747-8
Airplane Characteristics for Airport Planning

Boeing Commercial Airplanes

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747-8 AIRPLANE CHARACTERISTICS
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1.0 SCOPE AND INTRODUCTION

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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
- International Industry Working Group
- 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 Civil Aviation Organization
- International Coordinating Council of Aerospace Industries Associations
- Airports Council International – North America and World Organizations
- International Industry Working Group
- International Air Transport Association

1.2 Introduction

This document conforms to NAS 3601. It provides characteristics of the Boeing Model 747-8F (Freighter) and 747-8 (Intercontinental passenger) airplanes for airport planners, 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 certificated versions of the 747-8F and 747-8. The data will reflect typical airplanes in each model category. Data used is generic in scope and not customer-specific. The 747-8 series is an FAA Airplane Design Group VI and an ICAO Aerodrome Reference Code 4F category aircraft.

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1.3 A Brief Description of the 747-8

The 747-8 is the latest derivative of the 747 family of airplanes and is offered in both Freighter and Passenger versions. The 747-8 is externally similar to the 747-400 with a higher gross weight, longer fuselage and increased wingspan. The 747-8 Freighter retains the 747-400F nose cargo door, continuing the capability to easily load outsized cargo. The 747-8 has new high bypass ratio engines, GEnx 2B, which are the quiet and efficient GEnx engines developed for the 787 aircraft. The 747-8 has a cruise speed of Mach 0.845 for the Freighter and Mach 0.855 for the Intercontinental, which are increased speeds from the 747-400 series, due to changes in the wing, the new raked wingtips, and the GEnx engines. The 747-8F entered revenue service in October 2011. The 747-8 entered revenue service in 2012.

Other characteristics unique to the 747-8 compared to the 747-400 include:

- Next generation advanced alloys
- New wing design, including new airfoils and raked wingtips replacing the winglets
- GEnx-2B67 engines, including light weight composite fan case and fan blades, modified to provide current 747-8 bleed requirements
- Improved flight deck while preserving 747-400 operational commonality
- New interior architecture to enhance passenger experience
- Improved aerodynamic efficiency and reduced seat-mile cost (Passenger variant) and reduced ton-mile cost (Freighter variant)

2.0 AIRPLANE DESCRIPTION

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

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

Maximum Cargo Volume. The maximum space available for cargo.

Usable Fuel. Fuel available for aircraft propulsion.

CHARACTERISTICS	UNITS	747-8F	747-8F
MAX DESIGN TAXI WEIGHT	POUNDS	978,000	990,000
	KILOGRAMS	443,613	449,056
MAX DESIGN TAKEOFF WEIGHT	POUNDS	975,000	987,000
	KILOGRAMS	442,253	447,696
MAX DESIGN LANDING WEIGHT	POUNDS	761,000	763,000
	KILOGRAMS	345,184	346,091
MAX DESIGN ZERO FUEL WEIGHT	POUNDS	725,000	727,000
	KILOGRAMS	328,854	329,762
OPERATING EMPTY WEIGHT (1)	POUNDS	434,600	434,600
	KILOGRAMS	197,131	197,131
MAX STRUCTURAL PAYLOAD (1)	POUNDS	290,400	292,400
	KILOGRAMS	131,723	132,630
TYPICAL CARGO – MAIN DECK CONTAINERS	CUBIC FEET	24,462	24,462
	CUBIC METERS	693	693
MAX CARGO - LOWER DECK CONTAINERS (LD-1)	CUBIC FEET	5,850	5,850
	CUBIC METERS	166	166
MAX CARGO - LOWER DECK BULK CARGO	CUBIC FEET	520	520
	CUBIC METERS	14.7	14.7
USABLE FUEL CAPACITY	U.S. GALLONS	59,734 (2)	59,734 (2)
	LITERS	226,118	226,118
	POUNDS	400,218	400,218
	KILOGRAMS	181,536	181,536

NOTES:

1. ESTIMATED WEIGHTS FOR ENGINE/AIRFRAME CONFIGURATION SHOWN. OPERATING EMPTY WEIGHT REFLECTS STANDARD ITEM ALLOWANCES. ACTUAL OEW AND PAYLOAD WILL VARY WITH AIRPLANE AND AIRLINE CONFIGURATION. CONSULT USING AIRLINE FOR VALUES.
2. 747-8F IS NOT DESIGNED WITH TAIL FUEL TANKS

2.1.1 GENERAL CHARACTERISTICS

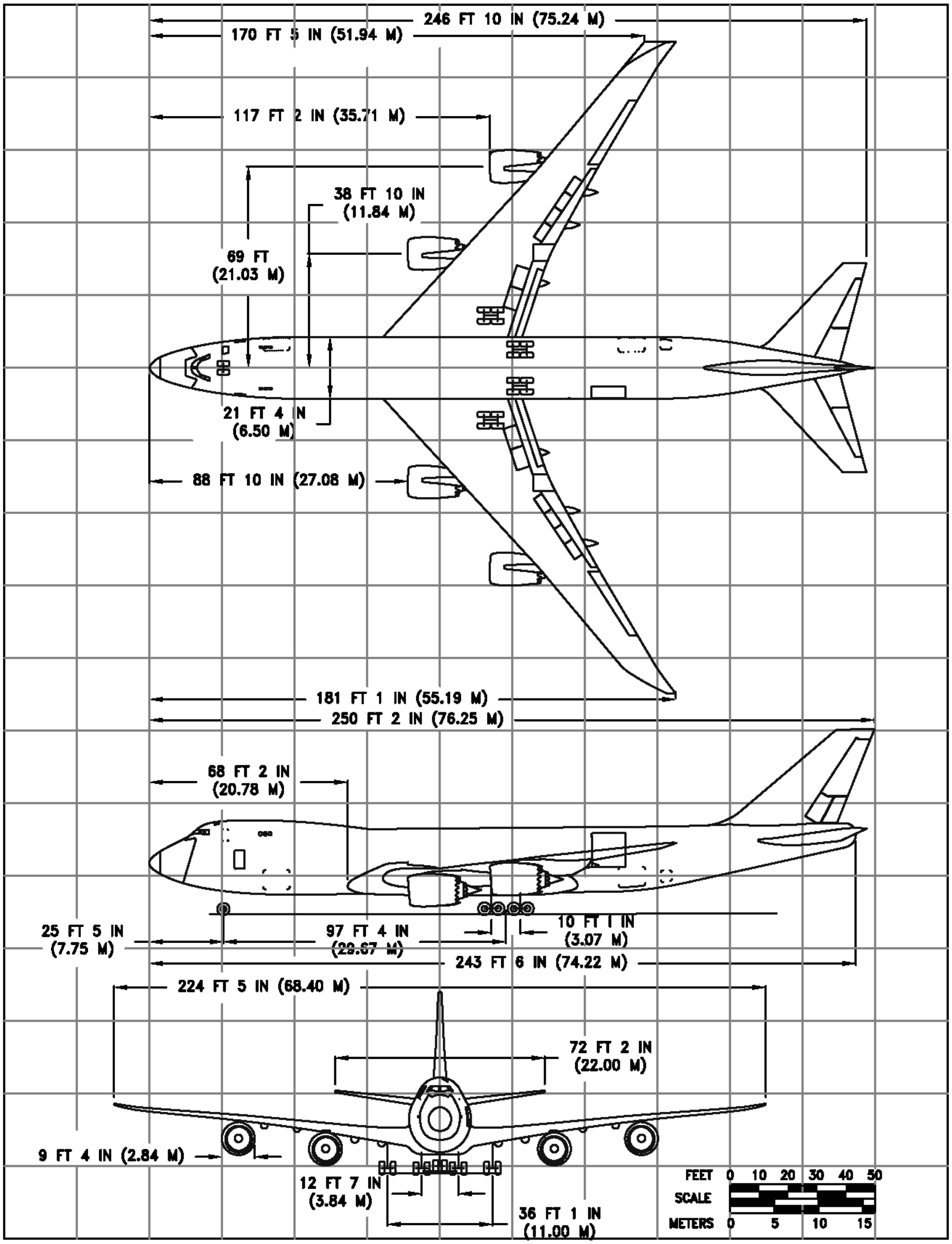
MODEL 747-8F

CHARACTERISTICS	UNITS	747-8
MAX DESIGN TAXI WEIGHT	POUNDS	990,000
	KILOGRAMS	449,056
MAX DESIGN TAKEOFF WEIGHT	POUNDS	987,000
	KILOGRAMS	447,696
MAX DESIGN LANDING WEIGHT	POUNDS	688,000
	KILOGRAMS	312,072
MAX DESIGN ZERO FUEL WEIGHT	POUNDS	651,000
	KILOGRAMS	295,289
OPERATING EMPTY WEIGHT (1)	POUNDS	485,300
	KILOGRAMS	220,128
MAX STRUCTURAL PAYLOAD	POUNDS	167,700
	KILOGRAMS	76,067
TYPICAL SEATING CAPACITY (INCLUDES UPPER DECK)	UPPER DECK	48 BUSINESS CLASS
	MAIN DECK	19 FIRST, 96 BUSINESS, 352 ECONOMY
MAX CARGO - LOWER DECK CONTAINERS (LD-1)	CUBIC FEET	5,705
	CUBIC METERS	162
MAX CARGO - LOWER DECK BULK CARGO	CUBIC FEET	640
	CUBIC METERS	18.1
USABLE FUEL CAPACITY	U.S. GALLONS	63,034 (2)
	LITERS	238,610
	POUNDS	426,109
	KILOGRAMS	193,280

NOTES:

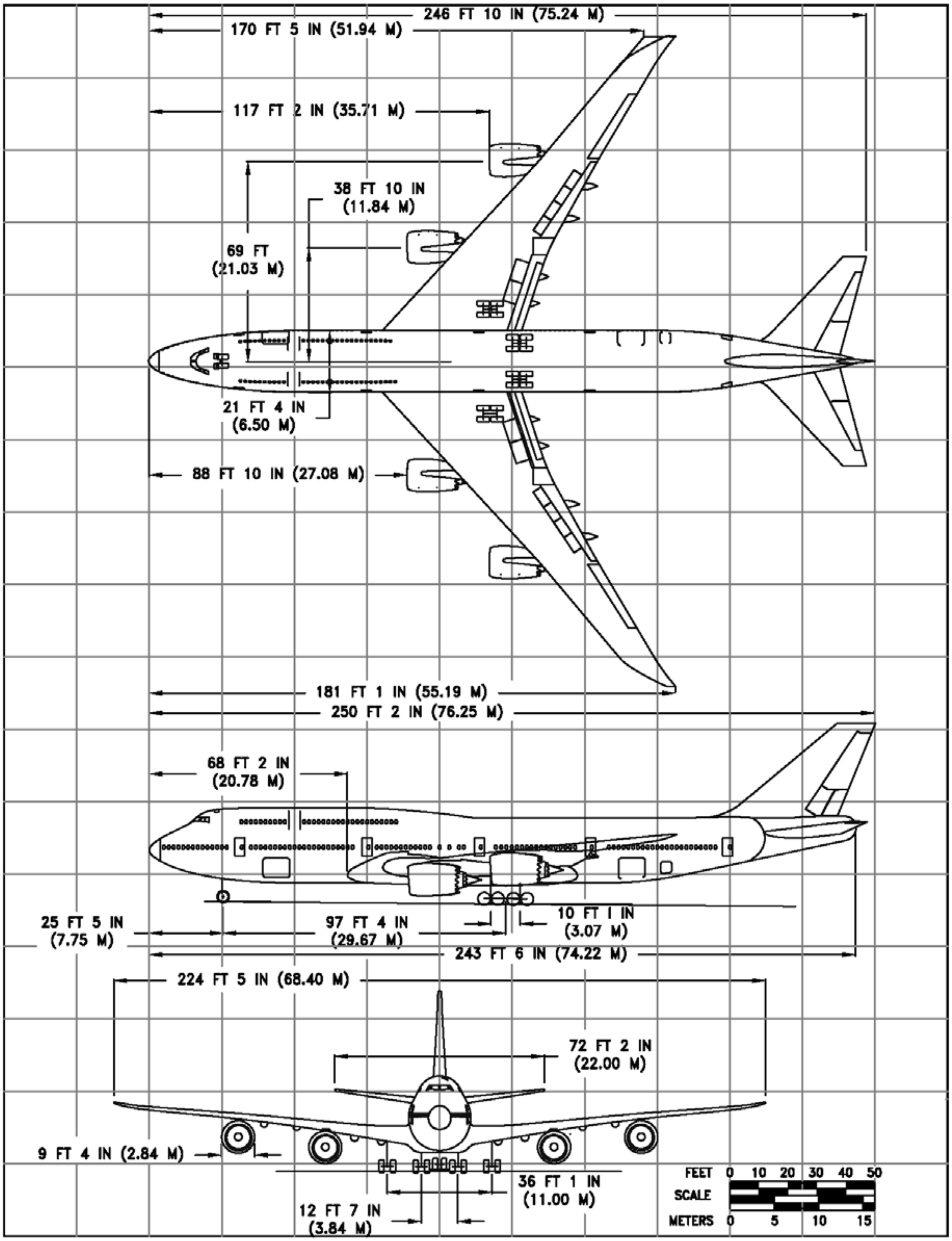
1. ESTIMATED WEIGHTS FOR ENGINE/AIRFRAME CONFIGURATION SHOWN. OPERATING EMPTY WEIGHT REFLECTS STANDARD ITEM ALLOWANCES. ACTUAL OEW AND PAYLOAD WILL VARY WITH AIRPLANE AND AIRLINE CONFIGURATION. CONSULT USING AIRLINE FOR VALUES.
2. VALUE INCLUDES TAIL FUEL TANK VOLUME.

2.1.2 GENERAL CHARACTERISTICS
MODEL 747-8



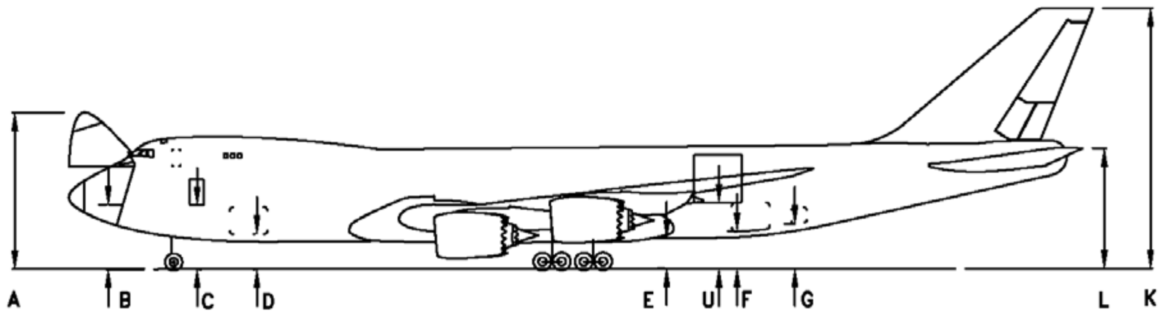
2.2.1 GENERAL DIMENSIONS

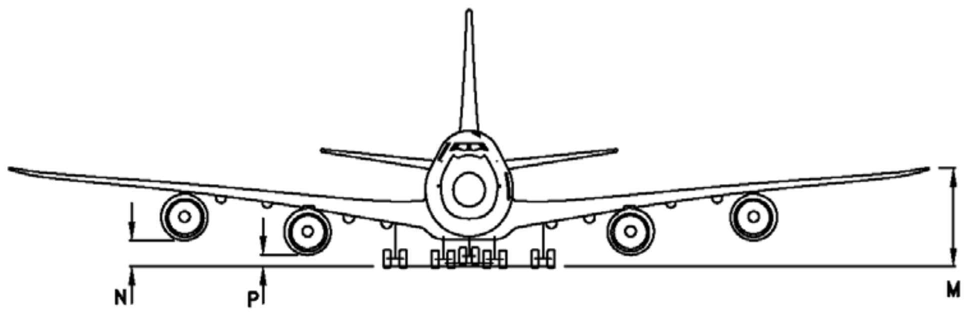
MODEL 747-8F



2.2.2 GENERAL DIMENSIONS

MODEL 747-8





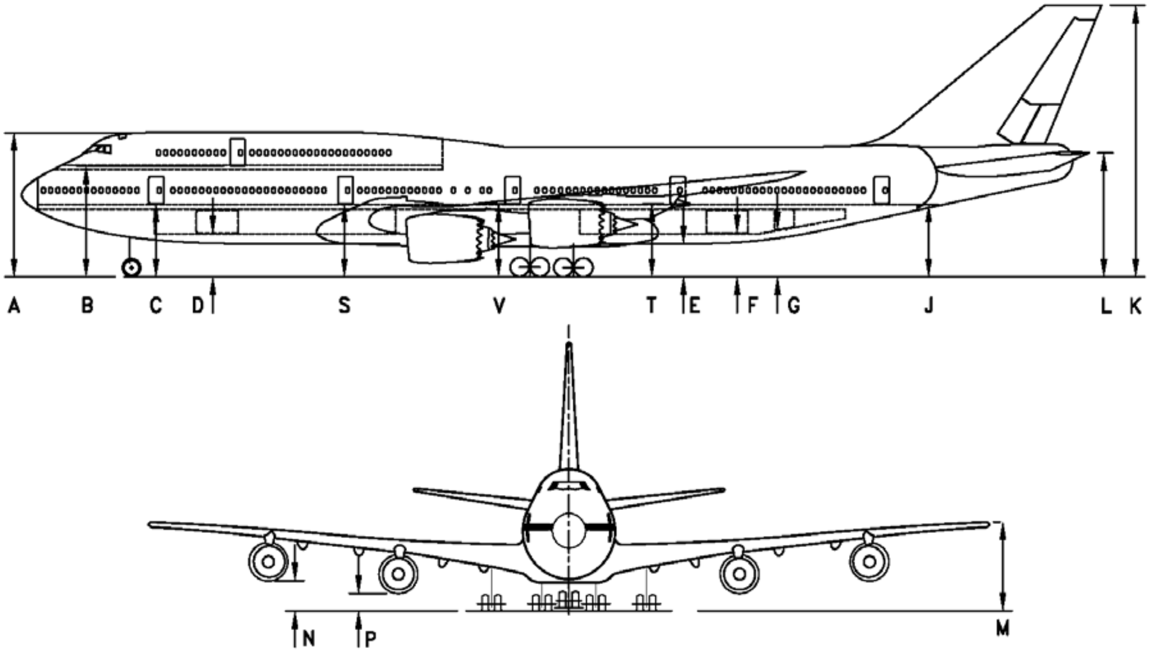
	MINIMUM		MAXIMUM	
	FT - IN	M	FT - IN	M
A	38 - 8	11.79	40 - 3	12.24
B	15 - 7	4.75	17 – 2	5.24
C	15 - 8	4.78	17 - 1	5.19
D	9 - 0	2.75	10 - 4	3.14
E	5 - 9	1.75	6 - 8	2.04
F	9 - 6	2.90	10 - 7	3.21
G	10 - 1	3.07	11 - 3	3.42
K	62 - 3	18.97	64 - 2	19.56
L	28 - 2	8.58	30 - 1	9.16
M	21 - 5	6.52	22 - 5	6.48
N	6 - 3	1.90	6 - 11	2.10
P	2 - 5	0.73	3 - 3	0.99
U	16 - 3	4.95	17 - 3	5.25

NOTES: VERTICAL CLEARANCES SHOWN OCCUR DURING MAXIMUM VARIATIONS OF AIRPLANE ATTITUDE. COMBINATIONS OF AIRPLANE LOADING/UNLOADING ACTIVITIES THAT PRODUCE THE GREATEST POSSIBLE VARIATIONS OF ATTITUDE WERE USED TO ESTABLISH THE VARIATIONS SHOWN. DURING ROUTINE SERVICING, THE AIRPLANE REMAINS RELATIVELY STABLE; PITCH AND ELEVATION CHANGES OCCUR SLOWLY.

A GSE TETHERING DEVICE MAY BE USED TO MAINTAIN STABILITY BETWEEN THE MAIN DECK DOOR SILL AND THE LOADING DOCK. CARGO BRIDGE ATTACHMENT FITTINGS LOCATED ON THE NOSE DOOR SILL AT THE FORWARD EDGE OF THE MAIN CARGO DOOR DECK MAY BE USED FOR NOSE DOOR SILL STABILIZATION.

2.3.1 GROUND CLEARANCES

MODEL 747-8F

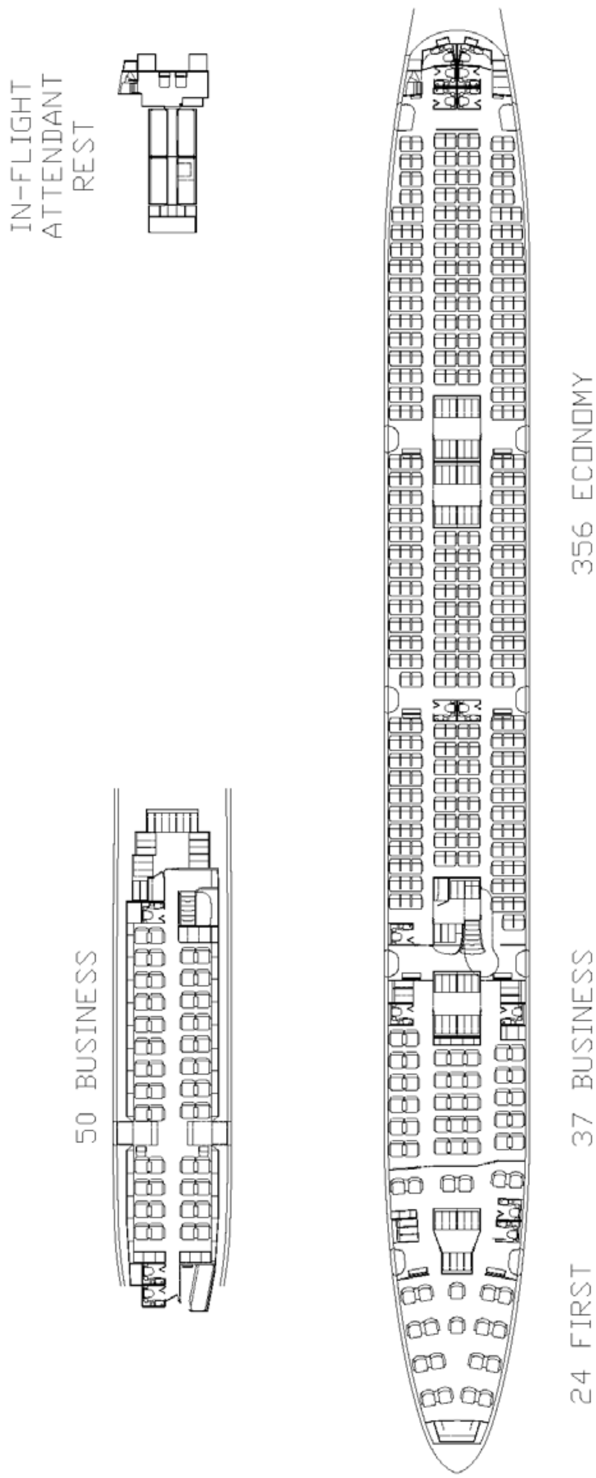


	MINIMUM		MAXIMUM	
	FT - IN	M	FT - IN	M
A	31 - 0	9.44	32 - 3	9.84
B	24 – 10	7.56	25 – 11	7.90
C	15 – 8	4.78	16 – 11	5.16
D	9 – 0	2.75	10 – 2	3.09
E	5 – 9	1.75	6 – 7	2.01
F	9 – 6	2.89	10 – 5	3.18
G	10 – 1	3.07	11 – 1	3.38
J	16 – 3	4.95	17 – 5	5.32
K	62 - 3	18.97	64 – 0	19.51
L	28 – 2	8.58	29 – 11	9.12
M	21 - 4	6.51	22 - 4	6.80
N	6 – 3	1.90	6 – 10	2.07
P	2 - 5	0.73	3 – 2	0.96
S	16 – 0	4.87	16 – 10	5.14
T	16 - 3	4.95	17 - 1	5.20
V	16 - 2	4.94	16 - 9	5.12

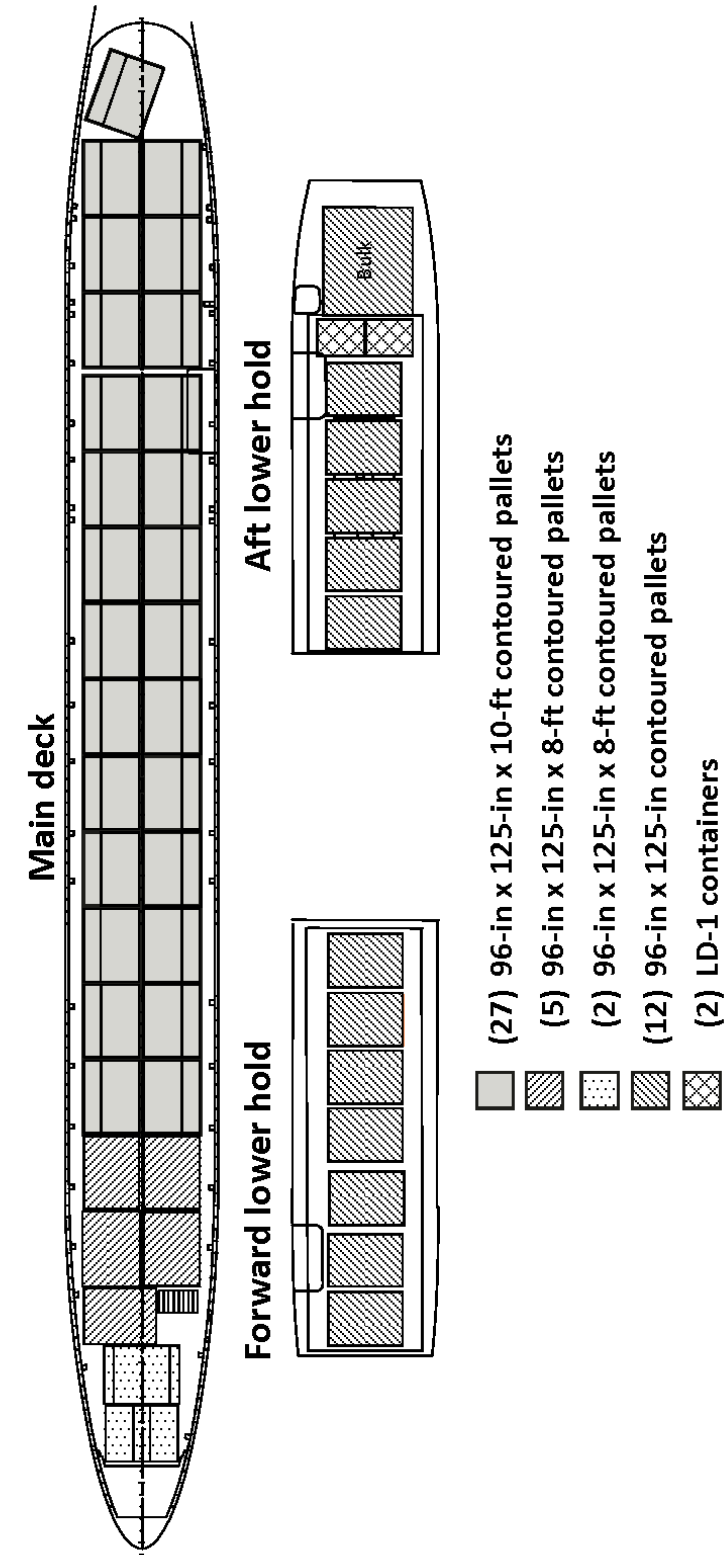
NOTES: VERTICAL CLEARANCES SHOWN OCCUR DURING MAXIMUM VARIATIONS OF AIRPLANE ATTITUDE. COMBINATIONS OF AIRPLANE LOADING/UNLOADING ACTIVITIES THAT PRODUCE THE GREATEST POSSIBLE VARIATIONS OF ATTITUDE WERE USED TO ESTABLISH THE VARIATIONS SHOWN. DURING ROUTINE SERVICING, THE AIRPLANE REMAINS RELATIVELY STABLE; PITCH AND ELEVATION CHANGES OCCUR SLOWLY

2.3.2 GROUND CLEARANCES

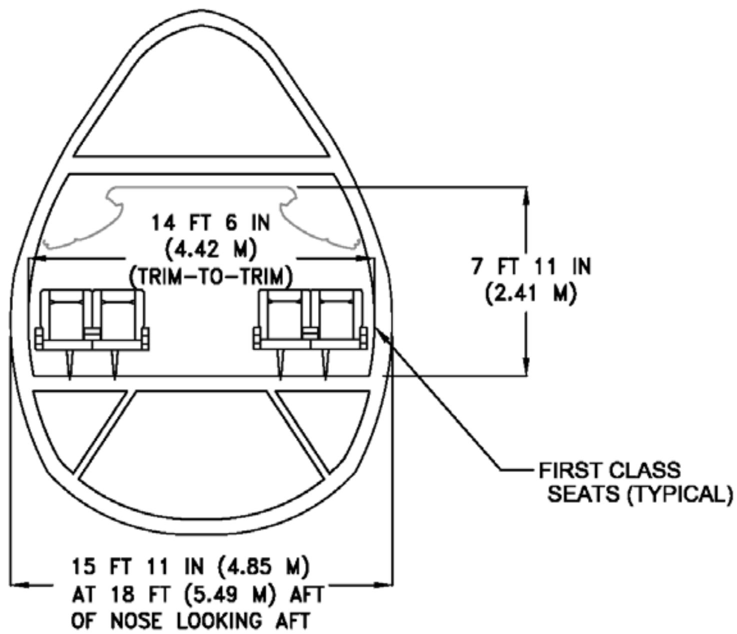
MODEL 747-8



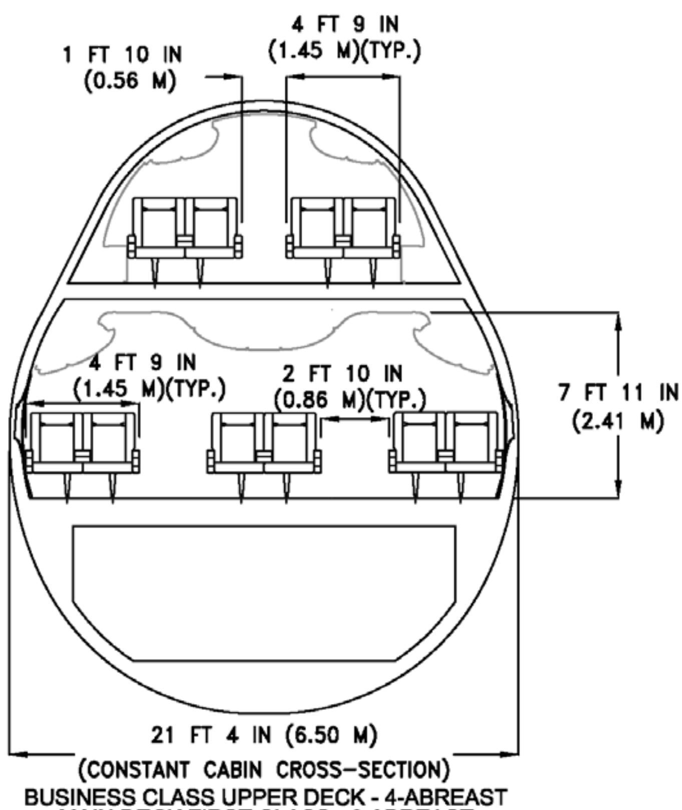
2.4.1 TYPICAL INTERIOR ARRANGEMENTS, THREE CLASS, 467 PASSENGERS
MODEL 747-8



2.4.3 TYPICAL INTERIOR ARRANGEMENTS – MAIN DECK CARGO
MODEL 747-8F

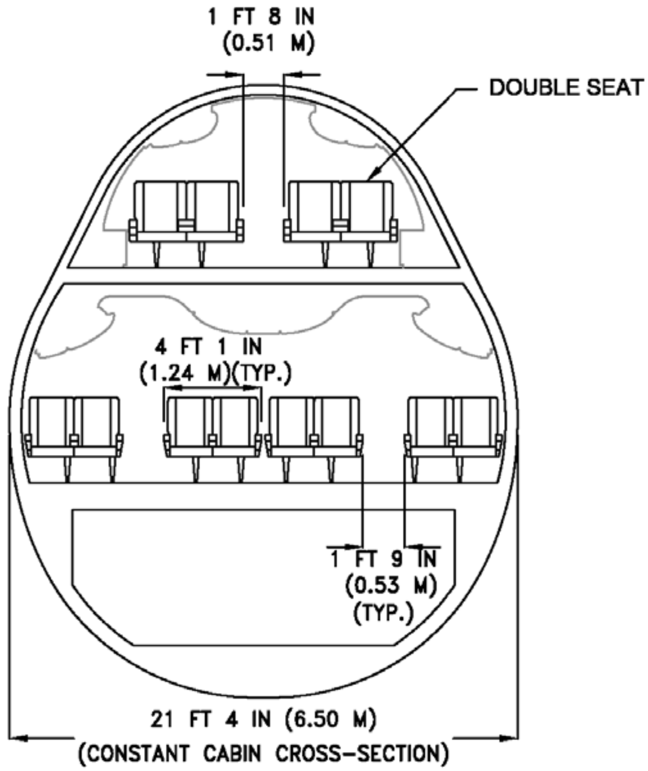


FORWARD CABIN

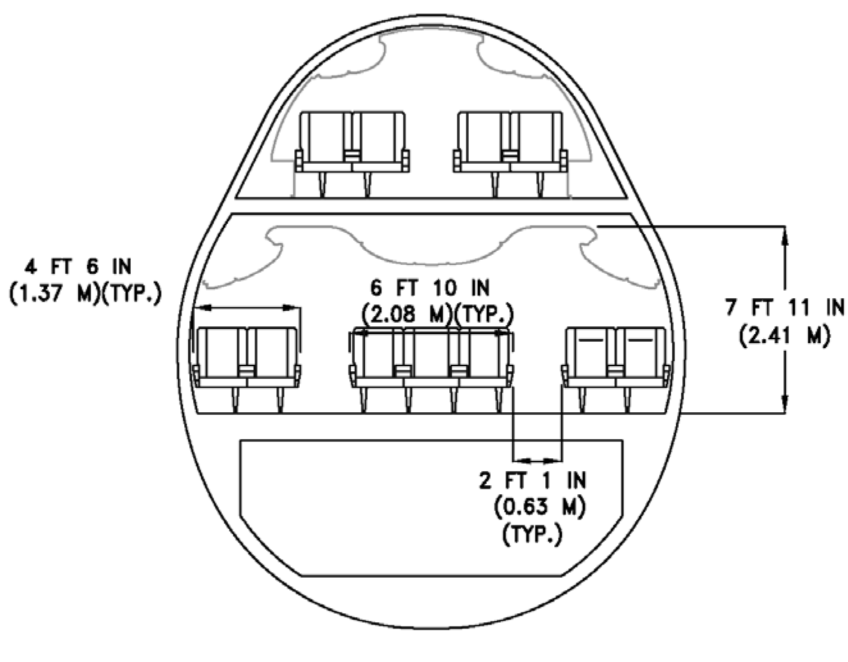


BUSINESS CLASS UPPER DECK - 4-ABREAST
MAIN DECK FIRST CLASS - 6-ABREAST

2.5.1 CABIN CROSS-SECTIONS
MODEL 747-8

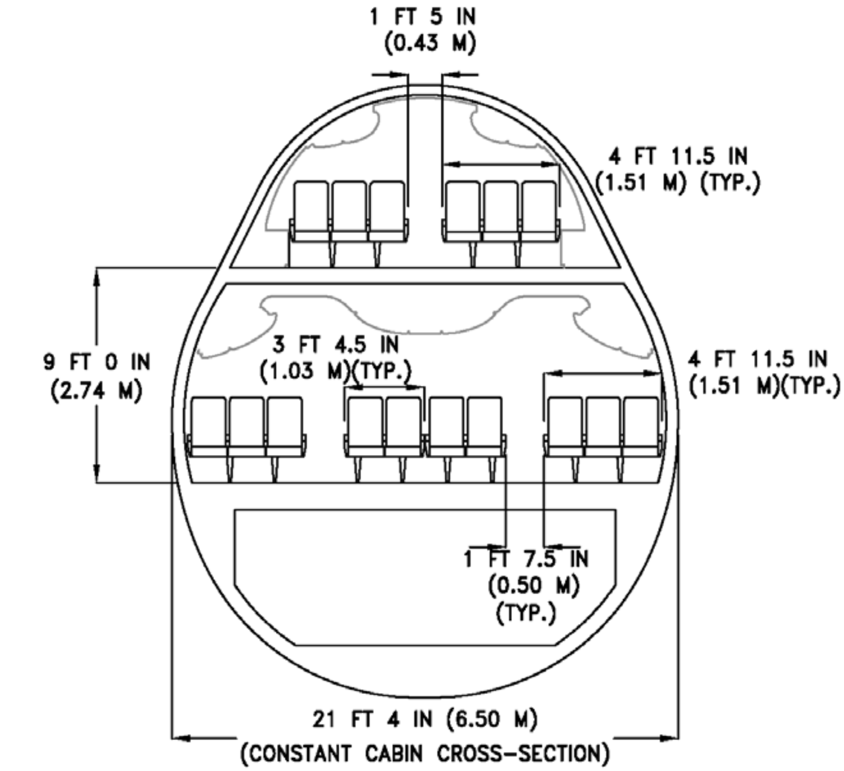


UPPER DECK - 4-ABREAST
MAIN DECK - 8-ABREAST

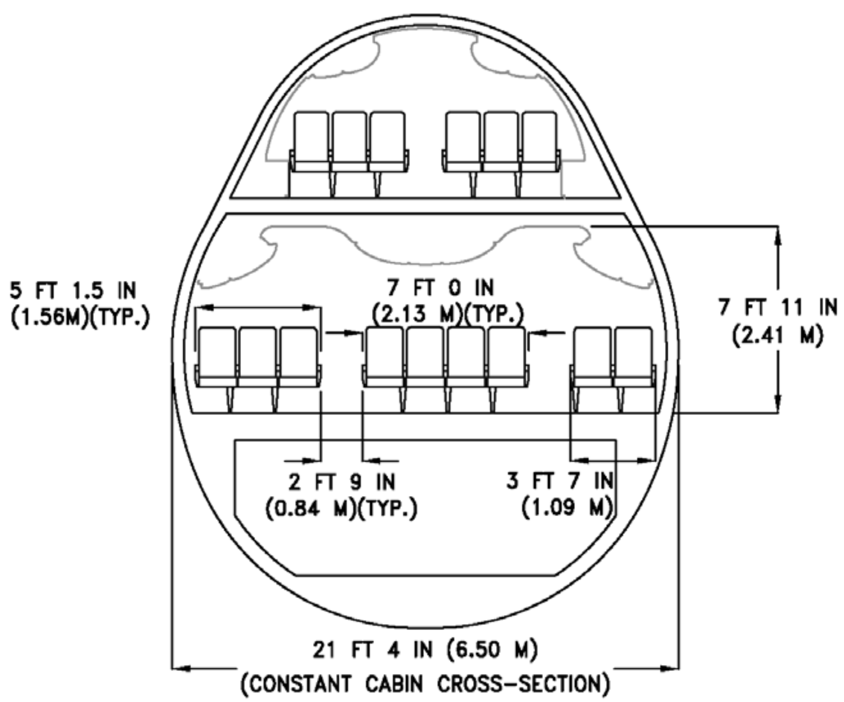


MAIN DECK - 7-ABREAST

2.5.2 CABIN CROSS-SECTIONS
MODEL 747-8

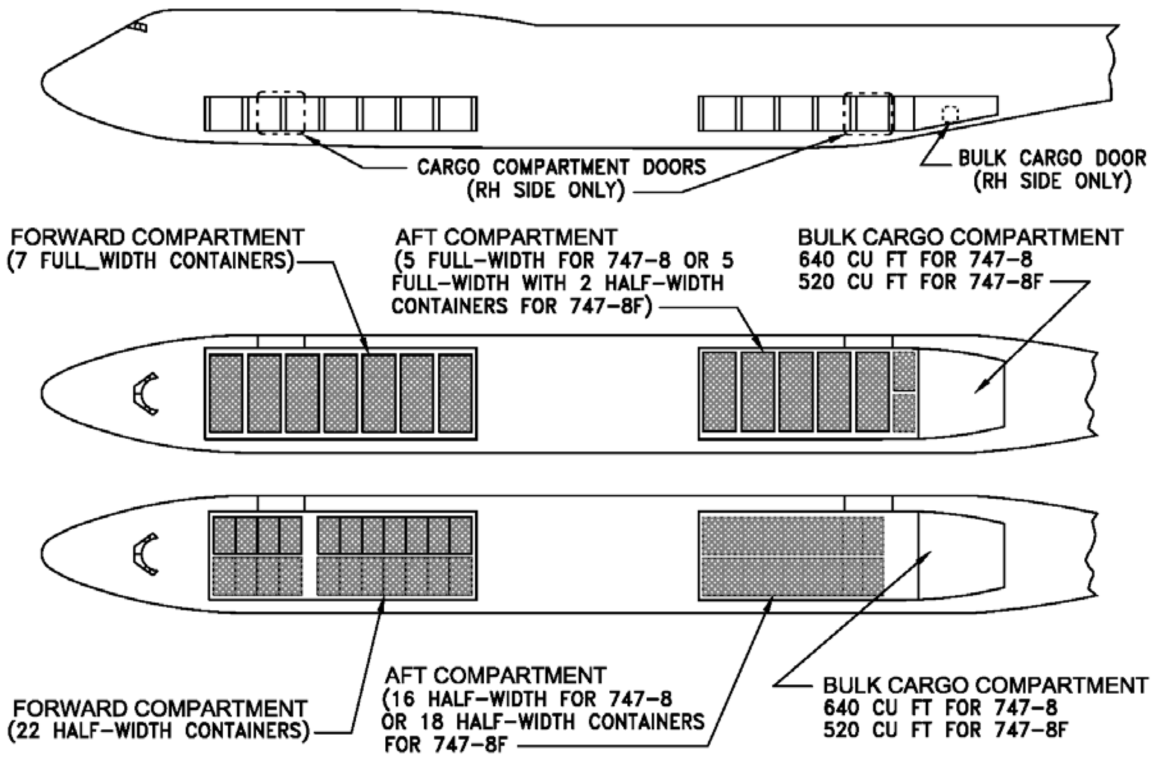


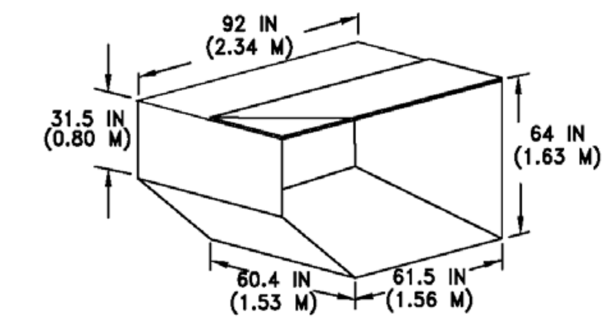
UPPER DECK - 6-ABREAST
MAIN DECK - 10-ABREAST



MAIN DECK - 9-ABREAST

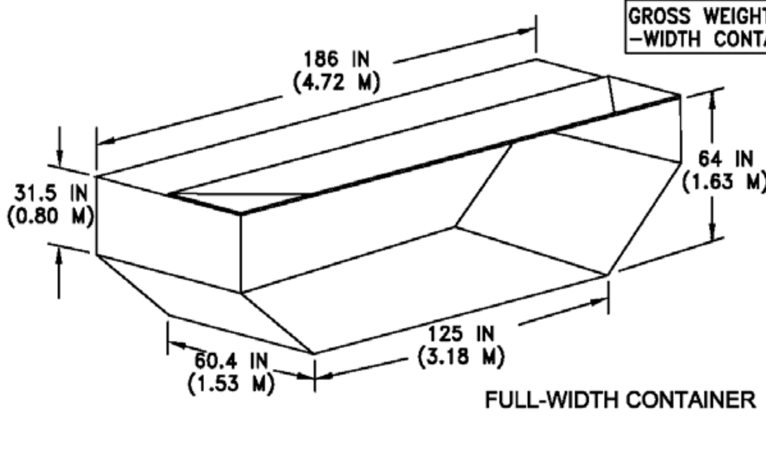
2.5.3 CABIN CROSS-SECTIONS
MODEL 747-8





HALF-WIDTH CONTAINER (LD1)

CONTAINER DATA	HALF-WIDTH	FULL-WIDTH
INTERNAL VOLUME PER CONTAINER	173 CU FT 4.9 CU M	350 CU FT 9.9 CU M
TARE WEIGHT	270 LB 123 KG	470 LB 213 KG
MAXIMUM CARGO WEIGHT PER CONTAINER	3,230 LB 1,465 KG	6,530 LB 2,962 KG
MAXIMUM GROSS WEIGHT PER CONTAINER	3,500 LB 1,588 KG	7,000 LB 3,175 KG
TOTAL VOLUME OF 12 FULL-WIDTH PLUS 2 HALF-WIDTH CONTAINERS IS 4,546 CU FT (129 CU M)		
GROSS WEIGHT FOR 12 FULL-WIDTH PLUS 2 HALF-WIDTH CONTAINERS IS 91,000 LB (41,277 KG)		



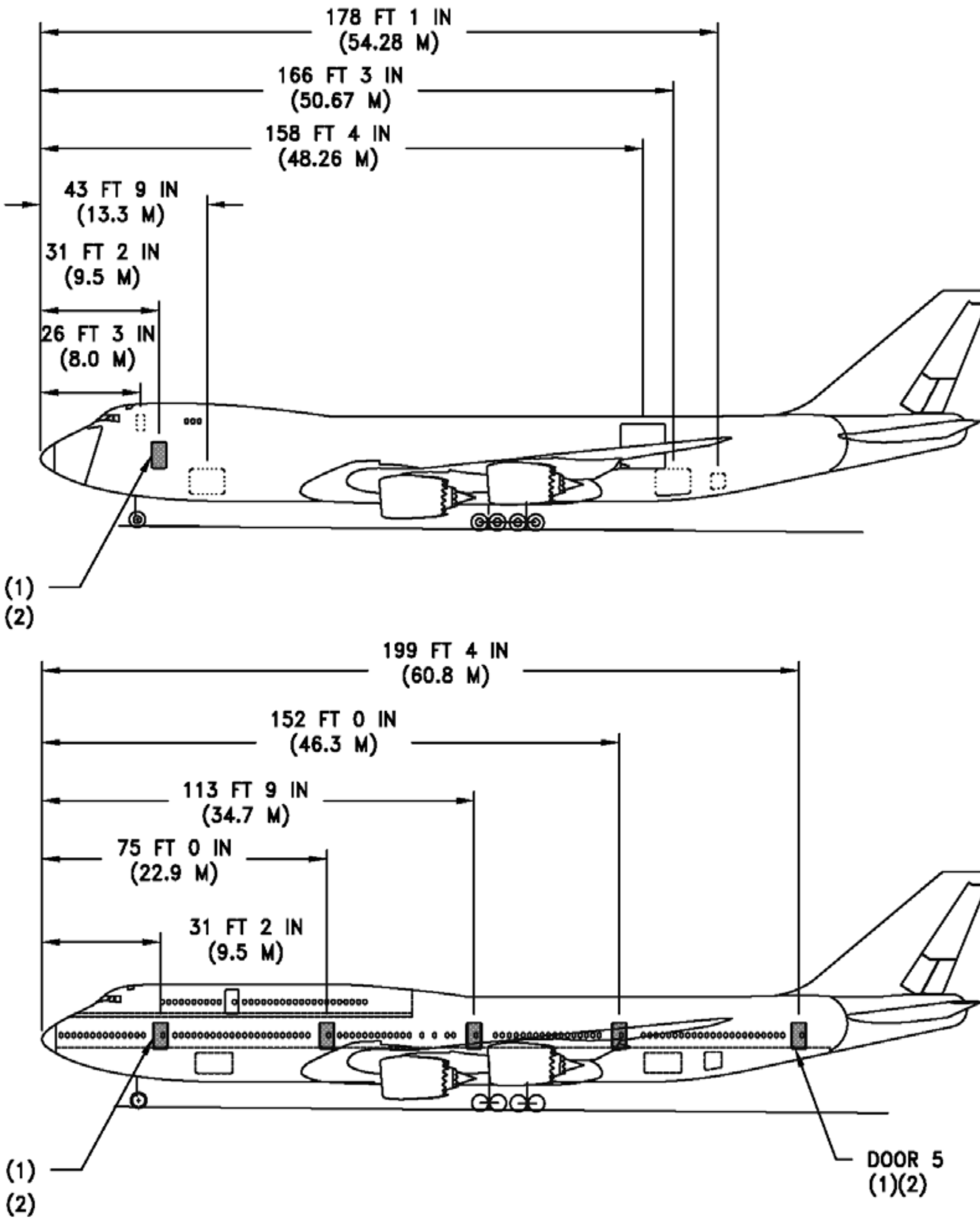
FULL-WIDTH CONTAINER

NOTES:

1. CONTAINER WEIGHT AND DATA ARE TYPICAL. CONSULT USING AIRLINE FOR SPECIFIC DATA.
2. OPTIONS ARE OFFERED FOR CARRAIGE OF CERTAIN STANDARD MILITARY AND COMMERCIAL PALLETS IN CONTAINER COMPARTMENTS.

