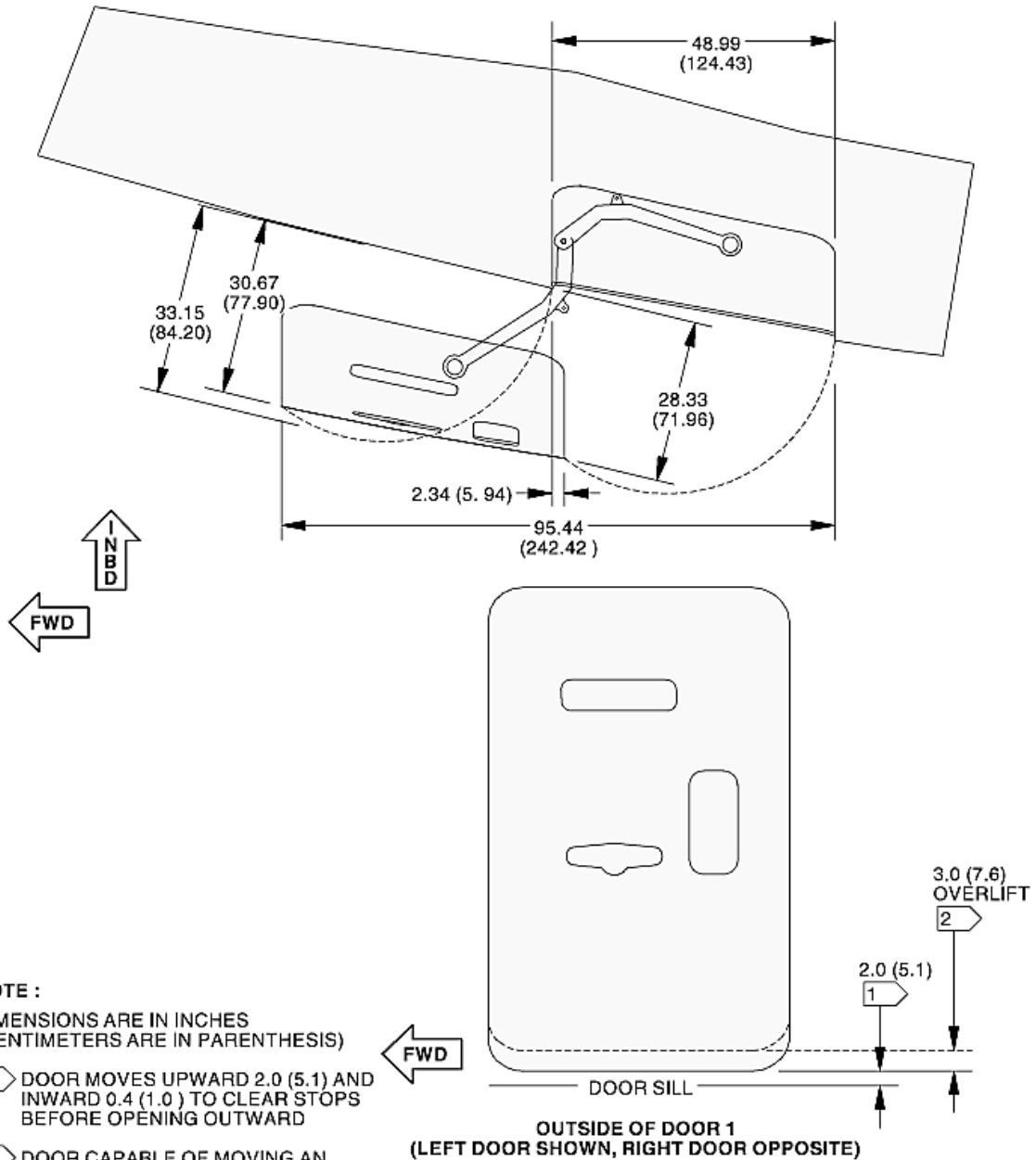
	Door Name	Door Location	Location FT-IN (M)	Clear Opening IN (M)
1	MAIN ENTRY/SERVICE DOOR NO 1 [2]	LEFT AND RIGHT	22-2 (6.76)	42 X 74 (1.07 X 1.88)
2	MAIN ENTRY/SERVICE DOOR NO 2 [2]	LEFT AND RIGHT	77-0 (23.47)	42 X 74 (1.07 X 1.88)
3	MAIN ENTRY/SERVICE DOOR NO 3 [2]	LEFT AND RIGHT	140-2 (42.72)	42 X 74 (1.07 X 1.88)
4	OPTIONAL EMERGENCY EXIT/SERVICE DOOR	LEFT AND RIGHT	164-3 (50.06)	34 X 72 (0.86 X 1.83)
5	MAIN ENTRY/SERVICE DOOR NO 4 [2]	LEFT AND RIGHT	202-9 (61.80)	42 X 74 (1.07 X 1.88)
6	FORWARD CARGO DOOR	RIGHT	38-9 (11.81)	106 X 67 (2.69 X 1.7)
7	STANDARD AFT CARGO DOOR	RIGHT	175-7 (53.52)	70 X 67 (1.78 X 1.7)
8	OPTIONAL AFT LARGE CARGO DOOR	RIGHT	177-1 (53.98)	106 X 67 (2.69 X 1.7)
9	BULK CARGO DOOR	RIGHT	192-3 (58.60)	36 X 45 (0.91 X 1.14)

NOTES:

1. SEE SEC 2.3 FOR DOOR SILL HEIGHTS
2. ENTRY DOORS LEFT SIDE, SERVICE DOORS RIGHT SIDE

PRELIMINARY INFORMATION

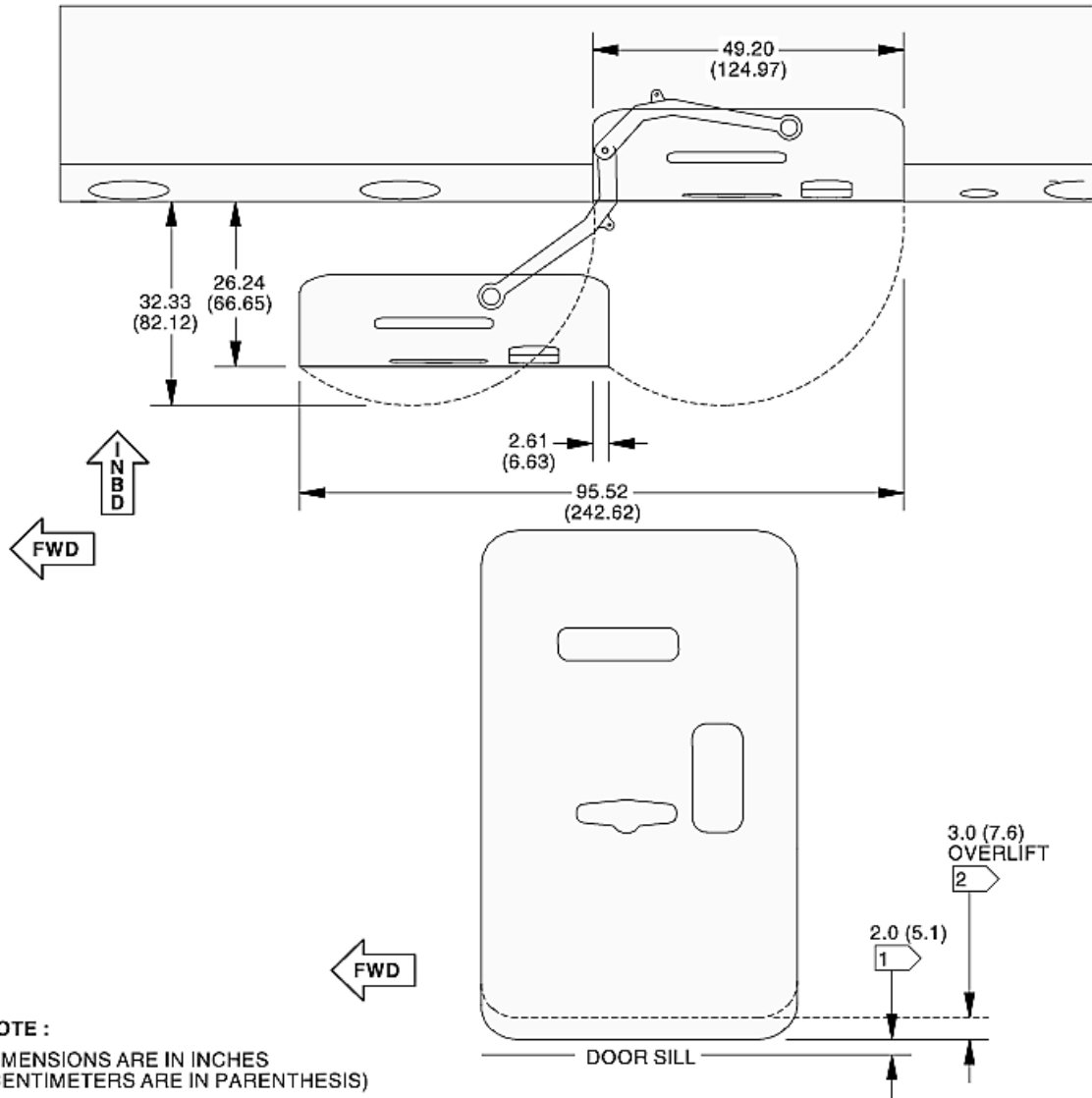
2.7.2 Door Clearances: Model 777-9, Main Entry Door No 1



D6-86073

PRELIMINARY INFORMATION

2.7.3 Door Clearances: Model 777-9, Main Entry Door No 2, and No 3



NOTE :

DIMENSIONS ARE IN INCHES
(CENTIMETERS ARE IN PARENTHESIS)

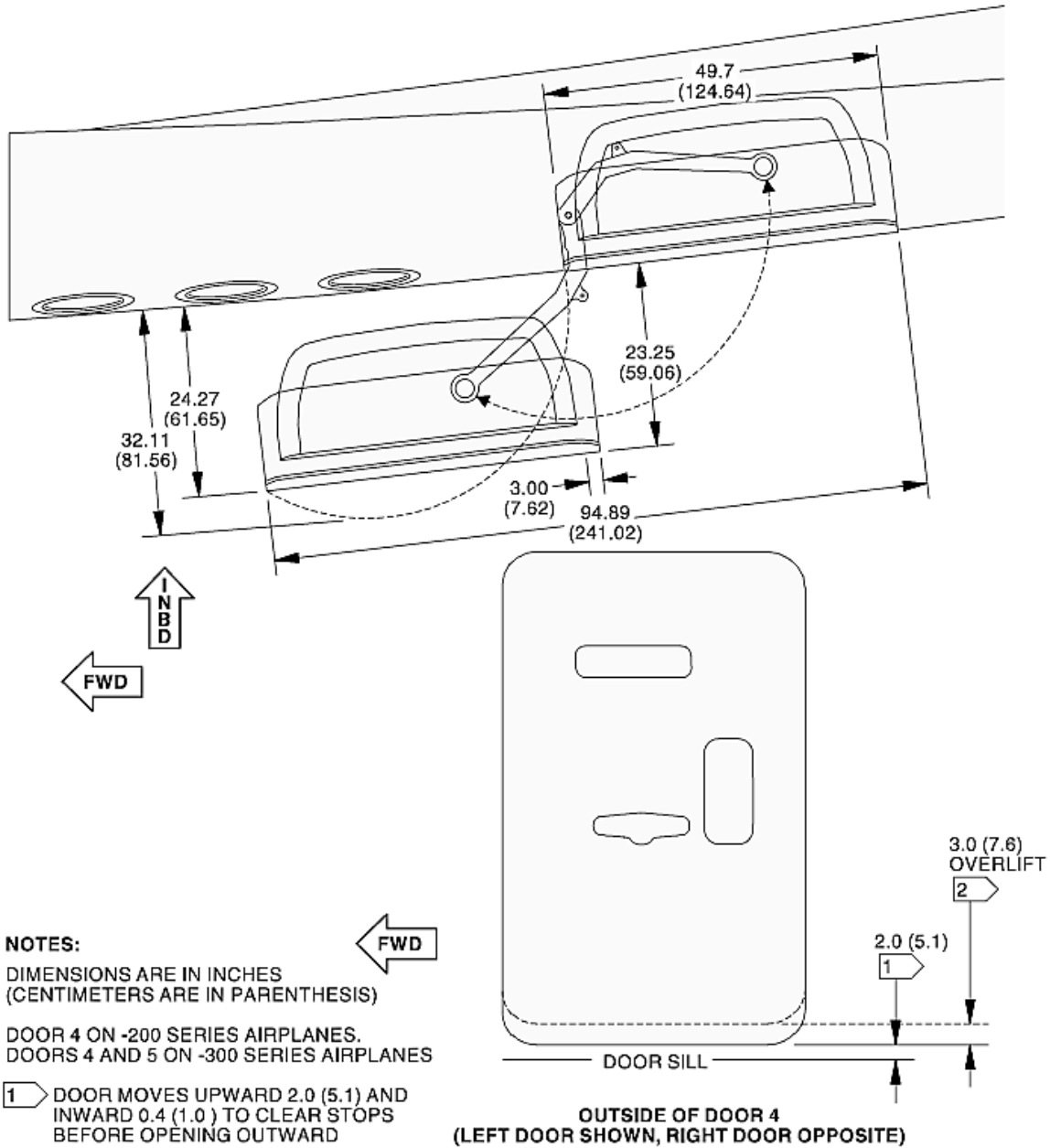
1 DOOR MOVES UPWARD 2.0 (5.1) AND INWARD 0.4 (1.0) TO CLEAR STOPS BEFORE OPENING OUTWARD

2 DOOR CAPABLE OF MOVING AN ADDITIONAL 3.0 (7.6) VERTICALLY (OVERLIFT) TO PRECLUDE DAMAGE FROM CONTACT WITH LOADING BRIDGE

OUTSIDE OF DOORS 2 & 3
(LEFT DOORS SHOWN, RIGHT DOORS OPPOSITE)

PRELIMINARY INFORMATION

2.7.4 Door Clearances: Model 777-9, Main Entry Door No 4



NOTES:

DIMENSIONS ARE IN INCHES
(CENTIMETERS ARE IN PARENTHESIS)

DOOR 4 ON -200 SERIES AIRPLANES.
DOORS 4 AND 5 ON -300 SERIES AIRPLANES

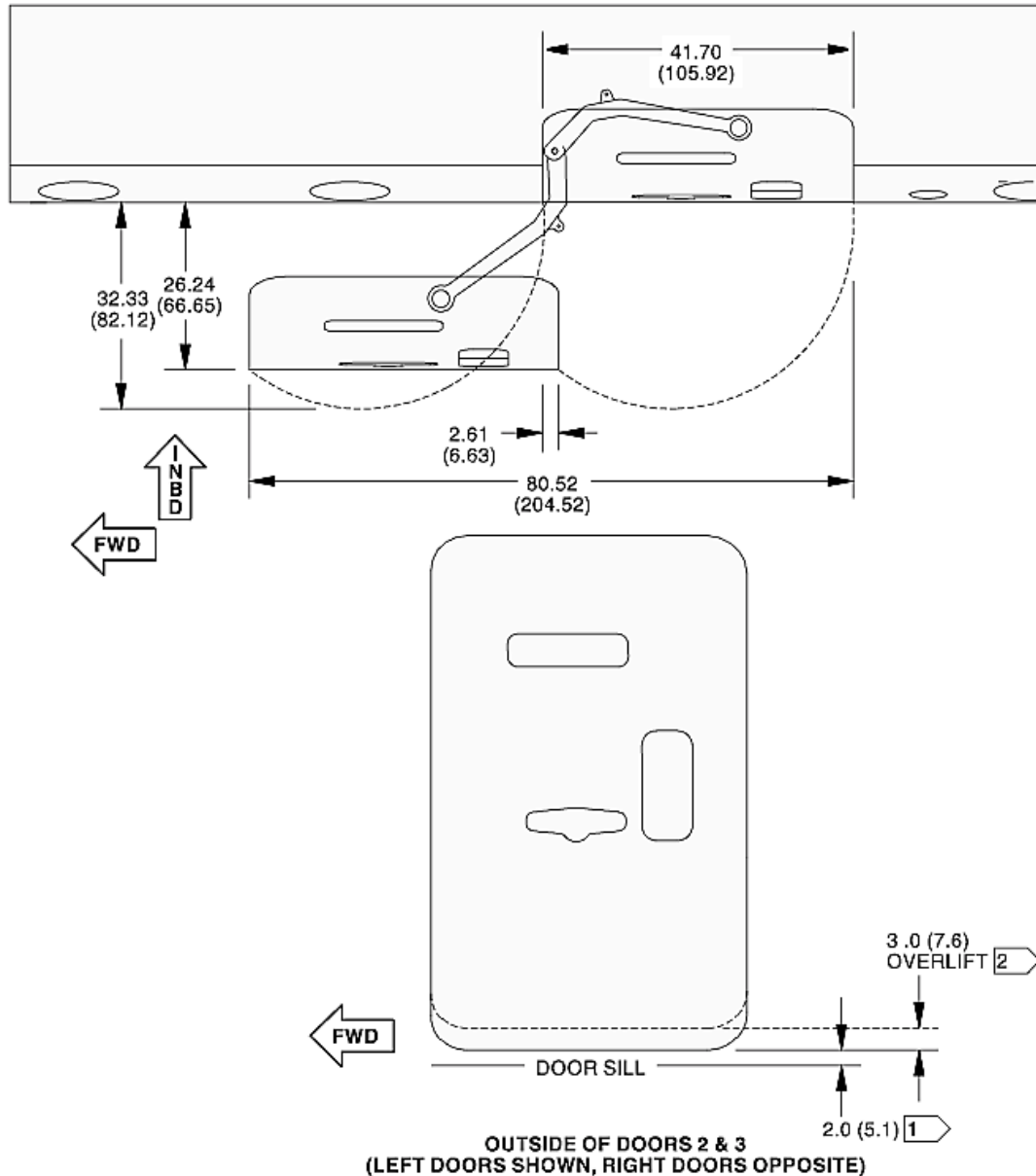
1 DOOR MOVES UPWARD 2.0 (5.1) AND
INWARD 0.4 (1.0) TO CLEAR STOPS
BEFORE OPENING OUTWARD

2 DOOR CAPABLE OF MOVING AN
ADDITIONAL 3.0 (7.6) VERTICALLY
(OVERLIFT) TO PRECLUDE
DAMAGE FROM CONTACT WITH
LOADING BRIDGE

OUTSIDE OF DOOR 4
(LEFT DOOR SHOWN, RIGHT DOOR OPPOSITE)

PRELIMINARY INFORMATION

2.7.5 Door Clearances: Model 777-9, Optional Service Door



NOTE:

DIMENSIONS ARE IN INCHES (CENTIMETERS ARE IN PARENTHESIS)

- 1 DOOR MOVES UPWARD 2.0 (5.1) AND INWARD 0.4 (1.0) TO CLEAR STOPS BEFORE OPENING OUTWARD
- 2 DOOR CAPABLE OF MOVING AN ADDITIONAL 3.0 (7.6) VERTICALLY (OVERLIFT) TO PRECLUDE DAMAGE FROM CONTACT WITH LOADING BRIDGE

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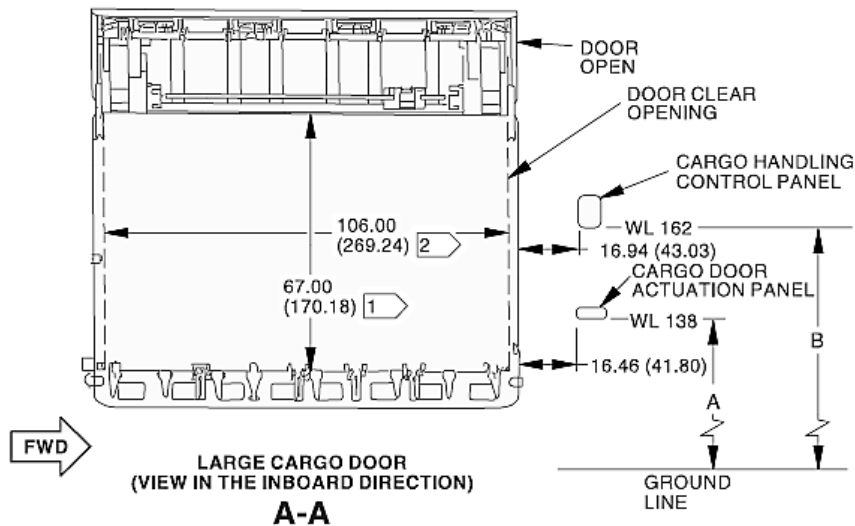
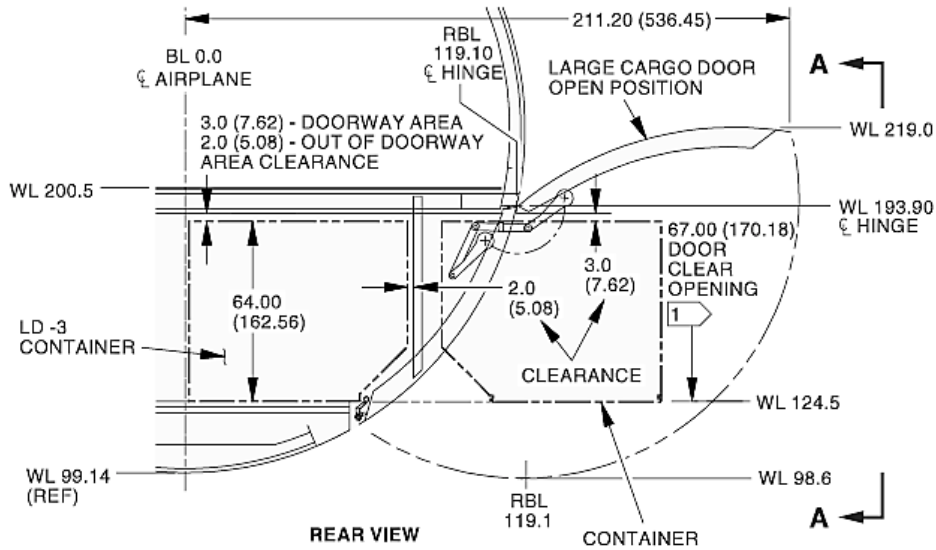
REV F

December 2024

2-13

PRELIMINARY INFORMATION

2.7.6 Door Clearances: Model 777-9, Large Forward Cargo Door



NOTE:

DIMENSIONS ARE IN INCHES
(CENTIMETERS ARE IN PARENTHESIS).

- 1 67 (170.18) IN DOORWAY AREA ONLY
66 (167.64) INSIDE REST OF THE COMPARTMENT
- 2 CLEAR OPENING BETWEEN GUIDE ROLLERS AT THE DOOR SILL AREA IS 97.1 (246.63)

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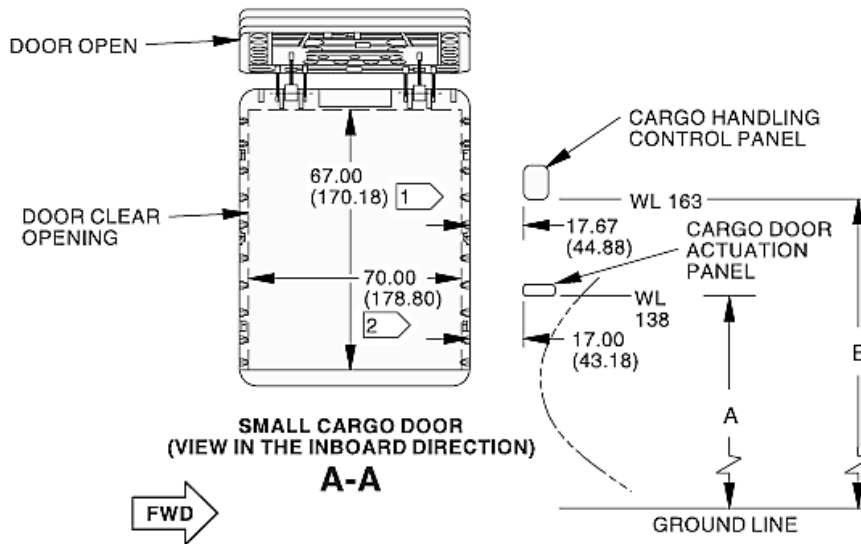
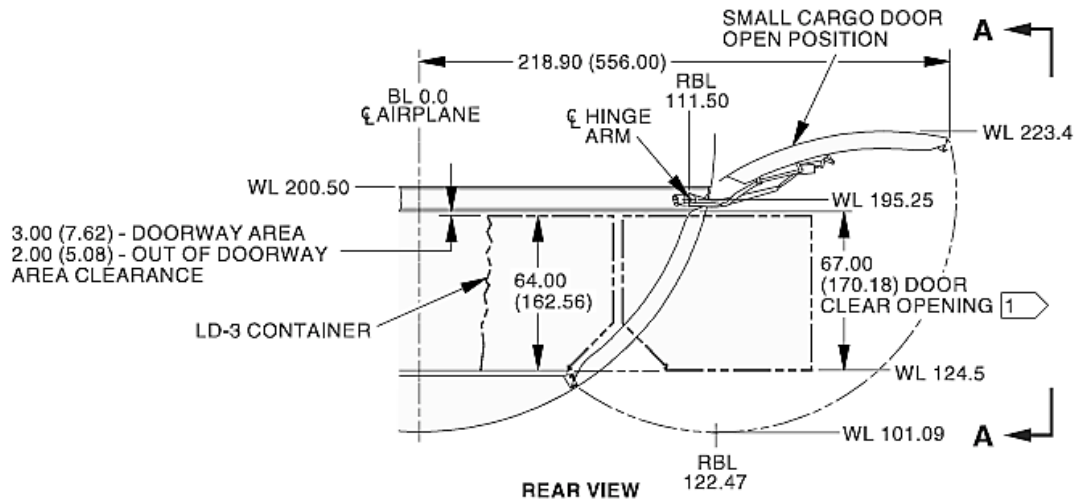
REV F

December 2024

2-14

PRELIMINARY INFORMATION

2.7.7 Door Clearances: Model 777-9, Small Aft Cargo Door



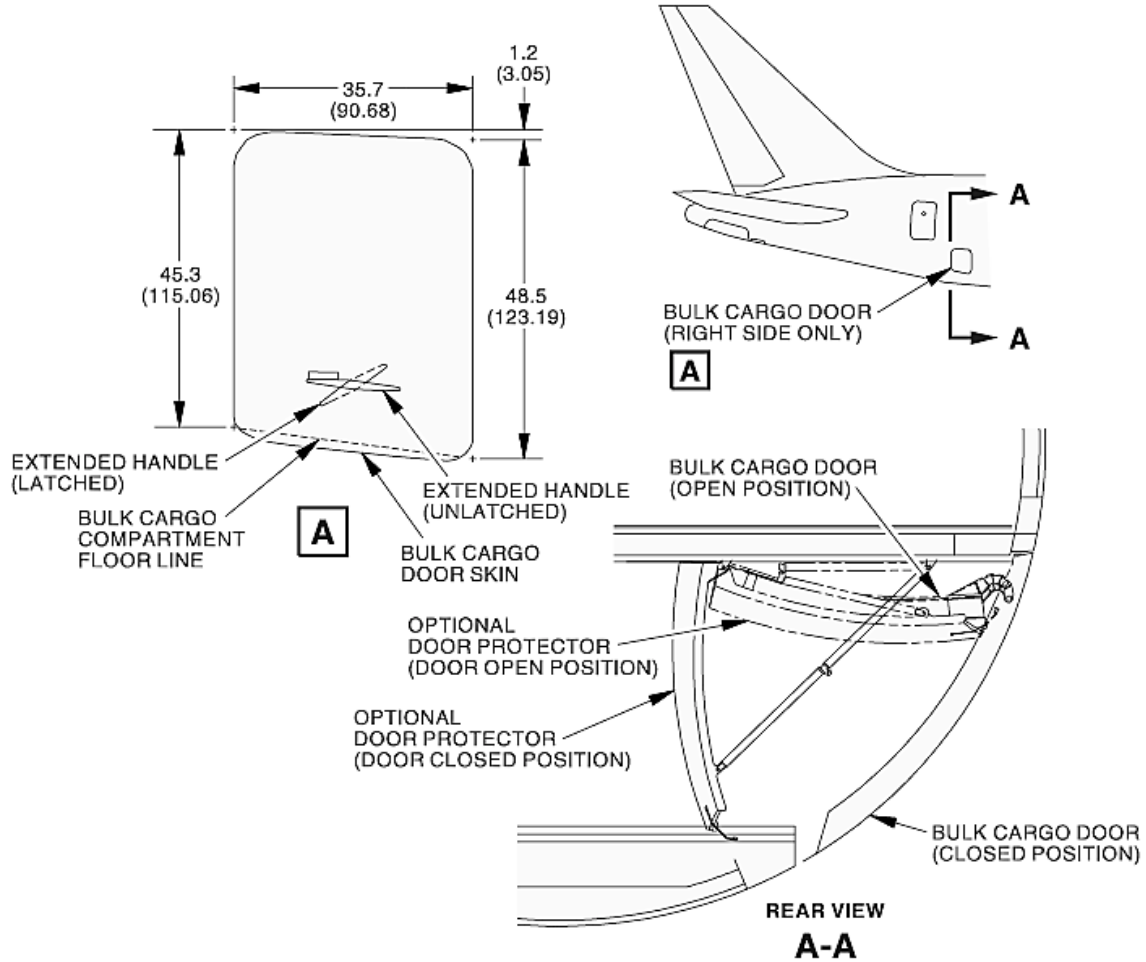
NOTE:

DIMENSIONS ARE IN INCHES
(CENTIMETERS ARE IN PARENTHESIS).

- 1 67 (170.18) IN DOORWAY AREA ONLY
66 (167.64) INSIDE REST OF THE COMPARTMENT
- 2 CLEAR OPENING BETWEEN GUIDE ROLLERS AT THE
DOOR SILL AREA IS 97.1 (246.63)

PRELIMINARY INFORMATION

2.7.8 Door Clearances: Model 777-9, Bulk Cargo Door



D6-86073

REV F

December 2024

2-16

PRELIMINARY INFORMATION

3.0 AIRPLANE PERFORMANCE

3.1 GENERAL INFORMATION

The graphs in Section 3.2 provide information on payload-range capability of the 777 airplane. To use these graphs, if the trip range and zero fuel weight (OEW + payload) are known, the approximate takeoff weight can be found, limited by maximum zero fuel weight, maximum design takeoff weight, or fuel capacity.

