FIGURE 3-57A RUNWAY OPERATIONS RATE
0 TO 35 OPERATIONS PER HOUR

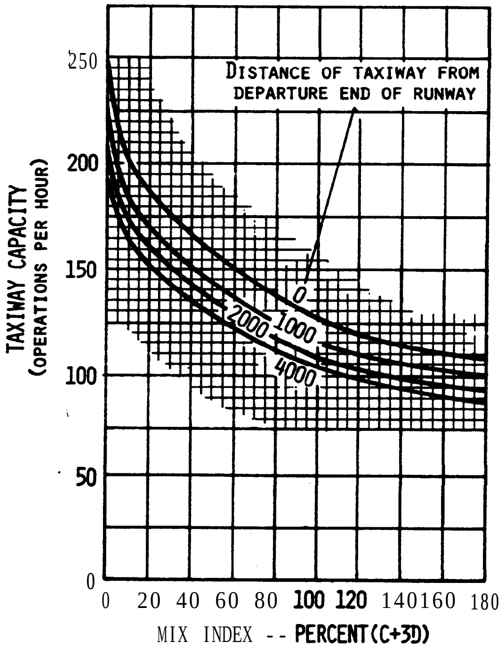


FIGURE 3-57B RUNWAY OPERATIONS RATE
36 TO 55 OPERATIONS PER HOUR

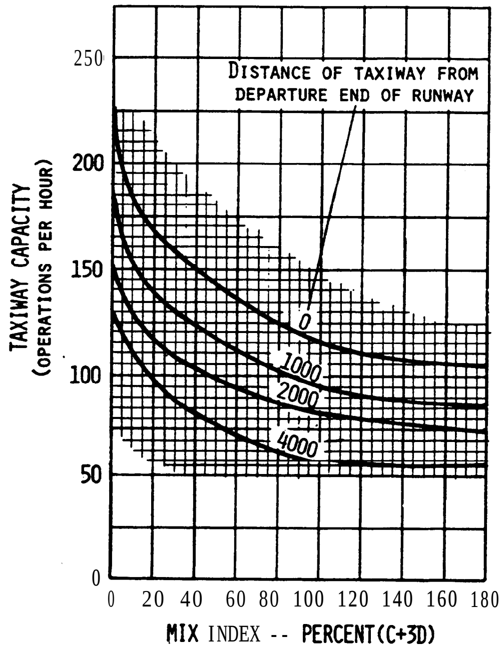


FIGURE 3-57C RUNWAY OPERATIONS RATE
56 TO 75 OPERATIONS PER HOUR

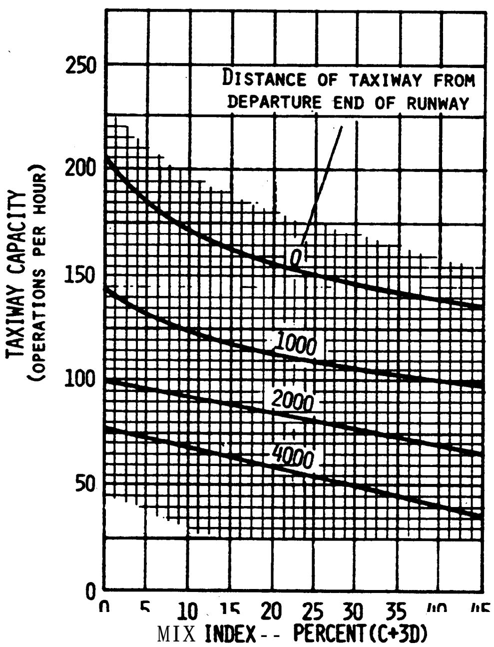


FIGURE 3-57D RUNWAY OPERATIONS RATE
76 TO 95 OPERATIONS PER HOUR

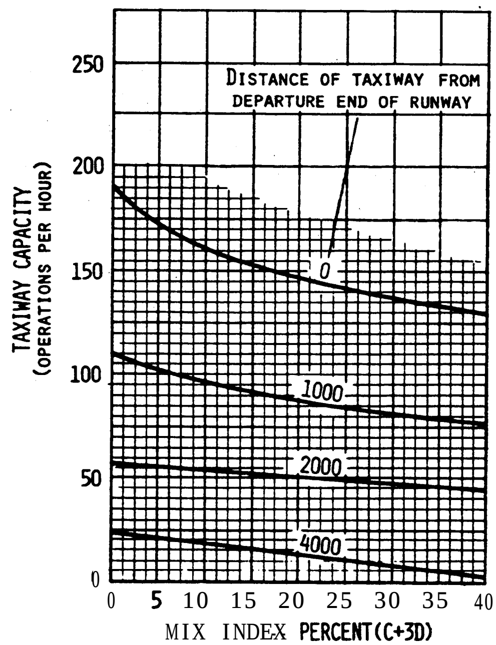


FIGURE 3-57. HOURLY CAPACITY OF A TAXIWAY CROSSING AN ACTIVE RUNWAY WITHOUT ARRIVALS.

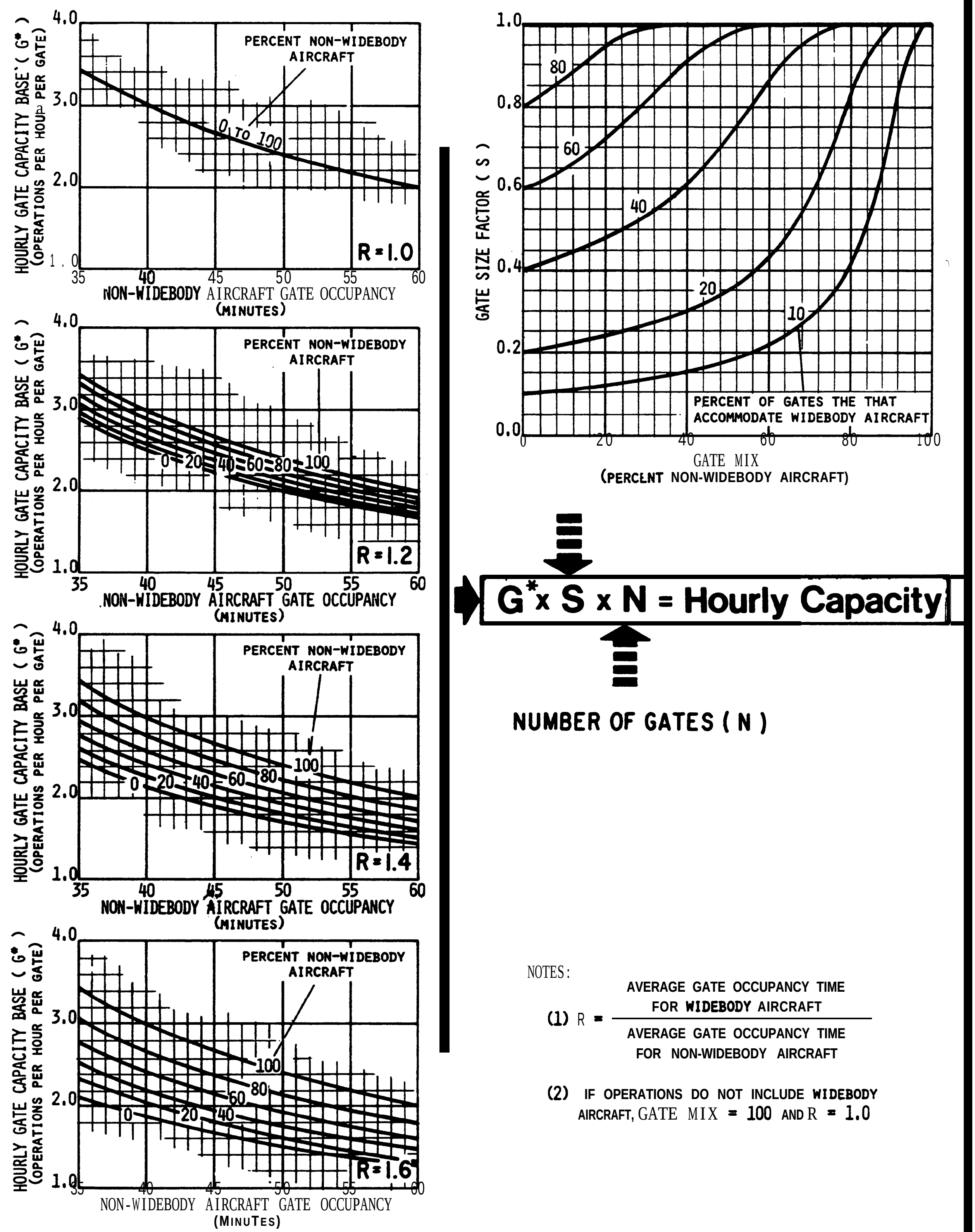


FIGURE 3-58. HOURLY CAPACITY OF GATES.

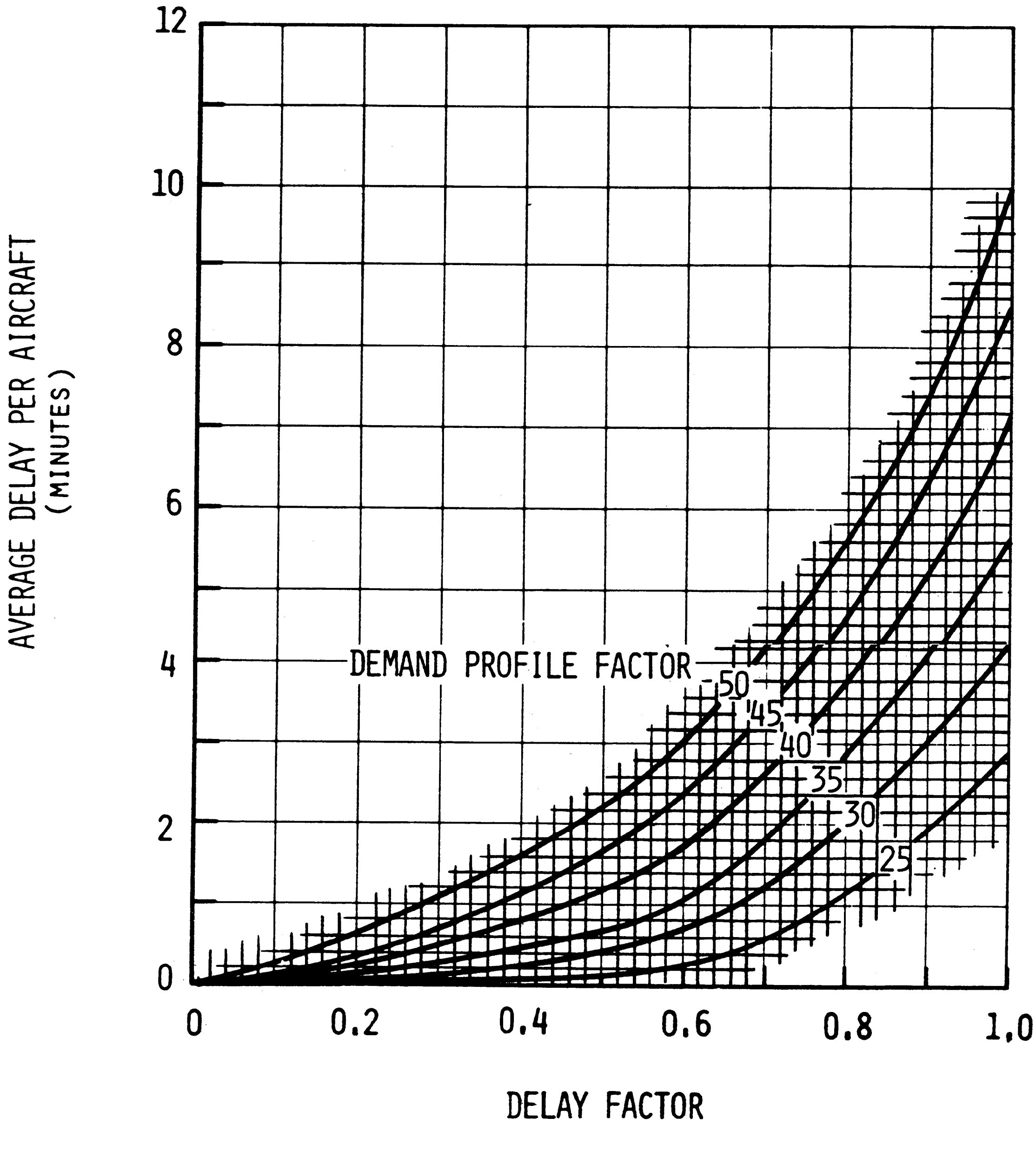
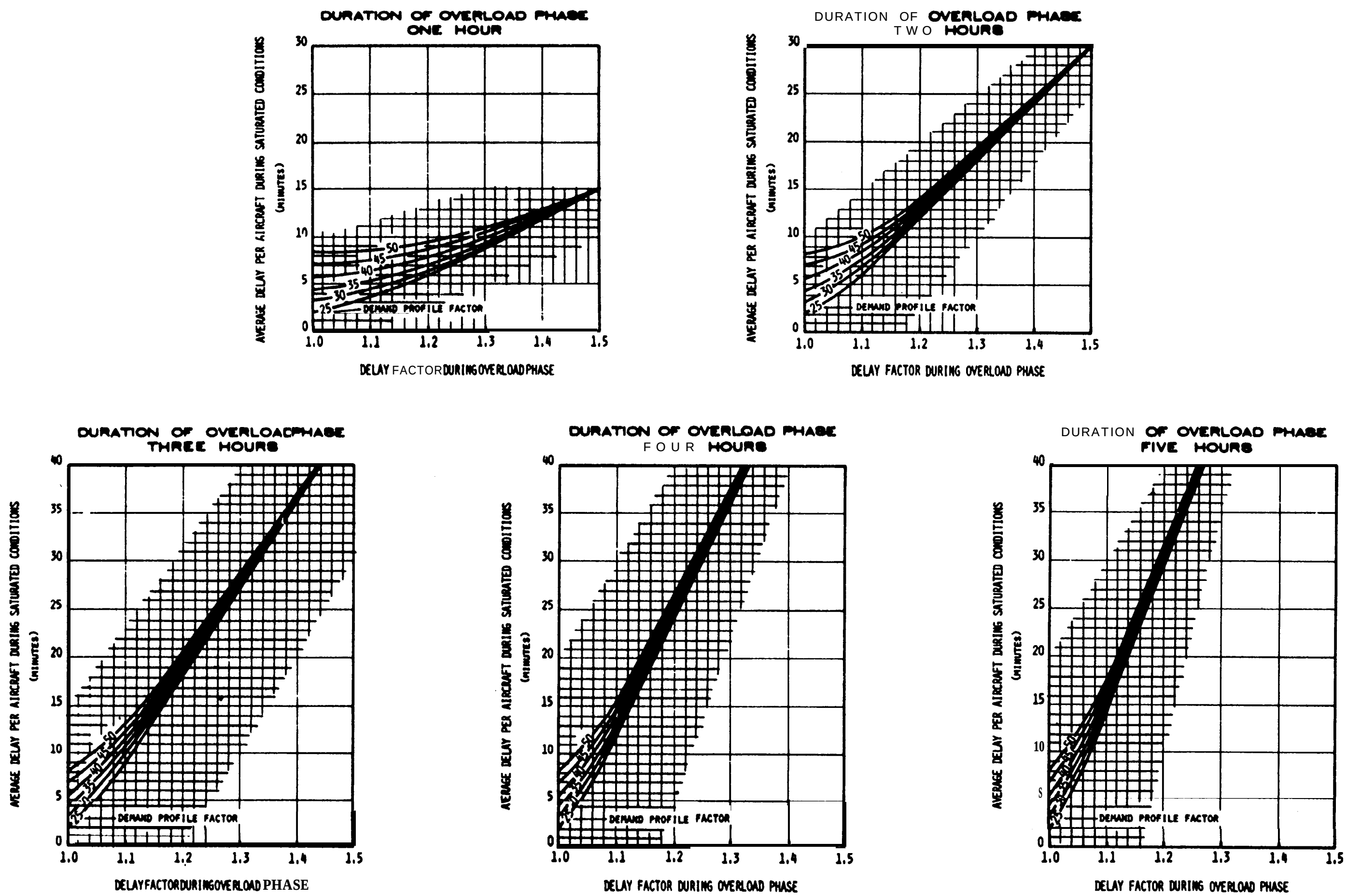


FIGURE 3-69. AVERAGE AIRCRAFT DELAY IN AN HOUR.



(NOTE: FOR DISCUSSION AND EXAMPLES OF THE TERMS "OVERLOAD PHASE" AND "SATURATED PERIODS", SEE PARAGRAPH 28.C ON PAGE 59.)

FIGURE 3-70. AVERAGE AIRCRAFT DELAY DURING SATURATED CONDITIONS.

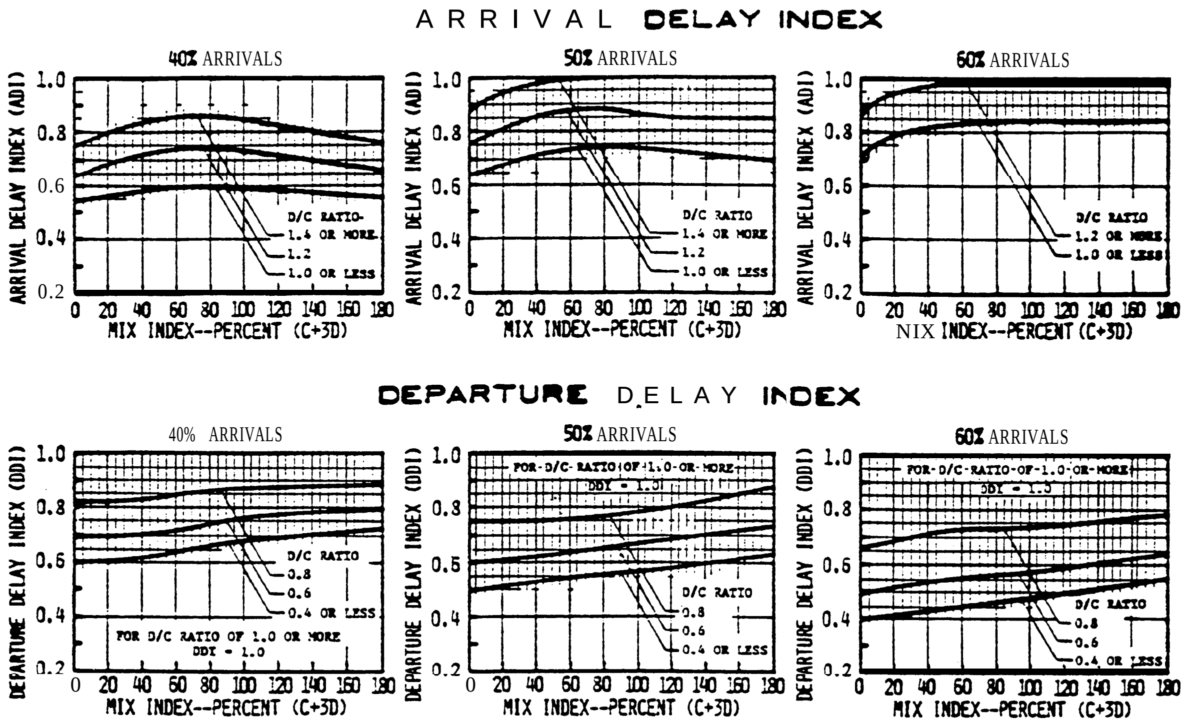


FIGURE 3-71. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 1, 9, 11, 12, 31, 42, 47, 48, 53, 54, 66, 68.70.71 FOR VFR CONDITIONS.

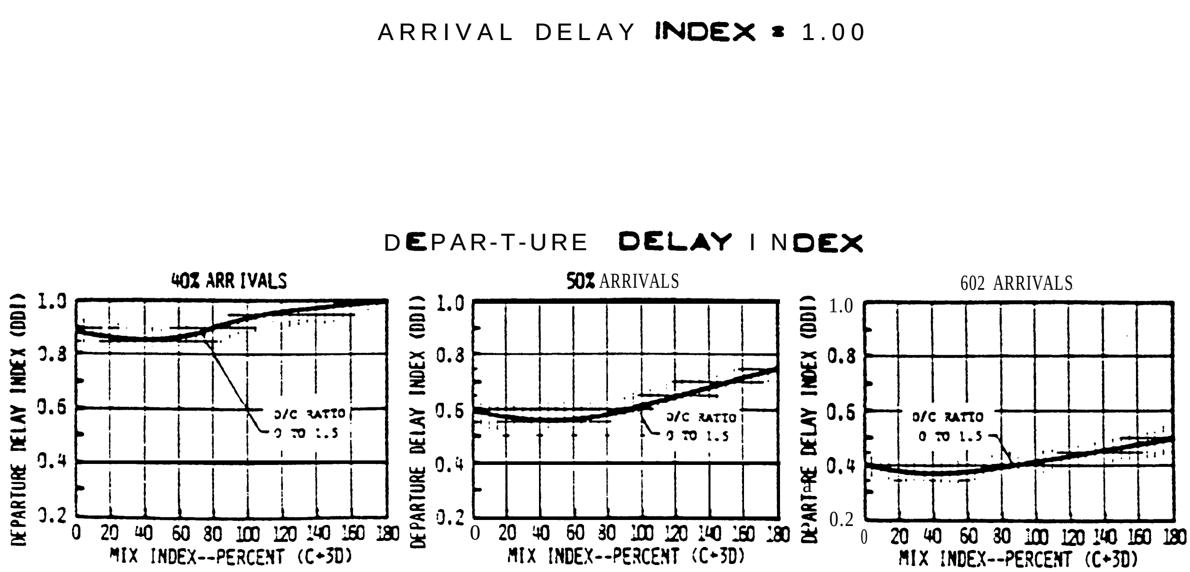


FIGURE 3-72. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 2, 32, 33, 67, 72, 73, 87, 88 FOR VFR CONDITIONS.

ARRIVAL DELAY INDEX = 1.00

DEPARTURE DELAY INDEX

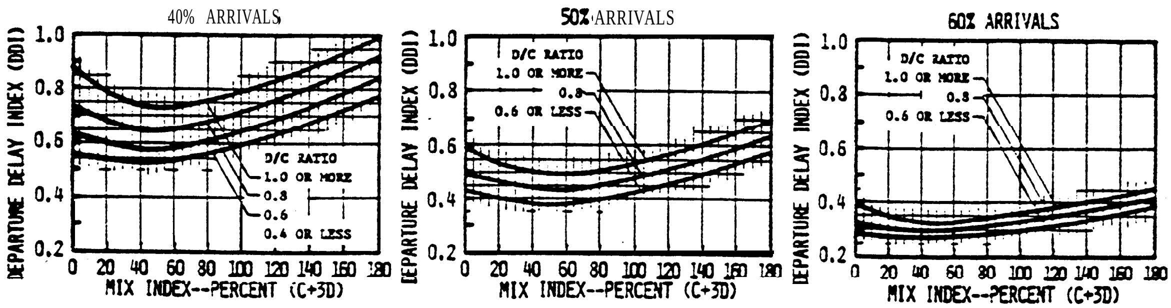


FIGURE 3-73. DELAY INDICES FOR RUNWAY-USE DIAGRAM NO. 3 FOR VFR CONDITIONS.

