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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 four 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.

Page 72 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 on Page 73.

Pavement requirements for commercial airplanes are customarily derived from the static analysis of loads imposed on the main landing gear struts. The chart on Page 74 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 (Page 75) are based on procedures set forth in Instruction Report No. S-77-1, "Procedures for Development of CBR Design Curves," dated June 1977, and as modified according to the methods described in ICAO Aerodrome Design Manual, Part 3, Pavements, 2nd Edition, 1983, Section 1.1 (The ACN-PCN Method), and utilizing the alpha factors approved by ICAO in October 2007. Instruction Report No. S-77-1 was prepared by the U.S. Army Corps of Engineers Waterways Experiment Station, Soils and Pavements Laboratory, Vicksburg, Mississippi. The line showing 10,000 coverages is used to calculate Aircraft Classification Number (ACN).

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 American Concrete Pavement 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.

new format described in the 1968 Portland Cement Association publication "Operating Instructions — Computer Program for Concrete Airport Pavement Design," (Program PDILB) by Robert G. Packard.

The following procedure is used to develop rigid pavement design curves such as those shown on **Page 80**:

1. Having established the scale for pavement thickness to the left and the scale for allowable working stress to the right, an arbitrary load line is drawn representing the main landing gear maximum weight to be shown.
2. All values of the subgrade modulus (k values) are then plotted as shown on **Page 80**.
3. Additional load lines for the incremental values of weight on the main landing gear are then established on the basis of the curve for $k = 300$, already established.

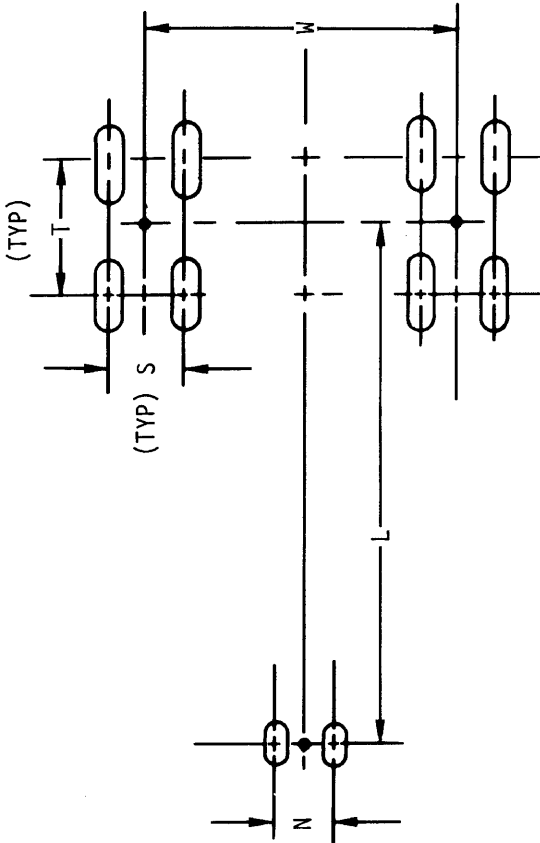
All LCN curves where shown have been plotted from data in the International Civil Aviation Organization (ICAO) Document 7920-AN/865/2, Aerodrome Manual, Part 2, "Aerodrome Physical Characteristics," 2nd Edition, 1965.

On the same charts showing LCN versus equivalent single-wheel load, there are load plots for the 720 and 720B showing equivalent single-wheel load versus pavement thickness (h) for flexible pavements and versus l (radius of relative stiffness) for rigid pavements.

Procedures and curves provided in the ICAO Aerodrome Manual, Part 2, Chapter 4, are used to determine equivalent single-wheel loads for use in making LCN conversion of rigid pavement requirements.

NOTE: Pavement requirements are presented for loads, tires, and tire pressures presently planned for certified commercial usage.

All curves represent data at a constant specified tire pressure.



7.2 LANDING GEAR FOOTPRINT
MODELS 720, 720B

MODEL	MAXIMUM RAMP WEIGHT	PERCENT OF WEIGHT ON MAIN GEAR	NOSE TIRE SIZE	NOSE TIRE PRESSURE	MAIN GEAR TIRE SIZE	MAIN GEAR TIRE PRESSURE	L	N	S	T	W
720	230,000 LB 104,400 KG	SEE PAGE (74)	(2) 34 X 9.9	100 PSI 7.04 KG/CM ²	(8) 40 X 14	145 PSI 10.2 KG/CM ²	50 FT 8 IN. (15.44 M)	1 FT 10 IN. (0.56 M)	2 FT 8 IN. (0.81 M)	4 FT 1 IN. (1.24 M)	21 FT 11 IN. (6.68 M)
720 B	235,000 LB 106,700 KG	SEE PAGE (74)	(2) 39 X 13	115 PSI 8.10 KG/CM ²	(8) 40 X 14	145 PSI 10.2 KG/CM ²	50 FT 8 IN. (15.44 M)	1 FT 10 IN. (0.56 M)	2 FT 8 IN. (0.81 M)	4 FT 1 IN. (1.24 M)	21 FT 11 IN. (6.68 M)

