

ASD-TR-84-5026

①



AD-A148 954

EVALUATION OF THE BIRDSTRIKE THREAT TO THE F-15 PRESENT FLEET, RAPID DEPLOYMENT FORCE, AND DUAL ROLE FIGHTER TRANSPARENCIES

PETER KOLODZIEJCZYK, Capt, USAF
Structures Branch
Flight Systems Engineering Division
Deputy for Tactical Systems

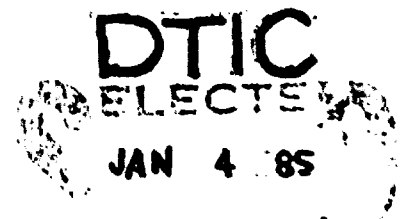
September 1984

DTIC FILE COPY

Approved for public release, distribution unlimited.

Best Available Copy

DEPUTY FOR ENGINEERING
AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433



84 12 27 059

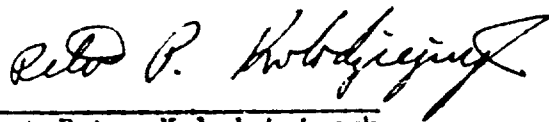
NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or sell any patented invention that may in any way be related thereto.

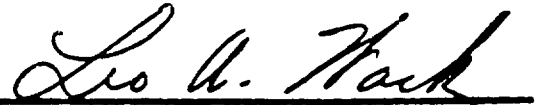
Operations Security (OPSEC) has been considered and OPSEC procedures have been incorporated in this publication in accordance with AFR 55-30/ AFSC Sup 1.

This report has been reviewed by the Information Office (ASD/PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

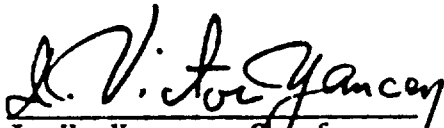
This technical report has been reviewed and is approved for publication.



Capt Peter Kolodziejczyk
Project Engineer



Leo A. Wack, Chief
Structures Branch



I. V. Yancey, Chief
Flight Systems Engineering Division

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

Best Available Copy

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ASD-TR-84-5026	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Evaluation of the Birdstrike Threat to the F-15 Present Fleet, Rapid Deployment Force, and Dual Role Fighter Transparencies		5. TYPE OF REPORT & PERIOD COVERED N/A
		6. PERFORMING ORG. REPORT NUMBER N/A
7. AUTHOR(s) Peter Kolodziejczyk, Capt, USAF		8. CONTRACT OR GRANT NUMBER(s) N/A
		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AFSC-0136
9. PERFORMING ORGANIZATION NAME AND ADDRESS Flight Systems Engineering ASD/TAEF WPAFB, OH 45433		12. REPORT DATE September 1984
		13. NUMBER OF PAGES 147
11. CONTROLLING OFFICE NAME AND ADDRESS Flight Systems Engineering ASD/TAEF WPAFB, OH 45433		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release, distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) N/A		
18. SUPPLEMENTARY NOTES N/A		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) structural, transparencies, bird impact, windshield, canopy, bird weight distribution, crew enclosure system, velocity distributions.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The information contained in this report is developed from analytical and empirical techniques used to establish statistical models for evaluating the birdstrike threat to the F-15 aircraft transparencies. Consideration is given to two areas: (1) the operational impact rate for specific aircraft usage profiles, and (2) the probability of a random birdstrike which could result in penetration of the aircraft cockpit.		

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 68 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Best Available Copy

FOREWARD

This report covers work performed by the author during his support of the F-15 Systems Program Office (SPO) at Aeronautical Systems Division, Air Force Systems Command, Wright-Patterson Air Force Base, OH. The period covered was January 1983 through July 1983. The purpose of the effort was to assess the F-15 Present Fleet, Rapid Deployment Force, and Dual Role Fighter windshield and canopy bird impact resistance capability.