The graphs in Section 3.3 provide information on FAA/EASA takeoff runway length requirements with typical engines at different pressure altitudes. Maximum takeoff weights shown on the graphs are the heaviest for the particular airplane models with the corresponding engines. Standard day temperatures for pressure altitudes shown on the FAA/EASA takeoff graphs are given below:

PRESSURE ALTITUDE		STANDARD DAY TEMP	
FEET	METERS	°F	°C
0	0	59.0	15.0
2,000	610	51.9	11.0
4,000	1,219	44.7	7.1
6,000	1,829	37.6	3.1
8,000	2,438	30.5	-0.8
10,000	3,048	23.3	-4.8
12,000	3,658	16.2	-8.8
14,000	4,267	9.1	-12.7

The graphs in Section 3.4 provide information on landing runway length requirements for different airplane weights and airport altitudes. The maximum landing weights shown are the heaviest for the particular airplane model.

PRELIMINARY INFORMATION

3.2 PAYLOAD/RANGE FOR LONG RANGE CRUISE

3.2.1 Payload/Range for Long Range Cruise: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

PRELIMINARY INFORMATION

3.3 FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS

3.3.1 FAA/EASA Takeoff Runway Length Requirements: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

PRELIMINARY INFORMATION

3.4 FAA/EASA LANDING RUNWAY LENGTH REQUIREMENTS

3.4.1 FAA/EASA Landing Runway Length Requirements: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

PRELIMINARY INFORMATION

4.0 GROUND MANEUVERING

4.1 GENERAL INFORMATION

The 777 main landing gear consists of two main struts, each strut with six wheels. The steering system incorporates aft axle steering of the main landing gear in addition to the nose gear steering. The aft axle steering system is hydraulically actuated and programmed to provide steering ratios proportionate to the nose gear steering angles. During takeoff and landing, the aft axle steering system is centered, mechanically locked, and depressurized.

The turning radii and turning curves shown in this section are derived from airplane geometry. Other factors that could influence the geometry of the turn include:

1. Engine power settings
2. Center of gravity location
3. Airplane weight
4. Pavement surface conditions
5. Amount of differential braking
6. Ground speed

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. These data should be used only as guidelines for the method of determination of such parameters and for the maneuvering characteristics of this aircraft.

In the ground operating mode, varying airline practices may demand that more conservative turning procedures be adopted to avoid excessive tire wear and reduce possible maintenance problems. Airline operating procedures will vary in the level of performance over a wide range of operating 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 area, or high risk of jet blast damage. For these reasons, ground maneuvering requirements should be coordinated with the using airlines prior to layout planning.

Section 4.2 presents turning radii for various nose gear steering angles. Radii for the main and nose gears are measured from the turn center to the outside of the tire.

Section 4.3 shows data on minimum width of pavement required for 180° turn.

Section 4.4 provides pilot visibility data from the cockpit and the limits of ambinocular vision through the windows. Ambinocular vision is defined as the total field of vision seen simultaneously by both eyes.

Section 4.5 shows approximate wheel paths for various runway and taxiway turn scenarios. The pavement fillet geometries are based on the FAA's Advisory Circular (AC) 150/5300-

PRELIMINARY INFORMATION

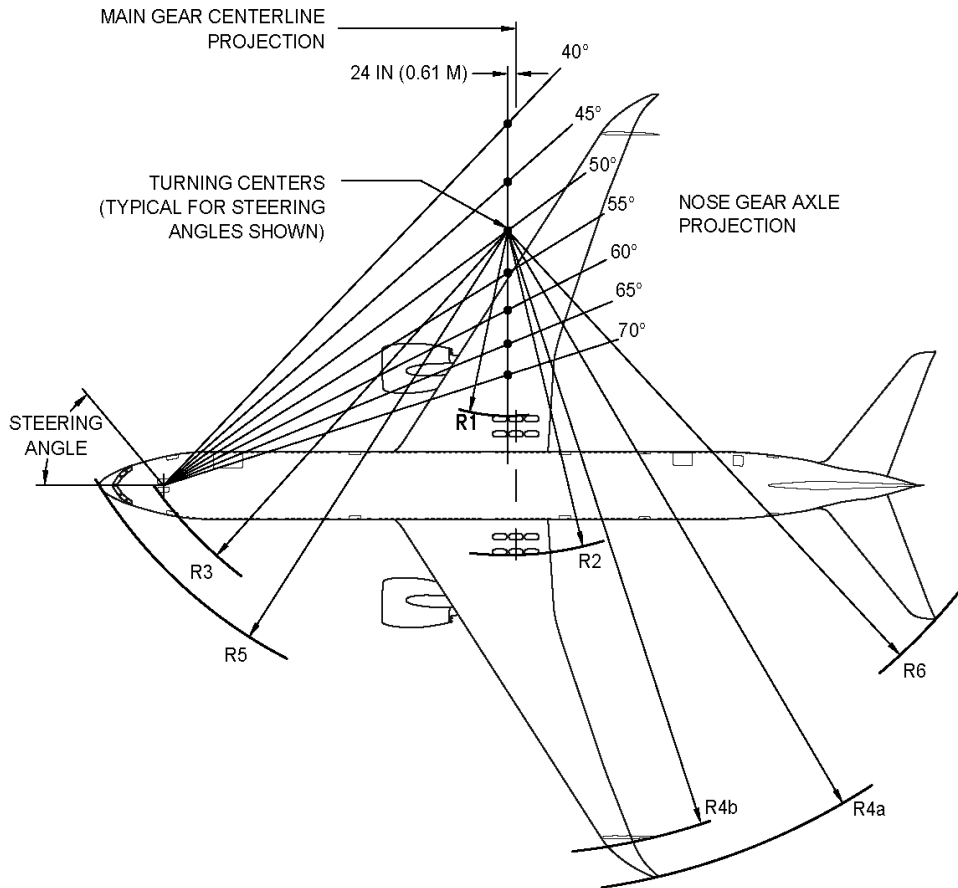
13 (thru change 16). They represent typical fillet geometries built at many airports worldwide. ICAO and other civil aviation authorities publish many different fillet design methods. Prior to determining the size of fillets, airports are advised to check with the airlines regarding the operating procedures and aircraft types they expect to use at the airport. Further, given the cost of modifying fillets and the operational impact to ground movement and air traffic during construction, airports may want to design critical fillets for larger aircraft types to minimize future operational impacts.

Section 4.6 illustrates a typical runway holding bay configuration.

PRELIMINARY INFORMATION

4.2 TURNING RADII

4.2.1 Turning Radii – No Slip Angle: Model 777-9



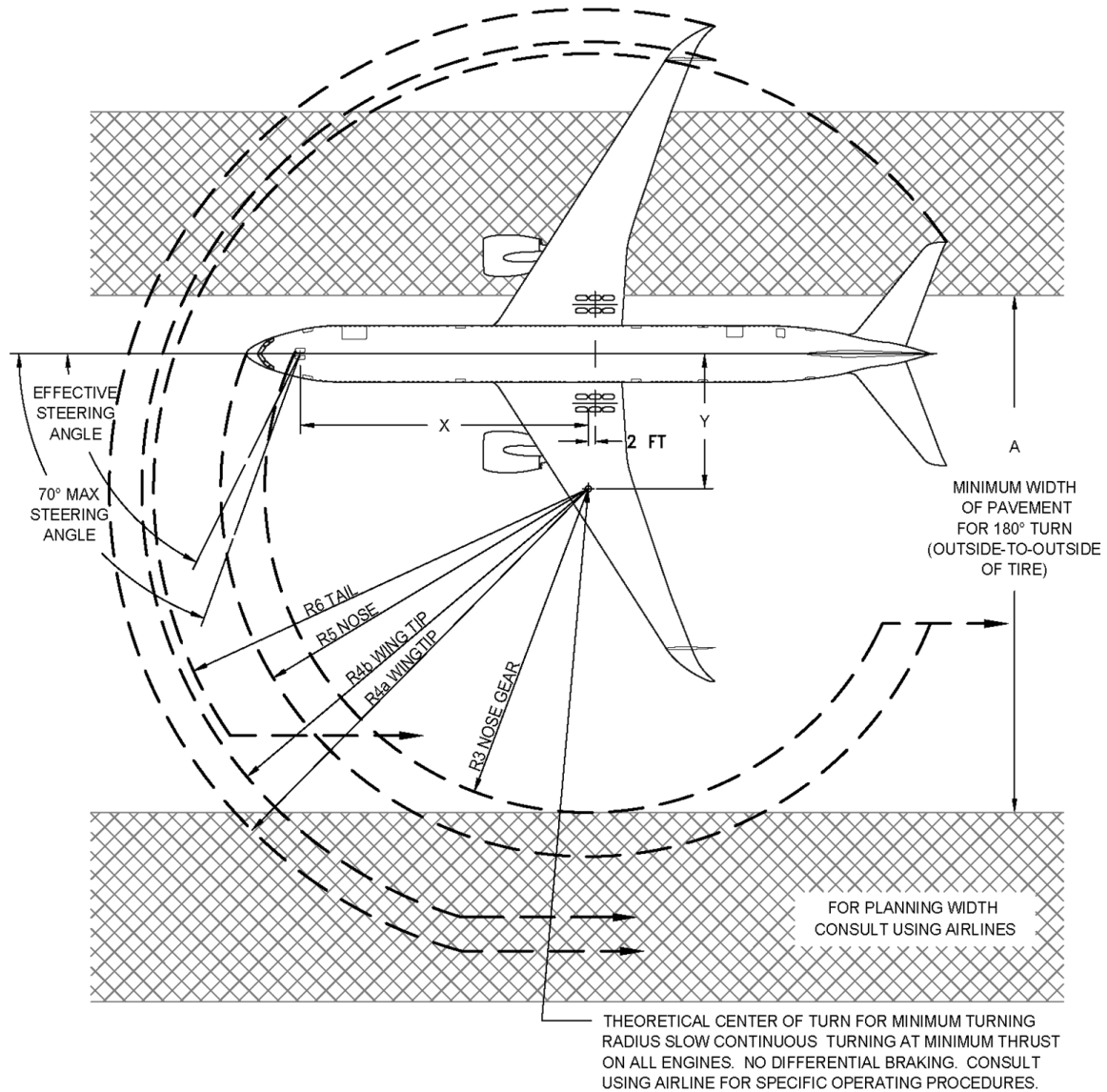
STEERING ANGLE (DEG)	R1 INNER GEAR		R2 OUTER GEAR		R3 NOSE GEAR		R4a WING TIP		R4b WING TIP		R5 NOSE		R6 TAIL	
	FT	M	FT	M	FT	M	FT	M	FT	M	FT	M	FT	M
30	160	48.8	202	61.6	211	64.3	302	92.0	290	88.4	219	66.8	256	78.0
35	128	39.0	170	51.8	184	56.1	270	82.3	259	78.9	194	59.1	229	69.8
40	104	31.7	145	44.2	164	50.0	246	75.0	235	71.6	175	53.3	209	63.7
45	84	25.6	125	38.1	150	45.7	226	68.9	215	65.5	162	49.4	194	59.1
50	67	20.4	109	33.2	138	42.1	210	64.0	199	60.7	152	46.3	181	55.2
55	52	15.8	94	28.7	130	39.6	196	59.7	185	56.4	144	43.9	172	52.4
60	40	12.2	81	24.7	123	37.5	183	55.8	172	52.4	138	42.1	163	49.7
65	28	8.5	70	21.3	117	35.7	172	52.4	161	49.1	133	40.5	157	47.9
70 (MAX)	17	5.2	59	18.0	113	34.4	162	49.4	151	46.0	130	39.6	151	46.0

NOTES: DATA SHOWN FOR AIRPLANE WITH AFT AXLE STEERING
 ACTUAL OPERATING TURNING RADII MAY BE GREATER THAN SHOWN
 CONSULT WITH AIRLINE FOR SPECIFIC OPERATING PROCEDURE
 DIMENSIONS ROUNDED TO NEAREST WHOLE FOOT AND 0.1 METER
 R4a: FOLDING WING TIP - EXTENDED
 R4b: FOLDING WING TIP - FOLDED

PRELIMINARY INFORMATION

4.3 CLEARANCE RADII

4.3.1 Clearance Radii – Model 777-9

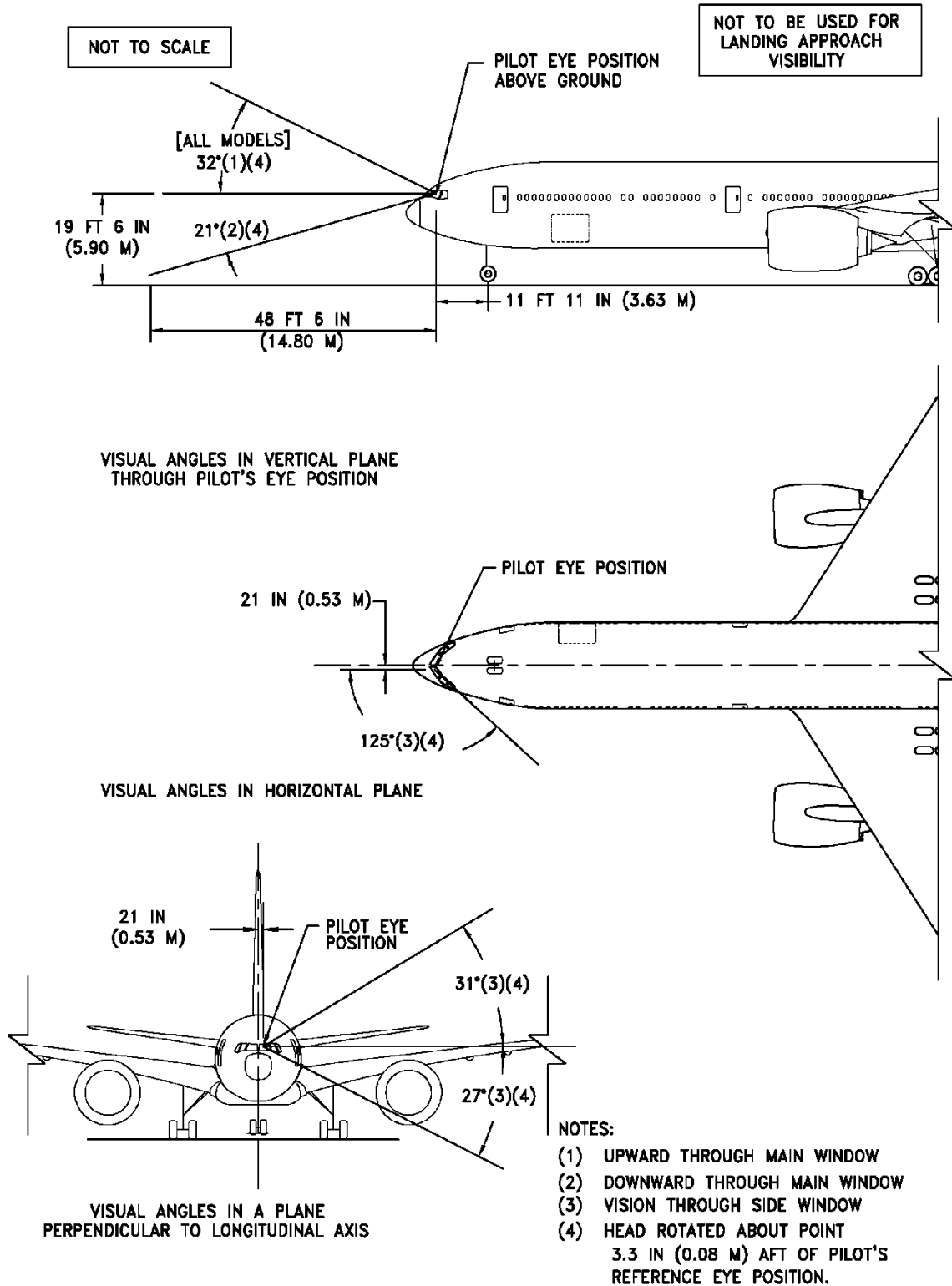


AIRPLANE MODEL	EFFECTIVE TURNING ANGLE (DEG)	X		Y		A		R3		R4a		R4b		R5		R6	
		FT	M	FT	M	FT	M	FT	M	FT	M	FT	M	FT	M	FT	M
777-9	64	104	31.7	51	15.5	190	57.9	118	36.0	174	53.0	163	49.7	134	40.8	158	48.2

NOTES: DIMENSIONS ARE ROUNDED TO THE NEAREST WHOLE FOOT AND 0.1 METER.
R4a: FOLDING WING TIP - EXTENDED
R4b: FOLDING WING TIP - FOLDED

PRELIMINARY INFORMATION

4.4 VISIBILITY FROM COCKPIT IN STATIC POSITION: MODEL 777-9



D6-86073

REV F

December 2024

4-5

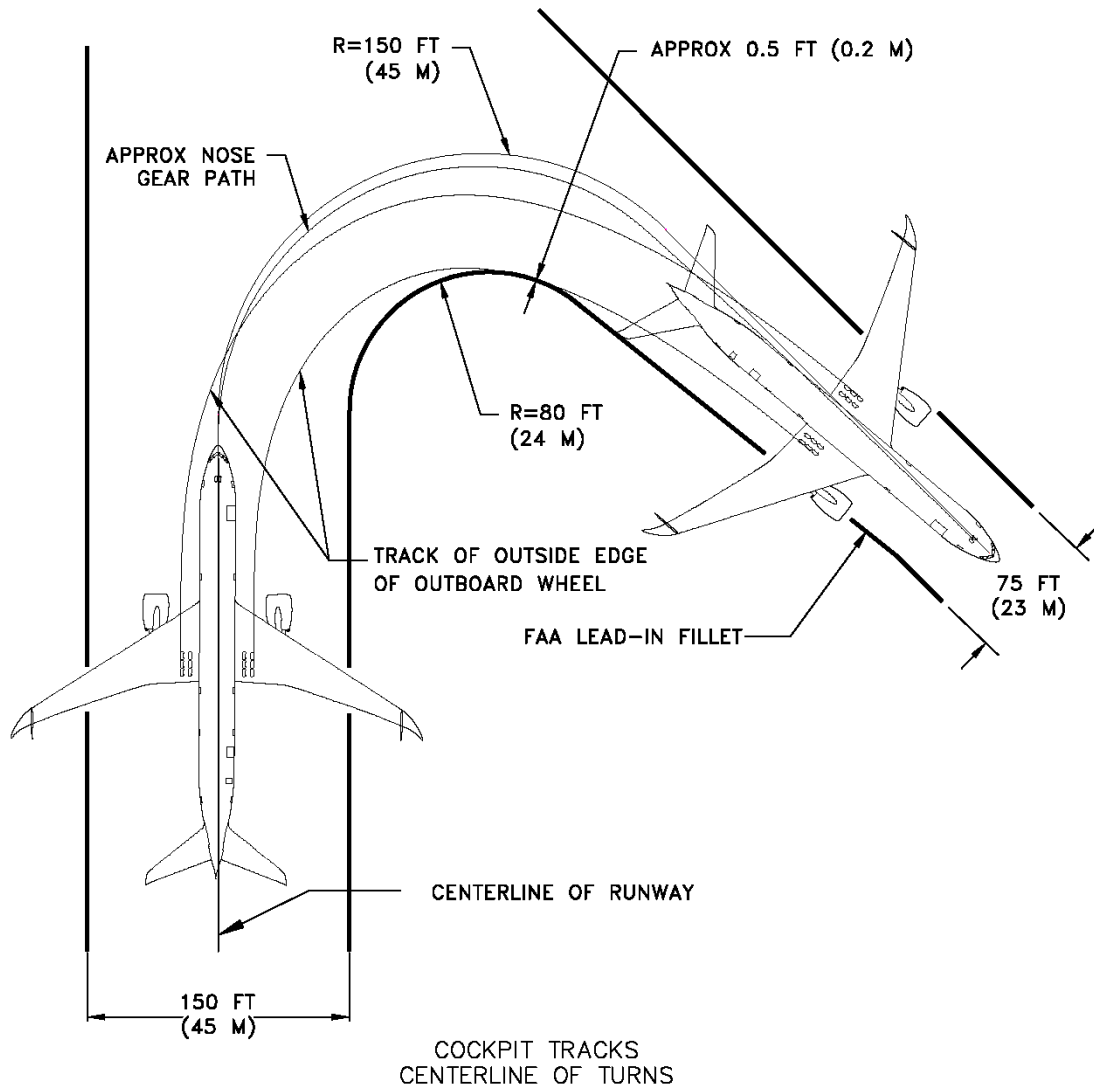
PRELIMINARY INFORMATION

4.5 RUNWAY AND TAXIWAY TURN PATHS

4.5.1 Runway and Taxiway Turn Paths - Runway-to-Taxiway, More Than 90 Degree Turn: Model 777-9

NOTES:

BEFORE DETERMINING THE SIZE OF THE INTERSECTION FILLET, CHECK WITH THE AIRLINES REGARDING THE OPERATING PROCEDURES THAT THEY USE AND THE AIRCRAFT TYPES THEY ARE EXPECTED TO USE AT THE AIRPORT



D6-86073

REV F

December 2024

4-6

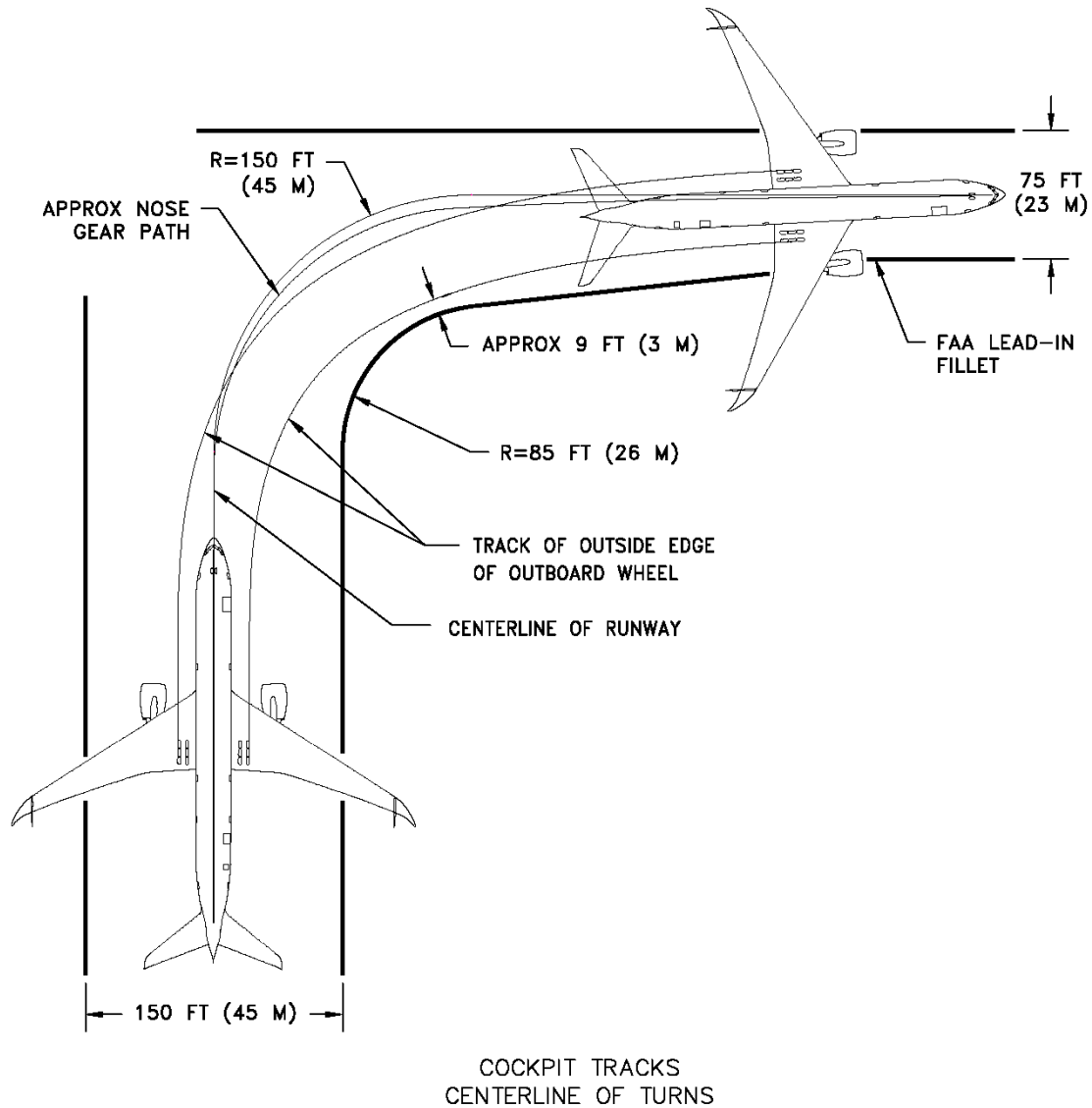
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PRELIMINARY INFORMATION

4.5.2 Runway and Taxiway Turn Paths - Runway-to-Taxiway, 90 Degree Turn: Model 777-9

NOTES:

BEFORE DETERMINING THE SIZE OF THE INTERSECTION FILLET, CHECK WITH THE AIRLINES REGARDING THE OPERATING PROCEDURES THAT THEY USE AND THE AIRCRAFT TYPES THEY ARE EXPECTED TO USE AT THE AIRPORT



D6-86073

REV F

December 2024

4-7

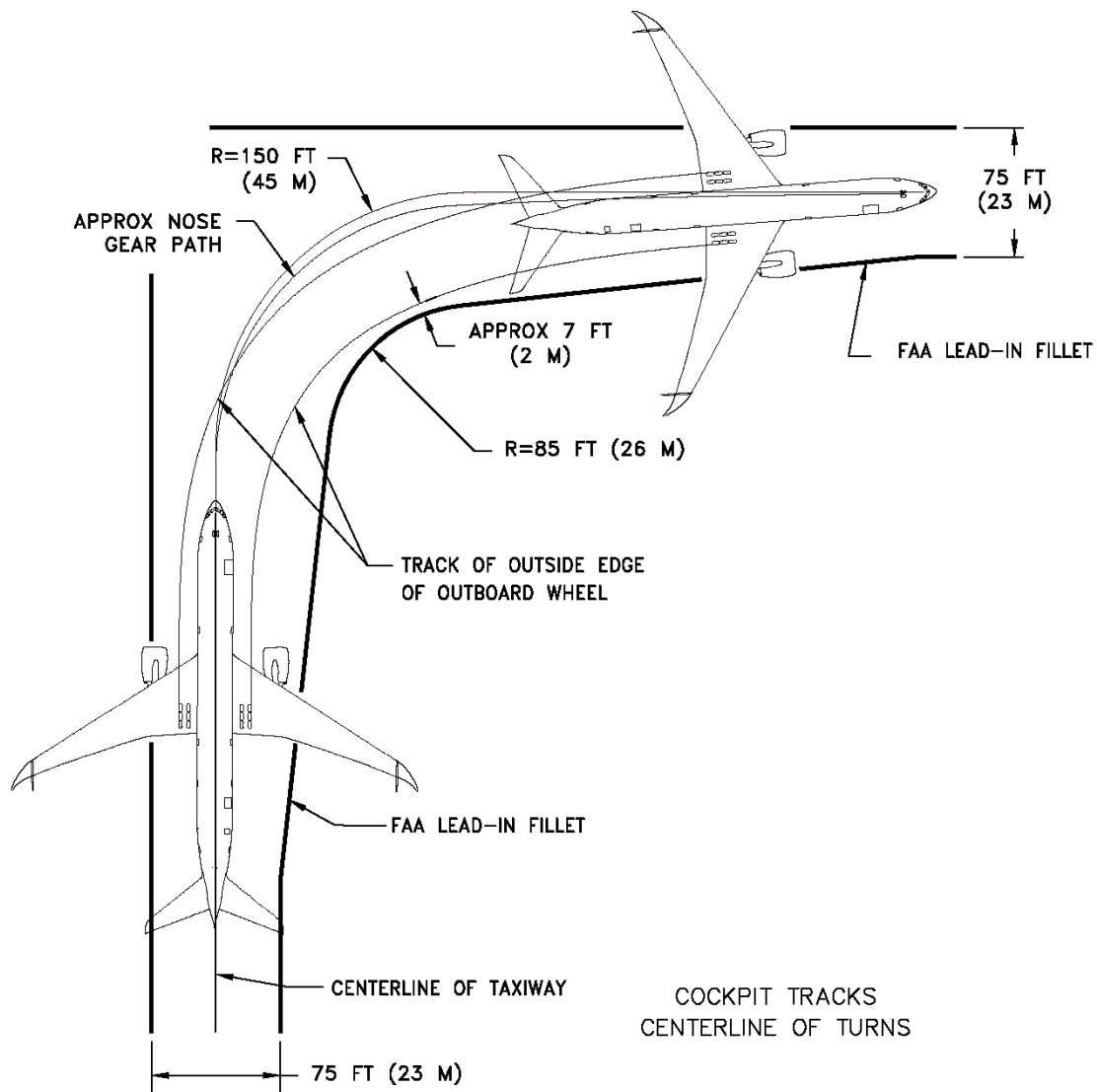
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PRELIMINARY INFORMATION

4.5.3 Runway and Taxiway Turn Paths - Taxiway-to-Taxiway, 90 Degree Turn: Model 777-9

NOTES:

BEFORE DETERMINING THE SIZE OF THE INTERSECTION FILLET, CHECK WITH THE AIRLINES REGARDING THE OPERATING PROCEDURES THAT THEY USE AND THE AIRCRAFT TYPES THEY ARE EXPECTED TO USE AT THE AIRPORT



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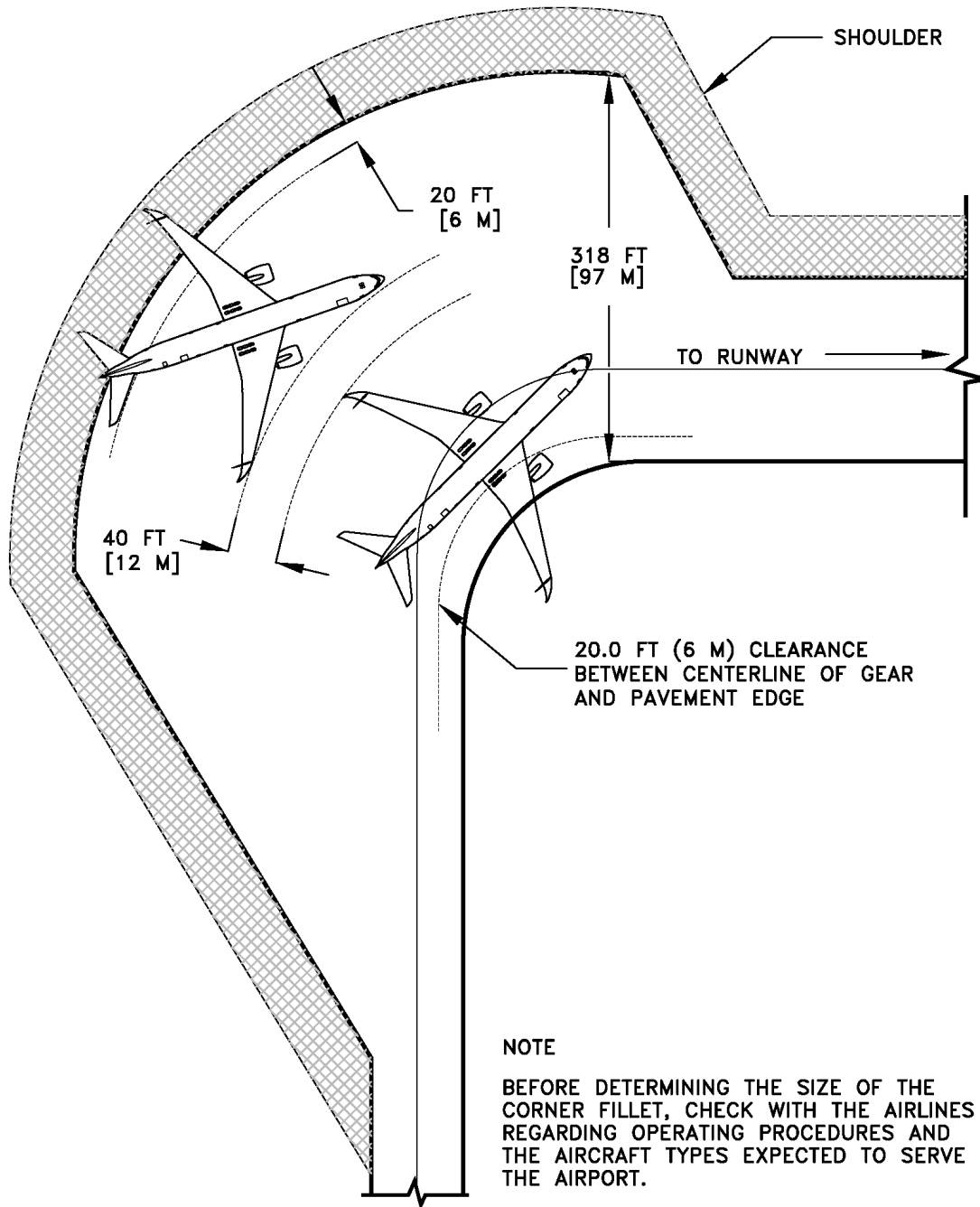
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4-8

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PRELIMINARY INFORMATION

4.6 RUNWAY HOLDING BAY: MODEL 777-9



D6-86073

REV F

December 2024

4-9

PRELIMINARY INFORMATION

5.0 TERMINAL SERVICING

During turnaround at the terminal, certain services must be performed on the aircraft, usually within a given time, to meet flight schedules. This section shows service vehicle arrangements, schedules, locations of service points, and typical service requirements. The data presented in this section reflect ideal conditions for a single airplane. Service requirements may vary according to airplane condition and airline procedure.