7.3 MAXIMUM GROUND LOADS
MODELS 720, 720B

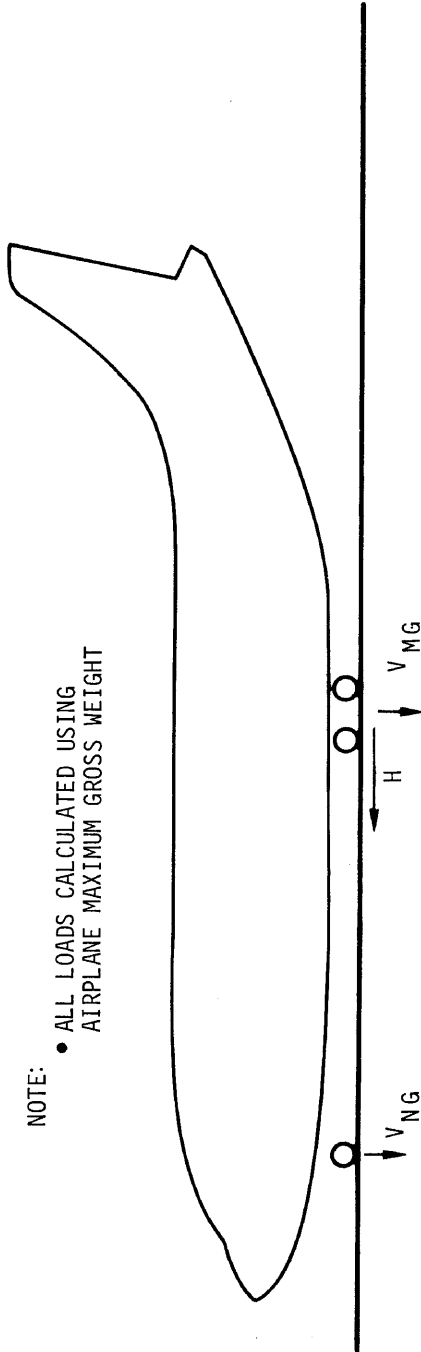
V_{NG} = MAXIMUM VERTICAL NOSE GEAR GROUND LOAD AT MOST FORWARD CG

V_{MG} = MAXIMUM VERTICAL MAIN GEAR GROUND LOAD AT MOST AFT CG

H = MAXIMUM HORIZONTAL GROUND LOAD FROM BRAKING

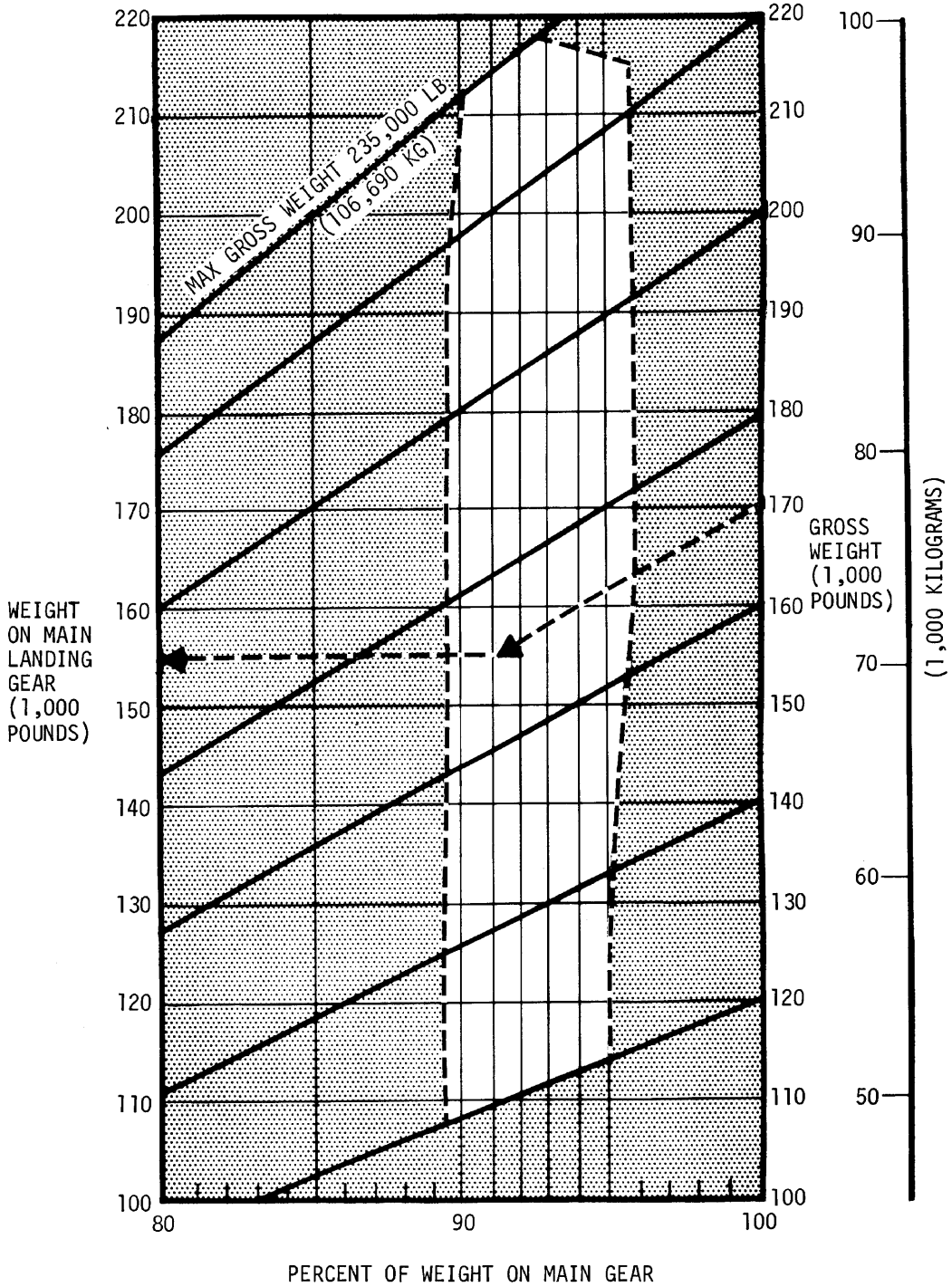
NOTE:

- ALL LOADS CALCULATED USING AIRPLANE MAXIMUM GROSS WEIGHT

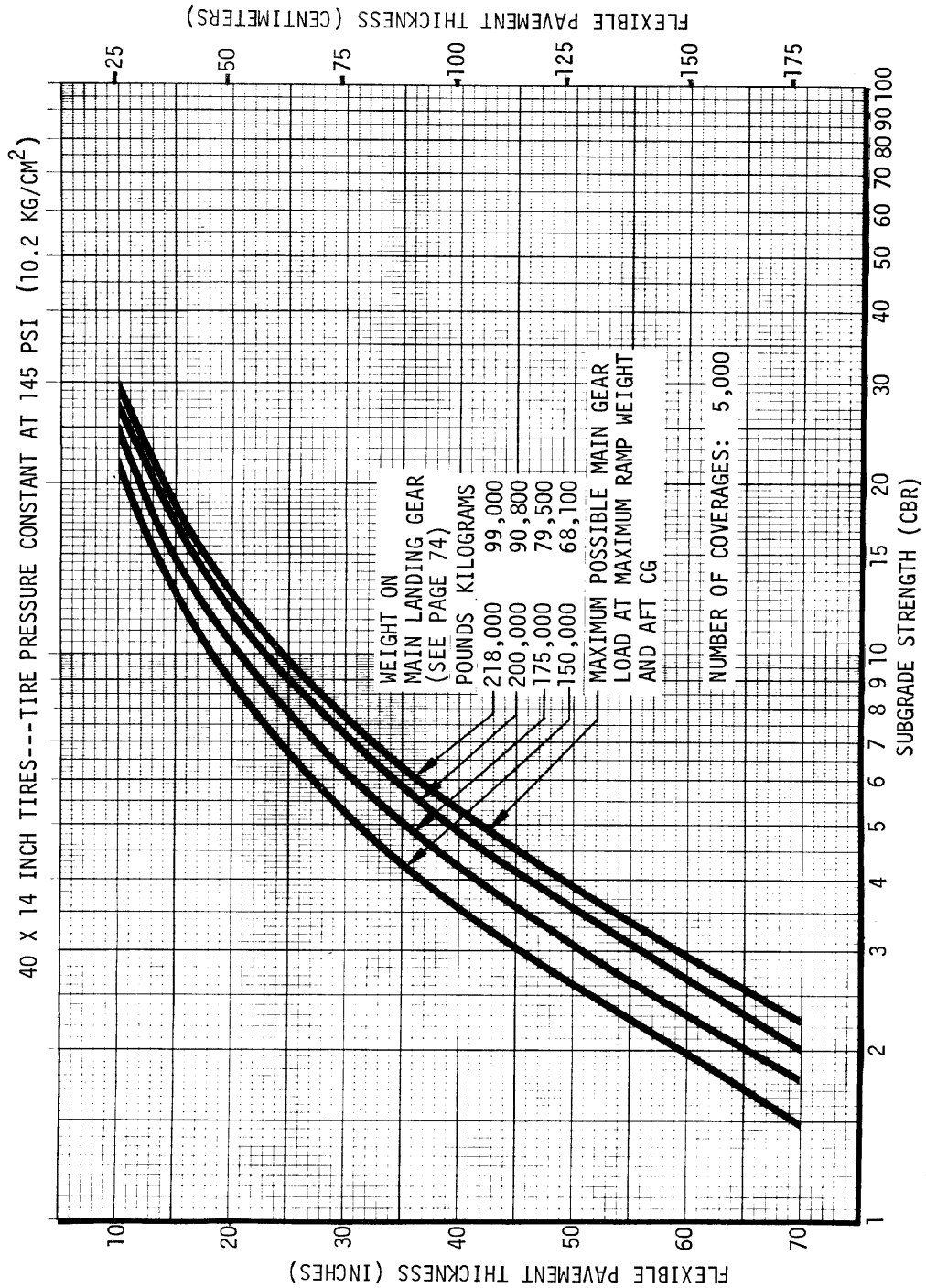


MODEL	MAXIMUM GROSS WEIGHT	V_{NG}		V_{MG} PER STRUT (2)	H (PER STRUT (2))	
		STATIC AT MOST FORWARD CG	STATIC + BRAKING @ 10 FT/SEC ² DECELERATION		MAXIMUM LOAD OCCURRING AT STATIC AFT CG	AT STEADY BRAKING 10 FT/SEC ² DECELERATION
	LB	KG	LB	KG	LB	KG
720	(720B LOADS ARE APPLICABLE TO THE 720)					
720B	235,000 LB	10,260	35,870	109,000	36,500	87,250
	106,700 KG	16,250	49,480	16,570	39,610	

NOTE: UNSHADED AREAS REPRESENT OPERATIONAL LIMITS



7.4 LANDING GEAR LOADING ON PAVEMENT
MODELS 720, 720B



7.5 FLEXIBLE PAVEMENT REQUIREMENTS, SEFL 165A — U.S. CORPS OF ENGINEERS DESIGN METHOD
MODELS 720, 720B

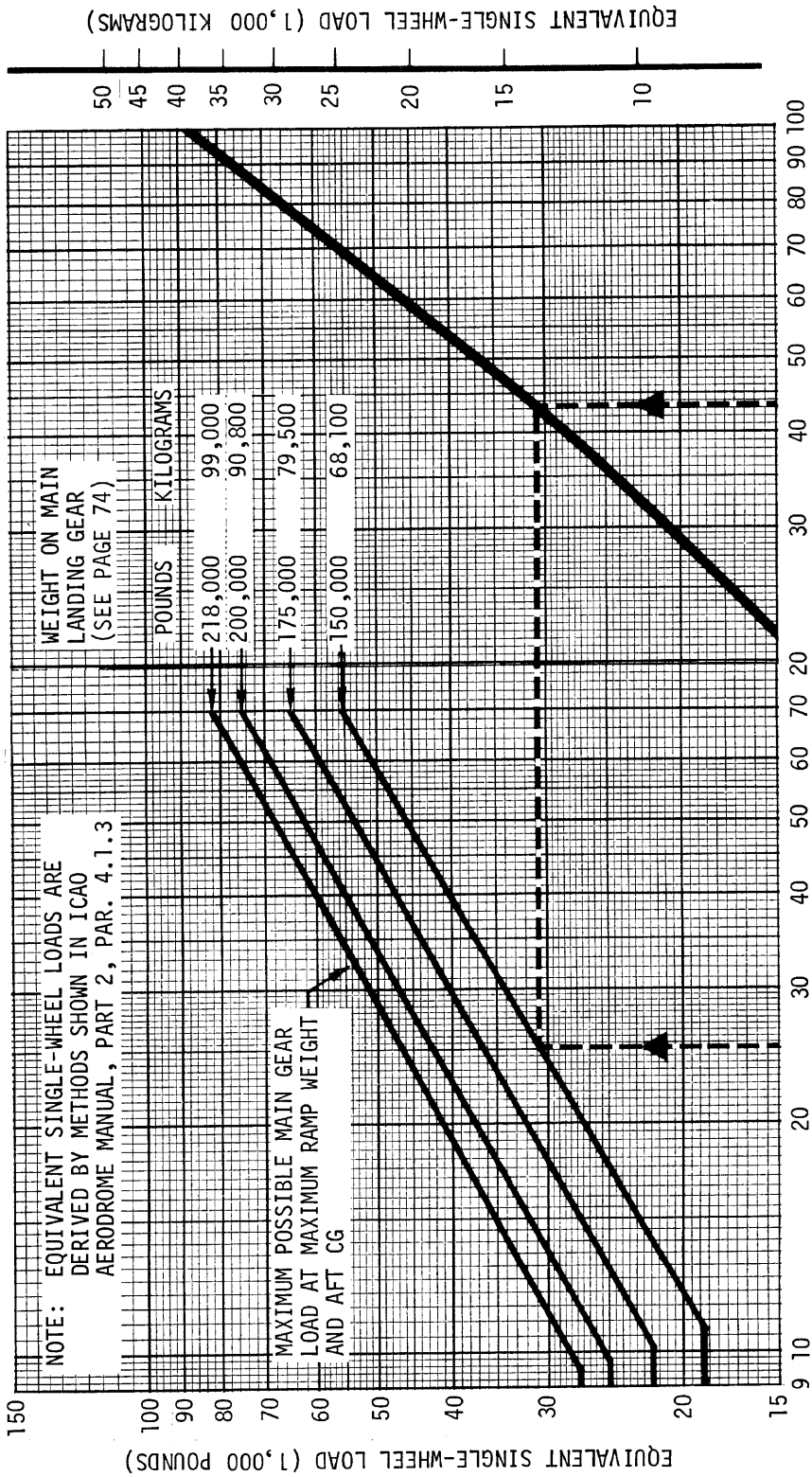
7.6 Flexible Pavement Requirements, LCN Conversion

In order to determine the aircraft weight that can be accommodated on a particular flexible pavement, both the LCN of the pavement and the thickness (h) of the pavement must be known.

In the example for the 720 and 720B, shown on Page 77, the flexible pavement thickness is shown at 25 inches with an LCN of 43. For these conditions the apparent maximum allowable weight permissible on the main landing gear is 150,000 pounds.