ARRIVAL DELAY INDEX = 1.00

DEPARTURE DELAY INDEX

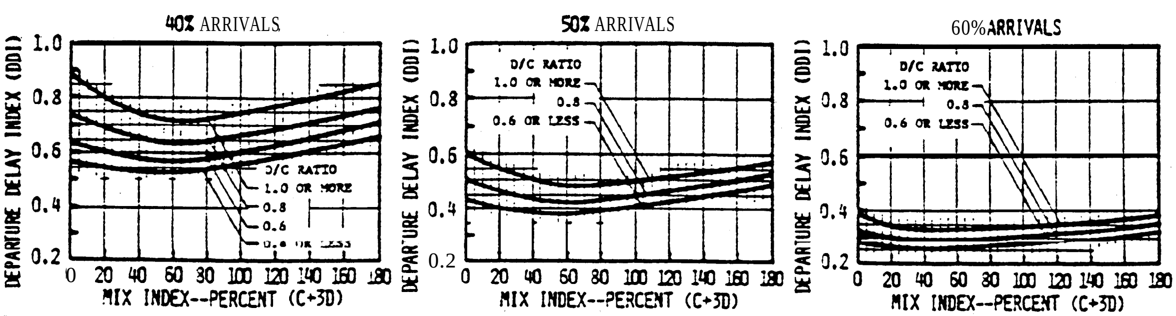


FIGURE 3-74. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 4, 74, 75, 85, 86. 89.
90, 100. 101 FOR VFR CONDITIONS.

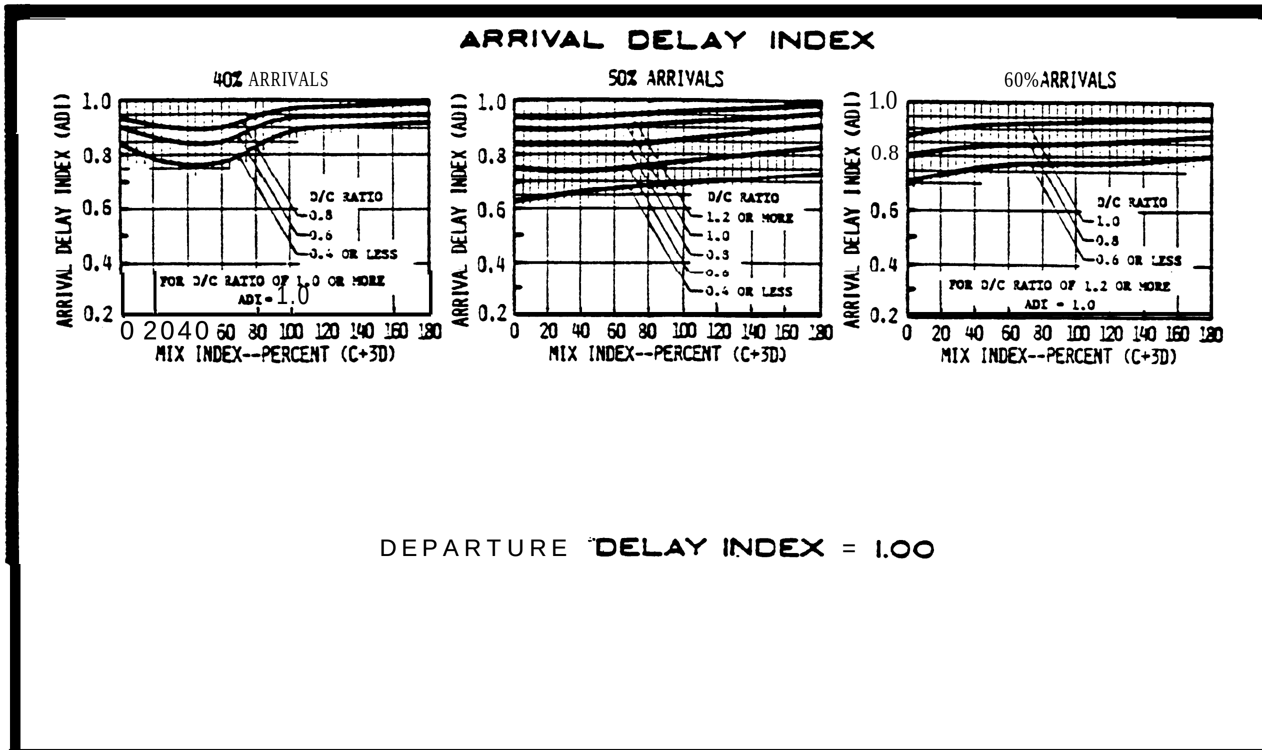


FIGURE 3-75. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 5, 7, 76, 91 FOR VFR CONDITIONS.

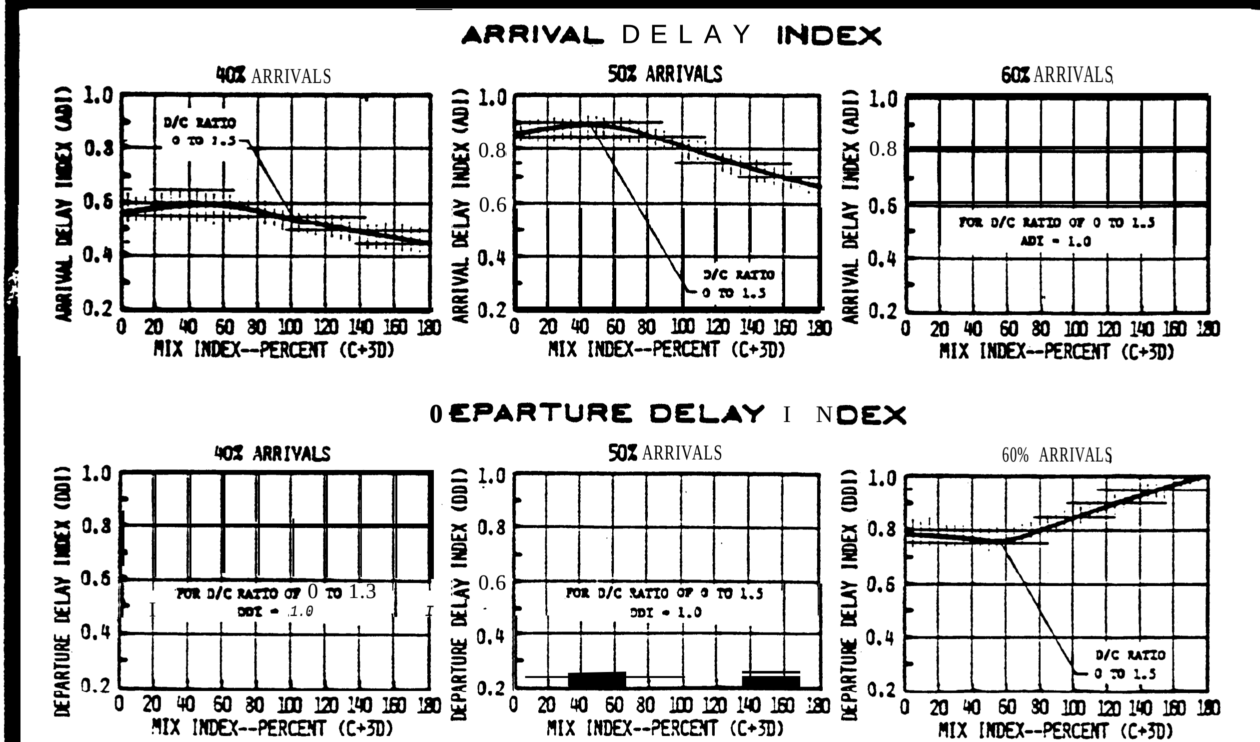


FIGURE 3-76. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 13, 15 FOR VFR CONDITIONS.

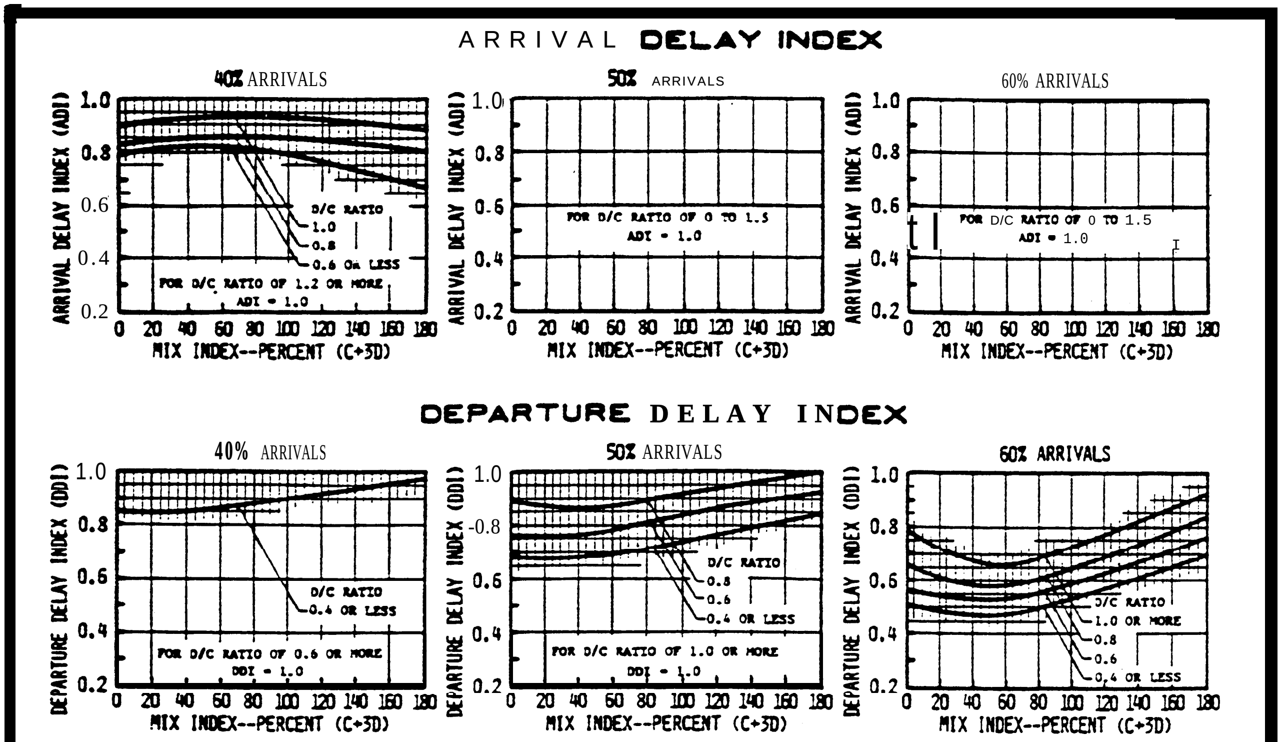


FIGURE 3-77. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 16, 79, 94 FOR VFR CONDITIONS.

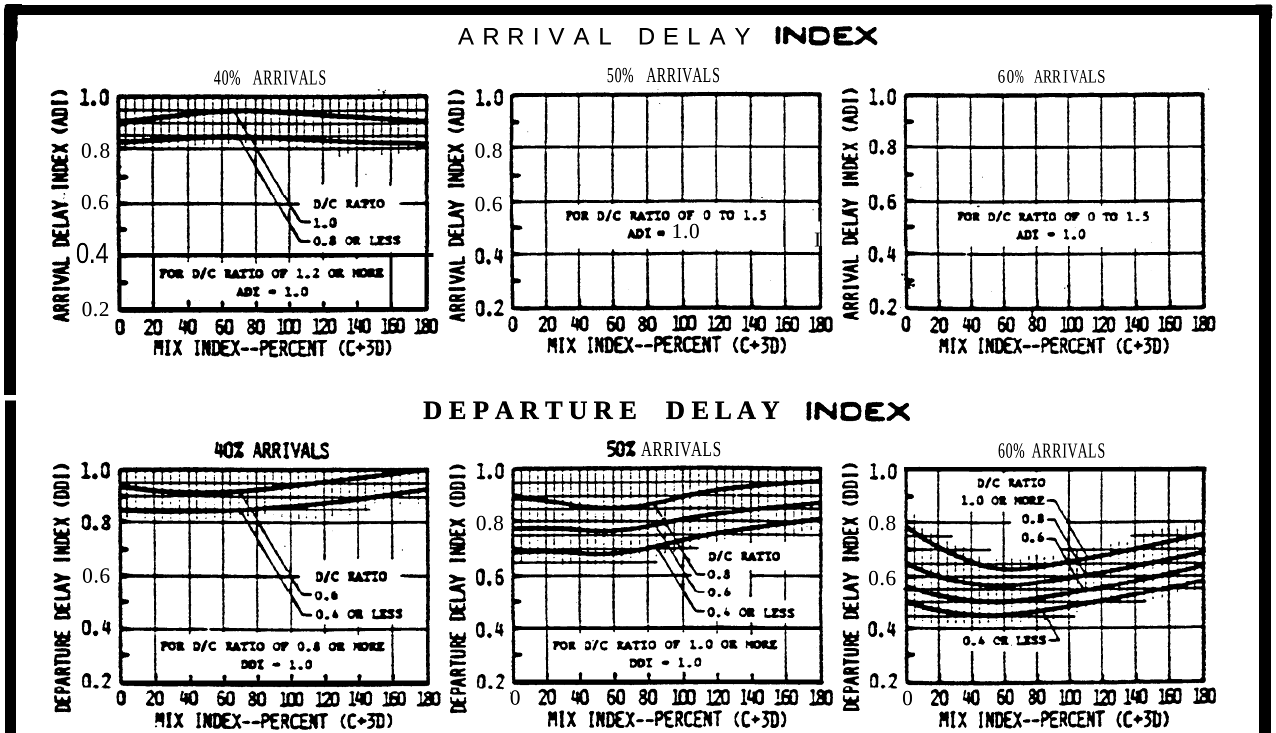


FIGURE 3-78. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 18, 19, 21, 22, 23, 77, 78, 92, 93 FOR VFR CONDITIONS.

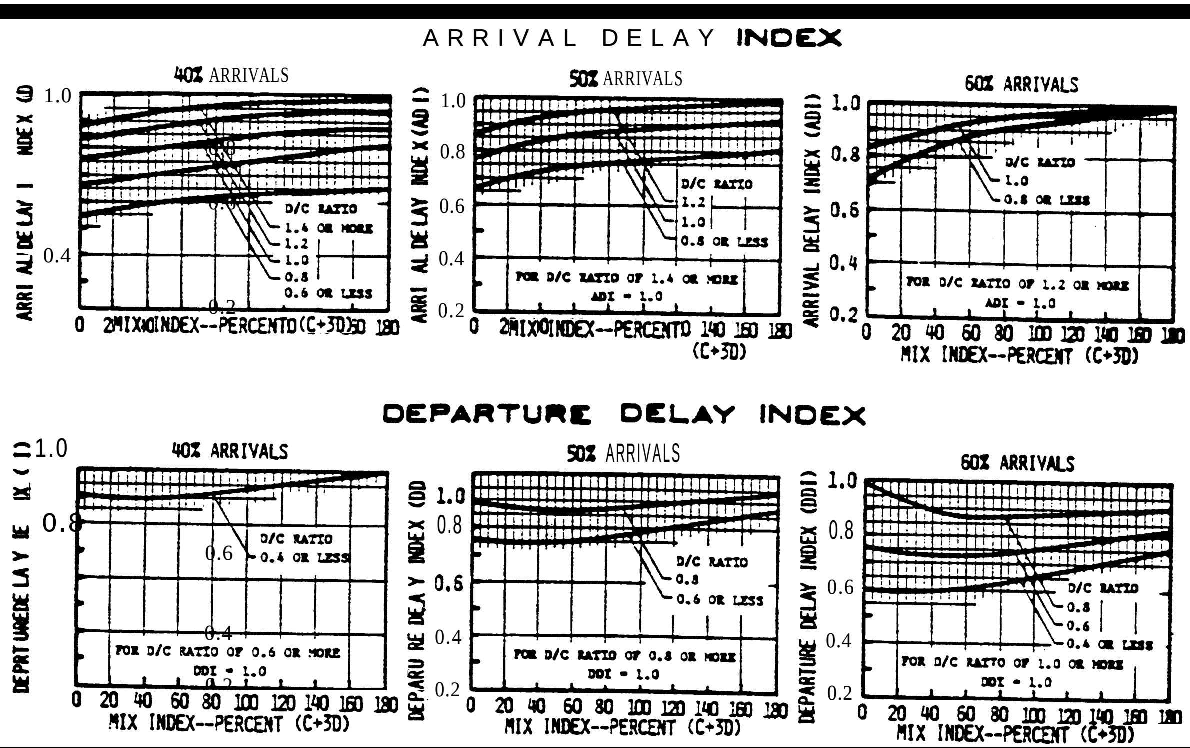


FIGURE 3-79. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 24, 27 FOR VFR CONDITIONS.

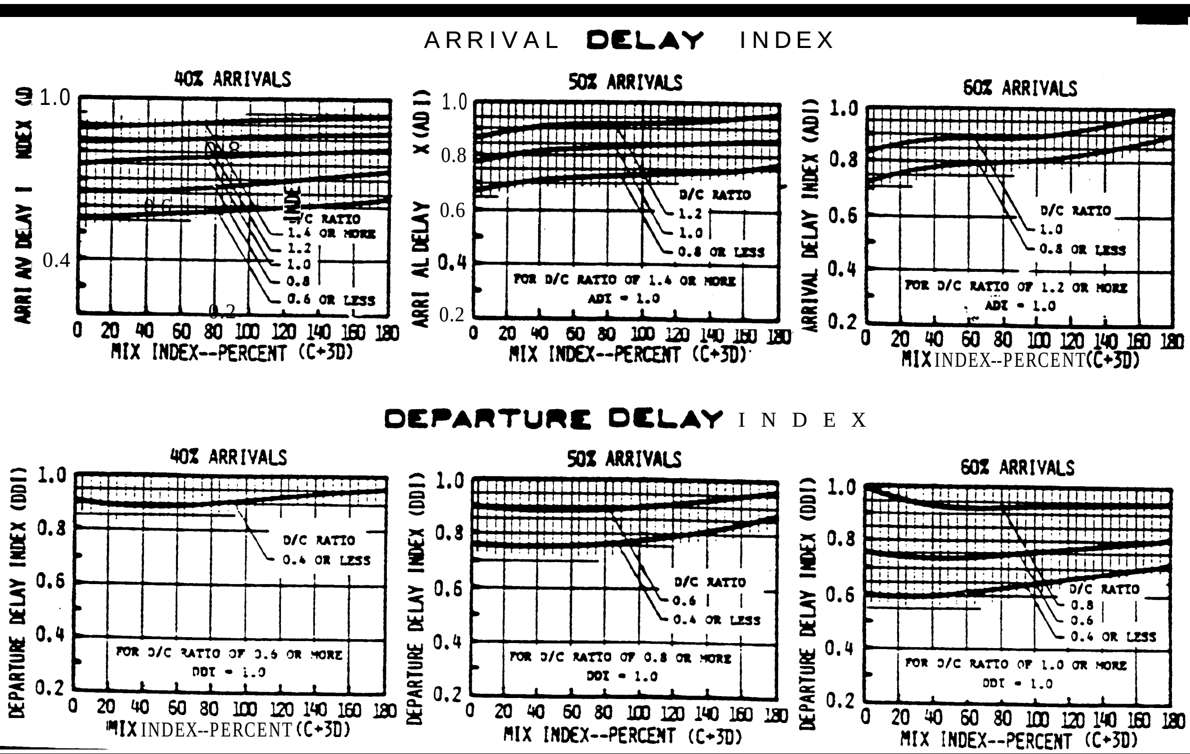


FIGURE 3-80. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 26, 28, 41, 82, 97 FOR VFR CONDITIONS.

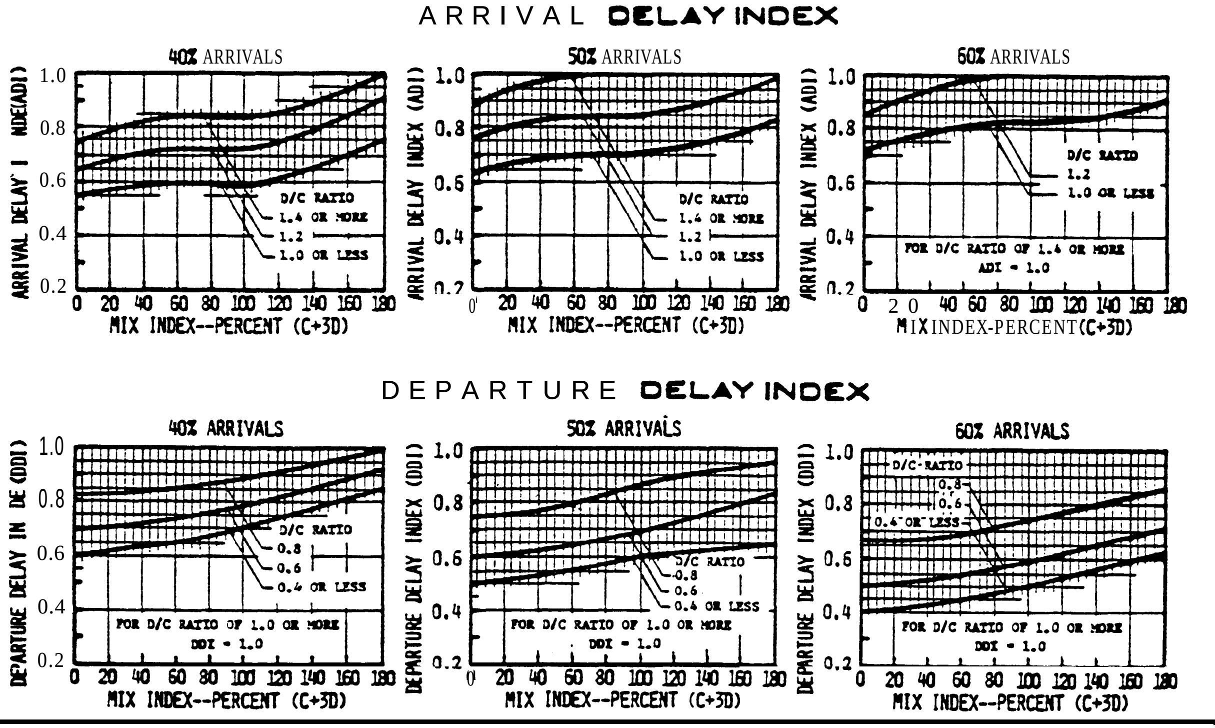


FIGURE 3-81. DELAY INDICES FOR RUNWAY-USE DIAGRAM NO. 29 FOR VFR CONDITIONS.