Section 5.1 shows typical arrangements of ground support equipment during turnaround. As noted, if the auxiliary power unit (APU) is used, the electrical, air start, and air-conditioning service vehicles would not be required. Passenger loading bridges or portable passenger stairs could be used to load or unload passengers.

Sections 5.2 and 5.3 show typical service times at the terminal. These charts give typical schedules for performing service on the airplane within a given time. Service times could be rearranged to suit availability of personnel, airplane configuration, and degree of service required.

Section 5.4 shows the locations of ground service connections in graphic and in tabular forms. Typical capacities and service requirements are shown in the tables. Services with requirements that vary with conditions are described in subsequent sections.

Section 5.5 shows typical sea level air pressure and flow requirements for starting the engines. The curves are based on an engine start time of 90 seconds.

Section 5.6 shows air conditioning requirements for heating and cooling (pull-down and pull-up) using ground conditioned air. The curves show airflow requirements to heat or cool the airplane within a given time at ambient conditions.

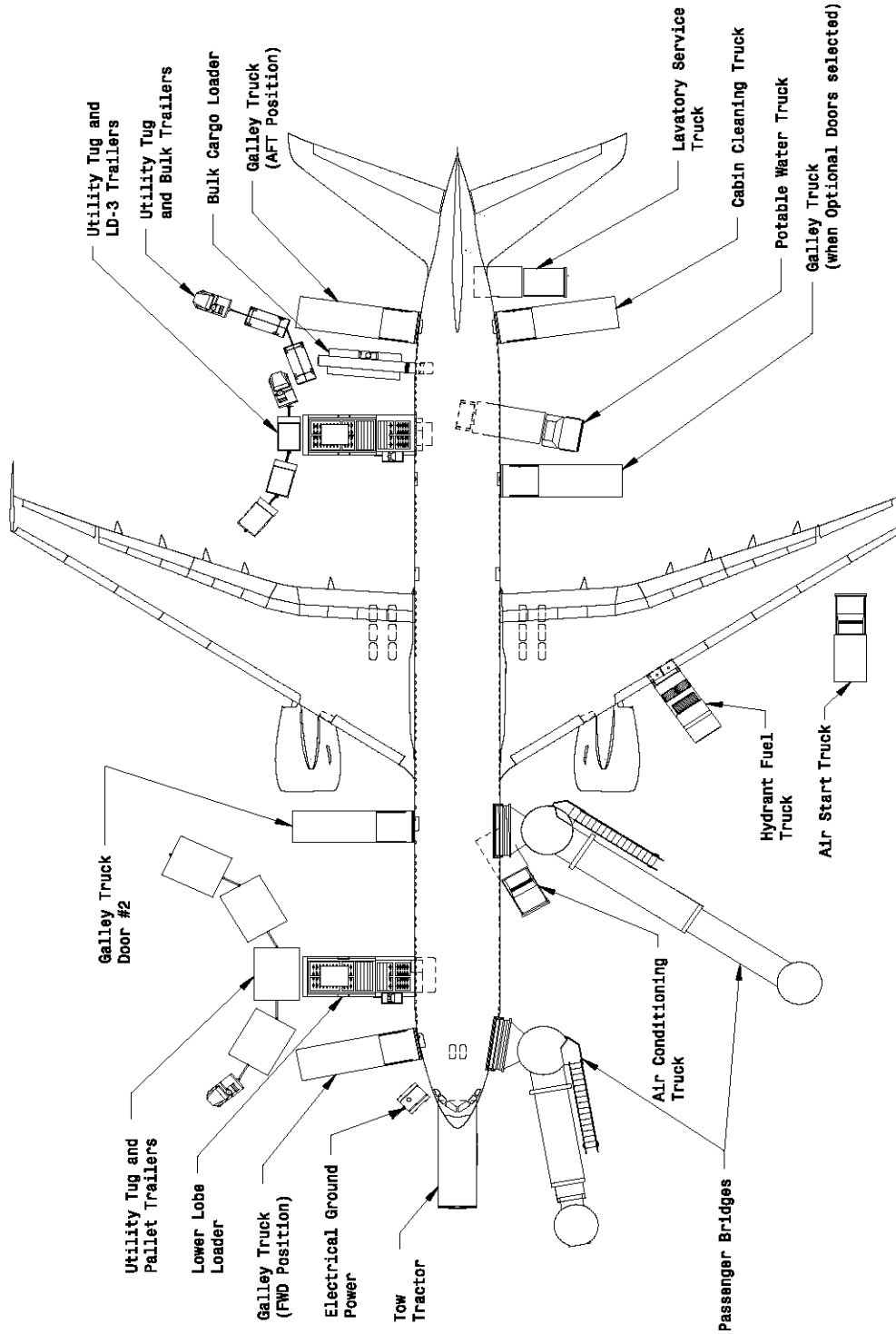
Section 5.7 shows air conditioning requirements for heating and cooling to maintain a constant cabin air temperature using low pressure conditioned air. This conditioned air is supplied through an 8-in ground air connection (GAC) directly to the passenger cabin, bypassing the air cycle machines.

Section 5.8 shows ground towing requirements for various ground surface conditions.

PRELIMINARY INFORMATION

5.1 AIRPLANE SERVICING ARRANGEMENT - TYPICAL TURNAROUND

5.1.1 Airplane Servicing Arrangement - Typical Turnaround: Model 777-9

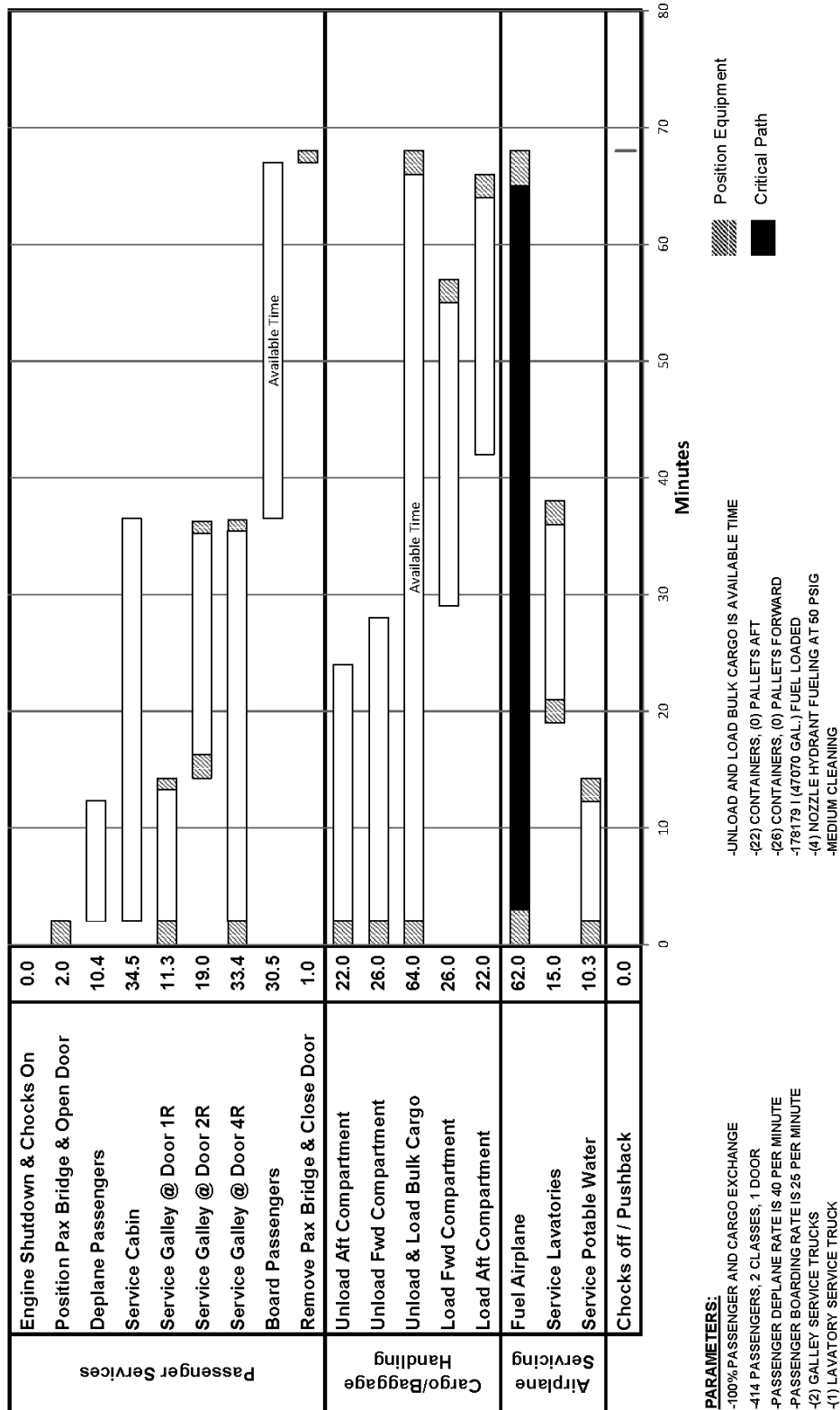


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PRELIMINARY INFORMATION

5.2 TERMINAL OPERATIONS - TURNAROUND STATION

5.2.1 Terminal Operations - Turnaround Station: Model 777-9

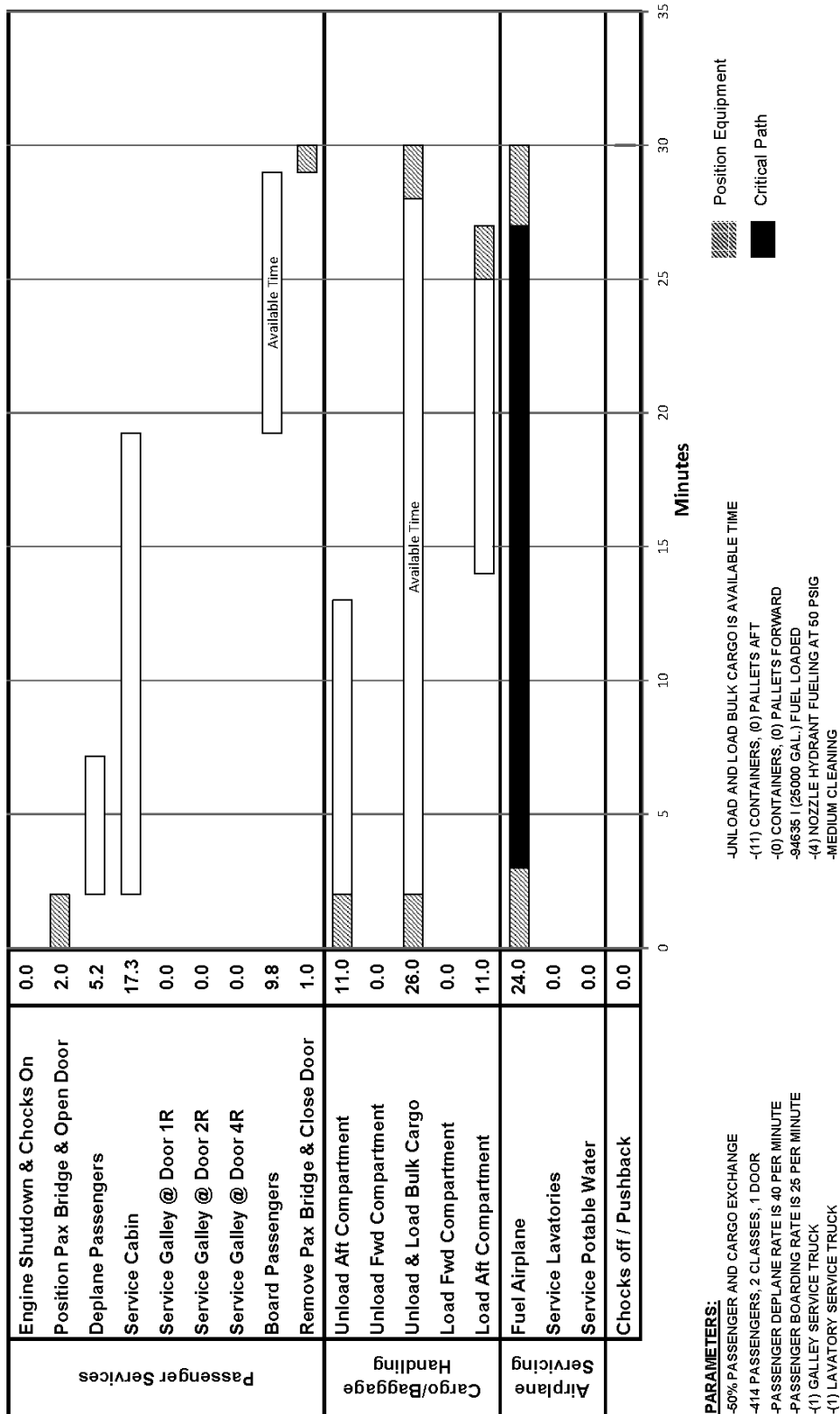


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PRELIMINARY INFORMATION

5.3 TERMINAL OPERATIONS - EN ROUTE STATION

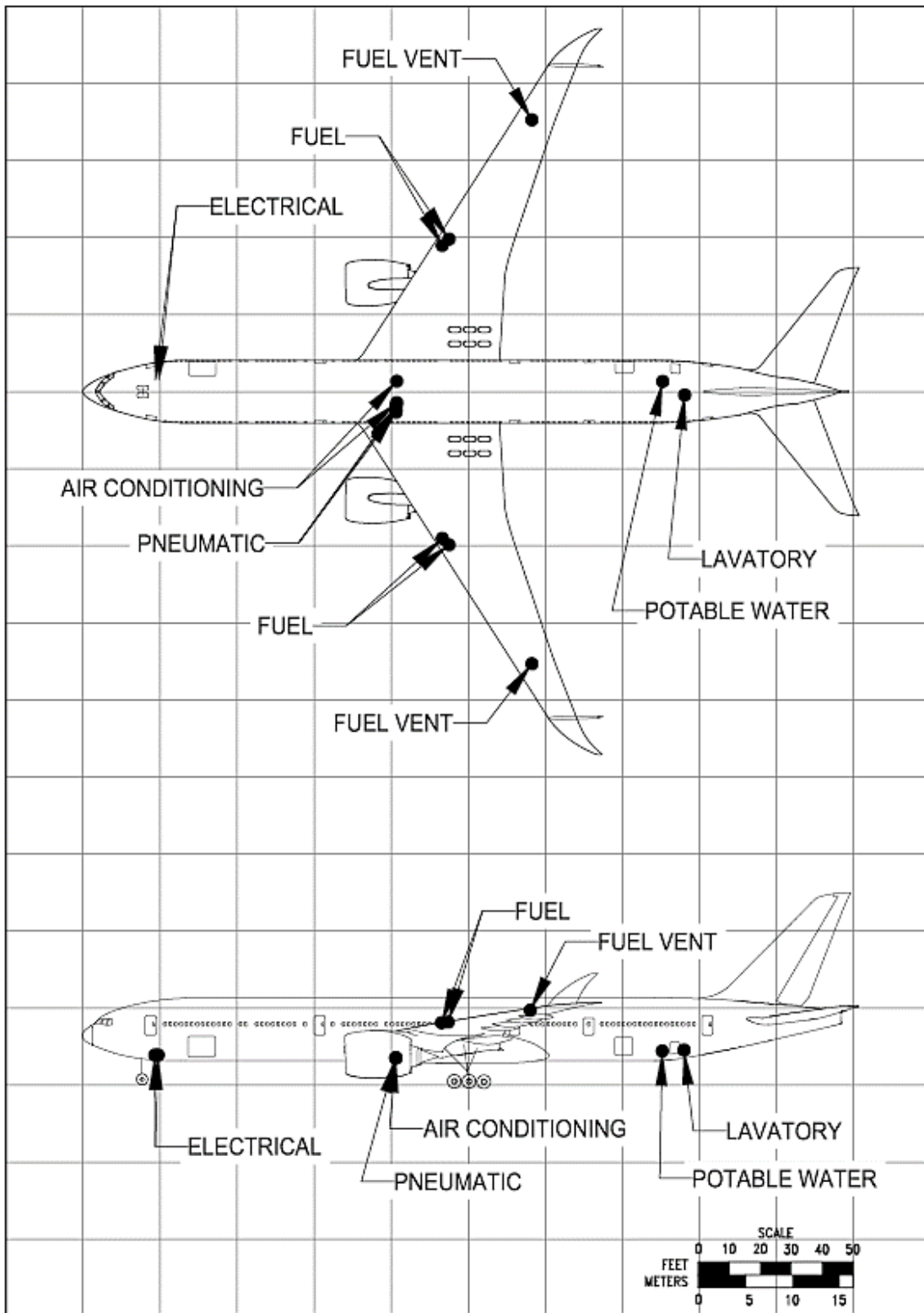
5.3.1 Terminal Operations - En Route Station: Model 777-9



PRELIMINARY INFORMATION

5.4 GROUND SERVICING CONNECTIONS

5.4.1 Ground Service Connections: Locations: Model 777-9



D6-86073

PRELIMINARY INFORMATION

5.4.2 Ground Servicing Connections and Capacities: Model 777-9

SYSTEM	MODEL	DISTANCE AFT OF		DISTANCE FROM AIRPLANE CENTERLINE				MAX HEIGHT ABOVE	
		NOSE [1]		LH SIDE [1]		RH SIDE [1]		GROUND [1]	
		FT-IN	M	FT-IN	M	FT-IN	M	FT-IN	M
CONDITIONED AIR TWO 8-IN (20.3 CM) PORTS	777-9	101-1	30.8	3-6	1.1	3-6	1.1	8-5	2.6
ELECTRICAL TWO CONNECTIONS 90 KVA, 200/115 V AC 400 HZ, 3-PHASE EACH	777-9	23-0 23-5	7.0 7.1	--	--	3-9	1.1	9-10	3.0
FUEL TWO UNDERWING PRESSURE CONNECTORS ON EACH WING	777-9	118-1 115-11	36.0 35.3	49-8 47-7	15.1 14.5	49-8 47-7	15.1 14.5	20-0 19-9	6.1 6.0
FUEL VENT FUEL VENT ON UNDERSIDE OF BOTH WINGS	777-9	145-0	44.2	88-5	27.0	88-5	27.0	24-5	7.4
LAVATORY [2] ONE SERVICE CONNECTION	777-9	194-8	59.3	1-0	0.3	--	--	10-1	3.1
PNEUMATIC THREE 3-IN (7.6-CM) PORTS	777-9	100-11	30.8	6-7 5-8 4-9	2.0 1.7 1.4	--	--	8-4	2.5
POTABLE WATER [3] ONE SERVICE CONNECTION	777-9	187-6	57.2	--	--	3-5	1.0	9-11	3.0

[1] DISTANCES OR HEIGHTS ROUNDED TO THE NEAREST INCH AND 0.1 METER

[2] COORDINATES FOR DRAIN CONNECTION

[3] COORDINATES FOR FILL CONNECTION

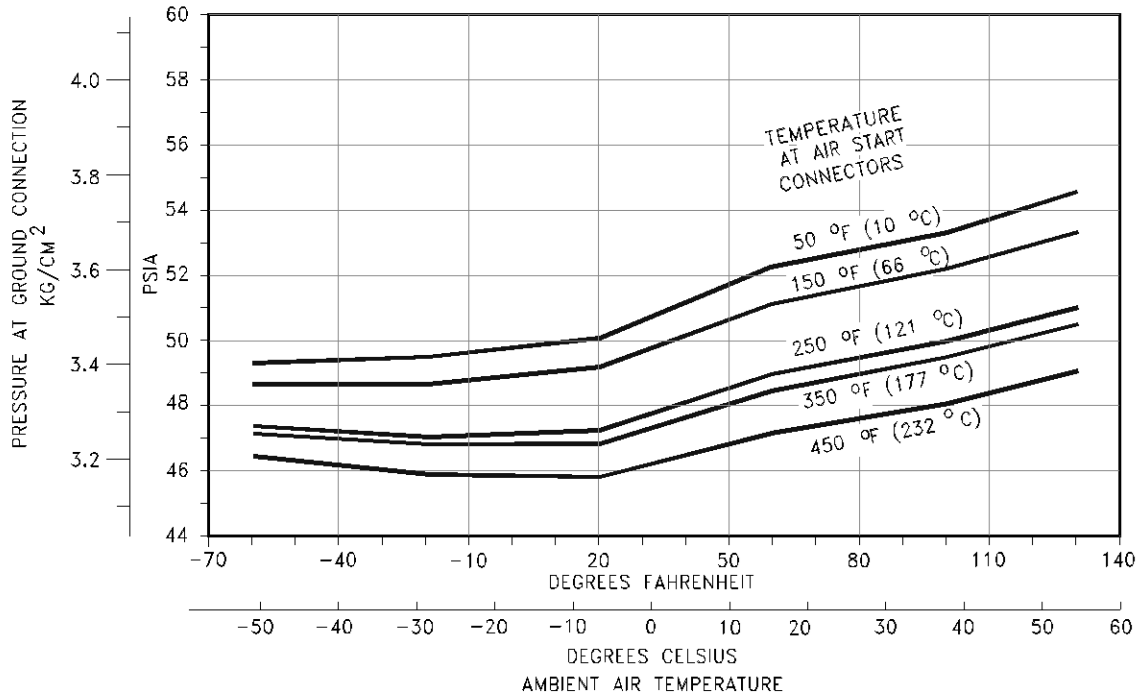
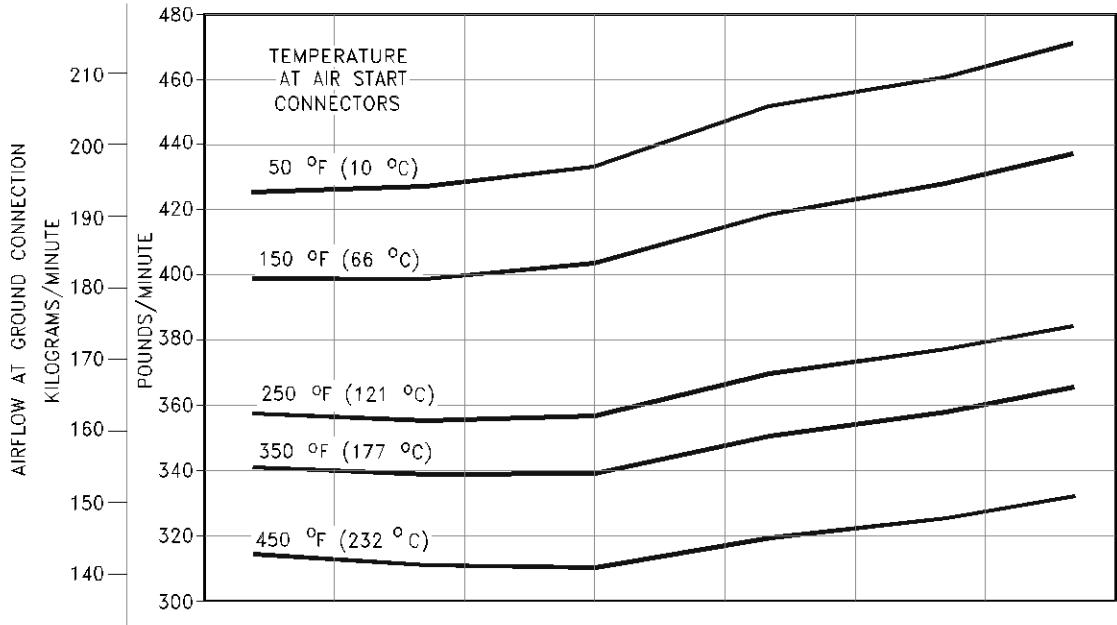
PRELIMINARY INFORMATION

5.5 ENGINE STARTING PNEUMATIC REQUIREMENTS

5.5.1 Engine Start Pneumatic Requirements - Sea Level: Model 777-9

NOTES:

1. ALTITUDE = SEA LEVEL
2. 90 SECONDS TO IDLE
3. 2 GROUND CONNECTIONS USED



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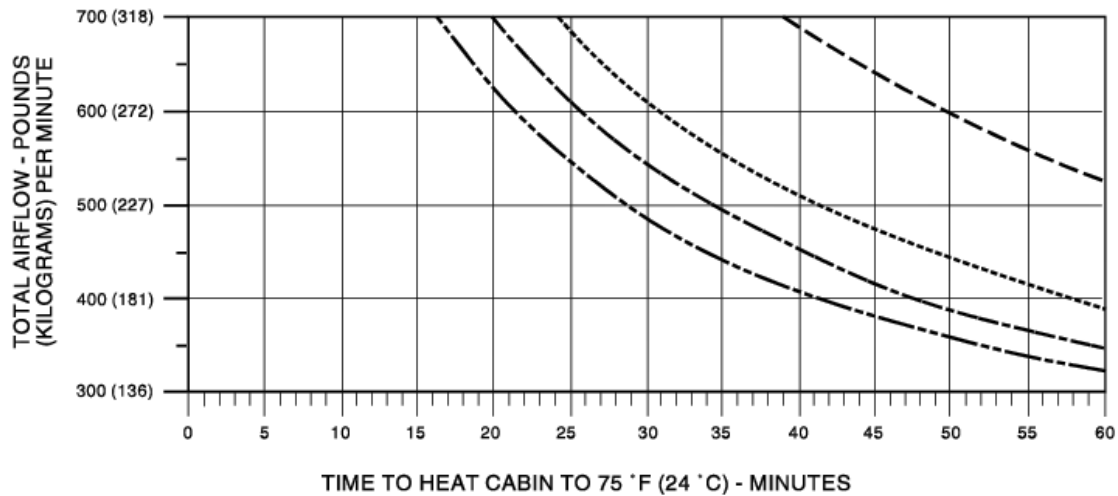
PRELIMINARY INFORMATION

5.6 GROUND PNEUMATIC POWER REQUIREMENTS

5.6.1 Ground Conditioned Air Requirements – Heating, Pull-Up: Model 777-9

CONDITIONS:

- ALL EXTERIOR DOORS AND WINDOWS CLOSED
- OUTSIDE TEMPERATURE -40° F (-40° C)
- INITIAL CABIN TEMPERATURE -25° F (-32° C)
- NO SOLAR HEAT LOAD
- RECIRCULATION FANS OFF
- CHILLERS OFF
- MINIMUM LIGHTING
- NO OCCUPANTS



LEGEND:

- 160 DEGREES F (71 DEGREES C)
- 150 DEGREES F (66 DEGREES C)
- 140 DEGREES F (60 DEGREES C)
- 120 DEGREES F (49 DEGREES C)

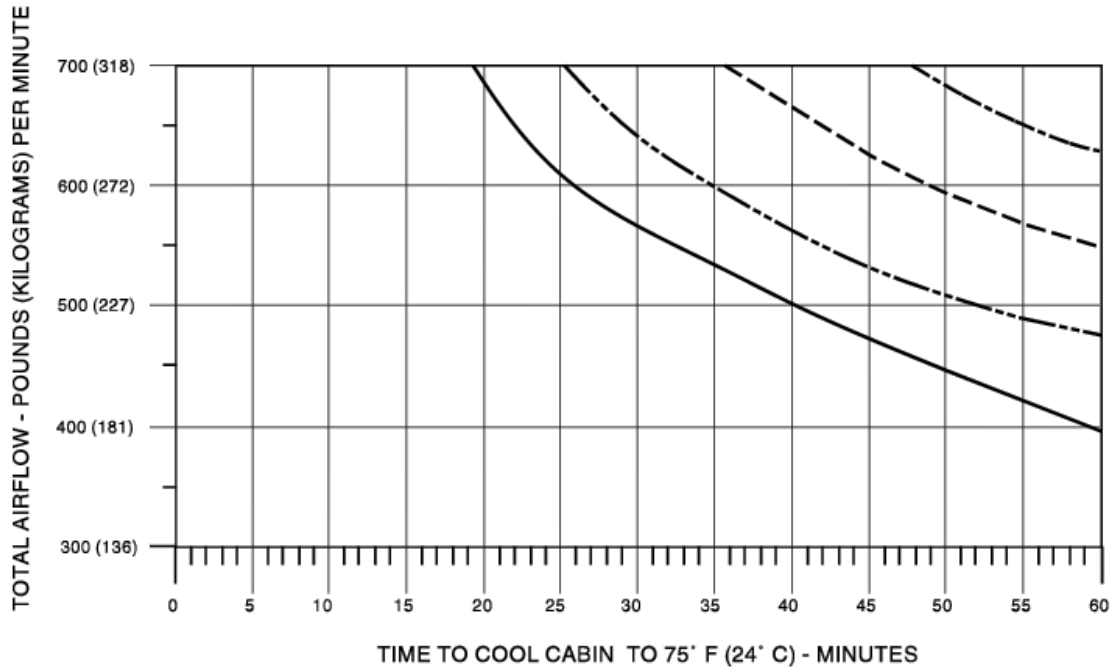
NOTE: THIS GRAPH PROVIDES THE TIME REQUIRED TO HEAT THE MAIN DECK FROM -25° F (-32° C) TO 75° F (24° C) AS A FUNCTION OF PRE-CONDITIONAL AIR FLOW AND TEMPERATURE, AT THE AIRPLANE'S GROUND AIR CONNECTORS, FOR THE CONDITIONS STATED.