2.6 LOWER CARGO COMPARTMENTS - CONTAINERS AND BULK CARGO

MODEL 747-8, 747-8F

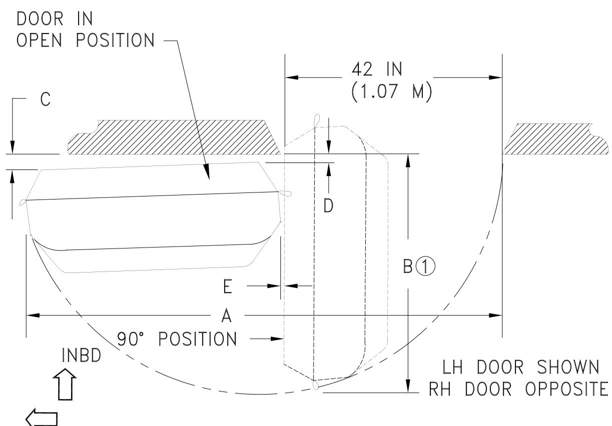


NOTES:

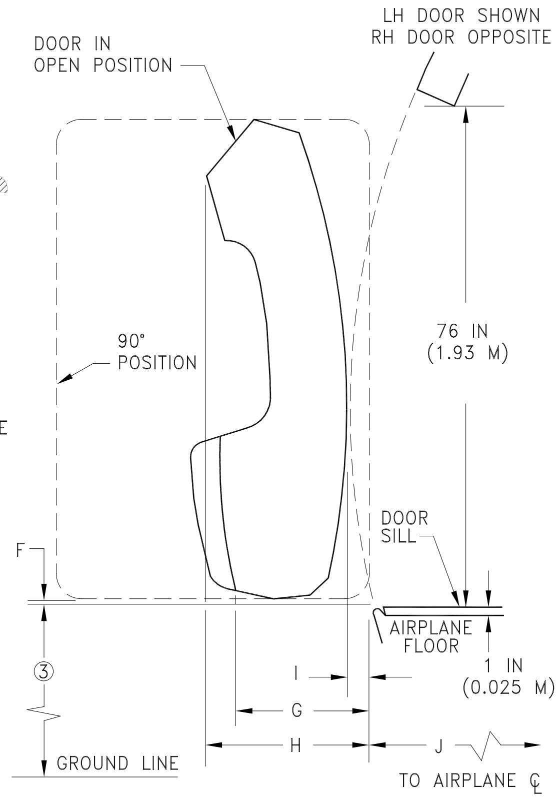
(1) 1 PASSENGER DOOR – LEFT SIDE ONLY FOR THE 747–8 FREIGHTER
10 PASSENGER DOORS – 5 EACH SIDE FOR THE 747–8 INTERCONTINENTAL
DOOR OPENING SIZE = 42 BY 76 IN (1.07 BY 1.93 M)
OVERALL DOOR SIZE = 47 BY 76 IN (1.19 BY 1.93 M)

(2) SEE SECTION 2.3 FOR DOOR SILL HEIGHTS

2.7.1 DOOR CLEARANCES - MAIN ENTRY DOOR LOCATIONS
MODEL 747-8, 747-8F



PLAN VIEW



SIDE VIEW

VIEW LOOKING FORWARD

	DOOR NUMBER			
	1 ②	2	3	4
A	7 FT 6 IN	7 FT 6 IN	7 FT 6 IN	7 FT 6 IN
	2.29 M	2.29 M	2.29 M	2.29 M
B ①	3 FT 9 IN	4 FT 0 IN	3 FT 8 IN	3 FT 8 IN
	1.14 M	1.22 M	1.12 M	1.12 M
C	6.7 IN	5 IN	4 IN	4 IN
	0.17 M	0.13 M	0.10 M	0.10 M
D	1 IN	1 IN	1 IN	1 IN
	0.03 M	0.03 M	0.03 M	0.03 M
E	1 IN	1 IN	1 IN	1 IN
	0.03 M	0.03 M	0.03 M	0.03 M
F	2 IN	2 IN	1 IN	1 IN
	0.05 M	0.05 M	0.03 M	0.03 M
G ①	1 FT 7 IN	1 FT 7 IN	1 FT 10 IN	1 FT 10 IN
	0.48 M	0.48 M	0.56 M	0.56 M
H ①	1 FT 11 IN	1 FT 11 IN	2 FT 0 IN	2 FT 0 IN
	0.58 M	0.58 M	0.61 M	0.61 M
I ①	1 IN	3 IN	0	3 IN
	0.03 M	0.08 M	0	0.08 M
J ①	9 FT 6 IN	10 FT 5 IN	10 FT 8 IN	10 FT 5 IN
	2.90 M	3.18 M	3.25 M	3.18 M

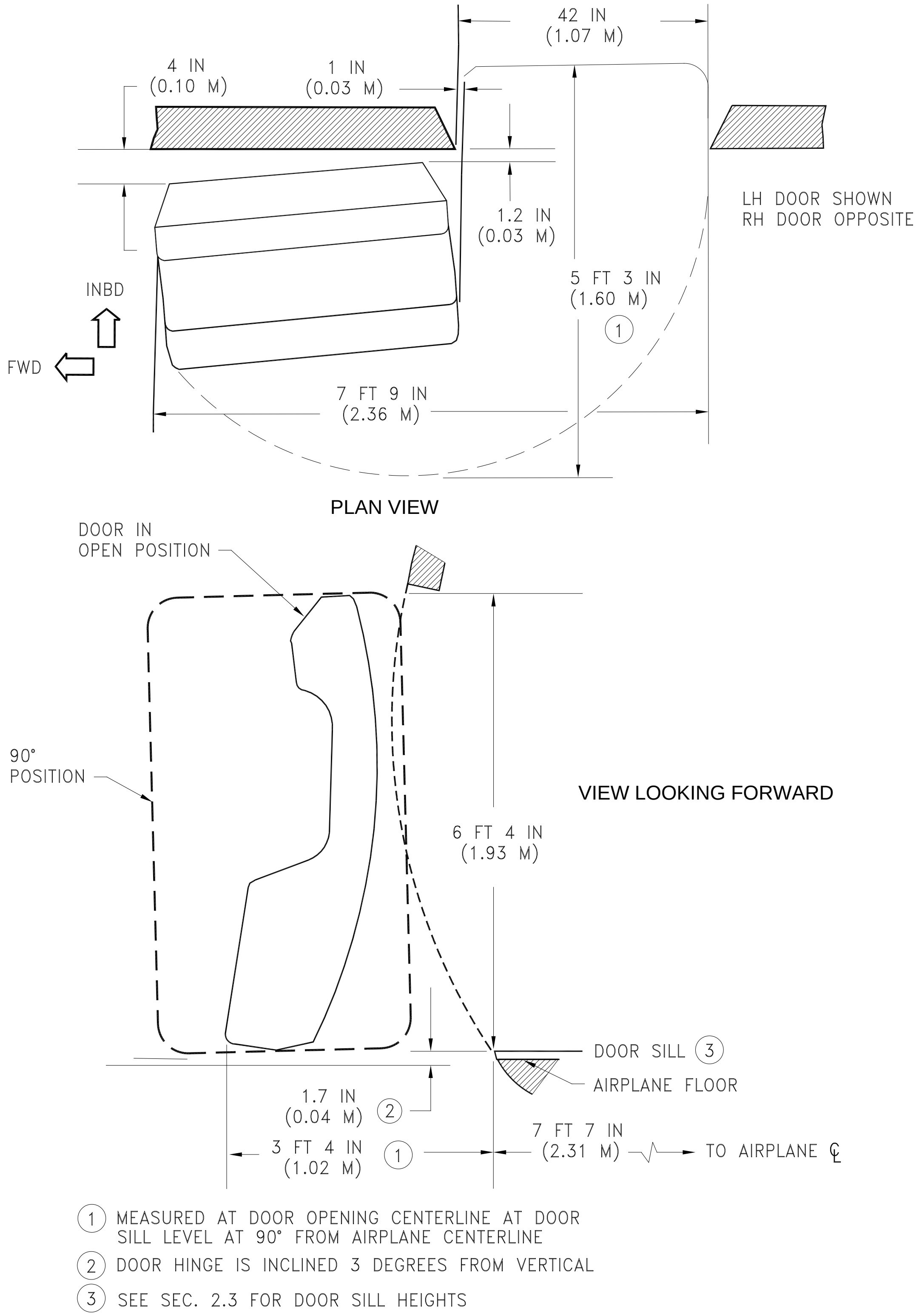
① MEASURED AT DOOR OPENING CENTERLINE AT DOOR SILL LEVEL AT 90° FROM AIRPLANE CENTERLINE.

② LH SIDE ONLY ON 747-8F.

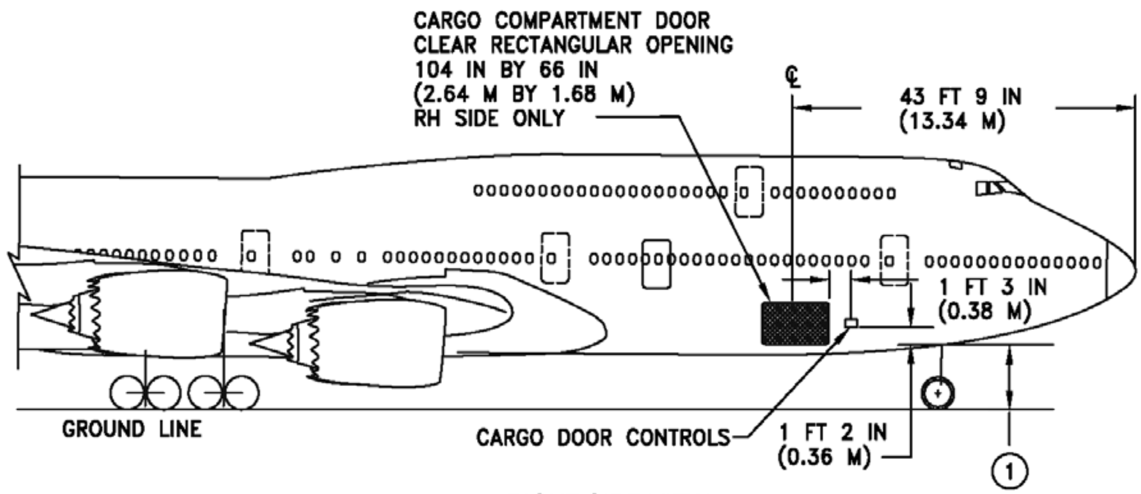
③ SEE SEC. 2.3 FOR DOOR SILL HEIGHTS

2.7.2 DOOR CLEARANCES - MAIN ENTRY DOORS 1-4

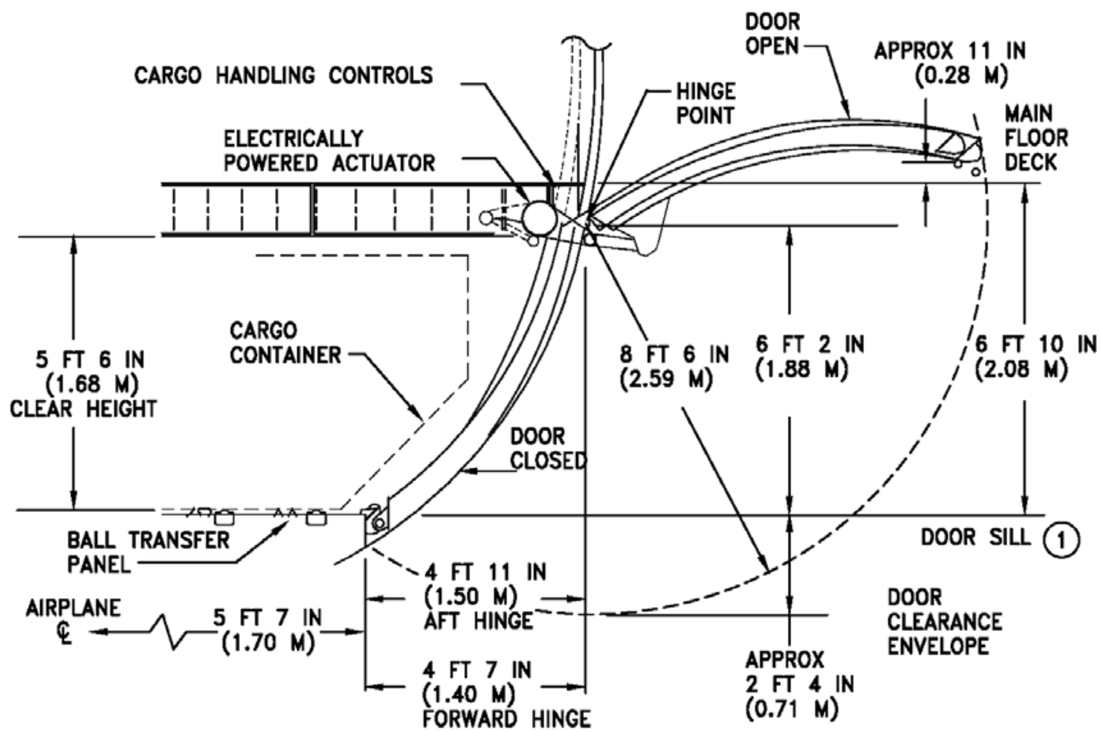
MODEL 747-8, 747-8F



2.7.3 DOOR CLEARANCES - MAIN ENTRY DOOR 5
MODEL 747-8



RIGHT SIDE VIEW

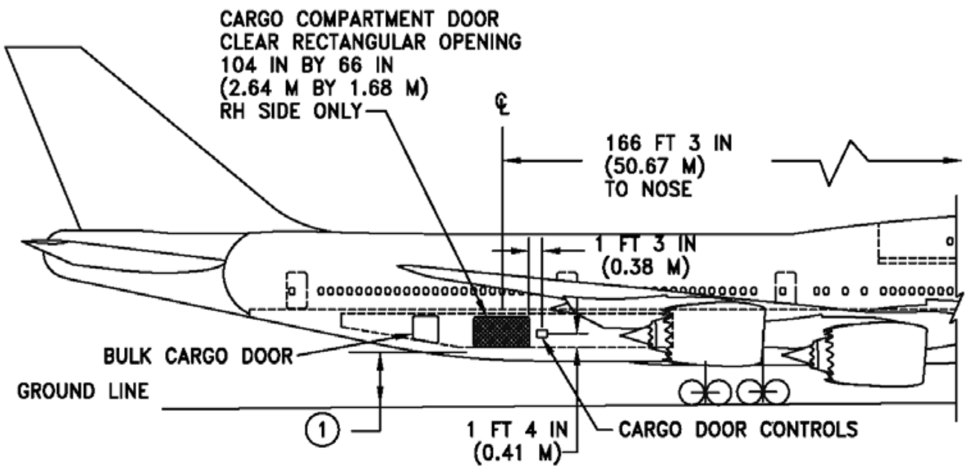


CARGO COMPARTMENT DOOR - VIEW LOOKING FORWARD

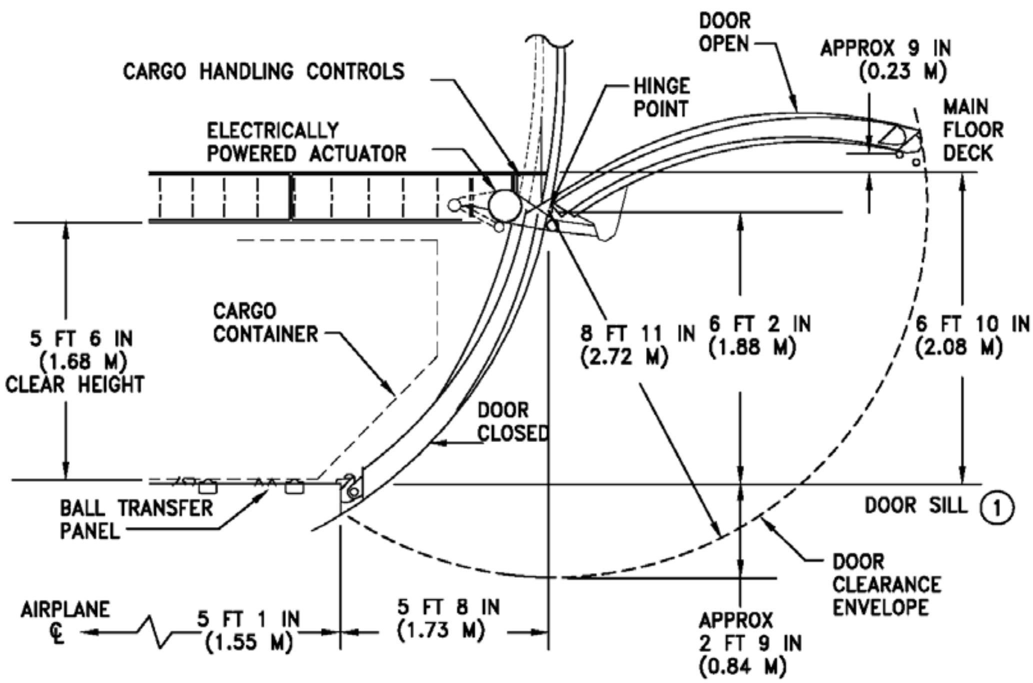
(1) SEE SECTION 2.3 FOR DOOR SILL HEIGHTS

2.7.4 DOOR CLEARANCES – LOWER FORWARD CARGO COMPARTMENT

MODEL 747-8, 747-8F



RIGHT SIDE VIEW

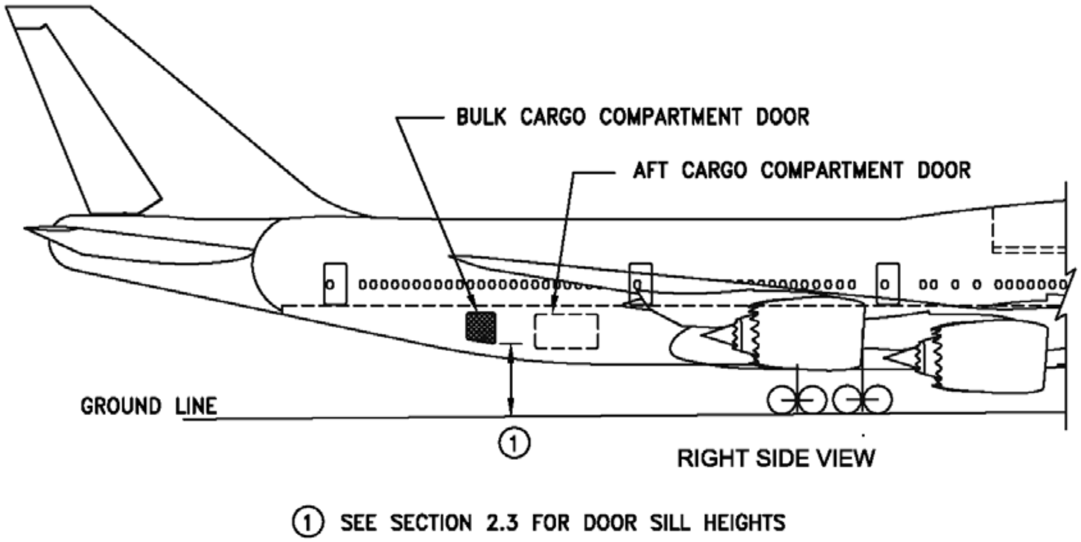


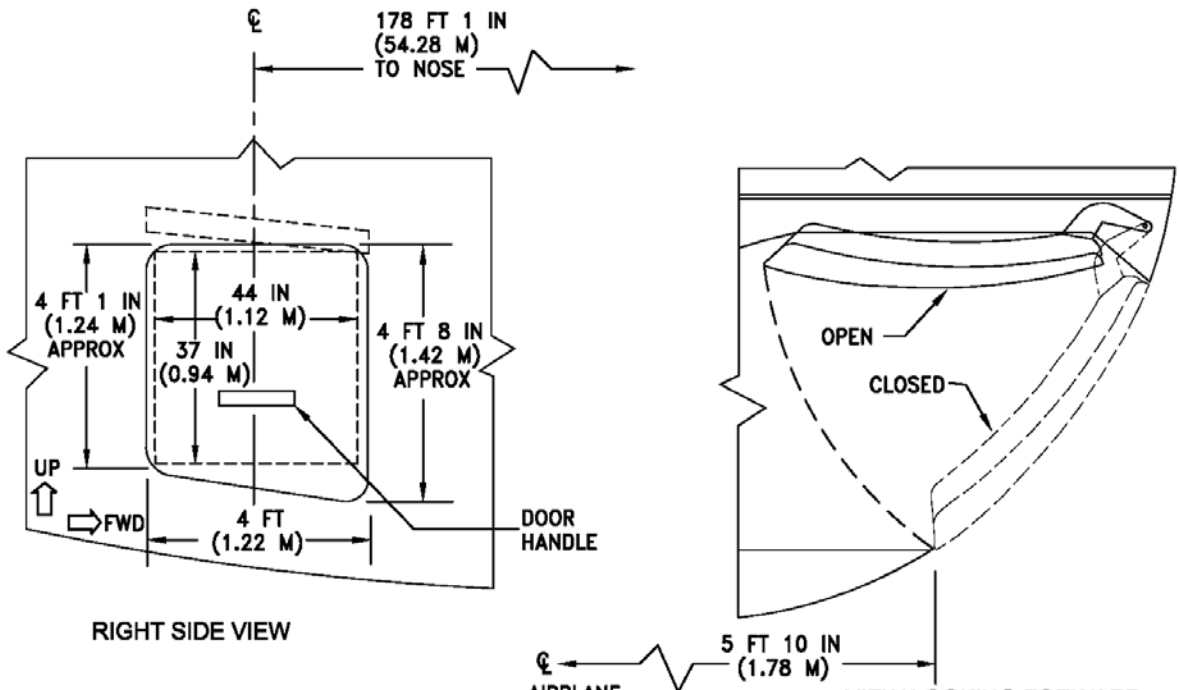
CARGO COMPARTMENT DOOR - VIEW LOOKING FORWARD

(1) SEE SECTION 2.3 FOR DOOR SILL HEIGHTS

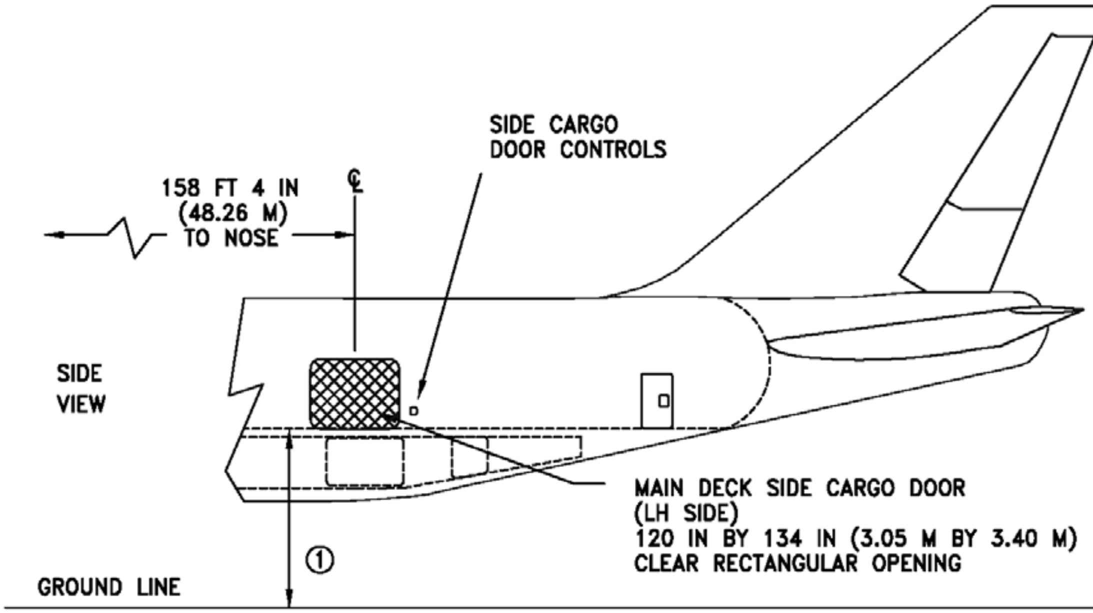
2.7.5 DOOR CLEARANCES – LOWER AFT CARGO COMPARTMENT

MODEL 747-8, 747-8F

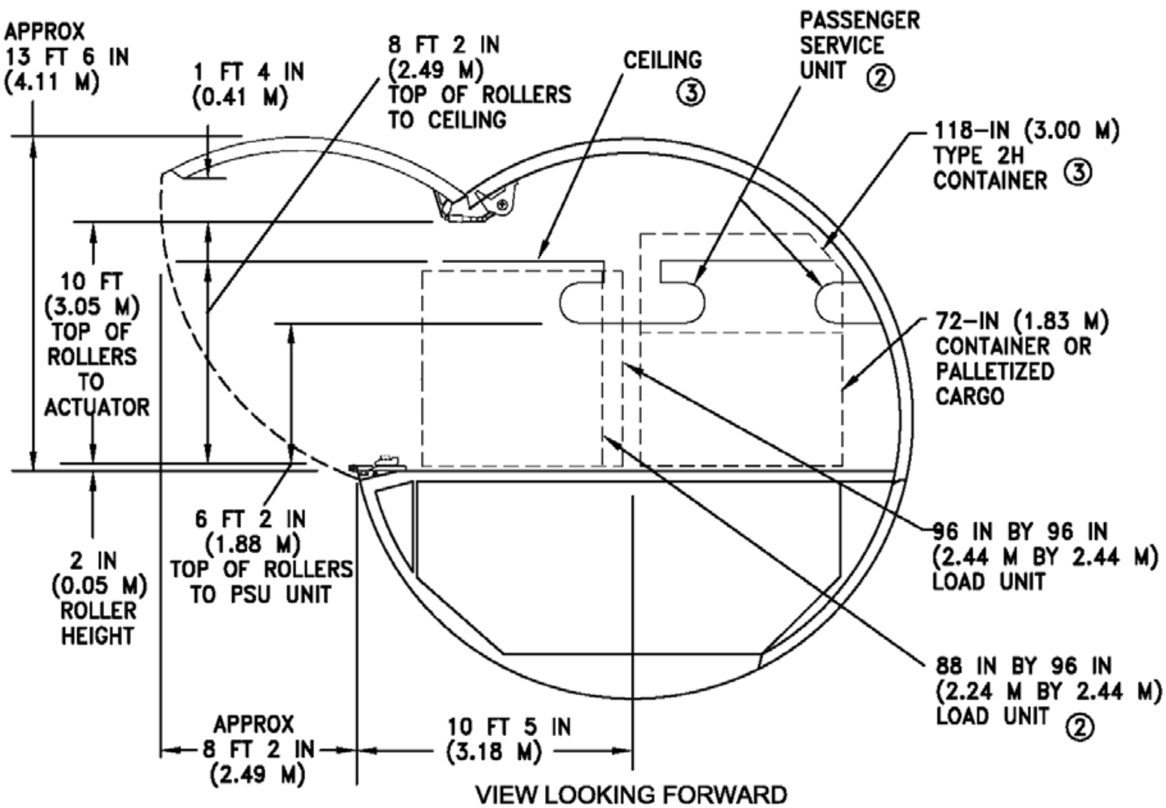




2.7.6 DOOR CLEARANCES - BULK CARGO COMPARTMENT
MODEL 747-8



LEFT SIDE VIEW

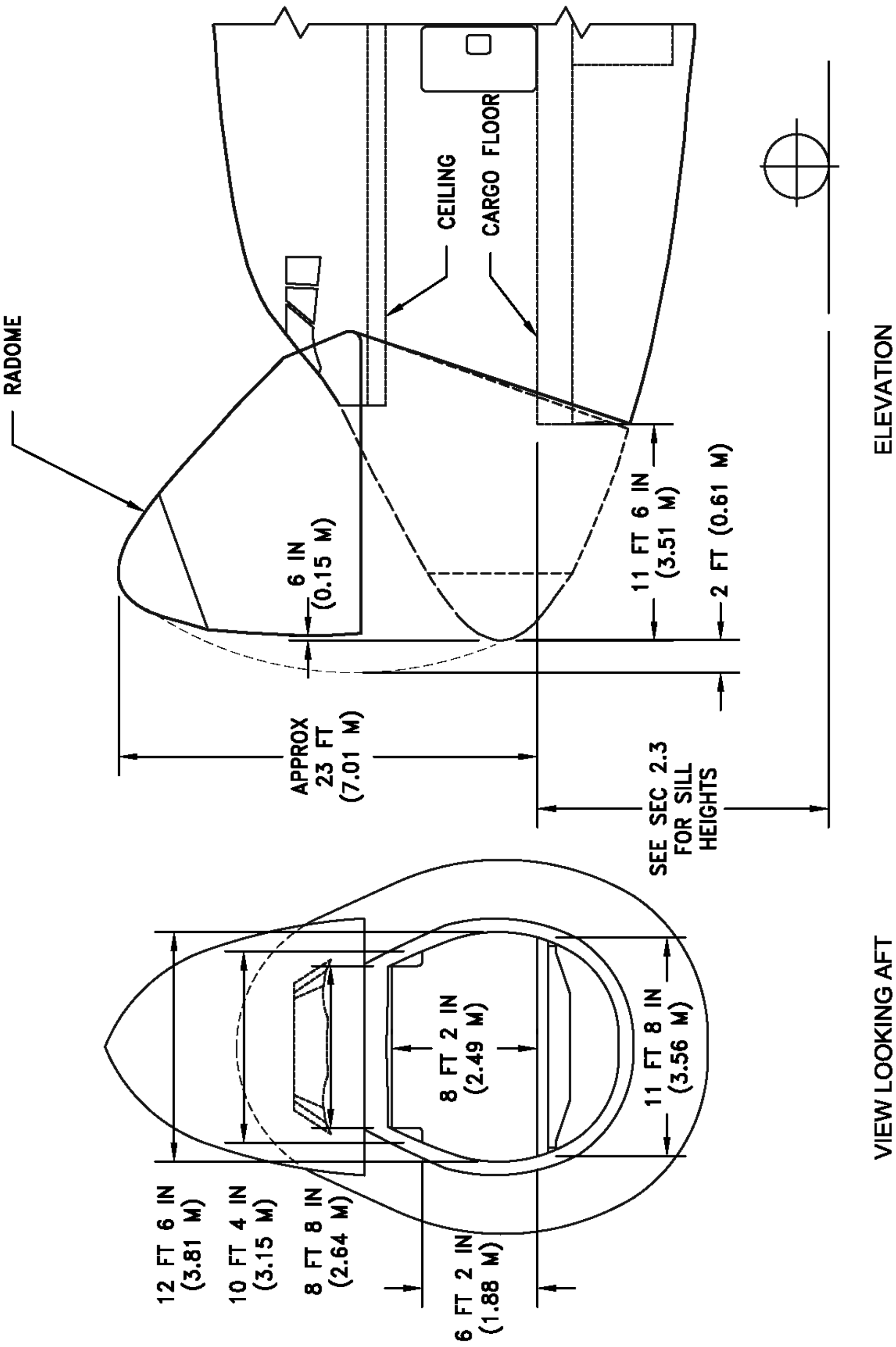


VIEW LOOKING FORWARD

① SEE SECTION 2.3 FOR DOOR SILL HEIGHTS

2.7.7 DOOR CLEARANCES – MAIN DECK CARGO DOOR

MODEL 747-8F



2.7.8 DOOR CLEARANCES - NOSE CARGO DOOR
MODEL 747-8F

3.0 AIRPLANE PERFORMANCE

3.1 General Information

3.2 Payload/Range

3.3 FAA/EASA Takeoff Runway Length Requirements

3.4 FAA/EASA Landing Runway Length Requirements

3.0 AIRPLANE PERFORMANCE

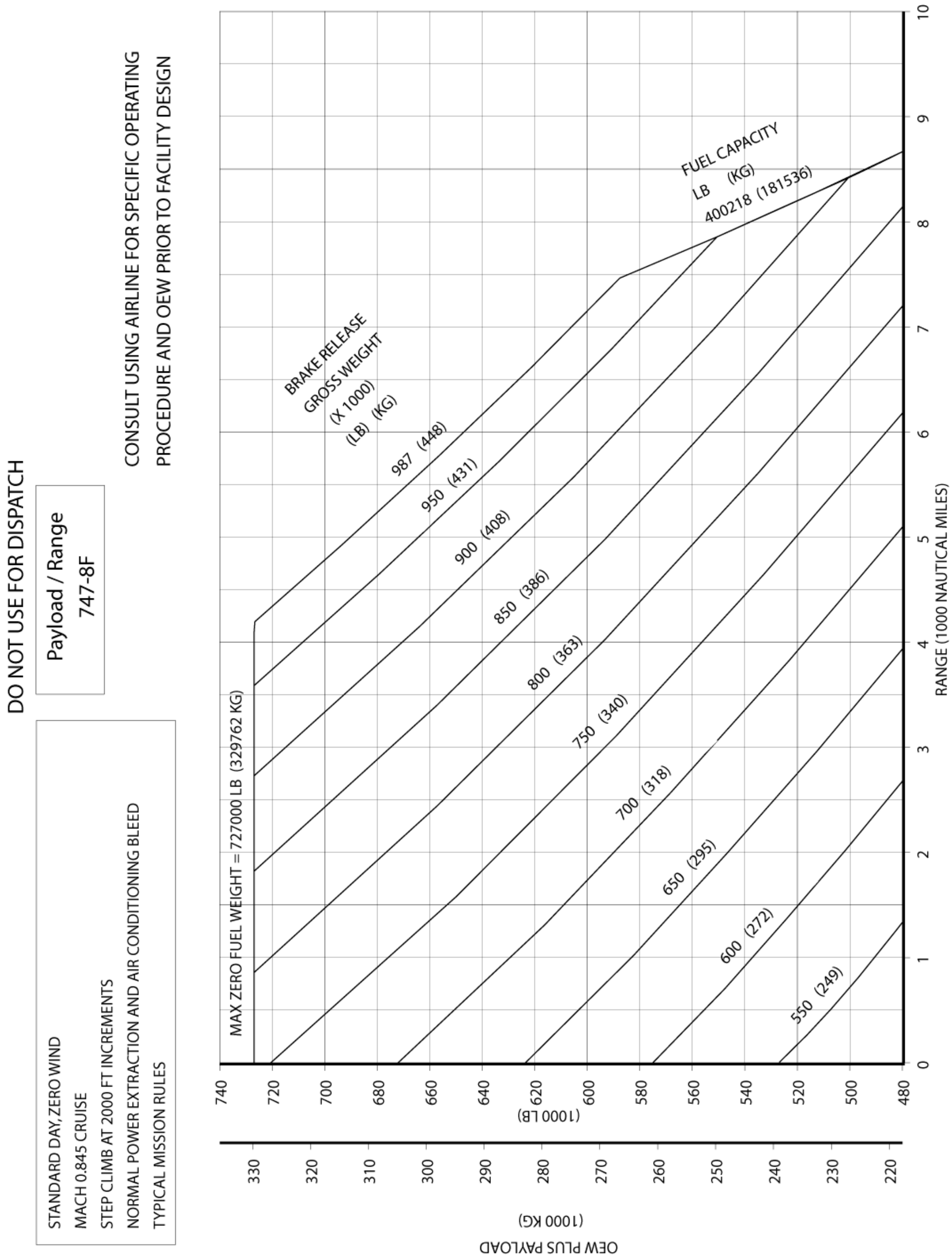
3.1 General Information

The graphs in Section 3.2 provide information on payload-range capability of the 747-8 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.

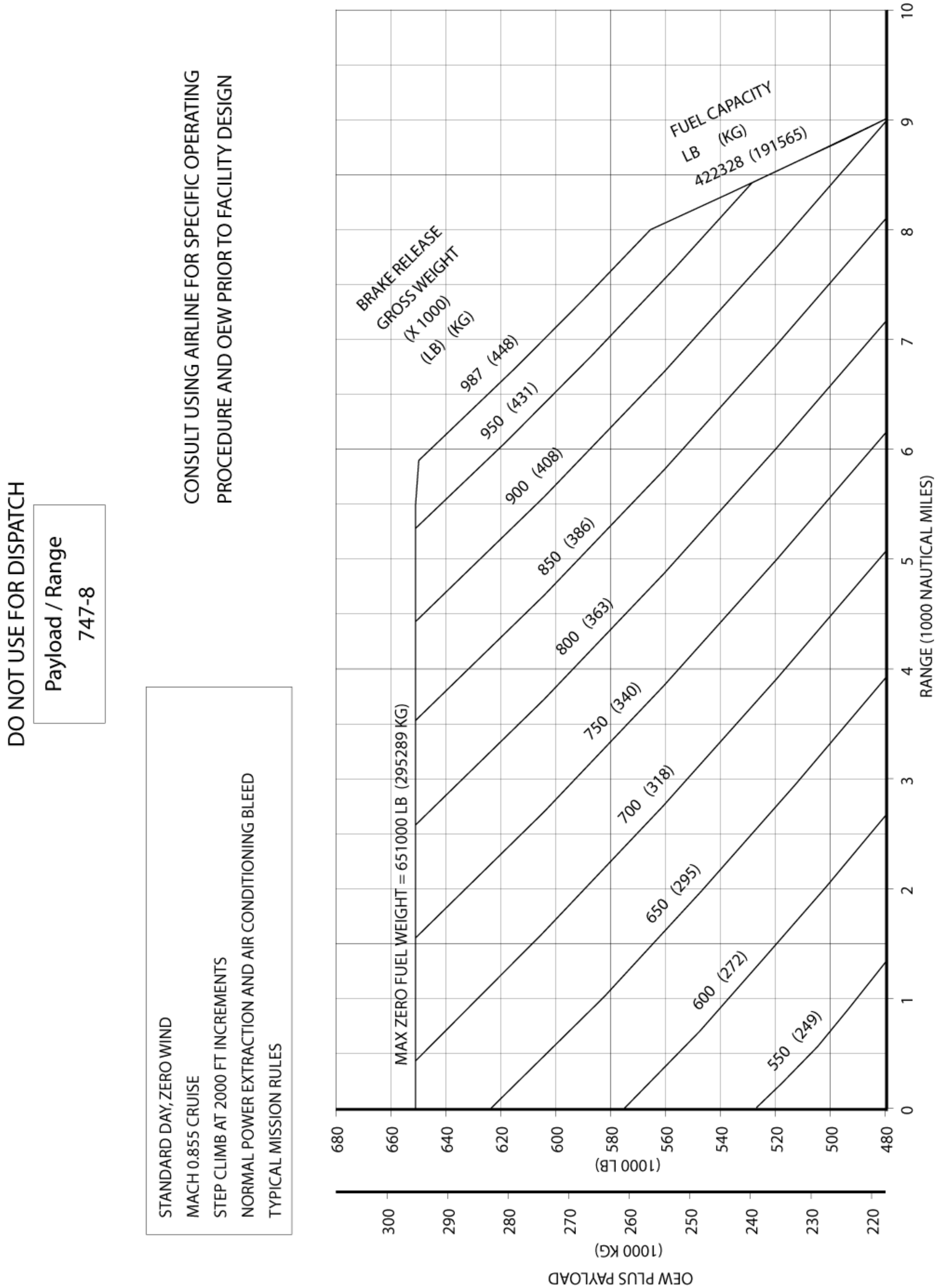
The graphs in Section 3.3 provide information on FAA/EASA takeoff runway length requirements with typical engines and various conditions. Maximum takeoff weights shown on the graphs are the heaviest for the particular airplane models with the corresponding engines. Standard day temperatures for pressure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

PRESSURE ALTITUDE		STANDARD DAY TEMP	
FEET	METERS	^{0}F	^{0}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.

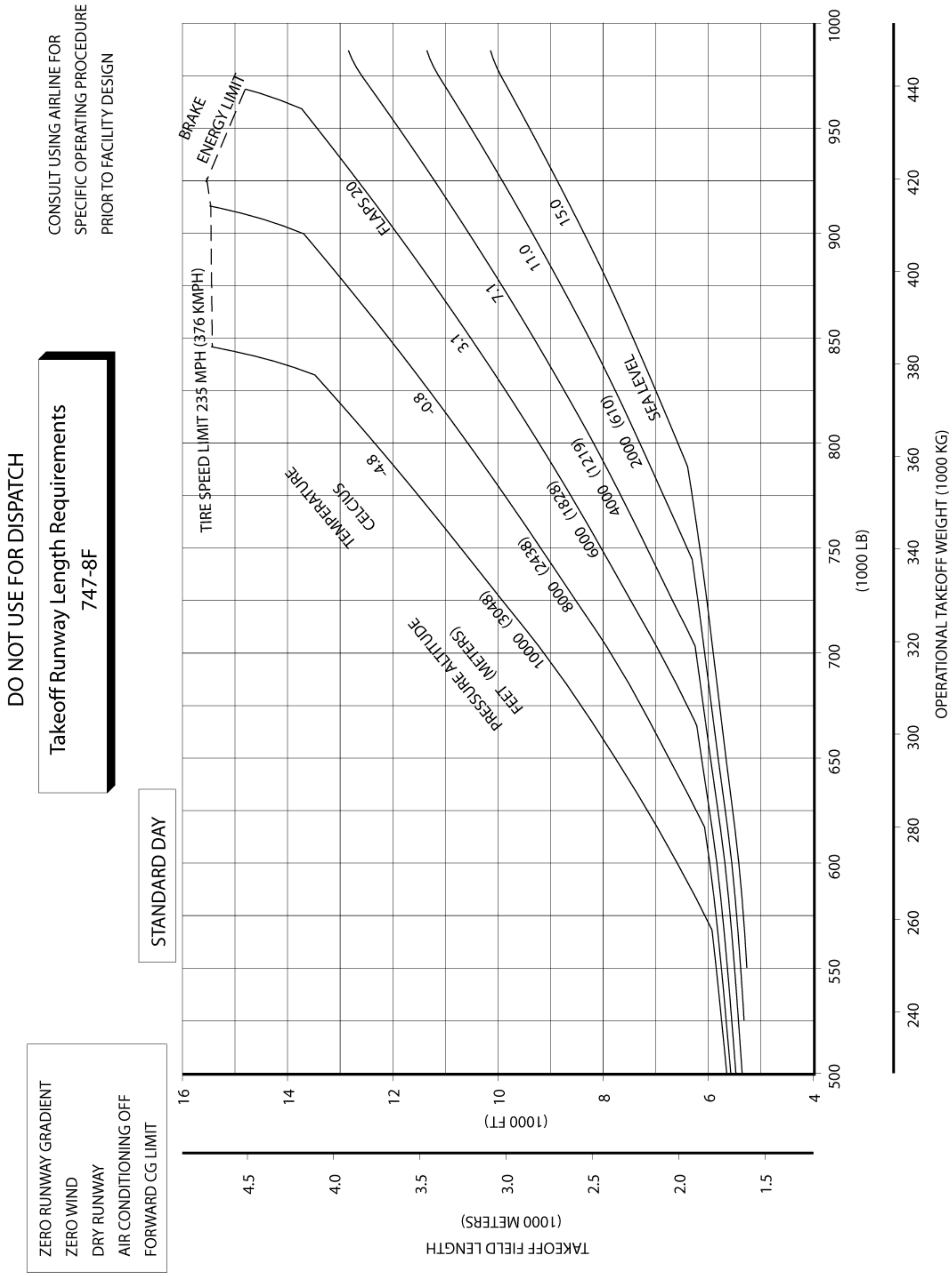


3.2.1 PAYLOAD/RANGE
MODEL 747-8F

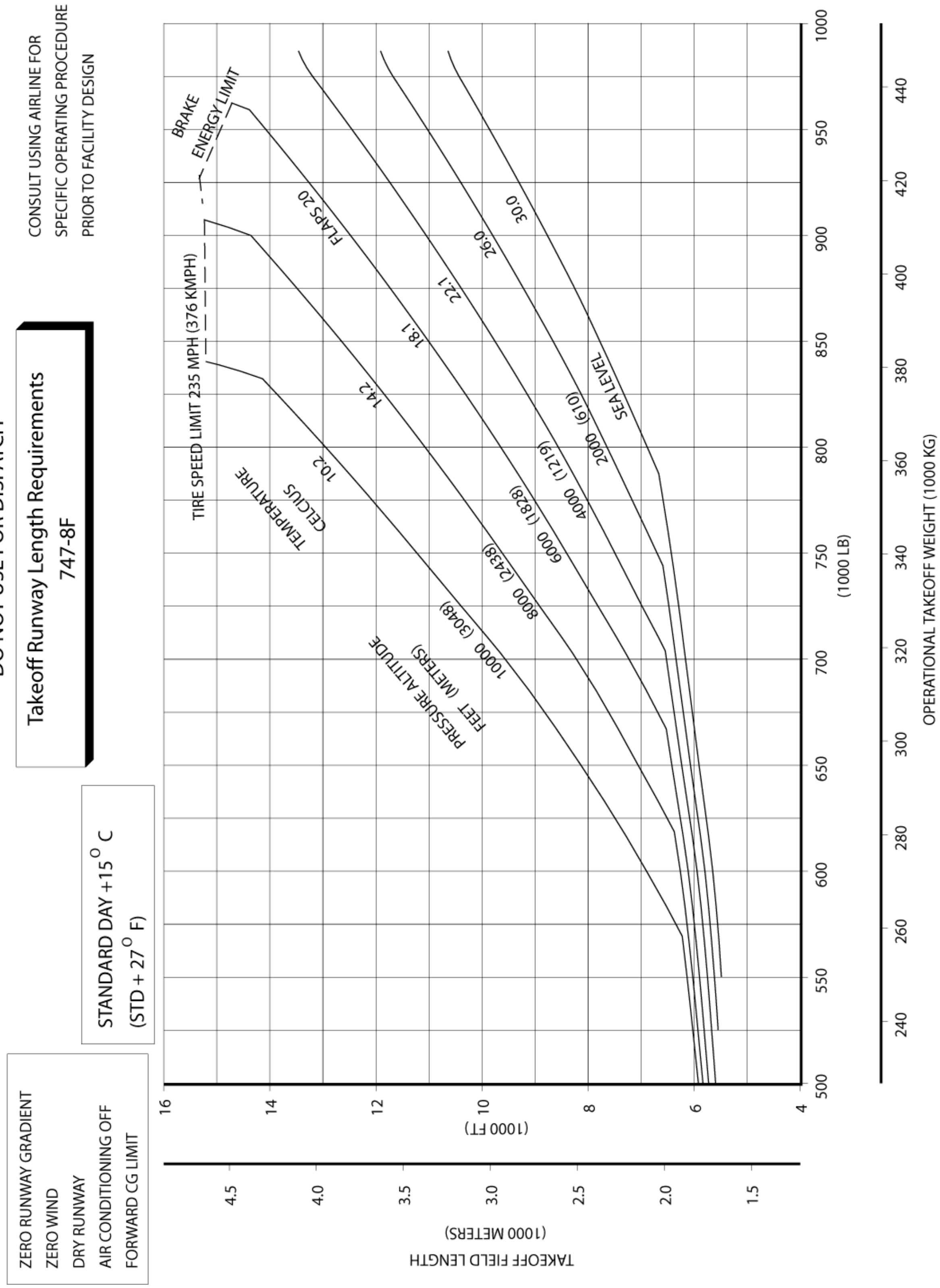


3.2.2 PAYLOAD/RANGE

MODEL 747-8

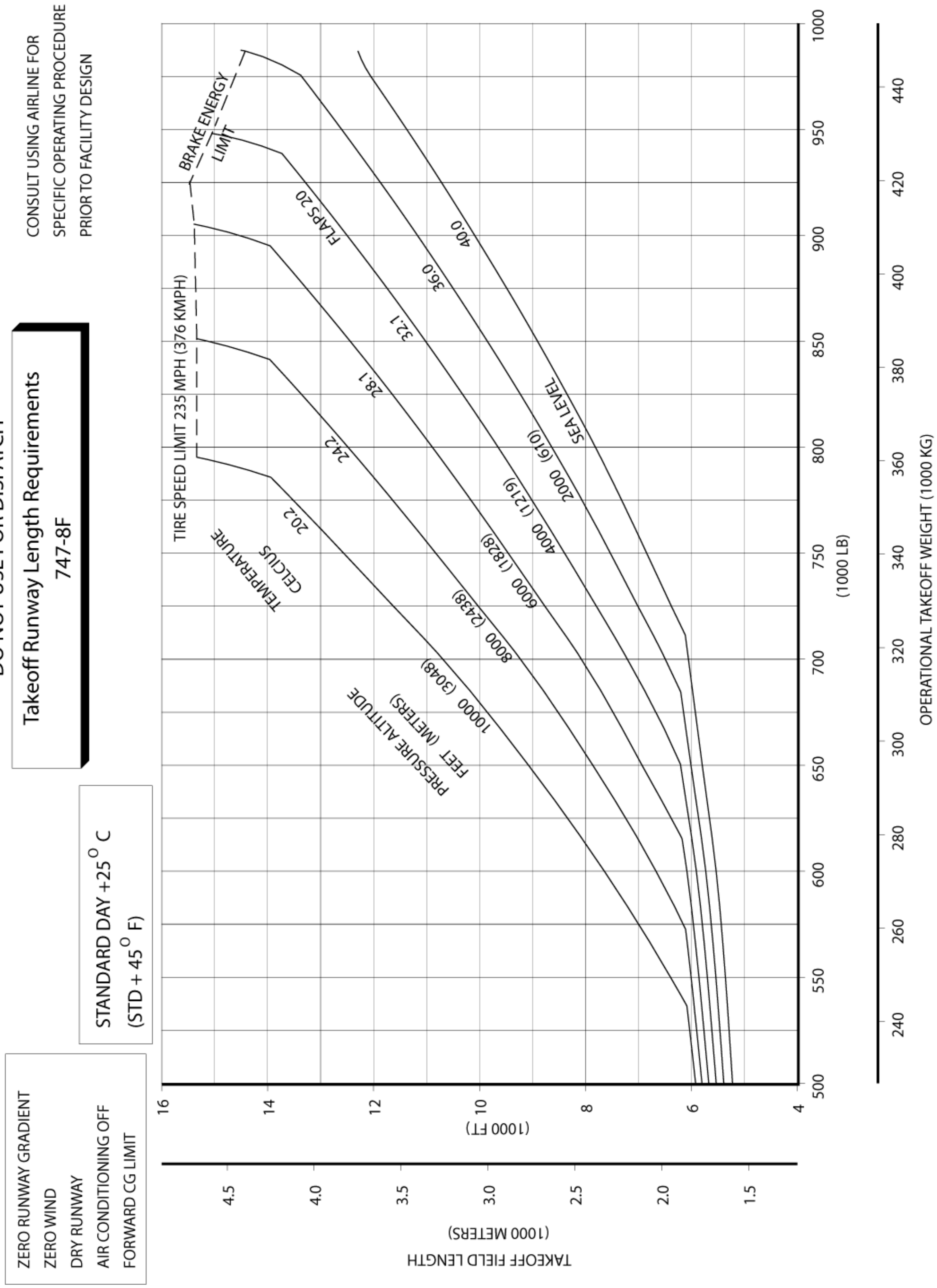


3.3.1 FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS - STANDARD DAY
MODEL 747-8F



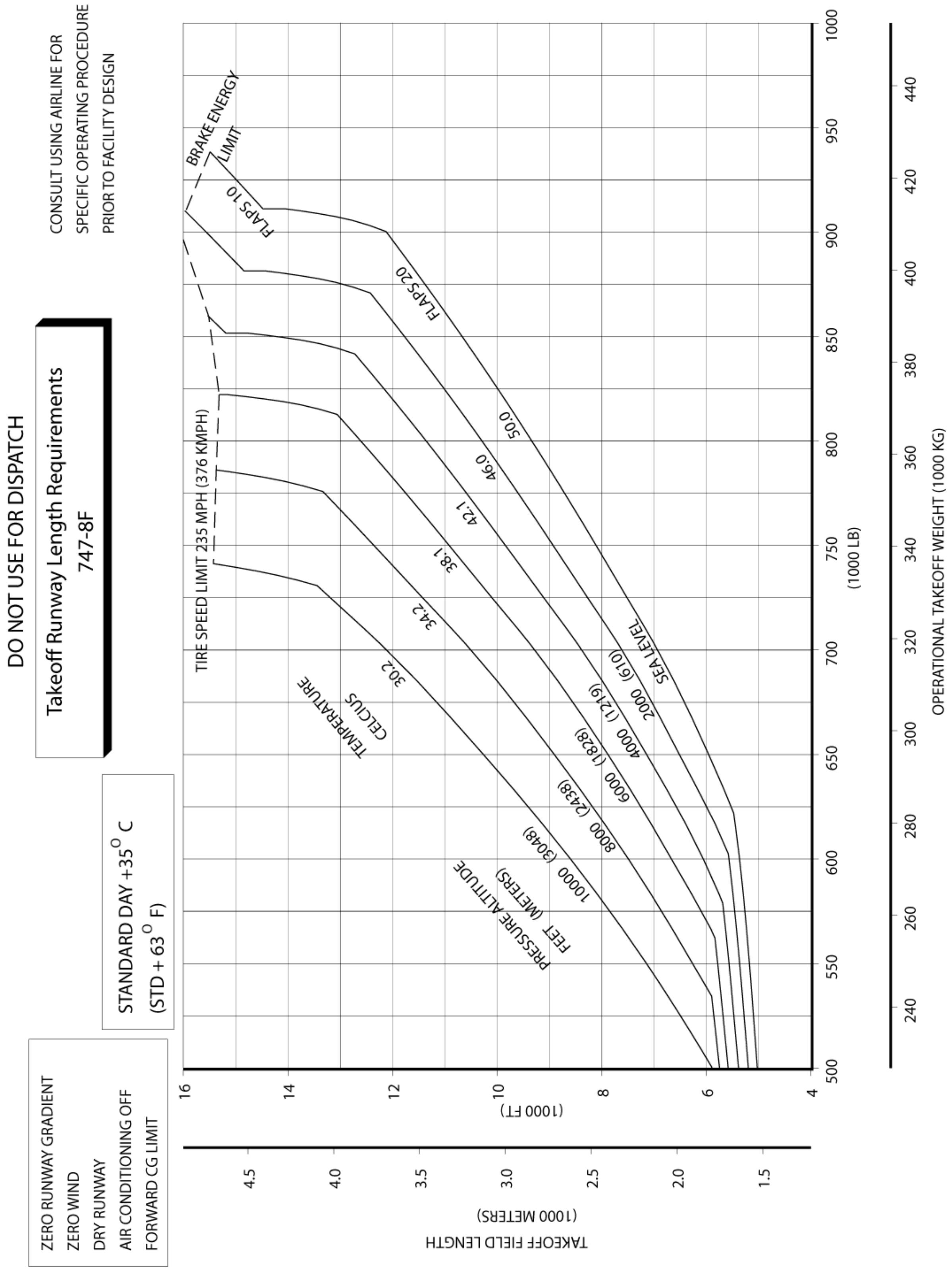
3.3.2 FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS - STANDARD DAY + 27°F (STD + 15°C)