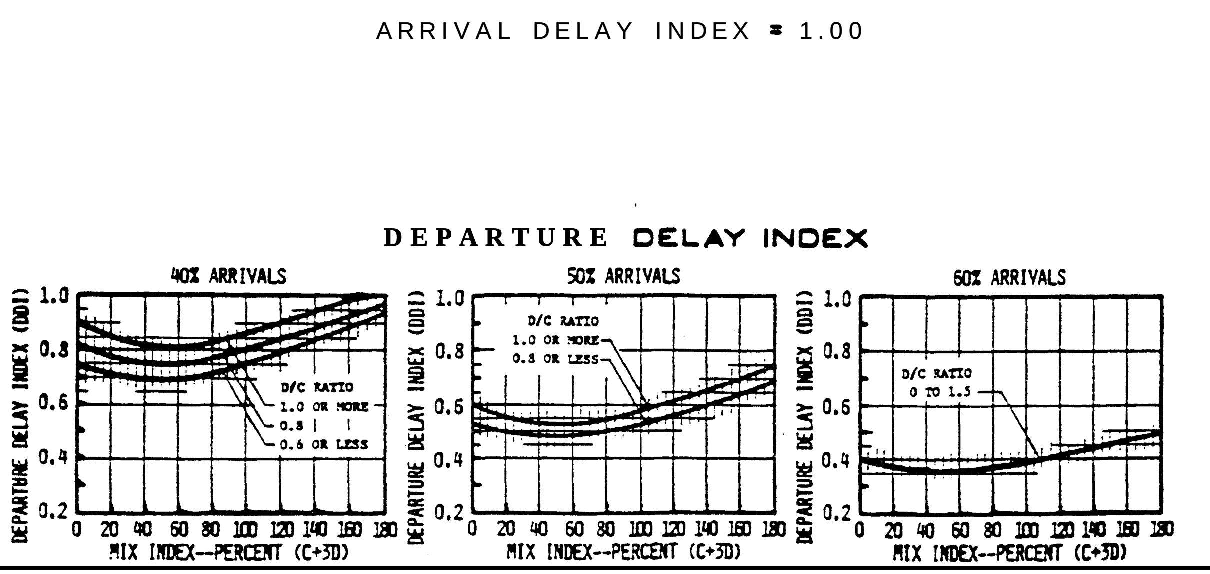


FIGURE 3-82. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 34, 35 FOR VFR CONDITIONS.

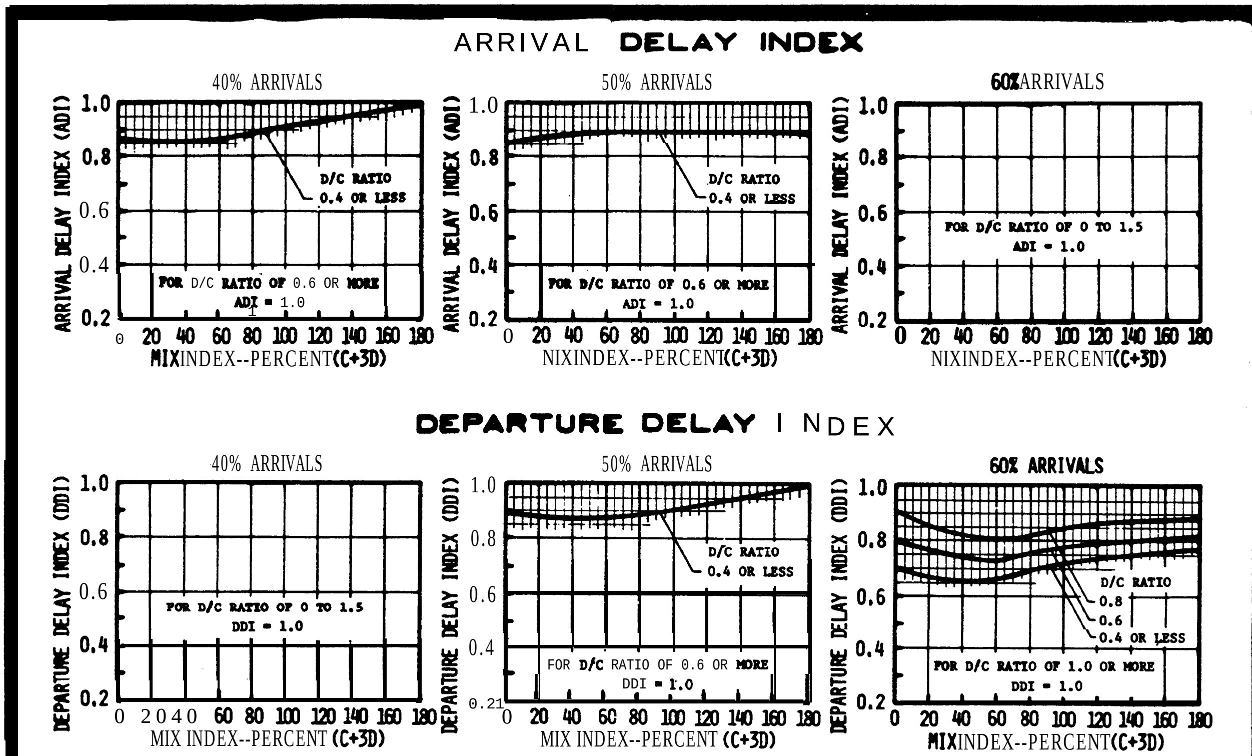


FIGURE 3-83, DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 36-38 FOR VFR CONDITIONS.

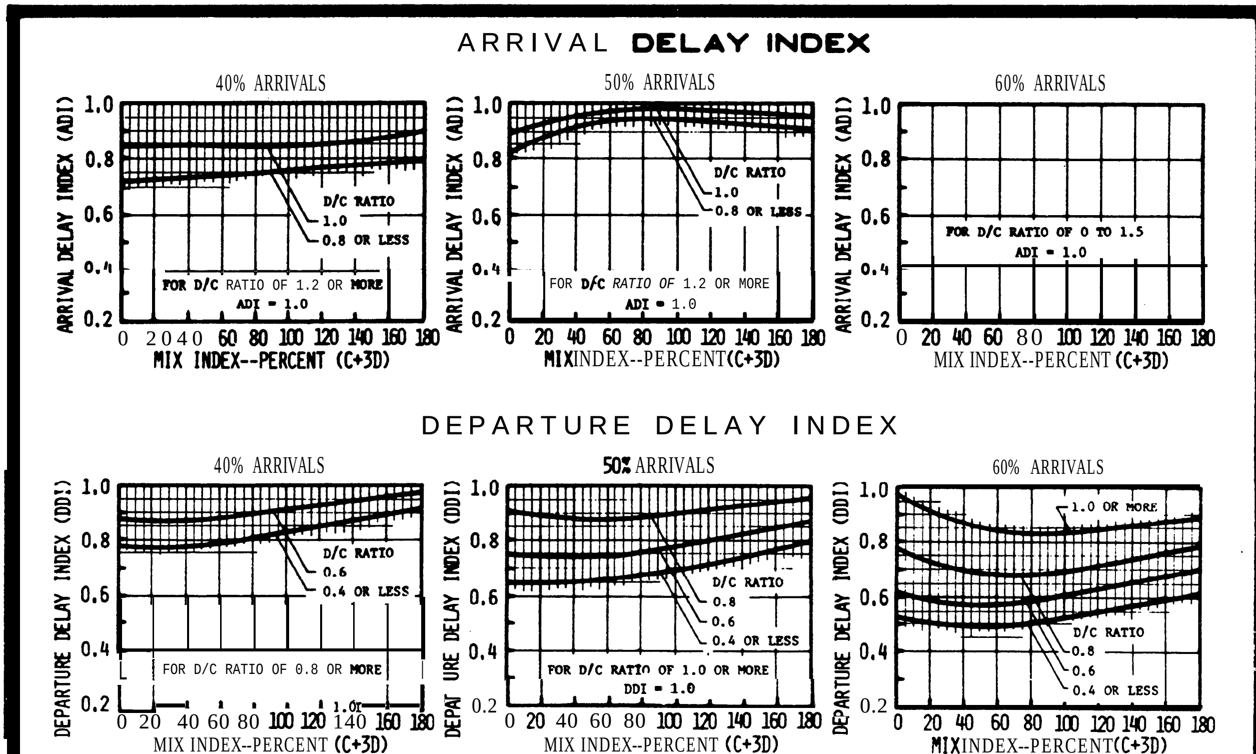


FIGURE 3-84, DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 39,40 FOR VFK CONDITIONS,

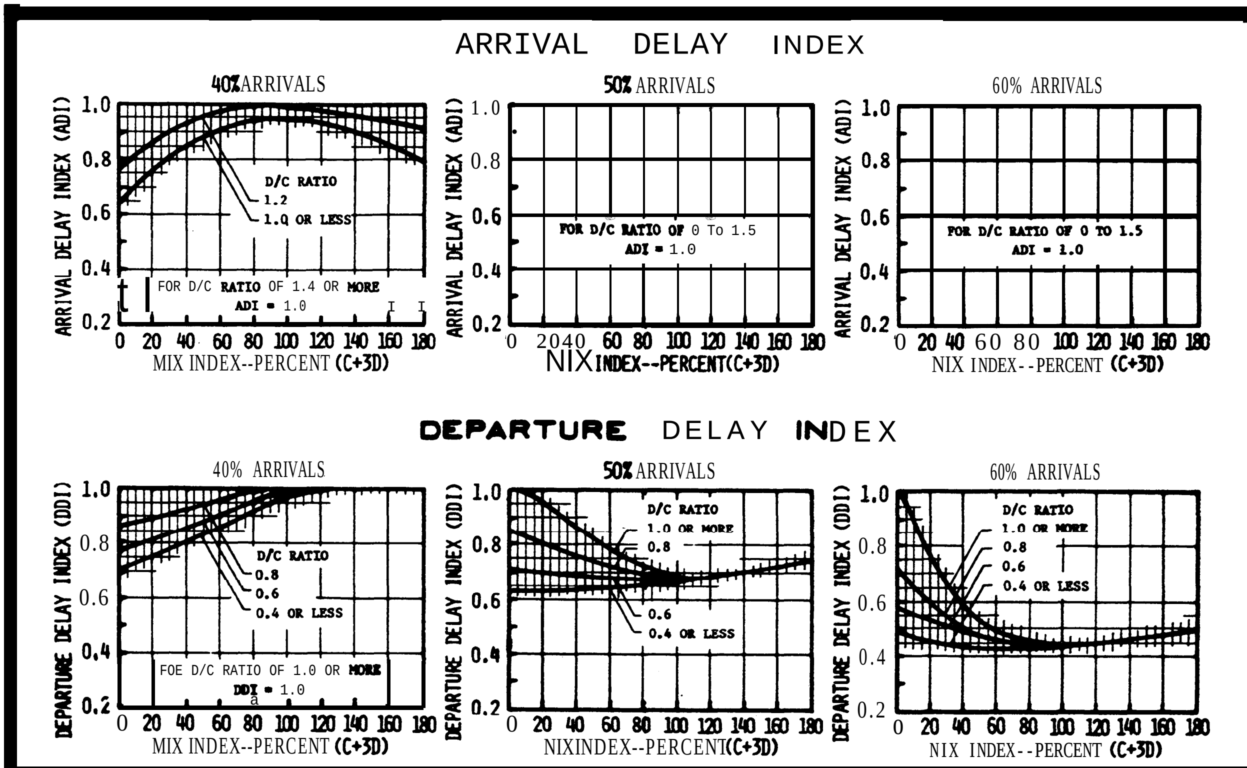


FIGURE 3-85. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 43,49,55,61 FOR VFR CONDITIONS.

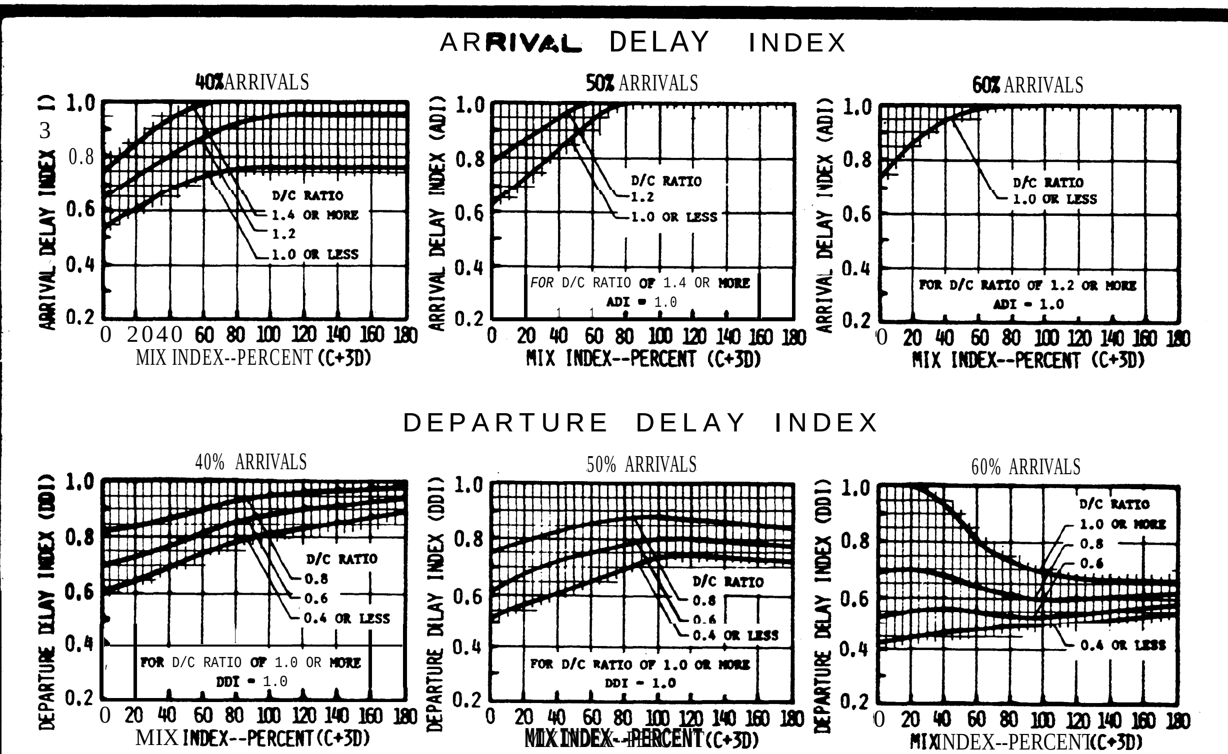


FIGURE 3-86. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 44-46,50-52,56-58,62-64 FOR VFR CONDITIONS.

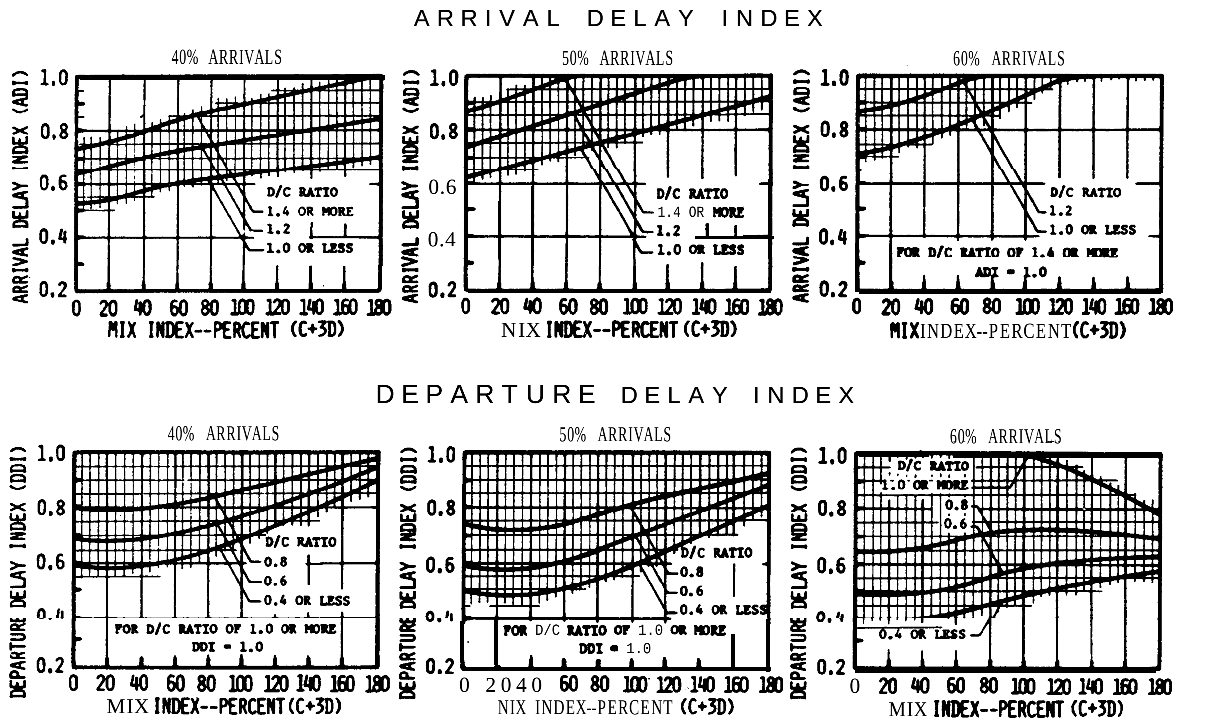


FIGURE 3-87, DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 59,60,65 FOR VFR CONDITIONS,

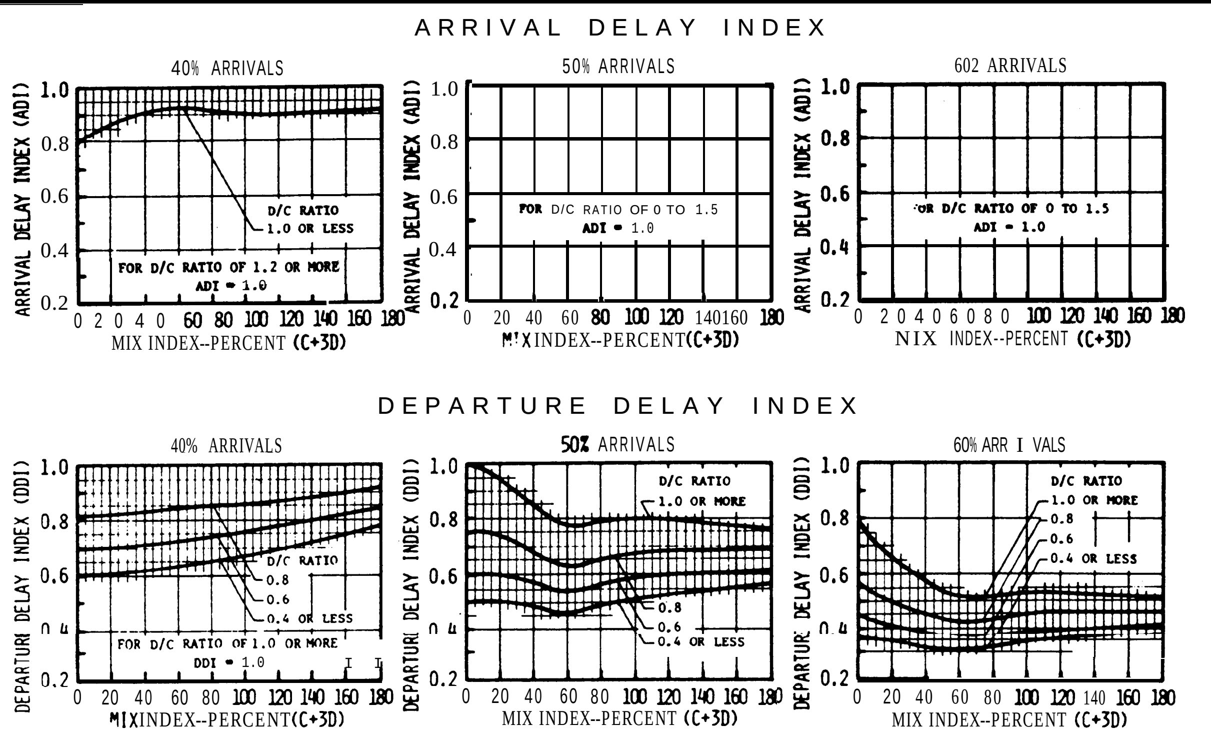


FIGURE 3-88. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 80,81,95 FOR VFR CONDITIONS,

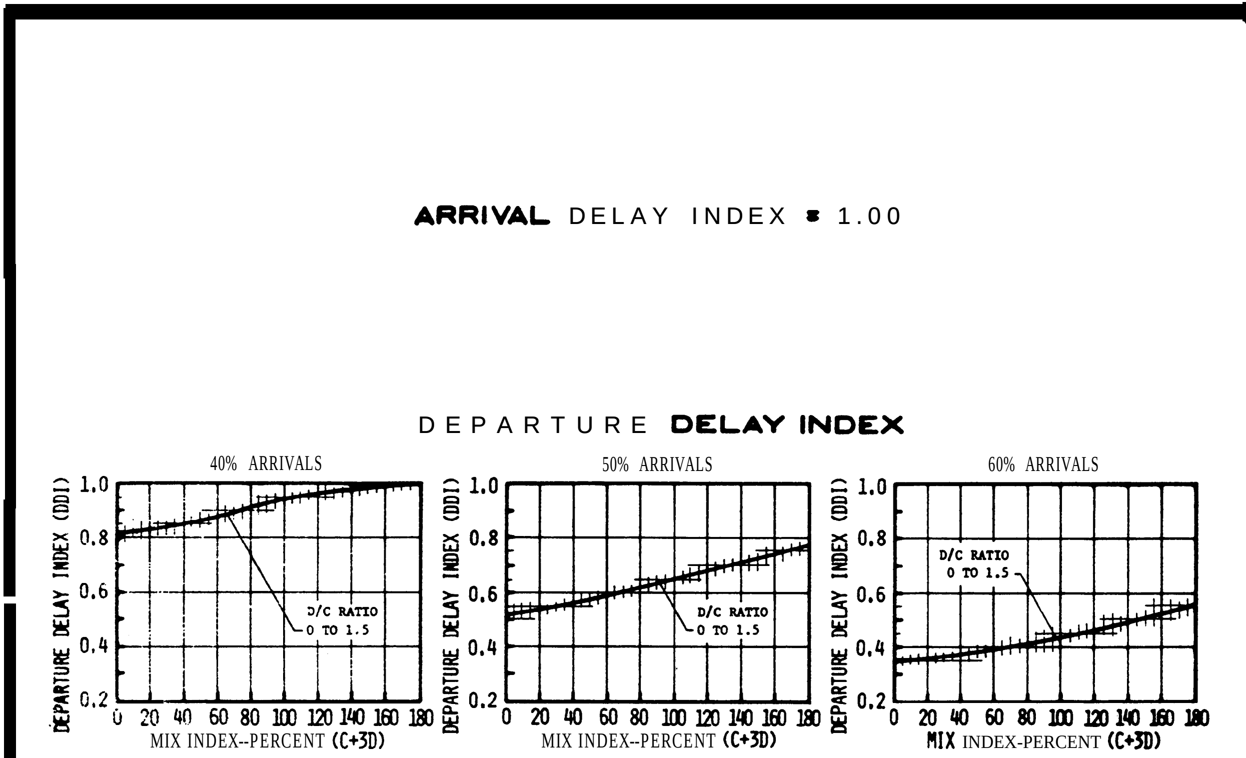


FIGURE 3-89. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 83,84,98,99,102 FOR VFR CONDITIONS.