PRELIMINARY INFORMATION

5.6.2 Ground Conditioned Air Requirements – Cooling, Pull-Down: Model 777-9

CONDITIONS:

- ALL EXTERIOR DOORS AND WINDOWS CLOSED
- OUTSIDE TEMPERATURE 103° F (39° C)
- INITIAL CABIN TEMPERATURE 115° F (46° C)
- FULL SOLAR LOAD
- RECIRCULATION FANS OFF
- CHILLERS ON
- MINIMUM LIGHTING
- NO OCCUPANTS



LEGEND:

- 35 DEGREES F (2 DEGREES C)
- - - 40 DEGREES F (4 DEGREES C)
- · - · 45 DEGREES F (7 DEGREES C)
- - - - 50 DEGREES F (10 DEGREES C)

NOTE: THIS GRAPH, WHICH WAS DERIVED ANALYTICALLY, PROVIDES THE TIME REQUIRED TO COOL THE MAIN DECK FROM 115° F (46° C) TO 75° F (24° C) AS A FUNCTION OF PRE-CONDITIONAL AIR FLOW AND TEMPERATURE, AT THE AIRPLANE'S GROUND AIR CONNECTORS, FOR THE CONDITIONS STATED.

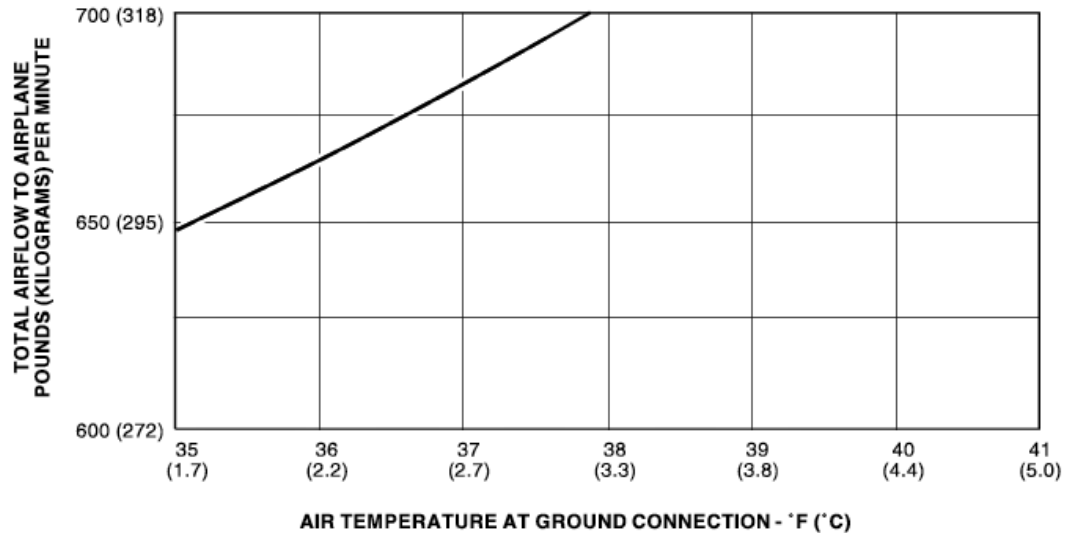
PRELIMINARY INFORMATION

5.7 CONDITIONED AIR REQUIREMENTS

5.7.1 Conditioned Air Flow Requirements - Steady State Airflow, Hot Day Operation: Model 777-9

CONDITIONS:

- ALL EXTERIOR DOORS AND WINDOWS CLOSED
- OUTSIDE TEMPERATURE: 103° F (39° C)
- FULL SOLAR AND ELECTRICAL HEAT LOADS
- RECIRCULATION FANS OFF
- CHILLERS AND CHILLER BOOST FANS ON
- CABIN TEMPERATURE MAINTAINED AT 75° F (24° C)
- SKIN TEMPERATURE: 118° F (48° C)
- FLIGHT DECK FLOW (FCAC OFF): 400 FT³ /MIN (11.3 M³ /MIN)
- HEAT TRANSFER TO DISTRIBUTION DUCTING INCLUDED



LEGEND:

— 777-9

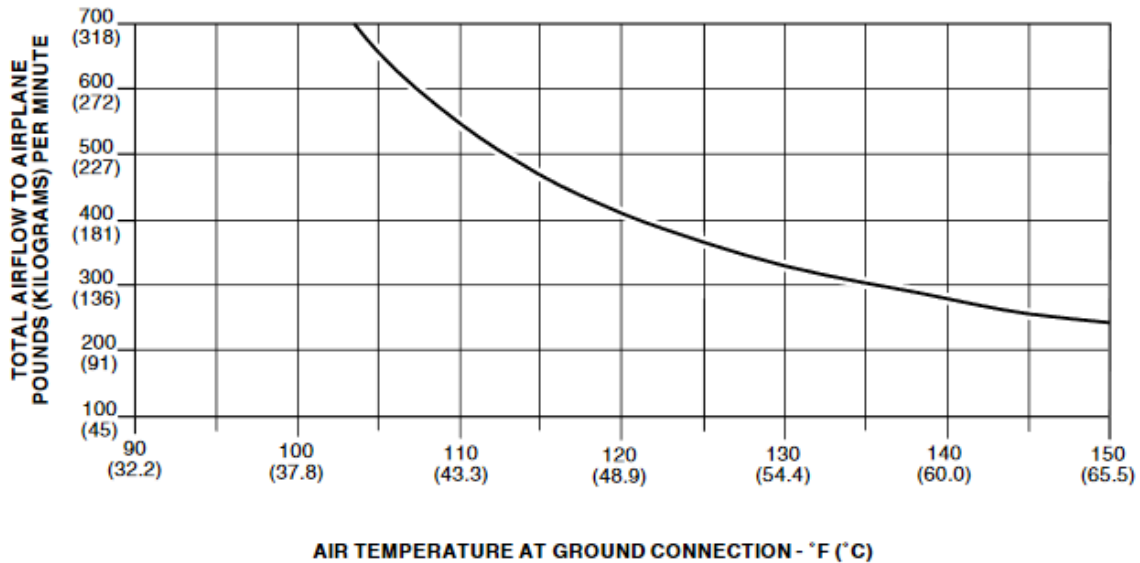
NOTE: THIS GRAPH, WHICH WAS DERIVED ANALYTICALLY, PROVIDES THE REQUIRED AIR TEMPERATURE AT THE GROUND CONNECTION FOR THE GIVEN CONDITIONS IN ORDER TO MAINTAIN THE CABIN AT 75° F (24° C), AS A FUNCTION OF AIRFLOW.

PRELIMINARY INFORMATION

5.7.2 Conditioned Air Flow Requirements - Steady State Airflow, Cold Day Operation: Model 777-9

CONDITIONS:

- ALL EXTERIOR DOORS AND WINDOWS CLOSED
- OUTSIDE TEMPERATURE -40° F (-40° C)
- NO SOLAR AND ELECTRICAL HEAT LOADS
- RECIRCULATION FANS OFF
- CHILLERS OFF
- NO OCCUPANTS
- CABIN TEMPERATURE MAINTAINED AT 75° F (24° C)



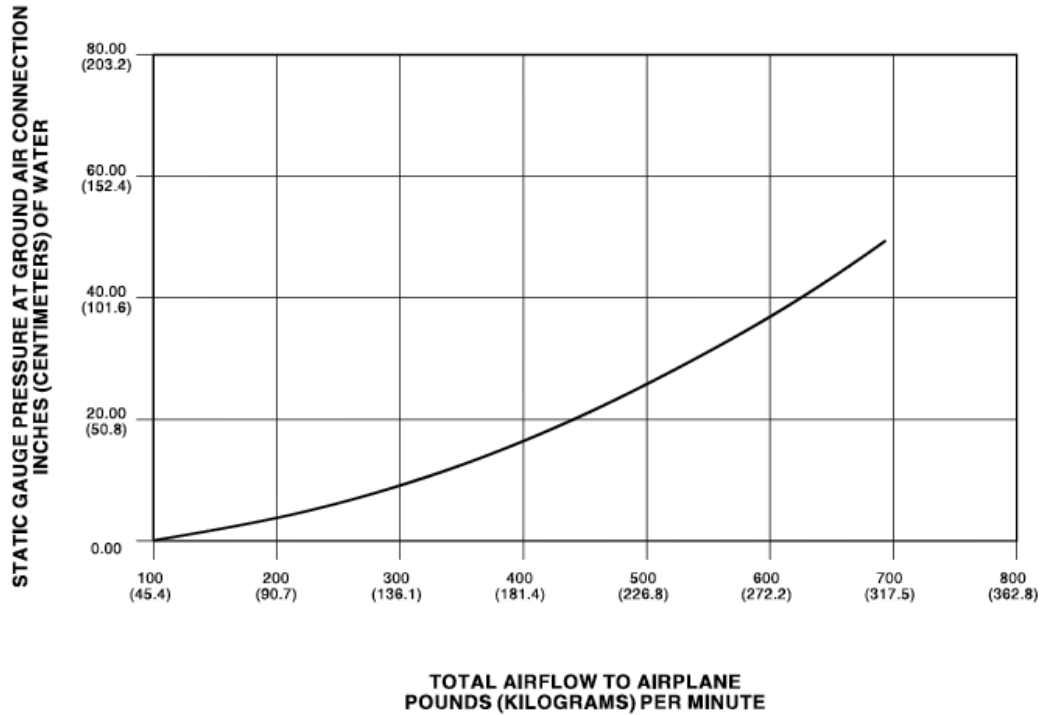
LEGEND:

— 777-9

NOTE: THIS GRAPH, WHICH WAS DERIVED ANALYTICALLY, PROVIDES THE REQUIRED AIR TEMPERATURE AT THE GROUND CONNECTION FOR THE GIVEN CONDITIONS IN ORDER TO HEAT THE CABIN TO 75° F (24° C), AS A FUNCTION OF AIRFLOW.

PRELIMINARY INFORMATION

5.7.3 Air Conditioning Gauge Pressure Requirements - Steady State Airflow: Model 777-9



NOTE:

THE GRAPH, WHICH WAS DERIVED ANALYTICALLY, SHOWS THE STATIC GAUGE PRESSURE AT THE CONNECTOR AS A FUNCTION OF AIRFLOW WHEN ONE GROUND CONNECTOR IS USED TO SUPPLY ALL OF THE AIR TO THE AIRPLANE. THIS GRAPH IS USED IN CONJUNCTION WITH THE PRECEDING GRAPHS (FLOW REQUIREMENTS FOR CONDITIONED AIR GROUND SOURCE), TO DETERMINE THE AIRFLOW AND PRESSURE REQUIREMENTS WHEN USING A CONDITIONED AIR GROUND SOURCE.

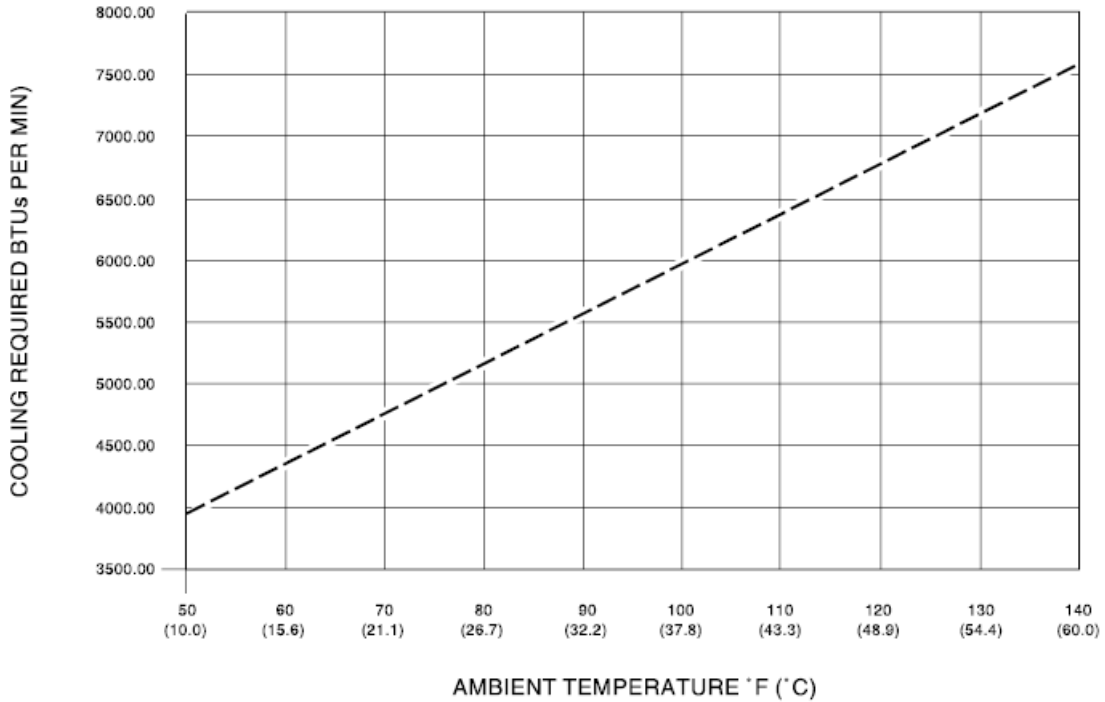
PLEASE NOTE THAT IF BOTH GROUND CONNECTIONS ARE USED TO SUPPLY CONDITIONED AIR TO THE AIRPLANE, THE TOTAL AIRFLOW TO THE AIRPLANE, AND NOT THE FLOW PER EACH GROUND CONNECTOR, MUST BE USED TO DETERMINE THE APPROXIMATE STATIC GAUGE PRESSURE AT EACH GROUND CONNECTOR. FOR EXAMPLE, IF AIR IS SUPPLIED USING BOTH GROUND CONNECTORS, WITH 250 POUNDS (114 KILOGRAMS) PER MINUTE SUPPLIED TO EACH GROUND CONNECTOR, THEN THE TOTAL FLOW IS 500 POUNDS (227 KILOGRAMS) PER MINUTE AND THE STATIC GAUGE PRESSURE IS APPROXIMATELY 26 INCHES (66 CENTIMETERS) OF WATER AT EACH CONNECTION.

PRELIMINARY INFORMATION

5.7.4 Conditioned Air Cooling Requirements - Steady State BTU's: Model 777-9

CONDITIONS:

- ALL EXTERIOR DOORS AND WINDOWS CLOSED
- FULL SOLAR AND ELECTRICAL HEAT LOAD
- RECIRCULATION FANS OFF
- CHILLER AND CHILLER BOOST FANS ON
- CABIN TEMPERATURE MAINTAINED AT 75°F (24°C)
- SKIN TEMPERATURE: $T_{\text{ambient}} + 15^\circ\text{F}$
- FLIGHT DECK FLOW (FCAC OFF): 400 FT³/MIN (11.3 M³/MIN)
- HEAT TRANSFER TO DISTRIBUTION DUCTING INCLUDED



LEGEND:

--- 777 - 9

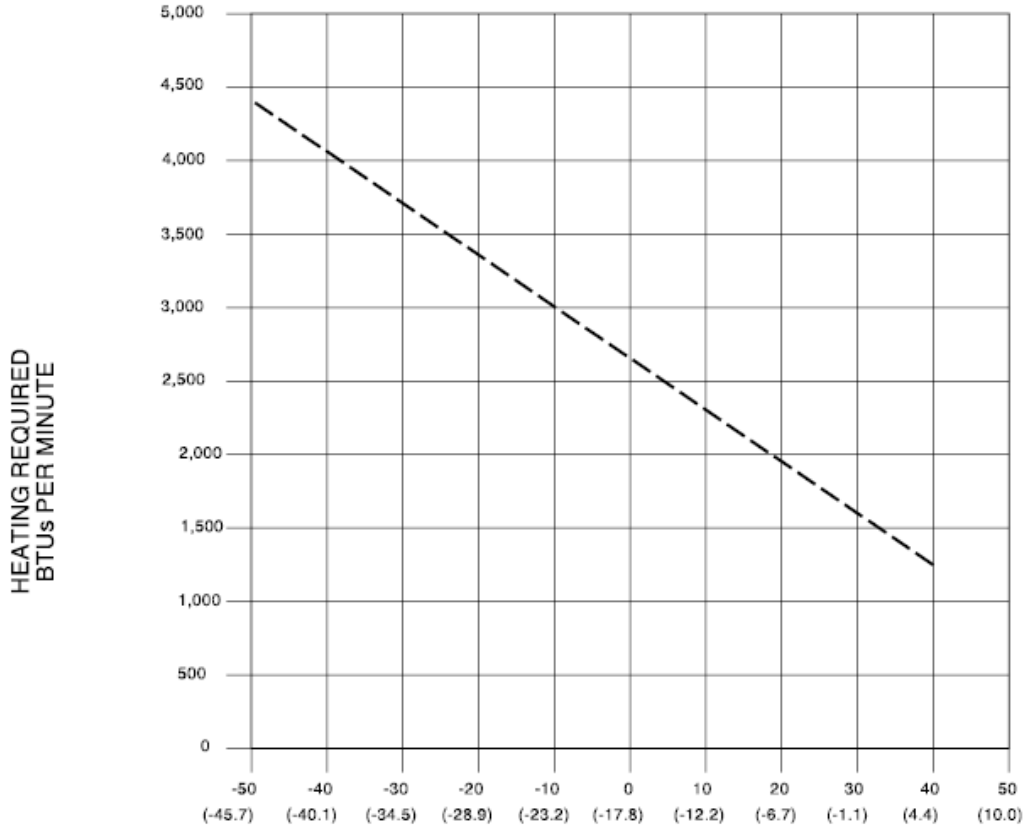
NOTE: THIS GRAPH, WHICH WAS DERIVED ANALYTICALLY, PROVIDES THE COOLING REQUIRED TO MAINTAIN THE CABIN AT 75°F (24°C) FOR THE GIVEN CONDITIONS, AS A FUNCTION OF AMBIENT TEMPERATURE.

PRELIMINARY INFORMATION

5.7.5 Conditioned Air Heating Requirements - Steady State BTU's: Model 777-9

CONDITIONS:

- ALL EXTERIOR DOORS AND WINDOWS CLOSED
- NO SOLAR AND ELECTRICAL HEAT LOADS
- RECIRCULATION FANS OFF
- CHILLERS ON
- NO OCCUPANTS
- CABIN TEMPERATURE MAINTAINED AT 75° F (24° C)



LEGEND:

AMBIENT TEMPERATURE - °F (°C)

--- 777-9

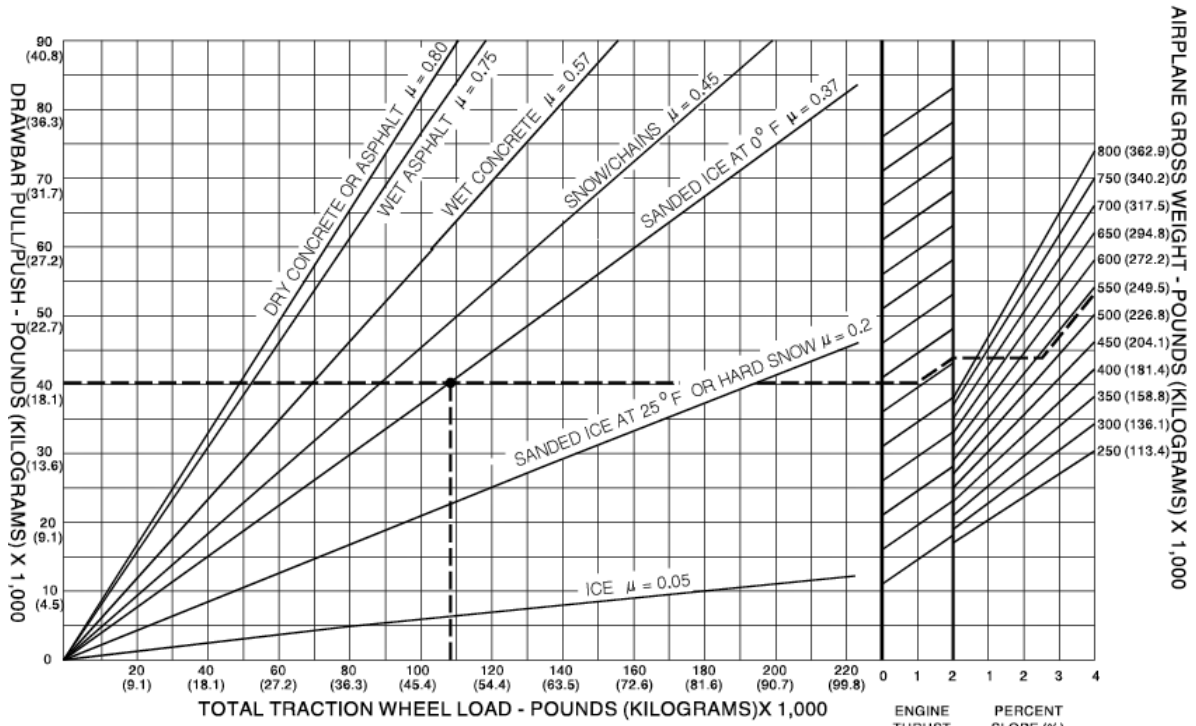
NOTE: THIS GRAPH, WHICH WAS DERIVED ANALYTICALLY, PROVIDES THE HEAT REQUIRED TO MAINTAIN THE CABIN AT 75° F (24° C) FOR THE GIVEN CONDITIONS, AS A FUNCTION OF AMBIENT TEMPERATURE.

D6-86073

PRELIMINARY INFORMATION

5.8 GROUND TOWING REQUIREMENTS

5.8.1 Ground Towing Requirements - Metric Units: Model 777-9



NOTES: 1. EXAMPLE - - - - - SHOWS A 777 WEIGHING 537,000 POUNDS (243,579 KILOGRAMS) BEING PUSHED UP A 2.5% SLOPE ON SANDED ICE AT 0° BACKING AGAINST ONE ENGINE AT IDLE THRUST. A RESULTING DRAW BAR PUSH OF 40,275 LB (18,268 KG) AND A TRACTION LOAD OF 108,851 LB (49,374 KG) ARE REQUIRED FOR TOWING.

- 2. UNUSUAL BREAKAWAY CONDITIONS NOT SHOWN
- 3. STRAIGHT-LINE TOW
- 4. COEFFICIENTS OF FRICTION (μ) ARE ESTIMATED FOR RUBBER-TIRED TOW VEHICLES

PRELIMINARY INFORMATION

6.0 JET ENGINE WAKE AND NOISE DATA

6.1 JET ENGINE EXHAUST VELOCITIES AND TEMPERATURES

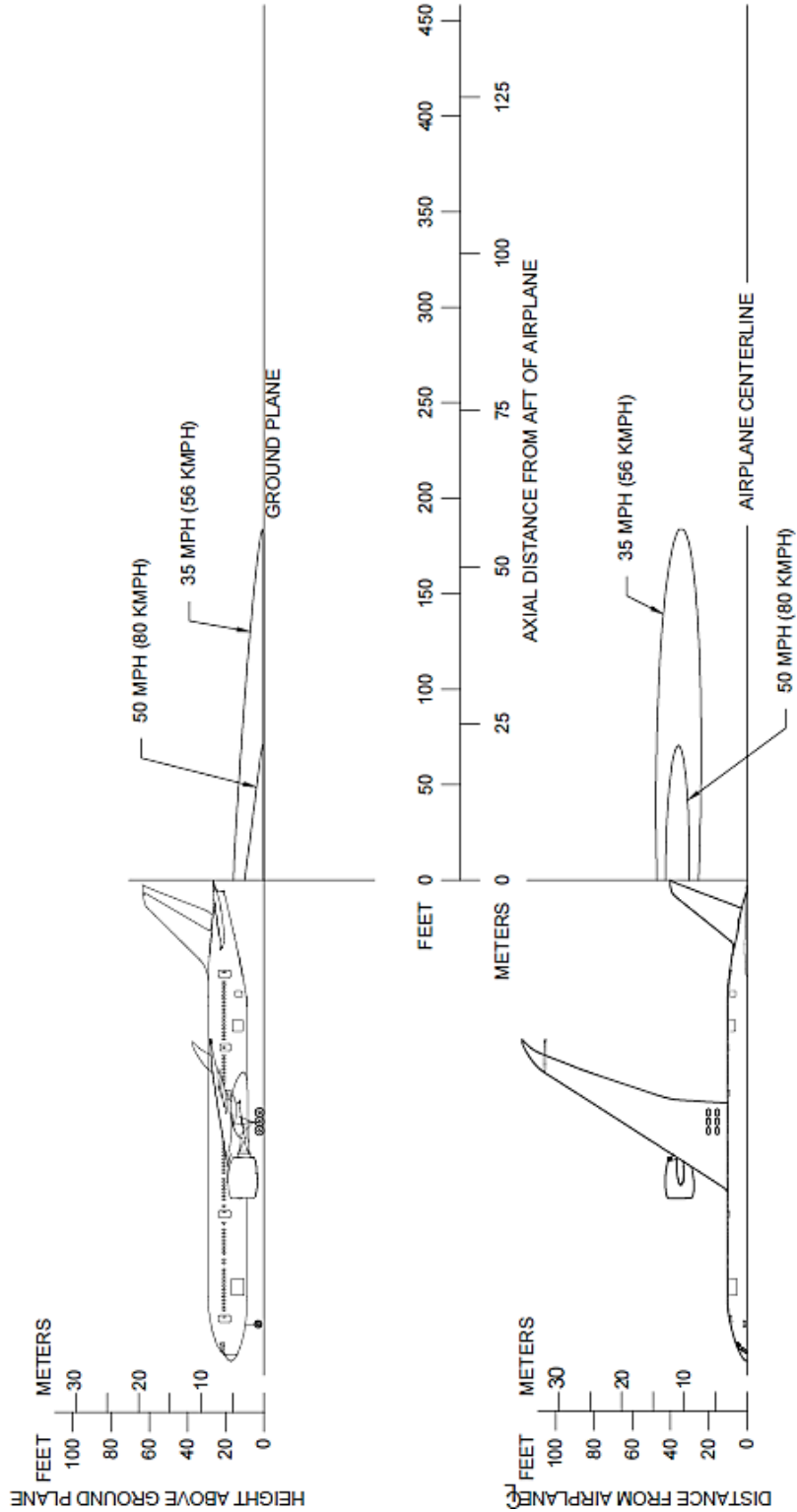
This section shows exhaust velocity and temperature contours aft of the 777-9 airplane. The contours were calculated from a standard computer analysis using three-dimensional viscous flow equations with mixing of primary, fan, and free-stream flow. The presence of the ground plane is included in the calculations as well as engine tilt and toe-in. Mixing of flows from the engines is also calculated. The analysis does not include thermal buoyancy effects which tend to elevate the jet wake above the ground plane. The buoyancy effects are considered to be small relative to the exhaust velocity and therefore are not included.

The graphs show jet wake velocity and temperature contours for a representative engine. The results are valid for sea level, static, standard day conditions. The effect of wind on jet wakes was not included. There is evidence to show that a downwind or an upwind component does not simply add or subtract from the jet wake velocity, but rather carries the whole envelope in the direction of the wind. Crosswinds may carry the jet wake contour far to the side at large distances behind the airplane.