MODEL 747-8F



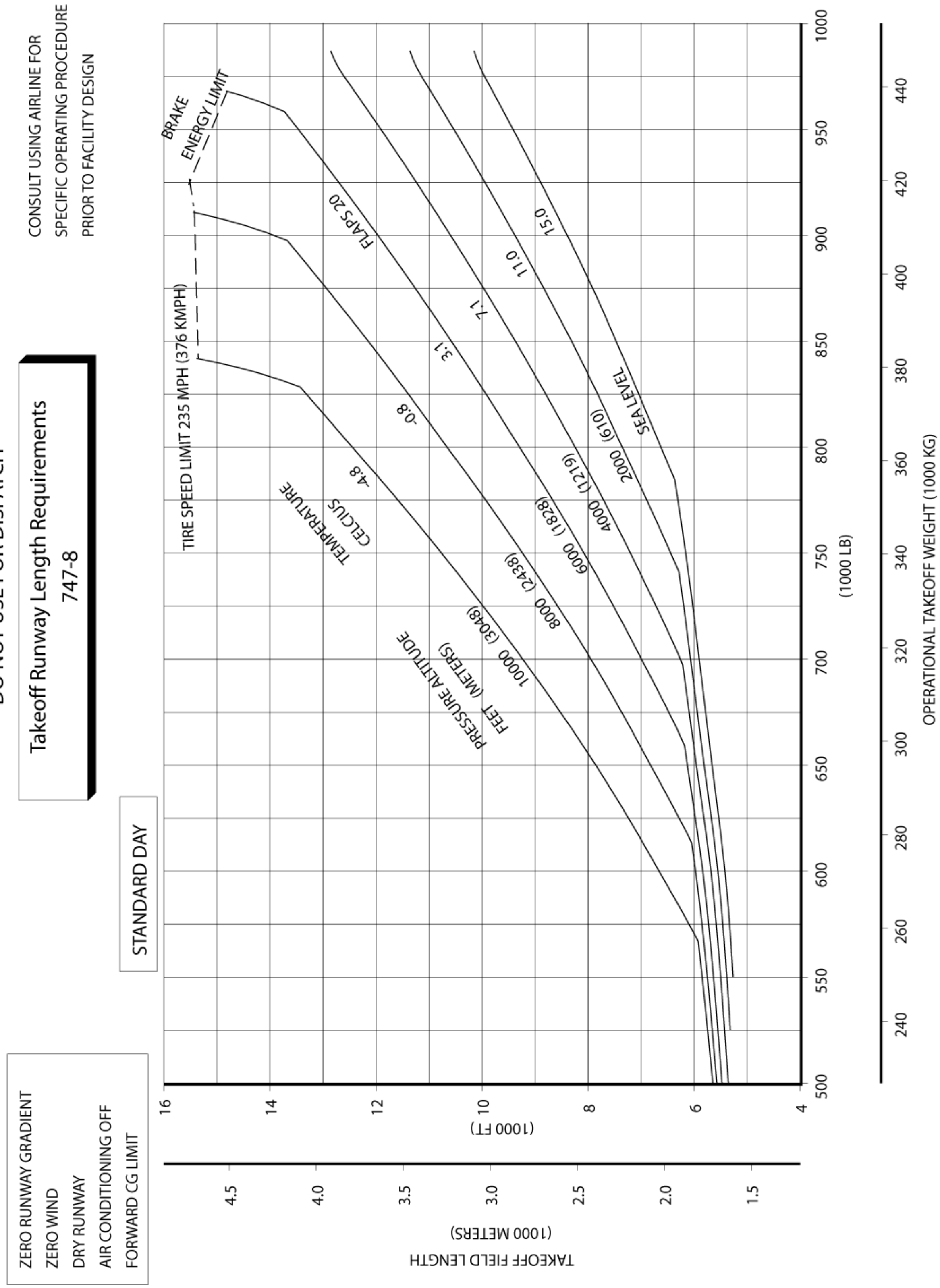
3.3.3 FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS - STANDARD DAY + 45°F (STD + 25°C)

MODEL 747-8F

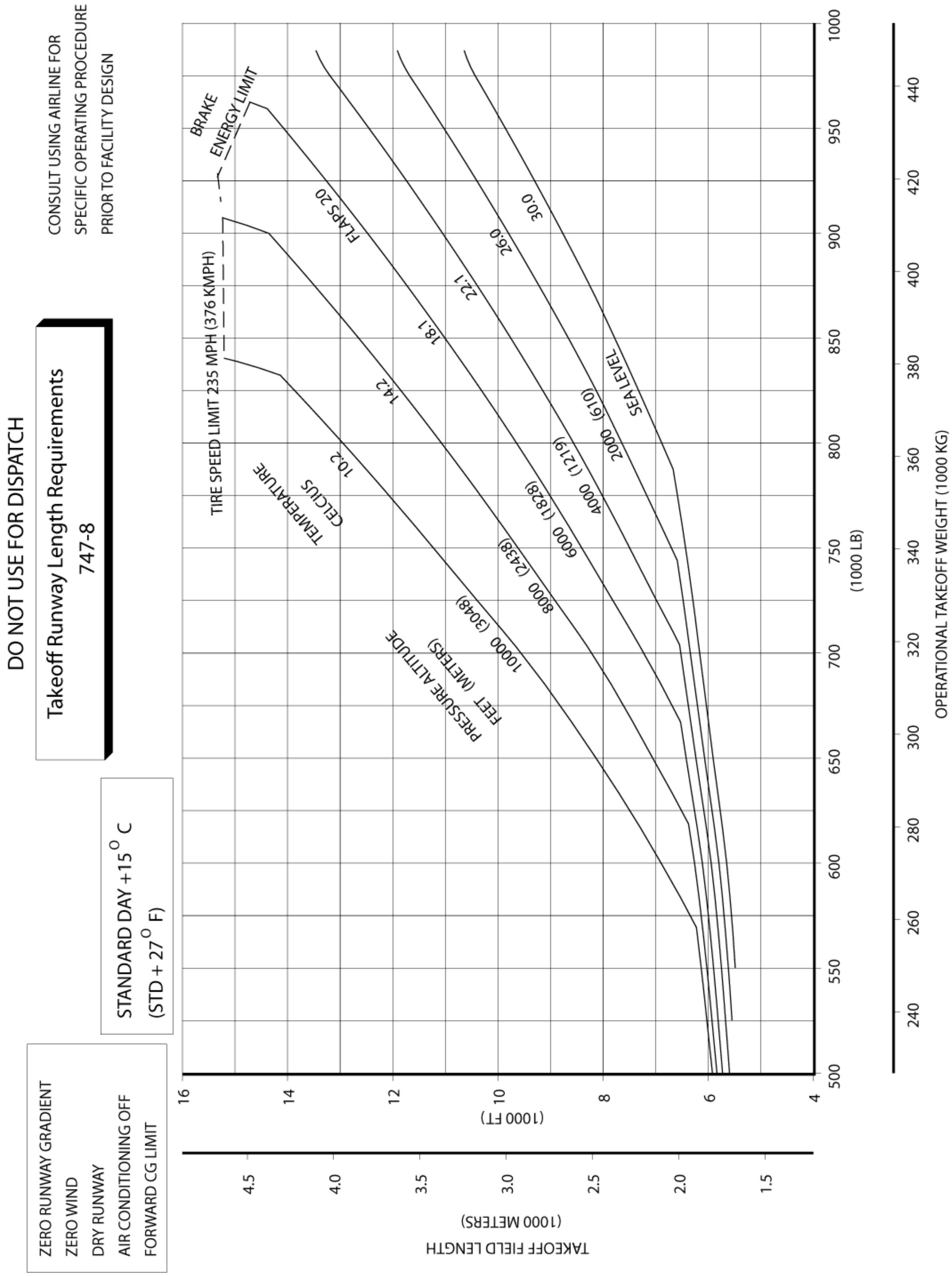


3.3.4 FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS – STANDARD DAY + 63˚F (STD + 35˚C)

MODEL 747-8F

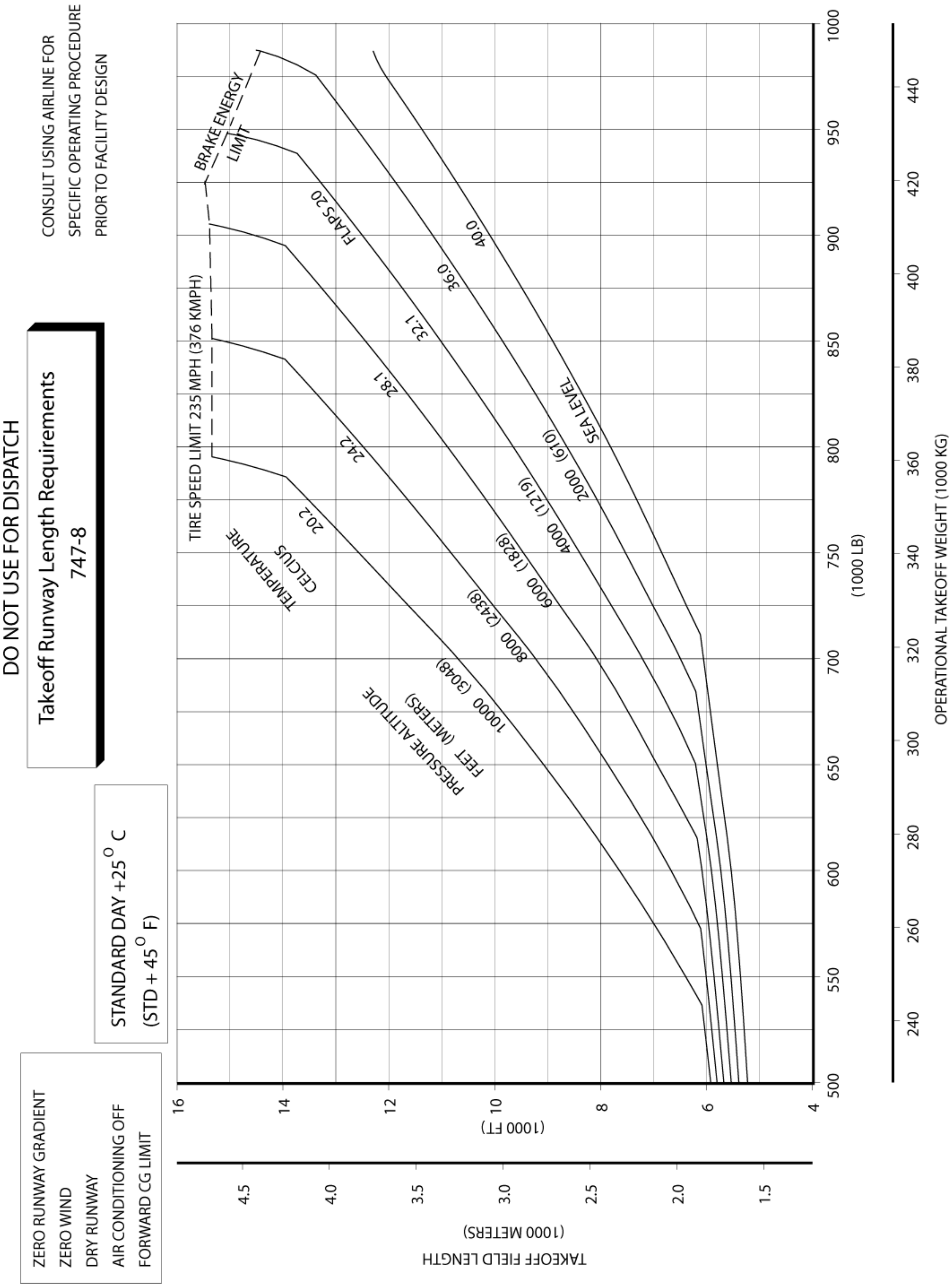


3.3.5 FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS - STANDARD DAY
MODEL 747-8



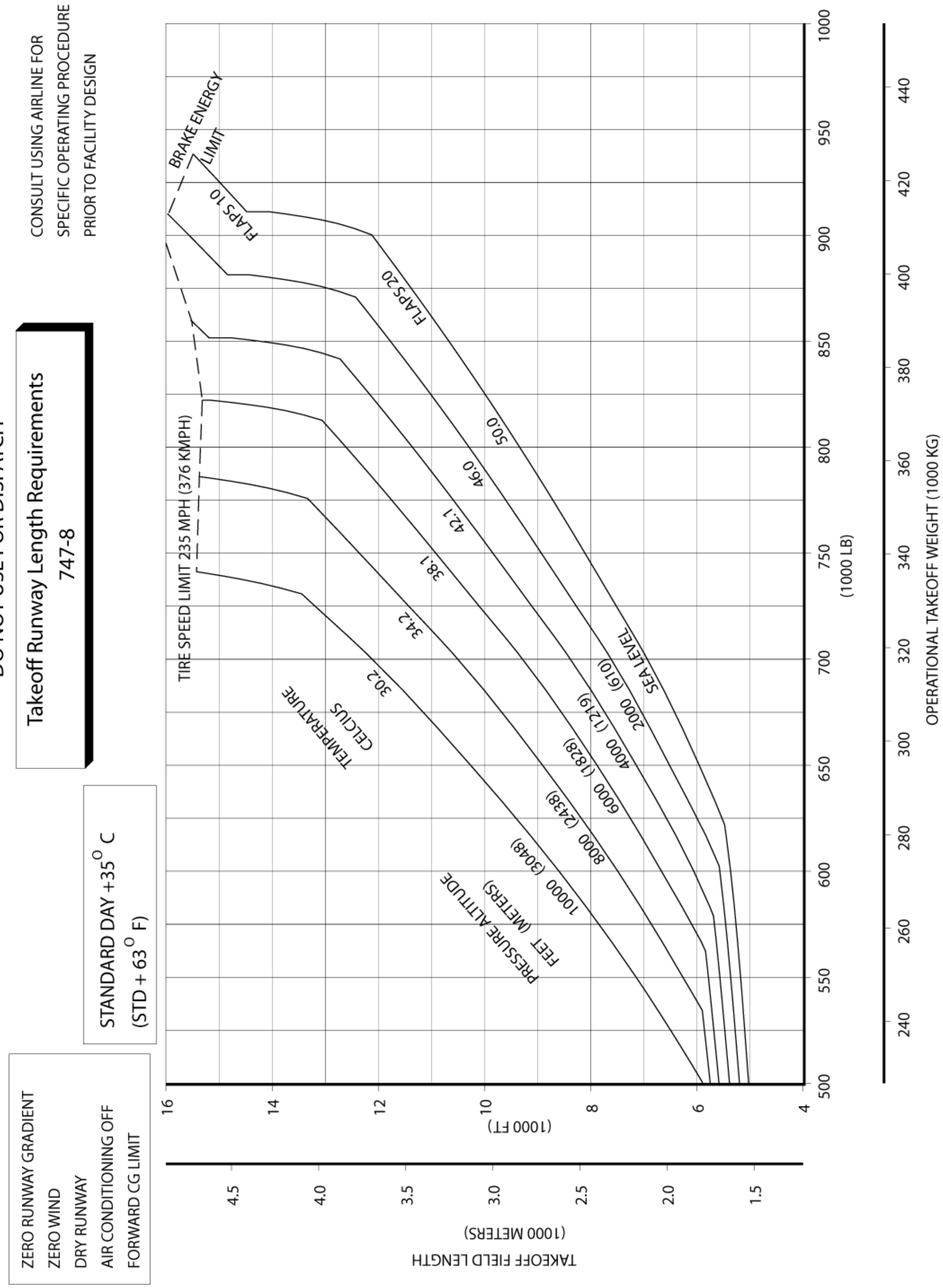
3.3.6 FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS - STANDARD DAY + 27°F (STD + 15°C)

MODEL 747-8

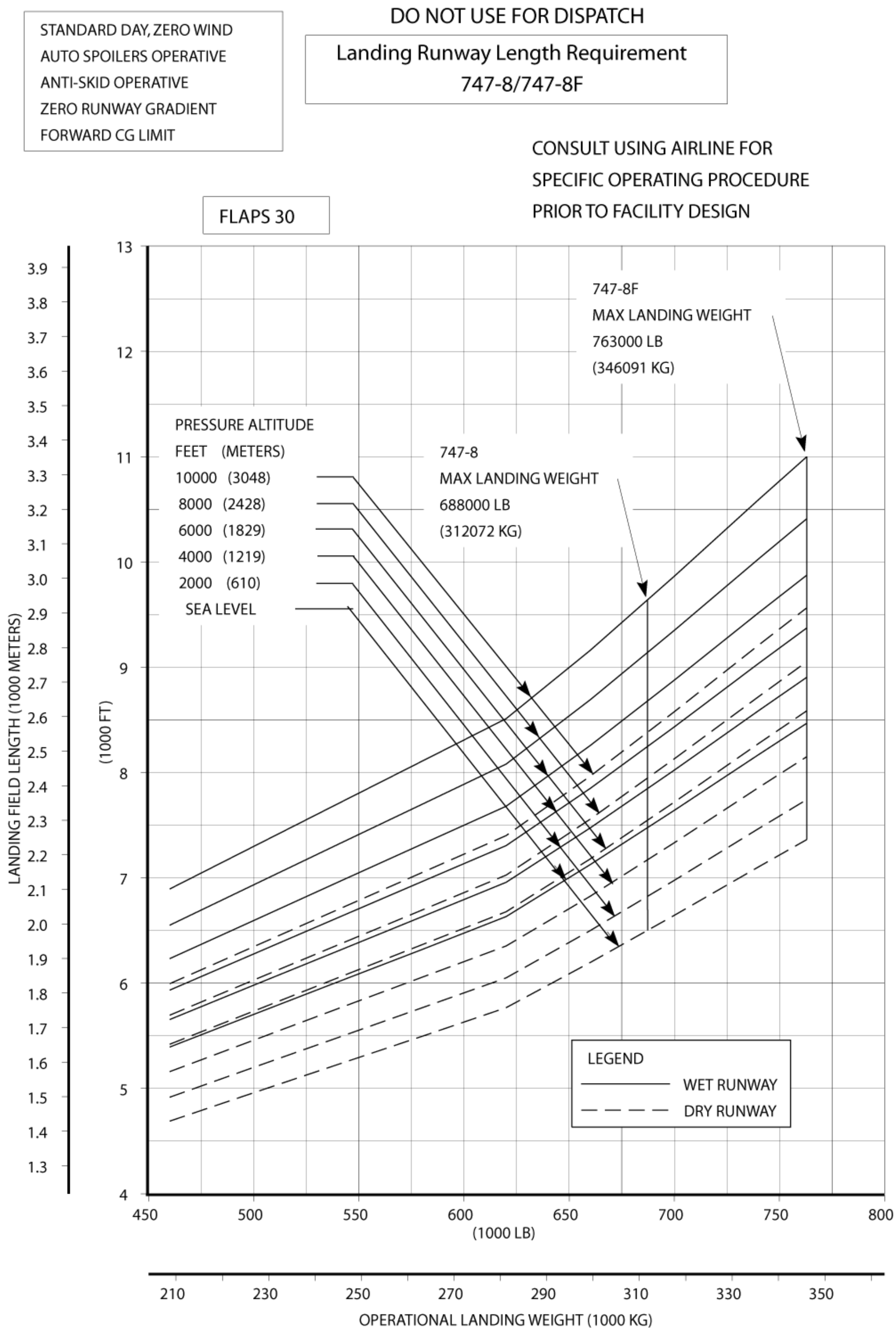


3.3.7 FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS - STANDARD DAY + 45°F (STD + 25°C)

MODEL 747-8

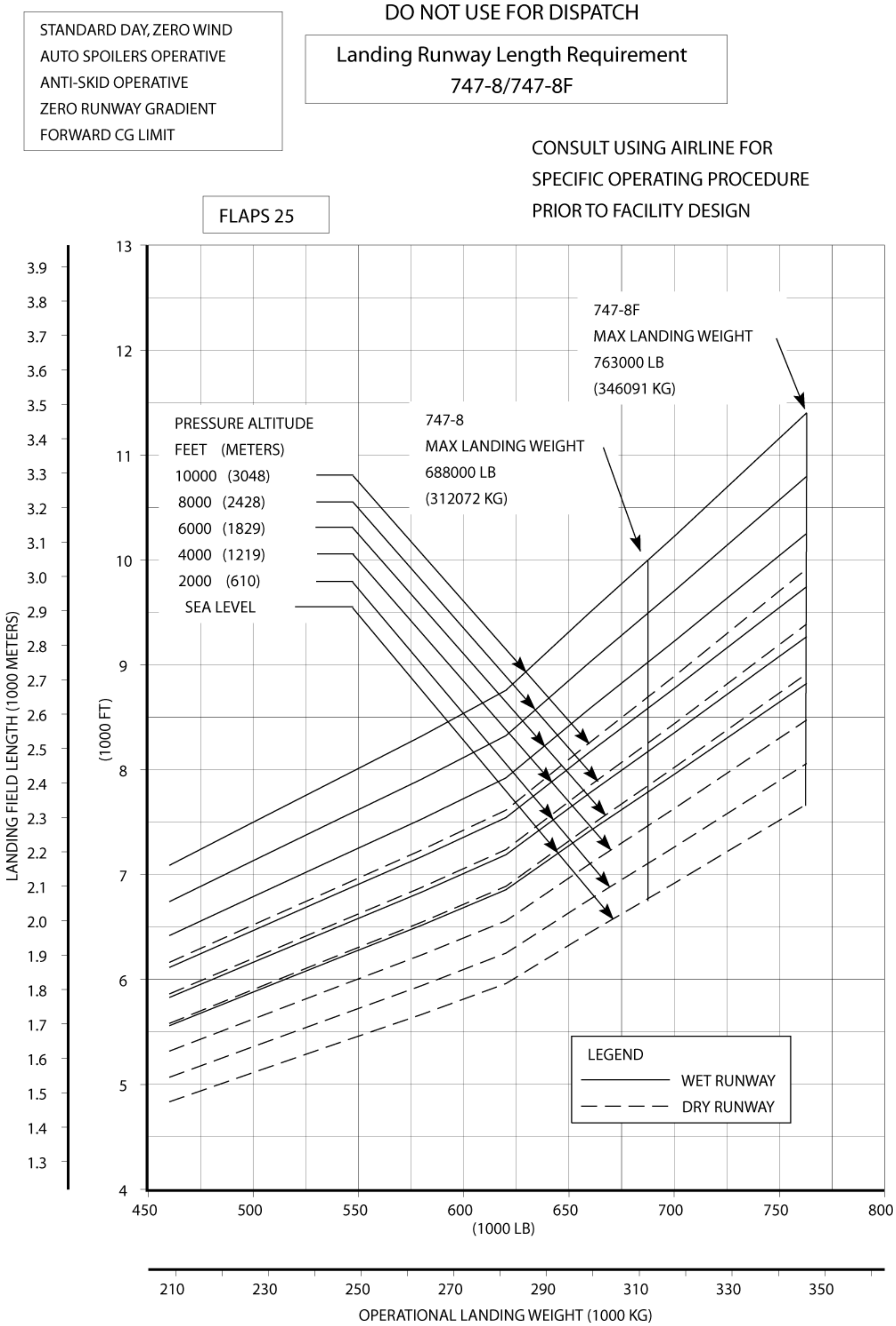


3.3.8 FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS – STANDARD DAY + 63°F (STD + 35°C)
MODEL 747-8



3.4.1 FAA/EASA LANDING RUNWAY LENGTH REQUIREMENTS - FLAPS 30

MODEL 747-8F AND 747-8



3.4.2 FAA/EASA LANDING RUNWAY LENGTH REQUIREMENTS - FLAPS 25

MODEL 747-8F AND 747-8

4.0 GROUND MANEUVERING

4.0 GROUND MANEUVERING

4.1 General Information

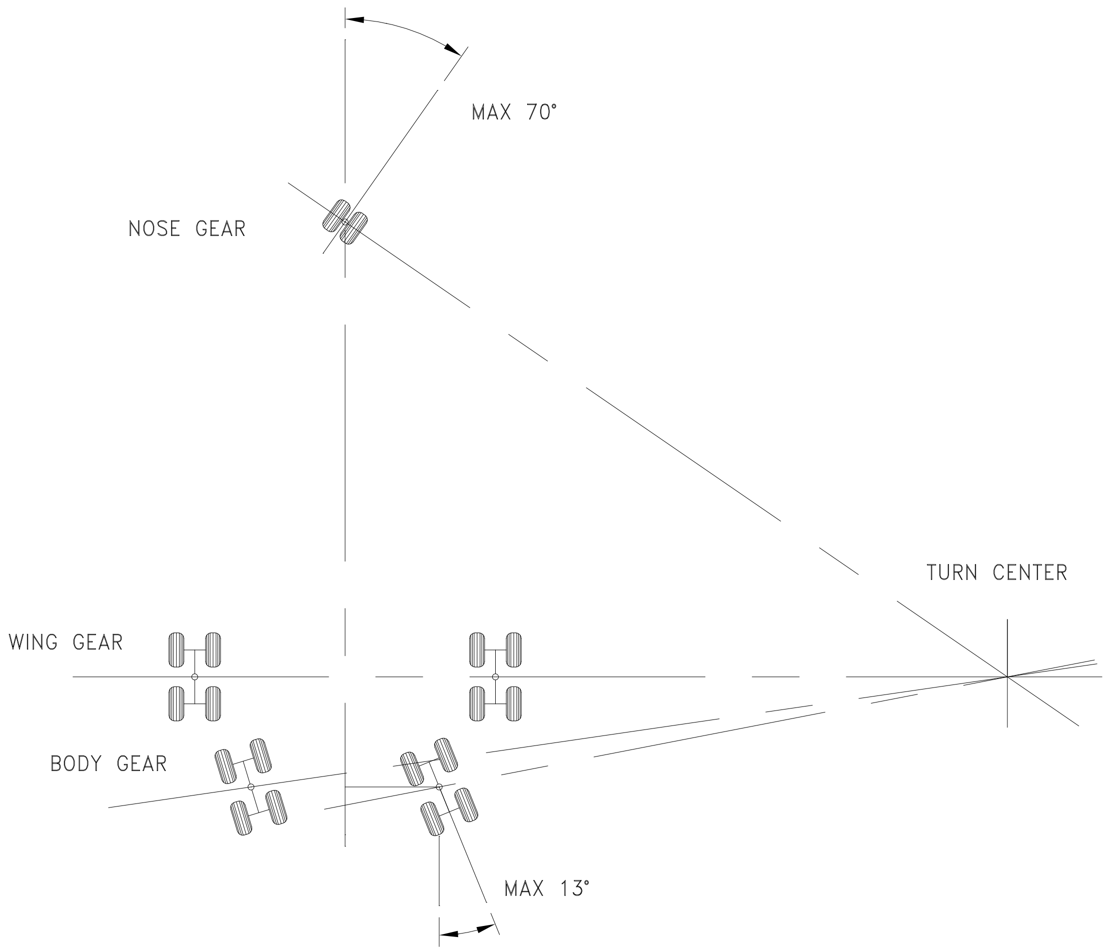
The 747-8 main landing gear consists of four main struts, each strut with four wheels. This geometric arrangement of the four main gears results in somewhat different ground maneuvering characteristics from those experienced with typical landing gear aircraft.

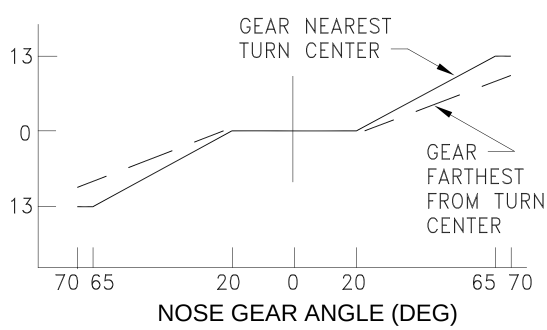
Basic factors that influence the geometry of the turn include:

1. Nose wheel steering angle
2. Engine power settings
3. Center of gravity location
4. Airplane weight
5. Pavement surface conditions
6. Amount of differential braking
7. Ground speed
8. Main landing gear steering

The steering system of the 747-8 incorporates steering of the main body landing gear in addition to the nose gear steering. This body gear steering system is hydraulically actuated and is programmed electrically to provide steering ratios proportionate to the nose gear steering angles. During takeoff and landing, the body gear steering system is centered, mechanically locked, and depressurized.

Steering of the main body gear has the following advantages over ground maneuvering without this steering feature; overall improved maneuverability, including improved nose gear tracking; elimination of the need for differential braking during ground turns, with subsequent reduced brake wear; reduced thrust requirements; lower main gear stress levels; and reduced tire scrubbing. The turning radii shown in Section 4.2 are derived from a previous test involving a 747-200. The 747-8 is expected to follow the same maneuvering characteristics.



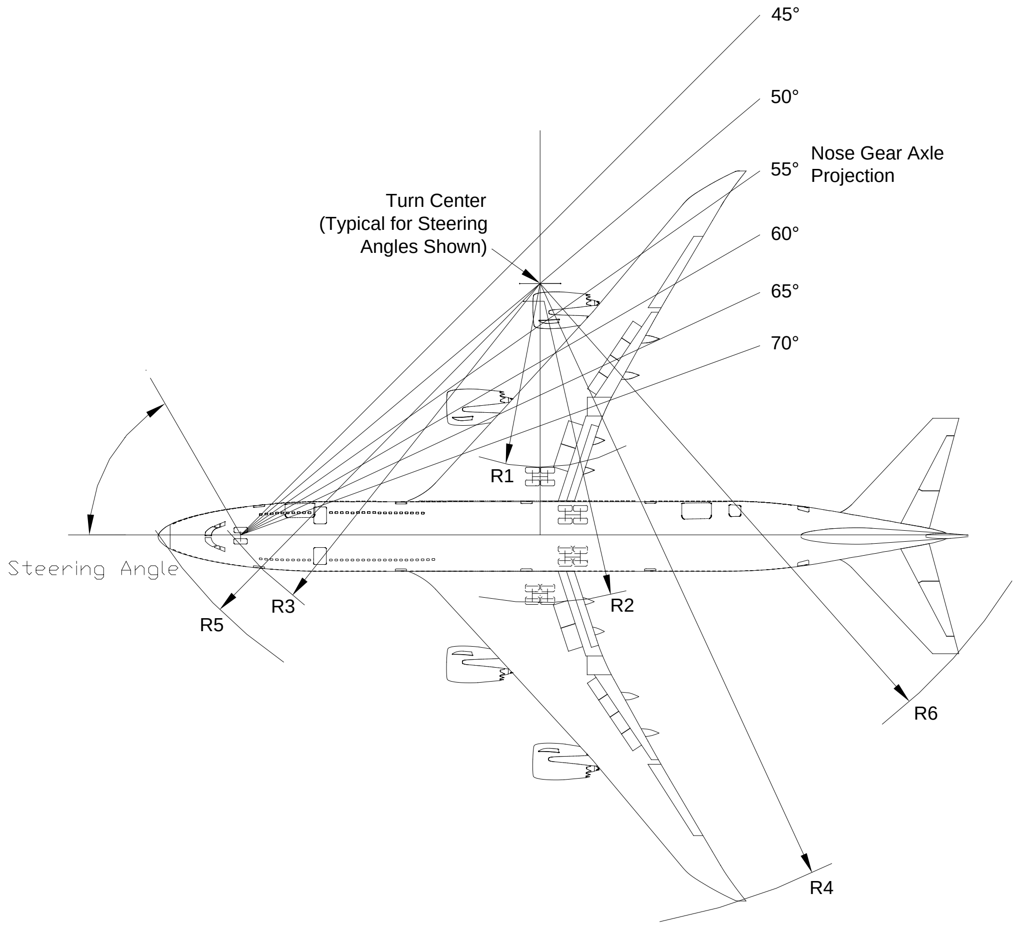


NOSE GEAR	BODY GEAR
0° TO 20°	0°
20° TO 70°	0° TO 13°

NOSE GEAR/BODY GEAR TURN RATIOS

4.1.1 GENERAL INFORMATION – BODY GEAR STEERING SYSTEM

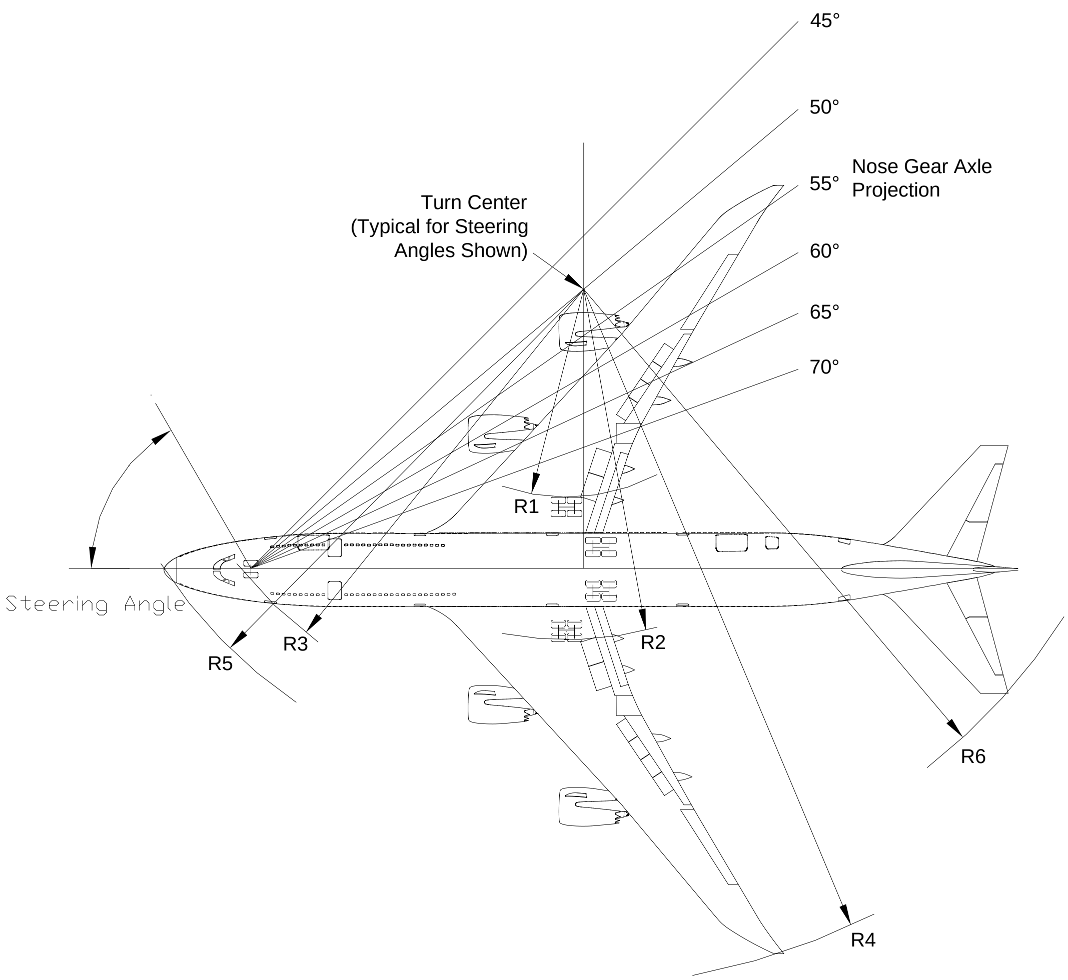
MODEL 747-8, 747-8F



NOTES: DATA SHOWN FOR AIRPLANE WITH BODY GEAR STEERING
ACTUAL OPERATING TURNING RADII MAY BE GREATER THAN SHOWN
CONSULT WITH AIRLINE FOR SPECIFIC OPERATING PROCEDURE
DIMENSIONS ROUNDED TO NEAREST FOOT AND 0.1 METER

STEERING ANGLE	R1 INNER GEAR		R2 OUTER GEAR		R3 NOSE GEAR		R4 WINGTIP		R5 NOSE		R6 TAIL	
(DEG)	FT	M	FT	M	FT	M	FT	M	FT	M	FT	M
30	139	42.4	181	55.2	188	57.3	280	85.3	199	60.7	233	71.0
35	111	33.8	153	46.6	164	50.0	252	76.8	177	54.0	210	64.0
40	89	27.1	131	39.9	147	44.8	231	70.4	161	49.1	193	58.8
45	72	21.9	113	34.4	134	40.8	214	65.2	150	45.7	180	54.9
50	57	17.4	98	29.9	124	37.8	200	61.0	141	43.0	170	51.8
55	44	13.4	86	26.2	116	35.4	188	57.3	134	40.8	162	49.4
60	33	10.1	74	22.6	110	33.5	177	54.0	129	39.3	155	47.2
65	22	6.7	64	19.5	105	32.0	168	51.2	125	38.1	149	45.4
70 (MAX)	13	4.0	55	16.8	101	30.8	159	48.5	123	37.5	144	43.9

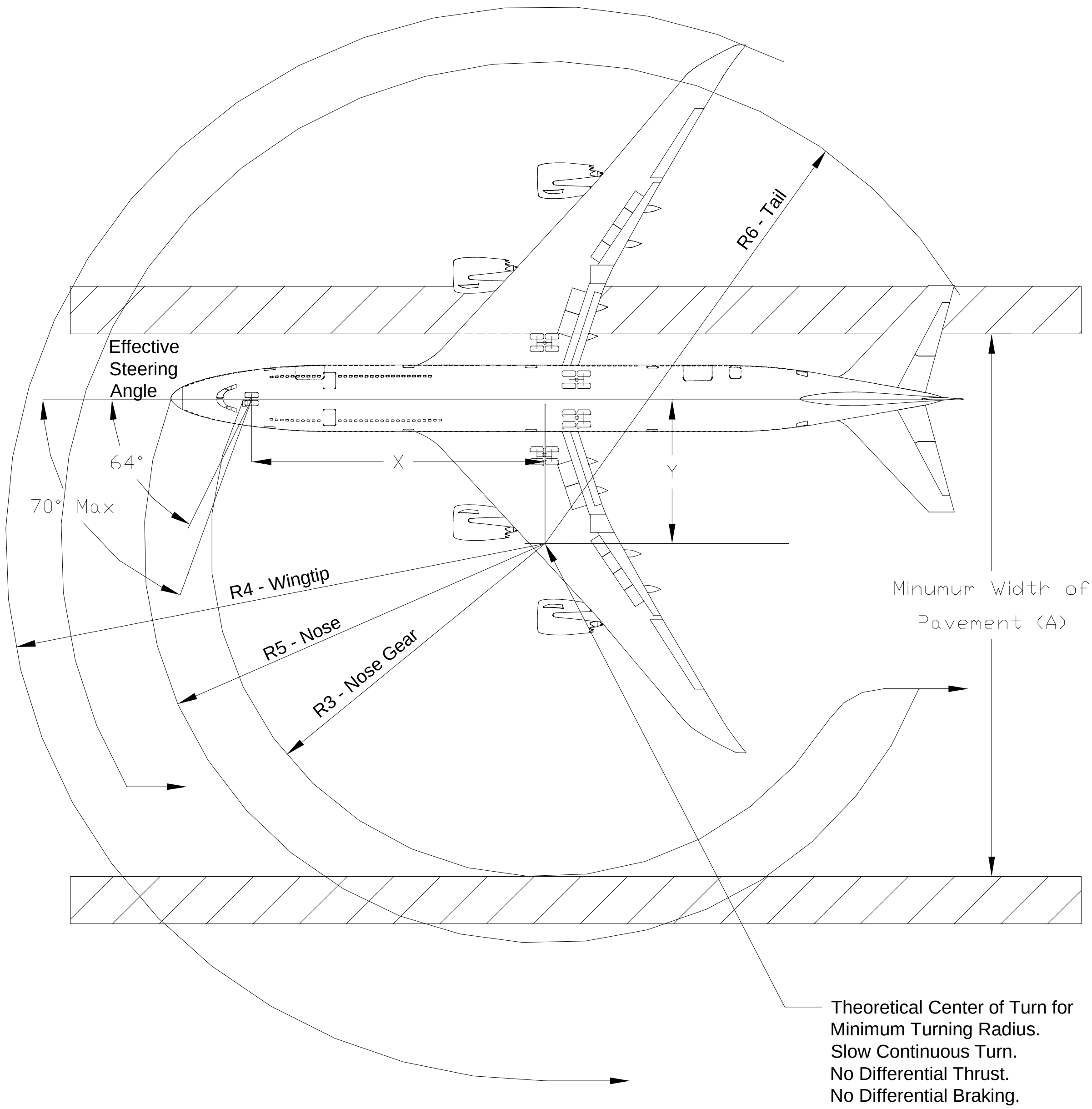
4.2.1 TURNING RADII – NO SLIP ANGLE – WITH BODY GEAR STEERING
MODEL 747-8, 747-8F



NOTES: DATA SHOWN FOR AIRPLANE WITH BODY GEAR STEERING INOPERATIVE
ACTUAL OPERATING TURNING RADII MAY BE GREATER THAN SHOWN
CONSULT WITH AIRLINE FOR SPECIFIC OPERATING PROCEDURE
DIMENSIONS ROUNDED TO NEAREST FOOT AND 0.1 METER

STEERING ANGLE	R1 INNER GEAR		R2 OUTER GEAR		R3 NOSE GEAR		R4 WINGTIP		R5 NOSE		R6 TAIL	
(DEG)	FT	M	FT	M	FT	M	FT	M	FT	M	FT	M
30	148	45.1	190	57.9	198	60.4	287	87.5	209	63.7	240	73.2
35	118	36.0	160	48.8	173	52.7	258	78.6	186	56.7	215	65.5
40	95	29.0	137	41.8	155	47.2	236	71.9	169	51.5	196	59.7
45	77	23.5	118	36.0	141	43.0	218	66.4	157	47.9	182	55.5
50	61	18.6	103	31.4	130	39.6	203	61.9	148	45.1	171	52.1
55	47	14.3	89	27.1	122	37.2	190	57.9	141	43.0	162	49.4
60	36	11.0	77	23.5	116	35.4	178	54.3	135	41.1	155	47.2
65	25	7.6	66	20.1	111	33.8	168	51.2	131	39.9	149	45.4
70 (MAX)	15	4.6	57	17.4	107	32.6	159	48.5	128	39.0	143	43.6

4.2.2 TURNING RADII – NO SLIP ANGLE –BODY GEAR STEERING INOPERATIVE
MODEL 747-8, 747-8F



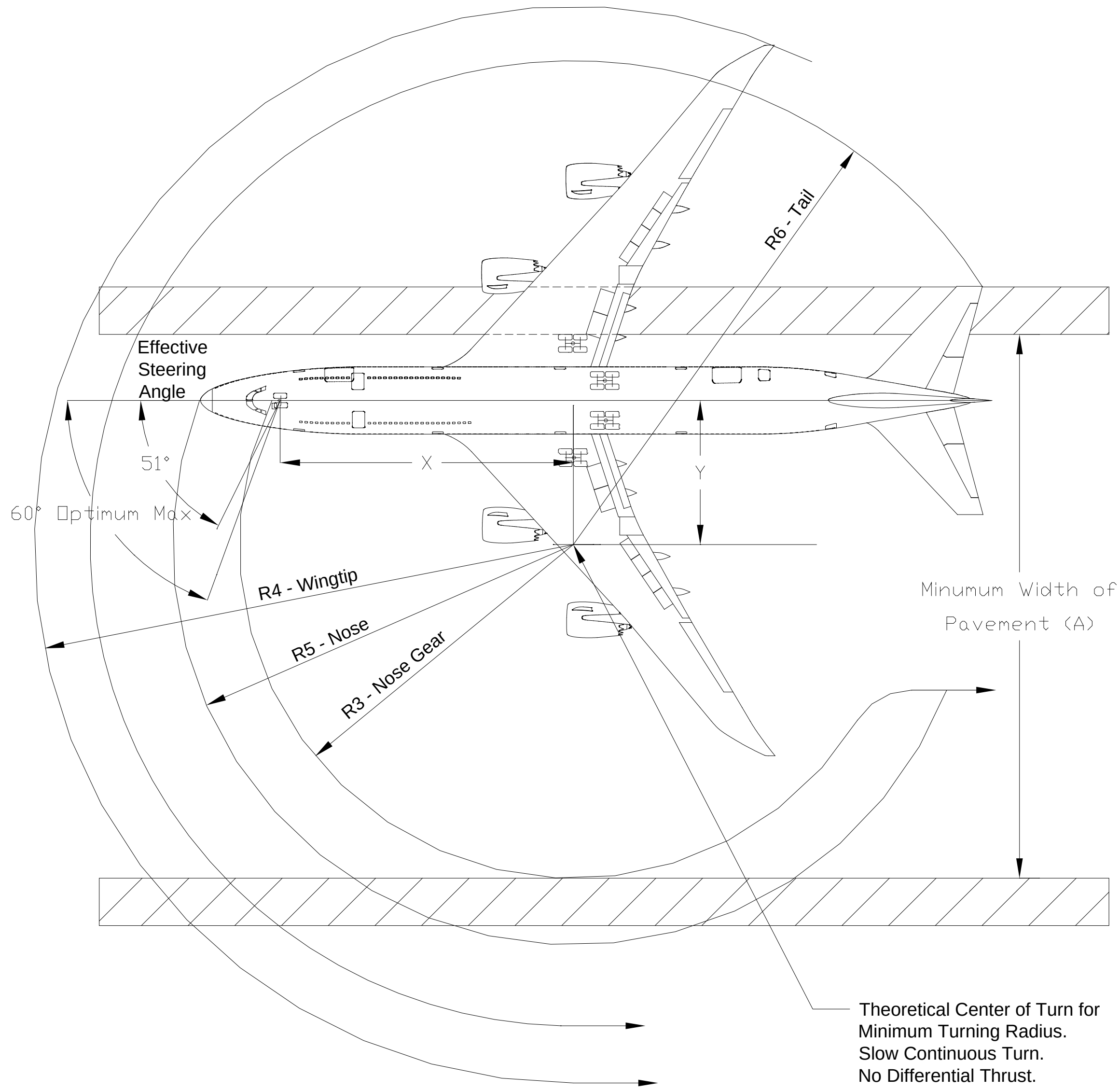
Notes:

- **6° Tire Slip Angle – Approximate Only For 70° Maximum Turn Angle**
- **Consult Airline For Actual Operating Data.**

AIRPLANE MODEL	EFFECTIVE TURNING ANGLE (DEG)	X		Y		A		R3		R4		R5		R6	
		FT	M	FT	M	FT	M	FT	M	FT	M	FT	M	FT	M
747-8, 747-8F	64	93	28.3	46	14.0	172	52.4	105	32.0	170	51.8	126	38.4	153	46.6

NOTE: DIMENSIONS ARE ROUNDED TO THE NEAREST FOOT AND 0.1 METER.