NOTE: Provided that the resultant aircraft LCN is not more than 10% above the published pavement LCN, it is the United Kingdom view that the bearing strength of the pavement can be considered sufficient for unlimited use by the aircraft. The figure of 10% has been chosen as representing the lowest degree of variation in LCN which is significant. (Reference: ICAO Aerodrome Manual, Part 2, "Aerodrome Physical Characteristics," Chapter 4, Paragraph 4.1.5.7v.)

40 X 14 INCH TIRES---TIRE PRESSURE CONSTANT AT 145 PSI (10.2 KG/CM²)



FLEXIBLE PAVEMENT REQUIREMENTS — LCN CONVERSION MODELS 720, 720B

7.7 Rigid Pavement Requirements, Portland Cement Association Design Method

Rigid pavement requirements, herein presented, are based upon two Portland Cement Association practices:

1. The former standard manual method of counting unit moment blocks on the Pickett and Ray influence charts (Reference: Portland Cement Association publication, "Design of Concrete Airport Pavement," 1955).
2. The new computerized version of the above as described in document XP-6705-2 "Computer Program for Airport Pavement Design," by Robert G. Packard, Portland Cement Association, 1967.

Higher stresses for equivalent pavement thicknesses are obtained by the computerized method. These occur because of the following:

1. Increased Radius of Influence

The effect of influence from adjacent wheels by the manual method was limited to approximately 2 times l (the radius of relative stiffness). The computer utilizes the Westergaard equation directly and includes influence from all wheels within a radius of 3 times l .

2. Maximizing Process

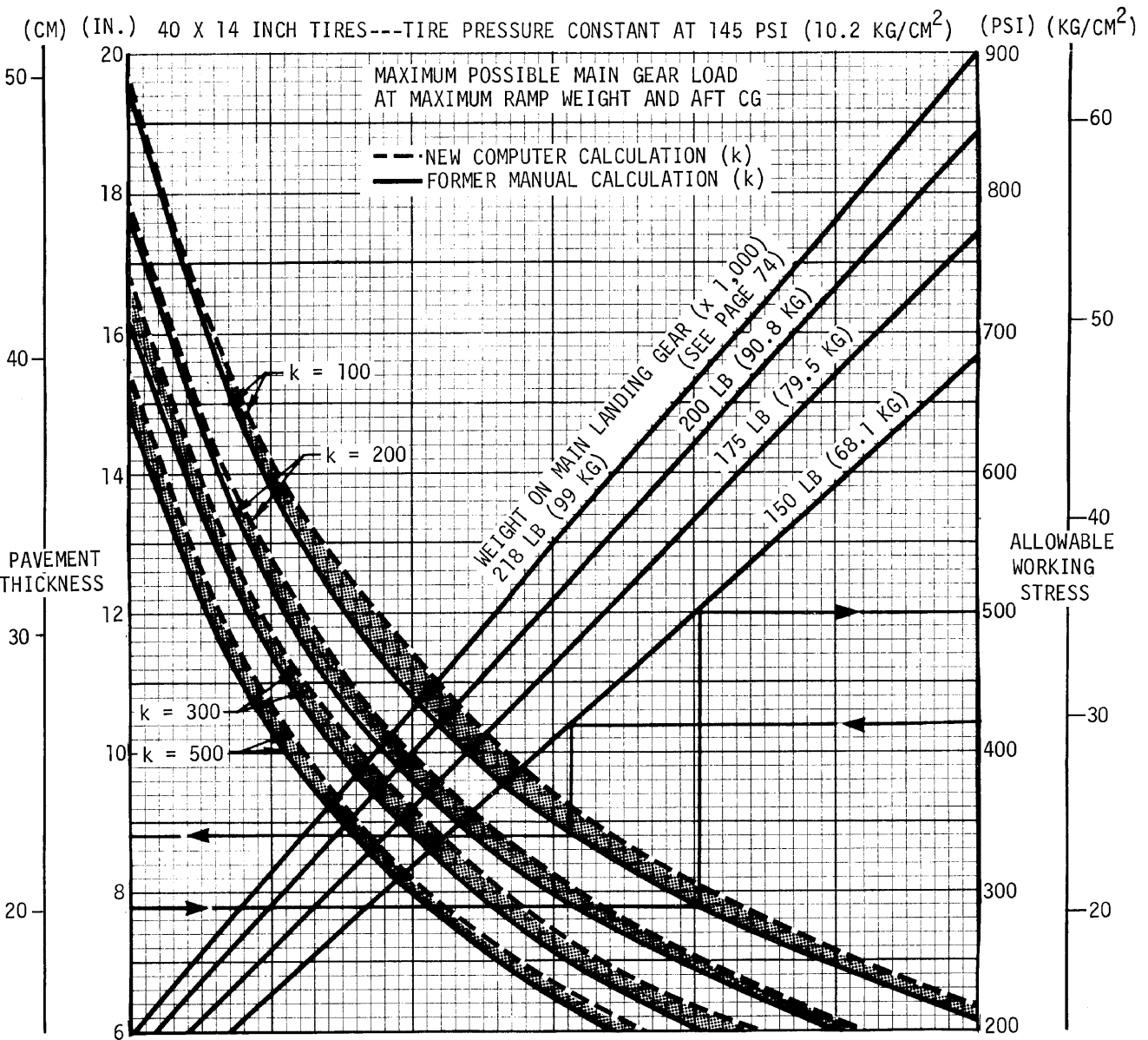
It has been common practice when using the manual count method to align the landing gear footprint on the major axis of the influence chart with one wheel centered over the origin. While this practice does not necessarily produce the maximum possible moment, the values obtained have been considered practical since the procedure eliminates arduous repetitive manual summations of moment blocks.

The computer determines the actual maximum stress values by a combination of shifting the footprint in relationship to the origin and by angular rotation of the footprint.

3. Difference in Footprint Shape

An elliptical contact area is used in the computerized version to represent a single-wheel footprint instead of a rectangle with rounded ends. The variance in moment attributed to this change is minor.

Actual pavement stress for any given model of airplane has not increased. The state of the art in calculation of pavement stress has advanced to permit prediction of stress values to a higher degree of certainty. This permits a proportionate decrease in design stress safety factor.