PRELIMINARY INFORMATION

6.1.1 Jet Engine Exhaust Velocity Contours - Idle Thrust: Model 777-9

- NOTES:
- ENGINE THRUST AT BREAKAWAY SETTING
 - CONTOURS CALCULATED FROM COMPUTER DATA
 - STANDARD DAY
 - SEA LEVEL
 - NO WIND
 - BOTH ENGINES RUNNING
 - 5,051 LBF/ENGINE

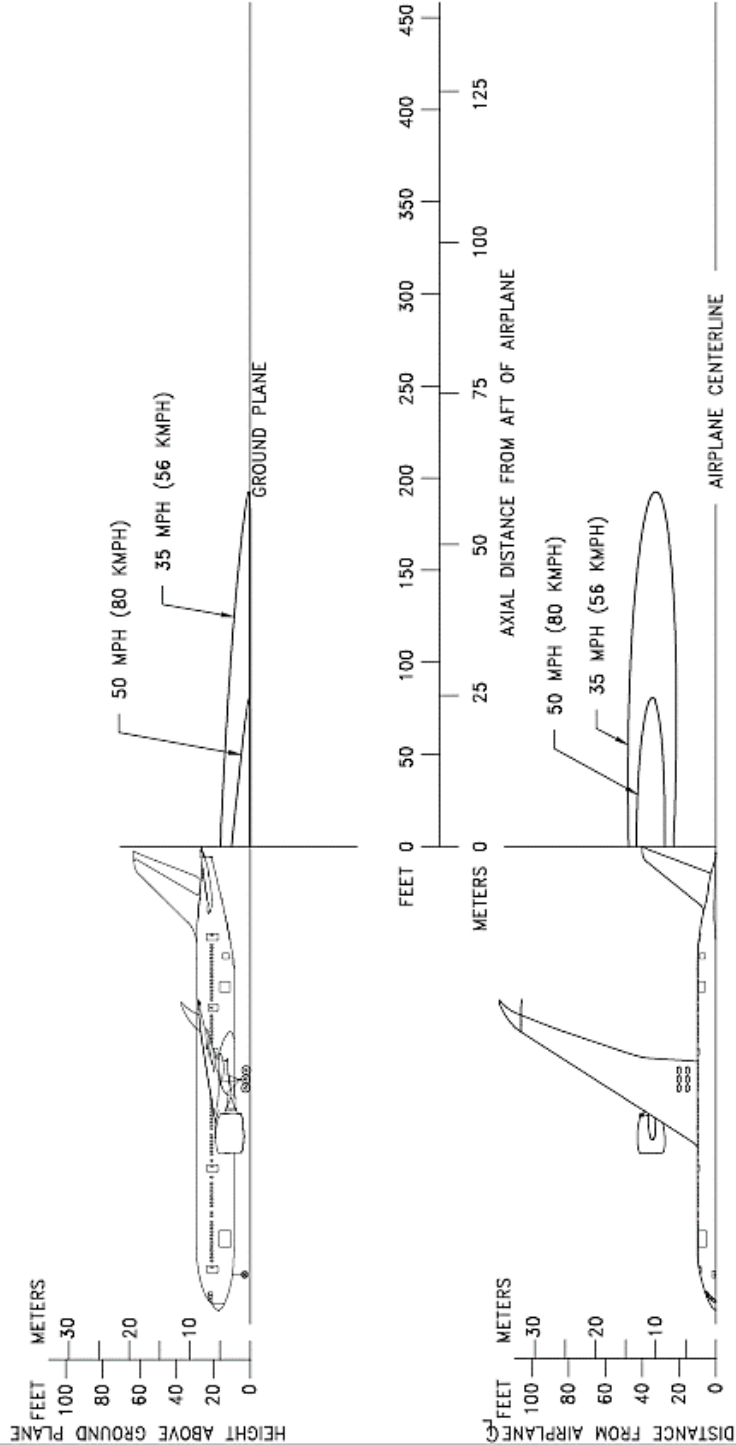


D6-86073

PRELIMINARY INFORMATION

6.1.2 Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 0% Slope / Both Engines / MTW: Model 777-9

- NOTES:
- * ENGINE THRUST AT BREAKAWAY SETTING
 - * CONTOURS CALCULATED FROM COMPUTER DATA
 - * STANDARD DAY
 - * SEA LEVEL
 - * NO WIND
 - * 0% SLOPE
 - * BOTH ENGINES RUNNING
 - * 5,245 LBF/ENGINE (MTW=777,000 LB)

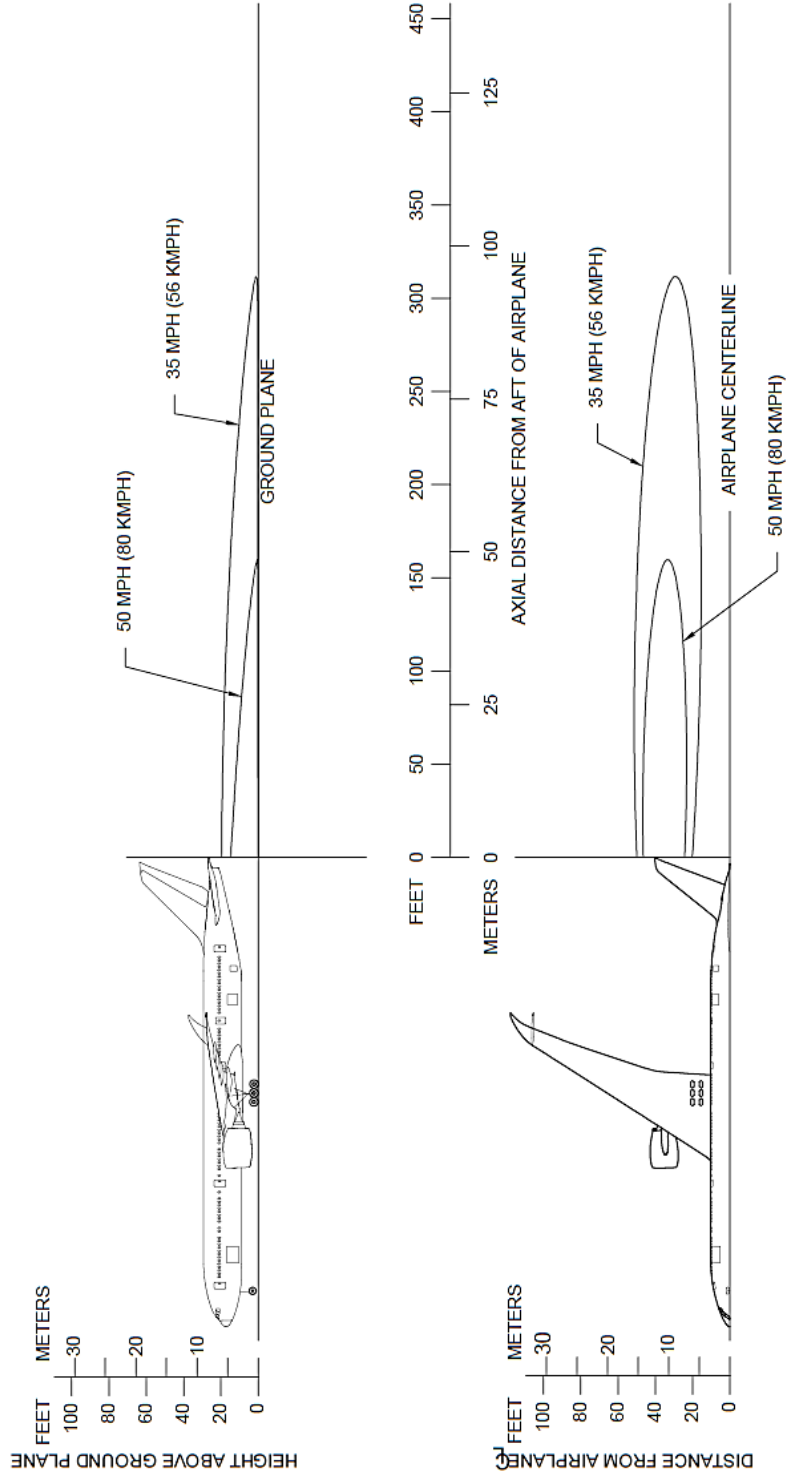


D6-86073

PRELIMINARY INFORMATION

6.1.3 Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 1% Slope / Both Engines / MTW: Model 777-9

- NOTES:
- ENGINE THRUST AT BREAKAWAY SETTING
 - CONTOURS CALCULATED FROM COMPUTER DATA
 - STANDARD DAY
 - SEA LEVEL
 - NO WIND
 - 1% SLOPE
 - BOTH ENGINES RUNNING
 - 9,129 LBF/ENGINE (MTW=777,000 LB)

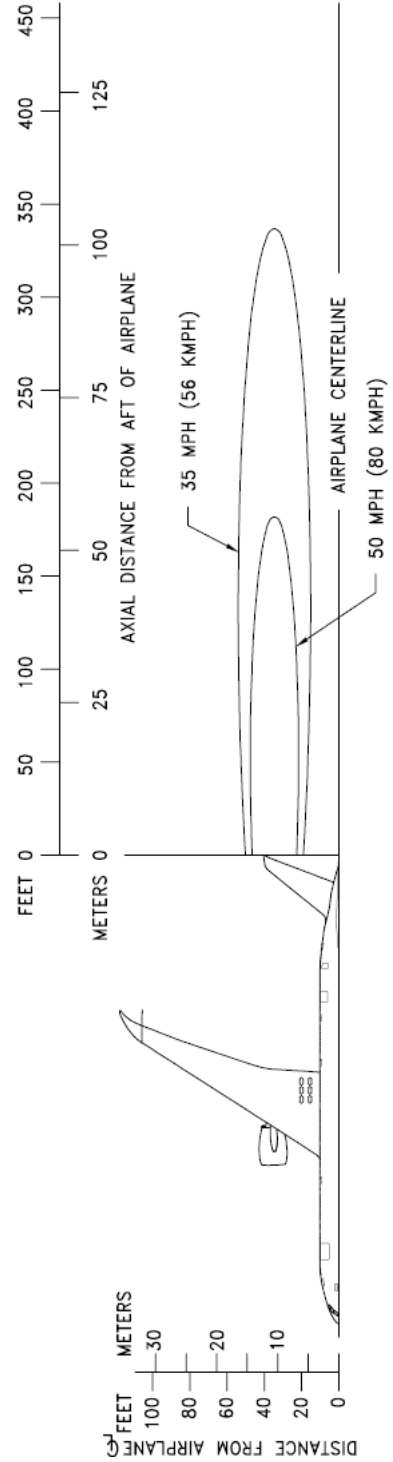
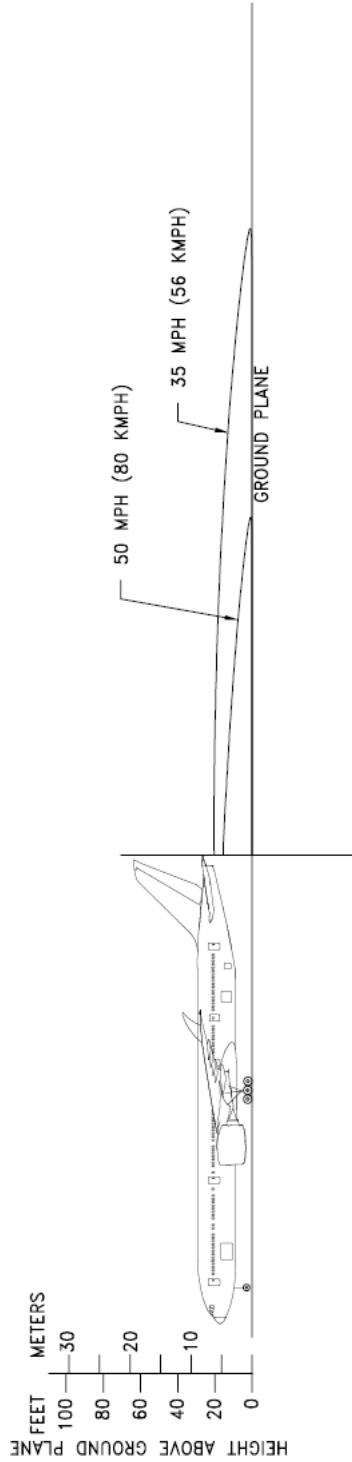


D6-86073

PRELIMINARY INFORMATION

6.1.4 Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 0% Slope / Single Engine / MTW: Model 777-9

- NOTES:
- * ENGINE THRUST AT BREAKAWAY SETTING
 - * CONTOURS CALCULATED FROM COMPUTER DATA
 - * STANDARD DAY
 - * SEA LEVEL
 - * NO WIND
 - * 0% SLOPE
 - * SINGLE ENGINE RUNNING
 - * 10,490 LBF/ENGINE (MTW=777,000 LB)

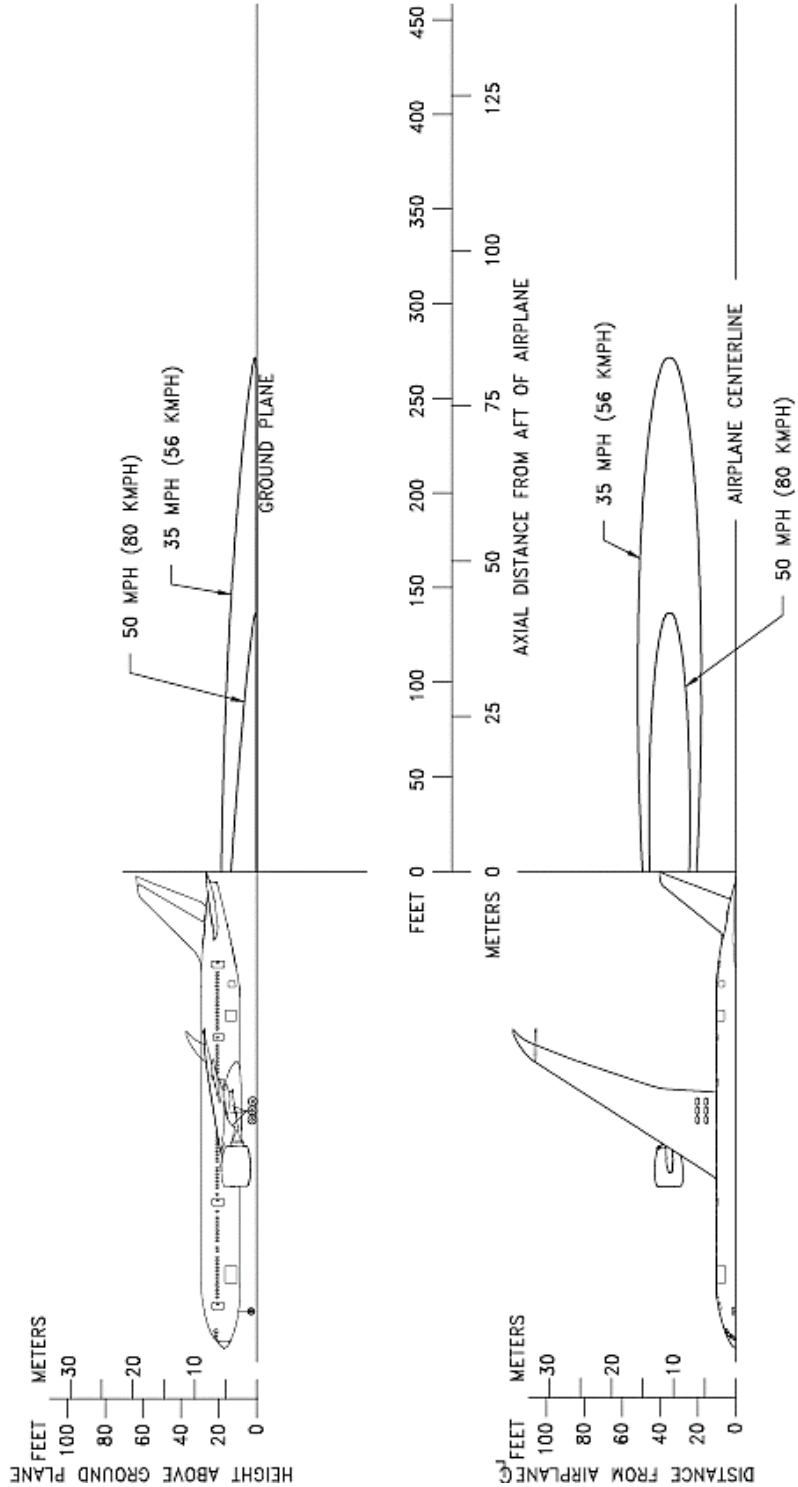


D6-86073

PRELIMINARY INFORMATION

6.1.5 Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 0% Slope / Single Engine / MLW: Model 777-9

- NOTES:
- * ENGINE THRUST AT BREAKAWAY SETTING
 - * CONTOURS CALCULATED FROM COMPUTER DATA
 - * STANDARD DAY
 - * SEA LEVEL
 - * NO WIND
 - * 0% SLOPE
 - * SINGLE ENGINE RUNNING
 - * 7,925 LBF/ENGINE (MLW=587,000 LB)

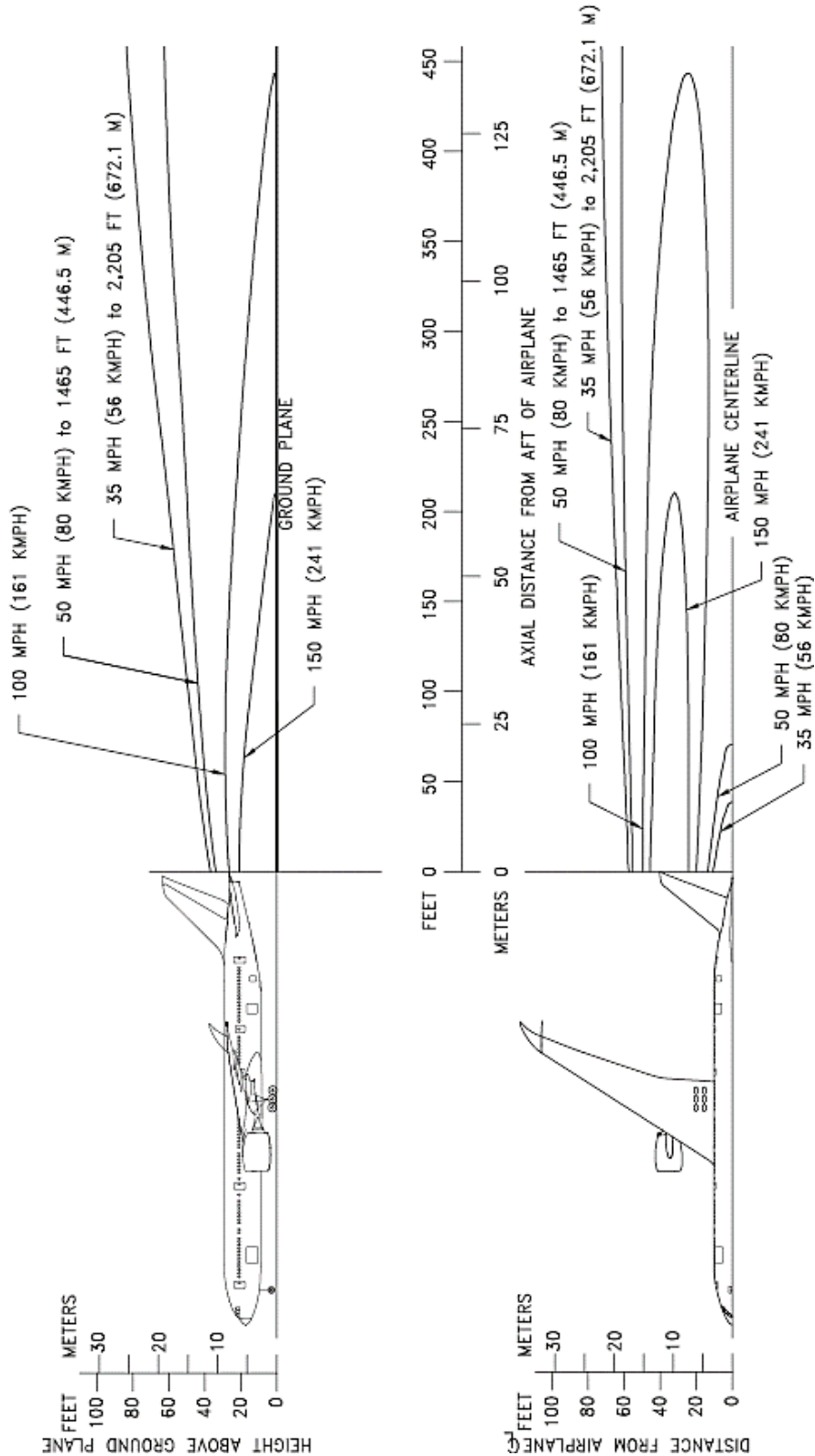


D6-86073

PRELIMINARY INFORMATION

6.1.6 Jet Engine Exhaust Velocity Contours - Takeoff Thrust: Model 777-9

- NOTES:
- * ENGINE THRUST AT TAKEOFF SETTING
 - * CONTOURS CALCULATED FROM COMPUTER DATA
 - * STANDARD DAY
 - * SEA LEVEL
 - * NO WIND
 - * BOTH ENGINES RUNNING
 - * 110,626 LBF/ENGINE



D6-86073

PRELIMINARY INFORMATION

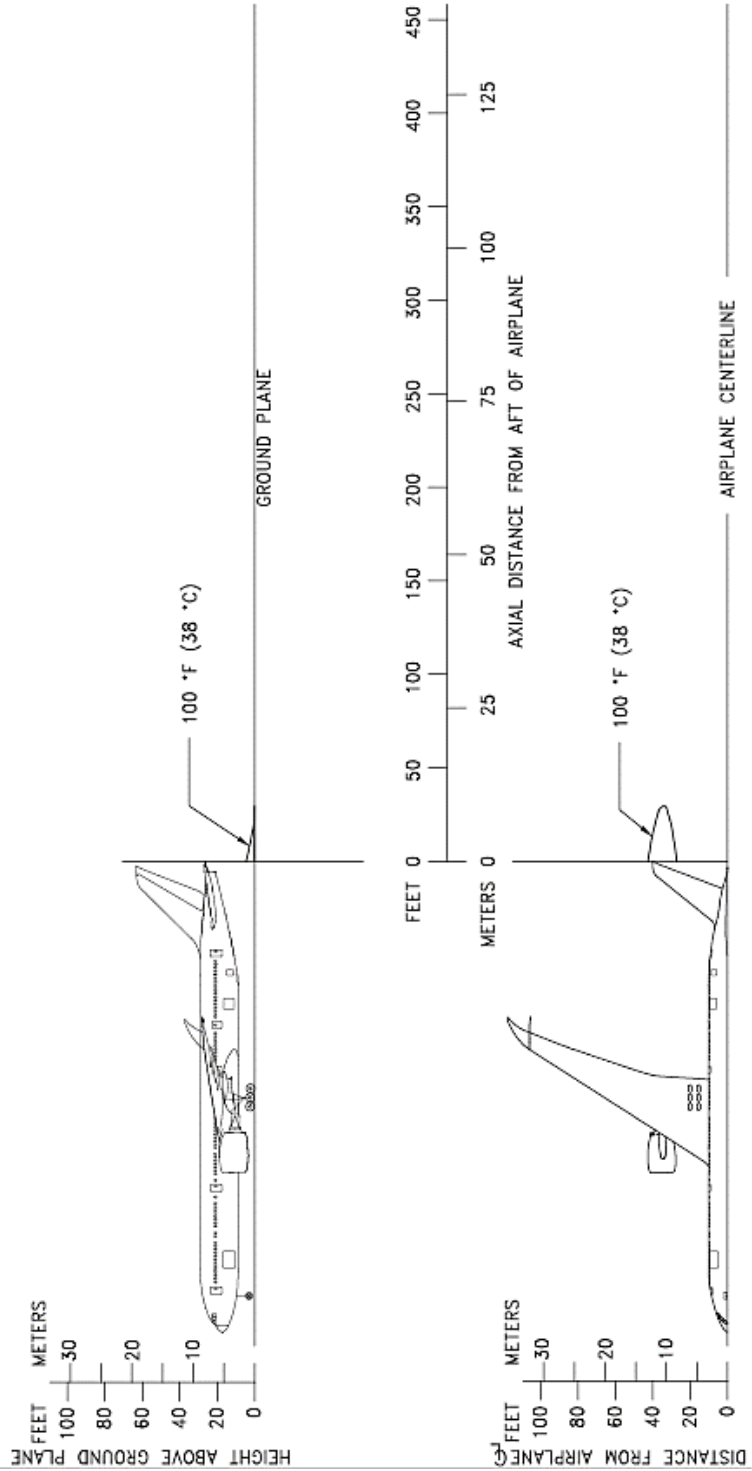
6.1.7 Jet Engine Exhaust Temperature Contours - Idle/Breakaway Thrust: Model 777-9

Temperature contours for idle/breakaway power conditions are not shown as the maximum temperature aft of the 777-9 is predicated to be less than 100° F (38° C) for standard day conditions of 59° F (15° C).

PRELIMINARY INFORMATION

6.1.8 Jet Engine Exhaust Temperature Contours - Takeoff Thrust: Model 777-9

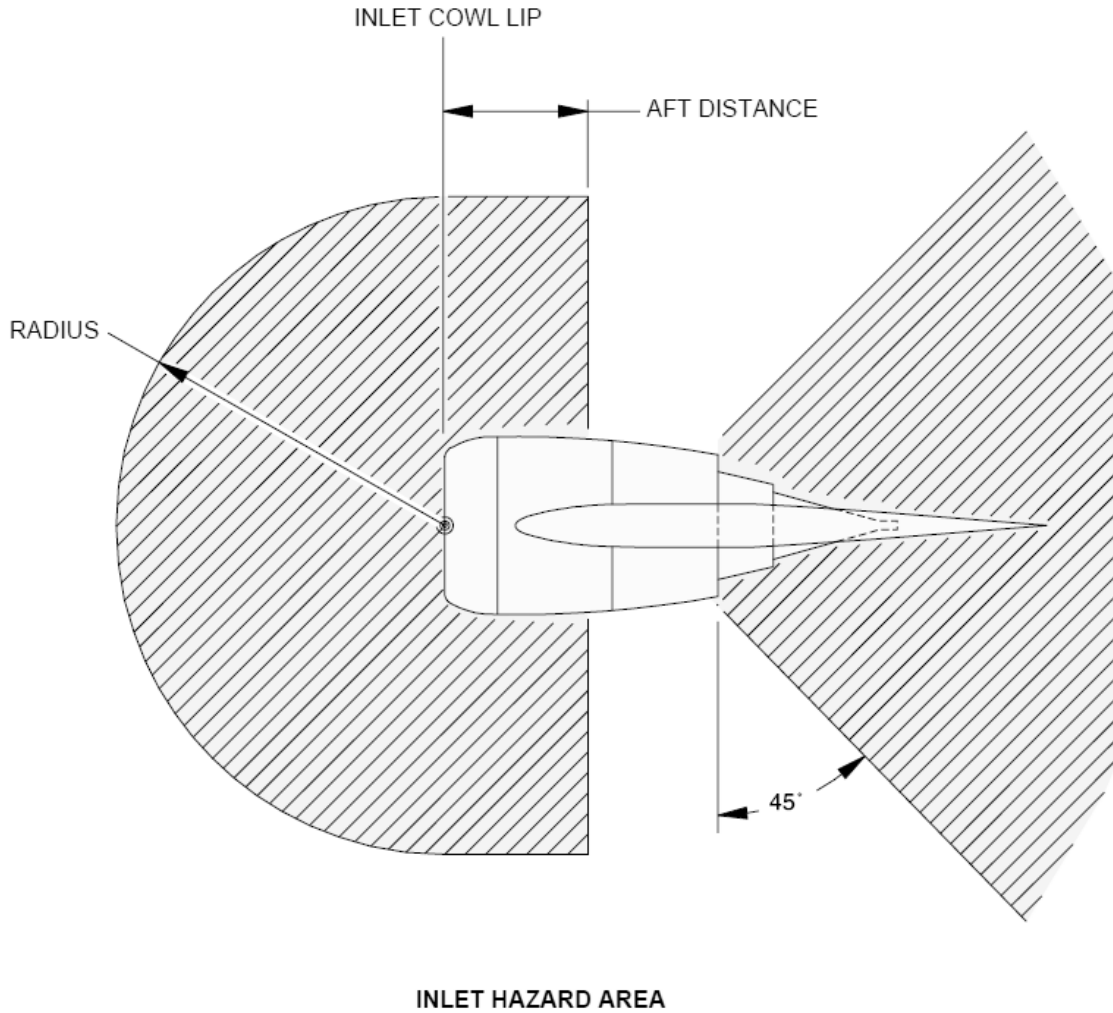
- NOTES:
- * ENGINE THRUST AT TAKEOFF SETTING
 - * CONTOURS CALCULATED FROM COMPUTER DATA
 - * STANDARD DAY
 - * SEA LEVEL
 - * NO WIND
 - * BOTH ENGINES RUNNING
 - * 110,626 LBF/ENGINE



D6-86073

PRELIMINARY INFORMATION

6.1.9 Inlet Hazard Areas: All Models



	RADIUS		AFT DISTANCE	
IDLE THRUST	20.4 FT	6.2 M	10.5 FT	3.2 M
BREAKAWAY THRUST	26.5 FT	8.1 M	14.6 FT	4.5 M
TAKEOFF THRUST	46.8 FT	14.3 M	18.1 FT	5.5 M

PRELIMINARY INFORMATION

6.2 AIRPORT AND COMMUNITY NOISE

Airport noise is of major concern to the airport and community planner. The airport is a major element in 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 the following:

7. 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.

8. 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.

9. Surface Condition-Shielding, Extra Ground Attenuation (EGA)

- a. 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 ground. Additionally, hills, shrubs, trees, and large buildings can act as sound buffers.

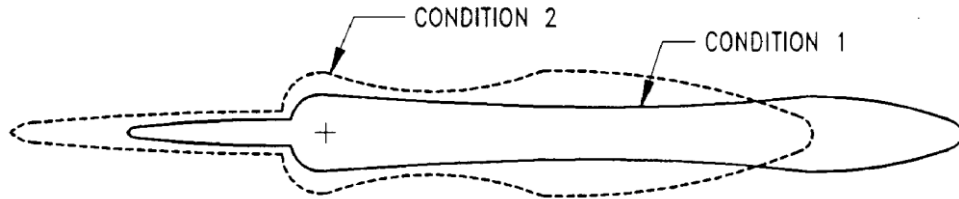
All these factors can alter the shape and size of the contours appreciably. To demonstrate the effect of some of these factors, estimated noise level contours for two different

PRELIMINARY INFORMATION

operating conditions are shown below. These contours reflect a given noise level upon a ground level plane at runway elevation.

Condition 1

Landing	Takeoff
Maximum Structural Landing Weight	Maximum Gross Takeoff Weight
10-knot Headwind	Zero Wind
3° Approach	84 °F
84 °F	Humidity 15%
Humidity 15%	



Condition 2

Landing	Takeoff
85% of Maximum Structural Landing Weight	80% of Maximum Gross Takeoff Weight
10-knot Headwind	10-knot Headwind
3° Approach	59 °F
59 °F	Humidity 70%
Humidity 70%	

As indicated from these data, the contour size varies substantially with operating and atmospheric conditions. Most aircraft operations are, of course, conducted at less than maximum design weights because average flight distances are much shorter than maximum aircraft range capability and average load factors are less than 100%. 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 zones to specific land uses. It is therefore expected that noise contour data for particular aircraft and the impact assessment

PRELIMINARY INFORMATION

methodology will be changing. To ensure that the best 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 shown herein are only for illustrating 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.

PRELIMINARY INFORMATION

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 depicted with a minimum range of five loads imposed on the main landing gear to aid in interpolation between the discrete values shown. All curves for any single chart represent data based on rated loads and tire pressures considered normal and acceptable by current aircraft tire manufacturer's standards. Tire pressures, where specifically designated on tables and charts, are at values obtained under loaded conditions as certificated for commercial use.

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 charts in Section 7.4 are 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 based on the US Army Corp of Engineers Method and the rigid pavement curves based on the Portland Cement Association Design Method are no longer provided in Sections 7.5 and 7.7. Refer to the State's design standards for pavement design requirements. For US airports, refer to FAA Advisory Circular (AC) 150/5320-6, [Airport Pavement Design and Evaluation](#) and pavement design program FAARFIELD for flexible and rigid pavement design requirements.

The Load Classification Number (LCN) curves are no longer provided in section 7.6 and 7.8 since the LCN system for reporting pavement strength is obsolete, being replaced by the ICAO recommended ACN/PCN system in 1983. For questions regarding the LCN system contact Boeing Airport Operations Engineering:

AirportCompatibility@boeing.com

For the rigid pavement design (Section 7.9) refer to the FAA AC 150/5320-6, [Airport Pavement Design and Evaluation](#) and pavement design program FAARFIELD. Both are available on the FAA website:

FAA AC 150/5320-6: https://www.faa.gov/airports/resources/advisory_circulars/

FAARFIELD: https://www.faa.gov/airports/engineering/design_software/

PRELIMINARY INFORMATION

The ACN/PCN system (Section 7.10) as referenced in ICAO Annex 14, Aerodromes, Volume I, “Aerodrome Design and Operations,” Ninth Edition, July 2022, provides a standardized international airplane/pavement rating system replacing the various S, T, TT, LCN, AUW, ISWL, etc., rating systems used throughout the world. ACN is the Aircraft Classification Number and PCN is the Pavement Classification Number. An aircraft having an ACN equal to or less than the PCN can operate on the pavement subject to any limitation on the tire pressure. Numerically, the ACN is two times the derived single-wheel load expressed in thousands of kilograms, where the derived single wheel load is defined as the load on a single tire inflated to 181 psi (1.25 MPa) that would have the same pavement requirements as the aircraft. Computationally, the ACN/PCN system uses the PCA program PDILB for rigid pavements and S-77-1 for flexible pavements to calculate ACN values.