The author wishes to express his appreciation to the following individuals for their support in this effort:

Dr Allan Berens	University of Dayton Research Institute
I. Victor Yancey	ASD/TAEF
Blaine West	University of Dayton Research Institute
Ralph Speelman	AFWAL/FIEA
Tony Cervantes	ASD/ENFSS
Peter Giron-Pagan	ASD/TAEF
Glenda White	ASD/TAOW
Lt Renald Lapierre	ASD/TAEF
Leo A. Wack	ASD/TAEF
Dr D. R. Barr	AFIT/ENG
Dr John Halpin	ASD/EN
Charlotte Spieth	ASD/TAEF



TABLE OF CONTENTS

Introduction	1
Operational Impact Rate	2
Cumulative Probability Distributions	16
Velocity Distribution for F-15 Present Fleet	18
F-15 Rapid Deployment Force (RPD) Velocity Distribution	27
F-15 Dual Role Fighter (DRF) Velocity Distribution	33
Bird Weight Distribution	38
Component Strength Distribution	53
Model Application	63
Use of Computer Program for Model Application	73
Evaluation of Results	74
Conclusions	75
Appendix A Program BAAPF	134
Appendix B CM Storage Used	137
Appendix C Program RAAPF	145
References	147



11

LIST OF ILLUSTRATIONS

FIGURE		PAGE
1	Volume Swept Out by Aircraft in Bird Environment	3
2	U vs W Transformation, F-15 Present Fleet, Air to Air Mission	24
3	F-15 Present Fleet Velocity Distribution Air to Air Mission from Structural Recorder Data	25
4	F-15 RD Velocity Distribution Air to Ground Mission from Structural Load Report	32
5	F-15 DRF Velocity Distribution, Air to Ground Mission from Structural Load Report	37
6	CONUS Bird Weight Distribution	51
7	Europe Bird Weight Distribution	52
8	Profile of F-15F and TF Windshield and Canopy	55
9	Existing F-15 Transparency Capability	56
10	Existing F-15 Transparency Penetration Values by a 4 lb Bird	56
11	450 Kt Windshield/300 Kt Canopy Capability (No Penetration)	57
12	450 Kt Windshield/300 Kt Canopy Capability Penetration Values by a 4 lb Bird	57
13	500 Kt Windshield/350 Kt Canopy Capability (No Penetration)	58
14	500 Kt Windshield/350 Kt Canopy Capability Penetration Values by a 4 lb Bird	58
15	Existing T-38 Transparency Penetration Values by a 4 lb Bird	59
16	Critical Area Distribution, F-15 Present Windshield and Canopy Capability	60
17	Critical Area Distribution, Increased Capability, 450 Kt Windshield and 300 Kt Canopy	61
18	Critical Area Distribution, Increased Capability, 500 Kt Windshield and 350 Kt Canopy	62

19	F-15 Present Fleet, CONUS, Air to Air, Windshield (0-5000 ft AGL)	82
20	F-15 Present Fleet, CONUS, Air to Air, Canopy (0-5000 ft AGL)	83
21	F-15 Present Fleet, Europe, Air to Air, Windshield (0-5000 ft AGL)	84
22	F-15 Present Fleet, Europe, Air to Air, Canopy (0-5000 ft AGL)	85
23	F-15 RPD, CONUS, Air to Air, Windshield (0-5000 ft.)	86
24	F-15 RPD, CONUS, Air to Air, Canopy (0-5000 ft.)	87
25	F-15 RPD, Europe, Air to Air, Windshield (0-5000 ft)	88
26	F-15 RPD, Europe, Air to Air, Canopy (0-5000 ft.)	89
27	F-15 RPD, CONUS, Air to Ground, Windshield (0-5000 ft.)	90
28	F-15 RPD, CONUS, Air to Ground, Canopy (0-5000 ft.)	91
29	F-15 RPD, Europe, Air to Ground, Windshield (0-5000 ft)	92
30	F-15 RPD, Europe, Air to Ground, Canopy (0-5000 ft.)	93
31	F-15 RPD, CONUS, 450 Kt., Air to Air, Windshield	94
32	F-15 RPD, CONUS, 300 Kt., Air to Air, Canopy	95
33	F-15 RPD, Europe, 450 Kt., Air to Air, Windshield	96
34	F-15 RPD, Europe, 300 Kt., Air to Air, Canopy	97
35	F-15 RPD, CONUS, 450 Kt., Air to Ground Windshield	98
36	F-15 RPD, CONUS, 300 Kt., Air to Ground, Canopy	99
37	F-15 RPD, Europe, 450 Kt., Air to Ground, Windshield	100
38	F-15 RPD, Europe, 300 Kt., Air to Ground, Canopy	101
39	F-15 RPD, CONUS, 500 Kt., Air to Air, Windshield	102
40	F-15 RPD, CONUS, 350 Kt., Air to Air Canopy	103
41	F-15 RPD, Europe, 500 Kt., Air to Air, Windshield	104