4.3.1 CLEARANCE RADII – WITH BODY GEAR STEERING
MODEL 747-8, 747-8F



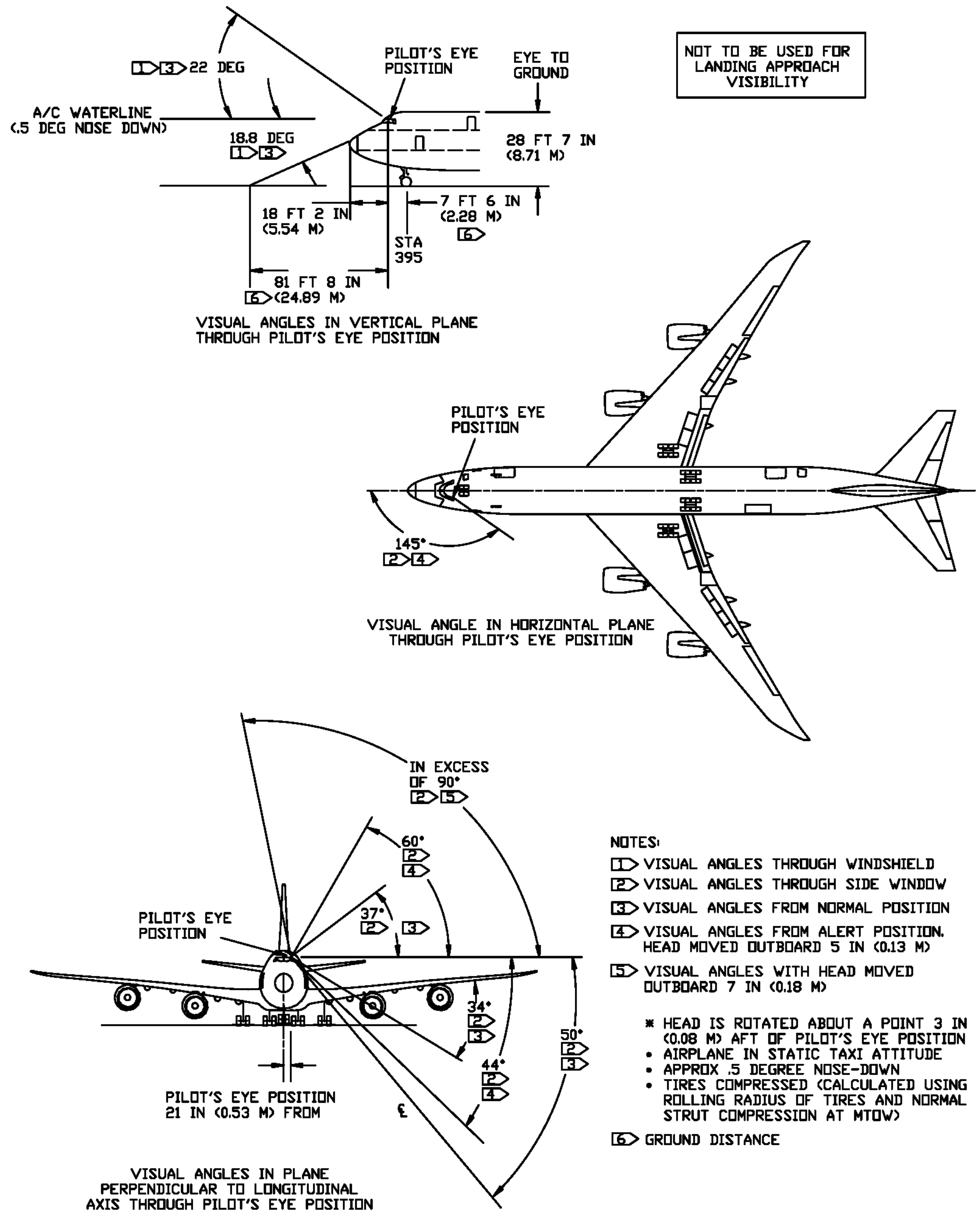
Notes:

- **Body Gear Steering Inoperative Rarely Occurs. Data Provided As Reference Only**
- **9° Tire Slip Angle – Approximate Only For 60° Turn Angle (Optimum Max Steering Angle)**
- **Consult Airline For Actual Operating Data.**

AIRPLANE MODEL	EFFECTIVE TURNING ANGLE (DEG)	X		Y		A		R3		R4		R5		R6	
		FT	M	FT	M	FT	M	FT	M	FT	M	FT	M	FT	M
747-8, 747-8F	51	98	29.9	79	24.1	228	69.5	129	39.3	200	61.0	146	44.5	169	51.5

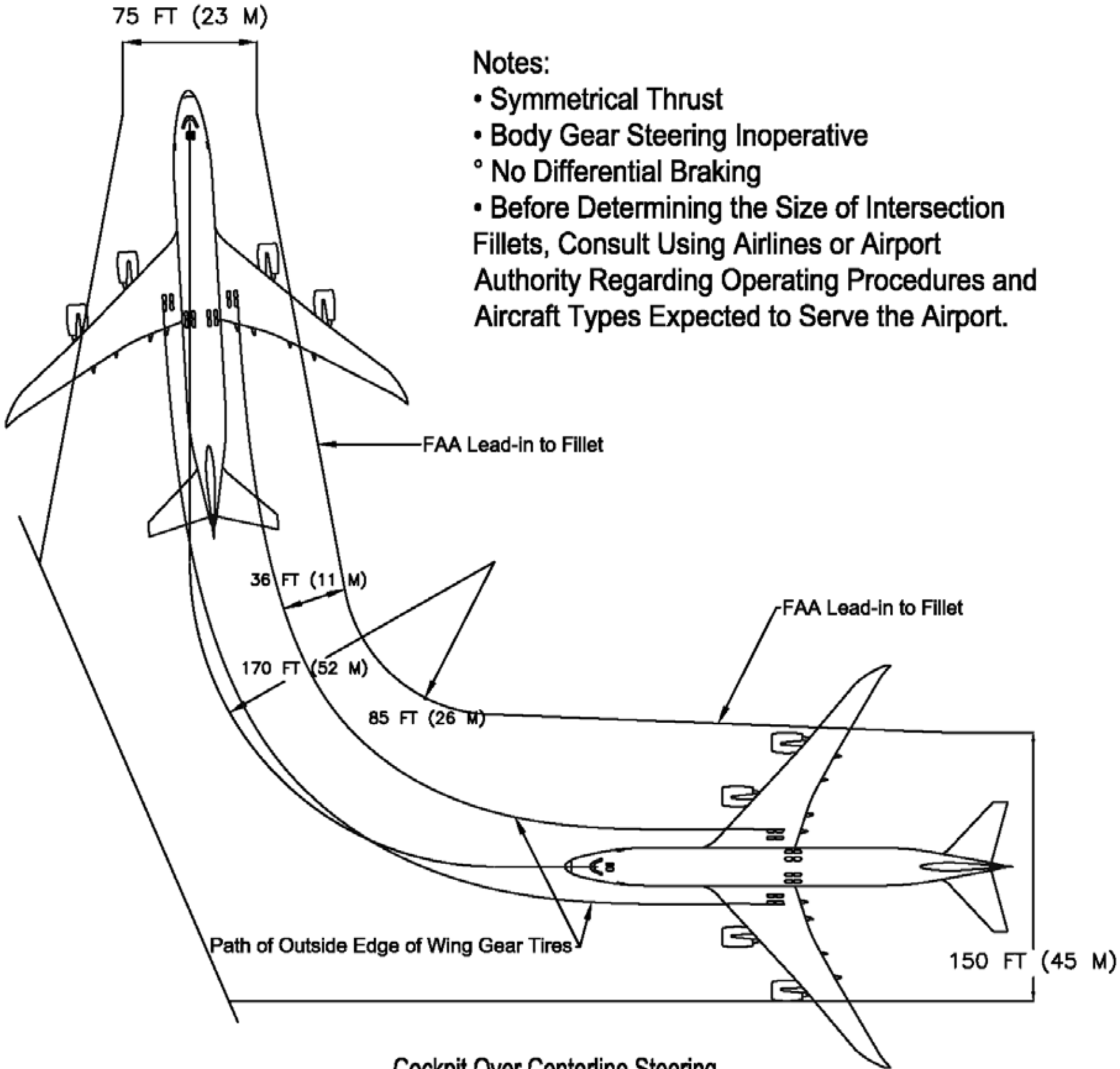
NOTE: DIMENSIONS ARE ROUNDED TO THE NEAREST FOOT AND 0.1 METER.

4.3.2 CLEARANCE RADII – BODY GEAR STEERING INOPERATIVE
MODEL 747-8, 747-8F



4.4 VISIBILITY FROM COCKPIT IN STATIC POSITION

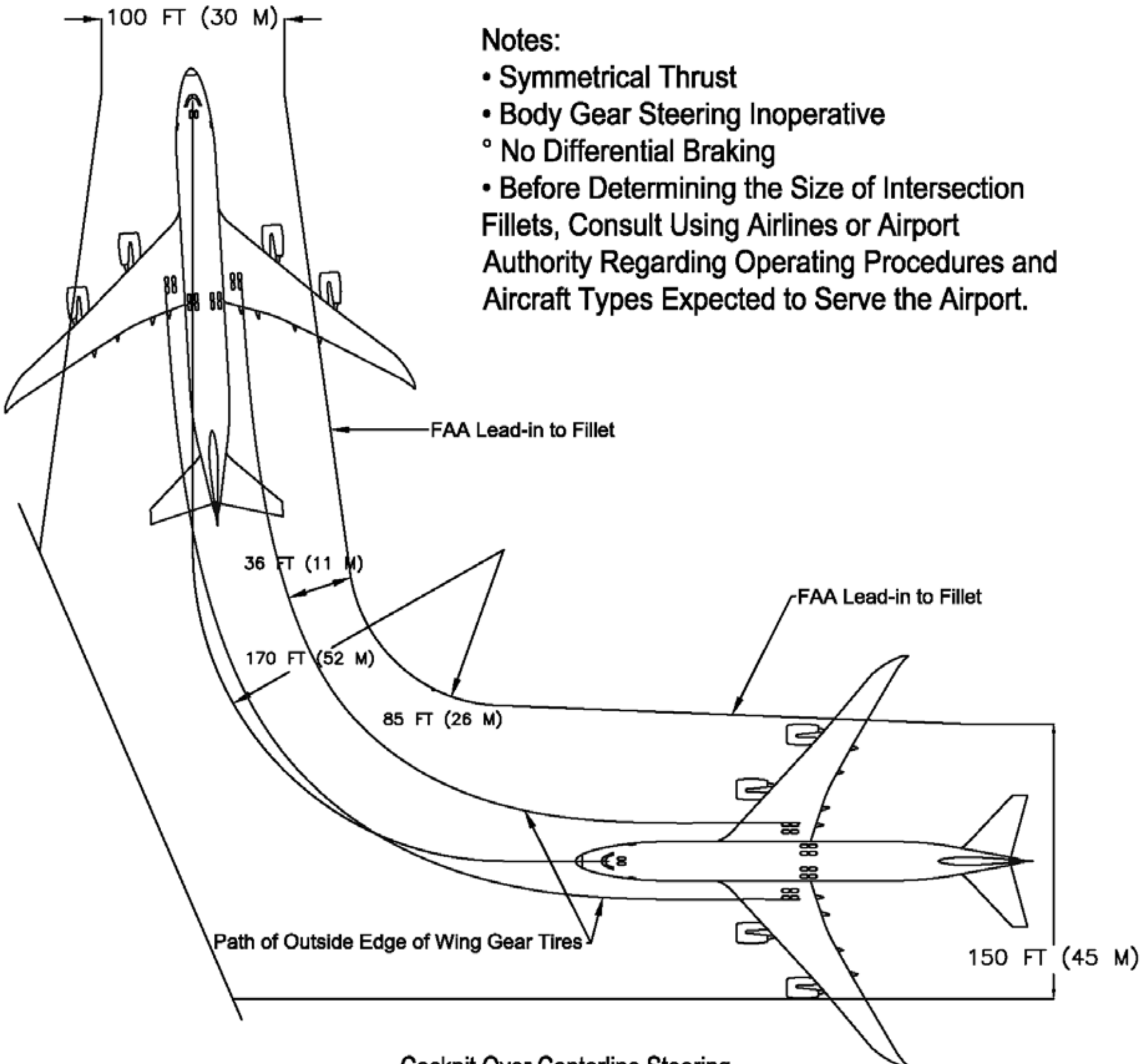
MODEL 747-8, 747-8F



Cockpit Over Centerline Steering
(Dimensions - Turn Radius and Fillet are FAA Group VI / Taxiway is FAA Group V)

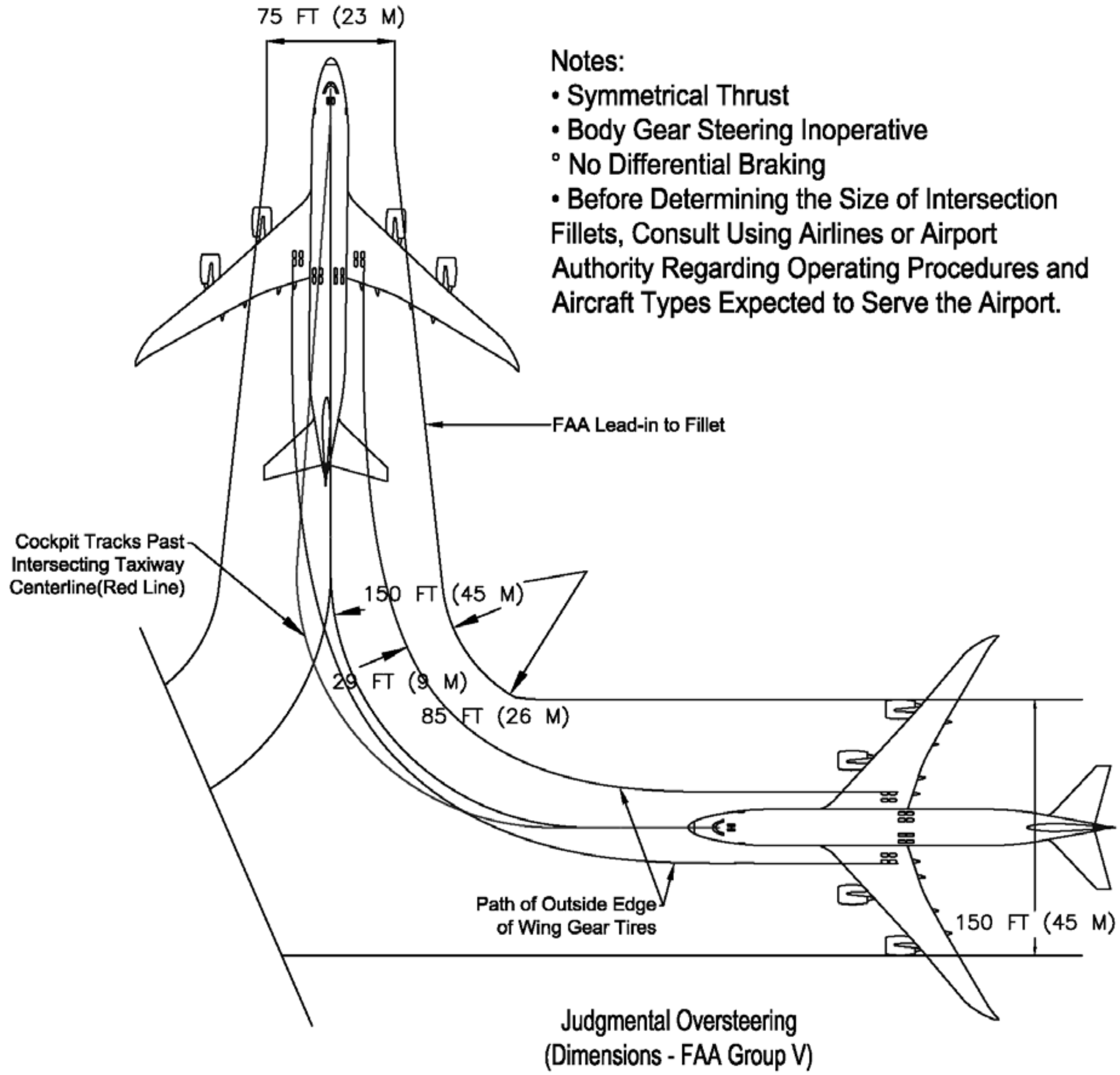
4.5.1 RUNWAY AND TAXIWAY TURNPATHS - RUNWAY-TO-TAXIWAY, 90 DEGREES, COCKPIT OVER CENTERLINE (FAA GROUP VI RADIUS/FILLET TO GROUP V TAXIWAY)

MODEL 747-8, 747-8F



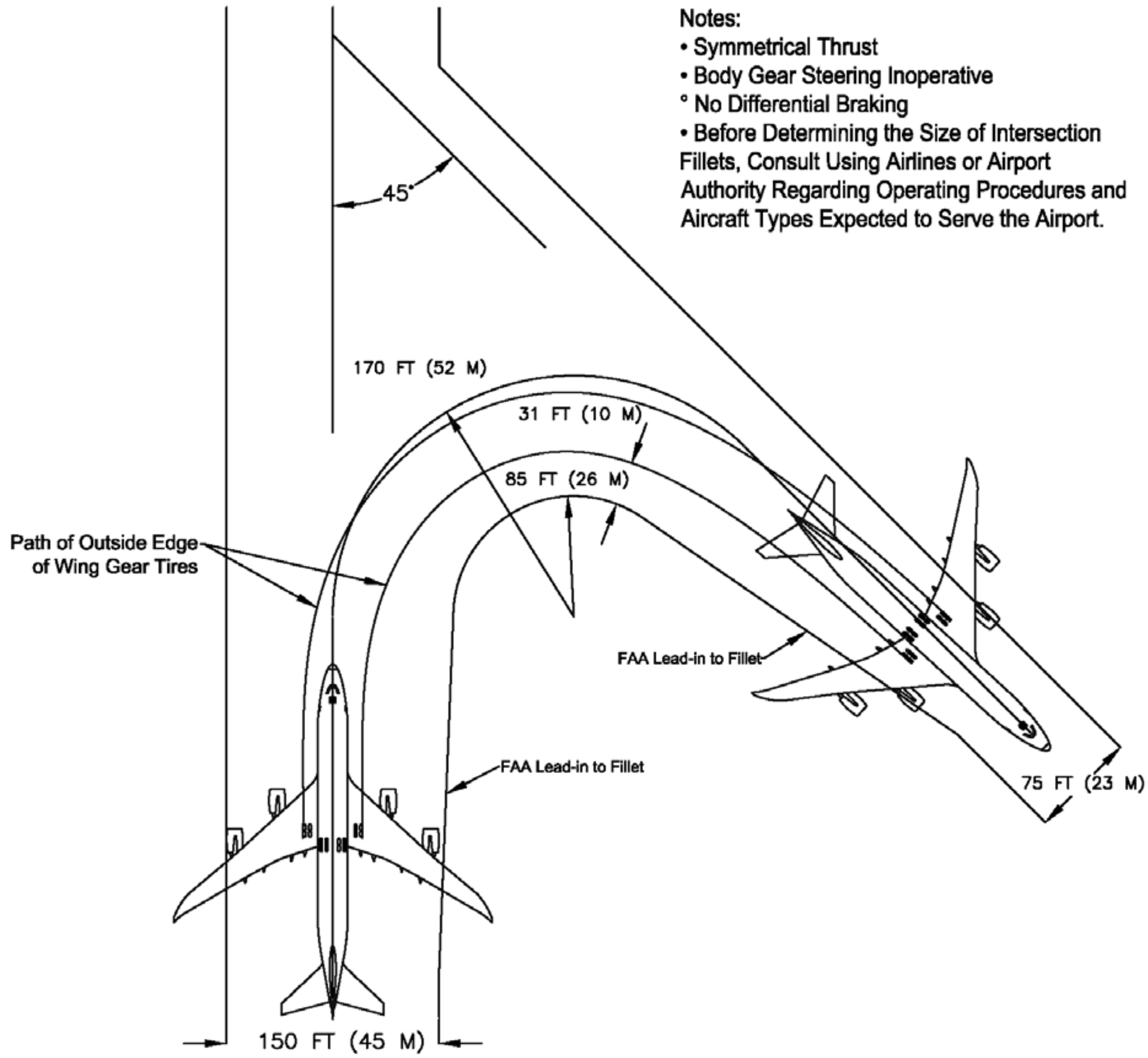
Cockpit Over Centerline Steering
(Dimensions - Turn Radius and Fillet are FAA Group VI / Taxiway is FAA Group VI)

4.5.2 RUNWAY AND TAXIWAY TURNPATHS - RUNWAY-TO-TAXIWAY, 90 DEGREES, COCKPIT OVER CENTERLINE (FAA GROUP VI RADIUS/FILLET TO GROUP VI TAXIWAY)
MODEL 747-8, 747-8F



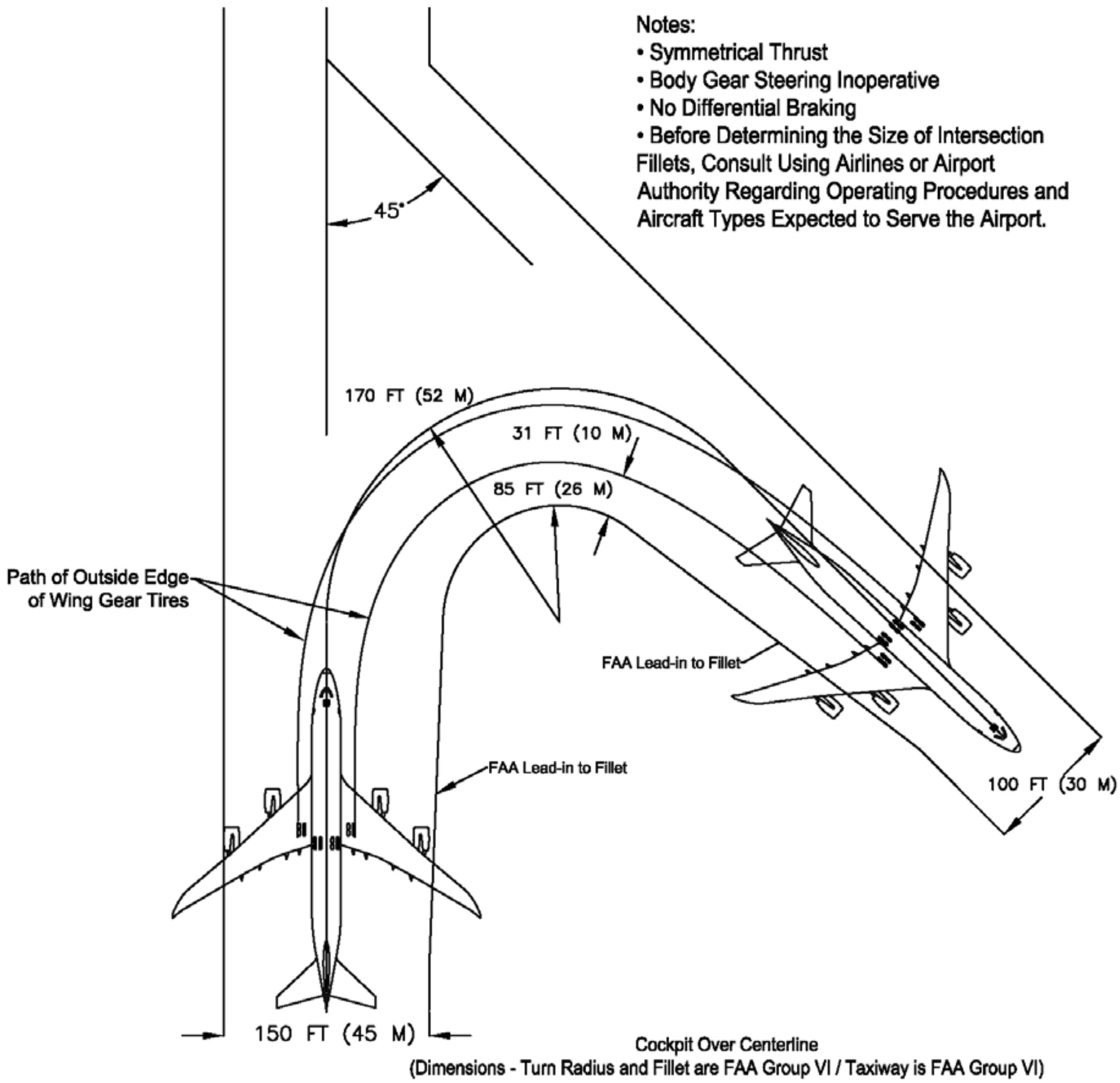
4.5.3 RUNWAY AND TAXIWAY TURNPATHS - RUNWAY-TO-TAXIWAY, 90 DEGREES, JUDGMENTAL OVERSTEER (FAA GROUP V RADIUS/FILLET TO GROUP V TAXIWAY)

MODEL 747-8, 747-8F



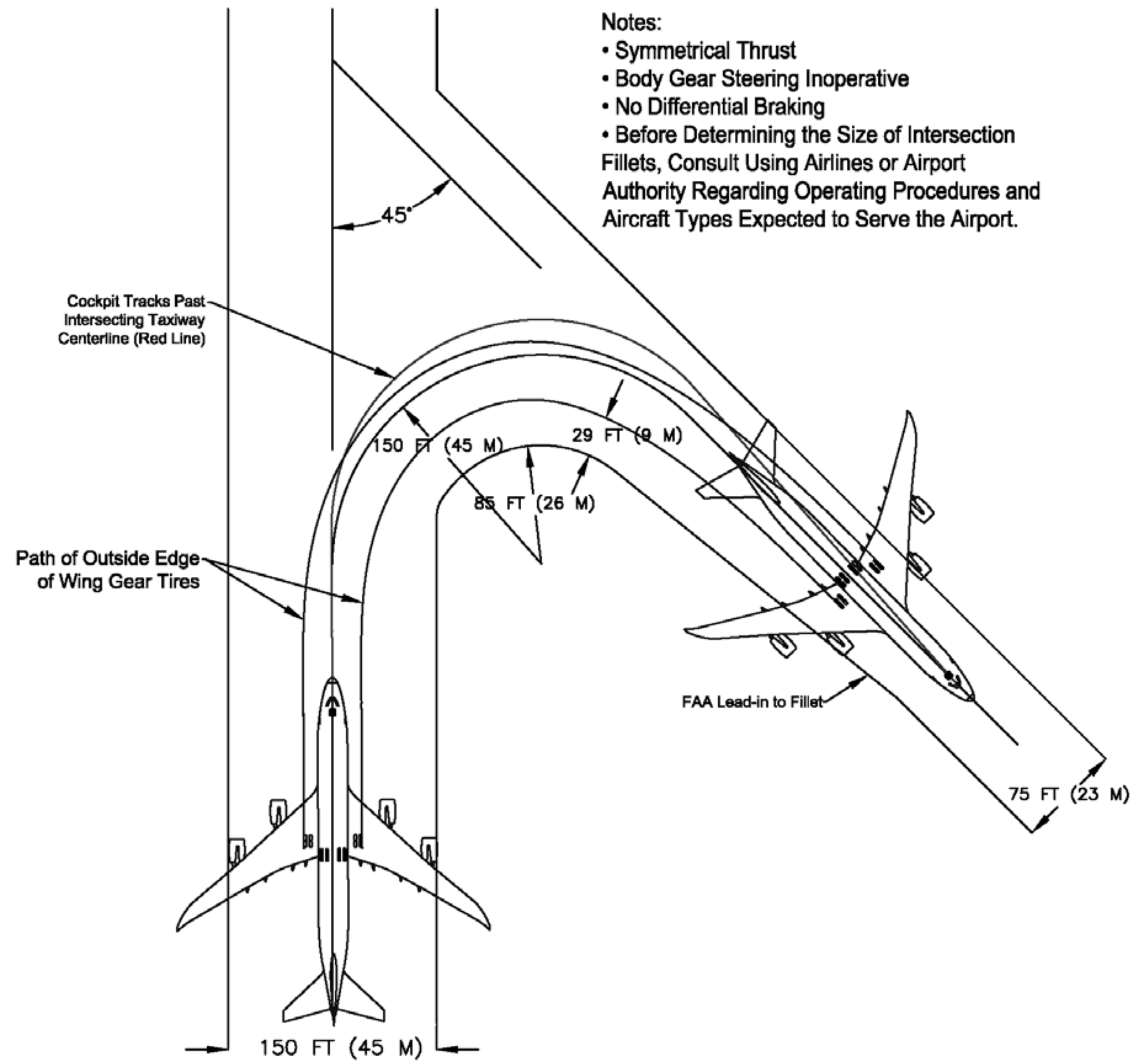
Cockpit Over Centerline
(Dimensions - Turn Radius and Fillet are FAA Group VI / Taxiway is FAA Group V)

4.5.4 RUNWAY AND TAXIWAY TURNPATHS - RUNWAY-TO-TAXIWAY, MORE THAN 90 DEGREES, COCKPIT OVER CENTERLINE (FAA GROUP VI RADIUS TO GROUP V TAXIWAY)
MODEL 747-8, 747-8F



4.5.5 RUNWAY AND TAXIWAY TURNPATHS - RUNWAY-TO-TAXIWAY, MORE THAN 90 DEGREES, COCKPIT OVER CENTERLINE (FAA GROUP VI RADIUS TO GROUP VI TAXIWAY)

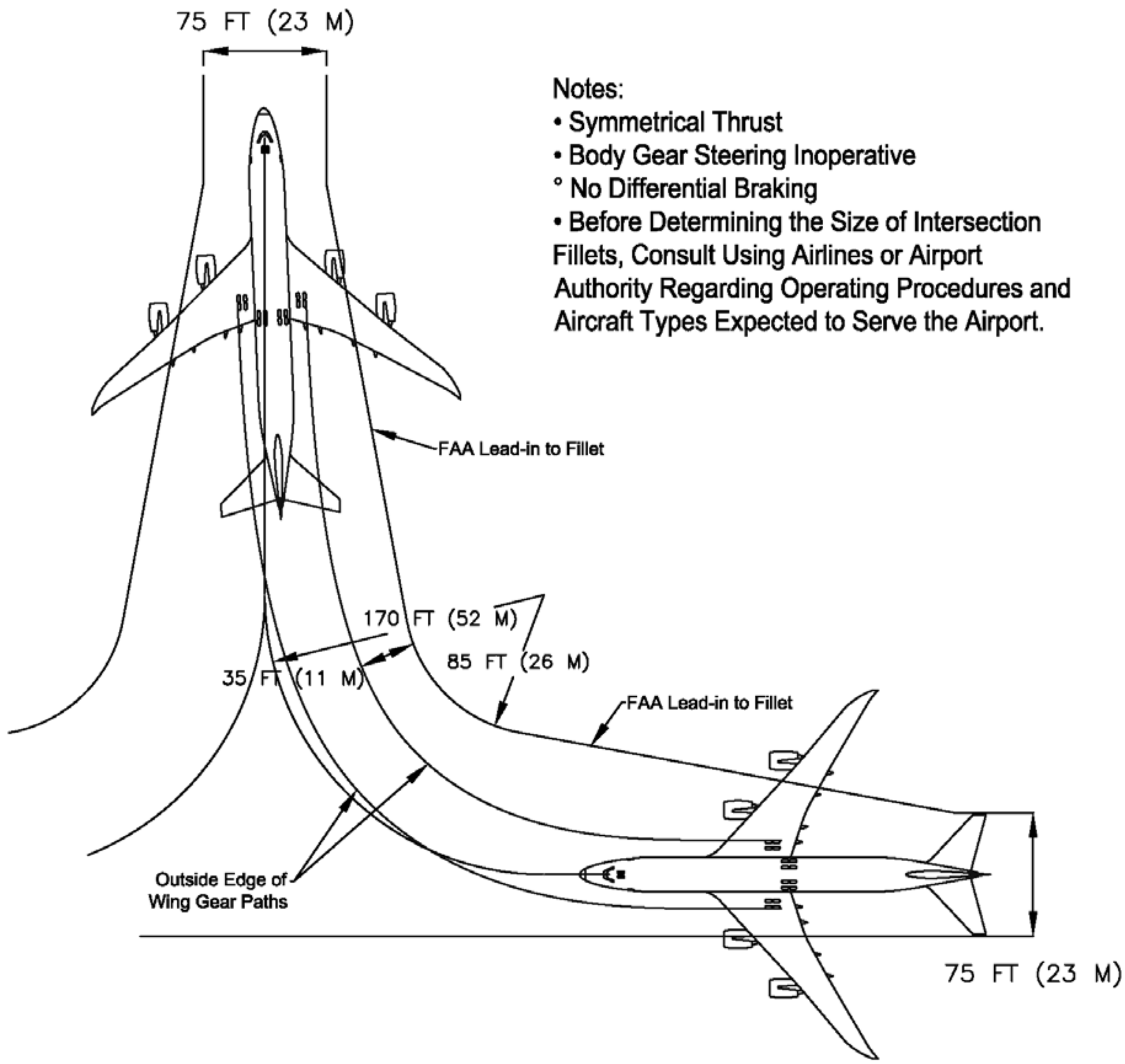
MODEL 747-8, 747-8F



Judgmental Oversteer
(Dimensions - Turn Radius and Fillet are FAA Group V / Taxiway is FAA Group V)

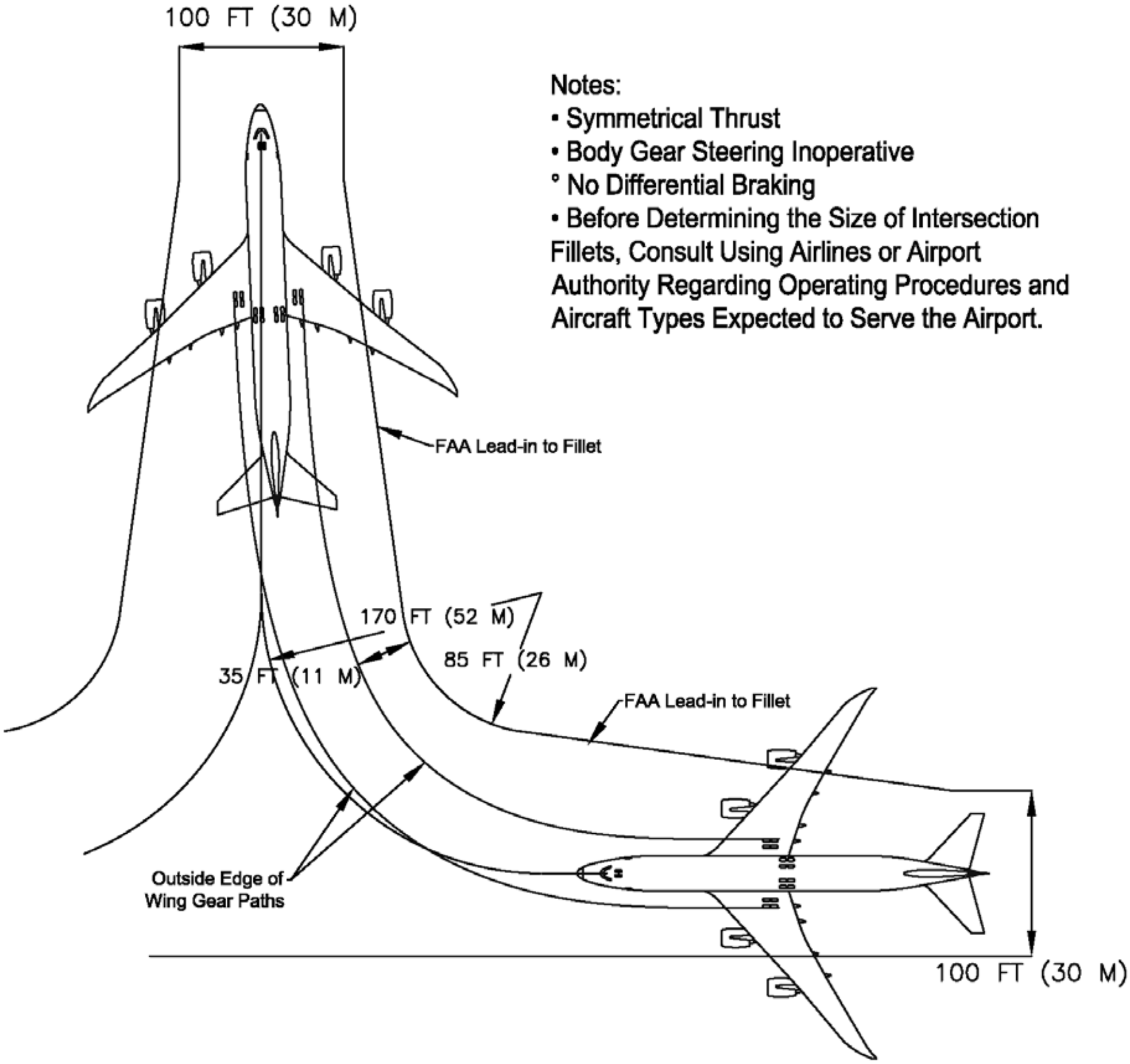
4.5.6 RUNWAY AND TAXIWAY TURNPATHS - RUNWAY-TO-TAXIWAY, MORE THAN 90 DEGREES, JUDGMENTAL OVERSTEER (FAA GROUP V RADIUS TO GROUP V TAXIWAY)

MODEL 747-8, 747-8F



Cockpit Over Centerline Steering
(Dimensions - Turn Radius and Fillet are FAA Group VI / Taxiways are FAA Group V)

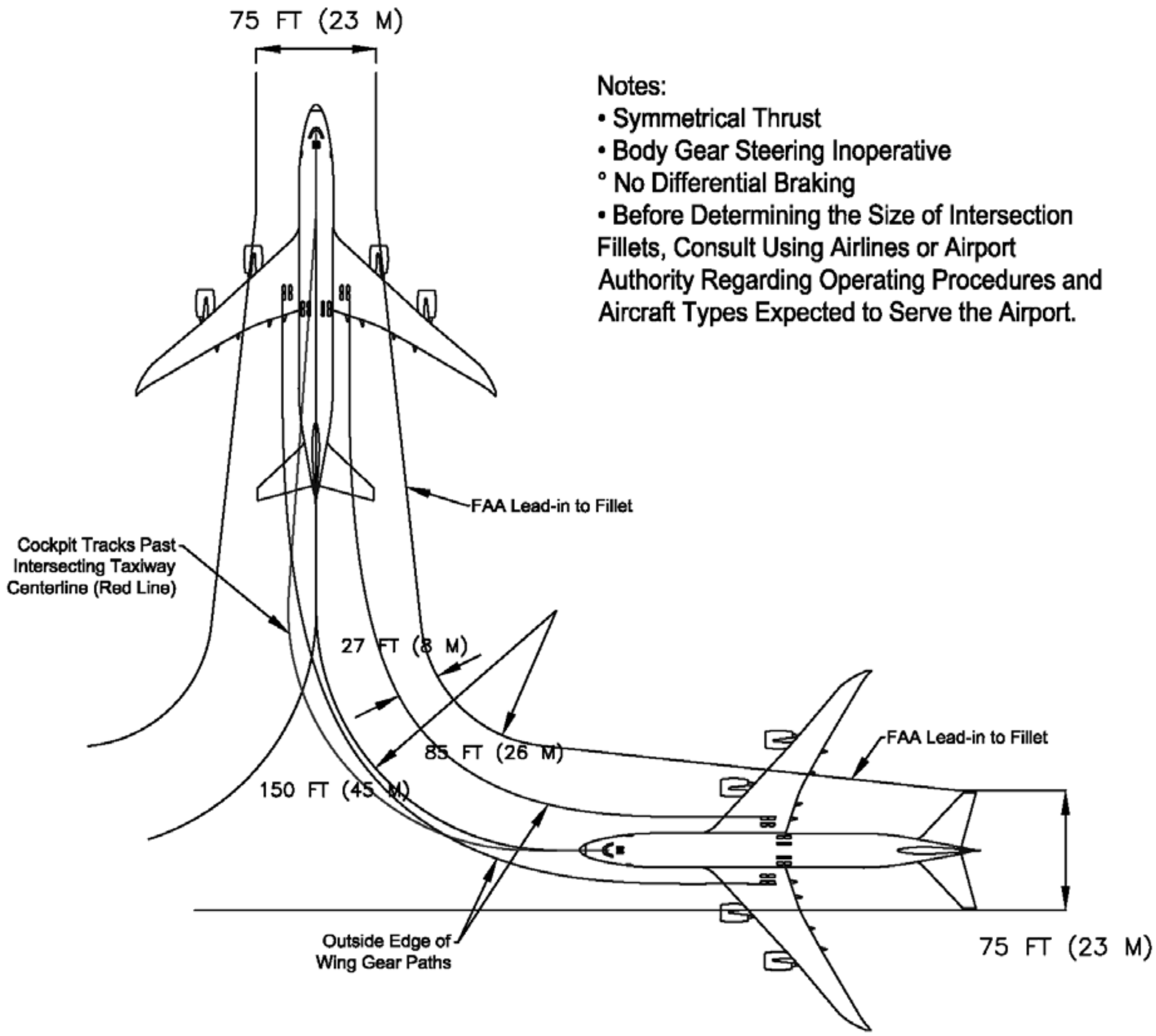
4.5.7 RUNWAY AND TAXIWAY TURNPATHS - TAXIWAY -TO-TAXIWAY, 90 DEGREES, COCKPIT OVER CENTERLINE (FAA GROUP VI RADIUS TO GROUP V TAXIWAYS)
MODEL 747-8, 747-8F



Cockpit Over Centerline Steering
(Dimensions - Turn Radius and Fillet are FAA Group VI / Taxiways are FAA Group VI)

4.5.8 RUNWAY AND TAXIWAY TURNPATHS - TAXIWAY -TO-TAXIWAY, 90 DEGREES, COCKPIT OVER CENTERLINE (FAA GROUP VI RADIUS TO GROUP VI TAXIWAYS)

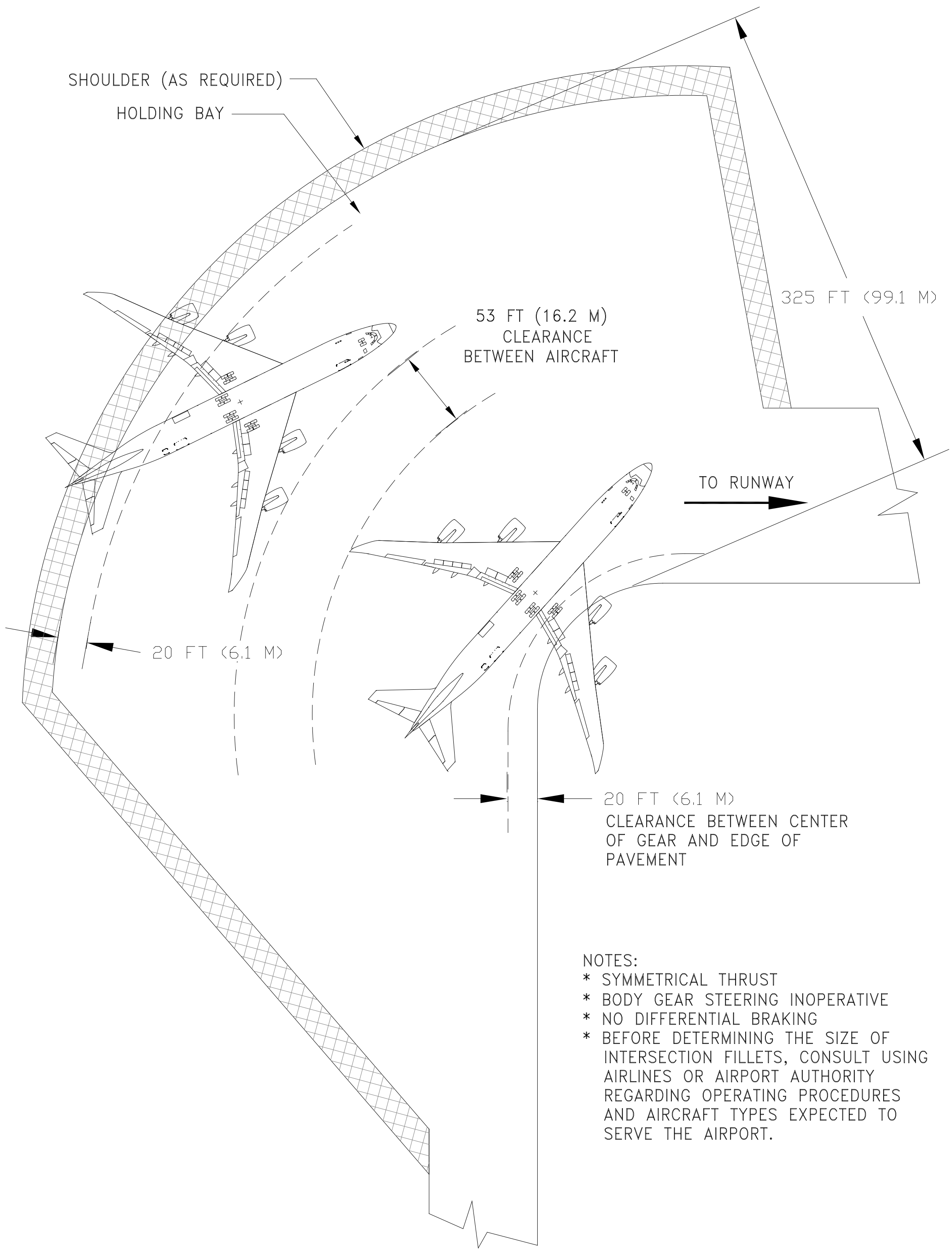
MODEL 747-8, 747-8F



Judgmental Oversteering
(Dimensions - Turn Radius and Fillet are FAA Group V / Taxiways are FAA Group V)

4.5.9 RUNWAY AND TAXIWAY TURNPATHS - TAXIWAY -TO-TAXIWAY, 90 DEGREES, JUDGMENTAL OVERSTEER (FAA GROUP V RADIUS TO GROUP V TAXIWAY)

MODEL 747-8, 747-8F



4.6 RUNWAY HOLDING BAY

MODEL 747-8, 747-8F

5.0 TERMINAL SERVICING

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. When the auxiliary power unit (APU) is used, the electrical, air start, and air-conditioning service vehicles may 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.