The ACR-PCR system (Section 7.11) follows ICAO Annex 14, Aerodromes, Volume I, “Aerodrome Design and Operations,” Ninth Edition, July 2022, and guidance from ICAO Doc 9157-AN/901, Aerodrome Design Manual, Part 3, “Pavements,” Third Edition, 2022, replacing the ACN/PCN system used throughout the world. ACR is the Aircraft Classification Rating and PCR is the Pavement Classification Rating. The ACR-PCR system allows an aircraft having an ACR equal to or less than the PCR to operate on the pavement subject to any limitation on the tire pressure. Numerically, the ACR is two times the derived single-wheel load expressed in hundreds of kilograms, where the derived single wheel load is defined as the load on a single tire inflated to 218 psi (1.5 MPa) that would have the same pavement requirements as the aircraft.

The method of pavement evaluation is left up to the airport with the results of their evaluation presented as follows:

PCN/PCR	PAVEMENT TYPE	SUBGRADE CATEGORY	TIRE PRESSURE CATEGORY	EVALUATION METHOD
	R = Rigid	A = High	W = No Limit	T = Technical
	F = Flexible	B = Medium	X = To 254 psi (1.75 MPa)	U = Using Aircraft
		C = Low	Y = To 181 psi (1.25 MPa)	
		D = Ultra Low	Z = To 73 psi (0.5 MPa)	

ACN values for flexible pavements are calculated for the following four subgrade categories:

Code A - High strength; characterized by CBR 15 and representing all CBR values above 13.

Code B - Medium strength; characterized by CBR 10 and representing a range in CBR of 8 to 13.

PRELIMINARY INFORMATION

Code C - Low strength; characterized by CBR 6 and representing a range in CBR of 4 to 8.

Code D - Ultra-low strength; characterized by CBR 3 and representing all CBR values below 4.

ACN values for rigid pavements are calculated for the following four subgrade categories:

Code A - High strength; characterized by $k = 150 \text{ MN/m}^3$ (552.6 pci) and representing all k values above 120 MN/m^3 .

Code B - Medium strength; characterized by $k = 80 \text{ MN/m}^3$ (294.7 pci) and representing a range in k values of 60 to 120 MN/m^3 .

Code C - Low strength; characterized by $k = 40 \text{ MN/m}^3$ (147.4 pci) and representing a range in k values of 25 to 60 MN/m^3 .

Code D - characterized by $k = 20 \text{ MN/m}^3$ (73.7 pci) and representing all k values below 25 MN/m^3 .

ACR values at any mass on rigid and flexible pavements are calculated for the following four subgrade categories:

Code A - High strength; characterized by $E = 200 \text{ MPa}$ (29,008 psi) and representing all E values equal to or above 150 MPa, for rigid and flexible pavements.

Code B - Medium strength; characterized by $E = 120 \text{ MPa}$ (17,405 psi) and representing a range in E equal to or above 100 MPa and strictly less than 150 MPa, for rigid and flexible pavements.

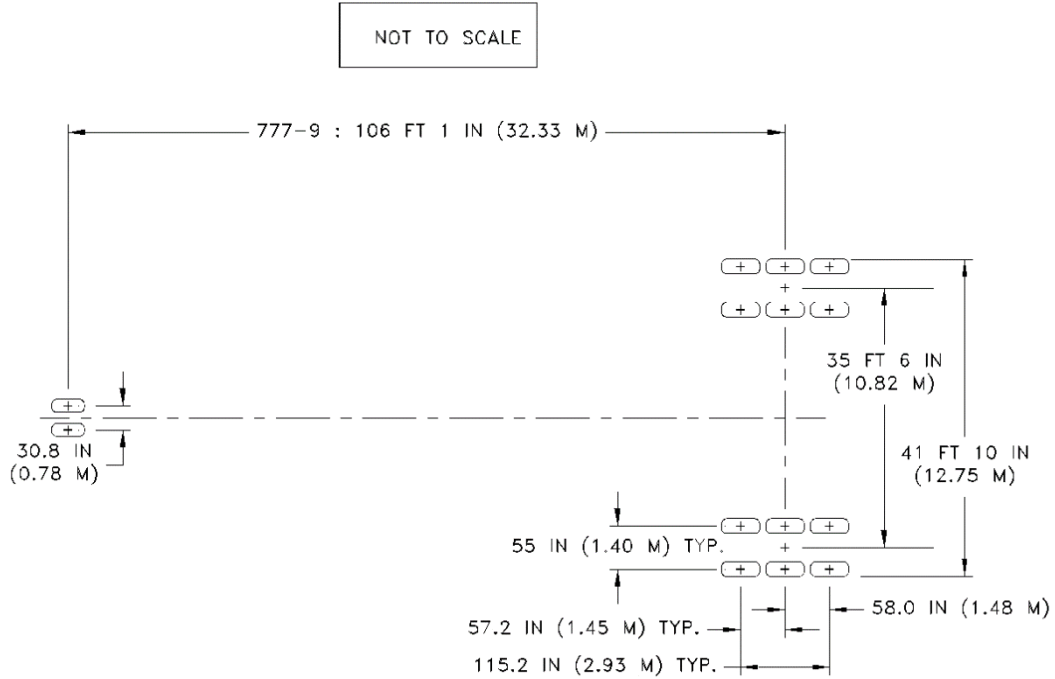
Code C - Low strength; characterized by $E = 80 \text{ MPa}$ (11,603 psi) and representing a range in E equal to or above 60 MPa and strictly less than 100 MPa, for rigid and flexible pavements.

Code D - Ultra-low strength; characterized by $E = 50 \text{ MPa}$ (7,252 psi) and representing all E values strictly less than 60 MPa, for rigid and flexible pavements.

PRELIMINARY INFORMATION

7.2 LANDING GEAR FOOTPRINT

7.2.1 Landing Gear Footprint: Model 777-9



	UNITS	MODEL 777-9
MAXIMUM DESIGN TAXI WEIGHT	LB	777,000
	KG	352,441
NOSE GEAR TIRE SIZE	IN.	43x17.5R17, 32PR
NOSE GEAR TIRE PRESSURE	PSI	218
	MPa	1.50
MAIN GEAR TIRE SIZE	IN.	52x21.0R22, 38PR
MAIN GEAR TIRE PRESSURE	PSI	224
	MPa	1.54

D6-86073

REV F

December 2024

7-4

PRELIMINARY INFORMATION

7.3 MAXIMUM PAVEMENT LOADS

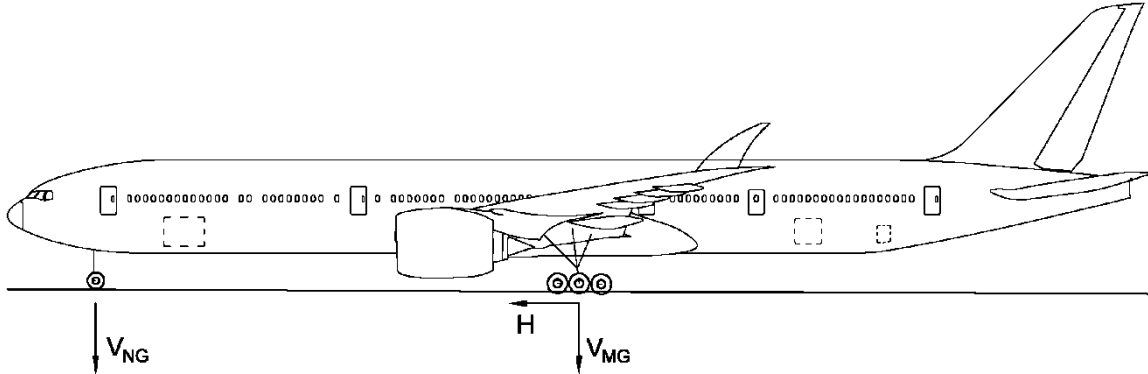
7.3.1 Maximum Pavement Loads: Model 777-9

V_{NG} = MAXIMUM VERTICAL NOSE GEAR GROUND LOAD AT MOST FORWARD CENTER OF GRAVITY

V_{MG} = MAXIMUM VERTICAL MAIN GEAR GROUND LOAD AT MOST AFT CENTER OF GRAVITY

H = MAXIMUM HORIZONTAL GROUND LOAD FROM BRAKING

NOTE: ALL LOADS CALCULATED USING AIRPLANE MAXIMUM DESIGN TAXI WEIGHT

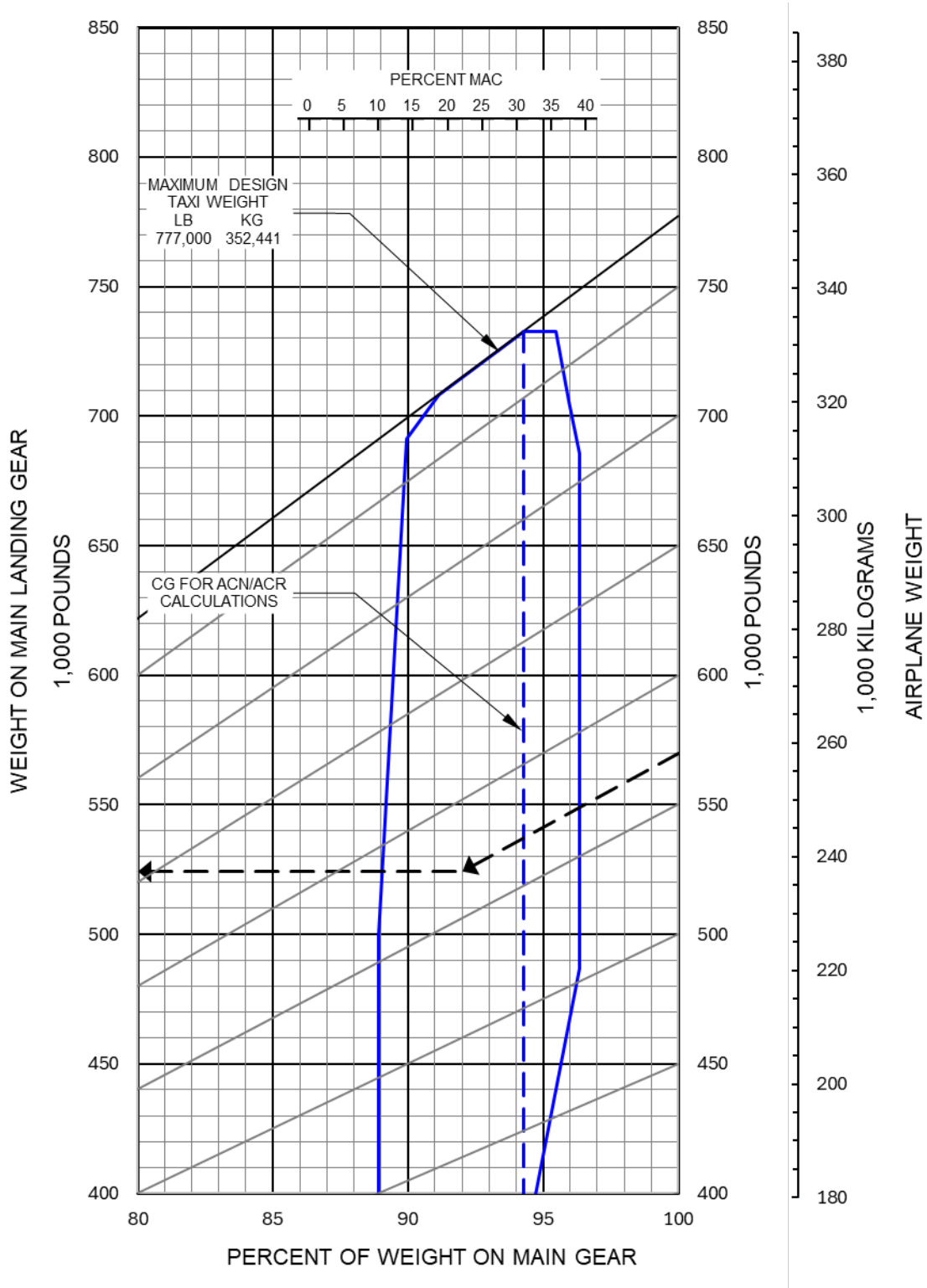


AIRPLANE MODEL	UNITS	MAX DESIGN TAXI WEIGHT	V_{NG}		V_{MG} PER STRUT AT MAX LOAD AT STATIC AFT C.G.	H PER STRUT	
			STATIC AT MOST FWD C.G.	STATIC + BRAKING 10 FT/SEC ² DECEL		STEADY BRAKING 10 FT/SEC ² DECEL	AT INSTANTANEOUS BRAKING ($\mu = 0.8$)
777-9	LB	777,000	68,796	105,543	366,337	120,668	293,070
	KG	352,441	31,205	47,873	166,168	54,734	132,934

PRELIMINARY INFORMATION

7.4 LANDING GEAR LOADING ON PAVEMENT

7.4.1 Landing Gear Loading on Pavement: Model 777-9



D6-86073

PRELIMINARY INFORMATION

7.5 FLEXIBLE PAVEMENT REQUIREMENTS - FAA DESIGN METHOD

For the flexible pavement design refer to the FAA AC 150/5320-6 "Airport Pavement Design and Evaluation" and pavement design program FAARFIELD. Both are available on the FAA website:

FAA AC 150/5320-6: https://www.faa.gov/airports/resources/advisory_circulars/

FAARFIELD: https://www.faa.gov/airports/engineering/design_software/

PRELIMINARY INFORMATION

7.6 FLEXIBLE PAVEMENT REQUIREMENTS - LCN CONVERSION

The Load Classification Number (LCN) curves are no longer provided in section 7.6 and 7.8 since the LCN system for reporting pavement strength is obsolete, being replaced by the ICAO recommended ACN/PCN system in 1983. For questions regarding the LCN system contact Boeing Airport Operations Engineering:

AirportCompatibility@boeing.com

PRELIMINARY INFORMATION

7.7 RIGID PAVEMENT REQUIREMENTS - PORTLAND CEMENT ASSOCIATION DESIGN METHOD

The rigid pavement requirements based on the Portland Cement Association method are no longer provided.

PRELIMINARY INFORMATION

7.8 RIGID PAVEMENT REQUIREMENTS - LCN CONVERSION

The Load Classification Number (LCN) curves are no longer provided in section 7.6 and 7.8 since the LCN system for reporting pavement strength is obsolete, being replaced by the ICAO recommended ACN/PCN system in 1983. For questions regarding the LCN system contact Boeing Airport Operations Engineering:

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PRELIMINARY INFORMATION

7.9 RIGID PAVEMENT REQUIREMENTS - FAA DESIGN METHOD

For the rigid pavement design refer to the FAA AC 150/5320-6, [Airport Pavement Design and Evaluation](#) and pavement design program FAARFIELD. Both are available on the FAA website:

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FAARFIELD: https://www.faa.gov/airports/engineering/design_software/

PRELIMINARY INFORMATION

7.10 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 chart in Section 7.10.1 shows that for a 777-9 aircraft with gross weight of 625,000 lb on a medium strength subgrade (Code B), the flexible pavement ACN is 53.5, which rounded to the nearest whole number is reported as 54. In Section 7.10.2, for the same aircraft weight and medium subgrade strength (Code B), the rigid pavement ACN is 62.5, which rounded to the nearest whole number is reported as 63.

The following table provides ACN data in tabular format similar to the one used by ICAO in Doc 9157-AN/901, Aerodrome Design Manual, Part 3, “Pavements,” Second Edition, 1983. If the ACN for an intermediate weight between maximum taxi weight and the minimum weight specified in the table is required, Sections 7.10.1 through 7.10.2 should be consulted.

The ACN curve graphs were developed based on standard recommended practices from ICAO Annex 14, Aerodromes, Volume I, “Aerodrome Design and Operations,” Ninth Edition, July 2022, and guidance material from ICAO Doc 9157-AN/901, Aerodrome Design Manual, Part 3, “Pavements,” Second Edition, 1983. The Federal Aviation Administration has developed the “ICAO-ACN 1.0” program to calculate the ACN values for aircraft on flexible and rigid airport pavements, and it is available for download at:

<https://www.airporttech.tc.faa.gov/Products/Airport-Safety-Papers-Publications/Airport-Safety-Detail/icao-acn-10>.

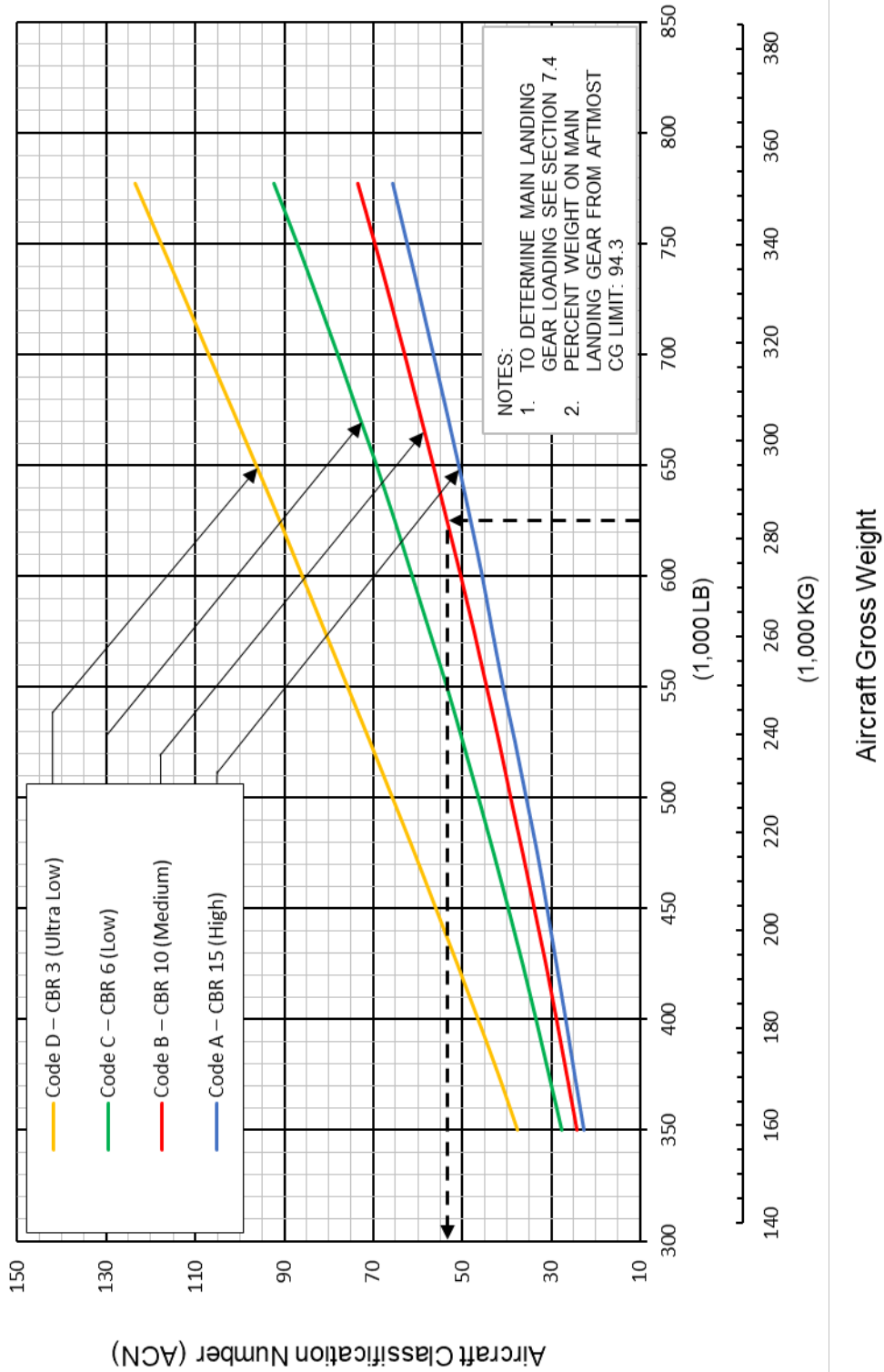
AIRCRAFT TYPE	MAXIMUM TAXI WEIGHT MINIMUM WEIGHT *[1] lb (kg)	LOAD ON ONE MAIN GEAR LEG (%)	TIRE PRESSURE psi (MPa)	ACN FOR FLEXIBLE PAVEMENT SUBGRADES CBR				ACN FOR RIGID PAVEMENT SUBGRADES k, pci (MN/m ³)			
				HIGH (A) 15	MEDIUM (B) 10	LOW (C) 6	ULTRA LOW (D) 3	HIGH (A) 550 (150)	MEDIUM (B) 300 (80)	LOW (C) 150 (40)	ULTRA LOW (D) 75 (20)
777-9	777,000 (352,441)	47.15	224 (1.54)	66	74	92	124	69	89	114	136
	350,000 (158,757)			23	24	28	38	24	27	33	41

*[1] Minimum weight used solely as a baseline for ACN curve generation.

PRELIMINARY INFORMATION

7.10.1 Aircraft Classification Number - Flexible Pavement: Model 777-9

- NOTES:
- TIRES - 52x21.0R22, 38PR
 - PRESSURE - 224 PSI (1.54 MPa)

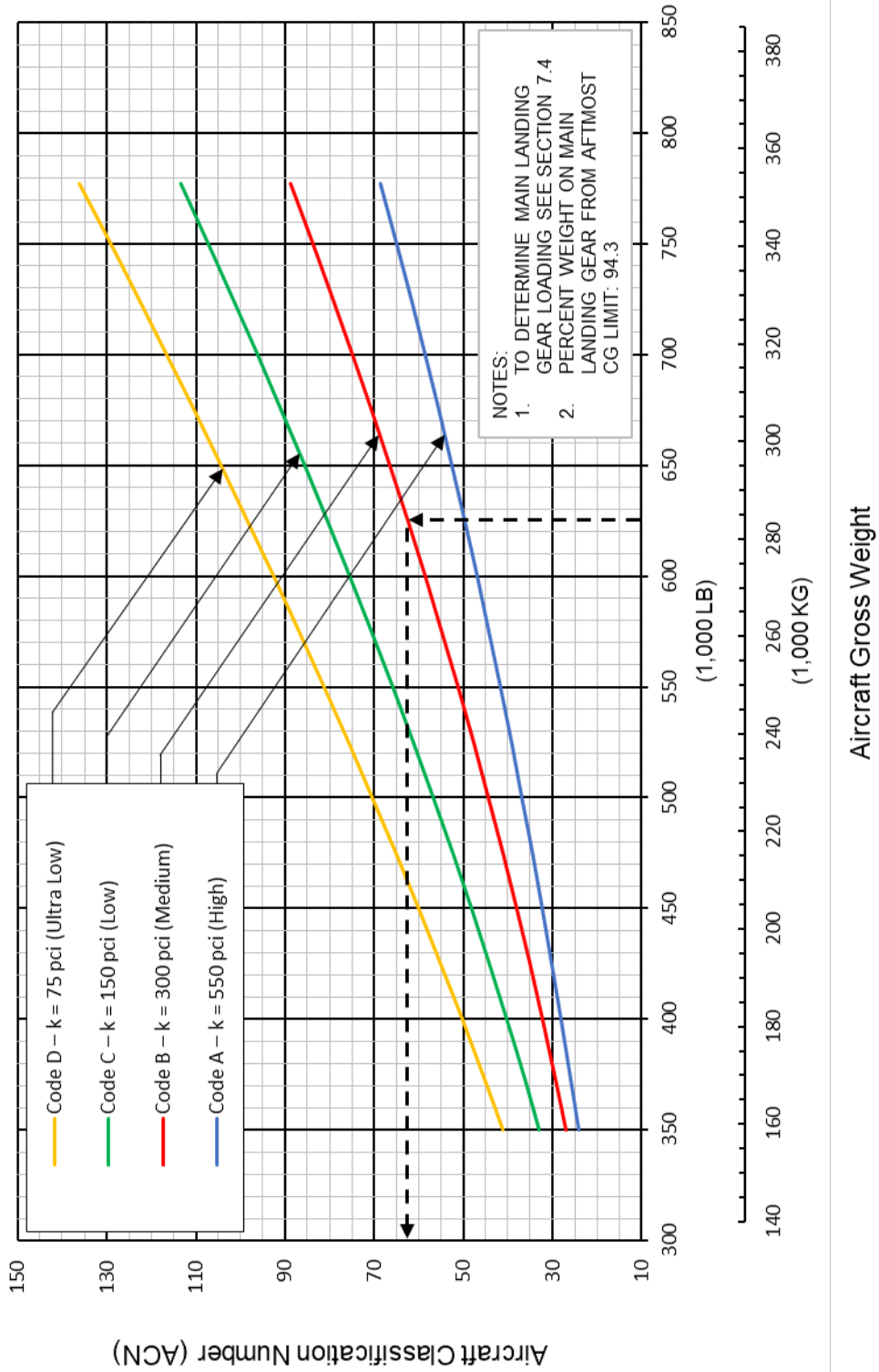


D6-86073

PRELIMINARY INFORMATION

7.10.2 Aircraft Classification Number - Rigid Pavement: Model 777-9

- NOTES:
- TIRES – 52x21 0R22, 38PR
 - PRESSURE – 224 PSI (1.54 MPa)



PRELIMINARY INFORMATION

7.11 ACR/PCR REPORTING SYSTEM - FLEXIBLE AND RIGID PAVEMENTS

To determine the ACR of an aircraft on flexible or rigid pavement, both the aircraft gross weight and the subgrade strength category must be known. The chart in Section 7.11.1 shows that for a 777-9 aircraft with gross weight of 625,000 lb on a medium strength subgrade (Code B), the flexible pavement ACR is 494, which rounded to the nearest multiple of ten is reported as 490. In Section 7.11.2, for the same aircraft weight and medium subgrade strength (Code B), the rigid pavement ACR is 718, which rounded to the nearest multiple of ten is reported as 720.

The following table provides ACR data in tabular format. If the ACR for an intermediate weight between maximum taxi weight and the minimum weight specified in the table is required, Sections 7.11.1 through 7.11.2 can be consulted.

The ACR curve graphs were developed based on standard recommended practices from ICAO Annex 14, Aerodromes, Volume I, “Aerodrome Design and Operations,” Ninth Edition, July 2022, and guidance material from ICAO Doc 9157-AN/901, Aerodrome Design Manual, Part 3, “Pavements,” Third Edition, 2022. The Federal Aviation Administration has developed the “ICAO-ACR 1.4” program to calculate the ACR values for aircraft on flexible and rigid airport pavements”, and it is available for download at:

<https://www.airporttech.tc.faa.gov/Products/Airport-Safety-Papers-Publications/Airport-Safety-Detail/ICAO-ACR-14>.

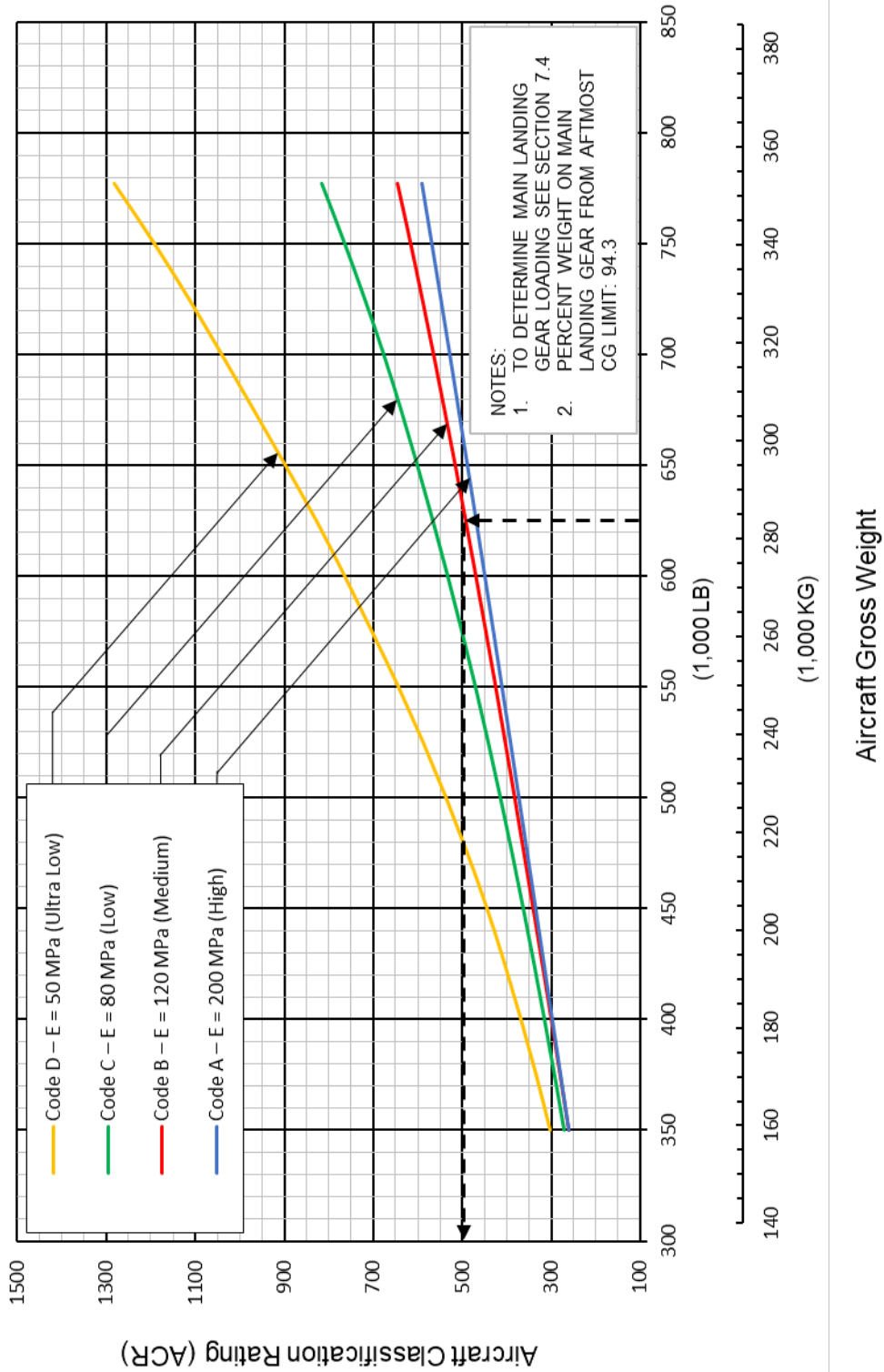
AIRCRAFT TYPE	MAXIMUM TAXI WEIGHT MINIMUM WEIGHT *[1] lb (kg)	LOAD ON ONE MAIN GEAR LEG (%)	TIRE PRESSURE psi (MPa)	ACR FOR FLEXIBLE PAVEMENT SUBGRADES				ACR FOR RIGID PAVEMENT SUBGRADES			
				HIGH (A) E = 200 MPa	MEDIUM (B) E = 120 MPa	LOW (C) E = 80 MPa	ULTRA LOW (D) E = 50 MPa	HIGH (A) E = 200 MPa	MEDIUM (B) E = 120 MPa	LOW (C) E = 80 MPa	ULTRA LOW (D) E = 50 MPa
777-9	777,000 (352,441)	47.15	224 (1.54)	590	650	820	1280	820	1040	1220	1400
	350,000 (158,757)			260	260	270	300	250	280	330	400

*[1] Minimum weight used solely as a baseline for ACR curve generation.