42	F-15 RPD, Europe, 350 Kt., Air to Air, Canopy	105
43	F-15 RPD, CONUS, 500 Kt., Air to Ground, Windshield	106
44	F-15 RPD, CONUS, 350 Kt., Air to Ground, Canopy	107
45	F-15 RPD, Europe, 500 Kt., Air to Ground, Windshield	108
46	F-15 RPD, Europe, 350 Kt., Air to Ground, Canopy	109
47	F-15 DRF, CONUS, Present Windshield Capability, Air to Air	110
48	F-15 DRF, CONUS, Present Canopy Capability, Air to Air	111
49	F-15 DRF, Europe, Present Windshield Capability, Air to Air	112
50	F-15 DRF, Europe, Present Canopy Capability Air to Air	113
51	F-15 DRF, CONUS, Present Windshield Capability, Air to Ground	114
52	F-15 DRF, CONUS, Present Canopy Capability, Air to Ground	115
53	F-15 DRF, Europe, Present Windshield Capability, Air to Ground	116
54	F-15 DRF, Europe, Present Canopy Capability Air to Ground	117
55	F-15 DRF, CONUS, 450 Kt., Air to Air, Windshield	118
56	F-15 DRF, CONUS, 300 Kt., Air to Air, Windshield	119
57	F-15 DRF, Europe, 450 Kt., Air to Air, Windshield	120
58	F-15 DRF, Europe, 300 Kt., Air to Air, Canopy	121
59	F-15 DRF, CONUS, 450 Kt., Air to Ground, Windshield	122
60	F-15 DRF, CONUS, 300 Kt., Air to Ground, Canopy	123
61	F-15 DRF, Europe, 450 Kt., Air to Ground, Windshield	124
62	F-15 DRF, Europe, 300 Kt., Air to Ground, Canopy	125
63	F-15 DRF, CONUS, 500 Kt., Air to Air, Windshield	126
64	F-15 DRF, CONUS, 350 Kt., Air to Air, Canopy	127

65	F-15 DRF, Europe, 500 Kt., Air to Air, Windshield	128
66	F-15 DRF, Europe, 350 Kt., Air to Air, Canopy	129
67	F-15 DRF, CONUS, 500 Kt., Air to Ground Windshield	130
68	F-15 DRF, CONUS, 350 Kt., Air to Ground, Canopy	131
69	F-15 DRF, Europe, 500 Kt., Air to Ground Windshield	
70	F-15 DRF, Europe, 350 Kt., Air to Ground, Canopy	133

LIST OF TABLES

TABLE		PAGE
1.0	F-15 Present Fleet Historical Operational Impact Rates	5
2.0	F-15 Present Fleet Total Usage (Flight hours)	6
3.0	Input Variables for EQN (5) OIR Extrapolation	7
4.0	Bird Strikes on Canopy and Windshield	9
4.1	Bird Strikes on Canopy and Windshield	10
4.2	Bird Strikes on Canopy and Windshield	11
4.3	Bird Strikes on Canopy and Windshield	12
4.4	Bird Strikes on Canopy and Windshield	13
4.5	Bird Strikes on Canopy and Windshield	14
5.0	F-15 Present Fleet Usage	19
5.2	Weibull U vs W Transformation	22
6.0	F-15 Rapid Deployment Force Mission Mix for the Air to Ground Mission	28
6.1	F-15 Rapid Deployment Force Air to Ground 1 Mission	29
6.2	F-15 Rapid Deployment Force Air to Ground 2A Mission	30
6.3	F-15 Rapid Deployment Force Air to Ground 2B	31
7.0	F-15 Dual Role Fighter Air to Ground 1 Mission	34
7.1	F-15 Dual Role Fighter Air to Ground 2 Mission	35
7.2	F-15 Dual Role Fighter Air to Ground 3 Mission	36
8.0	List of Identified Birds Involved in Bird Strikes Several Aircraft CONUS	39
8.1	List of Identified Birds Involved in Bird Strikes F-15 CONUS	41