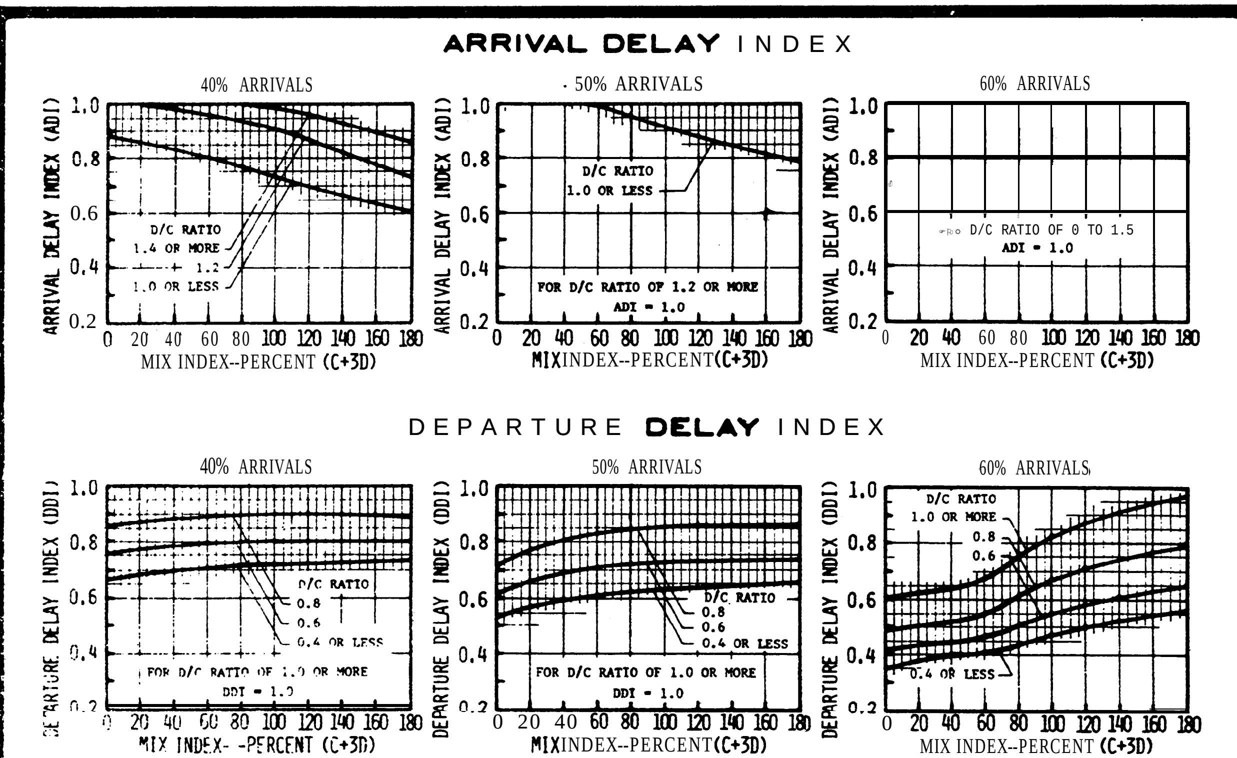


FIGURE 3-90. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 1,53,54 FOR IFR CONDITIONS.

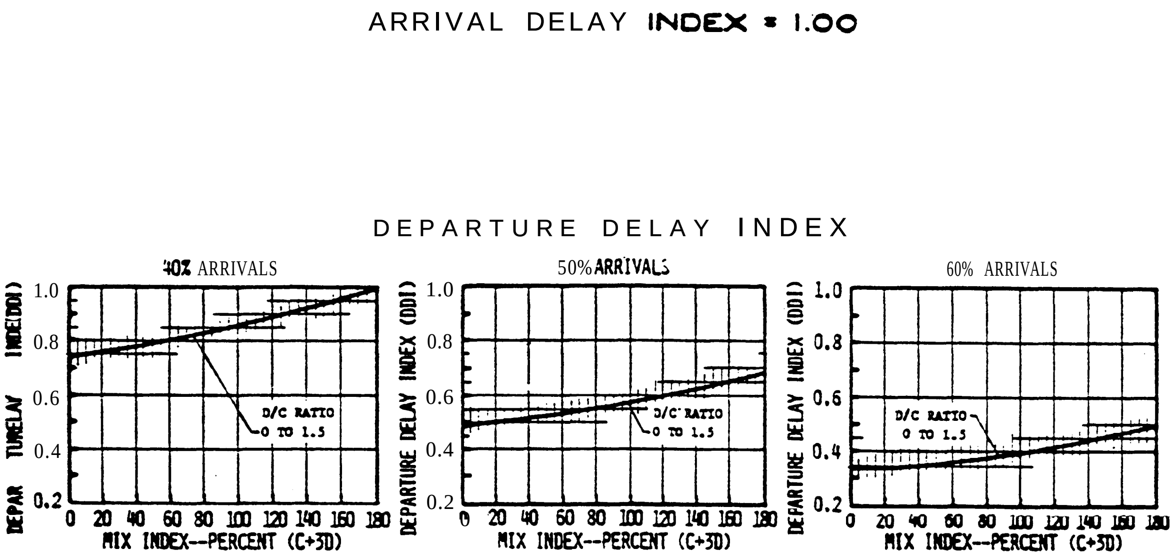


FIGURE 3-91. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 2, 3, 5, 9, 32 - 3537 - 43, 49, 55, 61 - 68, 72 - 74, 76, 77, 79, 80, 82 - 85, 87 - 89, 91, 92, 94, 95, 97 - 100, 102 FOR IFR CONDITIONS.

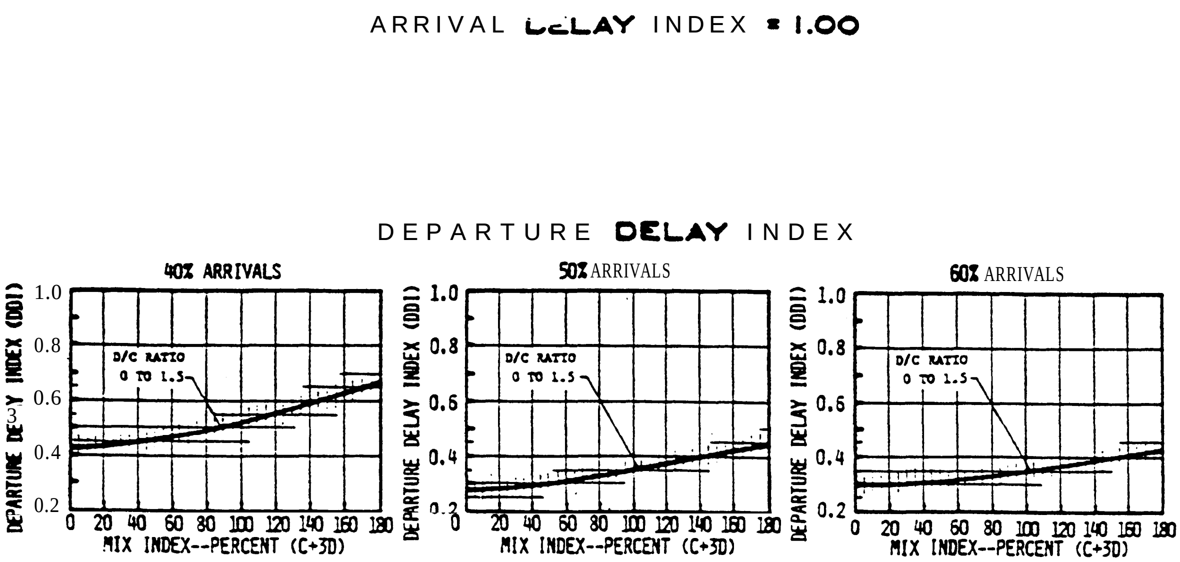


FIGURE 3-92. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 4, 75, 90 FOR IFR CONDITIONS.

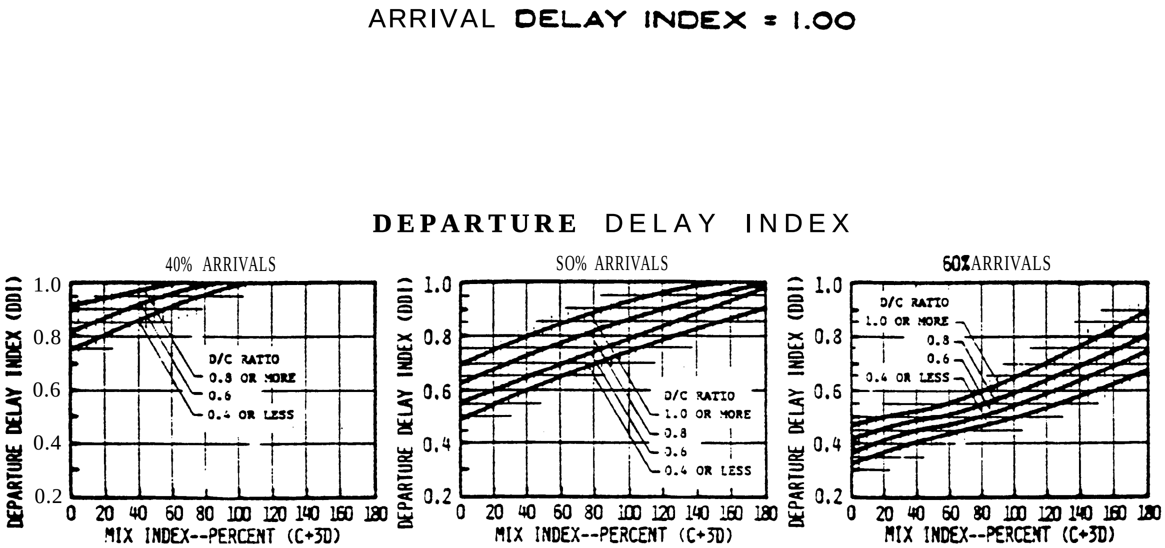


FIGURE 3-93. DELAY INDICES FOR RUNWAY-USE DIAGRAM NO. 7 FOR IFR CONDITIONS.

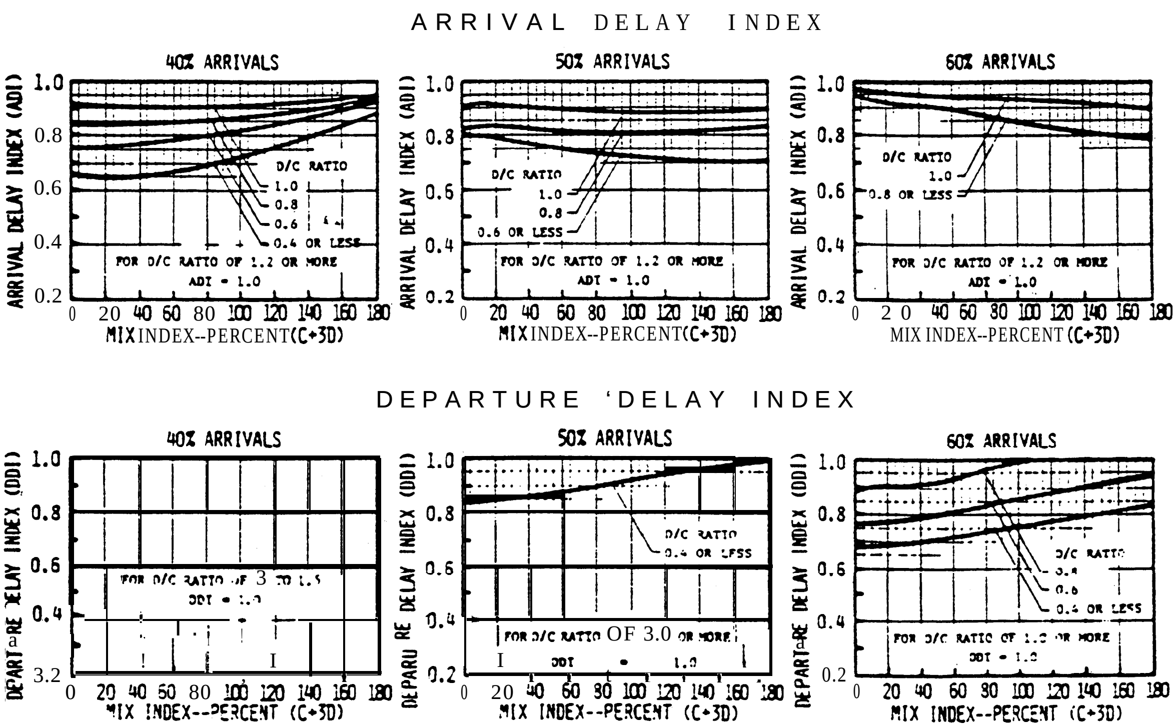


FIGURE 3-94. DELAY INDICES FOR RUNWAY&SE DIAGRAM NO. 8 FOR IFR CONDITIONS.

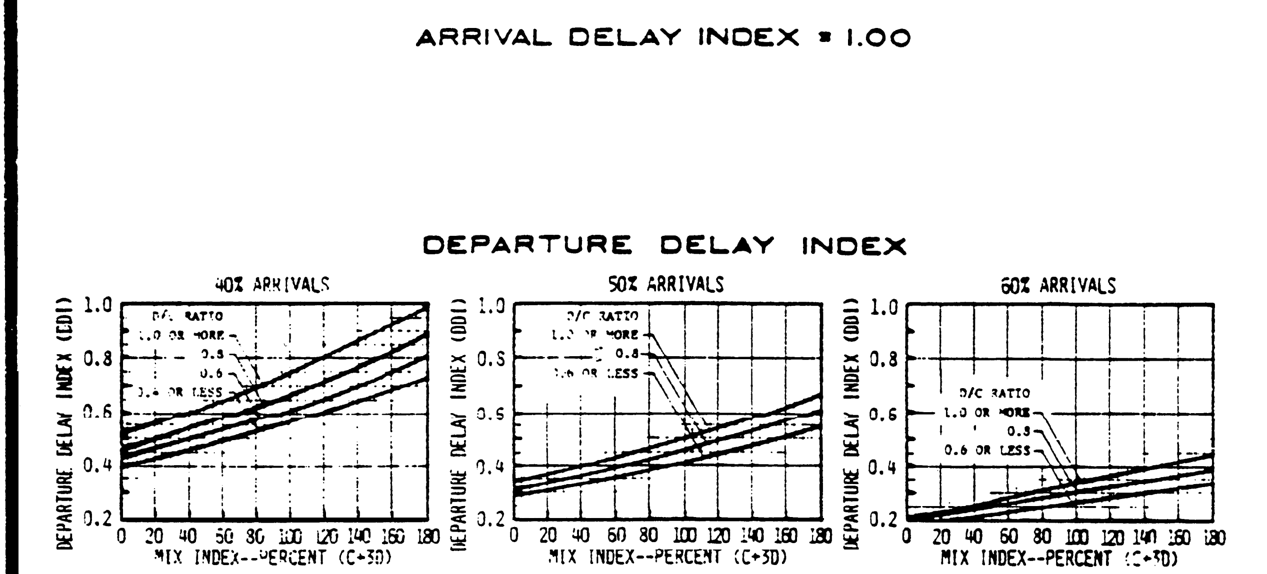


FIGURE 3-95. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS. 11, 21, 29, 70, 71 FOR IFR CONDITIONS.

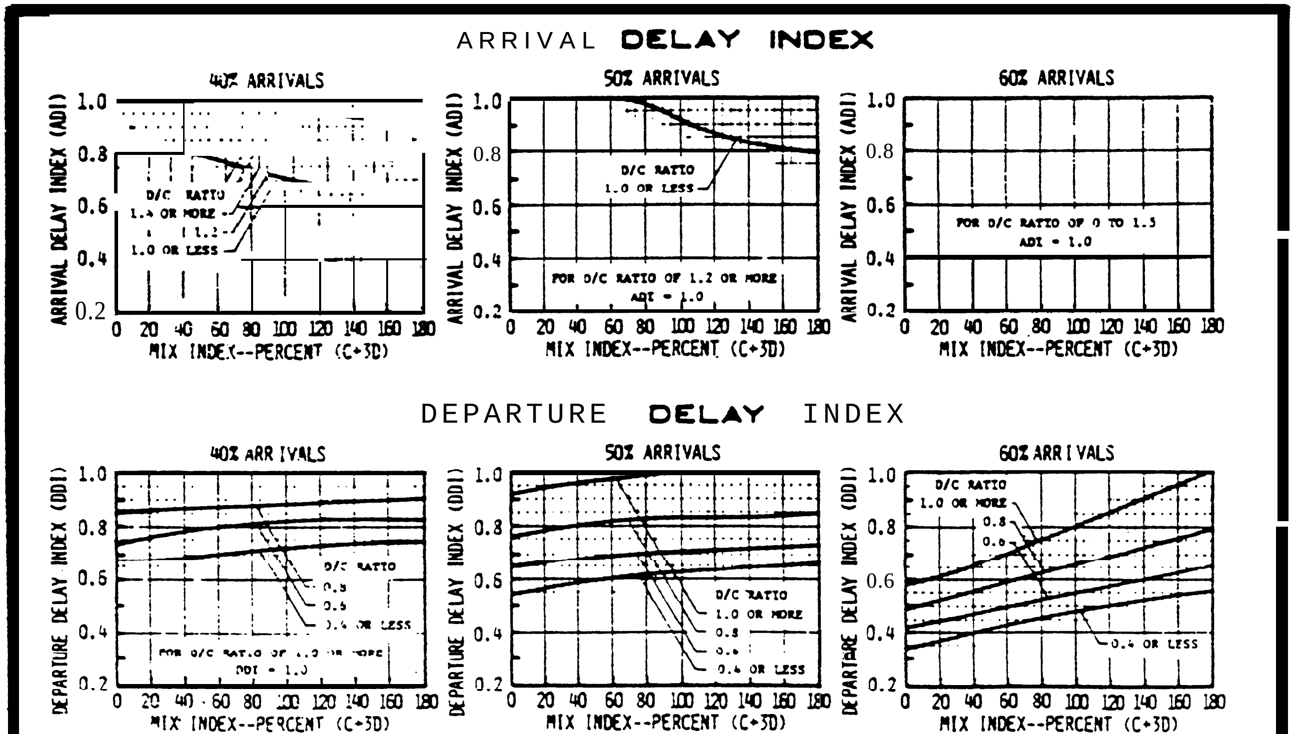


FIGURE 3-96. DELAY INDICES FOR RUNWAY-USE DIAGRAM NO. 12 FOR IFR CONDITIONS.

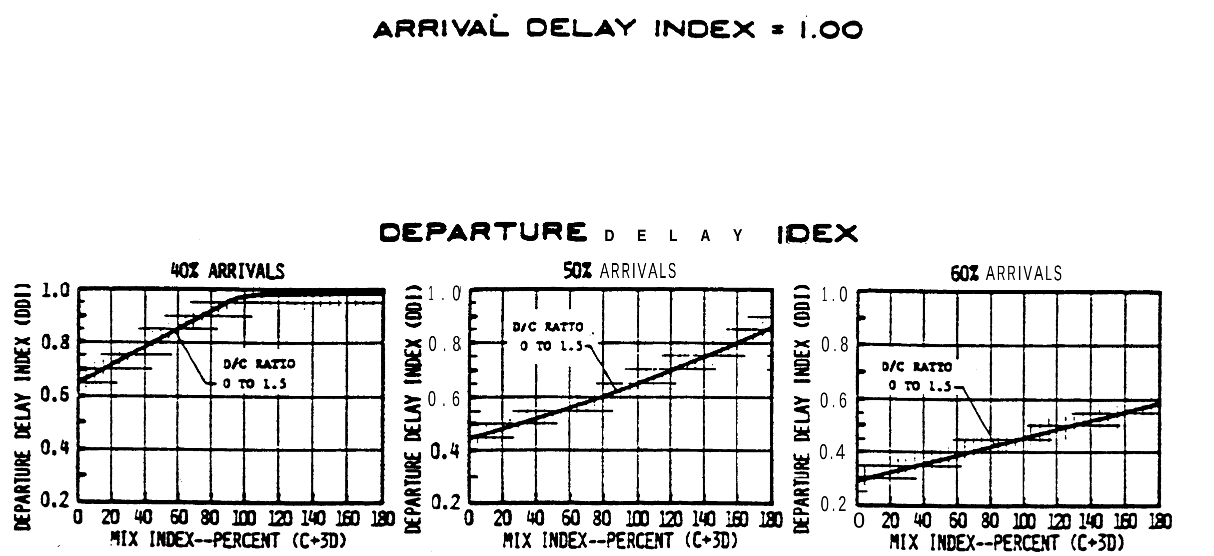


FIGURE 3-97. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 13, 16, 24, 27 FOR IFR CONDITIONS

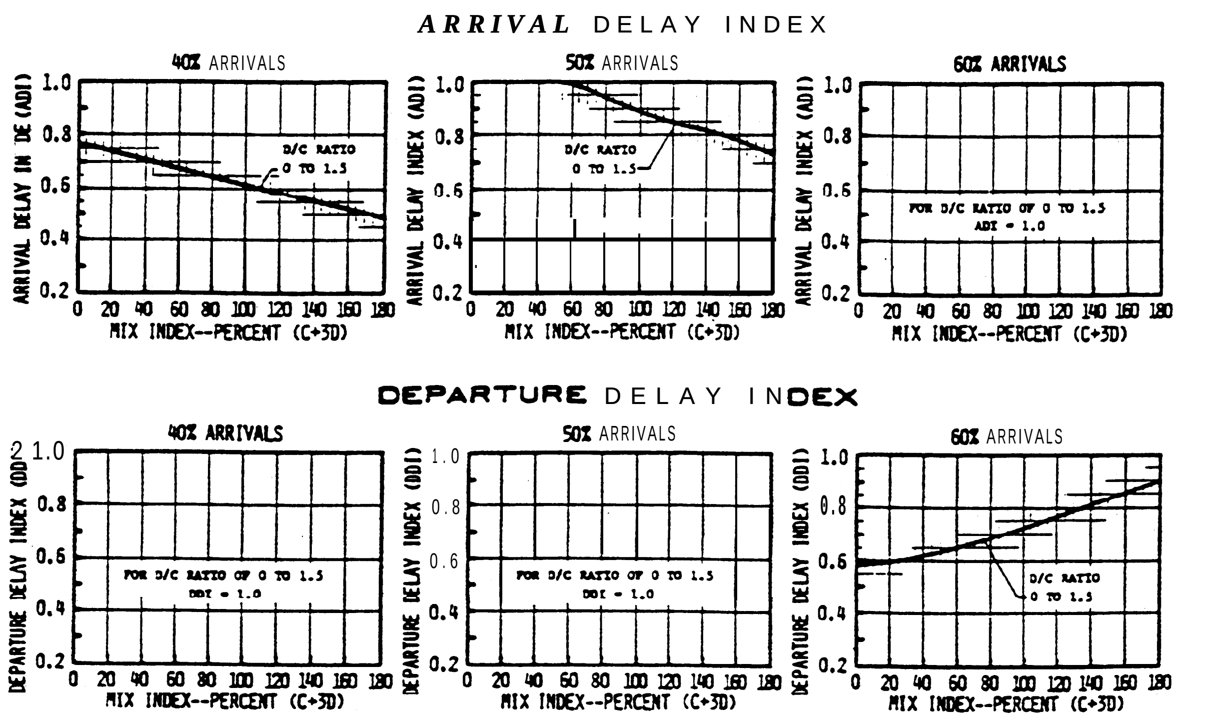


FIGURE 3-98. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 15, 28 FOR IFR CONDITIONS

ARRIVAL DELAY INDEX = 1.00

DEPARTURE DELAY INDEX

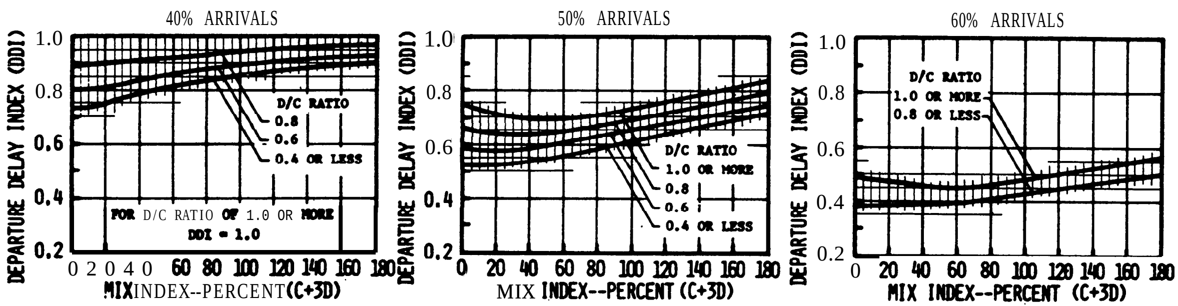


FIGURE 3-99, DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 18,22,26,31,36,44-46,50-52,56-58 FOR IFR CONDITIONS,

ARRIVAL DELAY INDEX = 1.00

DEPARTURE DELAY INDEX

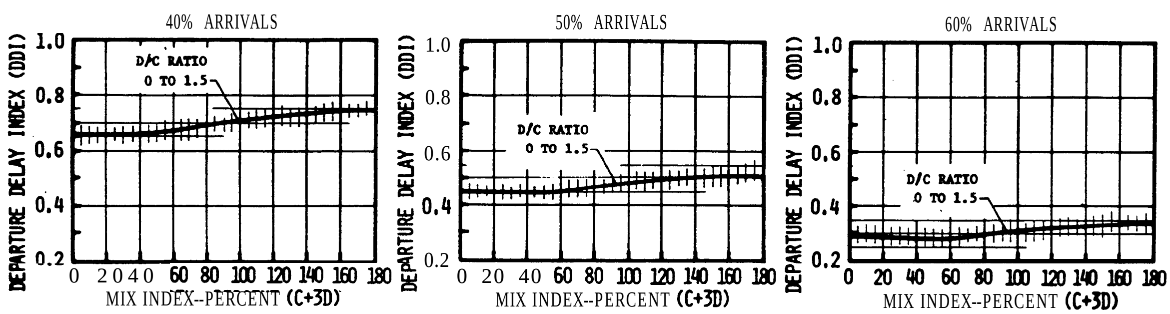


FIGURE 3-100. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 19,23 FOR IFK CONDITIONS.