PRELIMINARY INFORMATION

7.11.1 Aircraft Classification Rating - Flexible Pavement: Model 777-9

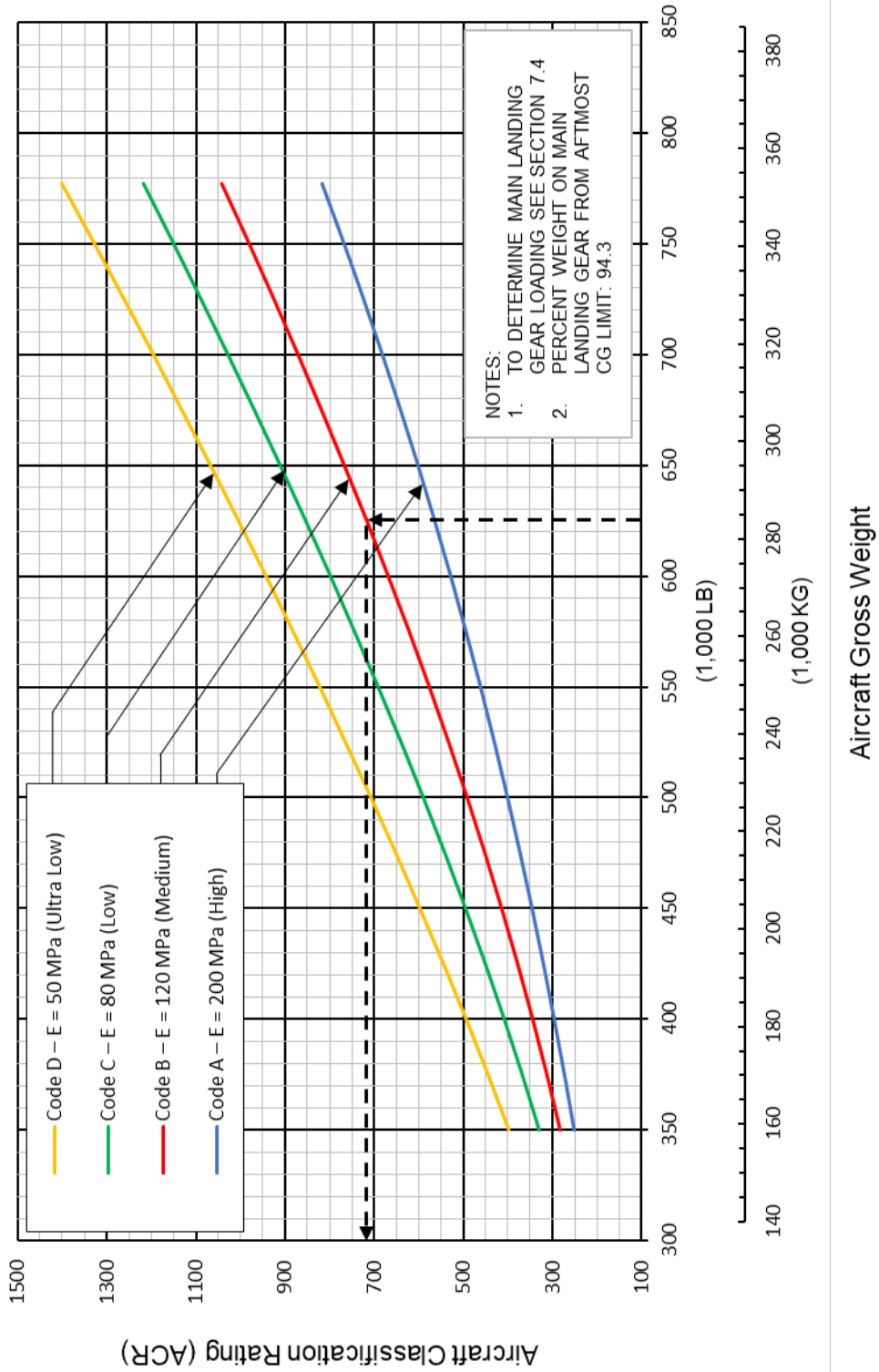
- NOTES:
- TIRES - 52x21.0R22, 38PR
 - PRESSURE - 224 PSI (1.54 MPa)



PRELIMINARY INFORMATION

7.11.2 Aircraft Classification Rating - Rigid Pavement: Model 777-9

- NOTES:
- TIRES – 52x21 0R22, 38PR
 - PRESSURE – 224 PSI (1.54 MPa)



PRELIMINARY INFORMATION

8.0 FUTURE 777 DERIVATIVE AIRPLANES

Boeing's philosophy is to evaluate the derivative potential of its airplanes to provide capabilities that maximize value to our customers.

Decisions to design and manufacture future derivatives of an airplane depend on many considerations, including customer requirements. Along with many other parameters, airport facilities are considered during the development of any future airplane.

PRELIMINARY INFORMATION

9.0 SCALED 777 DRAWINGS

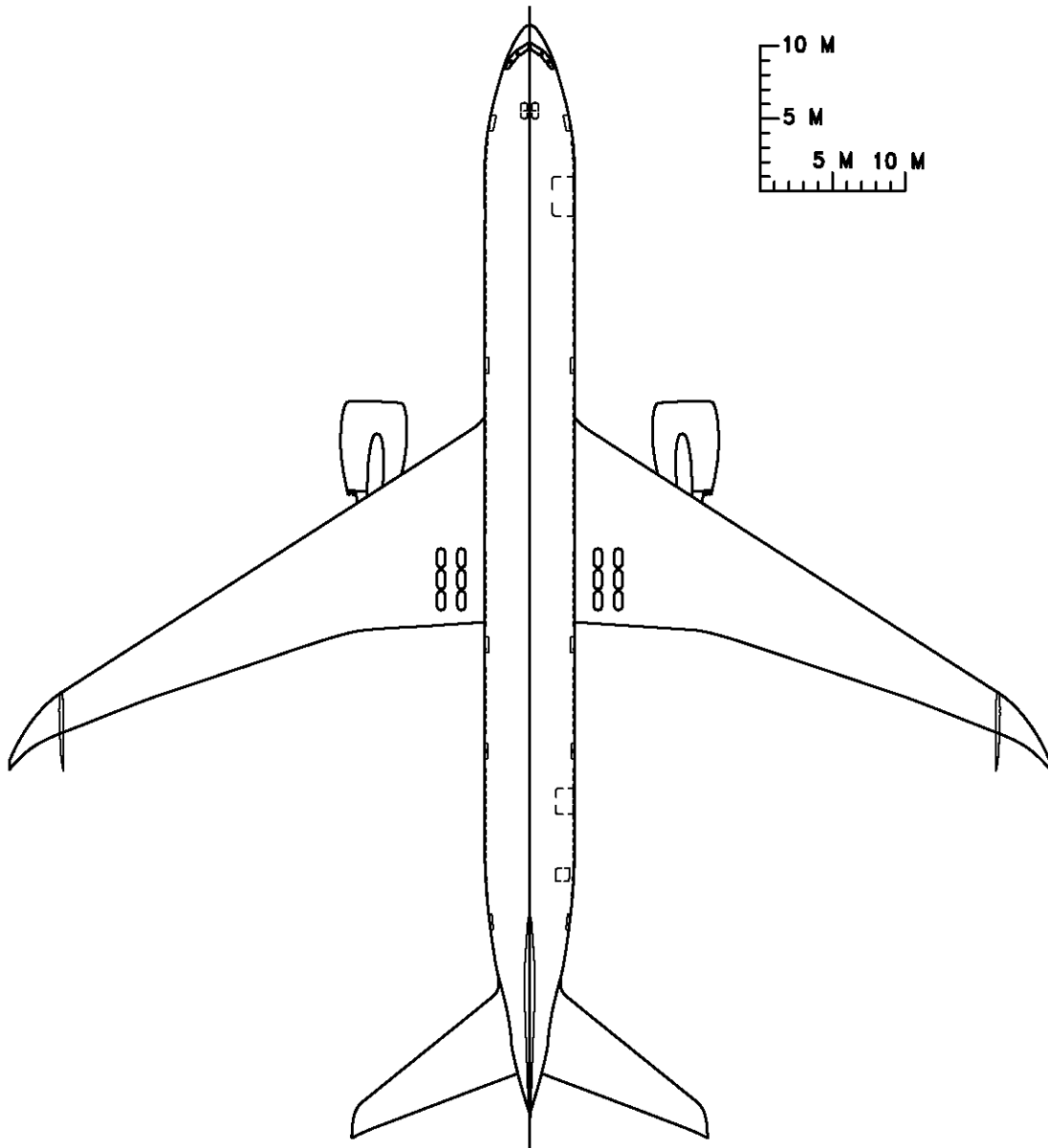
The drawings in the following pages show airplane plan view drawings, drawn to approximate scale as noted. The drawings may not come out to exact scale when printed or copied from this document. Printing scale should be adjusted when attempting to reproduce these drawings. Three-view drawing files of the 777X, along with other Boeing airplane models, can be downloaded from the following website:

<http://www.boeing.com/airports>

PRELIMINARY INFORMATION

9.1 MODEL 777-9

9.1.1 Scaled Drawings – 1:500: Model 777-9



NOTE: ADJUST SCALE WHEN PRINTING THIS PAGE

D6-86073

REV F

December 2024

9-2

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PRELIMINARY INFORMATION

10.0 APPENDICES

10.1 APPENDIX A – 777-9 FOLDING WING TIP CONCEPT OF NORMAL OPERATIONS (FWT CONOPS)

10.1.1 LIST OF ACRONYMS

ACAP	Aircraft Characteristics for Airport Planning
AIP	Aeronautical Information Publication
ANC	ICAO Air Navigation Commission
ARC	Aerodrome Reference Code
ATC	Air Traffic Control
EICAS	Engine Indication and Crew Alerting System
FWT	Folding Wing Tip
ICAO	International Civil Aviation Organization
MEL	Minimum Equipment List
RET	Rapid-Exit Taxiway

PRELIMINARY INFORMATION

10.1.2 INTRODUCTION

This document outlines the concept of operations for the 777-9 folding wing tip (FWT). Normal operational procedures for the FWT and other considerations for FWT airport operations are included.

This document does not address other airport considerations during normal 777-9 operations such as pavement strength, servicing, etc. For more information on standard 777-9 operations please see the 777-9 Aircraft Characteristics for Airport Planning (ACAP) document page at www.boeing.com/airports.

The International Civil Aviation Organization (ICAO)¹ determines International Standards and Recommended Practices for airport design. Included in the design are separation criteria between taxiways, runways, taxi lanes and objects based on the ARC (Aerodrome Reference Code of the operating aircraft), Code A through F. The 777-9 operations will be a Code E (same as the Boeing 747-400 and 777-300ER) with wings folded (wingspan of 64.8m) and a Code F with the wings extended (71.8m). The intent of FWT feature is to allow the 777-9 to operate at airports designed to ICAO Code E standards when on taxiways and at the gate/apron area.

This document outlines FWT procedures and considerations for the 777-9. However, it is recognized that at some airports, unique operational procedures may be required.

¹ International Civil Aviation Organization. *Annex 14 to the Convention on International Civil Aviation Aerodromes Volume 1, Aerodrome Design and Operations*, Seventh Edition July 2016. Montreal, Quebec, Canada

PRELIMINARY INFORMATION

10.1.3 NORMAL FWT OPERATIONS OVERVIEW

The FWT operational phases are shown in Figure 1. During the taxi for departure phase, the 777-9 taxis to the departure runway with the FWT folded. Once passing a predetermined location that assures wingtip clearance (the exact location to extend the FWT will be determined by an aerodrome based on its operational plans and physical layouts), the flight crew will initiate the command for the FWT to extend so as to be in the takeoff configuration (extended and locked) prior to the hold-short line. Due to the unique geometry of each airport, it will not be practical to automate the extension of the FWT and the extension action will be left to the flight deck crew for manual operation when required.

Upon landing, the FWT control logic will automatically fold the FWT after the aircraft has touched down and ground speed is below 50 kts. This ensures that the FWT will be folded before entering the parallel taxiway.

In the event of a non-normal FWT condition, an airport-specific Non-Normal FWT Operational Plan will be invoked. The 777-9 Non-Normal Folding Wing Tip operational Plan outlines a generic airport operations plan for 777-9 for ground maneuvering in the event of a non-normal FWT condition, so this scenario is not addressed in this document.

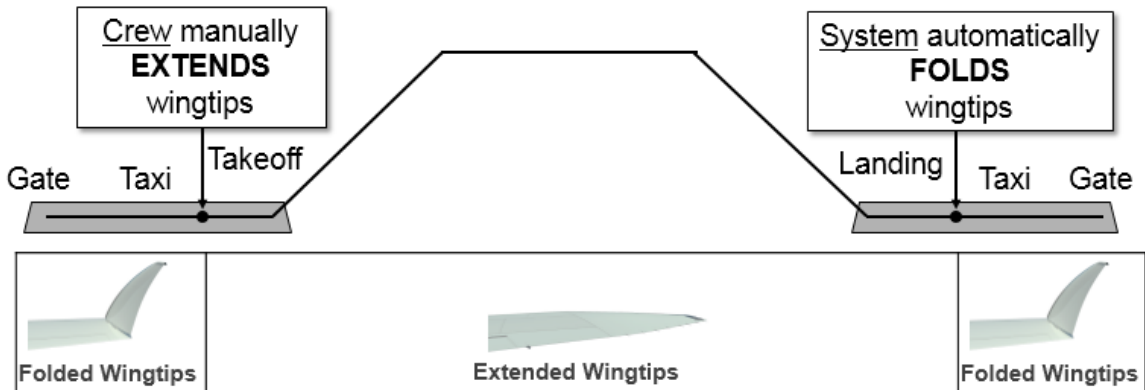


Figure 1: FWT Operational Concept

PRELIMINARY INFORMATION

10.1.4 FWT OPERATIONS BEFORE TAKEOFF

The FWT departure procedure is shown in Figure 2 below.

While at the gate, the FWT will remain folded and is prevented from extending. If maintenance is needed at the gate, a special function can be used to allow FWT extension that overrides system inhibit logic while the airplane is parked. Note that any maintenance that requires extending the FWT at a gate may require coordination with the airport operator to ensure there is adequate clearance.

During the taxi for departure phase, the 777-9 taxis to the runway with the FWT folded. The flight deck crew will initiate the command for FWT to extend so as to be in the takeoff configuration (extended and locked) prior to reaching the hold-short line. Extension of the wing tips FWT takes 20 seconds. The exact location to extend the FWT will be determined by an aerodrome based on its operational plans and physical layout; data from Attachment A and Attachment B provide information to support definition of the extend location. Apron procedures should consider moving parallel aircraft. Airline and airport procedures should allow the 777-9 to extend the FWT as early as possible. The location should be included in each airport's aeronautical information publication (AIP) to allow charts and procedures to be updated as required. The extend location will be part of the pre-flight briefing. The aircraft must enter the runway in a ready-for-takeoff configuration.

Extension of the FWT takes 20 seconds, which envelopes normally encountered conditions.

For an airport where FWT extension is not feasible prior to the hold short line, a supplemental procedure to allow extension of the FWT on the runway is available to the flight deck crew. Delaying wingtip extension until taxiing onto the departure runway could be required when there is limited clearance between runways and taxiways, runways where runway back taxi is required, during taxi route closures, or anytime obstacle clearance with wingtips extended cannot be assured during taxi.

Once the airplane is configured for takeoff, the flight deck crew will request ATC (Air Traffic Control) takeoff clearance. Wing tip configuration will not be specifically reported to ATC unless a non-normal condition is experienced. In this case, the non-normal condition will be annunciated on the EICAS screen. The flight deck crew will be alerted via EICAS messaging, and the non-normal FWT operation plan will be invoked.

In the event of a high-speed rejected takeoff (RTO) scenario, the automatic fold feature is enabled. If the airplane achieves a rejected takeoff ground speed of 85 kts or above, then the FWT will automatically fold once the airplane has decelerated below 50 kts ground speed. The 85 kts threshold is the same threshold for activating RTO autobrakes and speedbrakes. Rejected takeoffs that occur below 85 kts will not trigger the auto fold function and the flight deck crew will manually fold the FWT.

PRELIMINARY INFORMATION

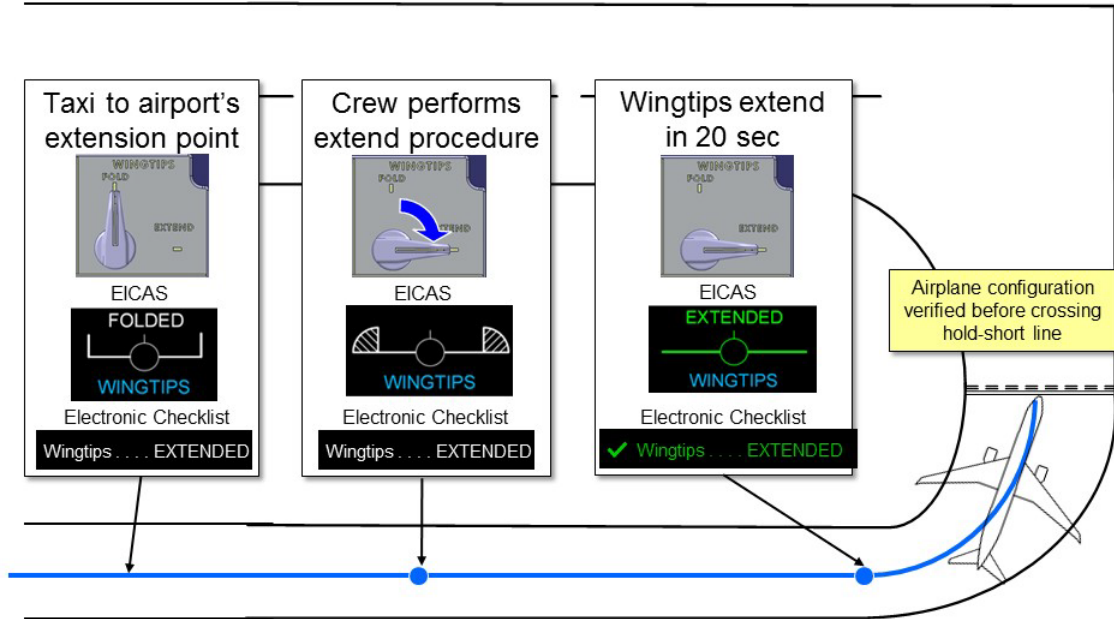


Figure 2: FWT Departure Procedure

PRELIMINARY INFORMATION

10.1.5 FWT OPERATIONS AFTER LANDING

The FWT arrival procedure is shown in Figure 3 below.

Upon landing, the FWT system will automatically fold the wing tips when the aircraft has touched down and ground speed is below 50 kts. Automatic fold of the wing tips prevents adding more tasks for the flight crew to perform during a high-workload phase of operation.

Folding of the wing tips takes 20 seconds, which envelopes normally encountered conditions. Boeing performed studies to confirm that the timing as part of the design will ensure that the FWT will be folded prior to entering the parallel taxiway. These studies considered high speed exits to rapid-exit taxiways designed to both ICAO and FAA separation standards.

Flight Deck Crews will be alerted via EICAS in the event of a non-normal configuration (failure to fold), and the FWT non-normal procedure will be invoked.

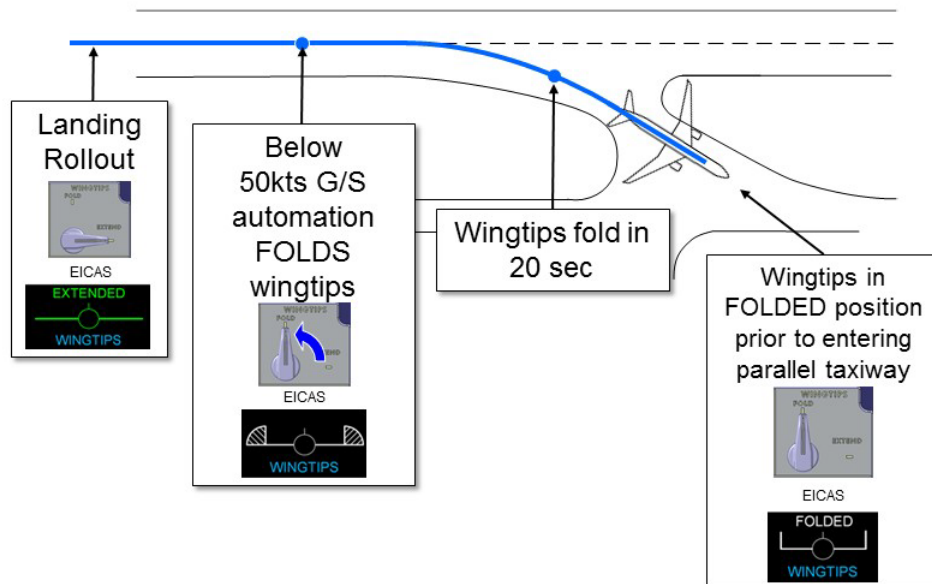


Figure 3: FWT Arrival Procedure

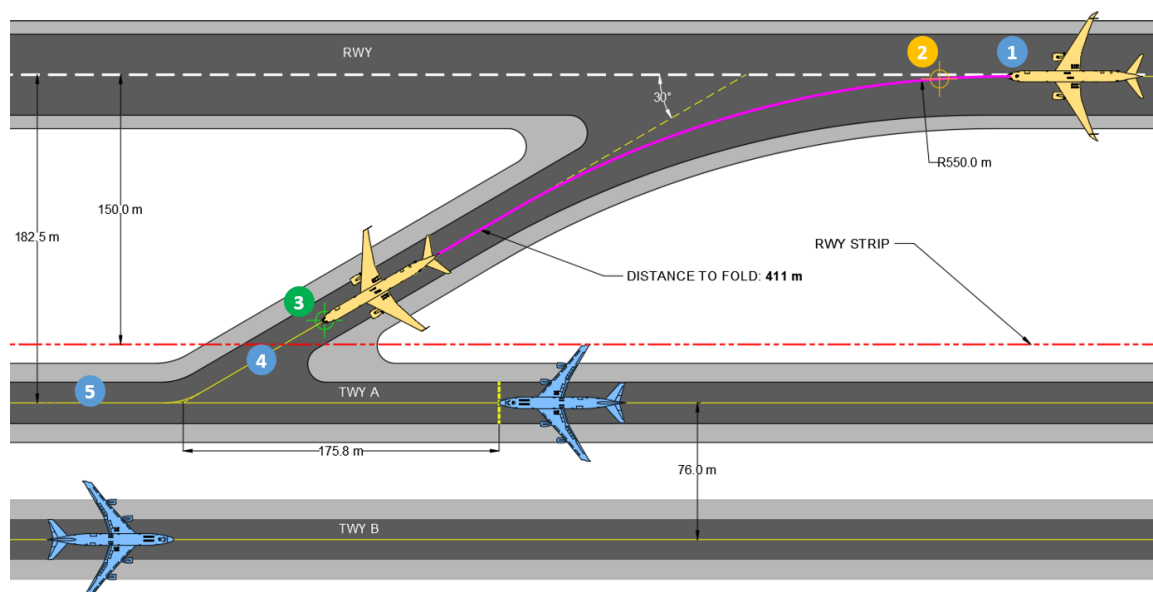
A simulation of a 777-9 taking an ICAO rapid-exit taxiway (RET) is shown in Figure 4 and Table 1 below. In order to maintain 11m separation to a Code E aircraft on the parallel taxiway, the 777-9 must have wing tips folded prior to reaching Point 5 in Figure 4. Prior point 5 the 777-9 is still maneuvering through the intersection and is not centered on the taxiway centerline, thus maintaining 11m wingtip separation. Point 5 is the point at which the wingtip, if still extended, will encroach on the parallel taxiway strip. All points marked in Figure 4 represent cockpit location and it is assumed the aircraft is taxiing with cockpit over centerline. The simulation uses the design parameters recommended in the ICAO Aerodrome Design Manual for a typical RET in terms of geometry and recommended speeds. A constant deceleration of -0.71 m/s^2 is calculated between the tangent points of the two curves to achieve the appropriate design speed for the respective radii. This is less

PRELIMINARY INFORMATION

than what the ICAO Aerodrome Design Manual assumes for braking action on a wet taxiway to develop RET geometry recommendations. This case demonstrates a reasonable worst-case scenario and envelopes all 400+ operationally recorded 777-300ER landings that Boeing evaluated. In all recorded cases, the aircraft would have completed wingtip folding prior to entering the taxiway.

1. Initial point where aircraft enters the RET (measured as the tangent point to the taxiway marking offset 0.9m from the runway centerline). Simulation is initiated at 52 kt ground speed. This is the design speed for a 550m radius curve as recommended by the ICAO Aerodrome Design Manual for a 30° RET. From this point it begins a constant deceleration to reach Point 4 at 14 kt. This is the design speed for a 40m radius curve as recommended by the ICAO Aerodrome Design Manual.
2. Transition of FWT to fold begins at 50 kt ground speed.
3. FWT are folded prior to entering the parallel taxiway—777-9 is Code E.
4. 777-9 reaches 14 kt ground speed and maintains it throughout the remainder of the RET.
5. Point by which 777-9 must have completed folding of the FWT to comply with 11m wingtip clearance to a Code E aircraft on TWY B. This corresponds to a path distance of 578m from Point 1.

A 777-8/9 will be in compliance with Code E aircraft on a parallel taxiway using Annex 14, 7th Edition, Amendment 13A, when entering the taxiway. This simulation is based on ICAO Annex 14, 7th Edition for code number 3-4 airplanes using a preferred intersection angle of 30° and design speeds per ICAO Aerodrome Design Manual Doc 9157, Part 2 for code number 3-4 airplanes. It must be noted that other RET configurations or specific operational procedures may be encountered, and must be evaluated on a case-by-case basis through a safety assessment study.



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December 2024

10-7

PRELIMINARY INFORMATION

Figure 4 Distance to Fold on RET, Simulation (Cockpit over Centerline)

	FWT State	Time (sec)	Ground speed (kt)	Distance Traveled (m)
1	Extended	-1.5	52.0	0
2	Transition	0	49.9	39.3
3	Folded	20	22.4	411.2
4	Folded	26	14.1	467.5
5	Folded	42	14.1	578.0

Table 1 Distance to Fold on RET, Simulation (Cockpit over Centerline)

PRELIMINARY INFORMATION

10.1.6 OTHER DESIGN CONSIDERATIONS

The FWT is designed to the same standards as other components on Boeing airplanes. The following list identifies some relevant topics that often arise, but is not an exhaustive list of FWT design considerations.

Threats

The FWT is designed with consideration to the same threats that must be taken into account for other aircraft wing design. For instance, a bird strike to the FWT on takeoff or approach to a landing is not different than a bird strike to other components of the wing structure.

Any realized threat that results in a FWT not being able to fold or extend normally will have an associated EICAS alert, be made evident to the flight crew through EICAS messaging, allowing the FWT non-normal procedure to be invoked.

De-icing/Anti-icing

The FWT can be de-iced/anti-iced in the folded or extended position. The plan is to treat the FWT no differently than other wing tip devices for de-icing/anti-icing operations (i.e. there will be no reduction in holdover time when the FWT is de-iced/anti-iced in the folded position). The FWT is not considered critical by Boeing for anti-icing. Boeing is seeking regulatory approval for this approach, approval is expected early 2018.

Wind

There are no limitations due to wind (including crosswinds) on the 777-9 specific to the FWT. The FWT is designed to operate within the wind envelope of the airplane.

When wind speeds are expected to be 85 kts or higher (Category II hurricane), a maintenance action will be required to extend and lock the FWT or install ground service equipment designed to hold the FWT in place in the folded position under these high wind loads.

Environment

The FWT is designed for operation in extremes of the in-service environment. Standard design practices are followed for systems and mechanisms directly exposed to harsh environments, similar to the other moveable surfaces on the wing. This includes but is not limited to water, salt spray, deicing fluid, sand/dust, ice, and vibration.

Aircraft Rescue and Fire Fighting

The FWT does not drive new or additional requirements for aircraft rescue and fire-fighting.

Reliability

PRELIMINARY INFORMATION

The FWT is a highly reliable system with built in redundancy and therefore non-normal operations are expected to be infrequent. Reliability is similar to other systems on existing 777 aircraft such as flaps, main landing gear steering, and thrust reversers.

PRELIMINARY INFORMATION

10.2 APPENDIX B – 777-9 FOLDING WING TIP CONCEPT OF NON-NORMAL OPERATIONS - FWT OPERATIONS PLAN

10.2.1 LIST OF ACRONYMS

ANC	ICAO Air Navigation Commission
ARC	Aerodrome Reference Code
EIS	Entry In Service
FWT	Folding Wing Tip
ICAO	International Civil Aviation Organization
CON-OPS	Concept of Normal Operations

PRELIMINARY INFORMATION

10.2.2 INTRODUCTION

This document outlines a generic airport operations plan for 777-9 on-ground maneuvering in the event of a non-normal Folding Wing Tip (FWT). As all airports are unique and have their own policies, procedures and regulations, this document is a generic guide to be used when writing specific operational plans.

This document does not address other airport considerations during normal 777-9 operations such as pavement strength, servicing, etc. For more information on standard 777-9 operations please see the 777-9 Aircraft Characteristics for Airport Planning (ACAP) document page at www.boeing.com/airports.

The International Civil Aviation Organization (ICAO)¹ determines International Standards and Recommended Practices for airport design. Included in the design are separation criteria between taxiways, runways, taxi lanes and objects based on the ARC (Aerodrome Reference Code of the operating aircraft), Code A through F. The 777-9 operations will be a Code E (same as the Boeing 747-400 and 777-300ER) with wings folded (wingspan of 64.8m) and a Code F with the wings extended (71.8m). The intent of FWT feature is to allow the 777-9 to operate at airports designed to ICAO Code E standards when on taxiways and at the gate/apron area. In the event of a non-normal FWT, the wingspan increases up to 3.5m on either side or both sides to a maximum wingspan of 71.8m, becoming a Code F airplane (same as the Boeing 747-8 and the Airbus A380). Therefore, this document will address 777-9 operations with a non-normal FWT on aircraft taxi routes designed to less than Code F specifications. Furthermore, it is assumed in this document that the 777-9 will be the largest commercial aircraft operating at the airport, and all other traffic will be at most Code E. Analysis is carried out on airport infrastructure designed per the 7th edition on ICAO Annex 14, Amendment 13A.