8.2	List of Identified Birds Involved in Bird Strike F-15 Europe	42
8.3	List of Identified Birds Involved in Bird Strike F-4 CONUS	43
8.4	List of Identified Birds Involved in Bird Strike F-4 Europe	47
8.5	List of Identified Birds Involved in Bird Strike F-111 CONUS	49
8.6	List of Identified Birds Involved in Bird Strike F-111 Europe	50
9.0	F-15 Present Fleet	64
9.1	F-15 Rapid Deployment Force (Air to Ground)	65
9.2	F-15 Rapid Deployment Force (Air to Air)	66
9.3	F-15 Dual Role Fighter (Air to Air)	67
9.4	F-15 Dual Role Fighter (Air to Ground)	68
9.5	Bird Weight Distribution (CONUS)	69
9.6	Bird Weight Distribution (Europe)	70
10.0	Kinetic Energy Matrix	71
10.1	Windshield Critical Area/Total Area, Present Capability	72
10.2	Canopy Critical Area/Total Area, Present Capability	72
11.0	F-15 Present Fleet Air to Air Mission	76
12.0	F-15 RPD Force Usage	77
12.2	F-15 RPD Air to Air Mission	78
12.3	F-15 RPD Air to Ground Mission	78
12.4	F-15 DRF Force Usage	79
12.5	F-15 DRF Force Usage	80
12.6	F-15 DRF Air to Air Mission	81
12.7	F-15 DRF Air to Ground Mission	81

INTRODUCTION

Collisions between birds and aircraft have become one of the major flight safety problems of the jet age. The most critical need for bird impact resistance design improvement is in military aircraft. Many high speed aircraft in USAF inventory were not designed to meet today's bird impact requirements because the threat in terms of lost aircraft and aircrews was not fully appreciated at the design stage.

A comprehensive review of analytically and empirically developed predictive techniques for bird impact structural performance has not revealed a simple approach, that is, simple to use on short notice or that requires a minimum of input information, nor one that is universally available and universally accepted.

The statistical model for evaluating the birdstrike threat to aircraft transparencies is based on two components: (1) the operational impact rate for a specific usage profile; and (2) the probability that a random birdstrike will occur with sufficient kinetic energy to cause penetration into the aircraft cockpit. This model is based on methods formulated by Dr John Halpin in evaluating the birdstrike threat on the F-16 canopy and Dr Allan Berens' model in evaluating the T-38 crew enclosure system.

This statistical simulation combines the velocity distribution of the aircraft, the bird weight distribution, and the capability of the crew enclosure expressed in terms of kinetic energy. The above distributions were developed for the F-15 Present Fleet, Rapid Deployment Force and Dual Role Fighter. Then, an assessment was made to determine the number of bird penetrations that can be expected on the windshield and canopy over a realistic usage profile.

The approach presented in this report is quite simple to use, since computer programs were generated to reduce the tedious calculations to a minimum. The use of these methods will allow an engineer to make a fairly quick assessment in regard to the adequacy/inadequacy of a crew enclosure system bird resistance capability.

OPERATIONAL IMPACT RATE

As an aircraft flies through a bird threat environment, usually 0 - 5000 ft AGL, it sweeps out a volume which is a function of the crew enclosure frontal projected area, time and aircraft velocity in the bird threat environment. Therefore, it can be concluded that:

$$\text{VOLUME} = \bar{V} \times A \times T_s \quad (1)$$

This volume per unit time that is swept out is projected through the bird threat environment with a given bird density ρ . The product of the volume per unit time and bird density is the Operational Impact Rate (OIR) on the crew enclosure (Figure 1)

$$\text{OIR} = \bar{V} \times A \times T_s \times \rho \quad (2)$$

where

- OIR = operational impact rate
- \bar{V} = aircraft mean true velocity
- A = windshield or canopy frontal projected area
- T_s = $\frac{\text{time in bird threat environment}}{\text{total flight time}}$
- ρ = bird density in environment

A ratio can be developed between any two aircraft if one knows the operational impact rate of one of the aircraft:

$$\text{OIR}_2 = \text{OIR}_1 \times \frac{\bar{V}_2 \times A_2 \times T_{s2} \times \rho_2}{\bar{V}_1 \times A_1 \times T_{s1} \times \rho_1} \quad (3)$$