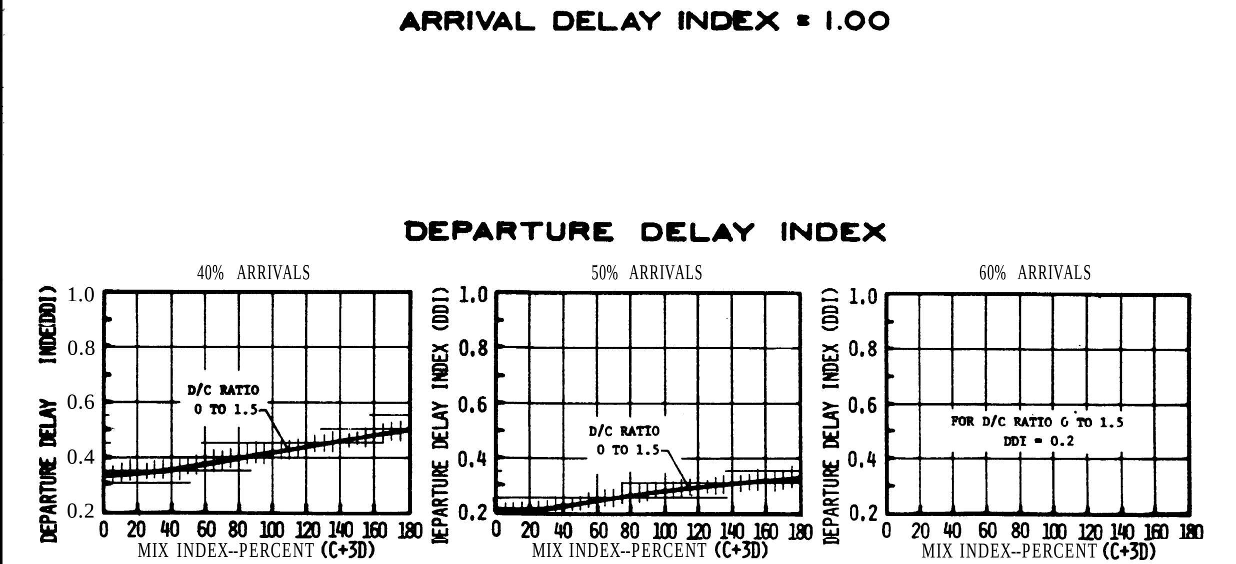


FIGURE 3-101. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 78,81,86,93,96,101 FOR IFR CONDITIONS.

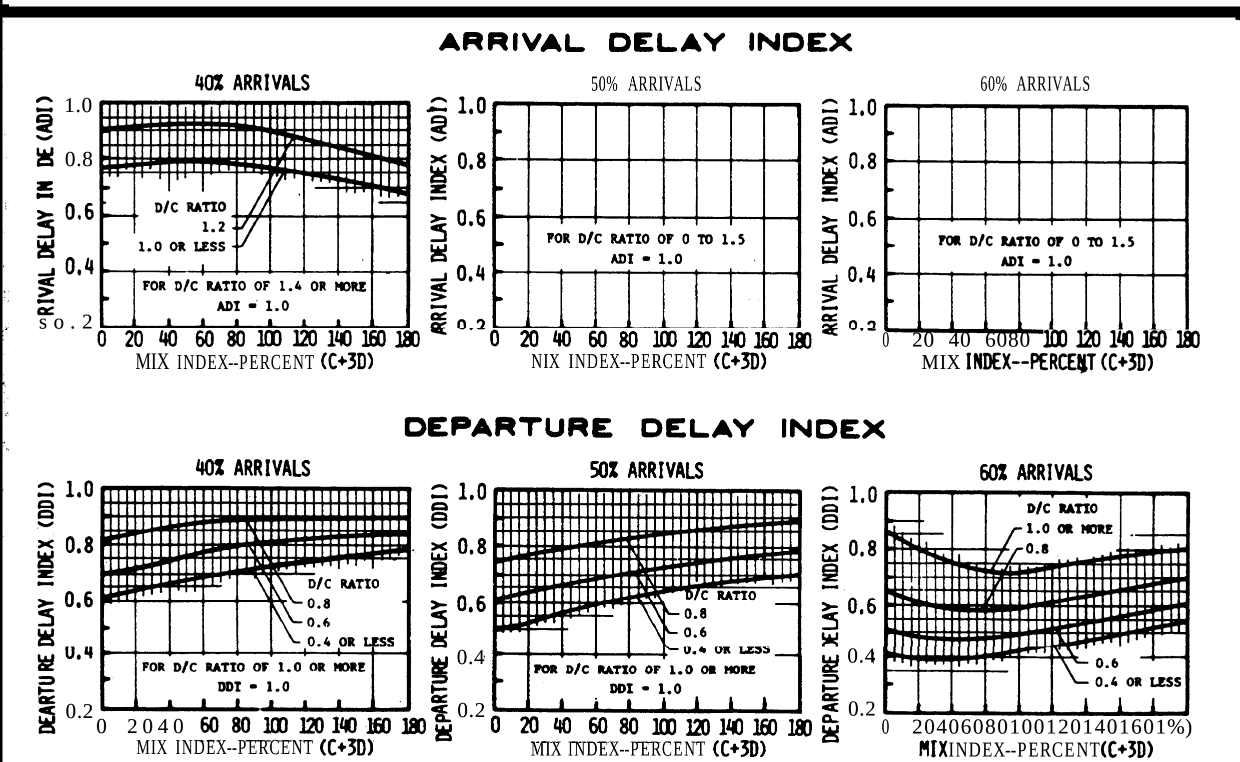


FIGURE 3-102. DELAY INDICES FOR RUNWAY-USE DIAGRAM NOS.: 47,48,59,60 FOR IFR CONDITIONS.

CHAPTER 4. SPECIAL APPLICATIONS

4-1. GENERAL. This chapter provides calculations of runway capacity for situations involving PVC conditions, the absence of radar coverage and/or ILS, and airports with one runway or a runway restricted to small aircraft. Appendix 3 contains examples of these calculations.

4-2. PVC CONDITIONS. Runway hourly capacity in PVC conditions is reduced by increased in-trail separations of approaches and departures and increased runway occupancy times. Calculate PVC runway component hourly capacity as follows:

a. Select the runway-use configuration in figure 4-1 which best represents the airport and identify the figure number for determining capacity in PVC conditions. To adjust for staggered thresholds, see paragraph 4-6.

b. Determine the percent of class C and D aircraft and calculate the mix index.

c. Determine the percent arrivals.

d. Determine the runway hourly capacity from the figure identified in paragraph b above.

4-3. ABSENCE OF RADAR COVERAGE OR ILS. Except for single runway airports used almost exclusively by class A and B aircraft (which are covered in paragraph 4-5), calculate the hourly capacity of the runway component in the absence of radar coverage or ILS as follows:

a. Select the runway-use configuration in figure 4-1 which best represents the airport and identify the figure number for determining capacity with an inoperative navaid.

b. Determine whether the radar or the ILS is operative and determine whether a straight-in or a circling approach is authorized.

c. Determine the percent of class C and D aircraft and calculate the mix index.

d Determine the runway hourly capacity from the figure identified in paragraph b above.

4-4. PARALLEL RUNWAY AIRPORTS WITH ONE RUNWAY RESTRICTED TO USE BY SMALL AIRCRAFT. Calculate the hourly capacity of a parallel runway configuration when one of the runways is unable to accommodate class C and D aircraft as follows:

a. Select the runway-use configuration in figure 4-1 which best represents the airport and identify the figure number for determining capacity in restricted runway use. To adjust for staggered thresholds, see paragraph 4-6.

b. Determine the percent of class C and D aircraft and calculate the mix index.

c. Determine the percent arrivals.

e. Determine the runway hourly capacity from the figure identified in paragraph b above.

4-5. SINGLE RUNWAY **AIRPORT--SMALL** AIRCRAFT ONLY. Calculate the capacity of a **small** airport **used** almost exclusively **by** Class A and B aircraft without radar coverage or ILS as follows:

a. Conditions.

(1) The airport is used almost exclusively by Class A and B aircraft.

(2) The airport does not have radar coverge or an ILS, but it has an approved approach procedure.

(3) Arrivals equal departures.

(4) There are no airspace limitations affecting runway use.

b. **Capacity** Calculations.

(1) Select the airport configuration **from** figure 4-26 that best represents the airport.

(2) Determine the percent of touch-and-go **operations.**

(3) **Read** the range of hourly VFR and IFR capacities **from** figure 4-26.

4-6. THRESHOLD STAGGER. FM ATC procedures permit **simultaneous** departures and **simultaneous** departure--arrival operations on parallel runways spaced 2,500 feet **apart with even** thresholds and at lesser/greater separations if the thresholds are staggered. When thresholds are staggered **,** the equivalent unstaggered separation is **calculated** increasing or decreasing the actual separation depending upon whether the arriving aircraft is approaching the near' or **far** threshold. 'Stagger adjustments are only applicable when the parallel runway separations that are at least 1000 feet apart and less than 4300 feet apart.

a. Calculation.

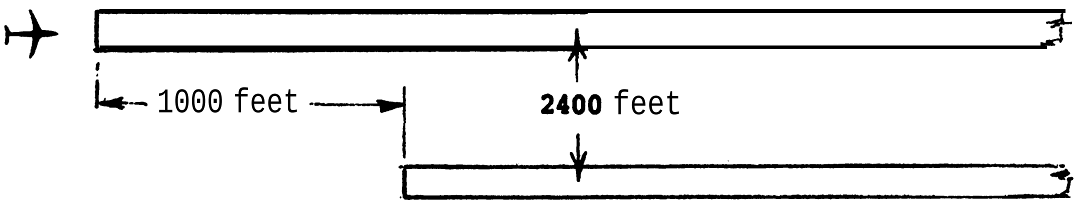
(1) If the approaches are to the near threshold and the separation is less than 4299 **feet,** the equivalent separation is the actual separation increased by 100 feet for each 500 feet of threshold stagger up to a maximum of 4299 feet.

(2) If the approaches are to the far threshold and the **separation** is greater than 1000 feet, the equivalent separation **is** the **actual separartion** decreased by 100 feet for each 500 feet of threshold stagger down to a minimum of 703 **feet.**

b. Application. Apply the equivalent separation to determine which parallel runway-use configuration to use. Note: the calculation for equivalency need only determine whether the equivalent runway separation is 2500 feet or greater or 2499 feet or less.

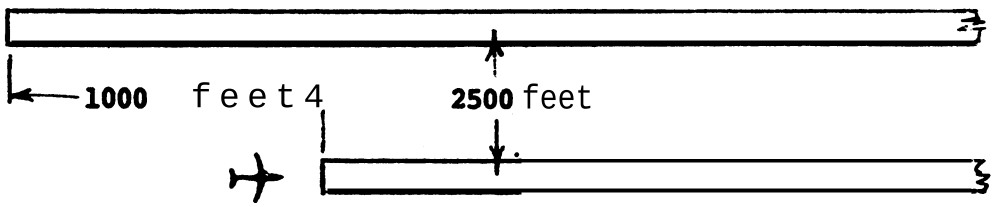
c. Examples.

case 1. Staggered thresholds, approaches to near threshold,



(1000/500) · 2 = 200
Separation for equivalency is increased by 200 feet
2400 + 200 = 2600 feet

Case 2. Staggered thresholds, approaches to far threshold.



(-1000/500) · 2 = -200
Separation for equivalency is decreased by 200 feet
2500 - 200 = 2300 feet

Runway-use Diagram	Diag. No.	Runway Spacing (S) in feet	Figure No. for Capacity: Poor Visibility Conditions	Inoperative Navaids	Restricted Runway-use: VFR	Restricted Runway-use: IFR
	1	NA	4-2	4-15	-	-
S	2a	700 to 2499	4-3	4-16	-	-
	2b	2500 or more	4-4			
	3	700 to 2499	4-3	4-16	-	-
c	4	2500 or more	4-5			
S	5	700 to 2499	4-3	4-16	-	-
	6	2500 to 2999	4-6			
	7	3000 to 4299	4-7			
	8	4300 or more	4-8			
S	9	700 to 2499	4-3	4-16	4-17	4-21
	10	2500 to 2999	4-9		4-18	
	11	3000 to 4299	4-10			4-22
	12	4300 or more	4-11			
c, S	28	2500 to 3499	-	-	4-19	4-23
	29	3500 or more				4-24
c, S, c	40	3500 or more	-	-	4-20	4-25
Y	44&47, &46, 45&48	X(ft): 0 to 1999; Y(ft): 0	4-12	4-15	-	-
	44&45&48	X(ft): 2000 to 4999 / 5000; Y(ft): 2800 to 8000	4-13, 4-14			
Y		X(ft): 0 to 1999; Y(ft): 0	4-12	4-15	-	-
	50&51&52	X(ft): 2000 to 5000; Y(ft): 0 to 8000	4-14, 4-13			

c = 700' to 2499'
(aircraft symbol) = Type of operation that can occur.
(solid bar) = Runway used only by A and B aircraft.

Figure 4-1. Special applications

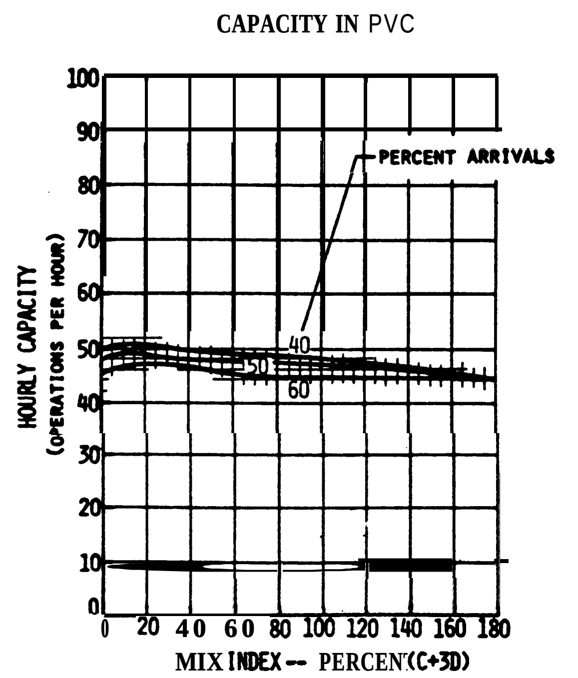


FIGURE 4-2. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 1.

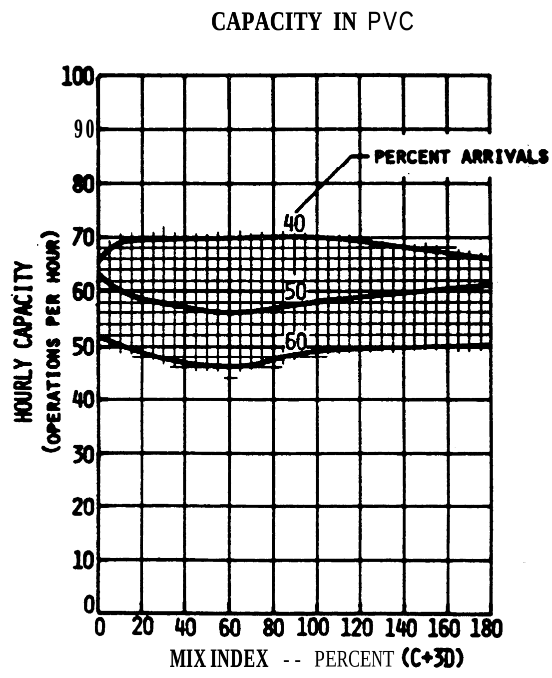


FIGURE 4-3, HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS. 2A, 3, 5, 9.

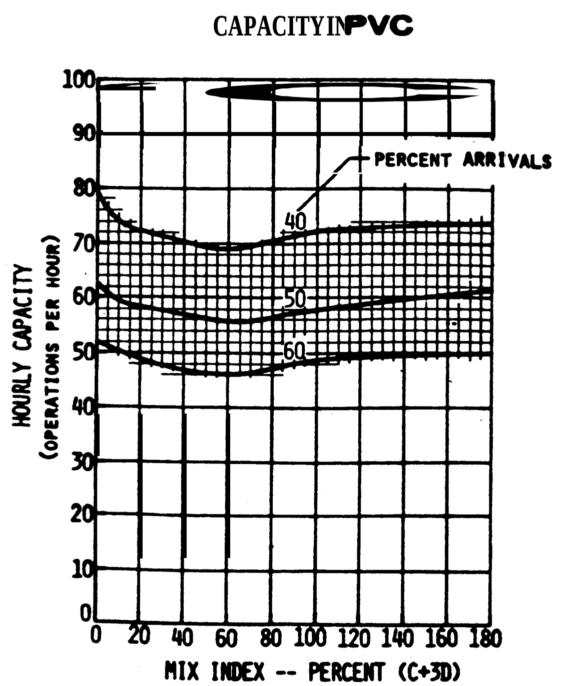


FIGURE 4-4. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO, 2B.

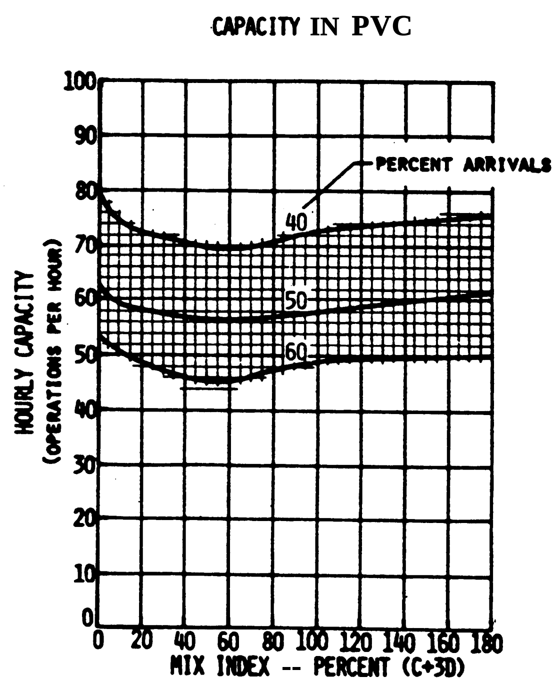


FIGURE 4-5. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 4.

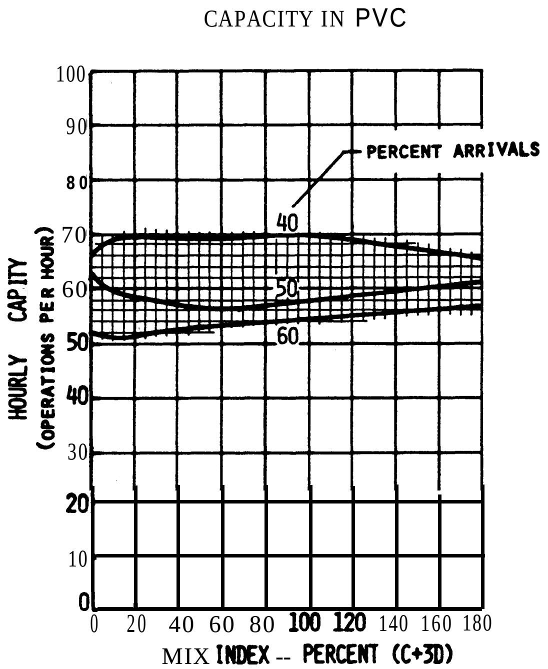


FIGURE 4-6. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 6.

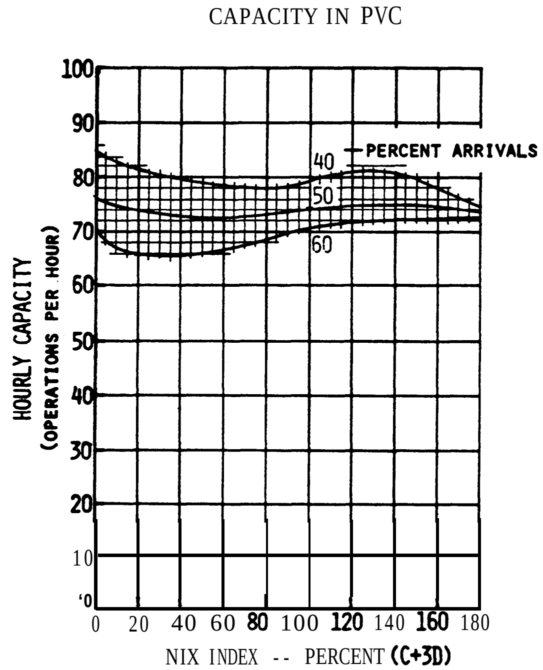


FIGURE 4-7. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 7.

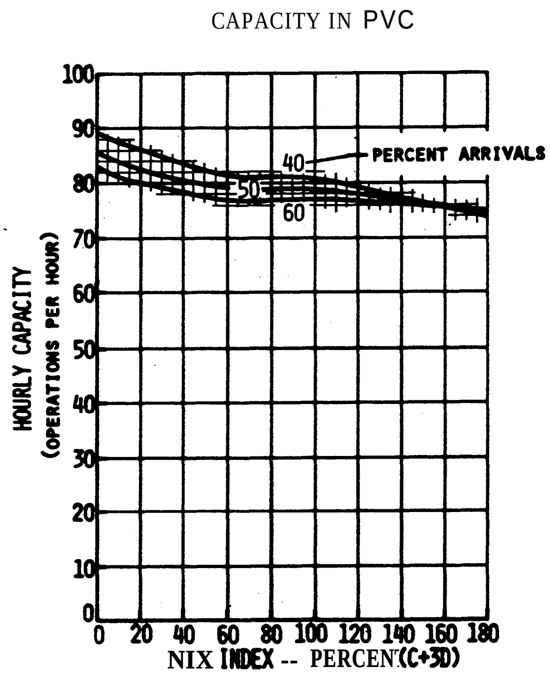


FIGURE 4-8. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 8.