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 ASSN

NOTICE: DUE TO CHANGES PER NEW COMPUTER METHOD, VALUES OF STRESS ARE HIGHER THAN OBTAINED BY FORMER STANDARD MANUAL METHOD. (SEE PAGE 78)

RIGID PAVEMENT REQUIREMENTS — PORTLAND CEMENT ASSOCIATION DESIGN METHOD MODELS 720, 720B

D6-58323

RADIUS OF RELATIVE STIFFNESS (ℓ)

VALUES OF ℓ IN INCHES

FOR E = 4,000,000 PSI AND $\mu = 0.15$

$$\text{RADIUS OF RELATIVE STIFFNESS} = \ell = 4 \sqrt{\frac{E d^3}{12(1-\nu^2)k}} = 24.1652 \sqrt{\frac{d^3}{k}}$$

d (IN.)	k=50	k=100	k=150	k=200	k=250	k=300	k=350	k=400	k=500
6	34.84	29.30	26.47	24.63	23.30	22.26	21.42	20.72	19.59
6.5	36.99	31.11	28.11	26.16	24.74	23.64	22.74	22.00	20.80
7	39.11	32.89	29.72	27.65	26.15	24.99	24.04	23.25	21.99
7.5	41.19	34.63	31.29	29.12	27.54	26.32	25.32	24.49	23.16
8	43.23	36.35	32.85	30.57	28.91	27.62	26.58	25.70	24.31
8.5	45.24	38.04	34.37	31.99	30.25	28.91	27.81	26.90	25.44
9	47.22	39.71	35.88	33.39	31.58	30.17	29.03	28.08	26.55
9.5	49.17	41.35	37.36	34.77	32.89	31.42	30.23	29.24	27.65
10	51.10	42.97	38.83	36.14	34.17	32.65	31.42	30.39	28.74
10.5	53.01	44.57	40.28	37.48	35.45	33.87	32.59	31.52	29.81
11	54.89	46.16	41.71	38.81	36.71	35.07	33.75	32.64	30.87
11.5	56.75	47.72	43.12	40.13	37.95	36.26	34.89	33.74	31.91
12	58.59	49.27	44.52	41.43	39.18	37.44	36.02	34.84	32.95
12.5	60.41	50.80	45.90	42.72	40.40	38.60	37.14	35.92	33.97
13	62.22	52.32	47.27	43.99	41.61	39.75	38.25	36.99	34.99
13.5	64.00	53.82	48.63	45.26	42.80	40.89	39.35	38.06	35.99
14	65.77	55.31	49.98	46.51	43.98	42.02	40.44	39.11	36.99
14.5	67.53	56.78	51.31	47.75	45.16	43.15	41.51	40.15	37.97
15	69.27	58.25	52.63	48.98	46.32	44.26	42.58	41.19	38.95
15.5	70.99	59.70	53.94	50.20	47.47	45.36	43.64	42.21	39.92
16	72.70	61.13	55.24	51.41	48.62	46.45	44.70	43.23	40.88
16.5	74.40	62.56	56.53	52.61	49.75	47.54	45.74	44.24	41.84
17	76.08	63.98	57.81	53.80	50.88	48.61	46.77	45.24	42.78
17.5	77.75	65.38	59.48	54.98	52.00	49.68	47.80	46.23	43.72
18	79.41	66.78	60.35	56.16	53.11	50.74	48.82	47.22	44.66
19	82.70	69.54	62.84	58.48	55.31	52.84	50.84	49.17	46.51
20	85.95	72.27	65.30	60.77	57.47	54.92	52.84	51.10	48.33
21	89.15	74.97	67.74	63.04	59.62	56.96	54.81	53.01	50.13
22	92.31	77.63	70.14	65.28	61.73	58.98	56.75	54.89	51.91
23	95.44	80.26	72.52	67.49	63.83	60.98	58.68	56.75	53.67
24	98.54	82.86	74.87	69.68	65.90	62.96	60.58	58.59	55.41

RADIUS OF RELATIVE STIFFNESS (REFERENCE:
PORTLAND CEMENT ASSOCIATION)

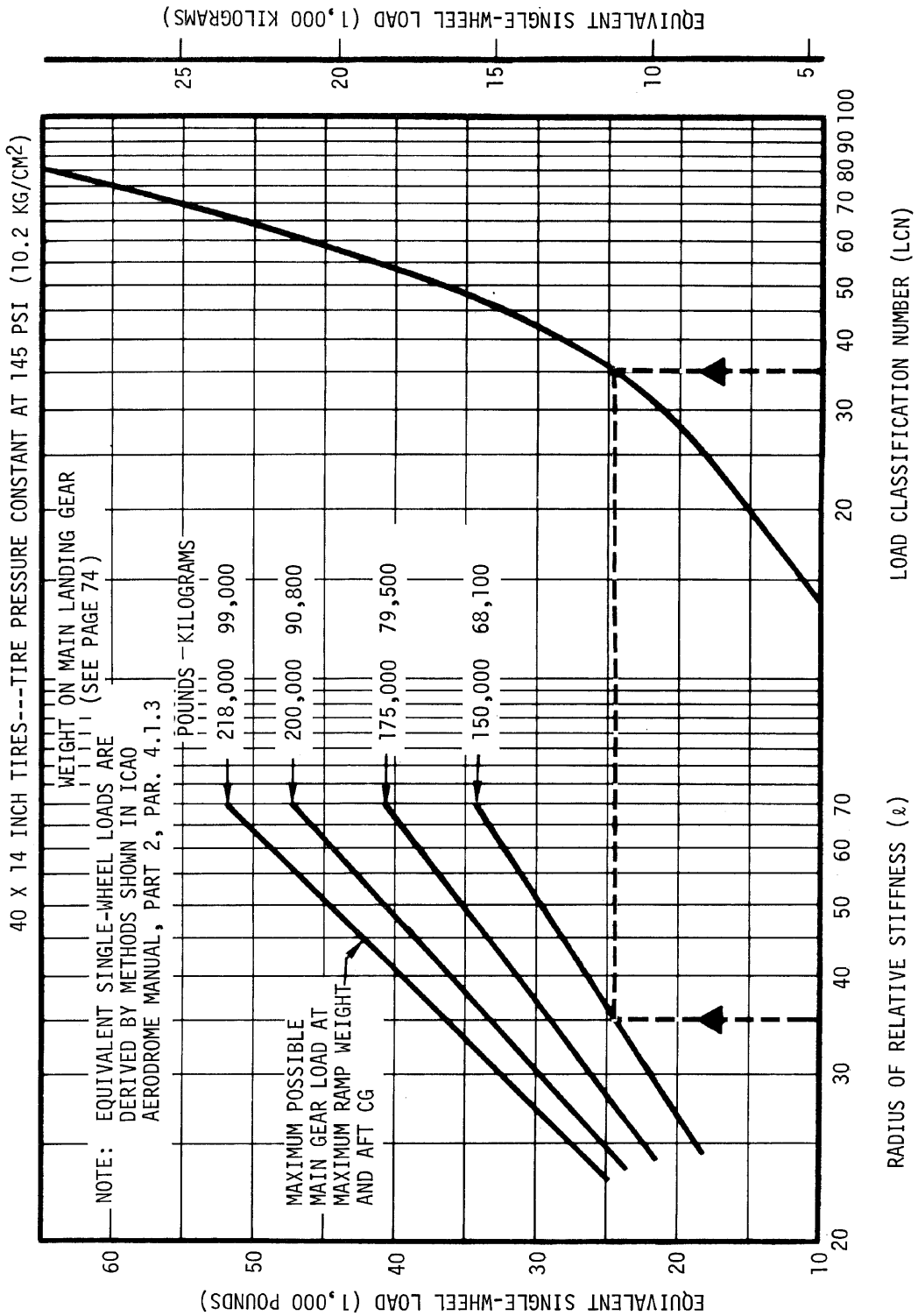
7.8 Rigid Pavement Requirements, LCN Conversion

In order to determine the aircraft weight that can be accommodated on a particular rigid pavement, both the LCN of the pavement and the radius of relative stiffness (f) of the pavement must be known.