This document recommends procedures that result in an acceptable level of safety when operating a 777-9 with a non-normal FWT in a non-Code F environment. However, it is recognized that at some airports, unique operational procedures may be required. In addition, the ICAO PANS – Aerodromes² document provides guidance to conduct safety assessment, address airport-airplane compatibility, operational procedures and mitigations.

¹ International Civil Aviation Organization. *Annex 14 to the Convention on International Civil Aviation Aerodromes* Volume 1, Aerodrome Design and Operations, Seventh Edition July 2016. Montreal, Quebec, Canada

² International Civil Aviation Organization. *PANS-Aerodromes, Procedures for Air Navigation Services*, Doc 9981, Second Edition, 2016

PRELIMINARY INFORMATION

10.2.3 NORMAL FWT OPERATIONS: BACKGROUND, TAKEOFF AND LANDING

During the taxi for departure phase, the 777-9 taxis to the runway with wings folded (Figure 1). The flight crew will initiate the command for the wings to extend so as to be in the takeoff configuration (extended and locked) prior to the hold line. Extension of the wing tips takes 20 seconds. The exact location to extend the wing tips will be determined by each aerodrome based on its operational plans and physical layouts. The location will be part of the preflight briefing. Upon confirmation that wings are in the takeoff configuration, the flight crew will receive ATC (Air Traffic Control) takeoff clearance.

When preparing to land a 777-9 at a specific airport, part of the approach briefing will include a review of the non-normal FWT alternate taxi routes developed by the airport as part of the “taxi routing to parking” discussion. These routes will specify whether the route is adequate for a single non-normal FWT on a specific side or failure on both sides. This briefing will be conducted to prepare the flight crew for an alternate taxi route in the event of a non-normal FWT.

Upon landing, the FWT system will automatically fold the wing tips when the aircraft has touched down and ground speed is below 50 kts in order to be folded before entering the taxiway environment. Folding of the wing tips takes 20 seconds.

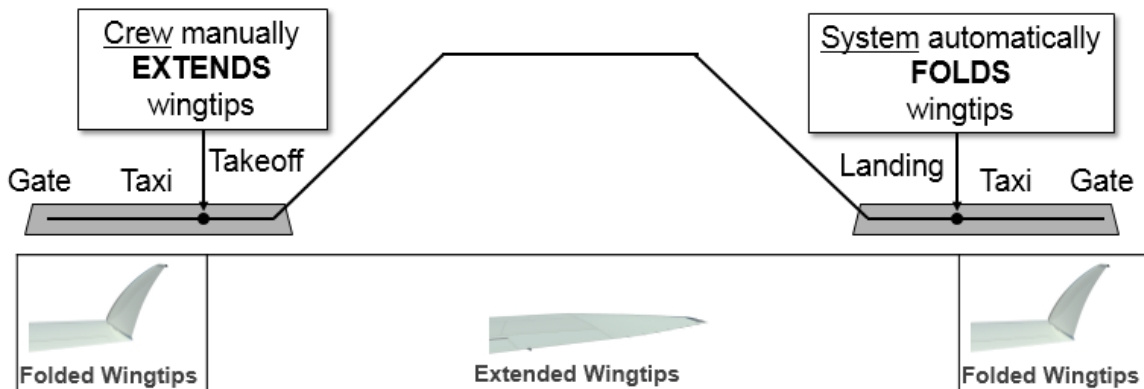


Figure 1: FWT Operational Concept

PRELIMINARY INFORMATION

10.2.4 FWT NON-NORMAL OPERATIONS BEFORE TAKEOFF

There are two types of non-normal FWT scenarios that can occur before takeoff/before departure. Both types, along with the associated procedures, will have been reviewed by the flight crew during the pre-flight briefing.

The first failure mode occurs when the FWT fails to extend when actioning the Folding Wing Tip Pilot Control Module lever. In this event, the flight crew will get **WINGTIPS DRIVE** message on the EICAS (Engine Indication and Crew Alerting System), as well as a master caution light and aural beeper indicating the malfunction. If both wings fail to extend and the wingspan remains a Code E, the flight crew will inform the tower of the malfunction and their need to return to the gate or to a pre-designated parking stand and wait for instructions. If one or both of the wing tips partially extend or only one wing tip extends, the flight crew can attempt to re-fold the wing tips. If re-folding is unsuccessful, the wingspan will not be Code E. EICAS will indicate which wingtip has failed, and continue to show the sensed position for the non-failed wingtip. The flight crew will then inform the tower of the malfunction and their intentions to follow the non-normal FWT taxi route back to the gate or other designated parking spot. The tower will either approve or offer an alternate to the request. The flight crew will then taxi the aircraft to the designated parking stand or gate via the taxi route agreed upon between the tower and flight crew. After the flight crew coordinates with the airline regarding passenger offload, the wing tips will then be repaired or manually configured for safe flight (see the paragraph below).

The second type of non-normal FWT during departure is when the airplane is dispatched per the minimum equipment list (MEL) with the wing tips manually locked in the extended position as a Code F airplane due to a pre-existing failure of the FWT system. The flight crew will review 777-9 non-normal FWT alternate taxi procedure during the pre-flight briefing and inform ground control of their configuration and intended taxi route. Once cleared for pushback, all precautionary and safety measures as defined in the airport's non-normal FWT operational plan are exercised to provide an equivalent level of safety to standard 777-9 operations. After pushback, the flight crew will taxi the aircraft along the predetermined non-normal FWT route and takeoff.

PRELIMINARY INFORMATION

10.2.5 FWT NON-NORMAL OPERATIONS AFTER LANDING

In the event that the FWT system does not automatically issue the fold command (autofold failure), the flight crew will receive a **WINGTIPS POSITION** caution message on the EICAS as well as a master caution light and aural beeper to alert them of the malfunction. The flight crew will action the Folding Wing Tip Pilot Control Module lever manually to command the wing tips to the Folded position and assume normal taxi operations to the gate.

In the event of non-normal FWT where one or both of the wing tips fail to move to or reach the Folded position, the flight crew will get a **WINGTIPS DRIVE** caution message on the EICAS of the malfunction, as well as a master caution light and aural beeper. EICAS will also indicate which wing tip has failed, and continue to show the sensed position of the non-failed wing tip. The flight crew will action the associated non-normal checklist. The flight crew will then inform the tower of the malfunction and their intentions to follow the non-normal FWT taxi route. The tower will either approve or offer an alternate to the request. The flight crew will then taxi the aircraft to the designated parking stand or gate via the taxi route agreed upon between the tower and flight crew. Details of apron operations with one or both wing tips failed in the extend position can be found in Section 7c, “Apron and Stand Operations”.

In some cases, the FWT system can detect specific malfunctions prior to landing that will prevent the wing tips from correctly folding. This failure condition is indicated with a **WINGTIPS SYS** advisory message, and enables the flight crew to immediately begin ATC, tower, and airline operations coordination in advance of landing.

PRELIMINARY INFORMATION

10.2.6 NON-NORMAL FWT TAXIWAY OPERATIONS

10.2.6.1 Taxiway To Runway Separations

The ICAO Aerodrome Design Manual for taxiways¹ clarifies that the runway to taxiway separation is based on the principle that the wing tip of an airplane taxiing on a parallel taxiway should not penetrate the runway strip. This relationship is currently quantified by the following equation:

$$\begin{aligned} & \textit{Runway to Taxiway Separation Distance} \\ &= \frac{1}{2} \textit{Wingspan taxiing aircraft} + \textit{Runway Strip Width} \end{aligned}$$

The ICAO Annex 14 7th edition (Amendment 13A) recommends a runway strip extending 150m each side of the centerline. The recommendation for taxiway to runway centerline separation based on this strip width is 182.5m for Code E operations and 190m for Code F operations. Applying this equation to a 777-9 with Non-Normal FWT, the result is a minimum Runway to Taxiway separation of 186m. Figure 2a shows a Code E aircraft on the runway with a 777-9 with Non-Normal FWT on the parallel taxiway with 182.5m separation.

¹ *Aerodrome Design Manual* Part 2, Taxiways, Aprons and Holding Bays Fourth Edition, 2005. Montreal, Quebec, Canada. Sect 1.2.46

PRELIMINARY INFORMATION

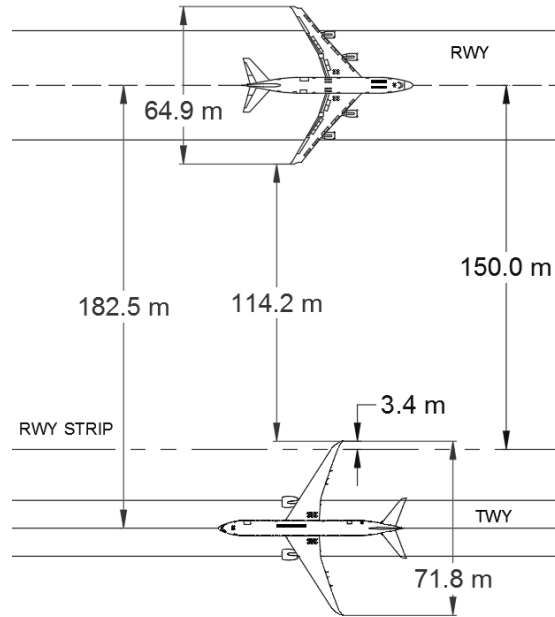


Figure 2a: Code E aircraft on runway with 777-9 with non-normal FWT on parallel taxiway (ICAO)

A 777-9 with non-normal FWT will encroach on the runway strip by 3.4m at the minimum ICAO Code E separation of 182.5. A safety assessment study should be performed or mitigation procedures enacted to ensure safety of operations¹.

¹ International Civil Aviation Organization. *PANS-Aerodromes*, Procedures for Air Navigation Services, Doc 9981, Second Edition, 2016, Chapter 3.

PRELIMINARY INFORMATION

The European Aviation Safety Agency (EASA) Certification Specifications and Guidance Material for Aerodromes Design (Issue 4, December 2017), CS ADR-DSN.D.260 Taxiway minimum separation distance from Taxiway to instrument Runways code number 3 and 4 is 172.5m for Code E and 180m for Code F.

Figure 2b shows a Code E aircraft on the runway with a 777-9 with Non-Normal FWT on the parallel taxiway with 172.5m separation.

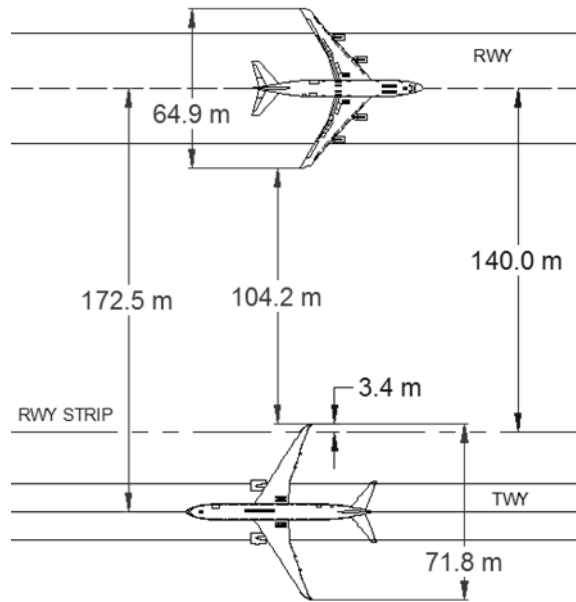


Figure 2b: Code E aircraft on runway with 777-9 with non-normal FWT on parallel taxiway (EASA)

PRELIMINARY INFORMATION

10.2.6.2 Taxiway To Taxiway Separations

ICAO Annex 14 7th edition, Amendment 13A, recommends a parallel taxiway centerline separation of 76m for Code E operations and 91m for Code F operations, in order to provide a minimum wing tip clearance of 11m for aircraft of the respective codes operating on parallel taxiways. The clearance between a 777-9 with Non-Normal FWT and a Code E aircraft on parallel taxiways built per this recommendation can be seen in Figure 3.

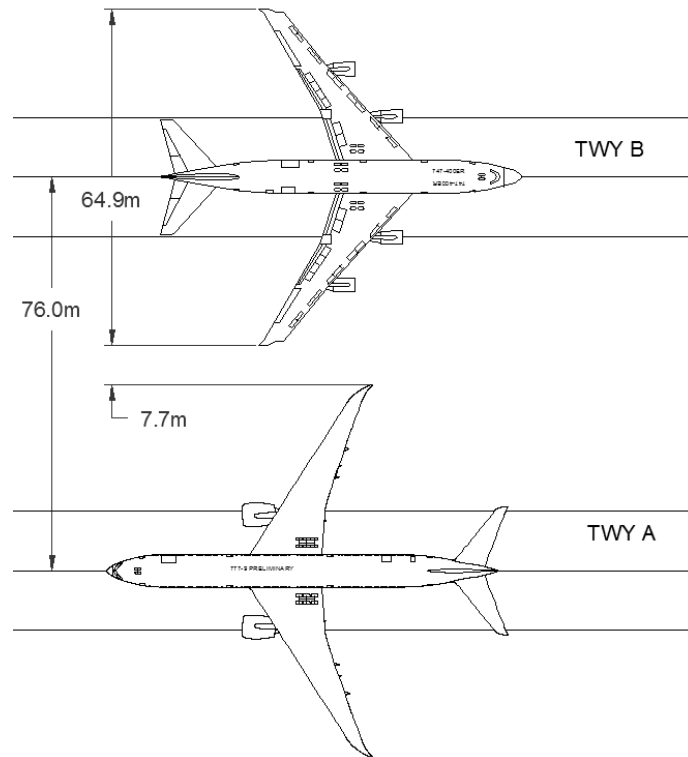


Figure 3: Wing tip clearances between a 747-400 (limiting Code E aircraft) and a 777-9 with non-normal FWT on parallel taxiways

During taxiway operations, a 777-9 with non-normal FWT will have 7.7m of wing tip clearance to a 747-400 (used as Code E limiting aircraft) on the parallel taxiway, which is less than the recommended 11m. In order for a Code E aircraft to maintain 11m separation to a 777-8/-9 with Non-Normal FWT, a parallel taxiway separation of at least 79.3m is required. As a possible mitigation, aircraft operating on TWY B can be limited to a wingspan of no more than 58.2m in order to maintain the current ICAO recommended wing tip clearance of 11m for Code E.

PRELIMINARY INFORMATION

During taxiway operations with non-normal FWT, it is possible to encounter another 777-9 on a parallel taxiway that has extended FWT in preparation for takeoff, a scenario illustrated in Figure 4

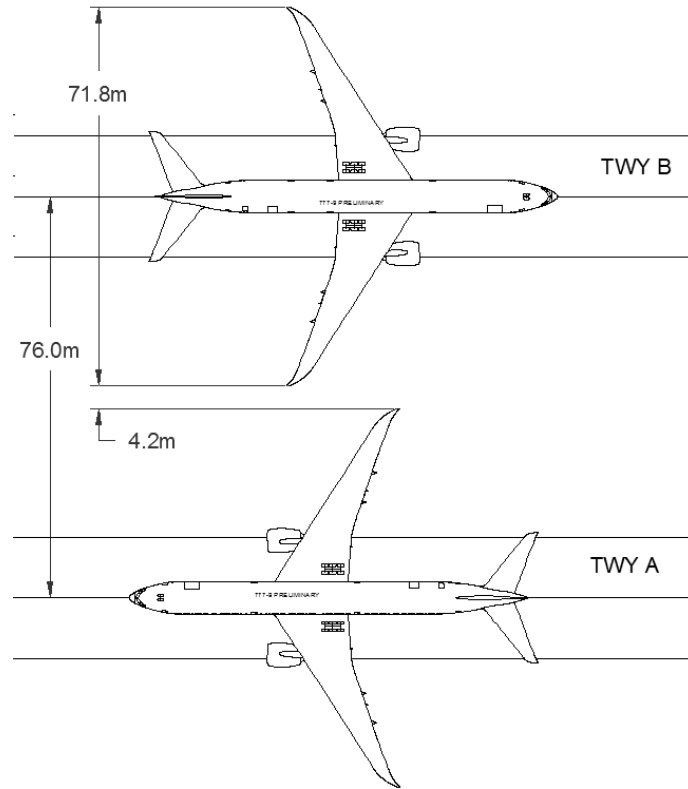


Figure 4: Wing tip clearances between a 777-9 with wings extended and a 777-9 with non-normal FWT on parallel Code E TWs

During taxiway operations of 777-9 with non-normal FWT will have 4.2m of wing tip clearance, which is less than the recommended 11m.

It may be permissible to operate a 777-9 with a non-normal FWT with less than 11m wingtip separation to aircraft on a parallel taxiway if a safety assessment study¹ indicates that such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of airplanes.

¹ International Civil Aviation Organization. *PANS-Aerodromes*, Procedures for Air Navigation Services, Doc 9981, Second Edition, 2016, Chapter 3

PRELIMINARY INFORMATION

10.2.6.3 Taxiway To Object Separations

Annex 14 7th edition, Amendment 13A, recommends a distance of 43.5m between the centerline of a taxiway and a stationary object, to ensure 11m wing tip clearance. The clearance between a 777-9 with Non-Normal FWT on a taxiway and an object at 43.5m from the taxiway centerline is show in Figure 5.

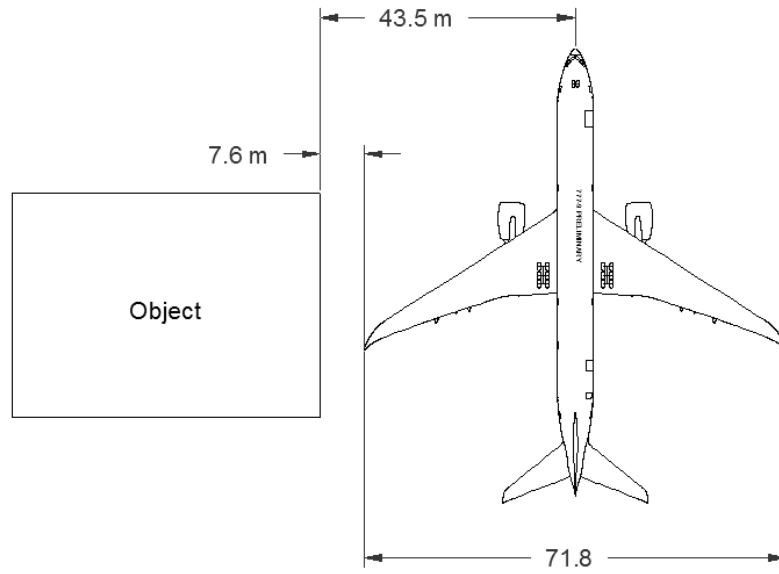


Figure 5: Wing tip clearances between a 777-9 with non-normal FWT on a taxiway and a stationary object

The resulting clearance is 7.6m, which is less than the recommended 11m. To maintain 11m wing tip separation in the event of a non-normal FWT, the recommended 777-9 taxiway centerline to object separation should be at least 46.9m.

It may be permissible to operate a 777-9 with a non-normal FWT with less than 11m wingtip separation to an object if a safety assessment study¹ indicates that such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of airplanes.

¹ International Civil Aviation Organization. *PANS-Aerodromes*, Procedures for Air Navigation Services, Doc 9981, Second Edition, 2016, Chapter 3.

PRELIMINARY INFORMATION

10.2.7 TAXILANE AND APRON OPERATIONS

10.2.7.1 Taxilane To Taxilane Separations

ICAO Annex 14 7th edition, Amendment 13A, recommends a parallel taxilane centerline separation of 72.5m for Code E operations and 87.5m for Code F operations, in order to provide a minimum wing tip clearance of 7.5m. The clearance between a 777-9 with Non-Normal FWT and a Code E aircraft on parallel taxilanes built per this recommendation can be seen in Figure 6.

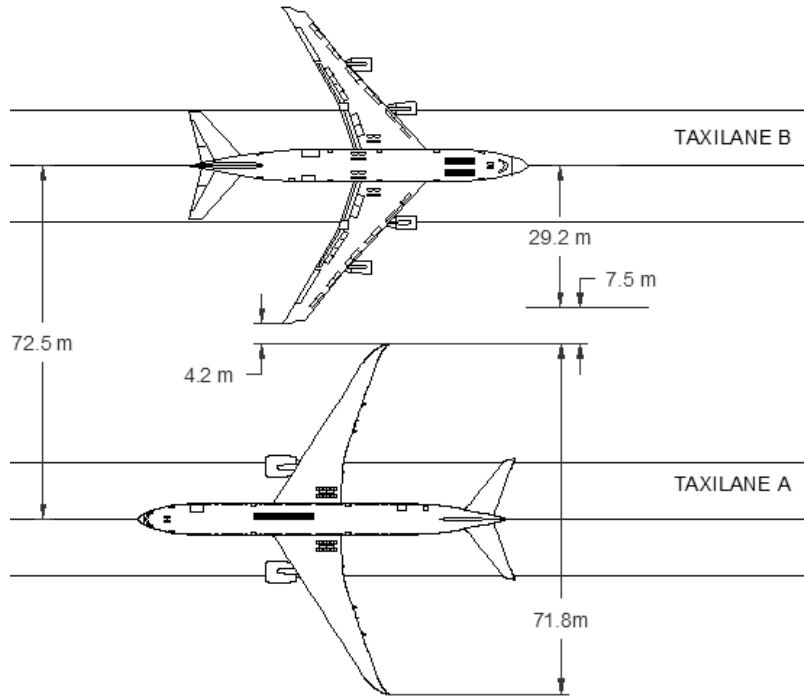


Figure 6: Wing tip clearances between a 747-400 (limiting Code E aircraft) and a 777-9 with non-normal FWT on parallel taxilanes

A 777-9 with non-normal FWT will have 4.2m of wing tip clearance to a 747-400 (used as Code E limiting aircraft) on the parallel taxilane, which is less than the recommended 7.5m. In order for a Code E aircraft to maintain the recommended 7.5m separation to a 777-9 with Non-Normal FWT, a minimum parallel taxilane separation of 75.8m is required. A possible mitigation, aircraft operating on Taxilane B would be limited to a wingspan of no more than 58.4m in order to maintain the current ICAO recommended wing tip clearance of 7.5m for Code E.

PRELIMINARY INFORMATION

In the event a taxilane-to-taxilane 7.5m wing tip clearance at an existing aerodrome is unavailable for 777-9 operations with a non-normal FWT, operations may be permissible with lower separation distances if a safety assessment study¹ indicates that such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of airplanes.

¹ International Civil Aviation Organization. *PANS-Aerodromes*, Procedures for Air Navigation Services, Doc 9981, Second Edition, 2016, Chapter 3.

PRELIMINARY INFORMATION

10.2.7.2 Taxilane To Object Separations

Annex 14 7th edition, Amendment 13A, recommends Code E and F taxilane centerline to object separations to 40m and 47.5m for Code E and F respectively, allowing for 7.5m of wing tip clearance for both reference codes. The resulting clearance for a 777-9 with Non-Normal FWT can be seen in Figure 7. The 4.1m clearance available to an object located 40m from the taxilane centerline is less than the recommended 7.5m. In order for the 777-9 with Non-Normal FWT to maintain 7.5m wing tip clearance, it would require a taxilane-to-object separation of at least 43.4m.

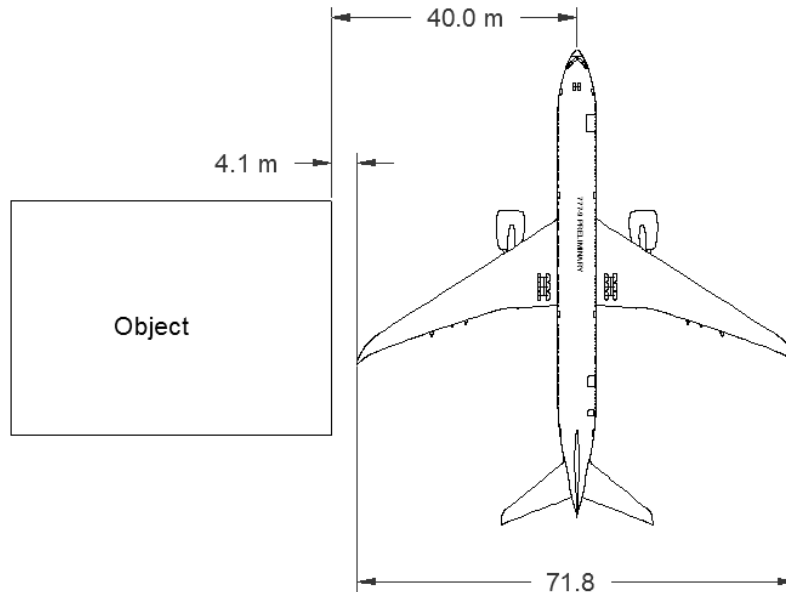


Figure 7: Wing tip clearances between a 777-9 with non-normal FWT on a taxilane and a stationary object

In the event a taxilane to an object 7.5m wing tip clearance at an existing aerodrome is unavailable for 777-9 operations with a non-normal FWT, operations may be permissible with lower separation distances if a safety assessment study¹ indicates that such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of airplanes.

¹ International Civil Aviation Organization. *PANS-Aerodromes*, Procedures for Air Navigation Services, Doc 9981, Second Edition, 2016, Chapter 3.

PRELIMINARY INFORMATION

10.2.7.3 Apron And Stand Operations

ICAO aerodrome design recommends a minimum aircraft body clearance of 7.5m for Code E and F aircraft parked at an aircraft stand. While the clearance does not change from Code E to Code F operation, it should be noted that any 777-9 with a non-normal FWT will be operating with a 3.5m wingspan increase on the side of the non-normal FWT. It is recommended that all 777-9 parking operations with a non-normal FWT maintain the 7.5m clearance at all times. Many airports allow less than 7.5m aircraft clearance with wing-walkers, visual docking guidance system and other services that provide an acceptable level of safety (see Figure 8).

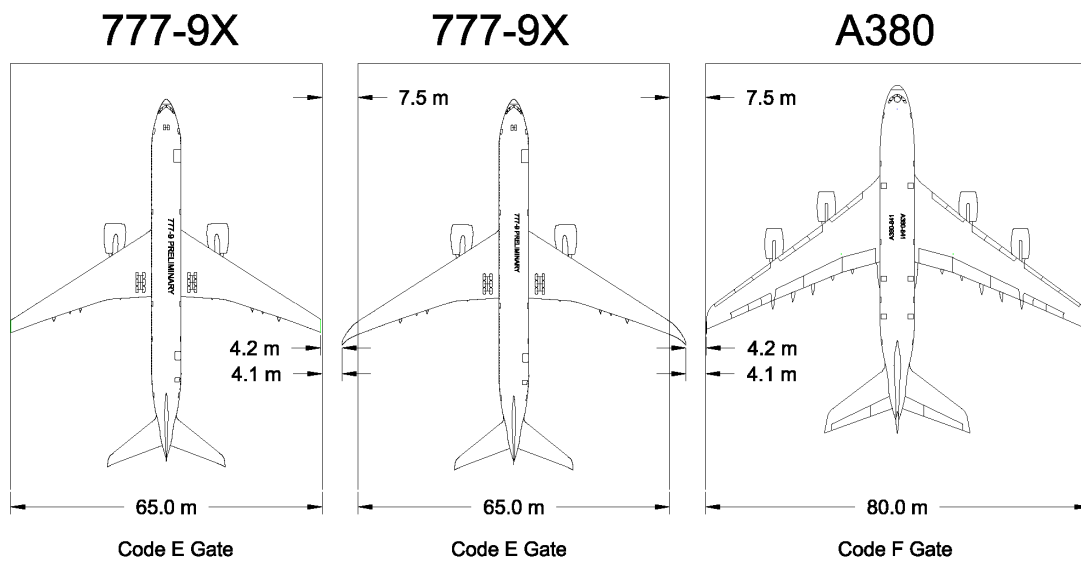


Figure 8: 777-9 with non-normal FWT Code E and F clearances

PRELIMINARY INFORMATION

Another option for accommodating a 777-9 with a non-normal FWT and still maintaining 7.5m wing tip clearance at the gate is to reduce the size of the aircraft parked at the adjacent gate. As Figure 9 shows, by reducing the size of the aircraft parked in the adjacent space a Code E gate can accommodate a 777-9. If a Code F gate is adjacent to the same side as a non-normal FWT, any aircraft with a wingspan under 76.5m (such as the 747-8) will be able to park at that gate and still maintain the 7.5m clearance.

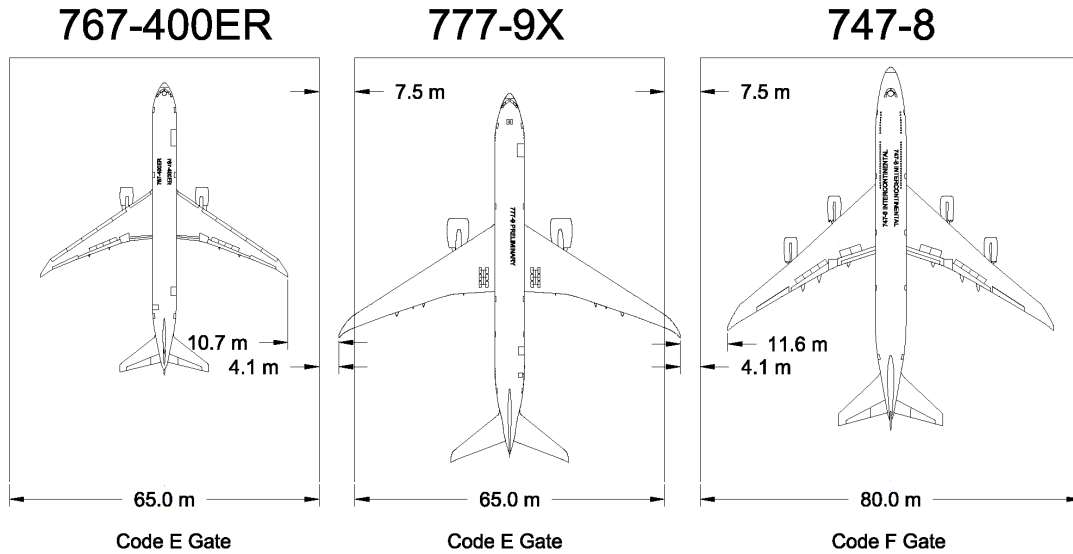


Figure 9: 777-9 with non-normal FWT Code E and F clearances

If the gate adjacent to the non-normal FWT is a Code E gate, then any aircraft with a wingspan less than 58.2m can park at the gate while maintaining the 7.5 m clearance.