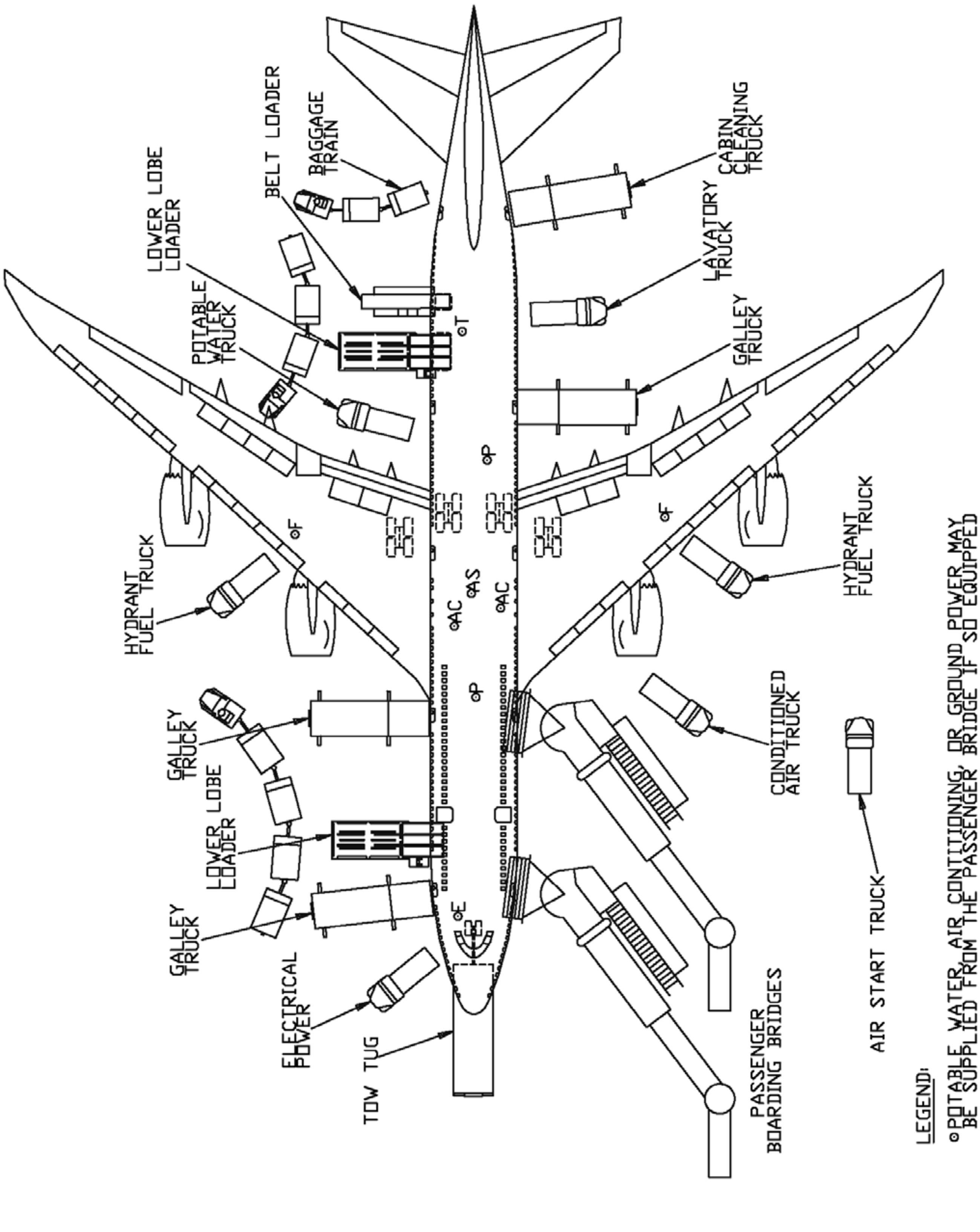
Section 5.4 shows the locations of ground service connections in graphic and in tabular forms. Typical capacities and service requirements are shown in the tables. Services with requirements that vary with conditions are described in subsequent sections.

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

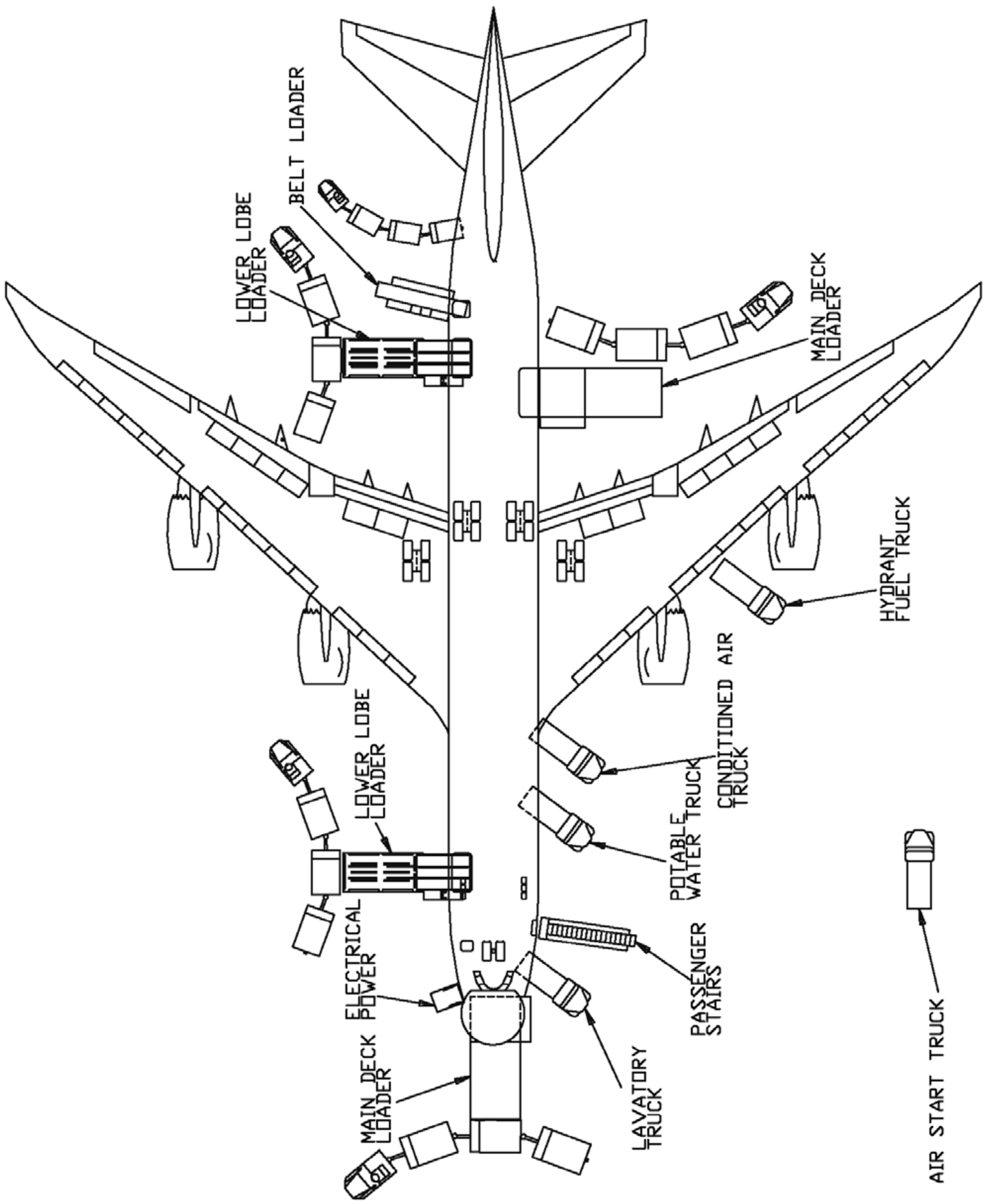
Section 5.6 shows pneumatic requirements for heating and cooling (air conditioning) using high pressure air to run the air cycle machine. The curves show airflow requirements to heat or cool the airplane within a given time and ambient conditions. Maximum allowable pressure and temperature for air cycle machine operation are 60 psia and 450^{o}F, respectively.

Section 5.7 shows pneumatic requirements for heating and cooling the airplane, 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.

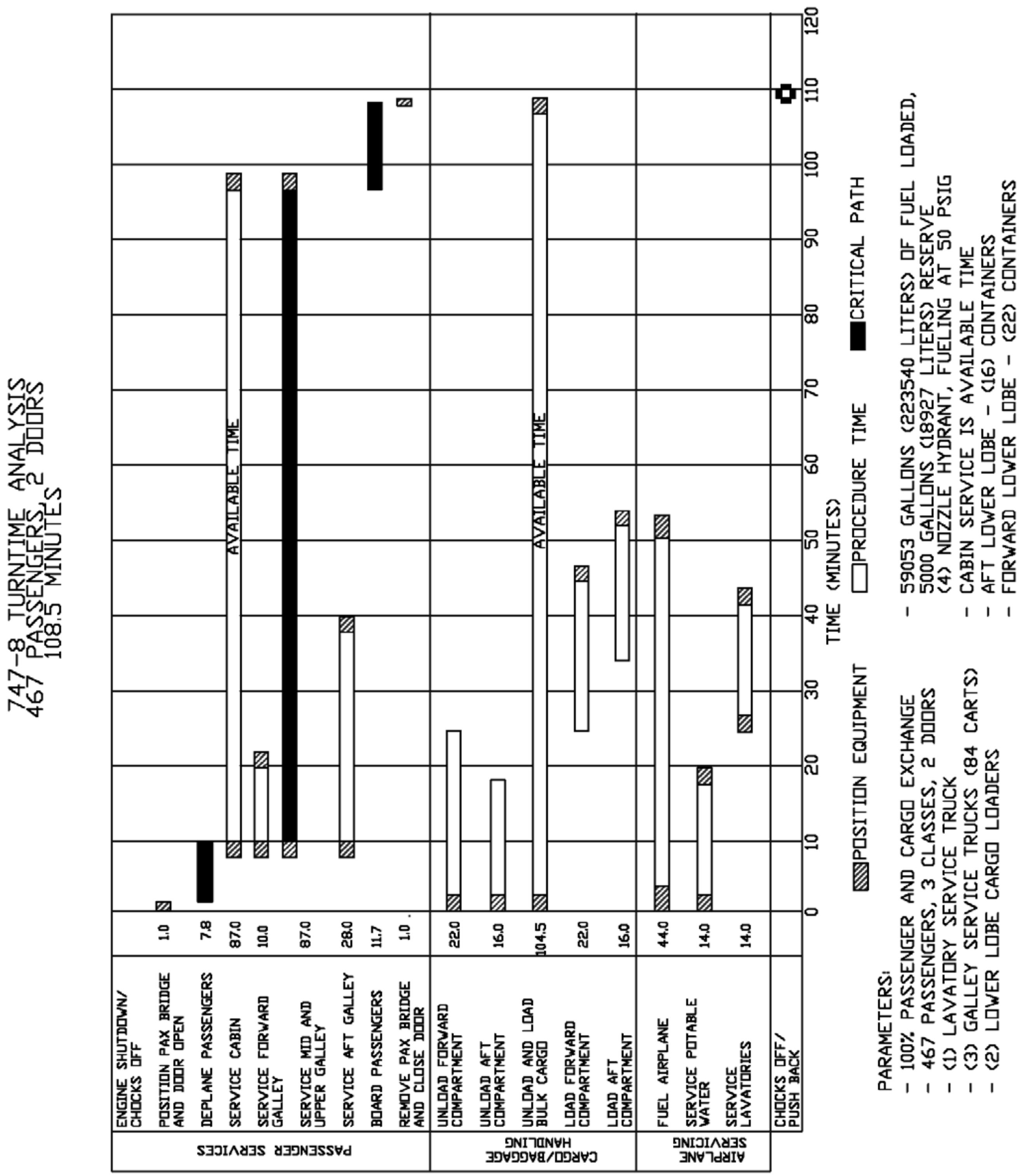
Section 5.8 shows ground towing requirements for various ground surface conditions.



5.1.1 AIRPLANE SERVICING ARRANGEMENT - TYPICAL TURNAROUND
MODEL 747-8

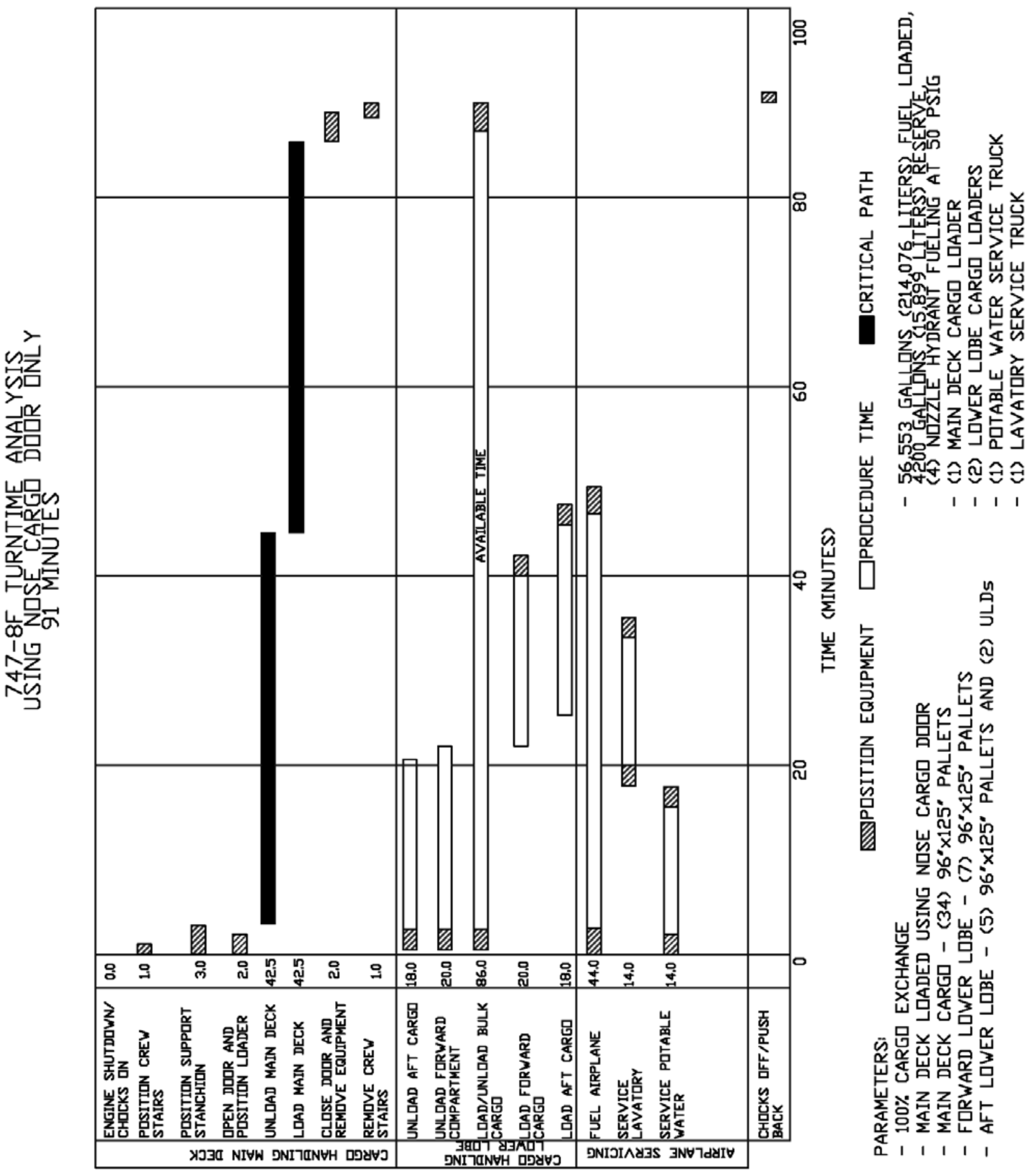


5.1.2 AIRPLANE SERVICING ARRANGEMENT - TYPICAL TURNAROUND
MODEL 747-8F



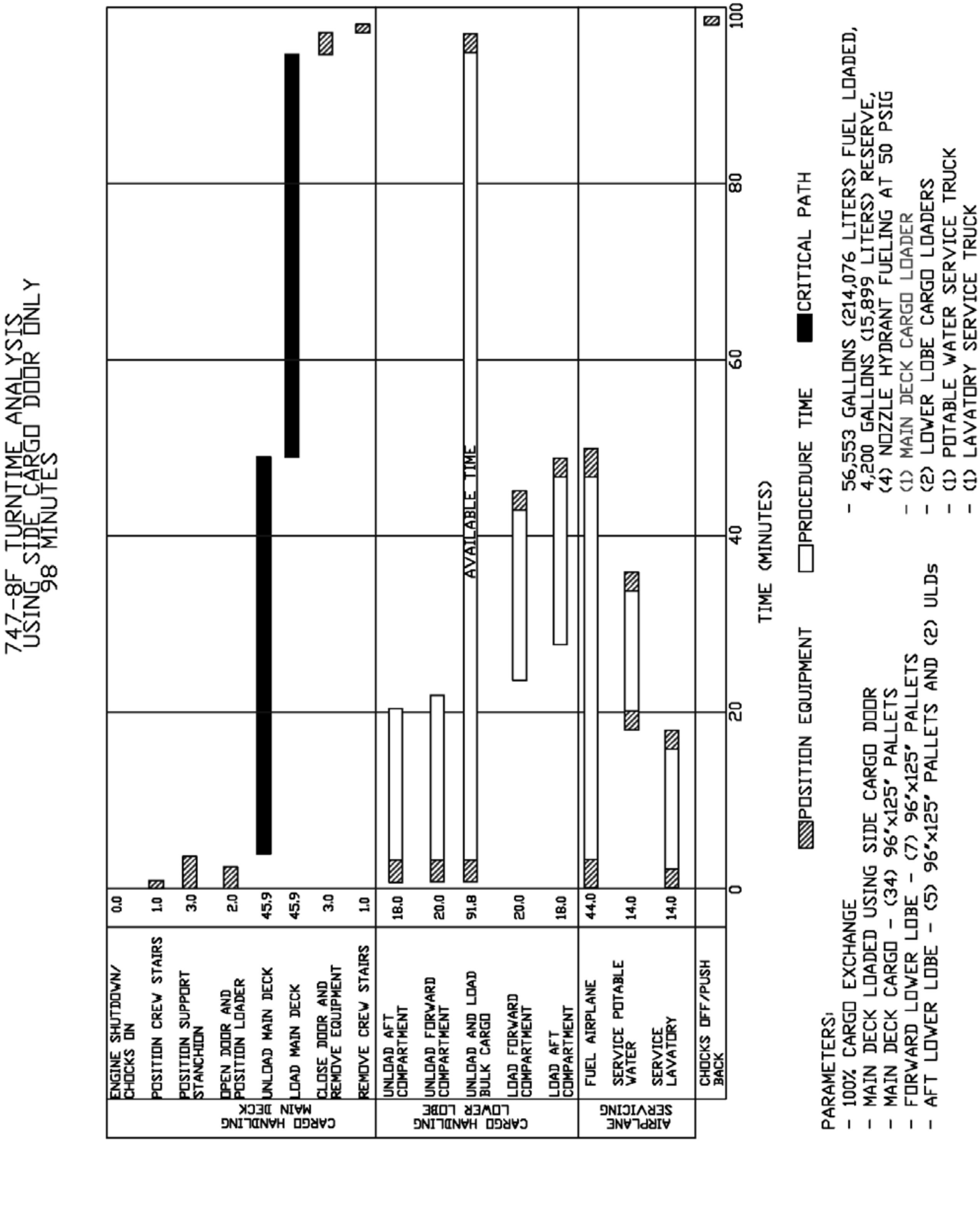
5.2.1 TERMINAL OPERATIONS - TURNAROUND STATION – ALL PASSENGER

MODEL 747-8



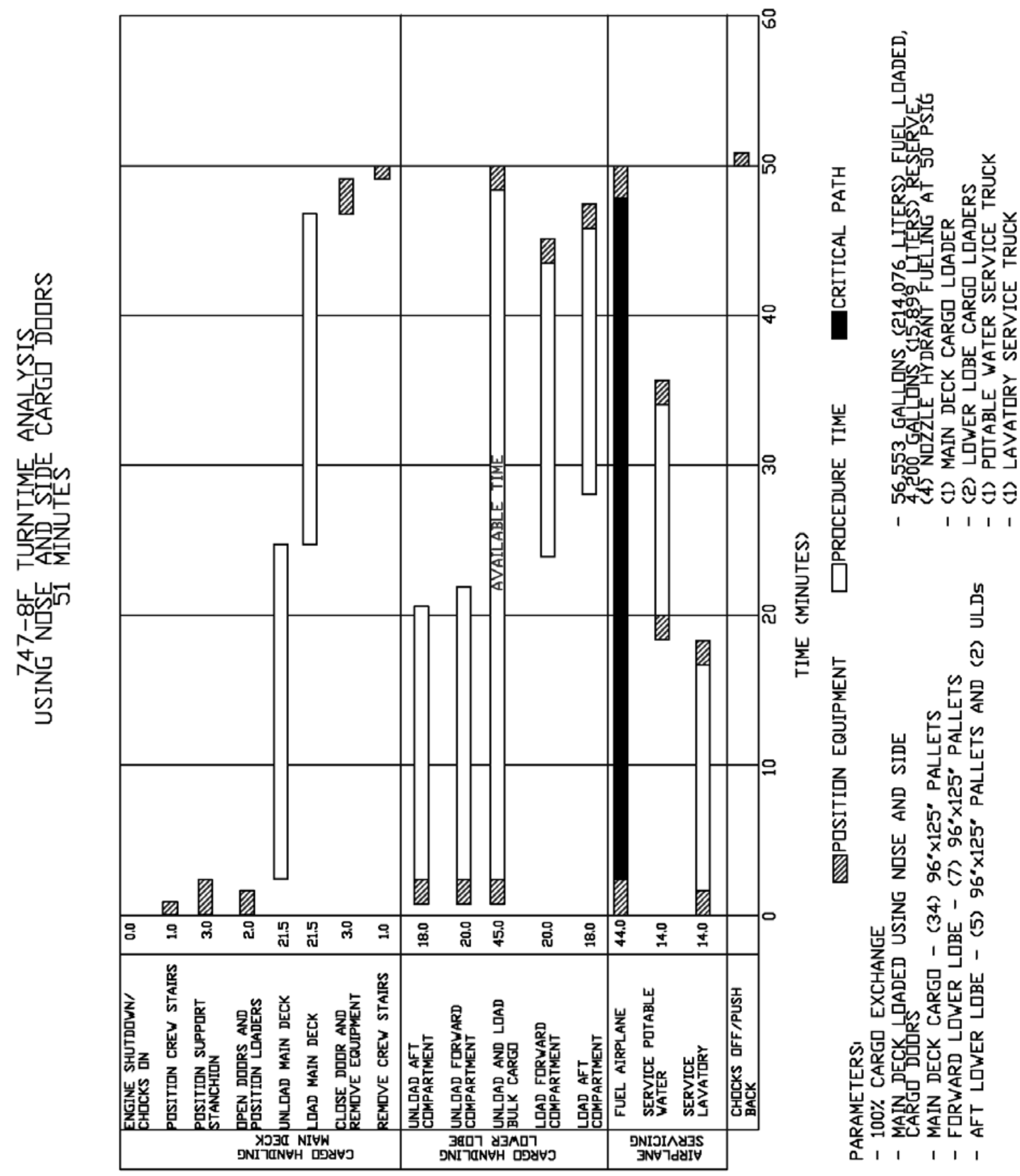
5.2.2 TERMINAL OPERATIONS - TURNAROUND STATION – ALL CARGO, NOSE DOOR LOADING

MODEL 747-8F



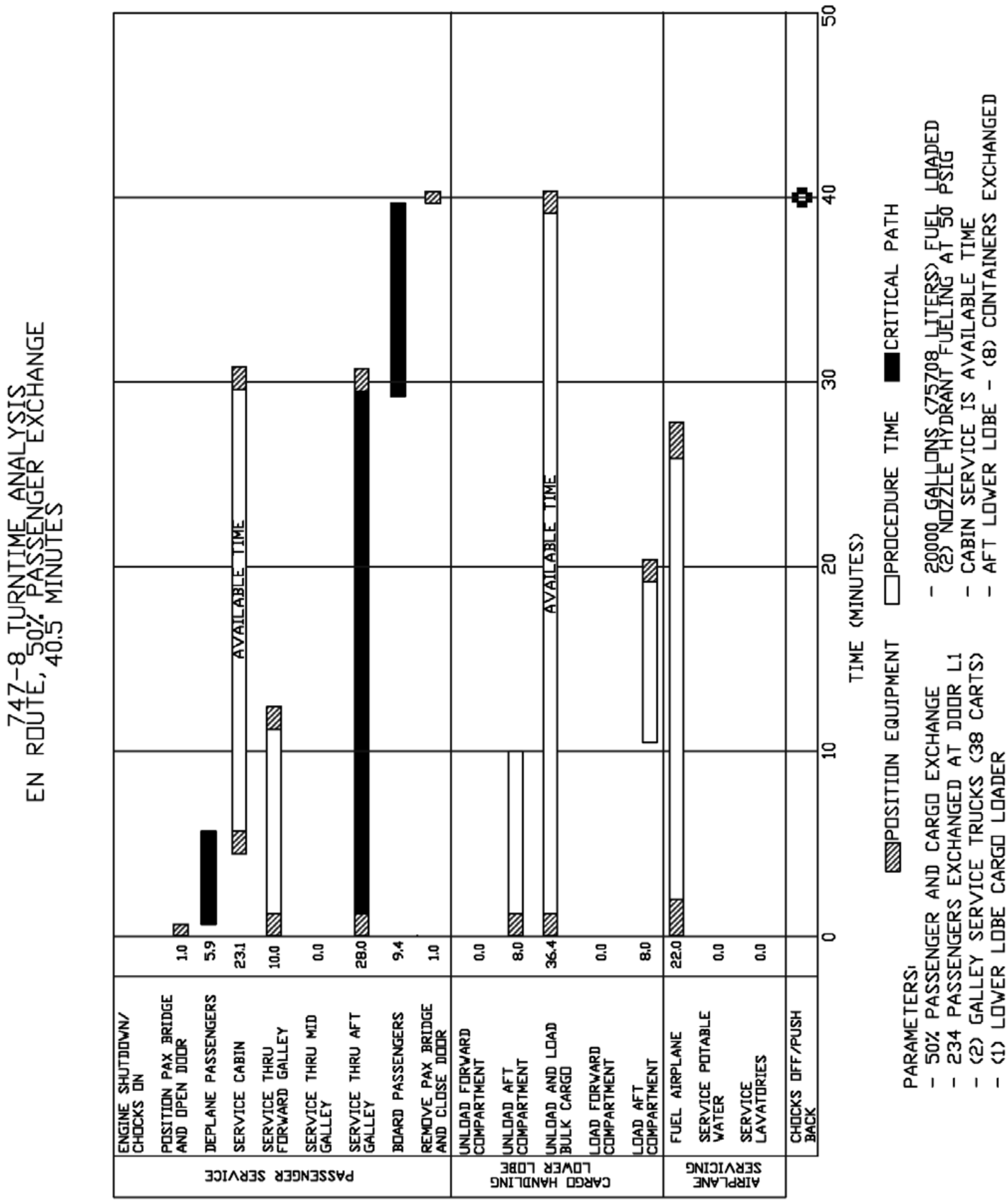
5.2.3 TERMINAL OPERATIONS - TURNAROUND STATION – ALL CARGO, SIDE DOOR LOADING

MODEL 747-8F



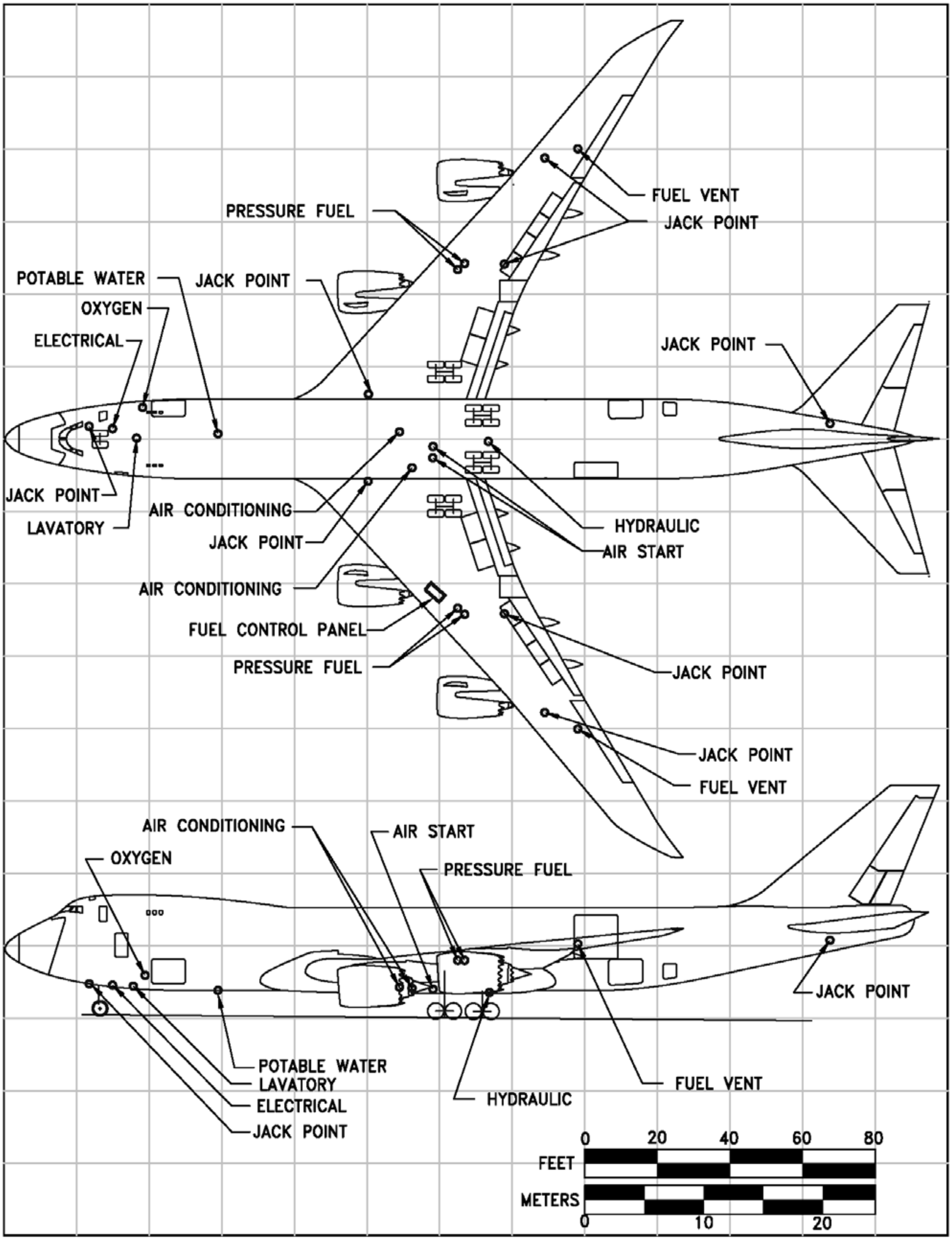
5.2.4 TERMINAL OPERATIONS – TURNAROUND STATION – ALL CARGO, NOSE AND SIDE DOOR LOADING

MODEL 747-8F

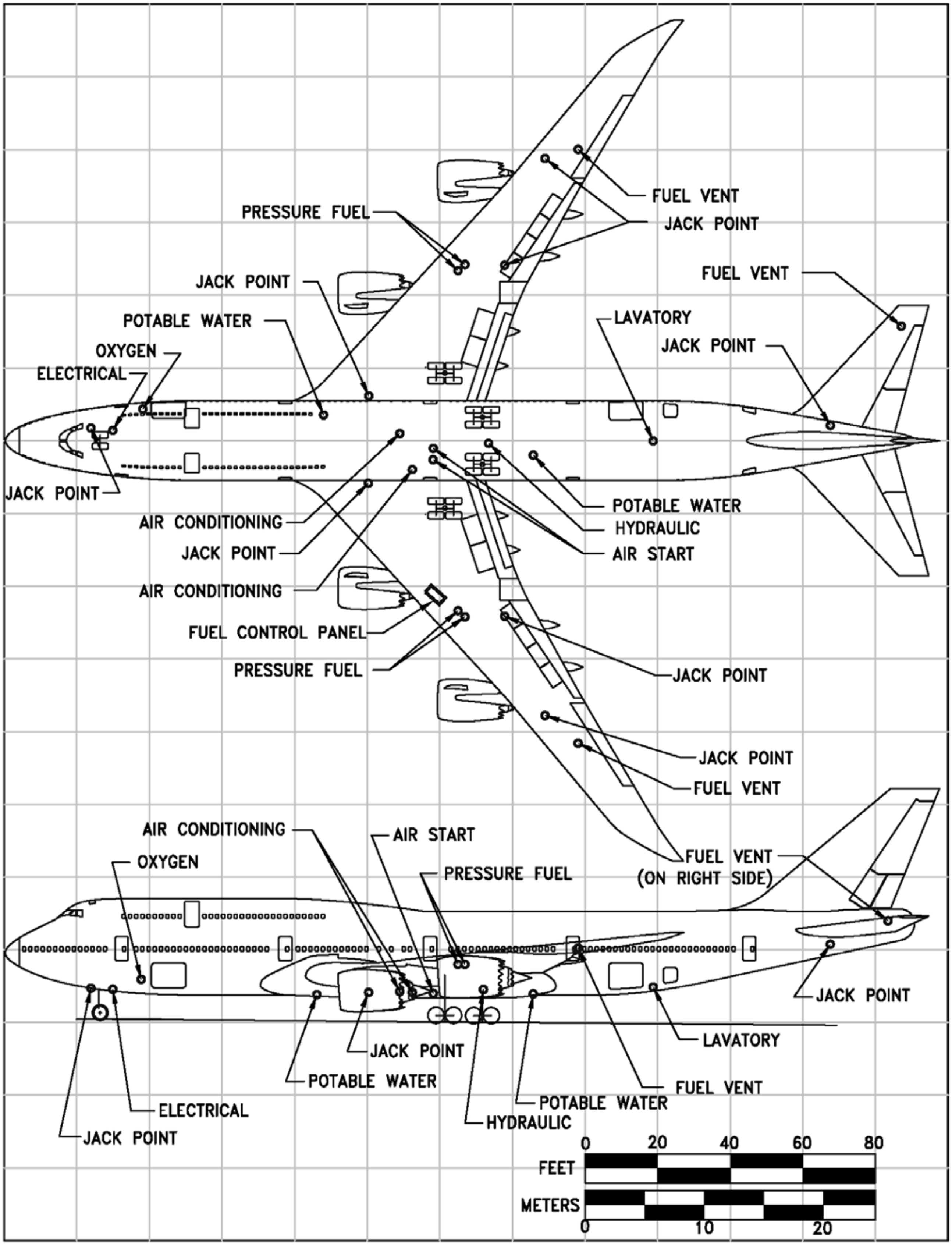


5.3.1 TERMINAL OPERATIONS - EN ROUTE STATION - ALL PASSENGER

MODEL 747-8



5.4.1 GROUND SERVICE CONNECTIONS
MODEL 747-8F



5.4.2 GROUND SERVICE CONNECTIONS

MODEL 747-8

SYSTEM	DISTANCE AFT OF NOSE		DISTANCE FROM AIRPLANE CENTERLINE				HEIGHT ABOVE GROUND			
			LH SIDE		RH SIDE		MINIMUM		MAXIMUM	
	FT-IN	M	FT-IN	M	FT-IN	M	FT-IN	M	FT-IN	M
ELECTRICAL TWO CO-LOCATED CONNECTORS - 90 KVA, 115/120 V AC 400 HZ, 3-PHASE EA.	26 - 9	8.15	-	-	3 - 4	1.02	8 - 1	2.46	9 - 3	2.82
FUEL OUTBOARD UNDER- WING PRESSURE CONNECTORS (2 EACH WING)	119 - 7	36.45	47 – 7	14.50	47 – 7	14.50	15 – 4	4.67	16 – 0	4.88
INBOARD UNDER- WING PRESSURE CONNECTORS (2 EACH WING)	118 - 9	36.20	46 – 7	14.20	46 – 7	14.20	15 – 3	4.65	15 – 10	4.83
MAX FUELING RATE 500 US GPM (1,890 LPM) PER NOZZLE										
TOTAL MAX FUEL PRESSURE 50 PSIG (3.52 KG/CM^2)										
FUELING CONTROL PANEL	117 - 3	35.74	44 – 10	13.67	-	-	15 - 3	4.65	15 - 9	4.80
WING FUEL VENT	166 - 4	50.70	92 - 7	28.22	92 - 7	28.22	16 - 10	5.13	19 - 3	5.87
TAIL FUEL VENT [1]	239 - 7	73.03	-	-	29 - 10	9.09	26 - 9	8.15	28 - 3	8.61

FUEL TANK	VOLUME	747-8F	747-8
RESERVE	U.S. GALLONS	1,534 EACH	1534 EACH
NO 1 & 4	LITERS	5,806 EACH	5,806 EACH
MAIN	U.S. GALLONS	5,320 EACH	5,320 EACH
NO 1 & 4	LITERS	20,138 EACH	20,138 EACH
MAIN	U.S. GALLONS	14,430 EACH	14,430 EACH
NO 2 & 3	LITERS	54,623 EACH	54,623 EACH
CENTER WING	U.S. GALLONS	17,000	17,000
	LITERS	64,352	64,352
HORIZONTAL STABILIZER	U.S. GALLONS	-	-
	LITERS	-	-
TOTAL USABLE	U.S. GALLONS	59,734	59,734
	LITERS	226,113	226,113

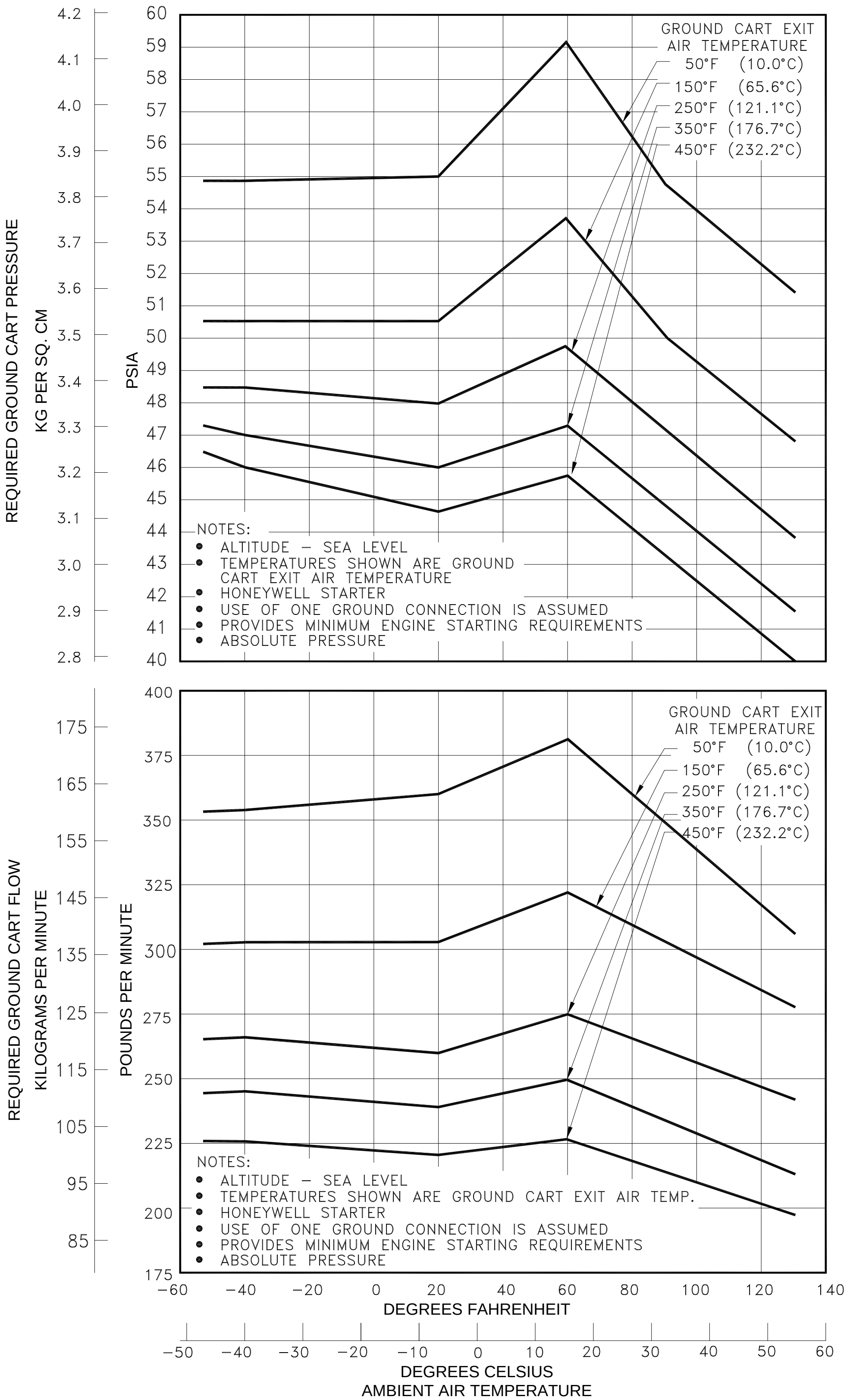
[1] PASSENGER AIRPLANE ONLY

5.4.3 GROUND SERVICE CONNECTIONS
MODEL 747-8, 747-8F

SYSTEM	DISTANCE AFT OF NOSE		DISTANCE FROM AIRPLANE CENTERLINE				HEIGHT ABOVE GROUND			
			LH SIDE		RH SIDE		MINIMUM		MAXIMUM	
	FT-IN	M	FT-IN	M	FT-IN	M	FT-IN	M	FT-IN	M
LAVATORY ONE SERVICE PANEL: THREE CONNECTIONS DRAIN: ONE 4-IN (10.0 CM) FLUSH: TWO 1-IN (3.0 CM) FLUSH REQS: FLOW: 10 GPM (38 LPM) , 30 PSIG (2.11 KG/CM^2) TOTAL CAPACITY, 4 TANKS 300 US GAL (1,135 L)	178 – 4	54.37	-	-	-	-	8 - 8	2.64	9 - 8	2.95
PNEUMATIC TWO 3-IN (7.67 CM) HIGH-PRESSURE PORTS	109-10	33.48	2 – 0	0.61	-	-	6 – 8	2.03	7 – 3	2.21
	109-10	33.48	3 – 0	0.91	-	-	6 – 8	2.03	7 – 3	2.21
TWO 8-IN (20 CM) GROUND CONDITIONED AIR CONNECTIONS	118 - 8	36.17	6 - 10	2.08	-	-	6 - 7	2.01	7 – 2	2.18
	119 – 5	36.40	8 - 0	2.44	-	-	7 – 0	2.13	7 – 7	2.31
TANK CAPACITIES: POTABLE WATER - ONE CONNECTION, SIZE 3/4 IN (1.90 CM), CAPACITY – 345 U.S GAL (1,306 L), MAX FILL PRESSURE – 60 PSIG (414 kPa), TYPICAL FILL RATE – 30 GPM (114.5 LPM) DRAIN SIZE 1 IN (2.54 CM)	87 - 8	26.72	-	-	1 - 4	0.41	7 - 4	2.24	8 - 1	2.46
-8F - SECOND CONNECTION CAPACITY 22 US GAL (83 L)	145 - 6	44.35	2 - 10	0.86	-	-	7 - 3	2.21	8 - 0	2.44
HYDRAULIC ONE SERVICE PANEL 4 RESERVOIRS ENG 1 - 9.5 U.S. GAL (35.9 L) ENG 2 - 5,5 U.S. GAL (20.8 L) ENG 3 - 5.5 U.S. GAL (20.8 L) ENG 4 - 9.5 U.S. GAL (35.9 L) 150 PSI (10.6 KG/CM^2) MAX	127 - 4	38.82	0 - 10	0.25	-	-	7 - 0	2.13	7 - 0	2.13
OXYGEN ONE CONNECTION - SIZE 3/16 IN (0.48 CM) 1850 PSIG (130 KG/CM^2) MAX	39 - 2	11.94	-	-	8 - 4	2.54	13 - 7	4.14	14 - 8	4.47