In the example for the 720 and 720B, shown on Page 83, the rigid pavement radius of relative stiffness (f) is shown at 35 with an LCN of 35. For these conditions, the apparent maximum allowable weight permissible on the main landing gear is 150,000 pounds.

NOTE: Provided that the resultant aircraft LCN is not more than 10% above the published pavement LCN it is the United Kingdom view that the bearing strength of the pavement can be considered sufficient for unlimited use by the aircraft. The figure of 10% has been chosen as representing the lowest degree of variation in LCN which is significant. (Reference: ICAO Aerodrome Manual, Part 2, "Aerodrome Physical Characteristics," Chapter 4, Paragraph 4.1.5.7v.)

RIGID PAVEMENT REQUIREMENTS, LCN CONVERSION
 MODELS 720, 720B



7.9 Flexible and Rigid Pavement Requirements, FAA Method

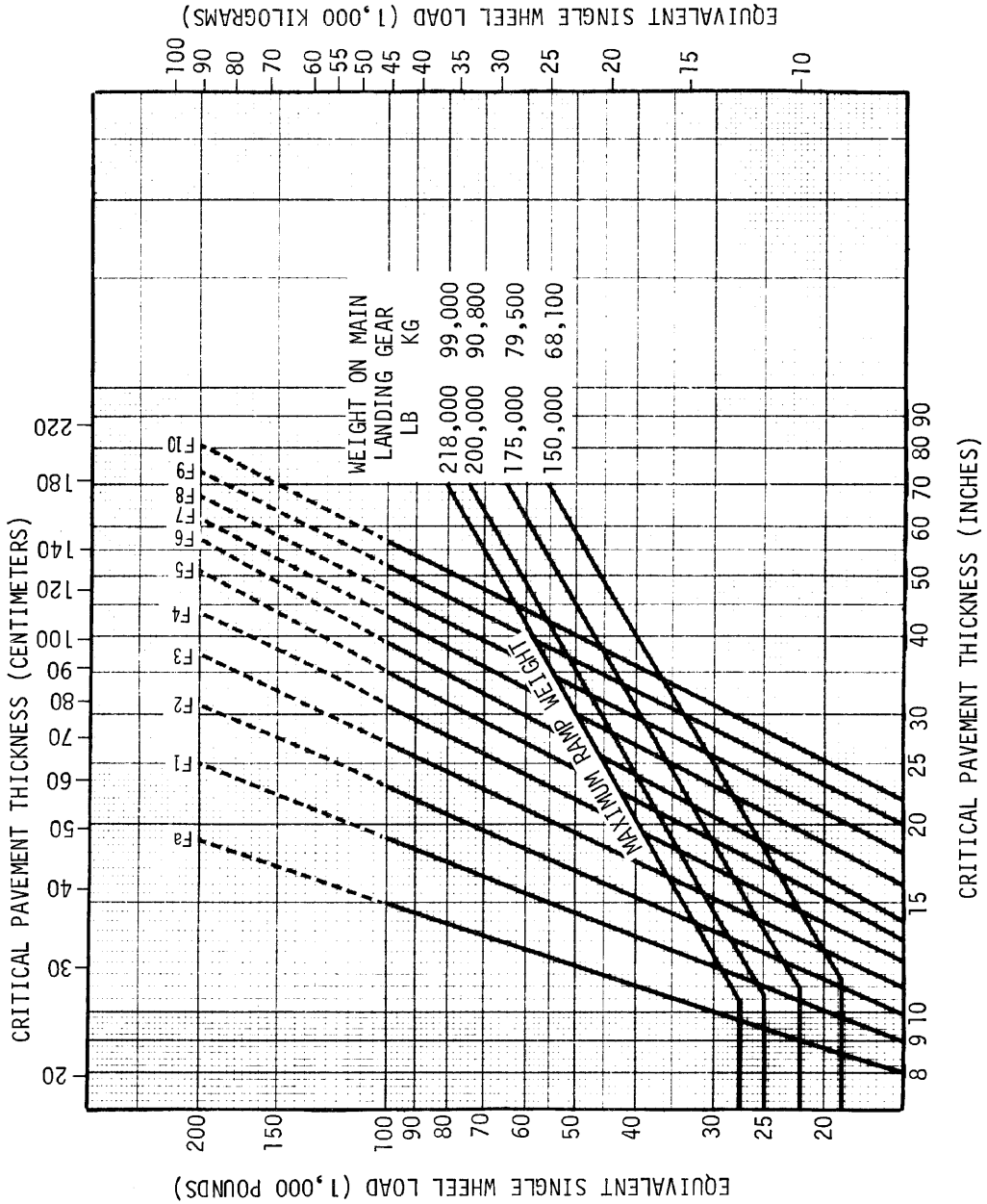
The charts on Pages 85 and 86 are developed directly from pages in FAA Advisory Circular AC 150/5320-6A, May 9, 1967.

Pavement thicknesses are shown for gross aircraft weight irrespective of landing gear configuration and tire pressure. The following general assumptions were made by the FAA in preparing the charts:

1. Ninety-five percent of the gross aircraft weight is assumed to be supported by the main gear.
2. Dual-tandem wheel spacings are not given specifically, but certain design compromises are made as described in the Advisory Circular Appendix 1 in order to develop the curves shown.

The subgrade ratings for pavements are shown as standard FAA designations. These ratings and their derivation are fully described in the Advisory Circular mentioned above.