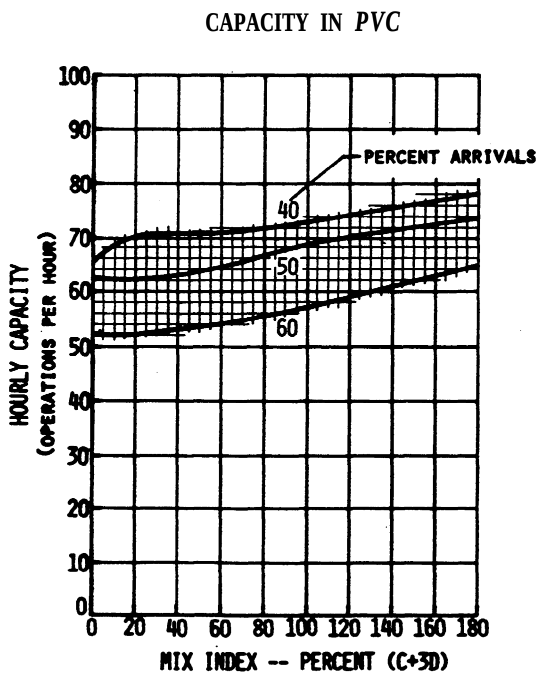


FIGURE 4-9. HOURLY CAPACITY OF RUNWAY-USC DIAGRAM NO. 10.

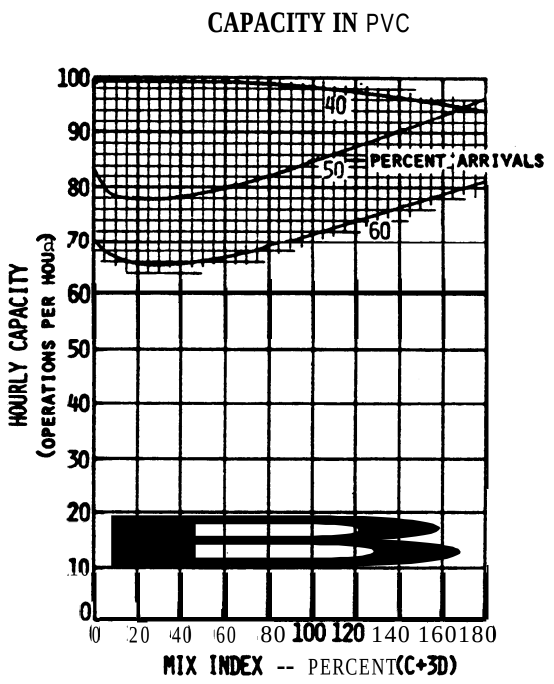


FIGURE 4-10. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM No. 11.

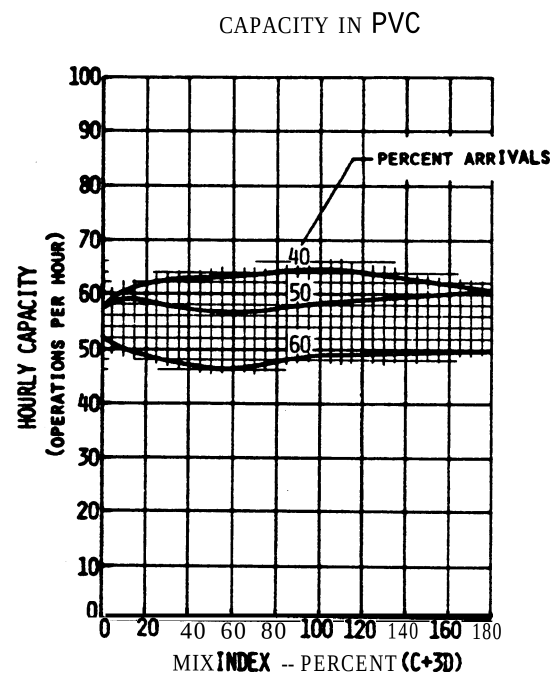


FIGURE 4-12. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS. 43, 45, 49, 52,

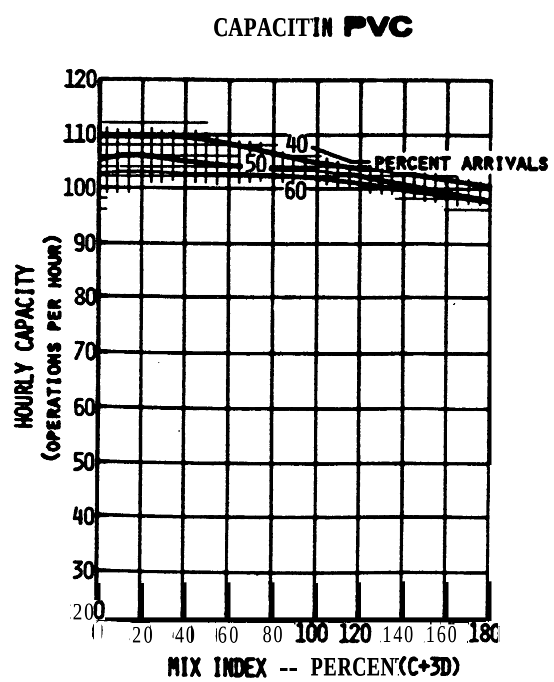


FIGURE 4-11. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 12.

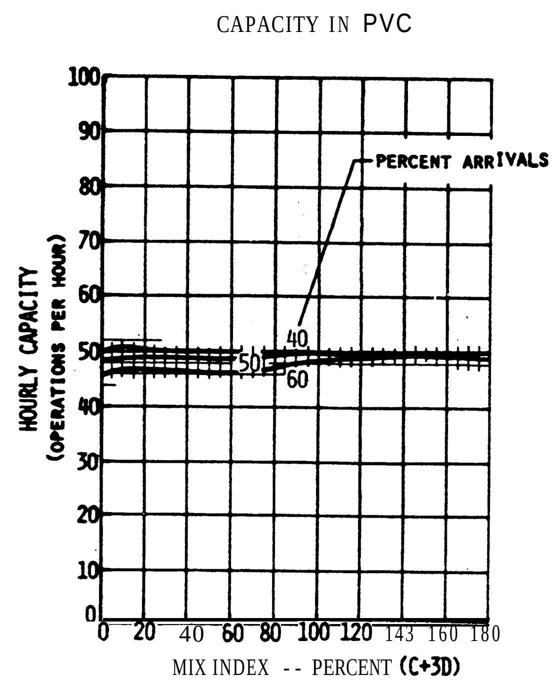


FIGURE 4-13. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS. 44, 47, 50, 53.

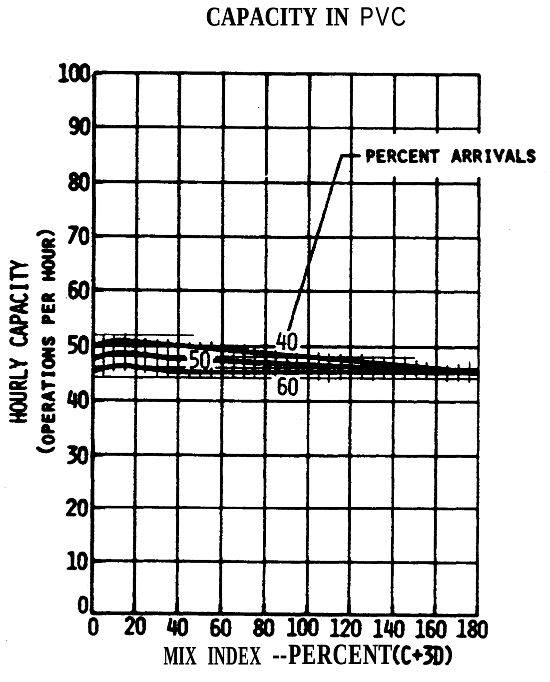


FIGURE 4-14. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS. 45, 48, 51, 54.

FIGURE A3-2A.
HOURLY CAPACITY IN RADAR ENVIRONMENT

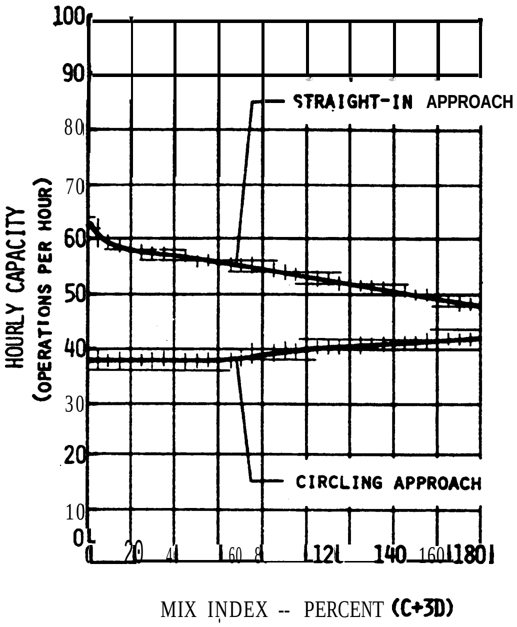


FIGURE A3-2B.
HOURLY CAPACITY IN NONRADAR ENVIRONMENT

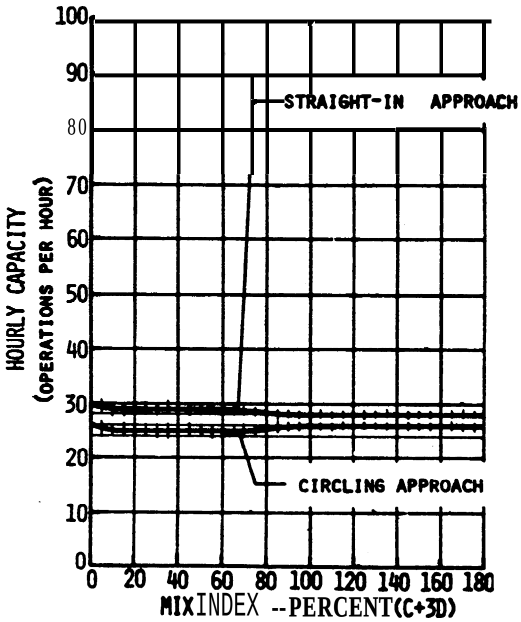


FIGURE 4-15. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS. 1, 43-54,

FIGURE A3-3A.
HOURLY CAPACITY IN RADAR ENVIRONMENT

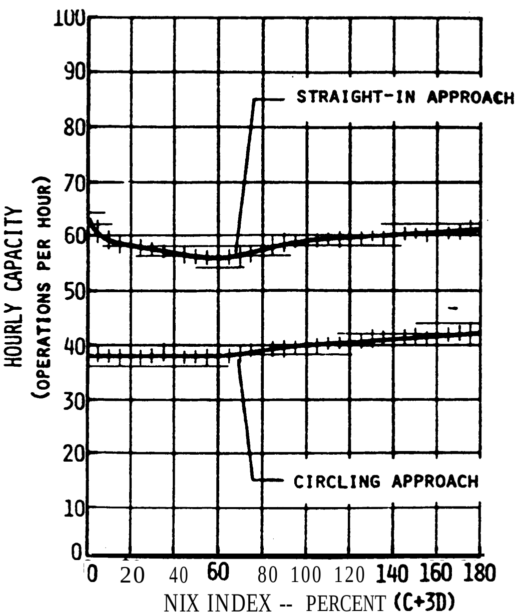


FIGURE A3-3B.
HOURLY CAPACITY IN NONRADAR ENVIRONMENT

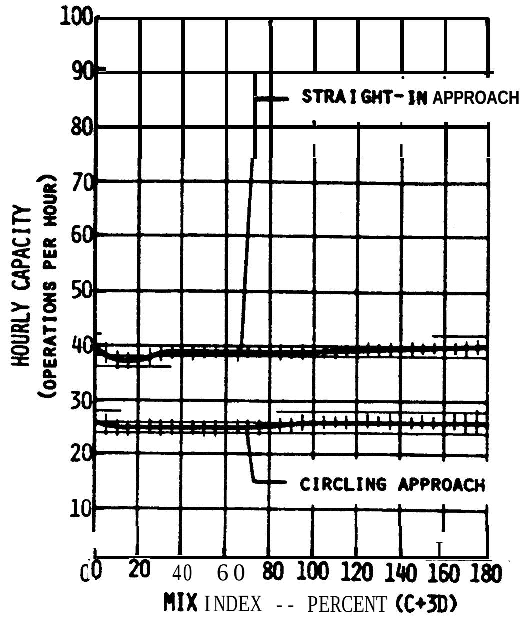


FIGURE 4-16. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS. 2A, 2B, 3-12,

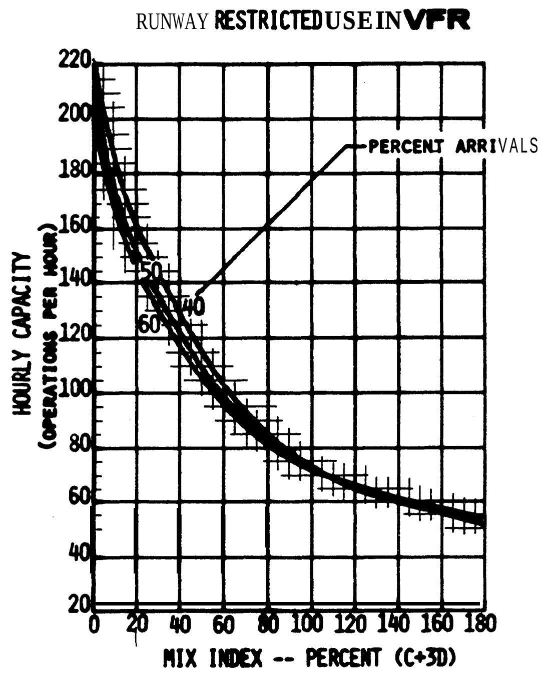


FIGURE 4-17, HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 9.

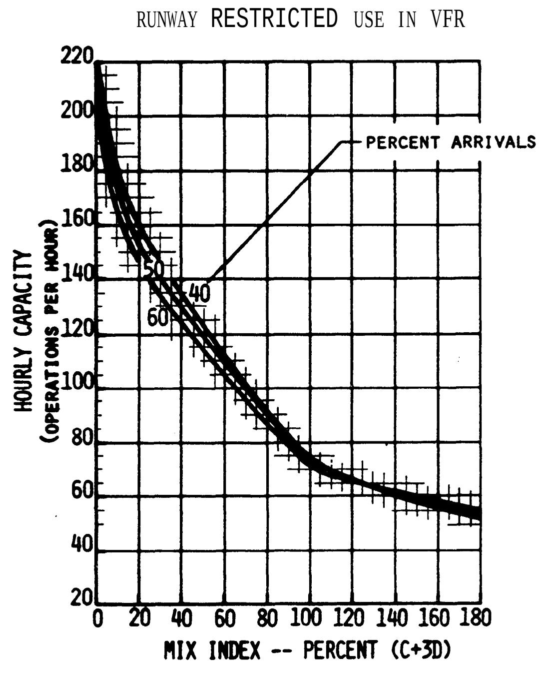


FIGURE 4-18. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS. 10, 11, 12.

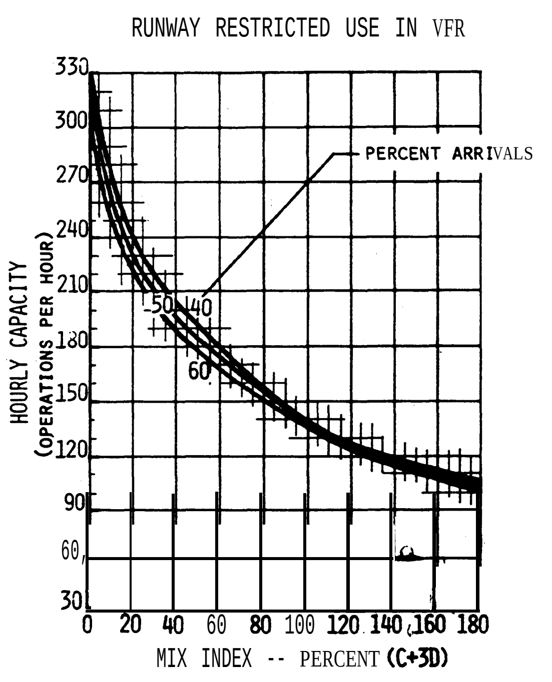


FIGURE 4-19. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS. 28, 29.

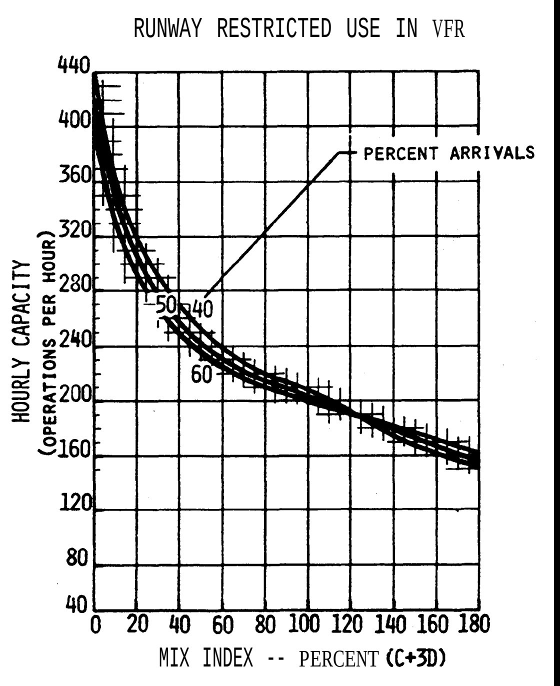


FIGURE 4-20. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 40.

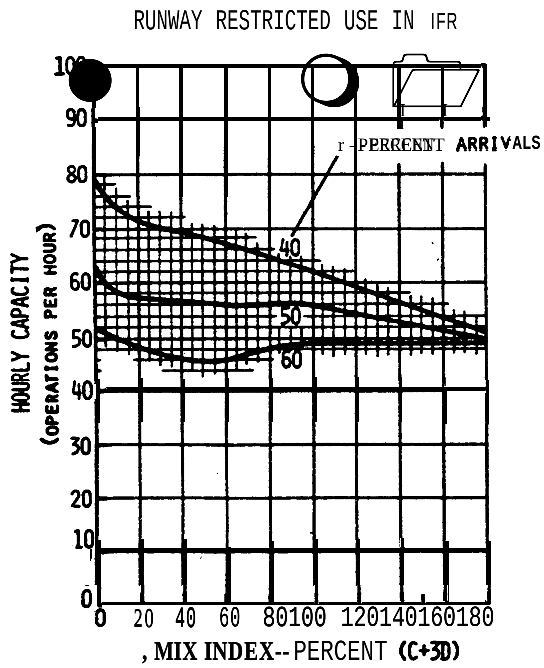


FIGURE 4-21, HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS. 9, 10, 11.

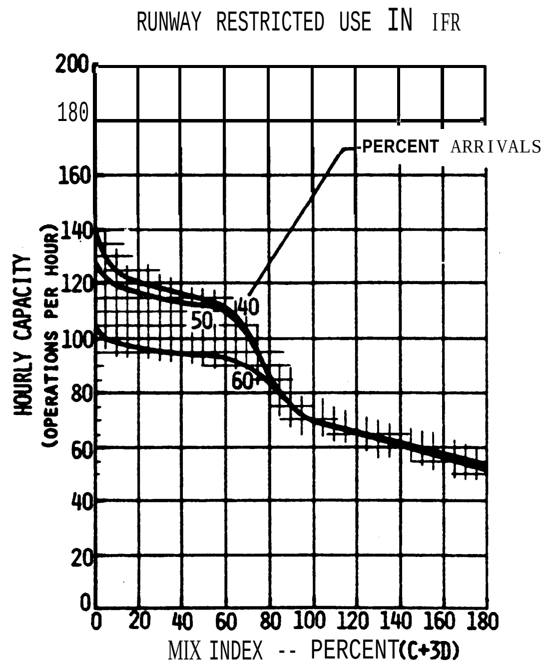


FIGURE 4-22. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 12.

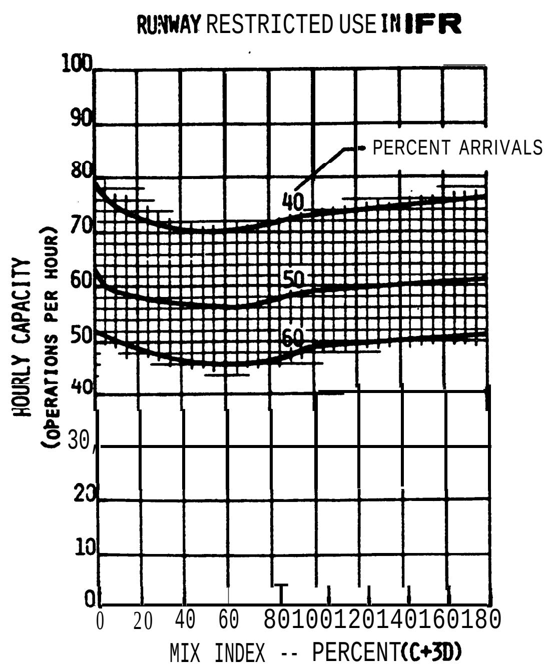


FIGURE 4-23, HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 28,

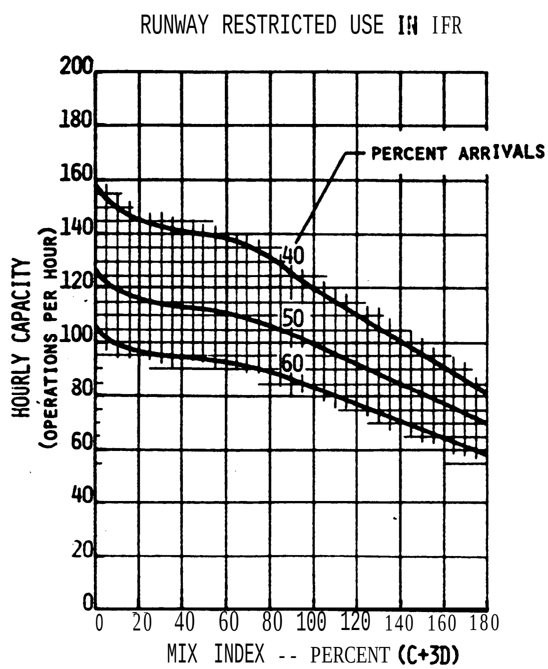


FIGURE 4-24. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 29.