The mean velocities, subsystem frontal areas and proportions of time are directly measurable and can be calculated with a moderate amount of effort. However, bird density is not directly measurable, and if one tries to determine the bird density analytically, such a density may be biased by huge populations of small birds such as robins and blackbirds, which have frequently impacted aircraft. Another approach would be to assume that the two aircraft fly in approximately the same environments and therefore experience the same bird densities. This would cancel out the two densities and leave the equation as:

$$\text{OIR}_2 = \text{OIR}_1 \times \frac{\bar{V}_2 \times A_2 \times T_{s2}}{\bar{V}_1 \times A_1 \times T_{s1}} \quad (4)$$

Caution needs to be used in this type of approximation, (assuming equal bird densities) since evaluation of existing bird impact data for the F-4 and F-111 (obtained from the Bird Aircraft Strike Hazard (BASH) TEAM at Tyndall AFB) revealed a significant difference in the predicted operational impact rates.

OPERATIONAL IMPACT RATE = (PROJECTED AREA) X (VELOCITY) X (TIME) X (BIRD DENSITY)

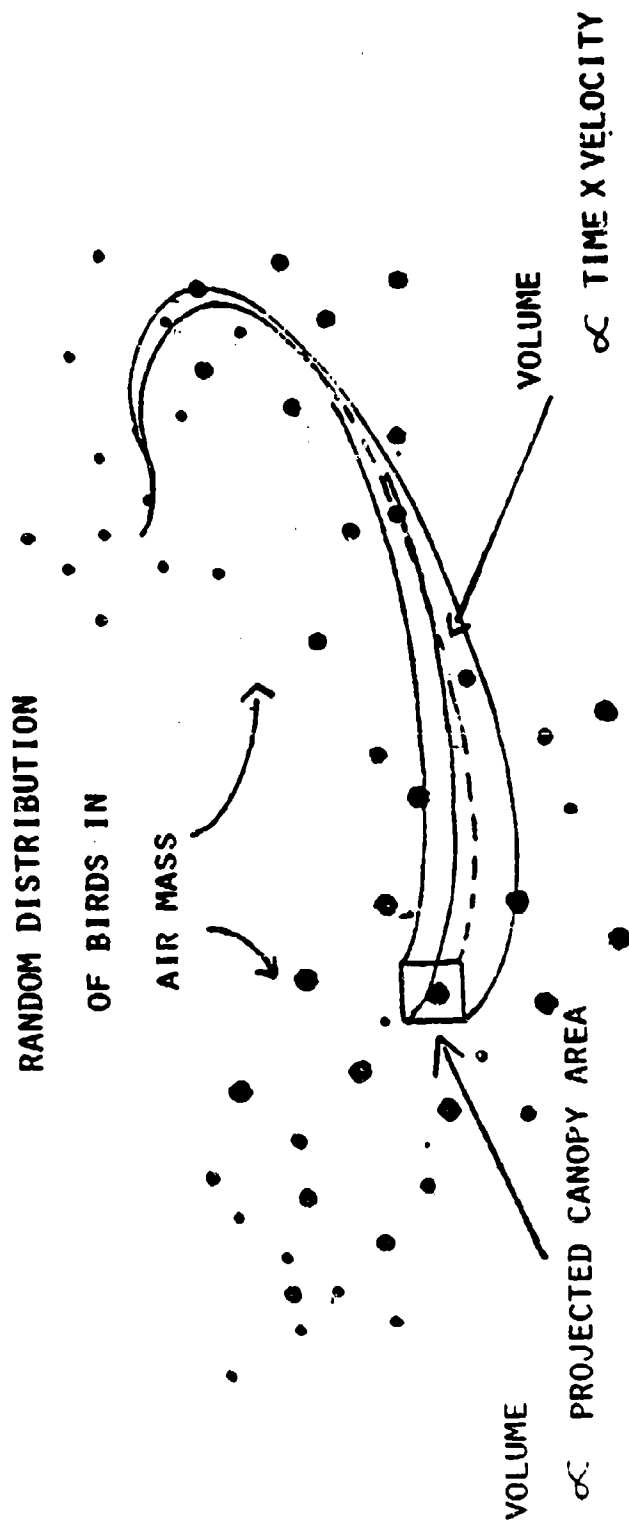


FIG.1 VOLUME SWEEPED OUT BY AIRCRAFT IN BIRD ENVIRONMENT

Using the known OIR for the F-4, the F-111 predicted OIR was high by approximately a factor of two. Reversing the simulation showed the F-4 predicted OIR to be low by approximately a factor of two. A realistic consideration of this disparity is quite logical, since each aircraft does not fly at the same exact locations of the world and therefore does not encounter the same bird densities. Any extrapolation between any two unique aircraft that are not based at the same locations will exhibit this phenomenon, and some sort of correction factor needs to be used.