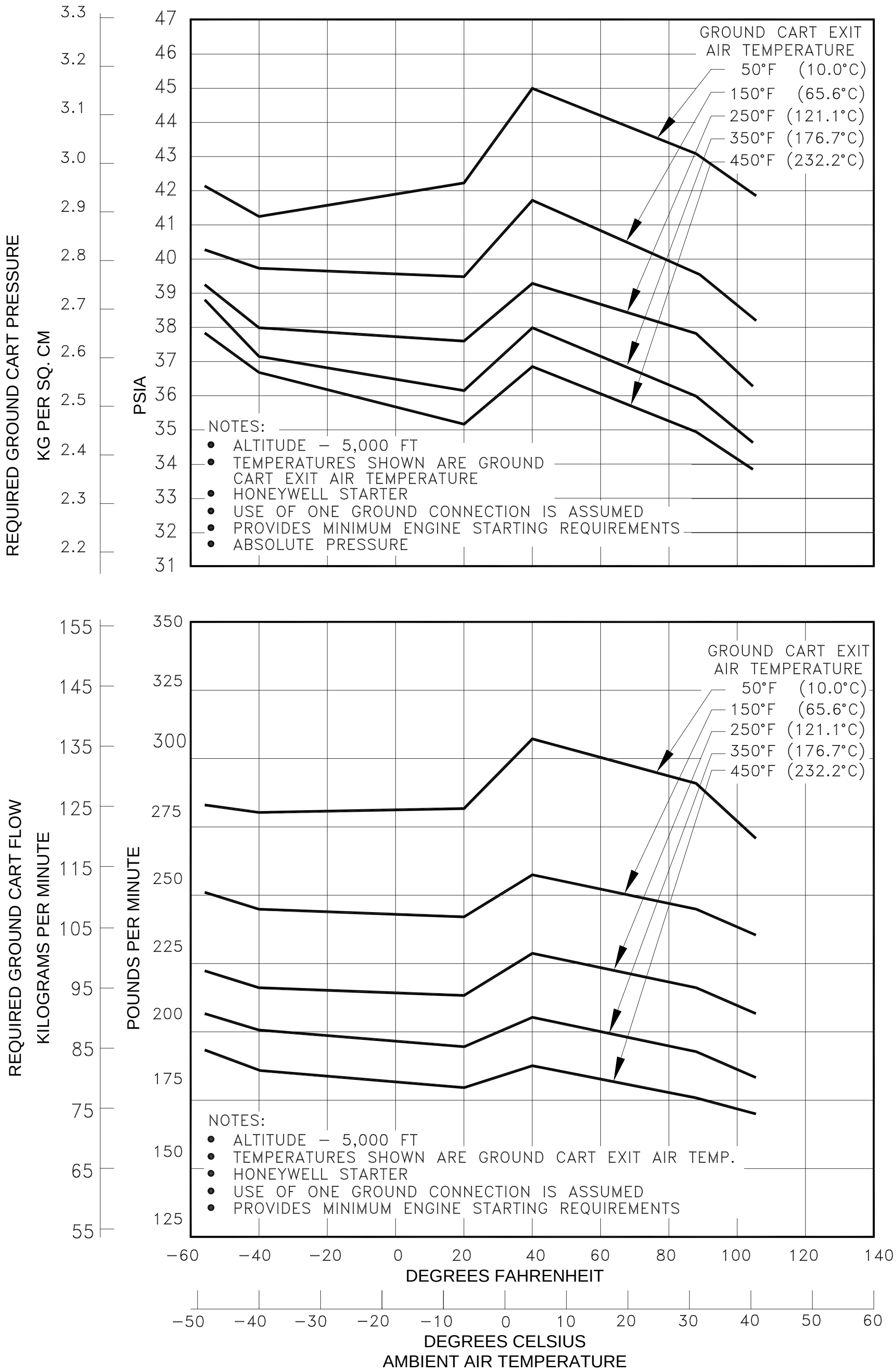
5.4.4 GROUND SERVICING CONNECTIONS

MODEL 747-8, 747-8F



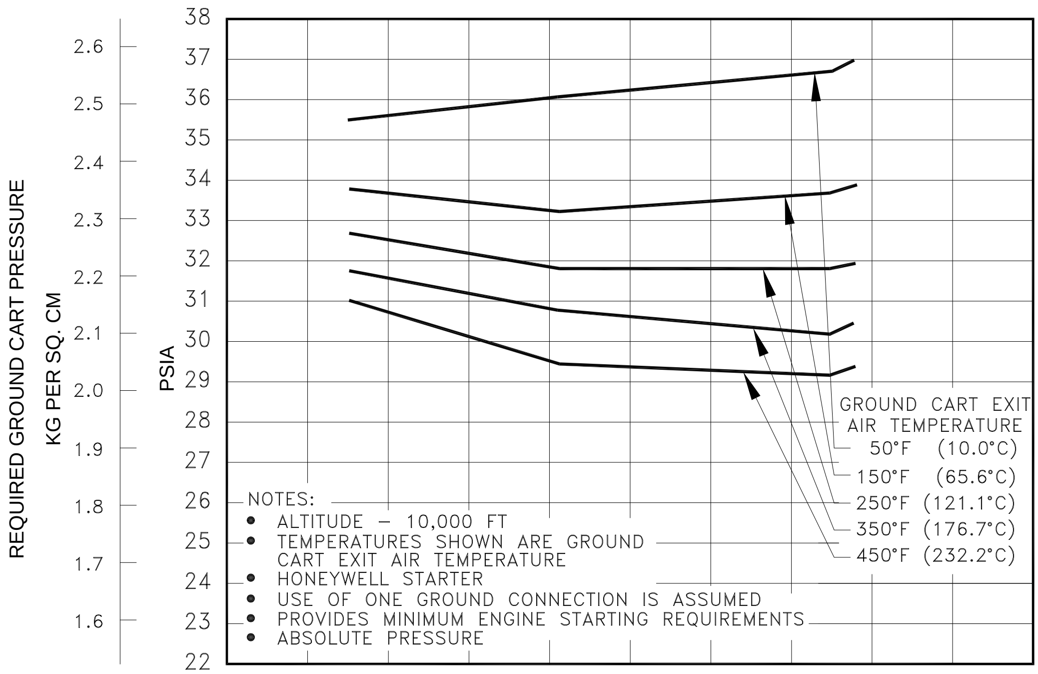
5.5.1 ENGINE START PNEUMATIC REQUIREMENTS - SEA LEVEL

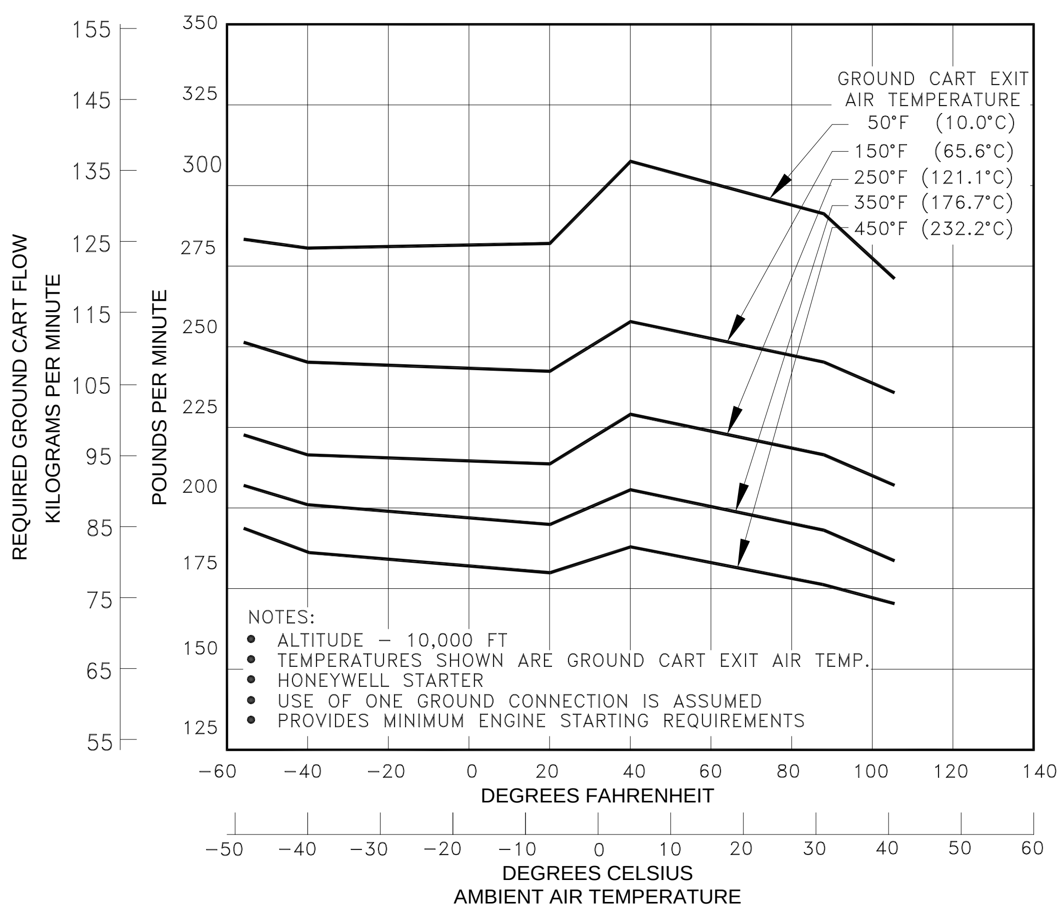
MODEL 747-8, 747-8F



5.5.2 ENGINE START PNEUMATIC REQUIREMENTS – 5,000 FT

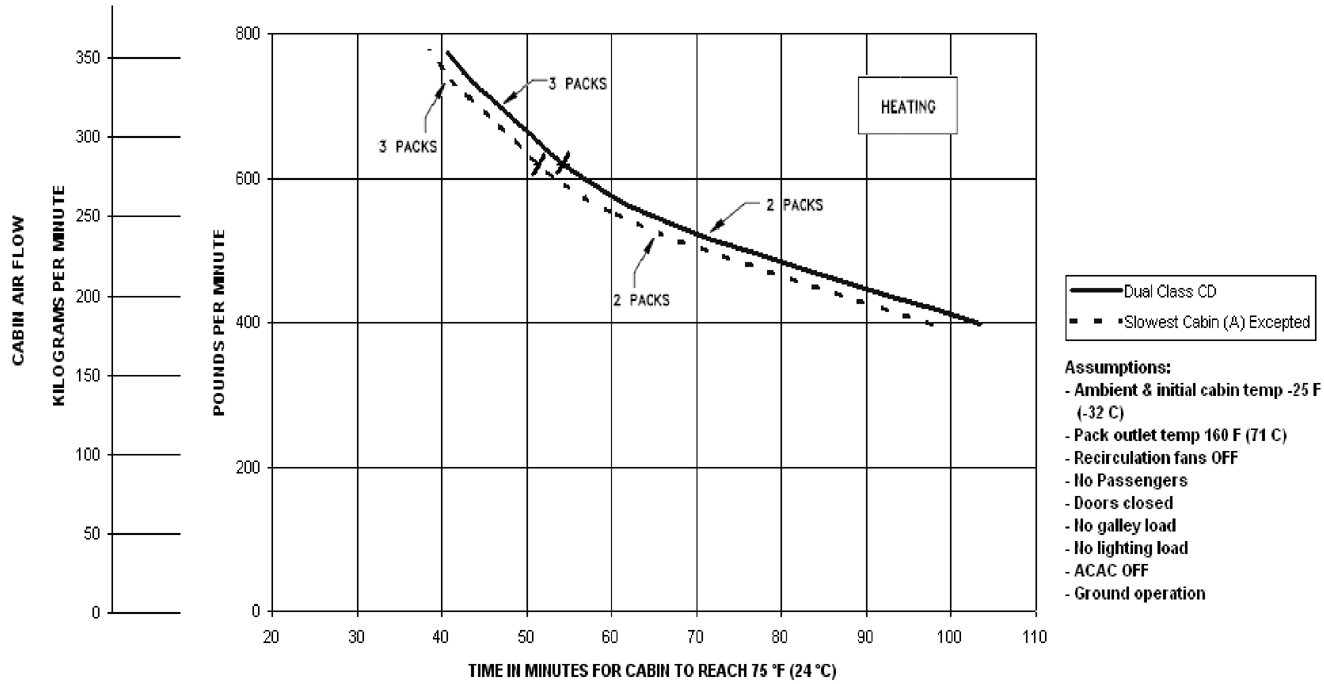
MODEL 747-8, 747-8F

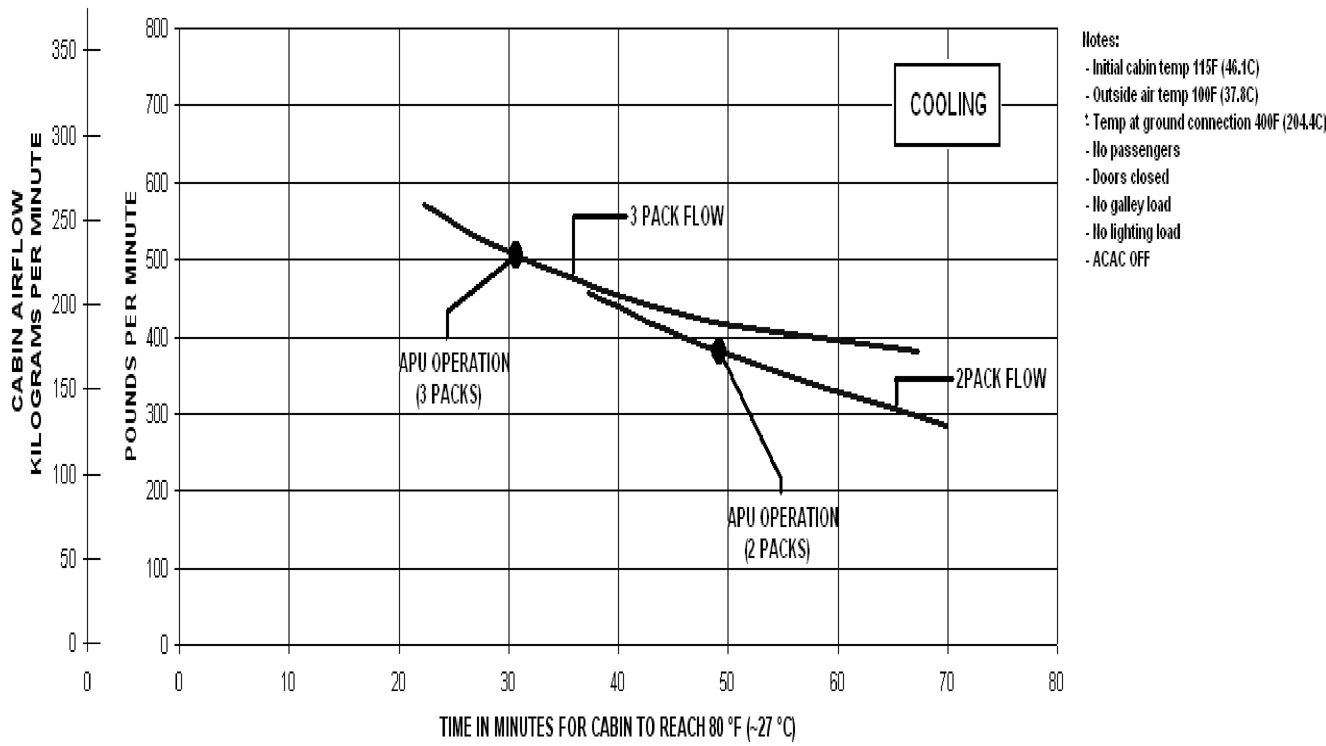




5.5.3 ENGINE START PNEUMATIC REQUIREMENTS – 10,000 FT

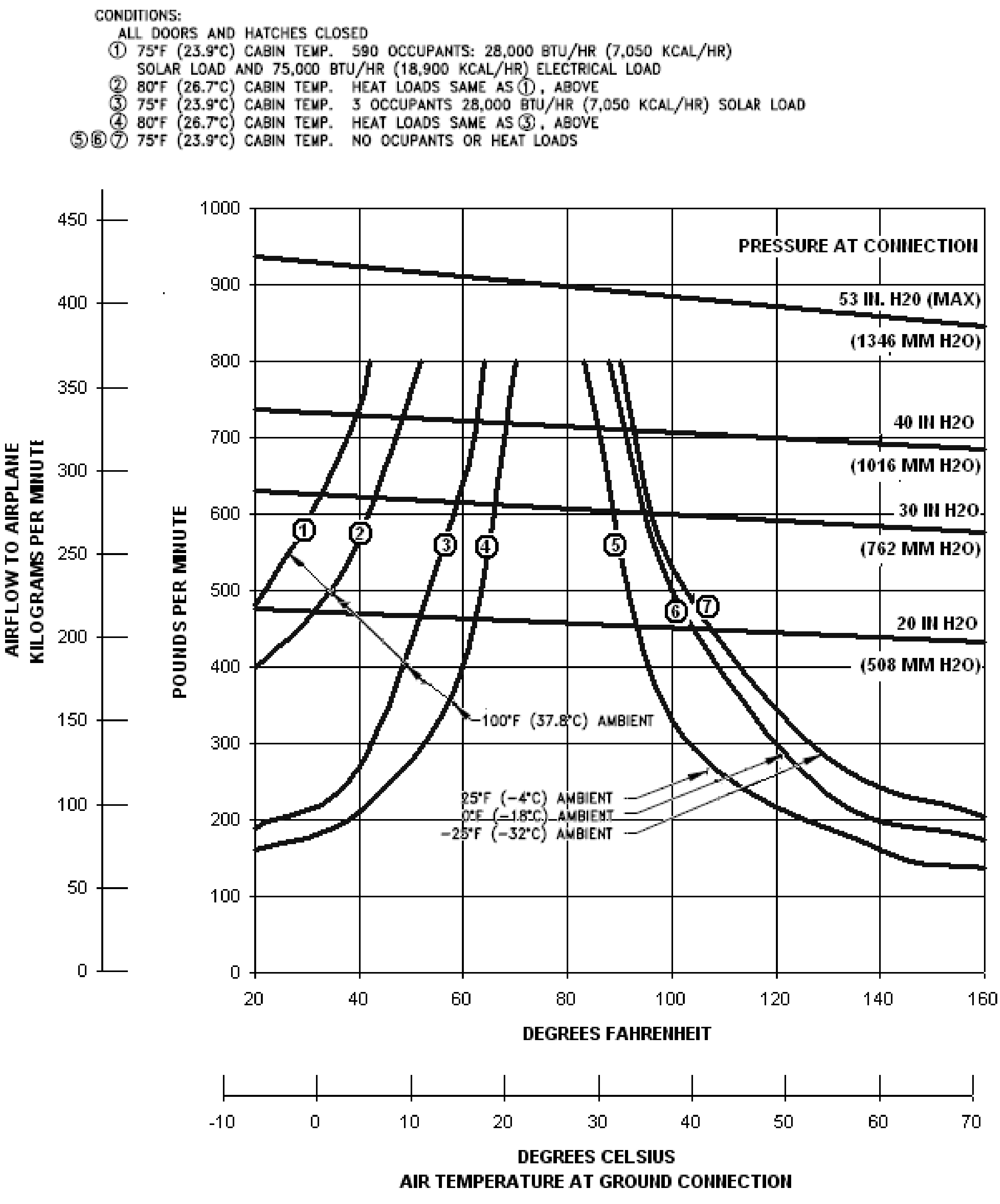
MODEL 747-8, 747-8F





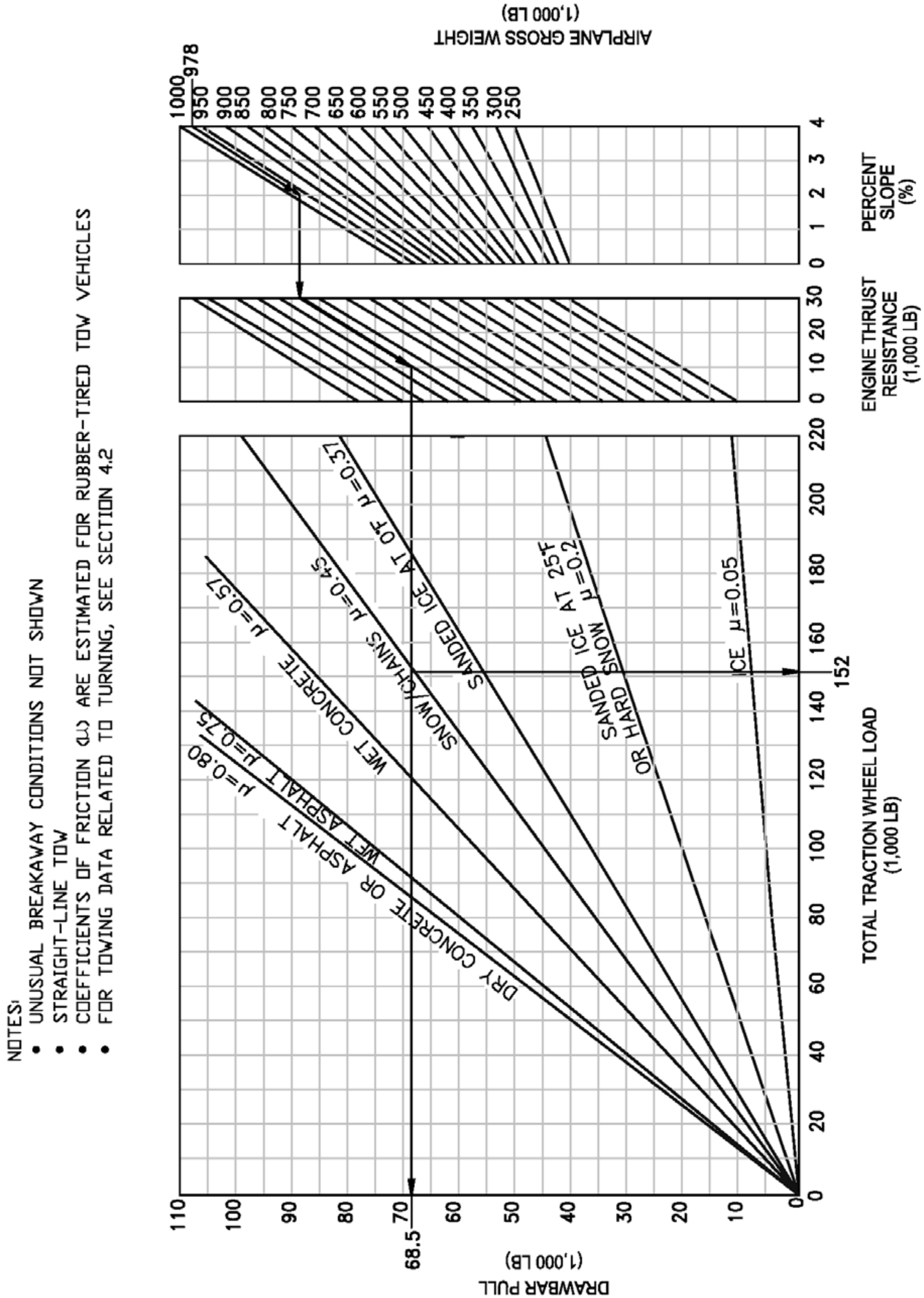
5.6.1 GROUND PNEUMATIC POWER REQUIREMENTS - HEATING/COOLING

MODEL 747-8, 747-8F



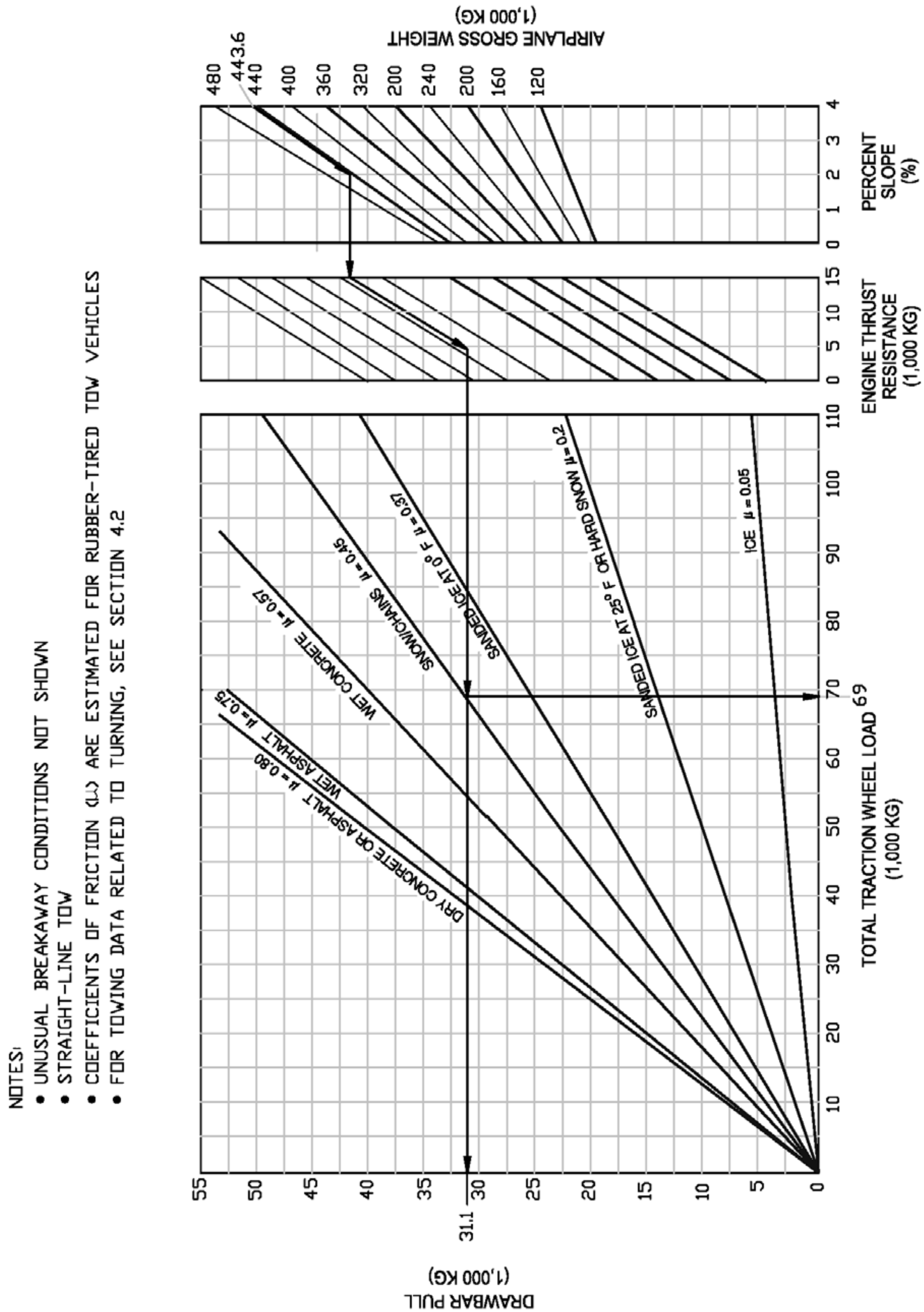
5.7.1 CONDITIONED AIR FLOW REQUIREMENTS

MODEL 747-8, 747-8F



5.8.1 GROUND TOWING REQUIREMENTS - ENGLISH UNITS

MODEL 747-8, 747-8F



5.8.2 GROUND TOWING REQUIREMENTS - METRIC UNITS

MODEL 747-8, 747-8F

6.0 JET ENGINE WAKE AND NOISE DATA

6.1 Jet Engine Exhaust Velocities and Temperatures

6.2 Airport and Community Noise

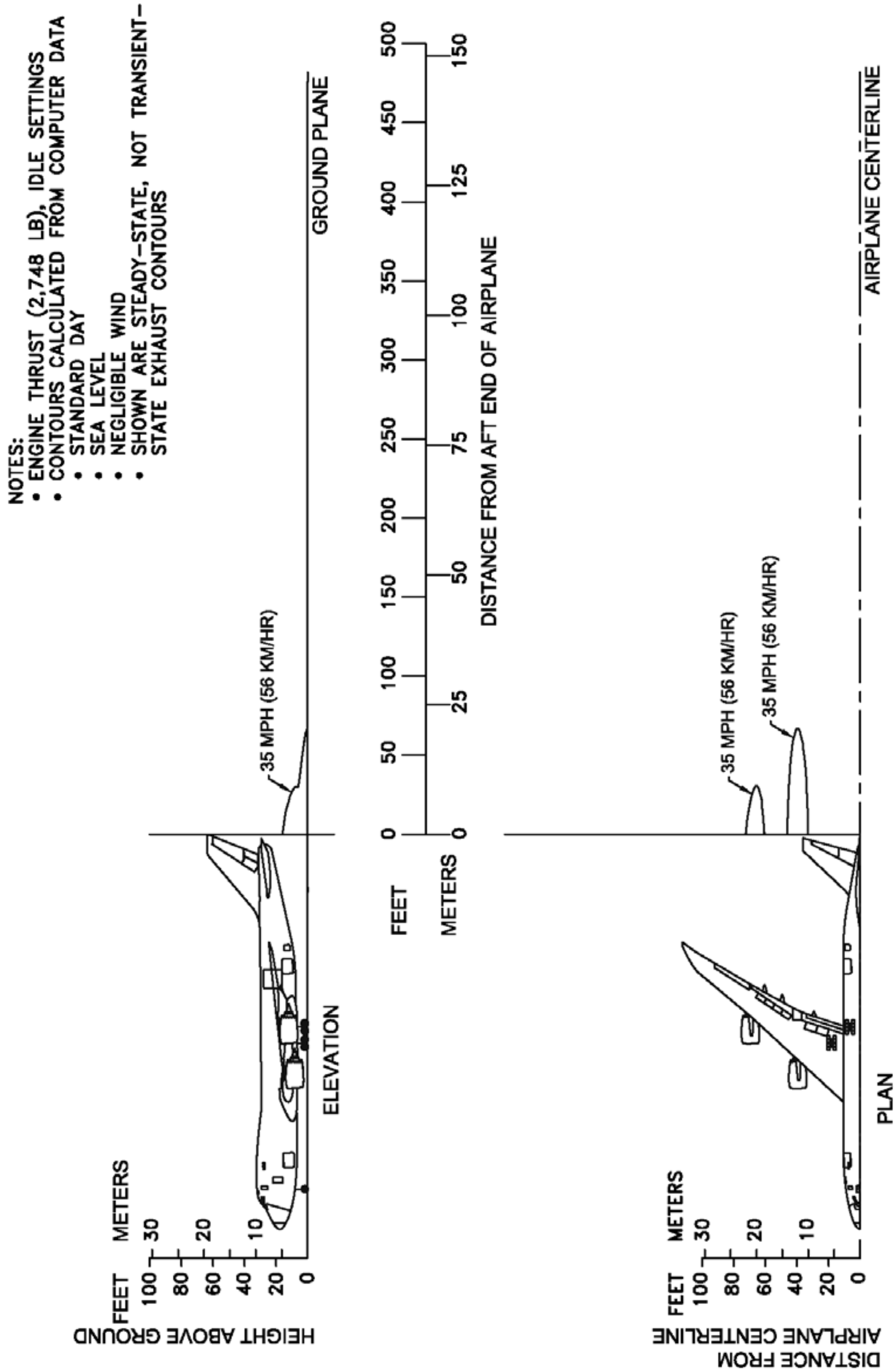
6.0 JET ENGINE WAKE AND NOISE DATA

6.1 Jet Engine Exhaust Velocities and Temperatures

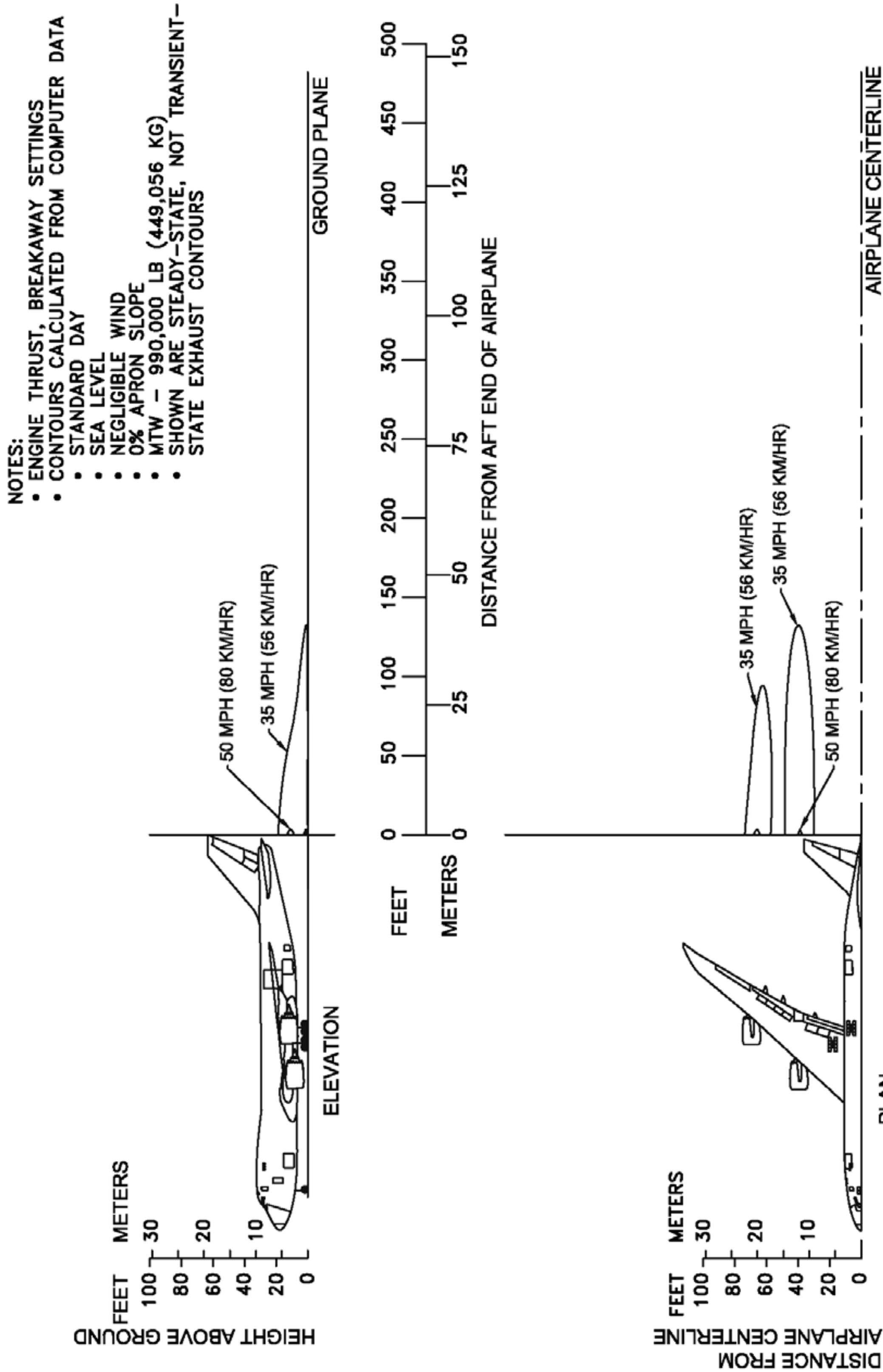
This section shows exhaust velocity and temperature contours aft of the 747-8 and 747-8 Freighter airplanes due to the use of the same engine and same weight for both airplanes. The contours were calculated from a standard computer analysis using three-dimensional viscous flow equations with mixing of primary, fan, and free-stream flow. The presence of the ground plane is included in the calculations. 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.

The users of these exhaust velocity contour data should understand that these data reflect steady-state at maximum taxi weight and not transient-state exhaust velocities. A steady-state is achieved with the aircraft in a fixed location, engine running at a given thrust level and measured when the contours stop expanding and stabilize in size, which could take several seconds. The steady-state condition, therefore, is conservative. Contours shown also do not account for performance variables such as ambient temperature or field elevation. For the terminal area environment, the transient-state is a more accurate representation of the actual exhaust contours when the aircraft is in motion and encountering static air with forward or turning movement, but it is very difficult to model on a consistent basis due to aircraft weight, weather conditions, the high degree of variability in terminal and apron configurations, and intensive numerical calculations. If the contours presented here are overly restrictive for terminal operations, The Boeing Company recommends conducting an analysis of the actual exhaust contours experienced by the using aircraft at the airport.

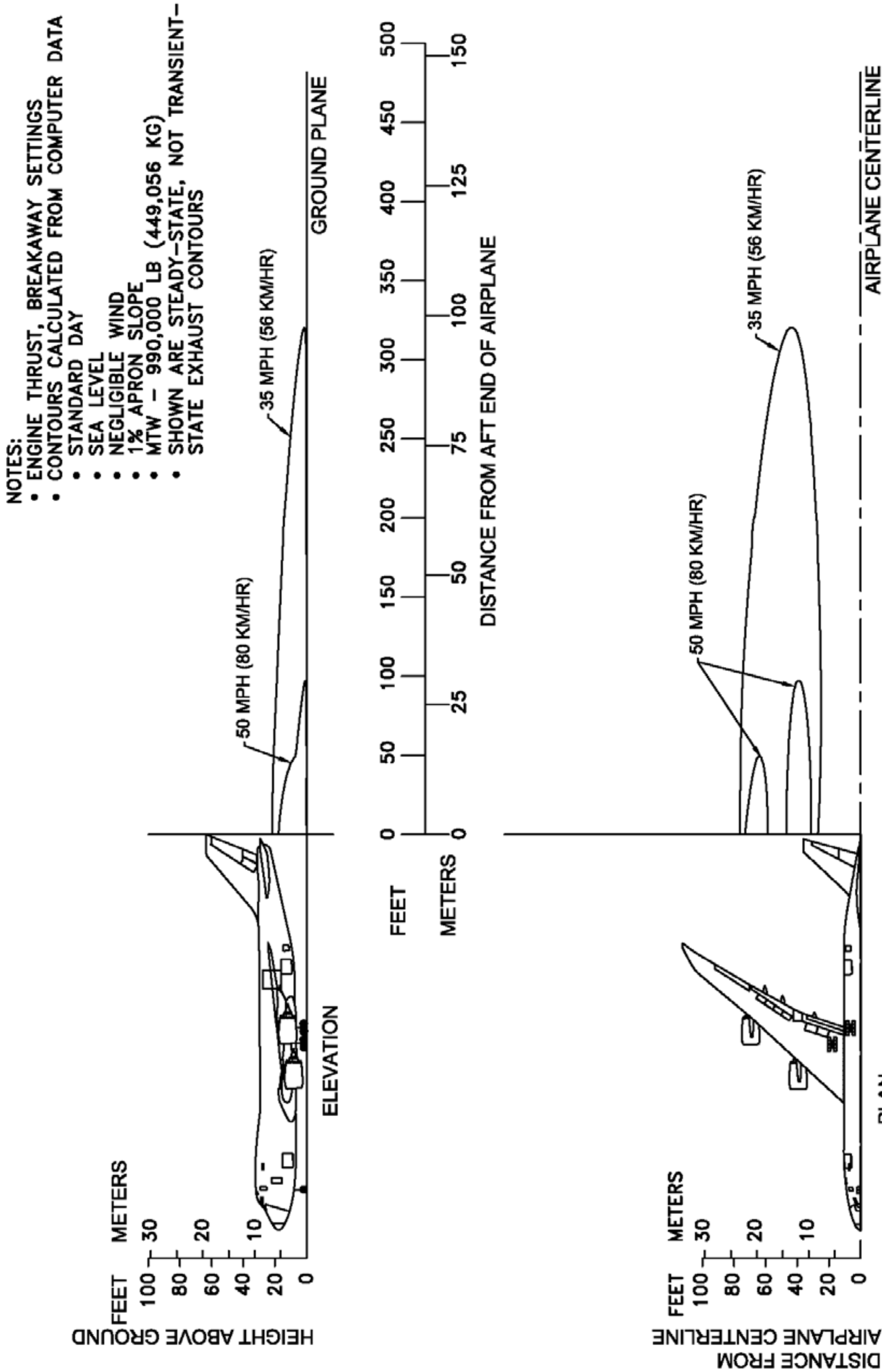


6.1.1 JET ENGINE EXHAUST VELOCITY CONTOURS – IDLE THRUST
MODEL 747-8, 747-8F



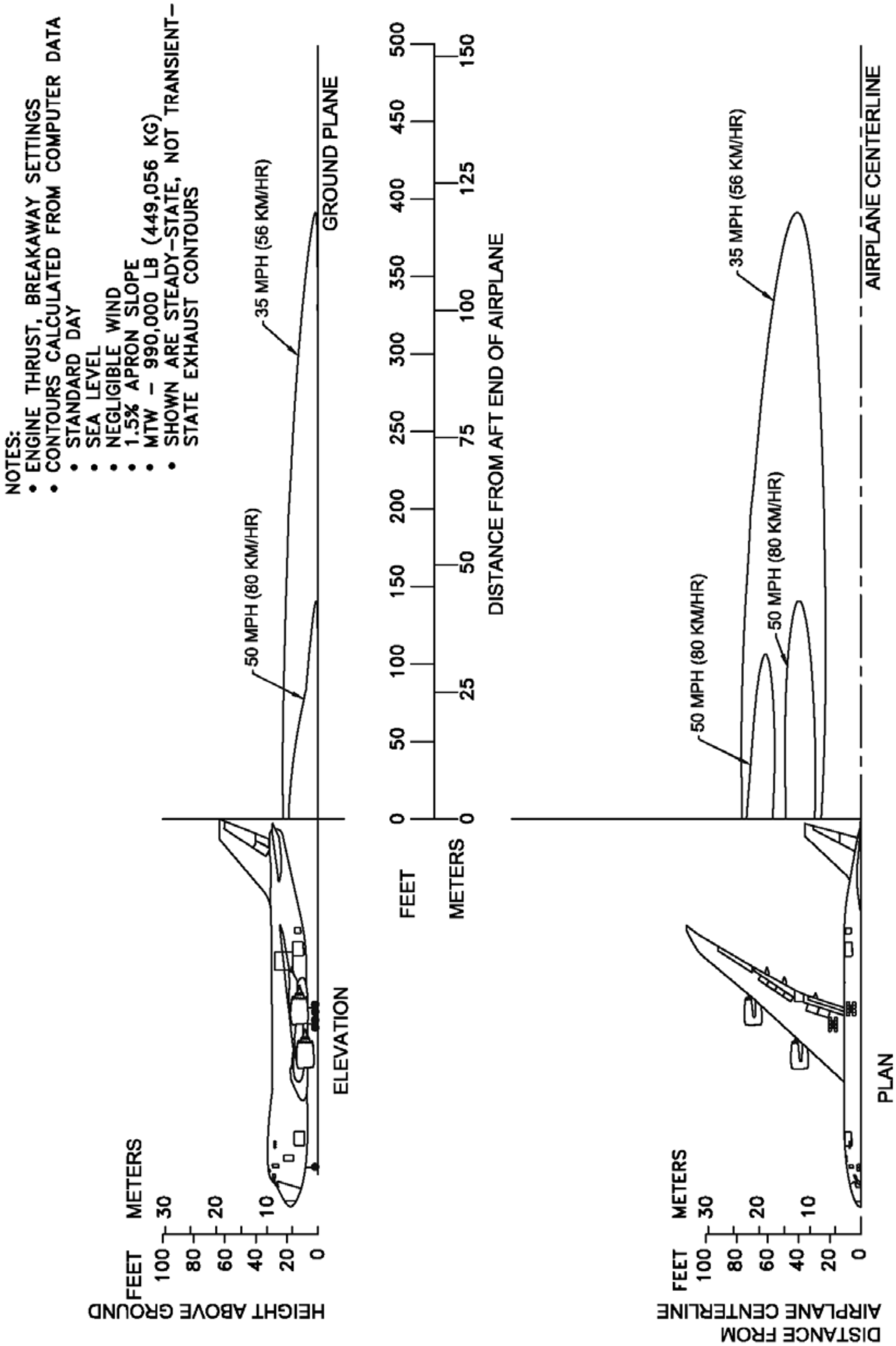
6.1.2 JET ENGINE EXHAUST VELOCITY CONTOURS – BREAKAWAY THRUST – LEVEL PAVEMENT

MODEL 747-8, 747-8F



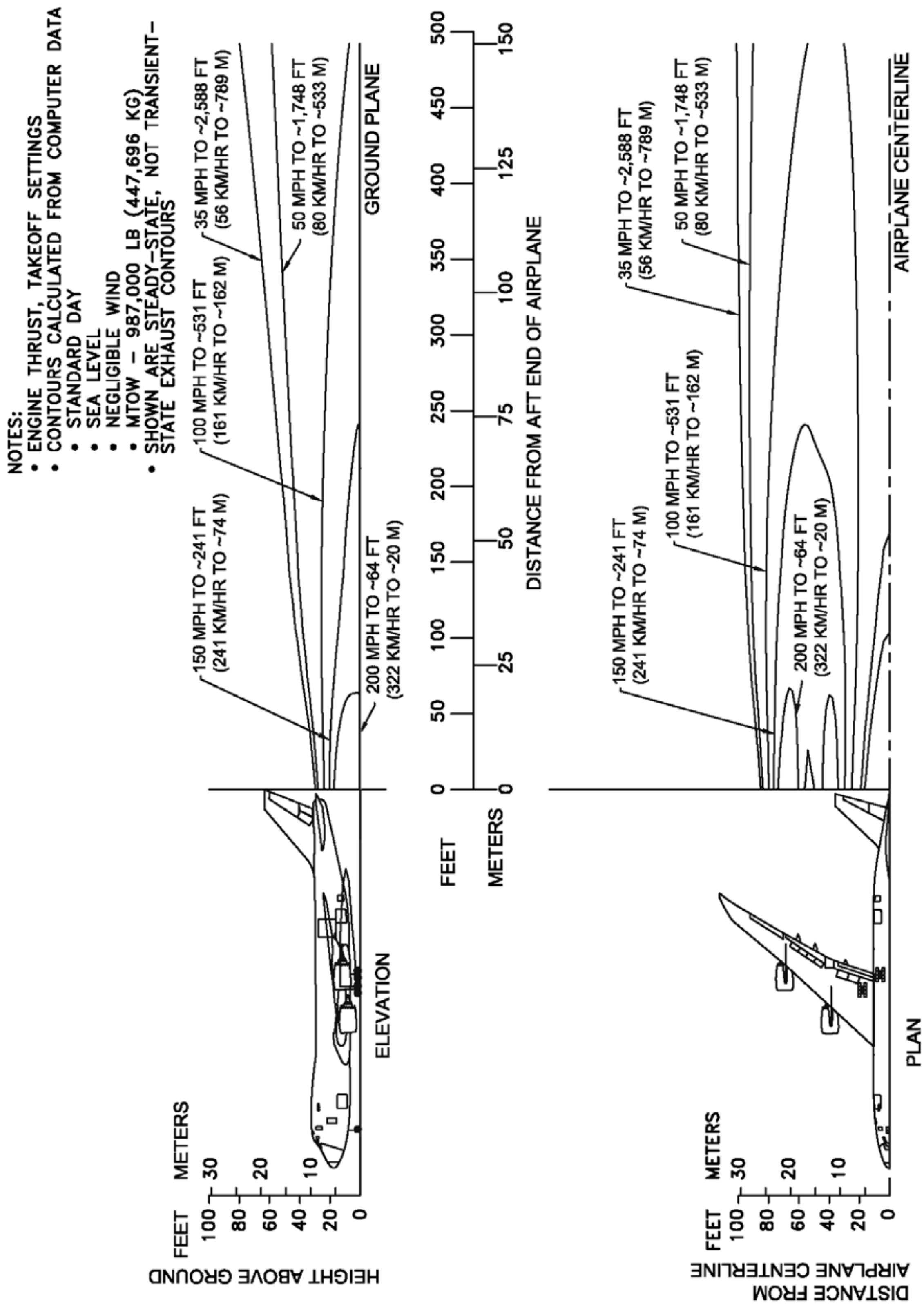
6.1.3 JET ENGINE EXHAUST VELOCITY CONTOURS – BREAKAWAY THRUST - 1% PAVEMENT UPSLOPE

MODEL 747-8, 747-8F



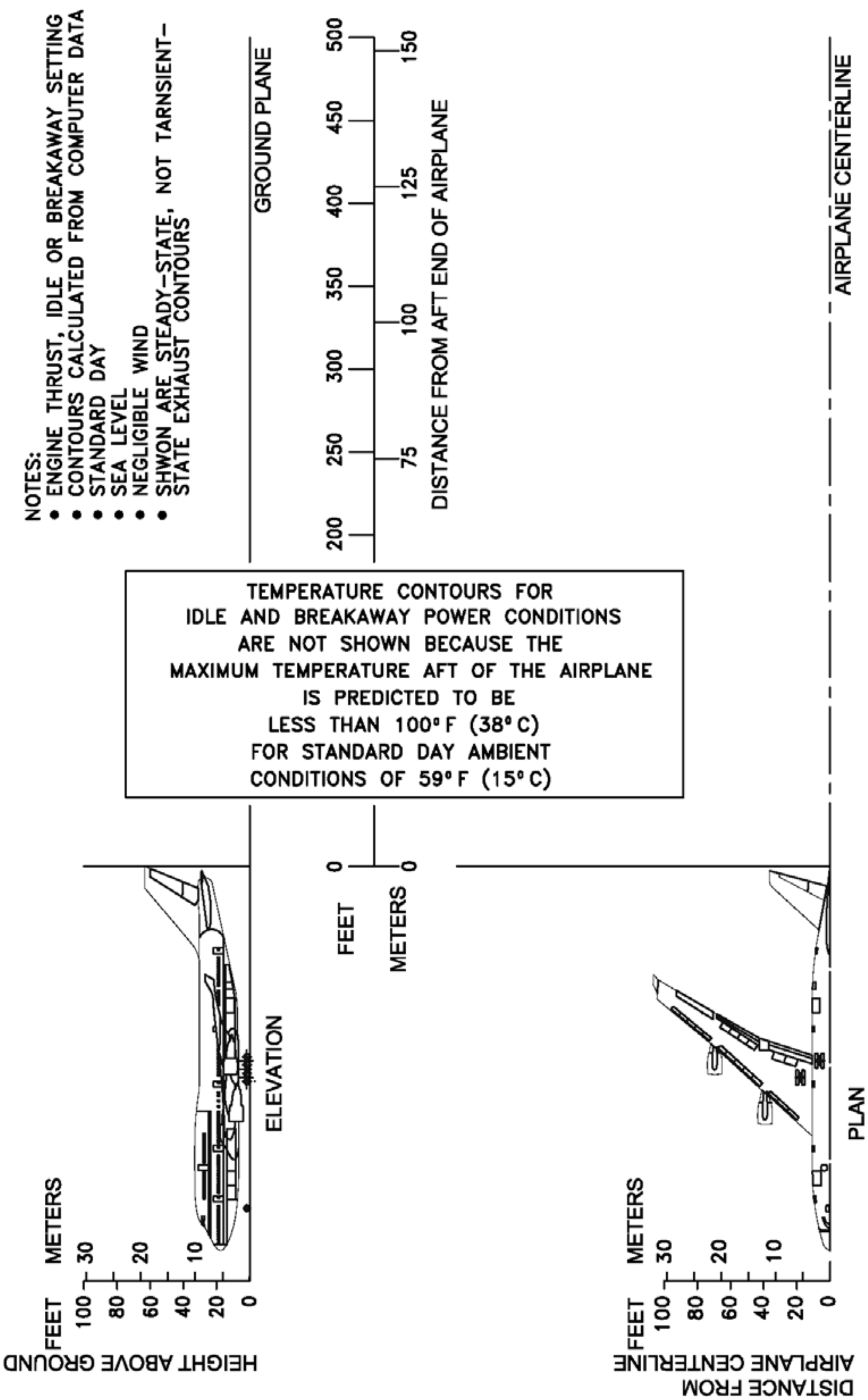
6.1.4 JET ENGINE EXHAUST VELOCITY CONTOURS - BREAKAWAY THRUST - 1.5% PAVEMENT UPSLOPE

MODEL 747-8, 747-8F

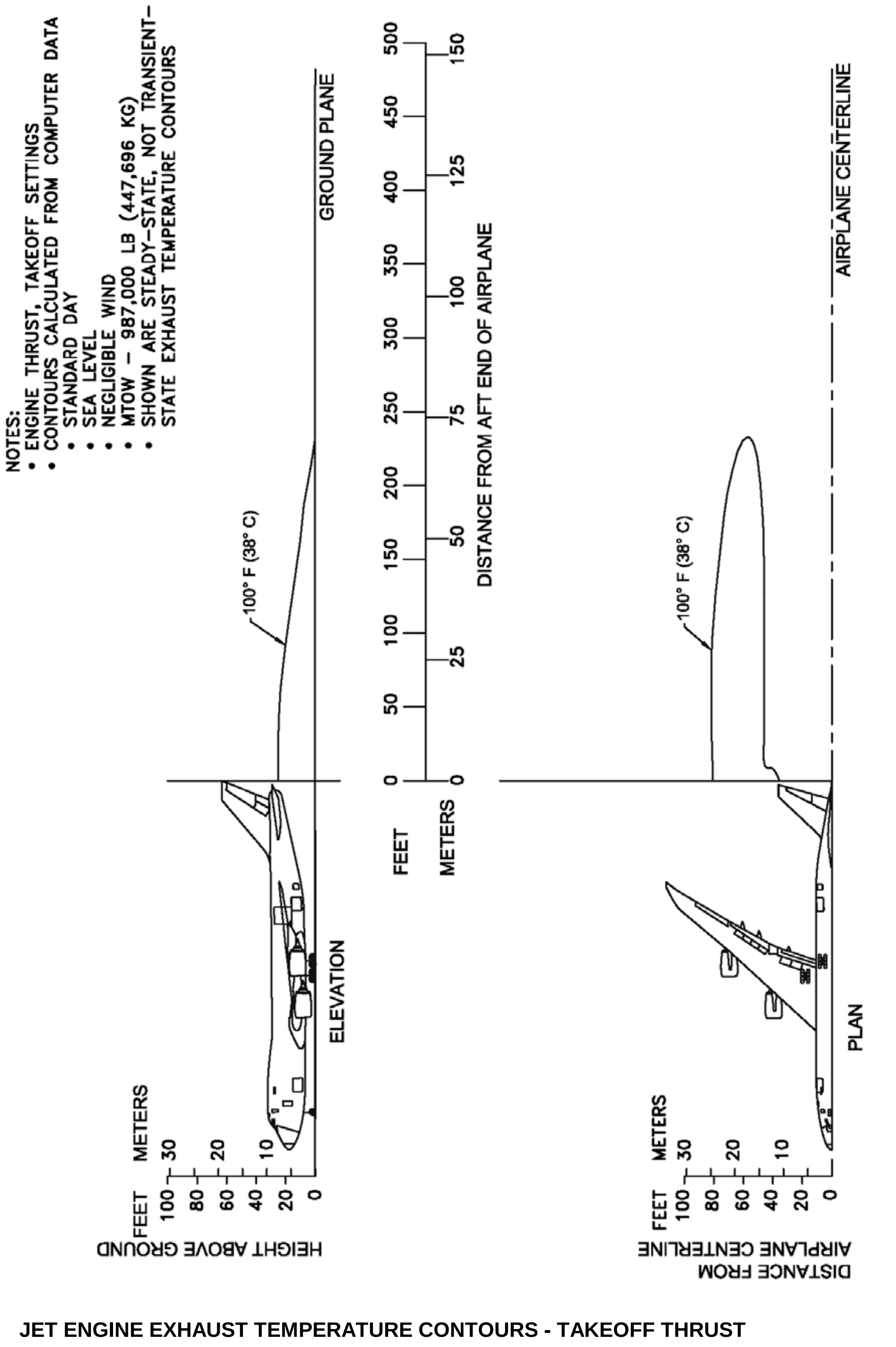


6.1.5 JET ENGINE EXHAUST VELOCITY CONTOURS - TAKEOFF THRUST

MODEL 747-8, 747-8F



6.1.6 JET ENGINE EXHAUST TEMPERATURE CONTOURS – IDLE AND BREAKAWAY
MODEL 747-8, 747-8F



6.1.7 JET ENGINE EXHAUST TEMPERATURE CONTOURS - TAKEOFF THRUST
MODEL 747-8, 747-8F

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:

1. Operational Factors

    (a) Aircraft Weight - Aircraft weight is dependent on operating empty weight, distance to be traveled, en route winds, payload, and reserve fuel anticipated from a potential aircraft delay upon reaching the destination.