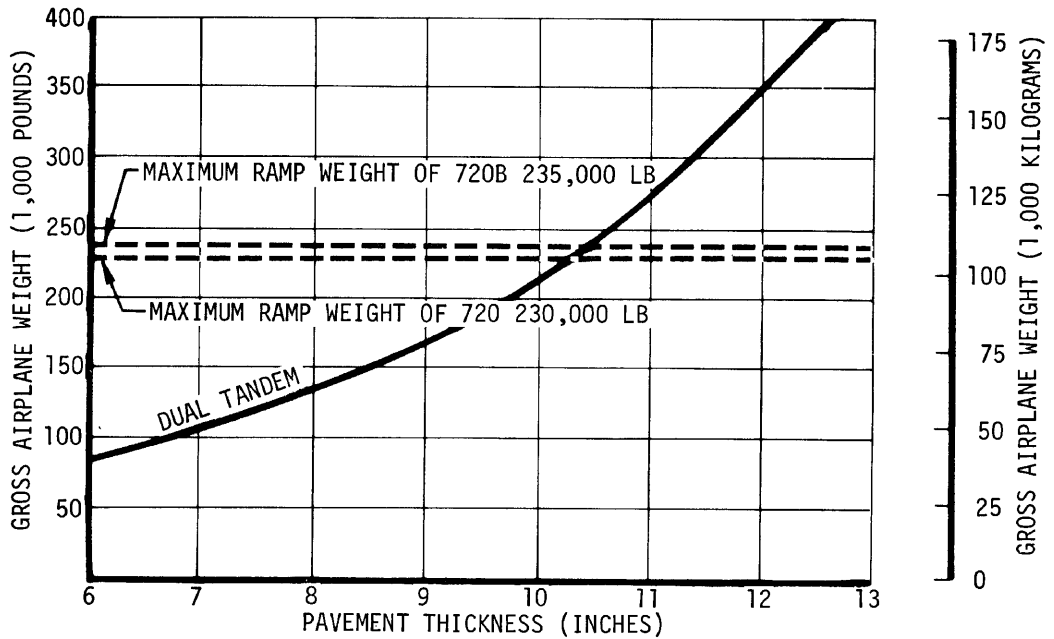
TIRE SIZE 40 X 14 IN.-TIRE PRESSURE CONSTANT AT 170 PSI



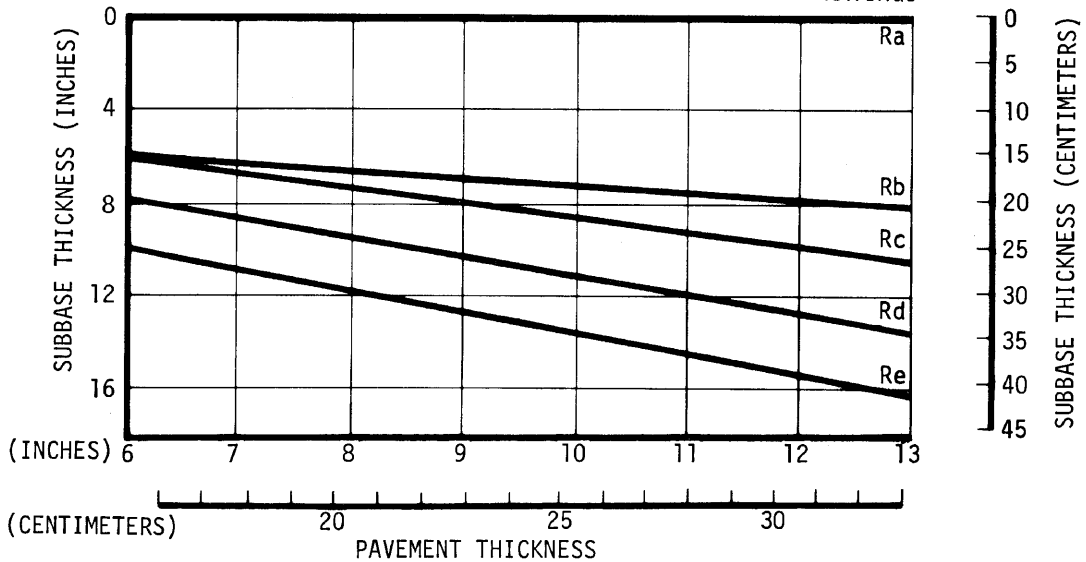
NOTES: • INTERSECTION OF A LINE DENOTING PAVEMENT SUBGRADE RATING (Fa, F1, F2) WITH WEIGHT LINE DETERMINES PAVEMENT THICKNESS

• ADAPTED FROM FAA ADVISORY CIRCULAR AC 150/5320 6A

**FLEXIBLE PAVEMENT REQUIREMENTS — FAA METHOD
MODEL 720, 720B**



NOTE: Ra, Rb, Rc, Rd, and Re ARE FAA PAVEMENT SUBGRADE RATINGS



NOTE: CHART ADAPTED FROM PAGE 31 (AND 32),
 PAR. 17 CHAP. 3 OF FAA ADVISORY CIRCULAR
 AC 150/5320-6A, DATED 9 MAY 1967.

RIGID PAVEMENT REQUIREMENTS, FAA METHOD
 MODELS 720, 720B

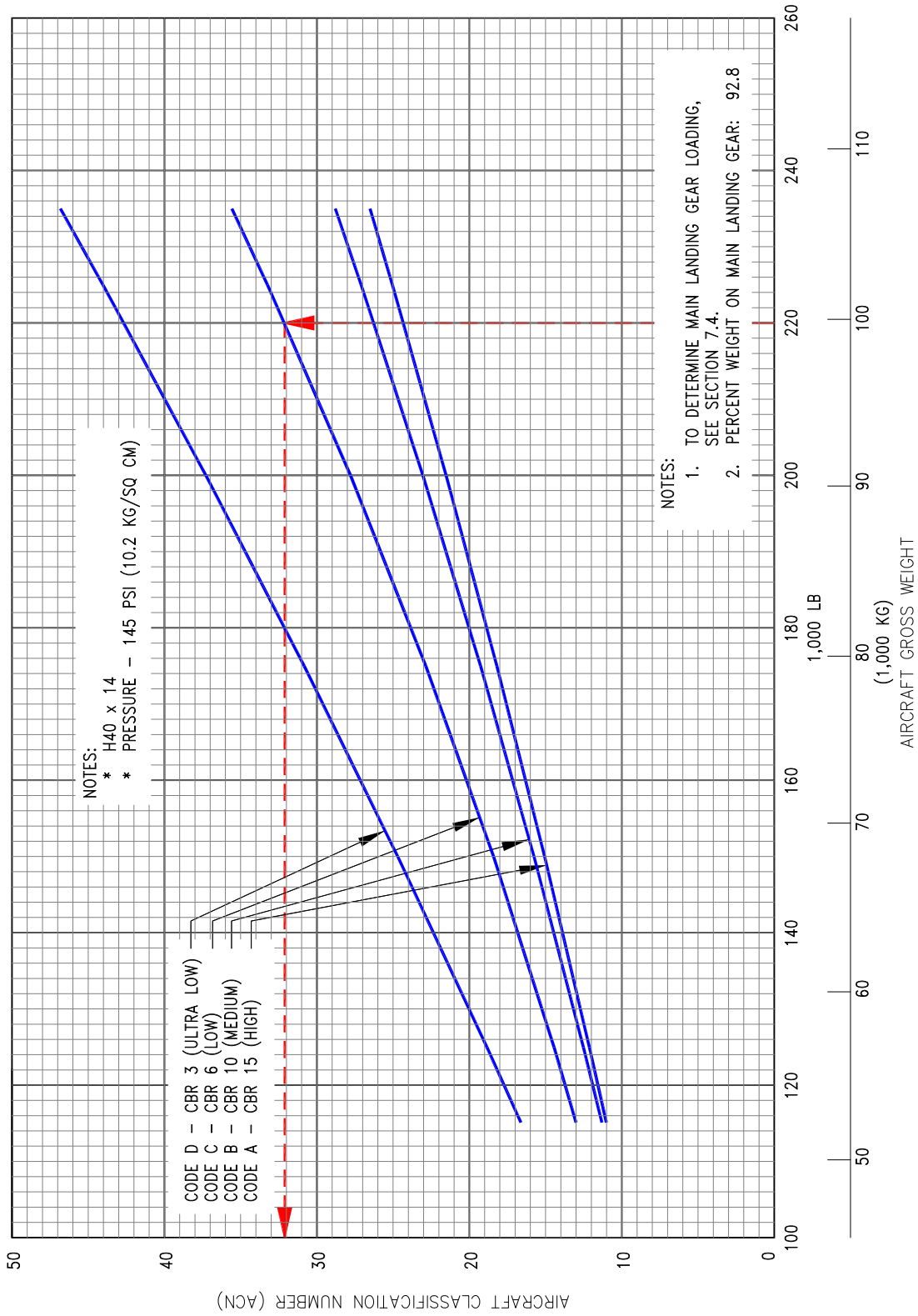
7.10 ACN/PCN Reporting System - Flexible and Rigid Pavements