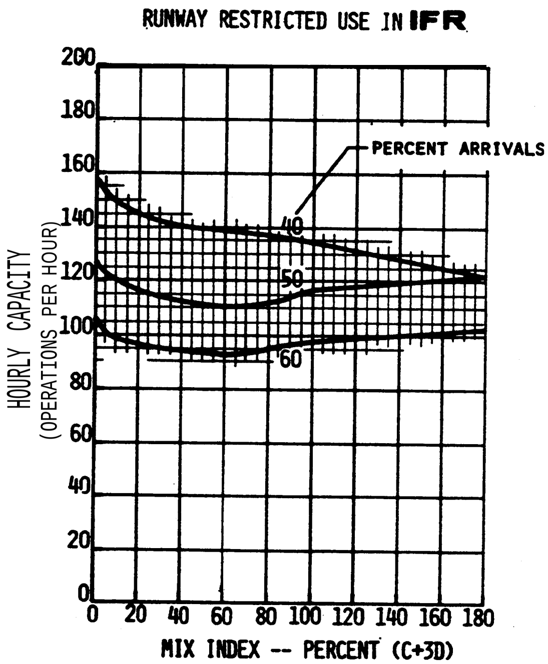
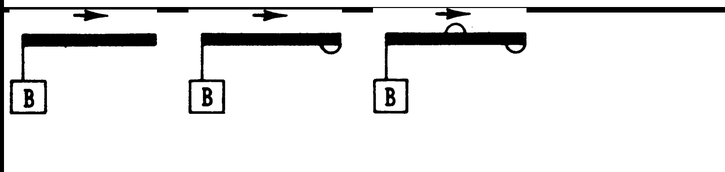
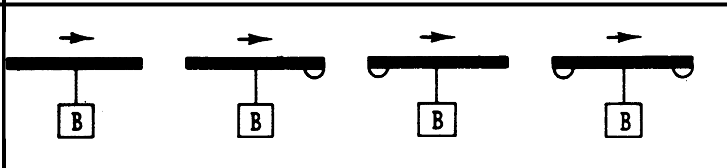
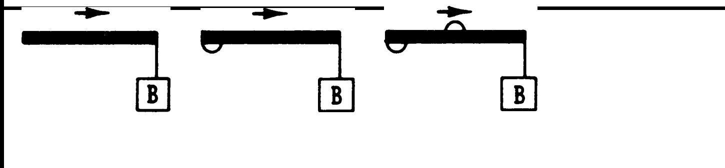
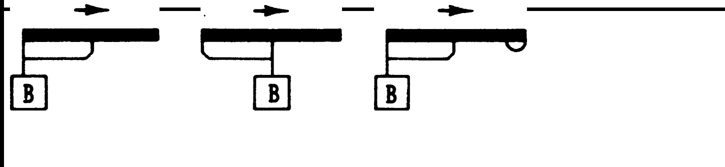
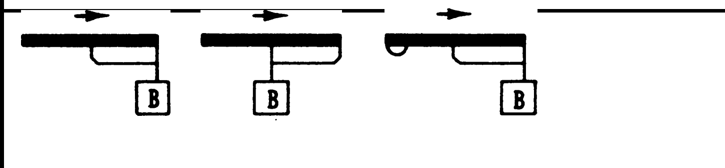
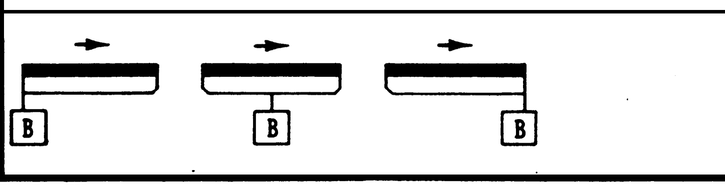


FIGURE 4-25. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NO. 40.

CONFIG. No,	AIRFIELD CONFIGURATION	HOURLY CAPACITY IN VFR PERCENT TOUCH-AND-GO 0 TO 25	HOURLY CAPACITY IN VFR PERCENT TOUCH-AND-GO 26 TO 50	HOURLY CAPACITY IN IFR
		(OPERATIONS PER HOUR)		
1		54 TO 66	66 TO 85	20 TO 24
2		59 TO 72	72 TO 92	20 TO 24
3		40 TO 50	50 TO 67	20 TO 24
4		82 TO 97	97 TO 117	20 TO 24
5		71 TO 85	85 TO 106	20 TO 24
6		60 TO 72	72 TO 92	20 TO 24
7		SEE CHAPTER 3		

LEGEND:

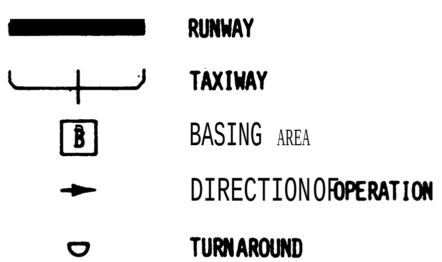


Figure **4-26. Hourly** capacity of single runway airports, **without** radar coverage **or ILS, serving** small aircraft only.

CHAPTER 5. COMPUTER PROGRAMS FOR AIRPORT CAPACITY AND AIRCRAFT DELAY

5-1. GENERAL. This chapter identifies computer models for determining airport capacity, aircraft delay, and the sensitivity of a proposed physical/operational change to an airport or air traffic procedure.

5-2. SIMULATION MODEL (SIMMOD). SIMMOD is a simulation model used by the FAA, airlines, airports, architects, and engineers to design airport improvements, calculate travel times and flow rates for an airport or an airport component, and/or develop procedural alternatives for domestic and international air traffic management, including the adjacent airspace. Specific applications of the **SIMMOD model** range from studies of a single runway airport with its network of taxiway and gates, to studies of terminal areas having multiple airports with complex airspace routings.

a. SIMMOD both the physical design and procedural aspects of all air traffic operations, allowing decision-makers to determine projected benefits and impacts in terms of airport capacity and in aircraft travel time, delay, and fuel consumption. The model incorporates **the** FAA's **Integrated Noise Model (INM)** as a post-processing function, allowing users to determine the impact of aircraft noise in the-planning process. SIMMOD is available in two versions which include magnetic media, manuals, and all required software licenses and libraries. The Summagraphics MG-3648 36"x 48" or Summagraphics Professional 12"x 18" digitizer, and CAD/CAM (Autocad) are recommended for data input and optional display.

(1) SIMMOD **Version 1.2** for 386/25 IBM compatible microcomputers with 80387 math coprocessors, 4 MB RAM, 80 MB hard disk, 1.2 MB (5.25") or 1.44 MB (3.5") floppy disk drive, VGA graphics system (board and monitor), Mouse (Microsoft-compatible), and a Epson/HP Laserjet or compatible printer. DOS 3. 1 or higher (DOS 4.0 is not recommended) or OS/2.

(2) SIMMOD Version 2.1 operates on SUN Sparc and HP9000/700 series computers. Parts of this version operate on IBM RS6000 machines having 32 MB RAM and 1.2 GB Hard drives.

b. Model Source. The SIMMOD model and information on the model may be obtained from:

FAA, Program Analysis and Operations Research (ASD-400)
800 Independence Avenue SW
Washington, D.C. 20591.
Telephone number (202) 358-5225
Internet Address: http://www .orlab. faa.gov/homepage.html

5-3. AIRPORT MODEL. This model is a general purpose airport simulation that can be used for any airport. It requires a DOS platform and-can produce animated graphic output. The input data include physical airfield layout, ATC rules and procedures, and aircraft performance characteristics. The input can also be modified in a user interface mode. Either actual or randomly-generated flight schedules can be used to drive the model. Among the unique features of the Airport Machine are detailed landing deceleration modeling, deceleration and exit selection, spacing of arrivals to allow runway crossing, controlled departure queuing, and user interface to allow optimization of outcomes. Information on this model may be obtained from:

FAA Technical Center, Attn: Mr. John Vander Veer
Aviation System Analysis and Modeling Branch (ACT-520A)
Atlantic City International Airport, N. J. 08405
Telephone number (609) 485-5645

5-4. AIRFIELD DELAY SIMULATION MODEL (ADSIM). ADSIM is a discrete-event simulation model that calculates travel time, delay and flow rate. It may also be used to analyze the components of an airport, airport operations, and operations in the adjacent airspace. The model implements the Monte Carlo sampling techniques. The procedural logic and physical network are used to simulate traffic using a series of probabilistic parameters such as gate service time, arrival runway separation time and may others. The output enables users to generate performance data based on hourly flow rates, delays encountered on different routes, travei time, and others.

5-5. AIRFIELD CAPACITY MODEL. This upgraded FAA Airfield Capacity Model is a computer program which analytically calculates the maximum operational capacity of a runway system under a wide range of conditions. The mode1 user has considerable freedom to vary the parameters of the computation, such as number and usage of runways, aircraft mix and speeds, and the characteristics of the ATC system.

5-6. MODEL AVAILABILITY. Tapes of the ADSIM and Airfield Capacity model are available from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia 22161. The NTIS accession code number for ADSIM (Model Simulation) is PB84-171560, for ADSIM User's Guide is PB84-171552. The NTIS accession code number for Upgrade FAA Airfield Capacity Model Supplemental User's Guide is AD-A104 154/0. Telephone orders (703) 487-4650 (TDD for the hearing impaired (703) 487-4639), or FAX orders (703) 321-8547.

5-7. AIRPORT DESIGN COMPUTER MODEL. This computer model requires minimal input and provides output which can be computed as specified in chapter 2. Refer to AC 150/5300-13, Airport Design, Appendix 14, Computer Program, for details on this computer model.

a. Computer Requirements. Airport Design runs on the IBM PC family of computers and all true IBM compatibles. It requires DOS of 3.1 or higher and at least 640K of RAM.

b. Software Source. Airport Design is available for downloading from the Office of Airport Safety and Standards Electronic Bulletin Board System.

Telephone number:	(202) 267-5205
Data bits:	8
Parity:	(N)one
Stop bits:	1
Baud rate:	300/1200/2400/9600/14400

5-8. PROPRIETARY MODELS. Consultants doing airport engineering and planning as well as individual airport engineering/planning departments have developed or purchased proprietary models to carry out airport capacity and delay studies. Information on computer requirements and licensing costs for a proprietary model must be obtained from the respective model owner.

APPENDIX 1. EXAMPLE APPLYING CHAPTER 2 CALCULATIONS

1. GENERAL. The examples in this appendix illustrate applications of chapter 2 capacity and delay calculations with portions of the appropriate tables and figures of chapter 2 reproduced in the examples. The work sheers provided in appendix 5 are used to record data.

2. EXAMPLES. The following four examples illustrate the progressive calculations of chapter 2.

a. Examples.

(1) Calculate existing runway capacity (figure Al-l).

(2) Identify airport improvements to accommodate demand (figure A1-2).

(3) Determine annual delay (figure Al-3).

(4) Calculate potential savings associated with reduced delay (figure A1-4).

b. Data. The following data is given for the four examples.

(1) The airport has a single runway with a full length parallel taxiway and entrance-exit taxiways. All required navigational and air traffic aids exists, or will exist, and there are no foreseeable airspace limitations.

(2) The airport has a forecast demand of 220,000 annual operations by the year 2000. The demand consists of 41 percent small aircraft (one half of these are single engine), 55 percent large aircraft, and 4 percent heavy aircraft. Air carrier operations predominate and touch-and-go operations are nominal.

EXAMPLE 1. Determine whether the runway capacity is adequate to accommodate the forecasted demand.

SOLUTION:

1. Aircraft Mix. Enter the mix of the forecasted demand (41% small, 53% large, 4% heavy) in columns 1 through 4 of the work sheet.

Table 1-1. Aircraft classifications

Aircraft Class	Max. Cert. T.O. Weight (lbs)	Number Engines	Wake Turbulence Classification
A	12,500 or less	Single	Small (S)
B		Multi	
C	12,500 - 300,000	Multi	Large (L)
D	over 300,000	Multi	Heavy (H)

2. Runway-use. Select the runway-use configuration from figure 2-1 that best represents the airport. Enter the diagram number (1) in column 6 and a line sketch of the configuration in column 7.

No.	Runway-use Configuration	Mix Index %(C+3D)	Hourly Capacity Ops/Hr VFR	Hourly Capacity Ops/Hr IFR	Annual Service Volume Ops/Yr
1.		0 to 20	98	59	230,000
		21 to 50	74	57	195,000
		51 to 80	63	56	205,000
		81 to 120	55	53	210,000
		121 to 180	51	50	240,000

3. Mix Index. Calculate the mix index, 55+3(4) = 67, and enter in column 5.

4. Hourly Capacity. Enter the hourly VFR and IFR capacities and the ASV, obtained from diagram 1, figure 2-1, in columns 8, 9, and 10.

Aircraft Mix %A	Aircraft Mix %B	Aircraft Mix %C	Aircraft Mix %D	Mix Index %(C+3D)	Configuration No.	Configuration Sketch	Capacity (Ops/Hour) VFR	Capacity (Ops/Hour) IFR	ASV (000)	Annual Demand (000)	Annual Demand / ASV	Average Delay per Aircraft (Minutes) Low	Average Delay per Aircraft (Minutes) High	Minutes of Annual Delay (000) Low	Minutes of Annual Delay (000) High
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
21	20	55	4	67	1	——	63	56	205						

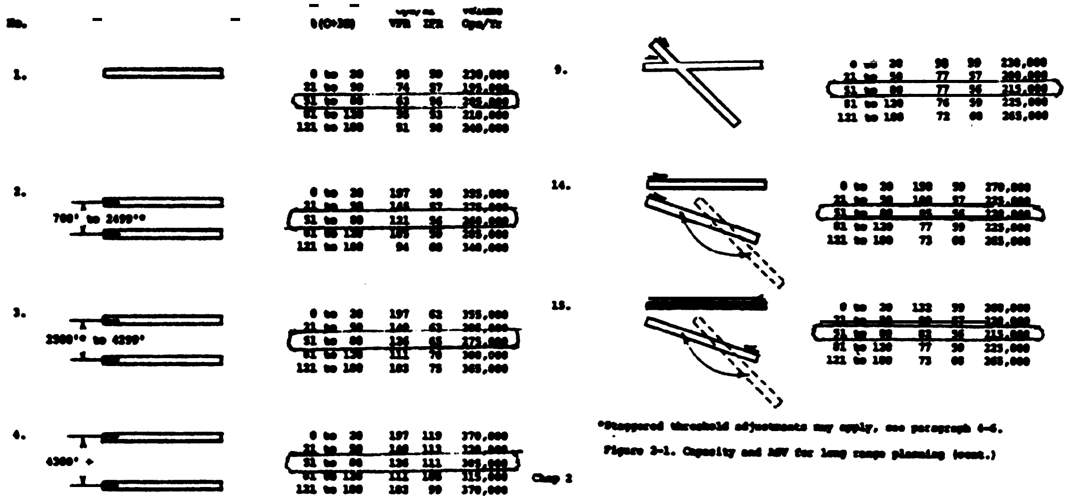
5. Conclusion. The ASV of 205,000 operations is less than the forecasted demand of 220,000 annual operations. Unless additional capacity is provided, delays will become costly.

Figure A1-1. Investigate runway capability

EXAMPLE 2. **Example** 1 **concluded** that the **ASV** of 205,000 **operations** is less than the forecasted 220,000 operational demand. Identify alternative. two-runway **configurations** that will **accommodate** the demand,

SOLUTION:

1. Capacity of Alternatives. **Repeat** each of the calculations of example 1 for **each** of the two-runway configurations.



Aircraft Mix				Mix Index	Configuration		Capacity (Ops/Hour)		ASV	Annual Demand	Annual Demand / ASV	Average Delay per Aircraft (Minutes)		Minutes of Annual Delay (000)	
%A	%B	%C	%D	%(C+3D)	No.	Sketch	VFR	IFR	(000)	(000)		Low	High	Low	High
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
21	20	55	4	67	1		63	56	205						
"	"	"	"	"	2		121	56	260						
"	"	"	"	"	3		126	65	275						
"	"	"	"	"	4		126	111	305						
"	"	"	"	"	9		77	56	215						
"	"	"	"	"	14		85	56	220						
"	"	"	"	"	15		82	56	215						

2. **Conclusion.** The parallel runway-use configuration **(4),** which meets the separation **requirements** for **simultaneous** instrument approaches, provides the best **VFR** and **IFR** hourly capacities and **ASV.** Any of the parallel runway-use configurations as **well** au **the** diverging runway-use configuration **meet** the **forecasted demand. The crossing** and **converging** runway-use configurations have less capacity than the **forecasted** demand.

Figure **A1-2.** Identify two-runway configurations

EXAMPLE 3. What annual delay is anticipated **for** the **existing and each of** the alternative runway-use **configurations?**

SOLUTION: The following calculations **are** for the **existing single** rummy-use configuration are repeated for each **of the** alternative **runway-use configurations.**

1. **Annual Demand.** Enter 220,000 **(operations)** in column **11.**

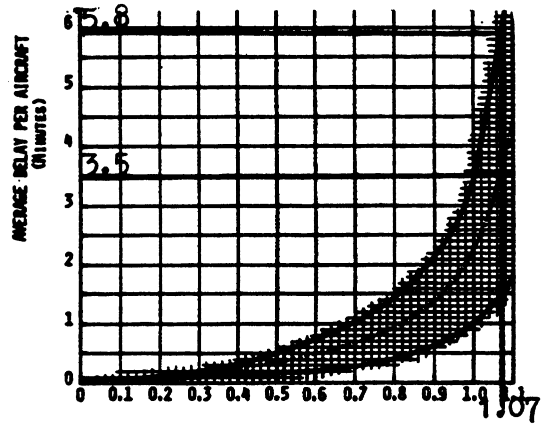
2. **Demand-ASV** Ratios. Divide **the annual demand** by the **ASV and enter** in **column 12.**

220/205 = 1.07

3. **Average** Aircraft **Delay.** Obtain the high and law average &lays pet aircraft from **figure 2-2** and **enter** in **columns 13 and 14.**

4. Annual Delay. **Calculate** annual delay and entet results in columns **15** and 16.

3.5 x 220,000 = 770,000 minutes
5.8 x 220,000 = 1,276,000 minutes



RATIO OF ANNUAL DEMAND TO ANNUAL SERVICE VOLUME

Figure 2-2. Average aircraft delay for long range planning

Aircraft Mix				Mix Index	Configuration		Capacity (Ops/Hour)		ASV	Annual Demand	Annual Demand / ASV	Average Delay per Aircraft (Minutes)		Minutes of Annual Delay (000)	
%A	%B	%C	%D	%(C+3D)	No.	Sketch	VFR	IFR	(000)	(000)		Low	High	Low	High
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
21	20	55	4	67	1		63	56	205	220	1.07	3.5	5.8	770	1276
"	"	"	"	"	2		121	56	260	"	.85	1.15	1.8	253	396
"	"	"	"	"	3		126	65	275	"	.80	.95	1.45	209	319
"	"	"	"	"	4		126	111	305	"	.72	.7	1.1	154	242
"	"	"	"	"	9		77	56	215	"	1.02	2.6	4.0	572	880
"	"	"	"	"	14		85	56	220	"	1.0	2.3	3.4	506	748
"	"	"	"	"	15		82	56	215	"	1.02	2.6	4.0	572	880

5. **Conclusions. Average delay per aircraft and annual delay with parallel runway-use configurations** are **significantly less than with any** of **the other runway-use configurations.**

Figure A1-3. Determine annual delay

EXAMPLE 4. What savings can be realized from the reduced delay anticipated in example 3 when going from runway-use configuration 1 to 3.

SOLUTION:

1. Allocate Usage. Distribute aircraft classes used for the capacity calculations (21% A, 20% B, 55% C, and 4% D) among the airport's different types of aircraft and users.

For this example the 21% A is distributed as follows:
6% small aircraft having 1-3 seats (GA),
12% small aircraft having 4+ seats (GA), and
3% small aircraft having 4+ seats (AT)

Comparable distributions are made for the other aircraft classifications.

2. Calculate Average Cost Per Minute. Using the delay costs provided in figure A5-12, calculate the average delev cost attributed to each type of aircraft.

NOTE: Other delay costs may be used. When other delay costs are used, identify the source of their delay costs or explain the rationale for the costs used.

Class A	1-3 seats	0.06 x 0.50 = 0.036
	4+ seats (GA)	0.12 x 1.00 = 0.120
	4+ seats. (AT)	0.03 x 1.80 = 0.054

NOTE: Similar calculations are made for the other aircraft classes and users.

3. Identify Time Savings. Subtract projected minutes of future delay from current estimates of delay to establish the potential savings. Use both the low and high range from figure AL3.

Current Delay (000 Minutes)	770	Low	1,276	High
Projected Delay (000 Minutes)	209	"	319	"
Potential Savings (000 Minutes)	561	"	957	"

4. Savings xample, the projected benefit of reduced delay is calculated to range from a low of $7,610,000 to a high of $12,982,000.

NOTE: Savings in this example do not include purchase or replacement costs of the airplane, airport fees, and other incidental costs incurred by an airline or by an airplane owner. Nor does the example attempt to include the benefits to passengers of reductions in flight delays.

Figure A1-4. Savings associated with reduced delay

Aircraft		Percent of Aircraft	Dollars Minute	Average cost
Class A 12,500 Pounds or less Single Engine	1-3 Seats	6	0.60	0.036
	4 + Seats (GA)	12	1.00	0.120
	4 + Seats (AT)	3	1.80	0.054
Class B 12,500 Pounds or less Multi Engine	Piston Twin (GA)	8	2.50	0.200
	Piston Twin (AT)	4	3.70	0.148
	Turbine Twin (GA)		5.20	
	Turbine Twin (AT)	8	6.80	0.544
Class C 12,500 to 300,000 Pounds	Piston Engine (GA)		2.80	-
	Piston Engine (AT)	2	4.00	0.080
	Piston Engine (AC)		2.90	
	Turbine Twin (GA)	2	5.60	0.112
	Turbine Twin (AT)	5	7.30	0.365
	Turbine Twin (AC)	6	6.60	0.396
	Turbine Four (AC)		15.10	
	2 Engine Jet (GA)	-	13.60	-
	2 Engine Jet (AT)	5	16.80	0.840
	2 Engine Jet (AC)	20	22.00	4.400
	3 Engine Jet (AC)	15	31.40	4.710
	4 Engine Jet (AC)	-	35.50	-
Class D Over 300,000 Pounds	2 Engine Jet (AC)	4	39.00	1.560
	3 Engine Jet (AC)	-	57.60	
	4 Engine Jet (AC)		79.30	
Helicopters	Piston (GA)		1.40	
	Piston (AT)		2.30	
	Turbine (GA)	-	3.30	
	Turbine (AT)	-	4.40	-
	Totals	100	Costs	13.565

(GA) General Aviation (AT) Air Taxi (AC) Air Carrier

	Low	High
Current Deiay (000 Minutes)	770	1,276
Projected Delay (000 Minutes)	209	319
Potential Savings (000 Minutes)	561	957
Average Cost Per Minute	13.565	13.565
Projected Benefit Per Year (000 Dollars)	7,610	12.982

Figure A1-4. Savings associated with reduced delay (cont.)

APPENDIX 2. EXAMPLES APPLYING CHAPTER 3 CALCULATIONS

1. GENERAL. The examples in this appendix illustrate applications of chapter 3 capacity and delay calculations with portions of the appropriate tables and figures of chapter 3 reproduced in the examples. The work sheets provided in appendix 5 are used to record data.

2. EXAMPLES. Ten examples, figures A2-1 through A2-10, illustrate the progressive calculations of chapter 3.

a. Examples.

(1) Hourly capacity of the runway component (figure A2-1).

(2) Hourly capacity of the taxiway component (figure A2-2).

(3) Hourly capacity of gate group components (figure A2-3).

(4) Airport hourly capacity (figure A2-4).

(5) Annual service volume (figure A2-5).

(6) Hourly delay to aircraft on the runway component (figure A2-6).

(7) Daily de&y to aircraft an the runway component when the D/C ratio is 1.0 or less for each hour (figure A2-7).