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

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

2. Atmospheric Conditions-Sound Propagation

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

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

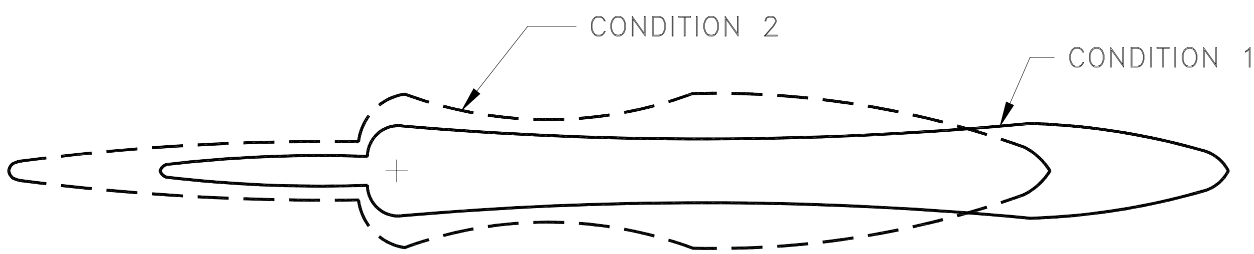
3. Surface Condition - Shielding, Extra Ground Attenuation (EGA)

(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 appreciable. To demonstrate the effect of some of these factors, estimated noise level contours for two different operating conditions are shown below. These contours reflect a given noise level upon a ground level plane at runway elevation.

Condition 1

Landing	Takeoff
Maximum Design Landing Weight	Maximum Design Takeoff Weight
10-knot Headwind	Zero Wind
3^{o} Approach	84 ^{o}F (29 ^{o}C)
84 ^{o}F (29 ^{o}C)	Humidity 15%
Humidity 15%	



Condition 2

Landing:	Takeoff:
85% of Maximum Design Landing Weight	80% of Maximum Design Takeoff Weight
10-knot Headwind	10-knot Headwind
3^{o} Approach	59 ^{o}F (15 ^{o}C)
59 ^{o}F (15 ^{o}C)	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 gross 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 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.

7.0 PAVEMENT DATA

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 six 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 chart in Section 7.4 is provided in order to determine these loads throughout the stability limits of the airplane at rest on the pavement. These main landing gear loads are used as the point of entry to the pavement design charts, interpolating load values where necessary.

The flexible pavement design curves (Section 7.5) are based on procedures set forth in Instruction Report No. S-77-1, "Procedures for Development of CBR Design Curves," dated June 1977, and as modified according to the methods described in ICAO Aerodrome Design Manual, Part 3, Pavements, 2^{nd} Edition, 1983, Section 1.1 (The ACN-PCN Method), and utilizing the alpha factors approved by ICAO in October 2007. Instruction Report No. S-77-1 was prepared by the U.S. Army Corps of Engineers Waterways Experiment Station, Soils and Pavements Laboratory, Vicksburg, Mississippi. The line showing 10,000 coverages is used to calculate Aircraft Classification Number (ACN).

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

1. Having established the scale for pavement depth at the bottom and the scale for CBR at the top, an arbitrary line is drawn representing 10,000 coverages.

2. Values of the aircraft weights on the main landing gear are then plotted.

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

All Load Classification Number (LCN) curves (Sections 7.6 and 7.8) have been developed from a computer program based on data provided in International Civil Aviation Organization (ICAO) document 9157-AN/901, Aerodrome Design Manual, Part 3, "Pavements," Second Edition, 1983. LCN values are shown directly for parameters of weight on main landing gear, tire pressure, and radius of relative stiffness (l) for rigid pavement or pavement thickness or depth factor (h) for flexible pavement.

Rigid pavement design curves (Section 7.7) have been prepared with the Westergaard equation in general accordance with the procedures outlined in the Design of Concrete Airport Pavement (1955 edition) by Robert G. Packard, published by the Portland Cement Association, 3800 North Wilke Road, Arlington Heights, Illinois 60004-1268. These curves are modified to the format described in the Portland Cement Association publication XP6705-2, Computer Program for Airport Pavement Design (Program PDILB), 1968, by Robert G. Packard.

The following procedure is used to develop the rigid pavement design curves shown in Section 7.7:

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

2. Values of the subgrade modulus (k) are then plotted.

3. Additional load lines for the incremental values of weight on the main landing gear are drawn on the basis of the curve for k = 300, already established.

For the rigid pavement design (Section 7.9) refer to the FAA website for the FAA design software COMFAA:

http://www.faa.gov/airports/engineering/design_software/

The ACN/PCN system (Section 7.10) as referenced in ICAO Annex 14, “Aerodromes,” Fifth Edition, July 2009, 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 twice 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 method of pavement evaluation is left up to the airport with the results of their evaluation presented as follows:

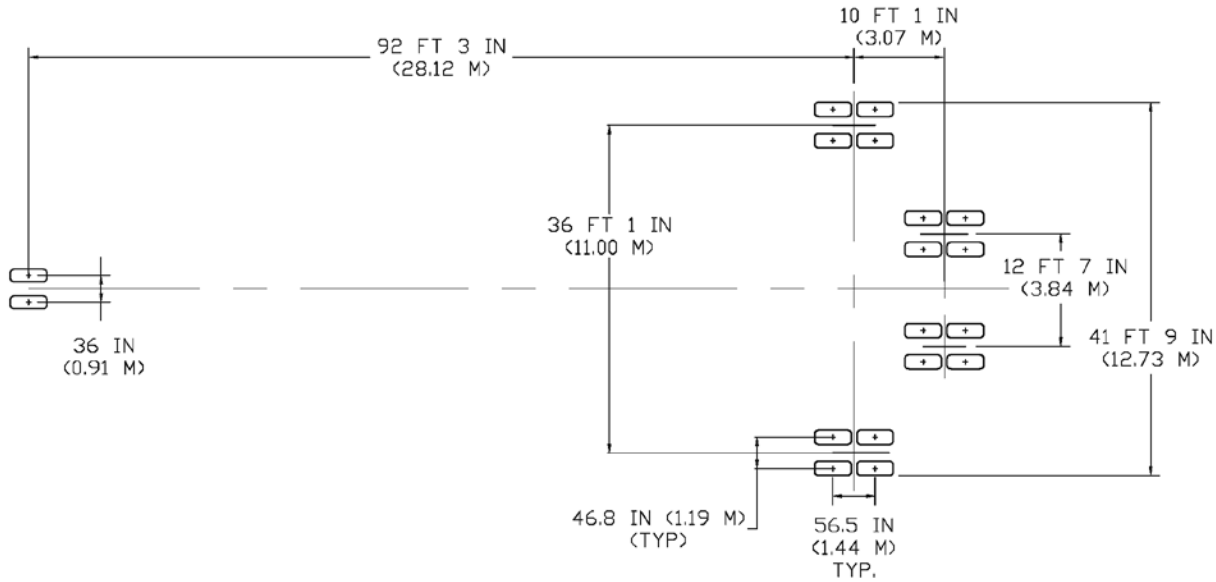
PCN	PAVEMENT TYPE	SUBGRADE CATEGORY	TIRE PRESSURE CATEGORY	EVALUATION METHOD
	R = Rigid	A = High	W = No Limit	T = Technical
	F = Flexible	B = Medium	X = To 254 psi (1.75 MPa)	U = Using Aircraft
		C = Low	Y = To 181 psi (1.25 MPa)	
		D = Ultra Low	Z = To 73 psi (0.5 MPa)	

Section 7.10.1 shows the aircraft ACN values for flexible pavements. The four subgrade categories are:

Code A - High Strength - CBR 15
Code B - Medium Strength - CBR 10
Code C - Low Strength - CBR 6
Code D - Ultra Low Strength - CBR 3

Section 7.10.2 shows the aircraft ACN values for rigid pavements. The four subgrade categories are:

Code A - High Strength, k = 550 pci (150 MN/m^3)
Code B - Medium Strength, k = 300 pci (80 MN/m^3)
Code C - Low Strength, k = 150 pci (40 MN/m^3)
Code D - Ultra Low Strength, k = 75 pci (20 MN/m^3)



NOT TO SCALE

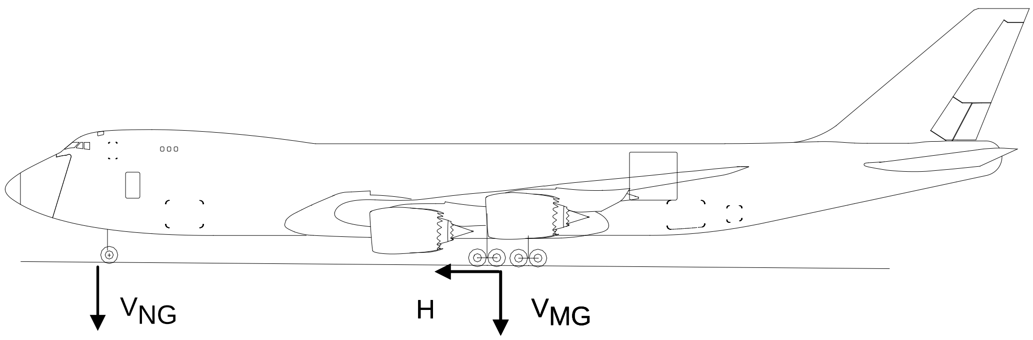
	UNITS	747-8F	747-8, 747-8F
MAXIMUM DESIGN TAXI WEIGHT	LB KG	978,000 443,613	990,000 449,056
PERCENT OF WEIGHT ON MAIN GEAR	%	SEE SECTION 7.4	
NOSE GEAR TIRE SIZE	IN.	50 X 20.0 R 22, 26 PR	50 X 20.0 R22, 26 PR
NOSE GEAR TIRE PRESSURE	PSI KG/CM^2	167 11.74	167 11.74
MAIN GEAR TIRE SIZE	IN.	52 X 21.0 R22, 36 PR	52 X 21.0 R22, 36 PR
MAIN GEAR TIRE PRESSURE	PSI KG/CM^2	221 15.54	221 15.54

7.2 LANDING GEAR FOOTPRINT

MODEL 747-8, 747-8F

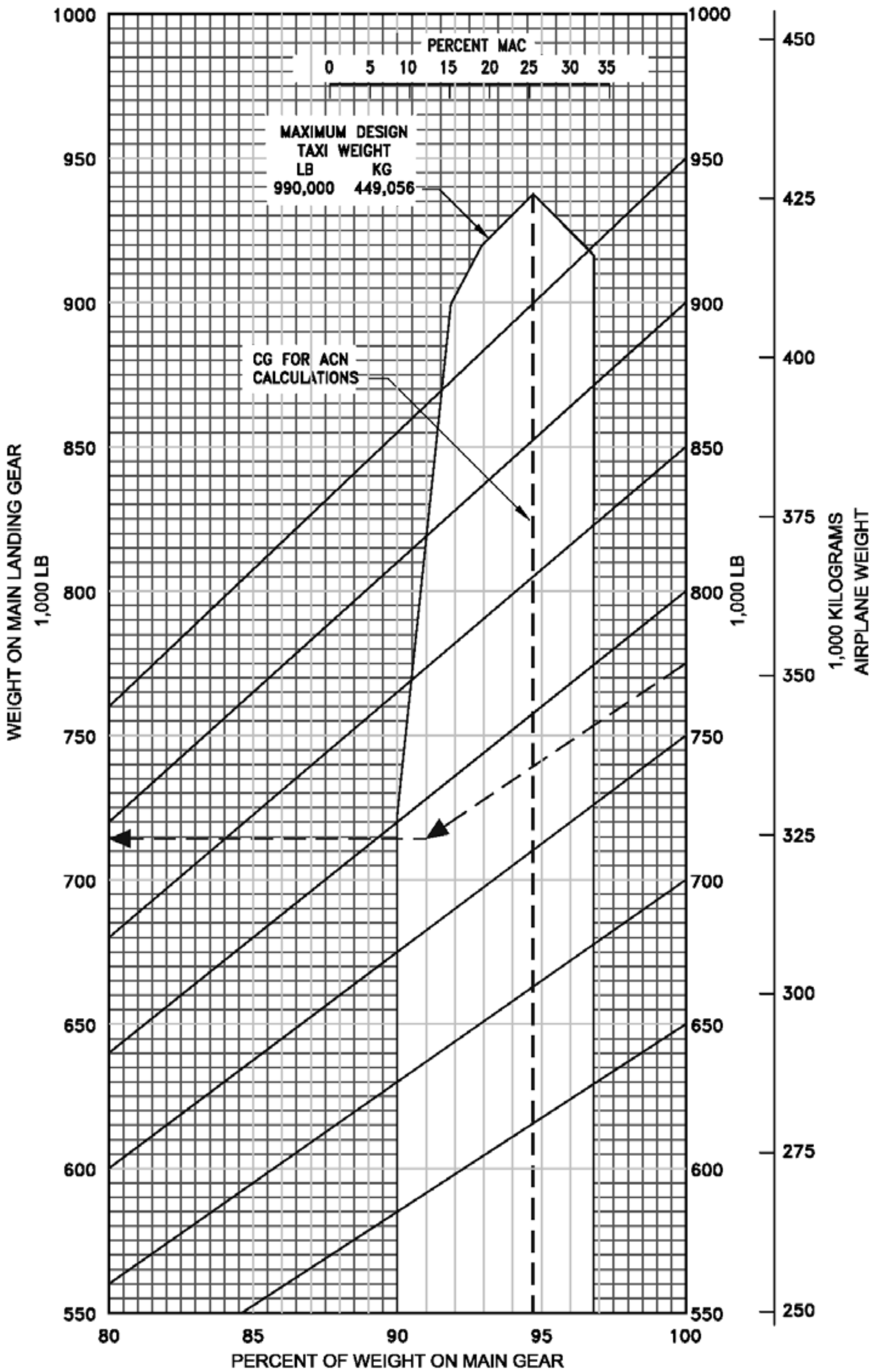
V_{NG} = MAXIMUM VERTICAL NOSE GEAR GROUND LOAD AT MOST FORWARD CENTER OF GRAVITY
V_{MG} = MAXIMUM VERTICAL MAIN GEAR GROUND LOAD AT MOST AFT CENTER OF GRAVITY
H = MAXIMUM HORIZONTAL GROUND LOAD FROM BRAKING

NOTE: ALL LOADS CALCULATED USING AIRPLANE MAXIMUM DESIGN TAXI WEIGHT

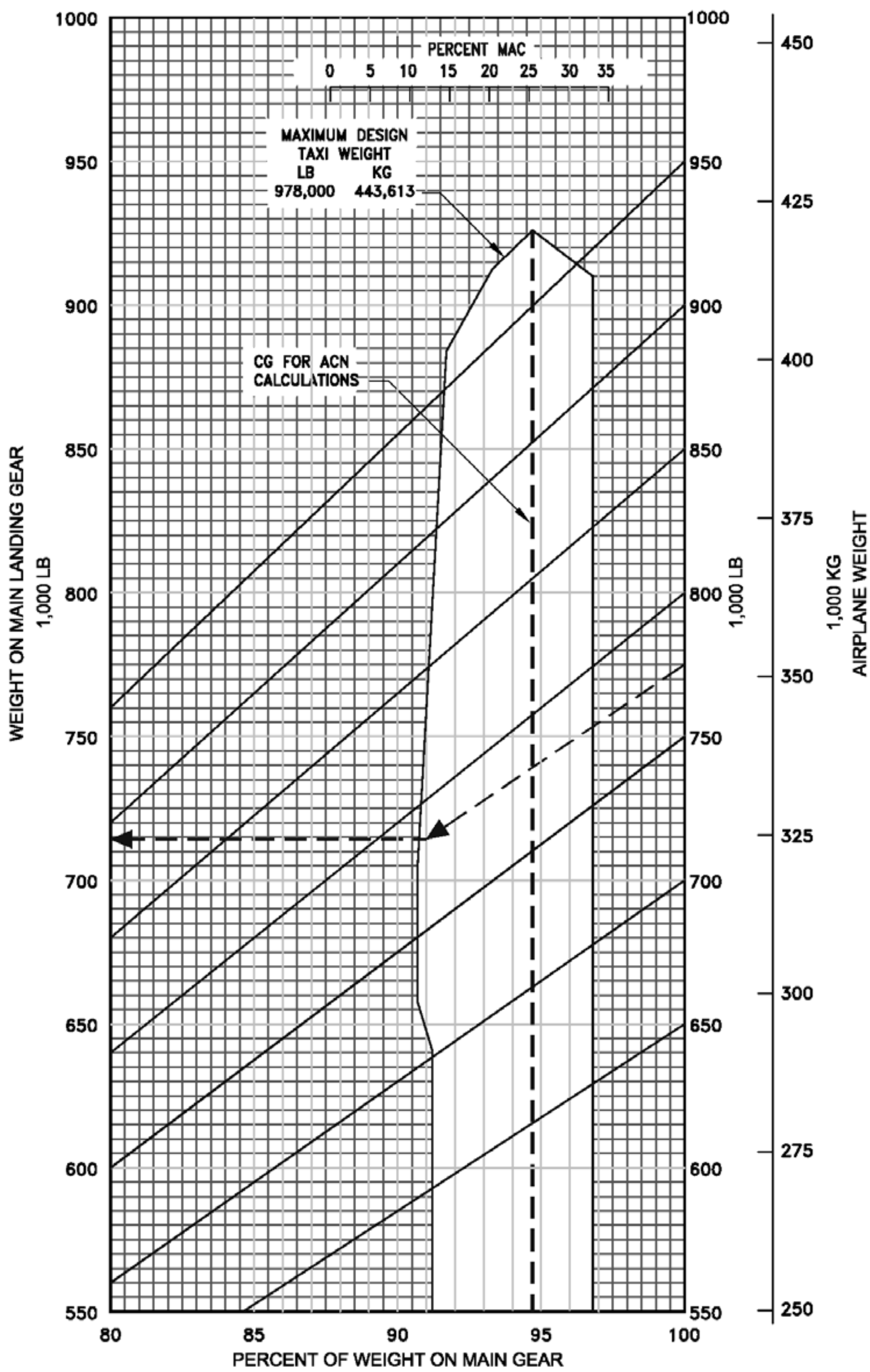


AIRPLANE MODEL	UNITS	MAX DESIGN TAXI WEIGHT	V_{NG}		V_{MG} PER STRUT (4)	H PER STRUT (4)	
			STATIC AT MOST FWD C.G.	STATIC + BRAKING 10 FT/SEC^2 DECEL	MAX LOAD AT STATIC AFT C.G.	STEADY BRAKING 10 FT/SEC^2 DECEL	AT INSTANTANEOUS BRAKING (μ = 0.8)
747-8	LB	990,000	70,112	119,606	234,348	76,874	187,478
	KG	449,056	31,802	54,252	106,299	34,870	85,039
747-8F	LB	978,000	65,145	116,380	231,507	75,942	185,206
	KG	443,613	29,549	52,789	105,010	34,447	84,008
747-8F	LB	990,000	70,112	119,606	234,515	76,874	186,812
	KG	449,056	31,802	54,252	105,921	34,870	84,736

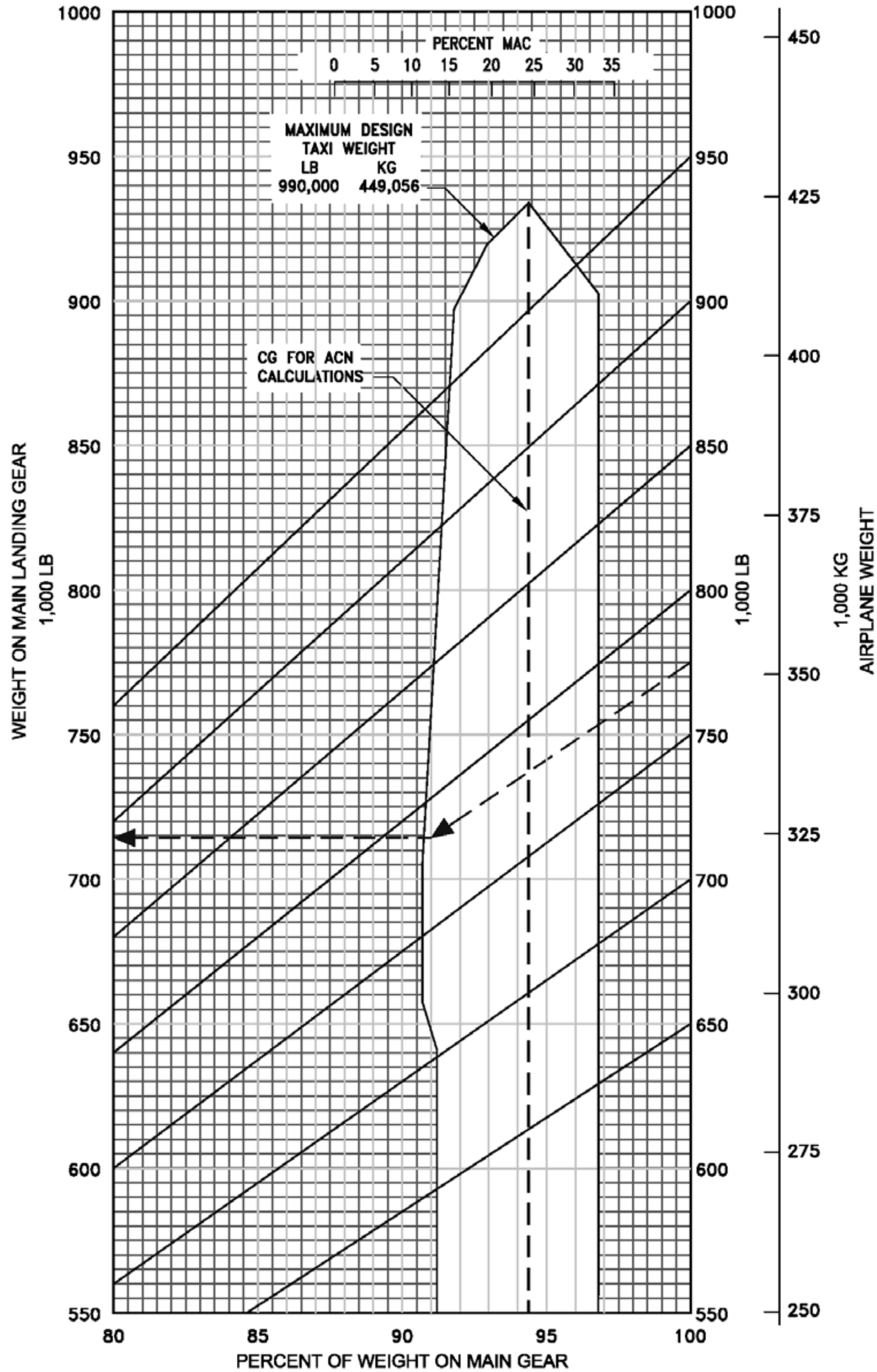
7.3. MAXIMUM PAVEMENT LOADS
MODEL 747-8, 747-8F



7.4.1 LANDING GEAR LOADING ON PAVEMENT
MODEL 747-8 (990,000 LB, 449,056 KG)



7.4.2 LANDING GEAR LOADING ON PAVEMENT
MODEL 747-8F (978,000 LB, 443,613 KG)



7.4.3 LANDING GEAR LOADING ON PAVEMENT
MODEL 747-8F (990,000 LB, 449,056 KG)

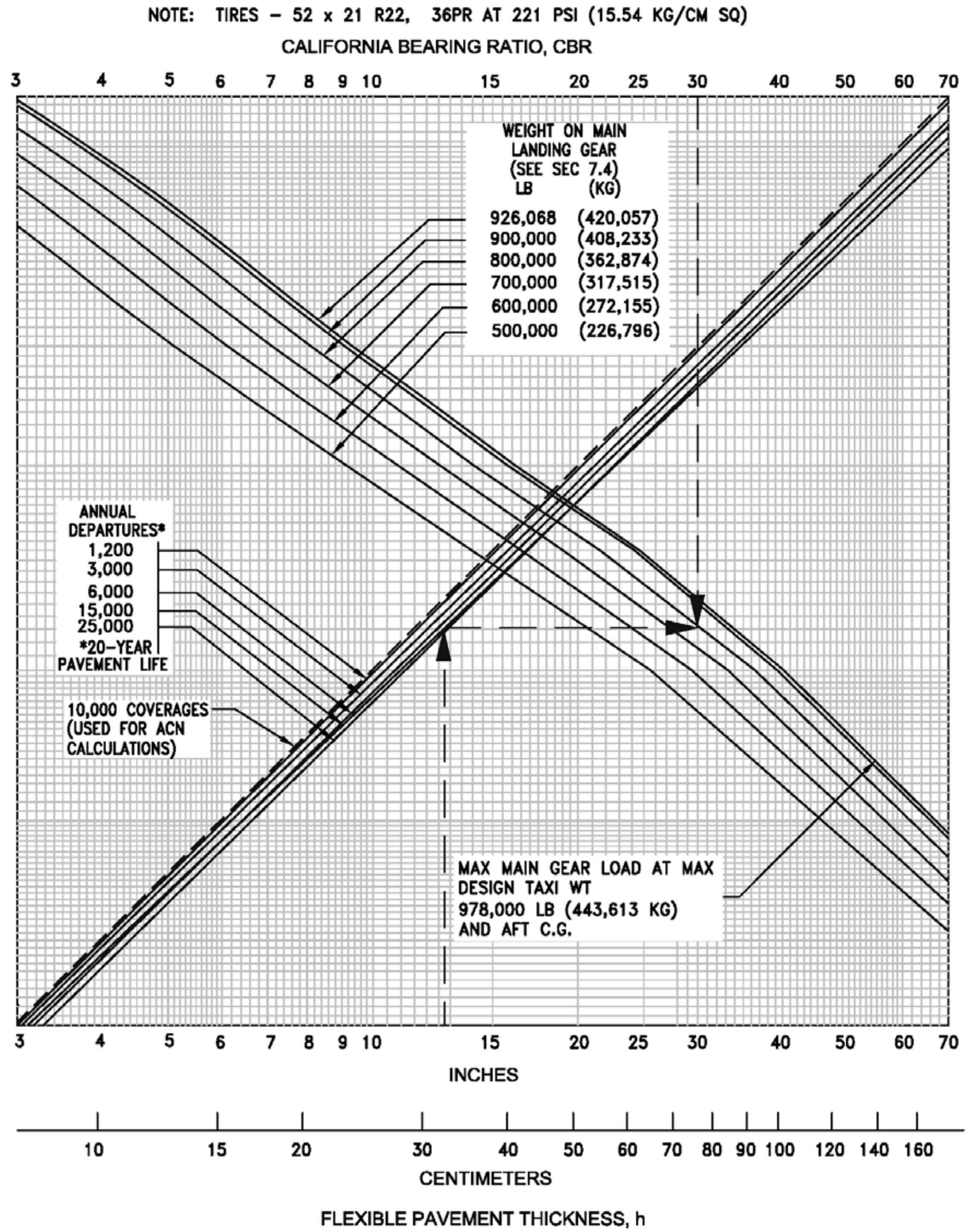
7.5 Flexible Pavement Requirements - U.S. Army Corps of Engineers Method (S-77-1)

The following flexible-pavement design chart presents the data of six incremental main-gear loads at the minimum tire pressure required at the maximum design taxi weight.

In the examples shown in Section 7.5.1 and 7.5.2, for a CBR of 30 and an annual departure level of 15,000, the required flexible pavement thickness for an airplane with a main gear loading of 800,000 pounds (362,874 kg) is 12.5 inches (31.8 cm).

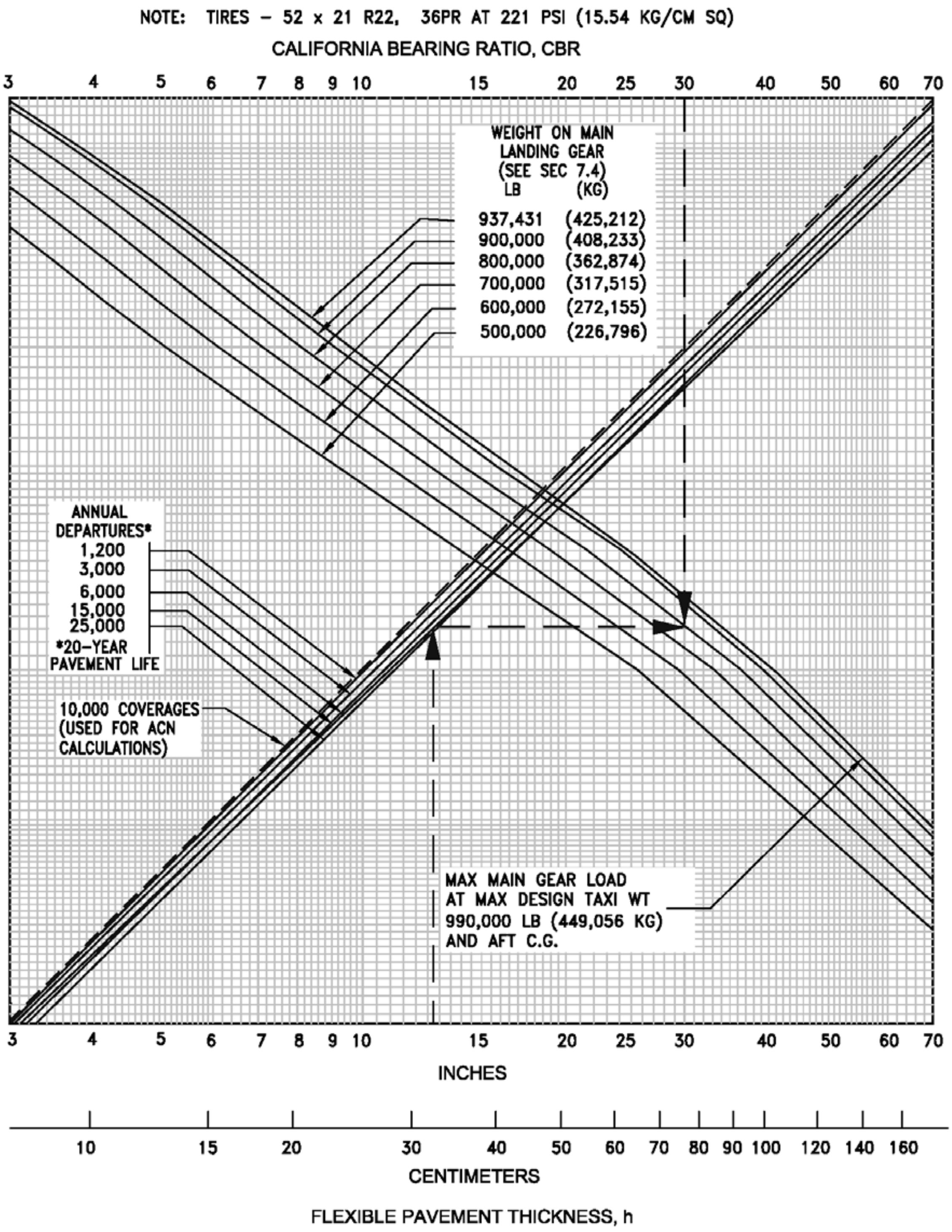
The line showing 10,000 coverages is used for ACN calculations (see Section 7.10).

The FAA design method uses a similar procedure using total airplane weight instead of weight on the main landing gears. The equivalent main gear loads for a given airplane weight could be calculated from Section 7.4.



7.5.1 FLEXIBLE PAVEMENT REQUIREMENTS - U.S. ARMY CORPS OF ENGINEERS DESIGN METHOD (S-77-1)

MODEL 747-8F (978,000 LB, 443,613 KG)



7.5.2 FLEXIBLE PAVEMENT REQUIREMENTS - U.S. ARMY CORPS OF ENGINEERS DESIGN METHOD (S-77-1)

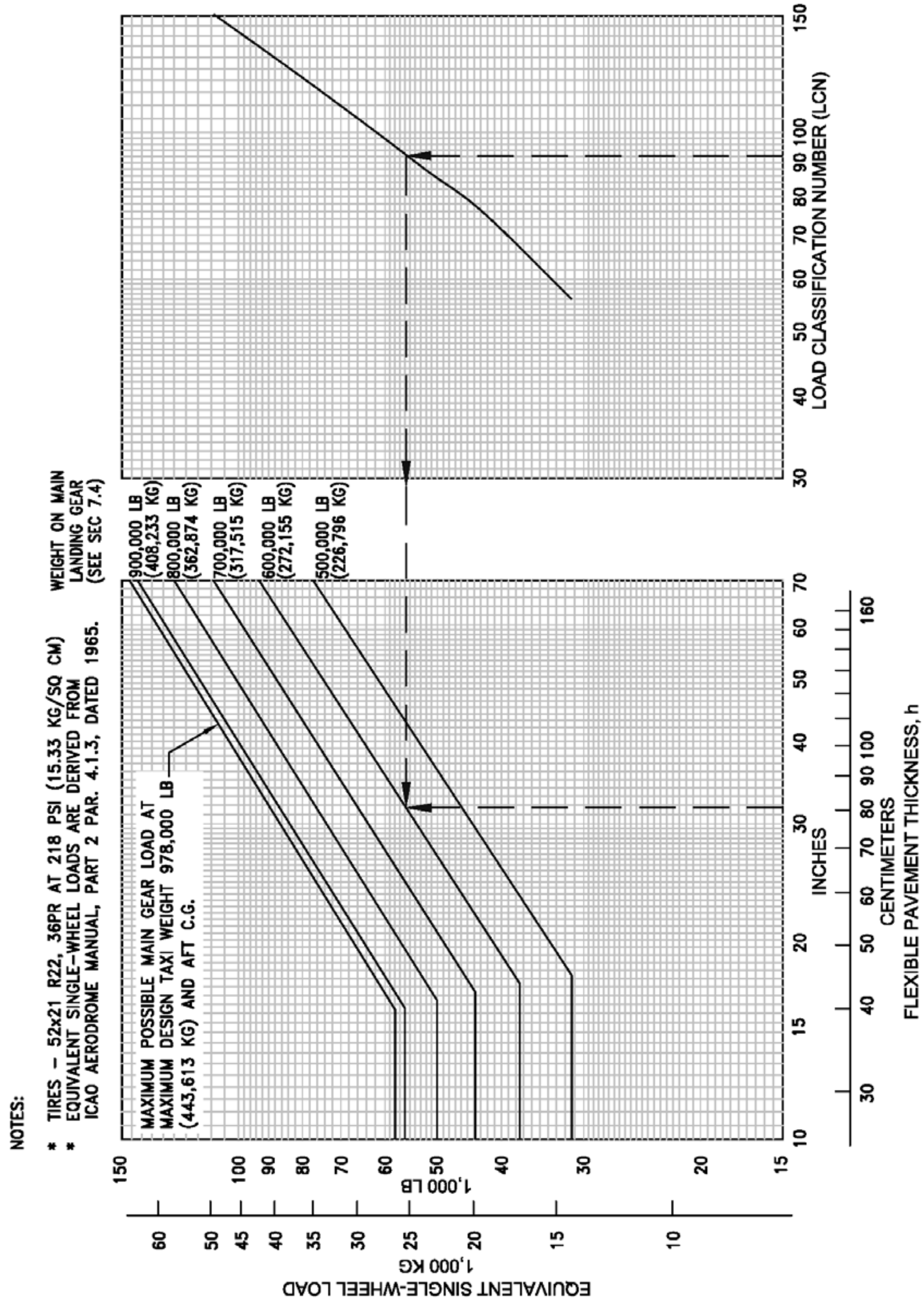
MODEL 747-8, 747-8F (990,000 LB, 449,056 KG)

7.6 Flexible Pavement Requirements - LCN Method

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

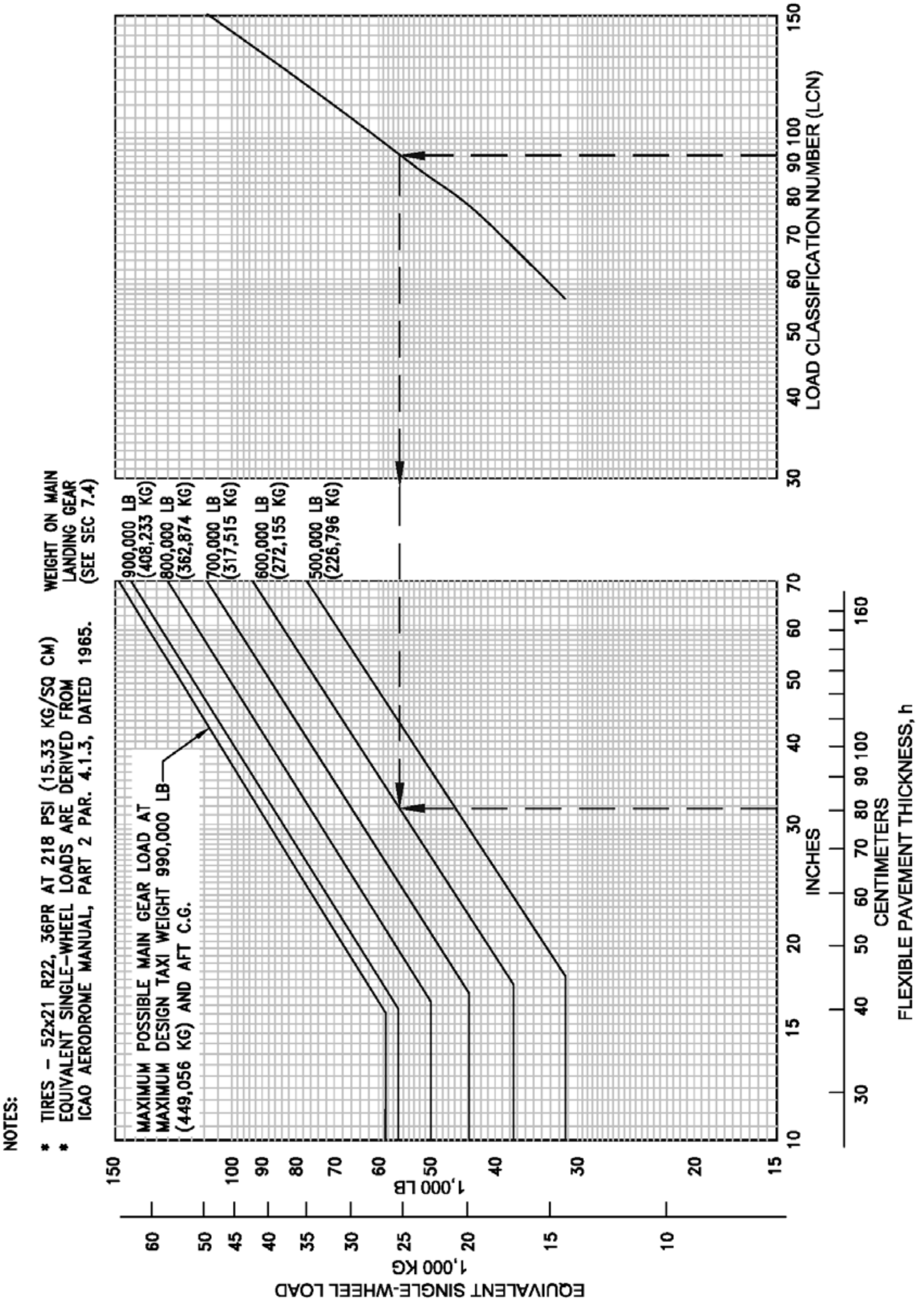
In the example shown in Section 7.6.1 and 7.6.2, flexible pavement thickness is shown at 32 in (81 cm). with an LCN of 92. For these conditions, the apparent maximum allowable weight permissible on the main landing gear is 600,000 lb (272,155 kg) for an airplane with 221-psi (15.54 kg/cm^2) main gear tires.

Note: If the resultant aircraft LCN is not more that 10% above the published pavement LCN, the bearing strength of the pavement can be considered sufficient for unlimited use by the airplane. The figure 10% has been chosen as representing the lowest degree of variation in LCN that is significant (reference: ICAO Aerodrome Design Manual, Part 2, "Aerodrome Physical Characteristics," Chapter 4, Paragraph 4.1.5.7v, 2nd Edition dated 1965).



7.6.1 FLEXIBLE PAVEMENT REQUIREMENTS - LCN METHOD

MODEL 747-8F (978,000 LB, 443,613 KG)



7.6.2 FLEXIBLE PAVEMENT REQUIREMENTS - LCN METHOD

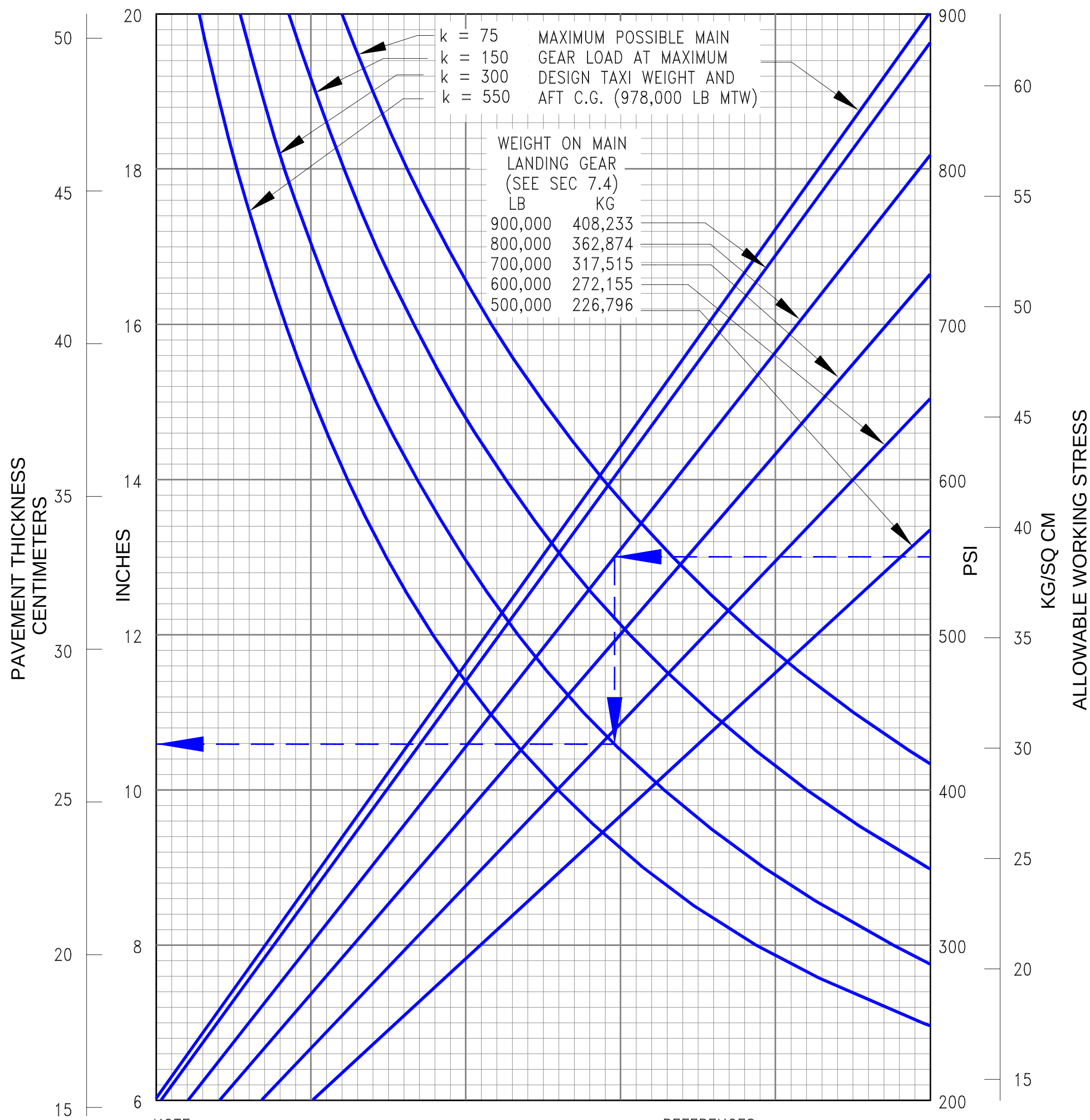
MODEL 747-8, 747-8F (990,000 LB, 449,056 KG)

7.7 Rigid Pavement Requirements - Portland Cement Association Design Method

The Portland Cement Association method of calculating rigid pavement requirements is based on the computerized version of "Design of Concrete Airport Pavement" (Portland Cement Association, 1965) as described in XP6705-2, "Computer Program for Airport Pavement Design" by Robert G. Packard, Portland Cement Association, 1968.