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 7.10.1, for an aircraft with gross weight of 210,000 lb on a (Code C), the flexible pavement ACN is 30. Referring to 7.10.2, the same aircraft on a low strength subgrade rigid pavement has an ACN of 32.5.

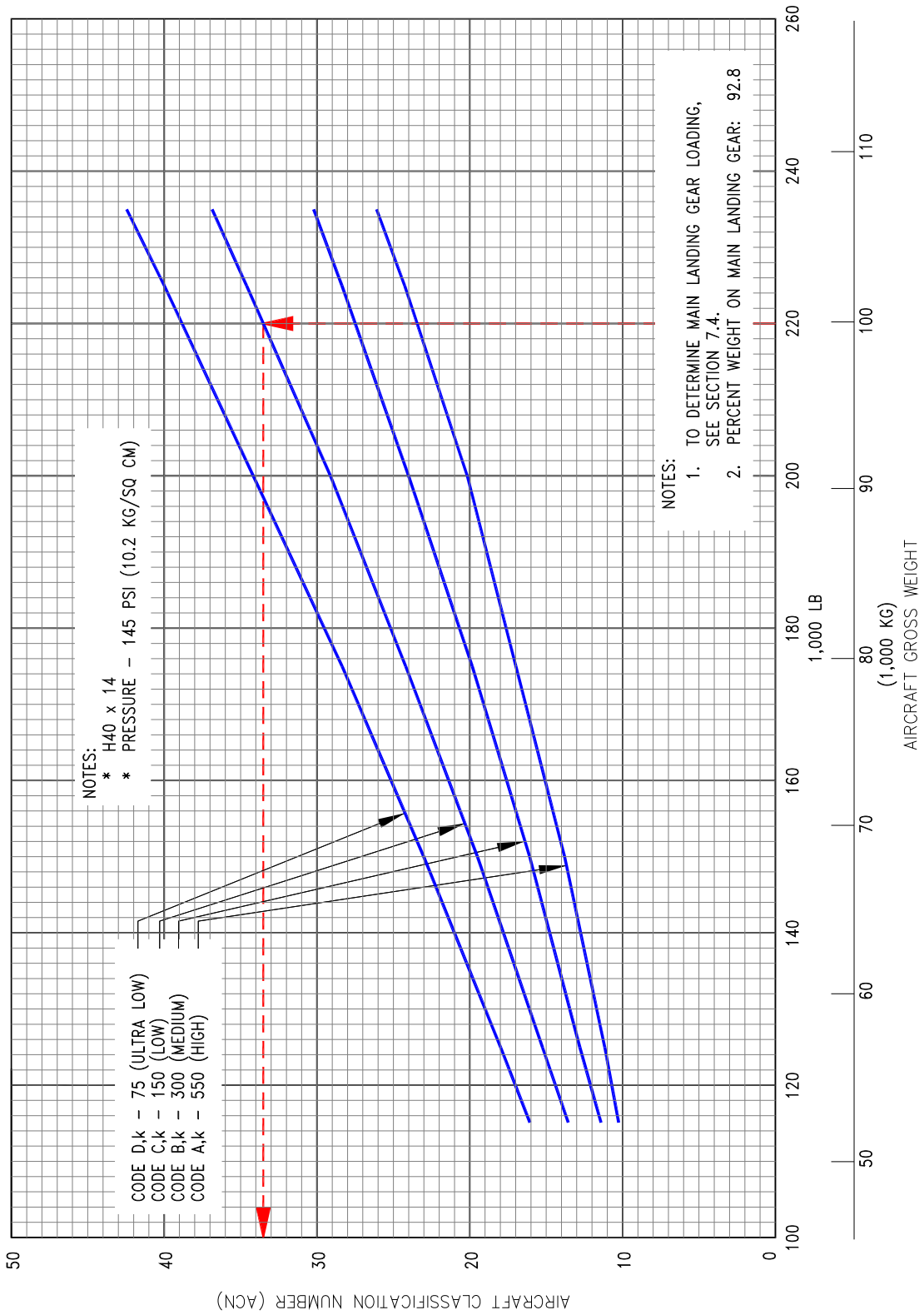
The following table provides ACN data in tabular format similar to the one used by ICAO in the “Aerodrome Design Manual Part 3, Pavements.” If the ACN for an intermediate weight between maximum taxi weight and minimum weight of the aircraft is required, Figures 7.10.1 through 7.10.2 should be consulted.

AIRCRAFT TYPE	MAXIMUM TAXI WEIGHT MINIMUM WEIGHT (1) LB (KG)	LOAD ON ONE MAIN GEAR LEG (%)	TIRE PRESSURE PSI (MPa)	ACN FOR RIGID PAVEMENT SUBGRADES – MN/m ³				ACN FOR FLEXIBLE PAVEMENT SUBGRADES – CBR			
				HIGH 150	MEDIUM 80	LOW 40	ULTRA LOW 20	HIGH 15	MEDIUM 10	LOW 6	ULTRA LOW 3
720B	235,000(106,700)	23.50	145 (0.99)	27	29	36	47	25	30	37	43
	115,000(52,200)			11	11	13	17	10	11	14	16

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



7.10.1 AIRCRAFT CLASSIFICATION NUMBER - FLEXIBLE PAVEMENT
MODEL 720B



7.10.2 AIRCRAFT CLASSIFICATION NUMBER - RIGID PAVEMENT
MODEL 720B