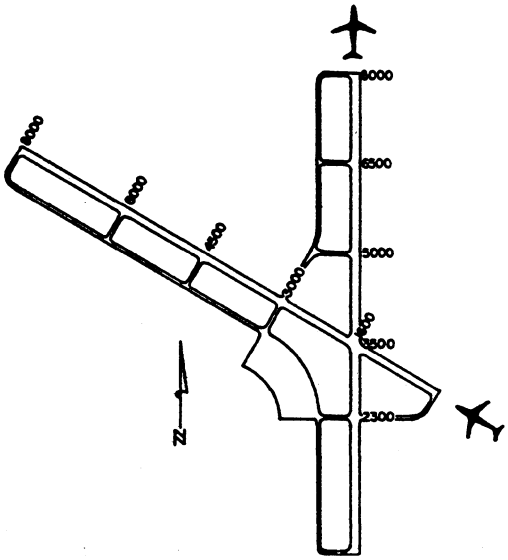
(8) Daily delay to aircraft on the runway component when the D/C ratio is greater than 1.0 for one or more hours (figure A2-8).

(9) Annual delay to aircraft on the rummy component (figure A2-9).

(10) Hourly demand corresponding to a specified level of average hourly delay (figure A2-10).

b. Data. Data necessary to solve each example is provided in the introductory statement. Tb the extent practical, results from one example are used in subsequent examples.

EXAMPLE 1. Determine **VFR** and **IFR** hourly capacities of the depicted **airport.** In the typical busy **hour,** it has 13 single-engine, 10 light twin-engine, 25 'transport **type,** and two **widebody** operations. During **VFR** conditions, **arrivals constitute 45 percent** of the operations and there are three touch and **go's.** During IFR conditions, the busy **hour** count of small aircraft **operations** drops to two single-engine and five light twin-engine aircraft and arrivals constitute 55 percent of the **operations.** There are no touch and **go's** during IFR conditions. The airport typically operates with arrivals on one runway and departures on the other.



SOLUTION: **The** work sheet on page 5 illustrates one method of recording data.

1. Weather. Enter the weather condition(s) applicable to the **capacity determination** in column 1.

2. Runway-use. From figure 3-2 (illustrated), the runway-use configuration **diagram** is No. **43.** Enter this diagram number in column 3, and a line sketch of the configuration in column **2.**

3. Capacity Figure **(s)** The appropriate figures for determining capacity are No. **3-27** for **VFR** conditions and No. 3-59 for IFR conditions. **These** VFR and IFR references are entered on the line in column 4 corresponding to the weather condition.

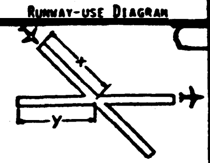
Runway-use Diagram	Diag. No.	Runway Intersection Distance in Feet (x)	(y)	Figure No. For Capacity VFR	For Capacity IFR	For Delay VFR	For Delay IFR
	43	0 to 1999	- 4000	3-27	3-59	3-85	3-91
	44	2000 to 4999	- 4000	3-28	3-60	3-86	3-99
	45	5000 to 8000	- 4000	3-29	3-61	3-86	3-99
	46	0 to 1999	• 4000	3-30	3-62	3-86	3-99
	47	2000 to 4999	• 4000	3-31	3-63	3-71	3-102
	48	5000 to 8000	• 4000	3-32	3-64	3-71	3-102

Figure **A2-1. Hourly** capacity of the runway **component**

4. Mix Index. **This** input is calculated using data **provided in the** example **statement.** Table 1-1 (illustrated) is used to make the conversion.

Table 1-1. **Aircraft classifications**

Aircraft Class	Max. Cert. T.O. Weight (lbs)	Number Engines	Wake Turbulence Classification
A	12,500 or less	Single	Small (S)
B		Multi	
C	12,500 - 300,000	Multi	Large (L)
D	wet 300,000	Multi	Heavy (H)

The **computation** of aircraft mix is carried out by setting up a table in the following format. The percent of operations by each aircraft **class** is recorded in columns 5 through **8.**

Aircraft		VFR Mix		IFR Mix	
Description	Class	No. ops.	% ops.	No. ops.	% Ops.
Single-engined	A	13	26	2	6
Light-twins	B	10	20	5	15
Transport-type	C	25	50	25	73
Widebodied	D	2	4	2	6
Totals (No. Ops. & % Ops.)		50	100	34	100

The mix indices are calculated and entered in column 9.

$$VFR = 50+3(4) = 62$$

$$IFR = 73+3(6) = 91$$

5. Percent Arrivals. The percent arrivals is given as 45 for VFR conditions and **55 for IFR** conditions. Enter **in column 10.**

6. Hourly **Capacity Base (C*).** Obtain **C* from** figure 3-27 for VFR and 3-59 for **IFR,** and enter in column **14.**

7. **Touch and** Go Factor **(T). The statement** specified **3 touch and gos during VFR and none in IFR.** Since a touch and go is a landing and a **takeoff (2 operations), the percent of touch and go** operations **in** VFR conditions **is 6/50 or 12 percent. Obtain the touch and go factor T from figure** 3-27 for VFR and 3-59 **for IFR and enter in column 15.**

Figure A2-1. Hourly capacity **of the** runway canponent (cont.)

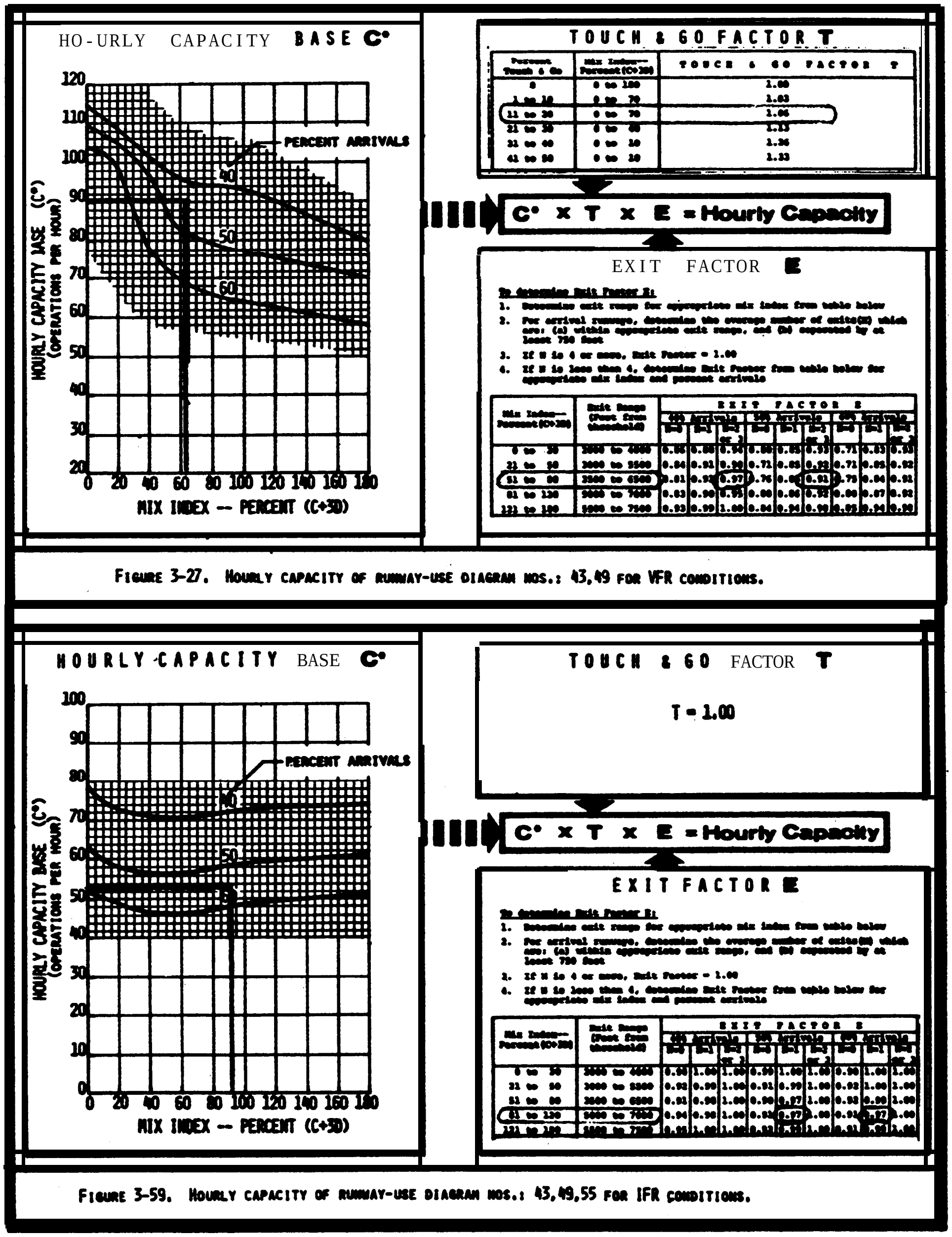


FIGURE 3-27. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS.: 43,49 FOR VFR CONDITIONS.

FIGURE 3-59. HOURLY CAPACITY OF RUNWAY-USE DIAGRAM NOS.: 43,49,55 FOR IFR CONDITIONS.

8. **Exit** Factor **E.** A landing aircraft might exit at the runway intersection (1600 **feet)** or at one of the three right-angled exits located 3000, 4500, and 6000 feet **from** the threshold. **From** figures **3-27** for **VFR** and **3-59** for IFR, determine the exit range and the exit factor E. In this **example,** only two exits are within the range between 3500 to 7000 feet. Enter the exit locations in columns 12 and the number of usable exits in column 13. The exit **factors E** are entered in column 16.

Figure **A2-1. Hourly** capacity of the **runway component (cont.)**

9. <u>Calculate</u> **<u>Capacity</u>**. **Compute the** hourly **capacity** of **the runway-use configuration and enter in column 17.**

VFR Capacity = 89·1.06·0.94 = 88.68 or 89 operations per hour

IFR capacity **= 53·1.00·0.97 =** 51.41 **or** 51 **operations per hour**

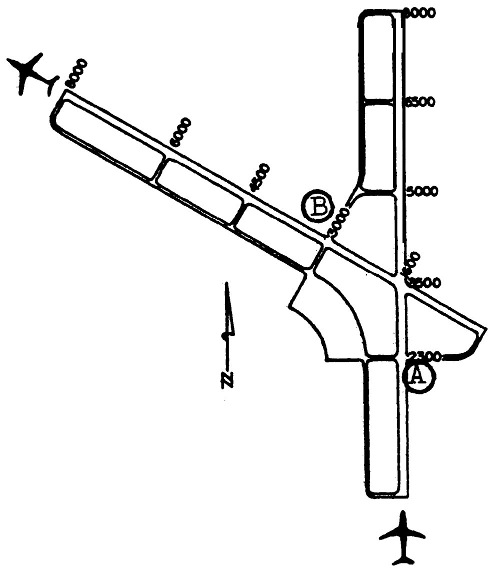
Weather	Runway-use: Diagram	Runway-use: No.	Capacity Figure No.	Aircraft Mix: %A	%B	%C	%D	Mix Index %(C+3D)	Percent Arrivals	Percent Touch & Go	Runway Exits (00 feet): Location			Runway Exits: No.	Hourly Capac. Base C*	T & G Factor T	Exit Factor E	Hourly Capacity C*·T·E
1	2	3	4	5	6	7	8	9	10	11	12			13	14	15	16	17
VFR IFR		43	3-27 3-59	26 6	20 15	50 73	4 6	62 91	45 55	12 0	45 60	60		2 1	89 53	1.06 1.00	.94 .97	89 51

Work sheet for runway hourly capacity.

10. **<u>Conclusion</u>. The calculated hourly capacities of the runway-use configuration of** 89 **operations per hour** in **VFR conditions** and **51 operations per hour** in **IFR** conditions **exceeds the aeronautical demands of 50 VFR operations and 34 IFR operations specified in the statement.**

Figure **A2-1. Hourly capacity** of **the runway component (cont.)**

<u>**EXAMPLE 2,**</u> **Determine the VFR and IFR capacity of taxiway crossings (A and B) for the airport of example 1 when operated as shown. Use the traffic data from example 1. NOTE: Runway usage is reversed from that used in example 1 to permit illustation of the crossing effect on both arrivals and departures.**



<u>**SOLUTION**</u>**: The work sheet on page 7 illustrates one method of recording data.**

1. <u>**Weather**</u>. **Enter type of weather in column 1.**

2. <u>**Crossing Location**</u>. **Identify and enter crossing locations in columns 2 and 3. Taxiway crossing (A) is 2300 feet from the arrival threshold and taxiway crossing (B) is 3000 feet from the departure threshold.**

3. <u>**Runway Operations Rate**</u>. **Determine operations rate and enter in column 4. The airport has a VFR demand of 50 operations per hour with 45 percent arrivals, i.e., 23 arrivals and 27 departures. The touch-and-go adjustment reduces the departure demand to 24 operations. In IFR there are 19 arrivals and 15 departures.**

4. <u>Mix Index</u>. **Calculate the mix index and enter in column 5. VFR mix index is 62 and IFR mix index is 91.**

5. <u>**Taxiway Crossing Capacities**</u>, **Obtain crossing capacities from figure 3-66A (illustrated) for the arrival crossing (A) and figure 3-67A (illustrated) for the departure crossing (B) and enter in columns 6 and 7.**

Crossing **A (arrivals)** **VFR** capacity **= 107, and IFR capacity = 92**

Crossing **B (departures)** **VFR capacity = 125,** and **IFR** capacity = 112

Figure A2-2. Hourly capacity of the **taxiway** component

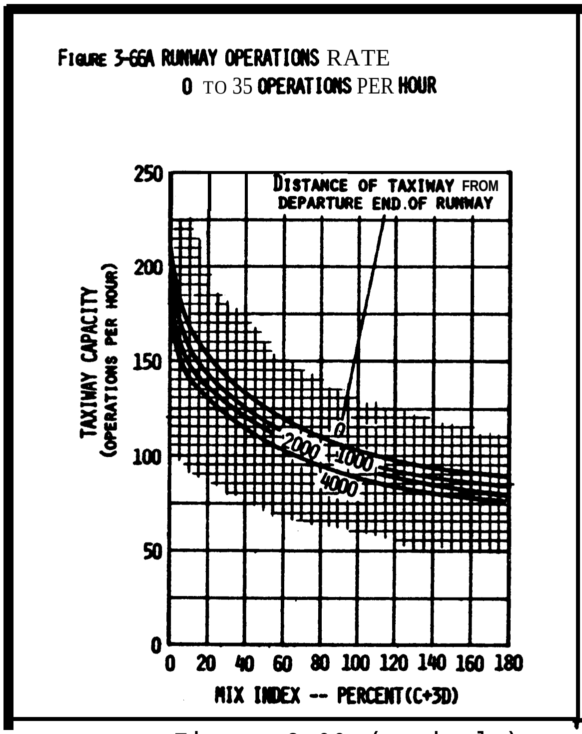


Figure 3-66 (arrivals).

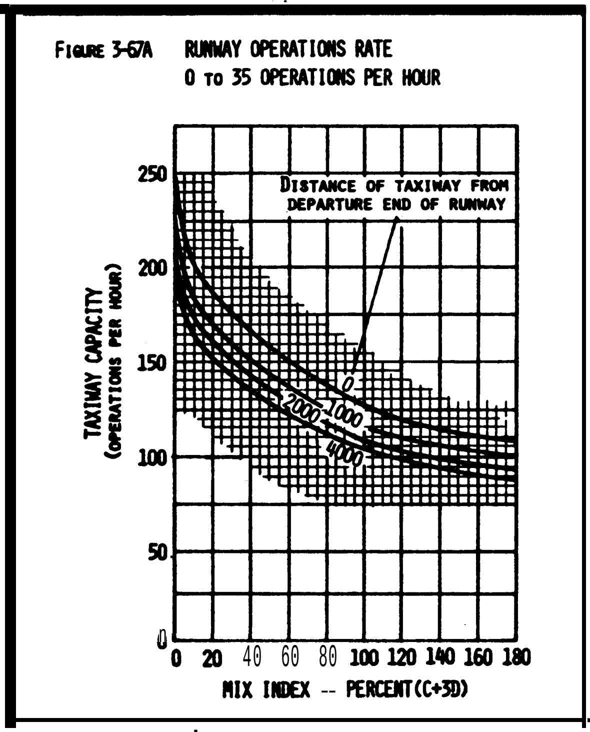


Figure 3-67 (departures).

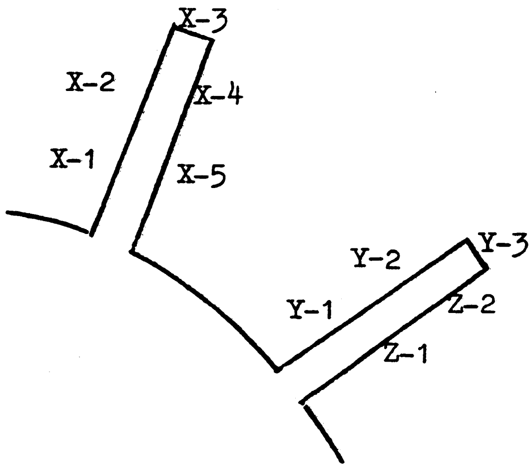
Weather	Taxiway Crossing	Distance from Threshold	Runway		Taxiway Crossing Capacities (Operations per Hour)	
			Ops. Rate	Mix Index	Arrivals and Mixed Operations	Departures Plus T & G
1	2	3	4	5	6	7
VFR	A	2300'	24	62	107	-
"	B	3000'	20	62	-	125
IFR	A	2300'	15	91	92	-
"	B	3000'	19	91	-	112

Work sheet for taxiway crossing capacities.

6. Conclusion. The taxiway crossing capacities for the stipulated operational conditions would not be capacity limiting since the demand is less than one-fourth of the theoretical capacity.

Figure A2-2. Hourly capacity of the taxiway component (cont.)

EXAMPLE 3. **Determine** the hourly capacity of the terminal gate **complex** at the airport of example 1. It has 10 gates allocated to three airlines **X, Y,** and 2. Only the end gates X-3 and Y-3 are capable of **accommodating** widebodied aircraft. During an **hour,** airline **X** schedules 13 non-widebodies with an average gate time of 45 minutes and two widebodies with an average gate time of 55 minutes. Airline Y schedules eight **non-widebodies** with an average gate time of 40 minutes and airline **Z** schedules four non-widebodies with an average gate time of 35 minutes.



SOLUTION: The work sheet on page 9 illustrates one method of recording data.

1. Gates Groups. The gate groups **(airlines** identification) and type of gates **are** entered in columns 1, 4, 5, and **13.**

2. Gate **Mix.** Operational demands are entered in columns 2 and 3. The gate mix **obtained** by dividing the number of non-widebodied operations by the total number of **operations** is entered in column 6.

3. Gate Percentage. Calculate the percentage 'of widebodied gates in each gate group and enter in column 7.

4. Gate Occupancy **Time.** Gate times are entered in columns 8 and **9.** Since gate **times** vary by airline and location**,** it is presumed that the **example average** gate occupancy times **were** obtained by on-site surveys.

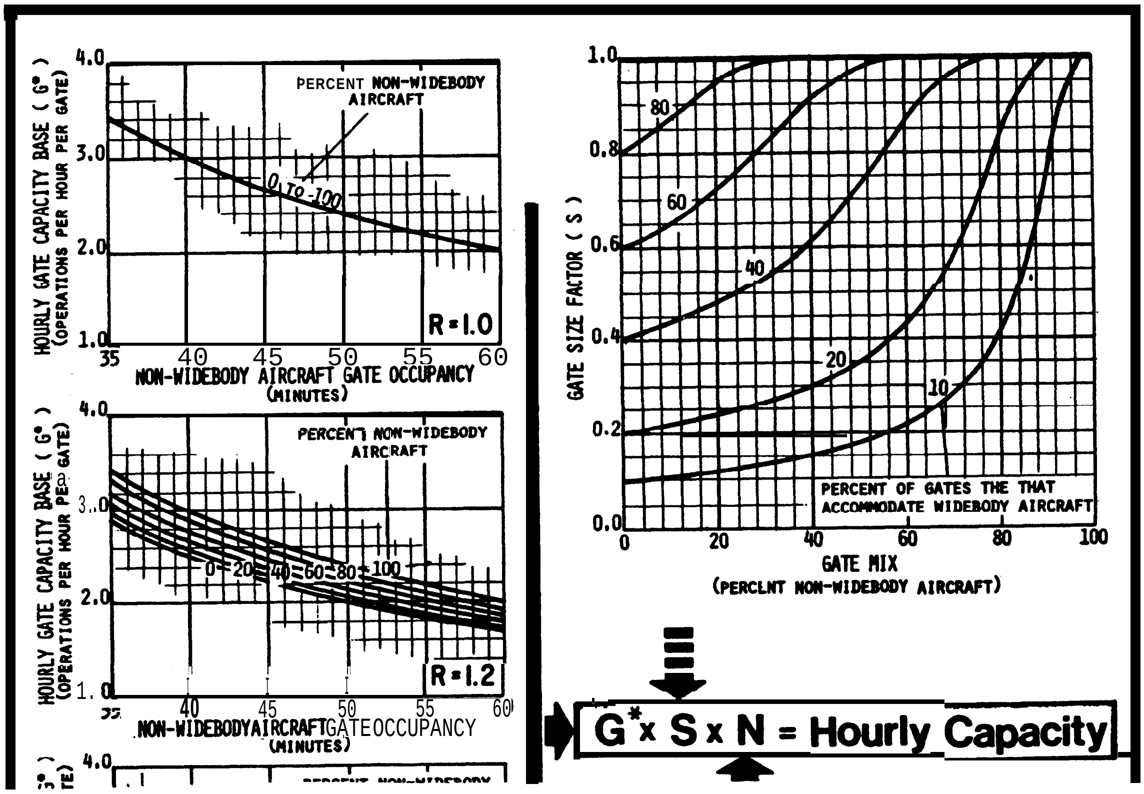
5. Gate Occupancy Ratio. Gate occupancy ratio (R) **,** entered in column 10, is **determined** by dividing the average gate occupancy time of the widebodied aircraft by that of the non-widebodied aircraft.

Airline X, R **= 55/45 =** 1.22

When no widebodied aircraft are **accomodated,** R **equals** 1.00

Figure **A2-3. Hourly capacity** of gate group **component**

6. Gate Capacity. Calculate the hourly capacity for each gate group from the equation G*•S•N where N equals the number of gates in the group. Obtain values for G* and S from figure 3-68 (illustrated) and entered in columns 11 and 12. Do not interpolate, use the chart with the lower R value.



Non-widebody (N) Widebody (W)

Gate Group	Demand		No. Gates		Gate Mix		Average Gate Time (Min.)		Gate Occupancy Ratio	Hourly Capac. Base	Gate Size	No. Gates	Hourly capacity
	(N)	(W)	(N)	(W)	(N) (%)	(W) (%)	(N) (T_n)	(W) (T_w)	(T_w/T_n) (R)	(G*)	(S)	(N)	(G*•S•N)
1	2	3	4	5	6	7	8	9	10	11	12	13	14
X	13	2	4	1	87	20	45	55	1.22	2.6	.97	5	13
Y	8	0	2	1	100	33	40	0	1.00	3.0	1.00	3	9
Z	4	0	2	0	100	0	35	0	1.00	3.4	1.00	2	7
Capacity of the Terminal													29

Work sheet for gate capacity.

7. Conclusion. The gate group capacity of airline X is two operations short of its demand, whereas the calculated gate group capacities of airlines Y and Z exceed their demand by one and three operations respectively. The terminal capacity exceeds the combined airline demand by two operations per hour.

Figure A2-3. Hourly capacity of gate group components (cont.)