The rigid pavement design charts in Section 7.7.1 and 7.7.2, present the data for six incremental main gear loads at the minimum tire pressure required at the maximum design taxi weight.

In the example shown, for an allowable working stress of 550 psi (38.67 kg/cm^2), a main gear load of 800,000 lb (362,874 kg), and a subgrade strength (k) of 300, the required rigid pavement thickness is 10.6 in (26.9 cm).

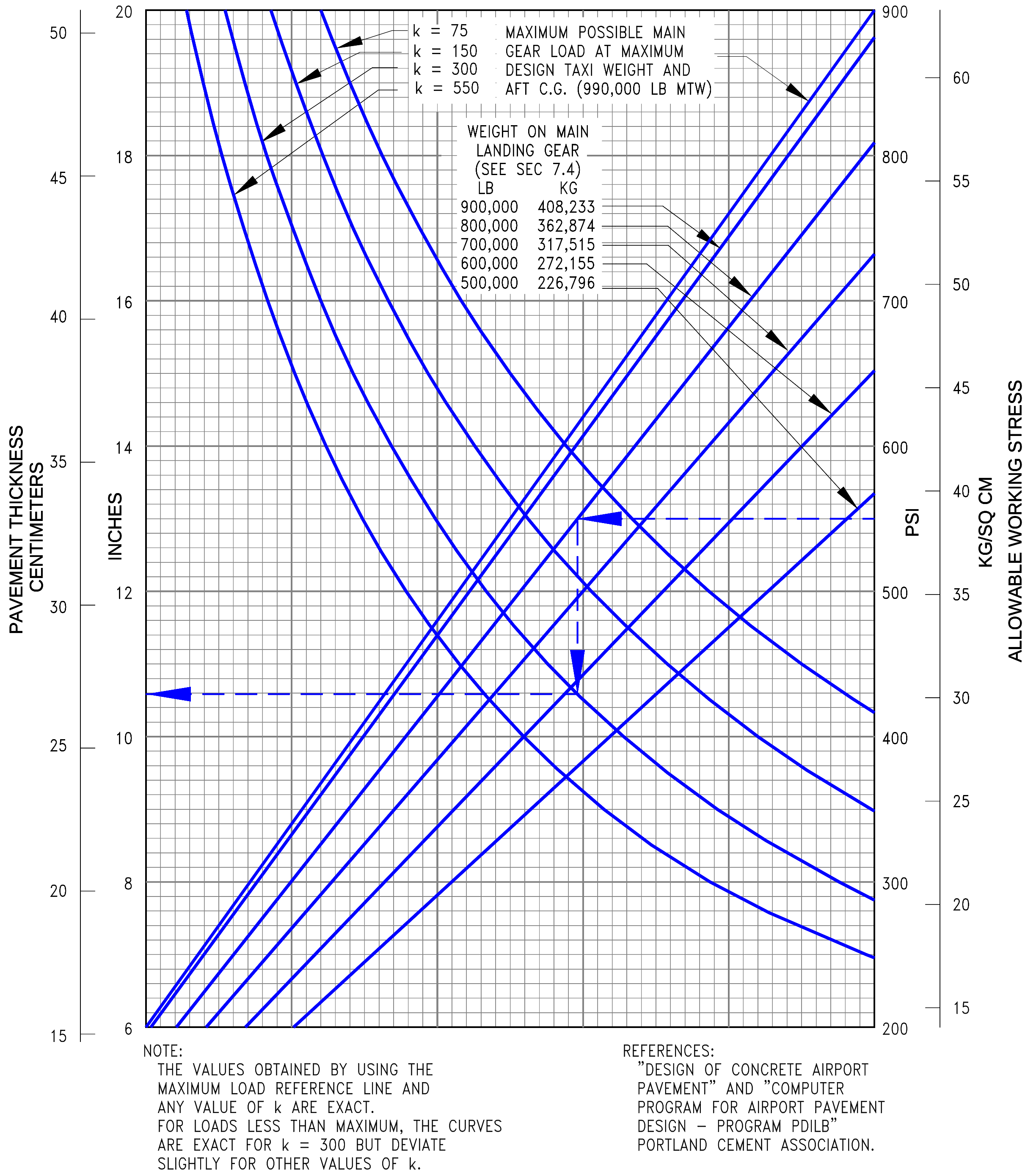


NOTE:
THE VALUES OBTAINED BY USING THE MAXIMUM LOAD REFERENCE LINE AND ANY VALUE OF k ARE EXACT.
FOR LOADS LESS THAN MAXIMUM, THE CURVES ARE EXACT FOR k = 300 BUT DEVIATE SLIGHTLY FOR OTHER VALUES OF k.

REFERENCES:
"DESIGN OF CONCRETE AIRPORT PAVEMENT" AND "COMPUTER PROGRAM FOR AIRPORT PAVEMENT DESIGN – PROGRAM PDILB" PORTLAND CEMENT ASSOCIATION.

7.7.1 RIGID PAVEMENT REQUIREMENTS - PORTLAND CEMENT ASSOCIATION DESIGN METHOD

MODEL 747-8F (978,000 LB, 443,613 KG)



7.7.2 RIGID PAVEMENT REQUIREMENTS - PORTLAND CEMENT ASSOCIATION DESIGN METHOD

MODEL 747-8, 747-8F (990,000 LB, 449,056 KG)

7.8 Rigid Pavement Requirements - LCN Conversion

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

In the examples shown in Section 7.8.2 for a rigid pavement with a radius of relative stiffness of 47 with an LCN of 91, and 7.8.3 for a rigid pavement with a radius of relative stiffness of 47 with an LCN of 87, the apparent maximum allowable weight permissible on the main landing gear is 600,000 lb (272,155 kg) for an airplane with 221-psi (15.54 kg/cm^2) main tires.

Note: If the resultant aircraft LCN is not more that 10% above the published pavement LCN, the bearing strength of the pavement can be considered sufficient for unlimited use by the airplane. The figure 10% has been chosen as representing the lowest degree of variation in LCN that is significant (reference: ICAO Aerodrome Design Manual, Part 2, "Aerodrome Physical Characteristics," Chapter 4, Paragraph 4.1.5.7v, 2nd Edition dated 1965).

RADIUS OF RELATIVE STIFFNESS (l)

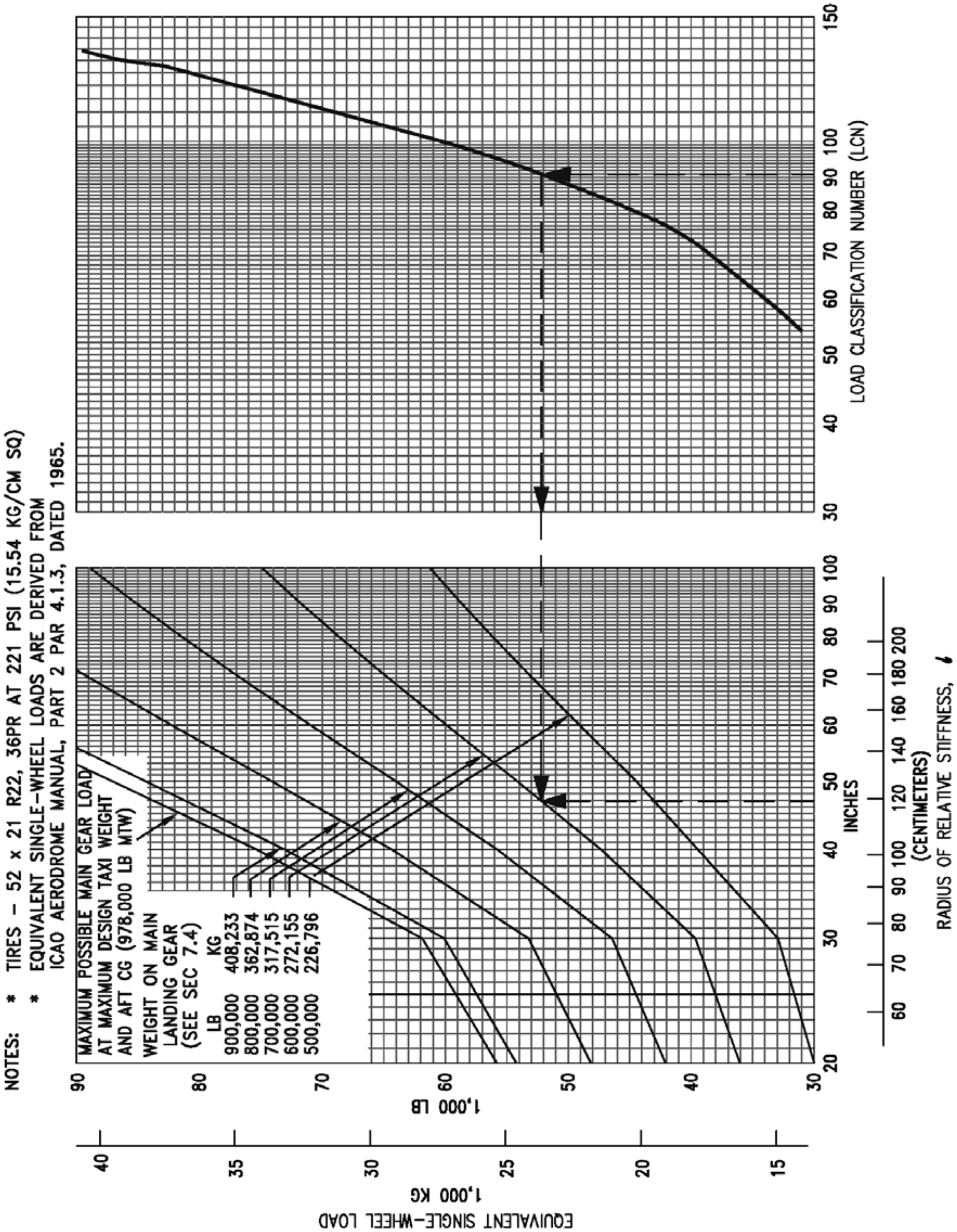
VALUES IN INCHES

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

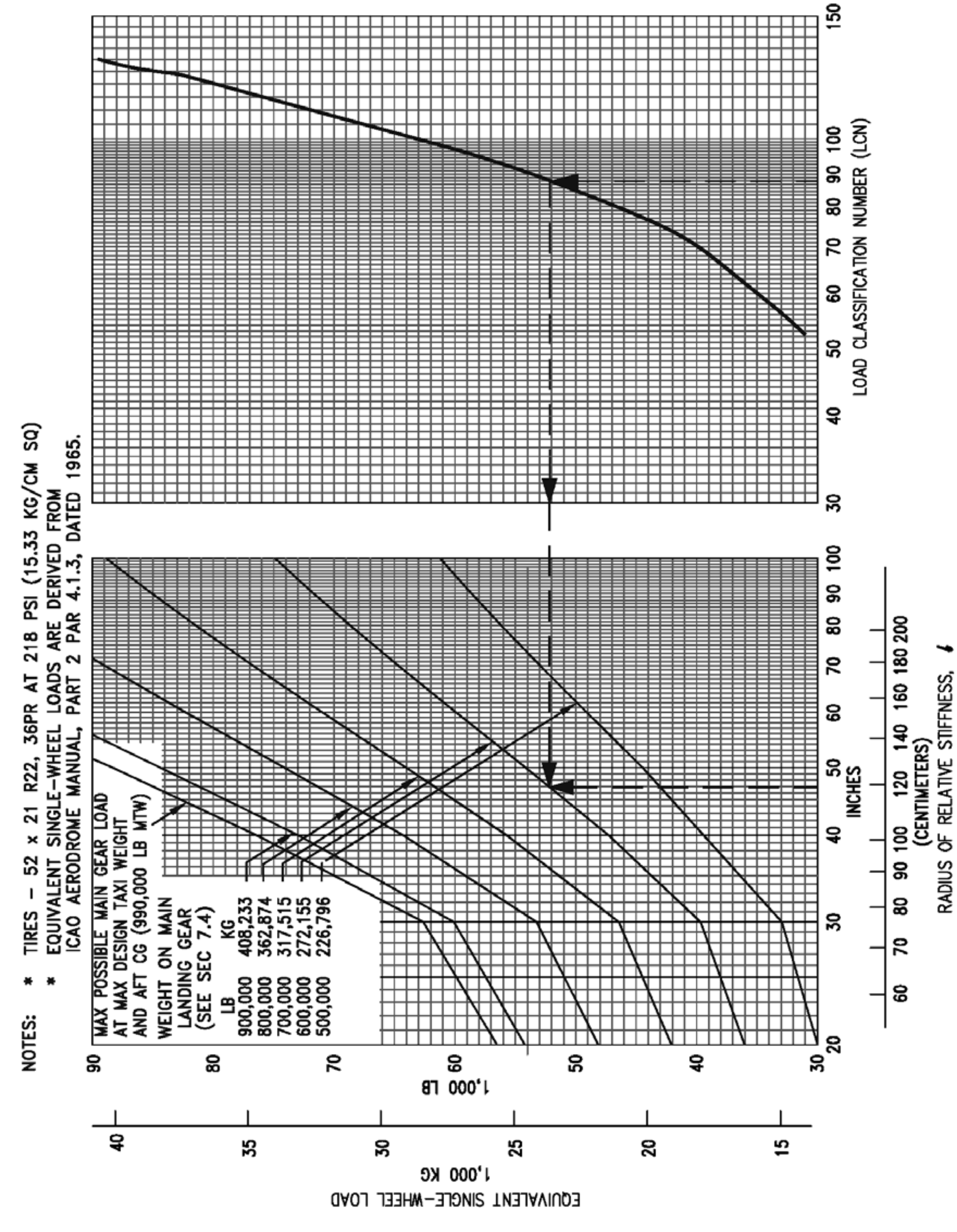
WHERE: E = YOUNG'S MODULUS OF ELASTICITY = 4 x 10^6 psi
k = SUBGRADE MODULUS, LB PER CU IN
d = RIGID PAVEMENT THICKNESS, IN
μ = POISSON'S RATIO = 0.15

d	k = 75	k = 100	k = 150	k = 200	k = 250	k = 300	k = 350	k = 400	k = 500	k = 550
6.0	31.48	29.29	26.47	24.63	23.30	22.26	21.42	20.71	19.59	19.13
6.5	33.42	31.10	28.11	26.16	24.74	23.63	22.74	21.99	20.80	20.31
7.0	35.33	32.88	29.71	27.65	26.15	24.99	24.04	23.25	21.99	21.47
7.5	37.21	34.63	31.29	29.12	27.54	26.31	25.32	24.49	23.16	22.61
8.0	39.06	36.35	32.84	30.56	28.91	27.62	26.57	25.70	24.31	23.73
8.5	40.87	38.04	34.37	31.99	30.25	28.90	27.81	26.90	25.44	24.84
9.0	42.66	39.70	35.88	33.39	31.57	30.17	29.03	28.07	26.55	25.93
9.5	44.43	41.35	37.36	34.77	32.88	31.42	30.23	29.24	27.65	27.00
10.0	46.17	42.97	38.83	36.13	34.17	32.65	31.41	30.38	28.73	28.06
10.5	47.89	44.57	40.27	37.48	35.44	33.87	32.58	31.52	29.81	29.10
11.0	49.59	46.15	41.70	38.81	36.70	35.07	33.74	32.63	30.86	30.14
11.5	51.27	47.72	43.12	40.12	37.95	36.26	34.89	33.74	31.91	31.16
12.0	52.94	49.26	44.51	41.43	39.18	37.43	36.02	34.83	32.94	32.17
12.5	54.58	50.80	45.90	42.71	40.40	38.60	37.14	35.92	33.97	33.17
13.0	56.21	52.31	47.27	43.99	41.60	39.75	38.25	36.99	34.98	34.16
13.5	57.83	53.81	48.63	45.25	42.80	40.89	39.34	38.05	35.99	35.14
14.0	59.43	55.30	49.97	46.50	43.98	42.02	40.43	39.10	36.98	36.11
14.5	61.01	56.78	51.30	47.74	45.15	43.14	41.51	40.15	37.97	37.07
15.0	62.58	58.24	52.62	48.97	46.32	44.25	42.58	41.18	38.95	38.03
15.5	64.14	59.69	53.93	50.19	47.47	45.35	43.64	42.21	39.92	38.98
16.0	65.69	61.13	55.23	51.40	48.61	46.45	44.69	43.22	40.88	39.92
16.5	67.22	62.55	56.52	52.60	49.75	47.53	45.73	44.23	41.83	40.85
17.0	68.74	63.97	57.80	53.79	50.87	48.61	46.77	45.23	42.78	41.77
17.5	70.25	65.38	59.07	54.97	51.99	49.68	47.80	46.23	43.72	42.69
18.0	71.75	66.77	60.34	56.15	53.10	50.74	48.82	47.22	44.65	43.60
19.0	74.72	69.54	62.83	58.47	55.30	52.84	50.84	49.17	46.50	45.41
20.0	77.65	72.26	65.30	60.77	57.47	54.91	52.83	51.10	48.33	47.19
21.0	80.55	74.96	67.73	63.03	59.61	56.95	54.80	53.00	50.13	48.95
22.0	83.41	77.62	70.14	65.27	61.73	58.98	56.75	54.88	51.91	50.68
23.0	86.23	80.25	72.51	67.48	63.82	60.98	58.67	56.74	53.67	52.40
24.0	89.03	82.85	74.86	69.67	65.89	62.95	60.57	58.58	55.41	54.10
25.0	91.80	85.43	77.19	71.84	67.94	64.91	62.46	60.41	57.13	55.78

7.8.1 RADIUS OF RELATIVE STIFFNESS
(REFERENCE: PORTLAND CEMENT ASSOCIATION)



7.8.2 RIGID PAVEMENT REQUIREMENTS - LCN CONVERSION
MODEL 747-8F (978,000 LB, 443,613 KG)



7.8.3 RIGID PAVEMENT REQUIREMENTS - LCN CONVERSION

MODEL 747-8, 747-8F (990,000 LB, 449,056 KG)

7.9 Rigid Pavement Requirements - FAA Design Method

For the rigid pavement design, refer to the FAA website for the FAA design software COMFAA:

http://www.faa.gov/airports/engineering/design_software/

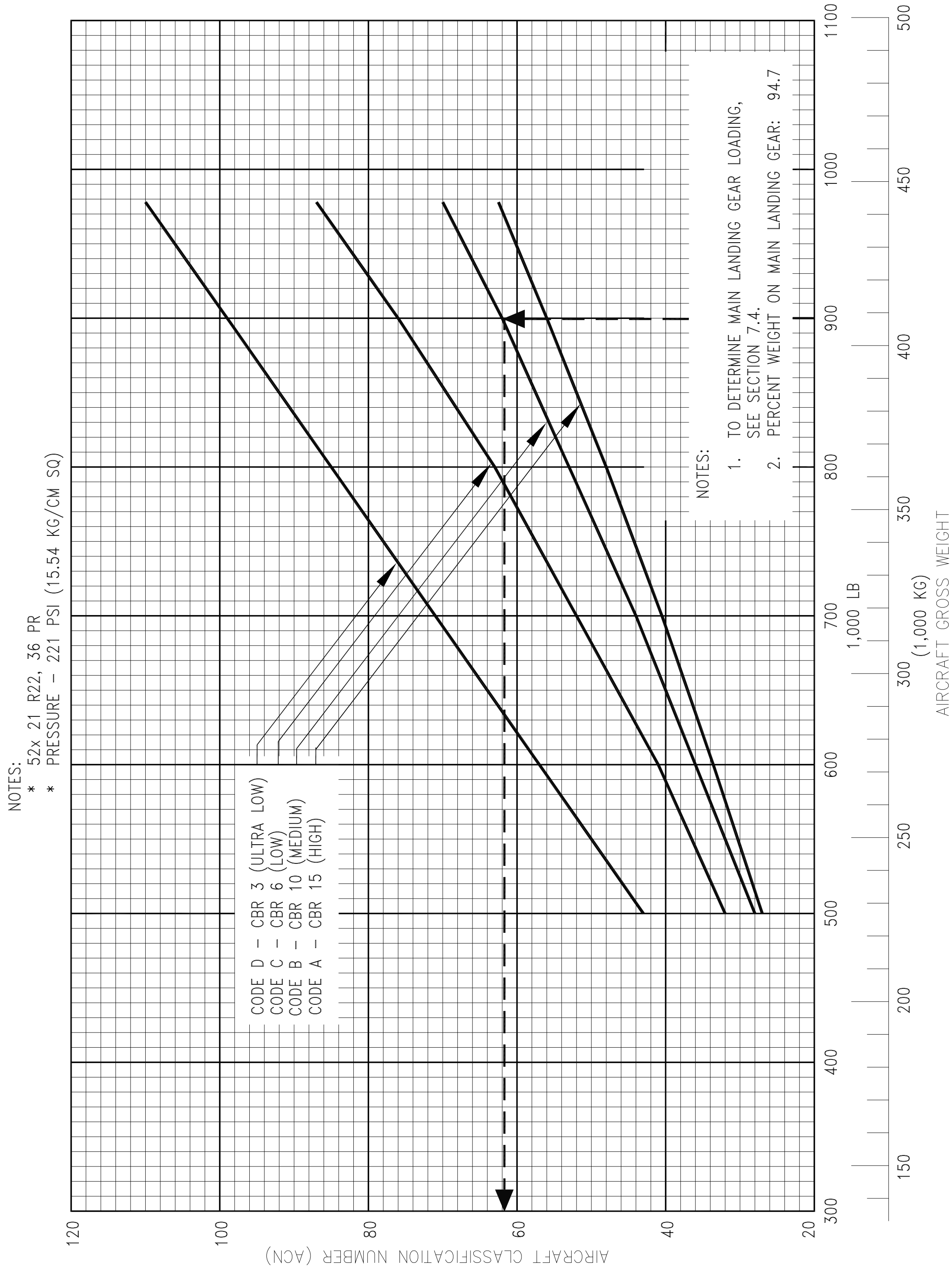
7.10 ACN/PCN Reporting System: Flexible and Rigid Pavements

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. In the chart in Section 7.10.1 and 7.10.3, for an aircraft with gross weight of 900,000 lb (408,233 kg) and medium subgrade strength, the flexible pavement ACN is 62. In Section 7.10.2 and 7.10.4, for the same gross weight and subgrade strength, the rigid pavement ACN is 67.

The following table provides ACN data in tabular format similar to the one used by ICAO in the "Aerodrome Design Manual Part 3, Pavements". If the ACN for an intermediate weight between maximum taxi weight and the empty weight of the aircraft is required, Figures 7.10.1 through 7.10.4 should be consulted.

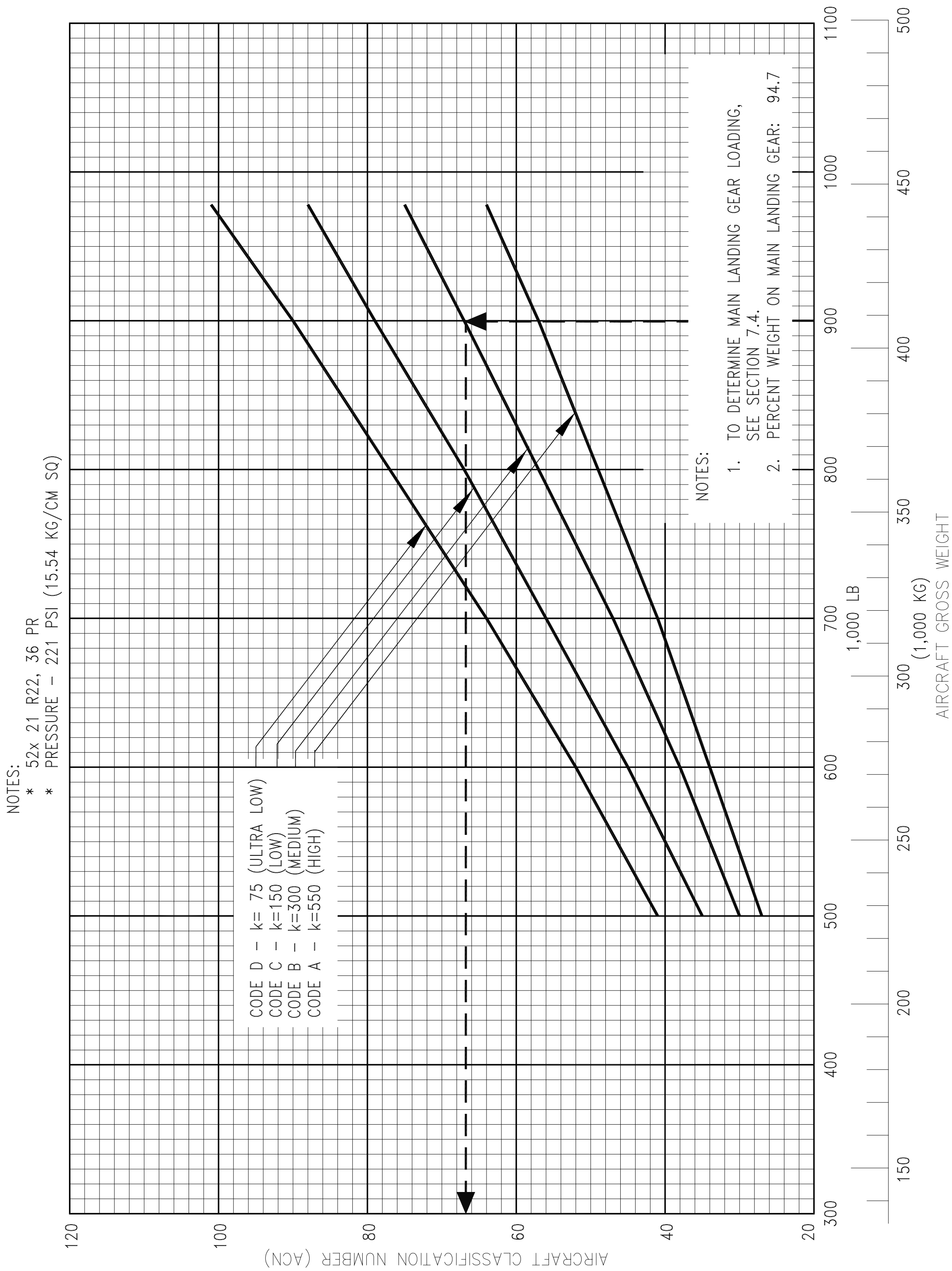
				ACN FOR RIGID PAVEMENT SUBGRADES – MN/m^3				ACN FOR FLEXIBLE PAVEMENT SUBGRADES – CBR			
AIRCRAFT TYPE	MAXIMUM TAXI WEIGHT MINIMUM WEIGHT (1) LB (KG)	LOAD ON ONE MAIN GEAR LEG (%)	TIRE PRESSURE PSI (MPa)	HIGH 150	MEDIUM 80	LOW 40	ULTRA LOW 20	HIGH 15	MEDIUM 10	LOW 6	ULTRA LOW 3
747-8F	978,000 (443,613) 500,000 (226,796)	23.67	221 (1.52)	64 27	75 30	88 35	101 41	63 27	70 28	87 32	110 43
747-8F	990,000 (449,056) 500,000 (226,796)	23.59	221 (1.52)	65 27	76 30	90 35	102 41	63 27	70 28	88 32	111 43
747-8	990,000 (449,056) 500,000 (226,796)	23.67	221 (1.52)	65 27	77 30	90 35	102 41	63 27	71 28	88 32	112 43

(1) Minimum weight used solely as a baseline for ACN curve generation.

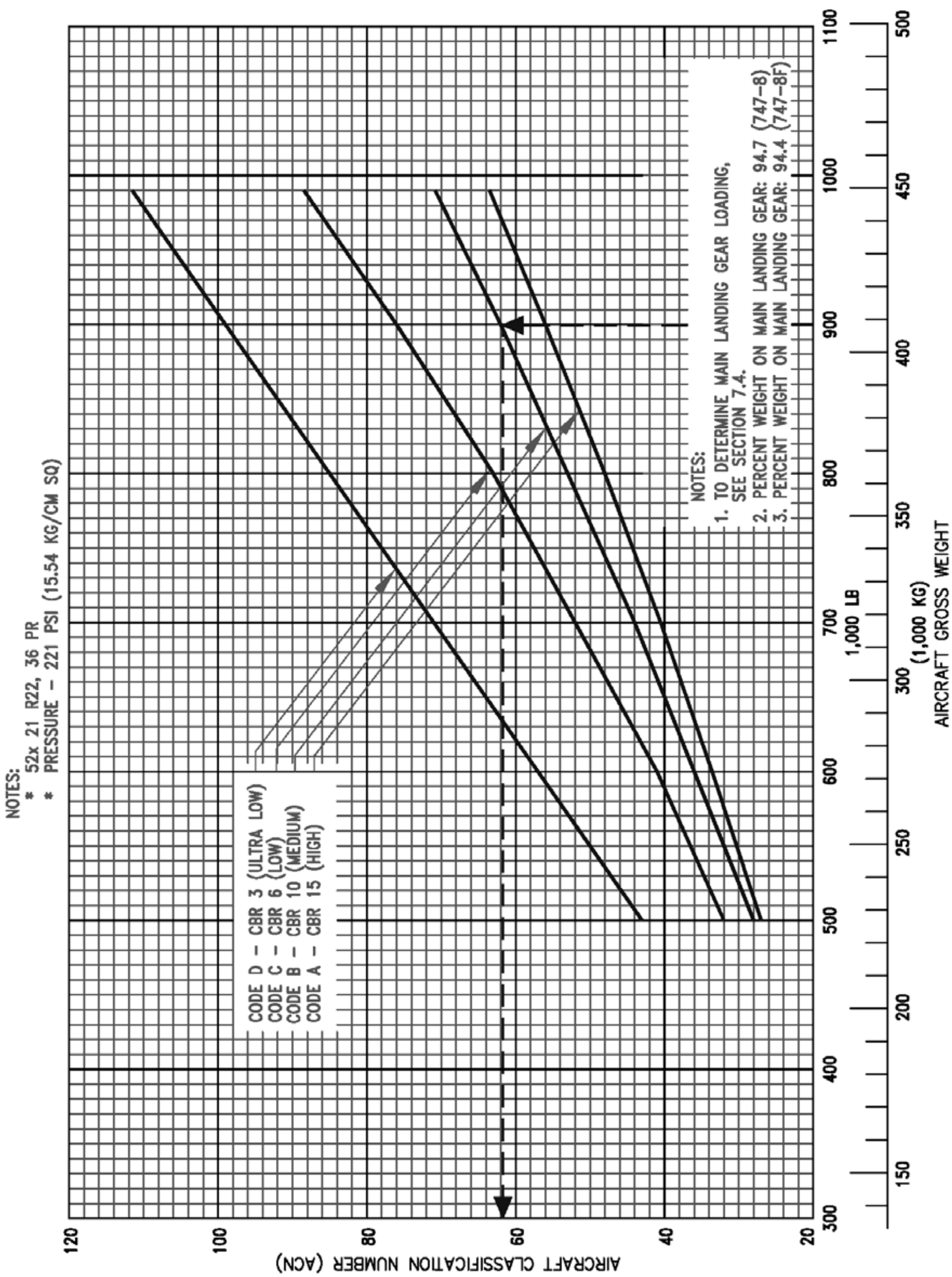


7.10.1 AIRCRAFT CLASSIFICATION NUMBER - FLEXIBLE PAVEMENT

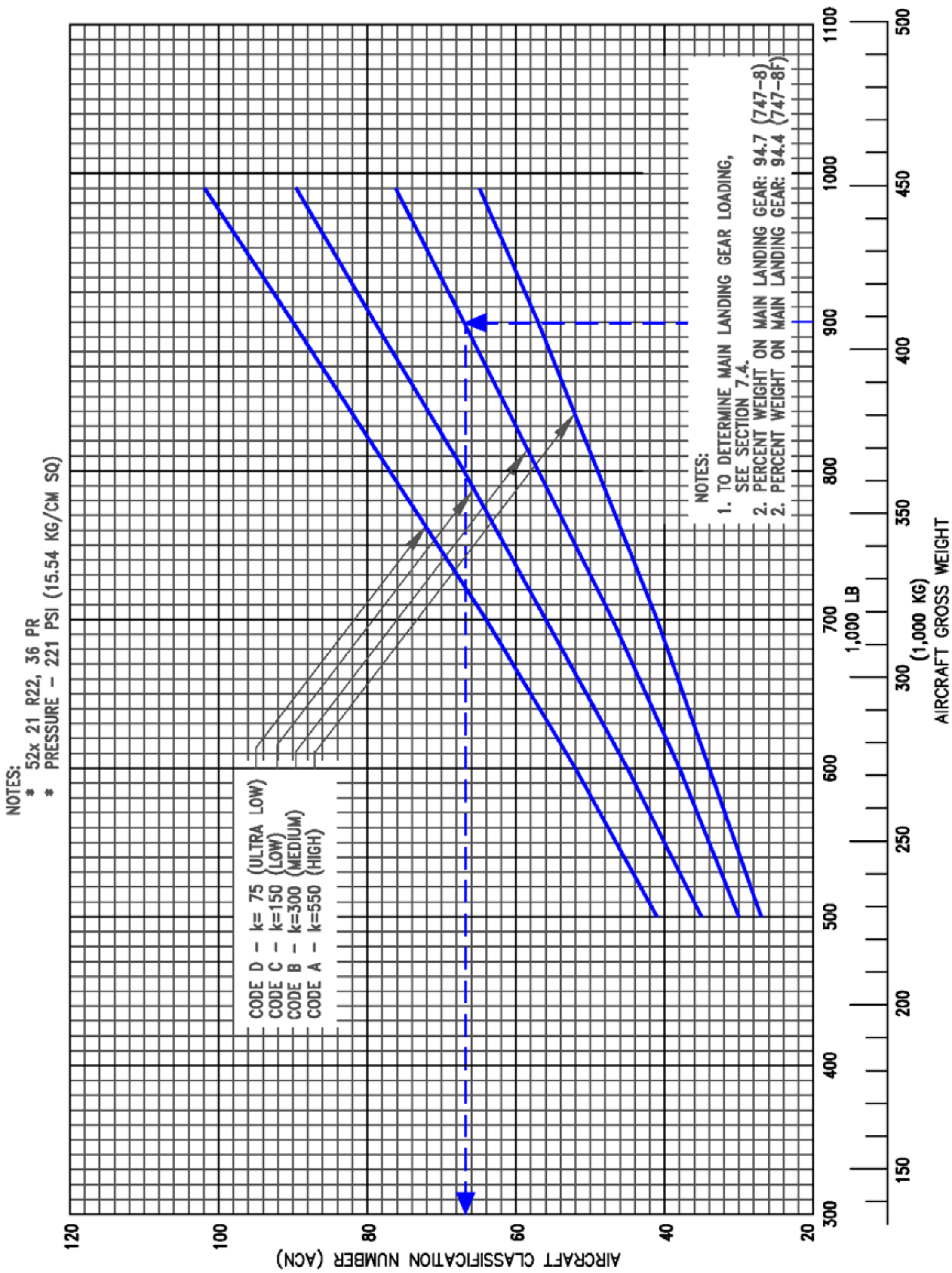
MODEL 747-8F (978,000 LB, 443,613 KG)



7.10.2 AIRCRAFT CLASSIFICATION NUMBER - RIGID PAVEMENT
MODEL 747-8F (978,000 LB, 443,613 KG)



7.10.3 AIRCRAFT CLASSIFICATION NUMBER - FLEXIBLE PAVEMENT
MODEL 747-8 and 747-8F (990,000 LB, 449,056 KG)

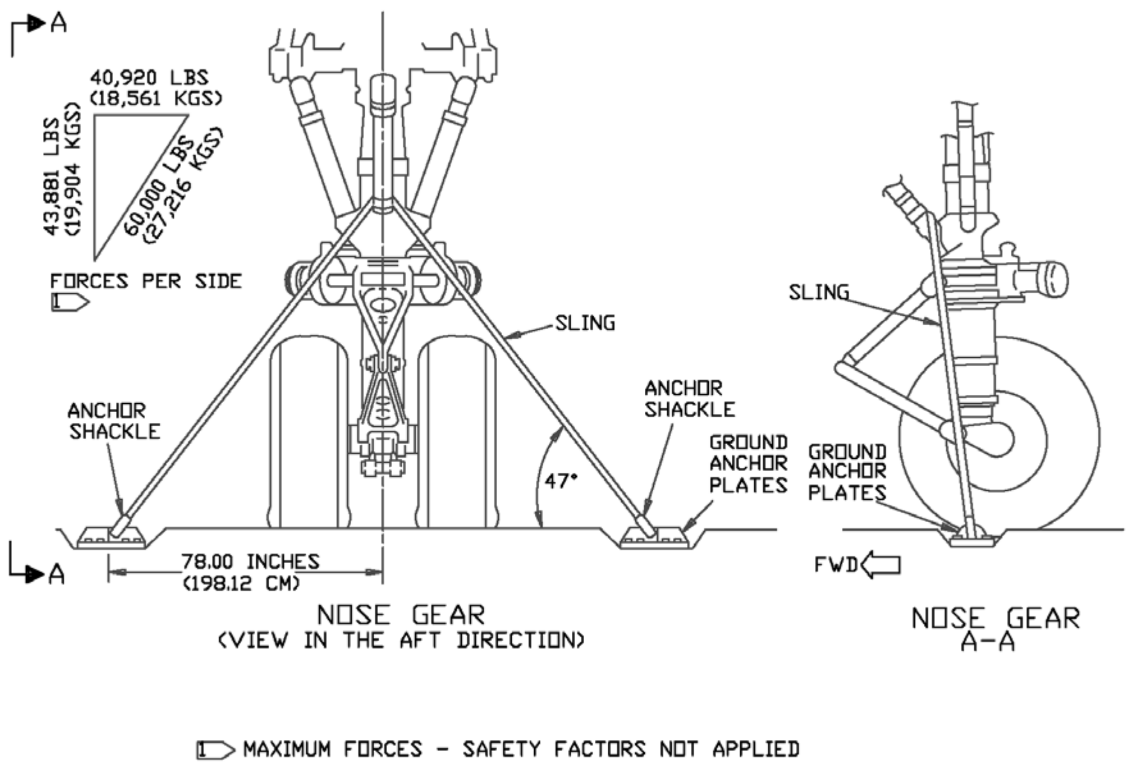


7.10.4 AIRCRAFT CLASSIFICATION NUMBER - RIGID PAVEMENT
MODEL 747-8 and 747-8F (990,000 LB, 449,056 KG)

7.11 Nose Gear Tethering (Optional)

There are two typical methods used to provide support to prevent airplane tipping during ramp operations. During use of a tail stanchion, pavement strength is considered sufficient and there should be no additional requirements.

The alternate method of tethering the nose landing gear may also be used. Boeing does not have a tool design for straps to tether the airplane. Figure 7.11.1 is provided to supply load conditions sufficient to design and/or verify ramp strength is adequate for this purpose.



7.11.1 NOSE GEAR TETHERING (OPTIONAL)
MODEL 747-8 (990,000 LB, 449,056 KG)

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8.0 FUTURE 747-8 DERIVATIVE AIRPLANES

8.0 FUTURE 747-8 DERIVATIVE AIRPLANES

As with most Boeing airplane programs, derivative models are typically being studied to provide additional capabilities of the 747-8 family of airplanes. Future growth versions could address additional passenger count, cargo capacity, increased range, or environmental performance.

Whether and/or when these or other possibilities are actually built is entirely dependent on future airline requirements. In any event, the impact on airport facilities will be a consideration in configuration and design.

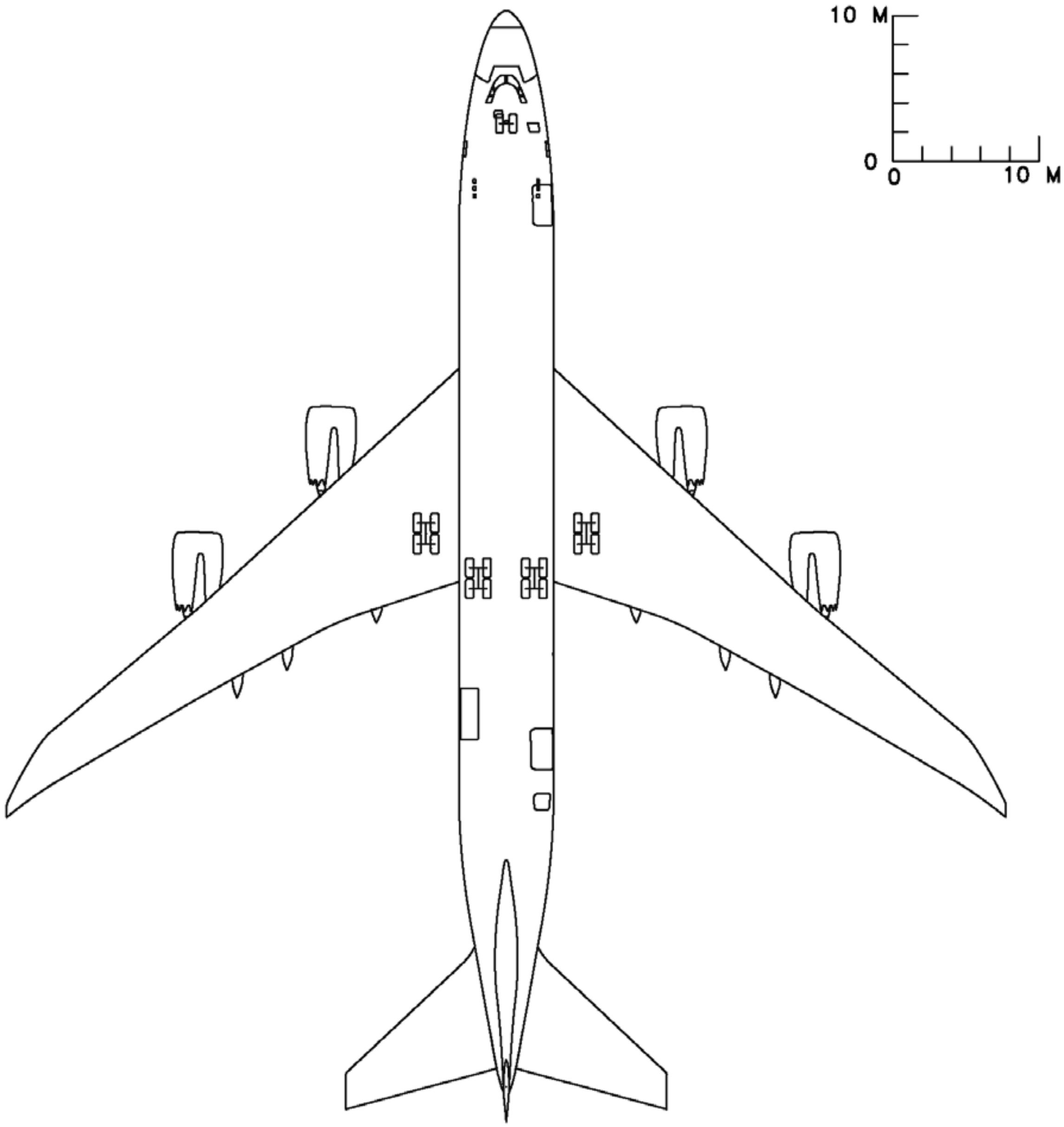
9.0 SCALED 747-8 DRAWINGS

9.1 747-8, 747-8F

9.0 SCALED 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 747-8, along with other Boeing airplane models, may be downloaded from the following website:

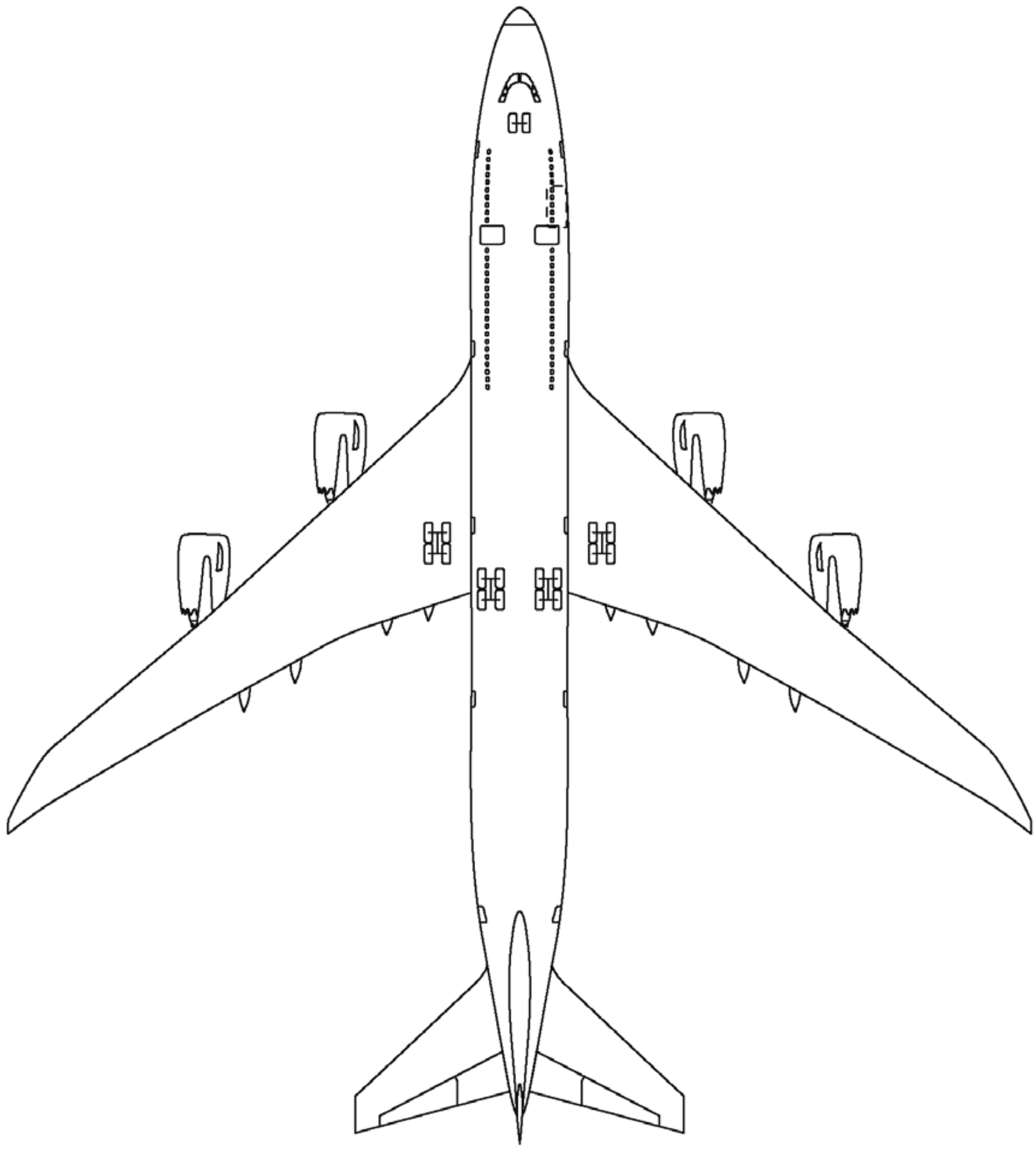
http://www.boeing.com/airports



NOTE: ADJUST FOR PROPER SCALING WHEN PRINTING THIS PAGE

9.1.1 SCALED DRAWING - 1:500

MODEL, 747-8F



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9.1.2 SCALED DRAWING - 1:500

MODEL, 747-8