In the analysis of the F-15 present fleet, Rapid Deployment Force (RPD) and Dual Role Fighter (DRF), the bird densities were assumed constant since the RPD and DRF are expected to fly at the same bases from which the historical OIR was obtained.

FOR EXAMPLE: Windshield, Europe

$$\begin{array}{r}
 \text{OIR} \\
 \text{DRF} \\
 \text{Europe}
 \end{array}
 =
 \begin{array}{r}
 \text{OIR} \\
 \text{Present} \\
 \text{Fleet} \\
 \text{Europe}
 \end{array}
 \times
 \frac{\bar{V} \text{ DRF}}{\bar{V} \text{ Present Fleet}}
 \times
 \frac{X \text{ Ts DRF}}{X \text{ Ts Present Fleet}}
 \times
 \frac{X \text{ A DRF}}{X \text{ A Present Fleet}}
 \times
 \frac{\rho \text{ DRF}}{\rho \text{ Present Fleet}}
 \times
 \frac{1}{1}
 \quad (5)$$

Table 1 summarizes the historical operational impact rates for the present fleet based on the time frame of April 1976 - 1 May 1983. Table 2 summarizes the flight hours flown by each F-15 using command. Conus flight hours is a summation of TAC, Systems, and Logistic Commands usage. Alaskan Command and PACAF were not analyzed since to date their operational impact rate on the windshield and canopy is zero, and their hourly usage was minimal compared to the usage in Conus and Europe (USAFE). Finally, Eqn. (5) is used with the appropriate inputs from Table 3 to determine the predicted OIR for the RPD and DRF for each of the following:

- (A) Conus and Europe
- (B) Air to Air and Air to Ground missions
- (C) Windshield and Canopy
- (D) T_g variable from 0 - .9

Example Application of Eqn (5)

For F-15 DRF, Windshield, Europe, A/G Mission Assume DRF $t_g = .7$

$$\begin{array}{r}
 \text{OIR} \\
 \text{DRF} \\
 \text{EUROPE}/10^6 \text{ HRS}
 \end{array}
 =
 21.97/10^6 \text{ HRS}
 \times
 \frac{445.91}{279.24}
 \times
 \frac{.70}{.2307}
 \times
 \frac{602.5}{602.5}
 \times
 1$$

$$\begin{array}{r}
 \text{OIR} \\
 \text{DRF} \\
 \text{EUROPE}/10^6 \text{ HRS}
 \end{array}
 =
 106.45 \text{ IMPACTS}$$

TIME FRAME = APRIL 1976 - 1 MAY 1983

CONUS

HOURS FLOWN = 473,008

Windshield	OIR	= 14.00
	OIR/10 ⁶ Hrs	= 29.60
		Ts = .1198
Canopy	OIR	= 2.00
	OIR/10 ⁶ Hrs	= 4.23

5

EUROPE

HOURS FLOWN = 136,576

Windshield	OIR	= 3.00
	OIR/10 ⁶ Hrs	= 21.97
		Ts = .2307
Canopy	OIR	= 7.00
	OIR/10 ⁶ Hrs	= 51.25

BIRD IMPACTS OBTAINED FROM BASH TEAM, TYNDALL AFB, COMPUTER FILES FOR ABOVE TIME FRAME

TABLE 1 F-15 PRESENT FLEET HISTORICAL OPERATIONAL IMPACT RATES

YEAR	COMPOSITE ALL A.F.	ALASKAN COMMAND	USAFE	LOG COMMAND	PACAF	SYSTEMS COMMAND	TAC
Apr 1976	1,211	0	0	0	0	61	1,150
May 1976	1,124	0	0	0	0	37	1,087
Jun 1976	1,394	0	0	0	0	124	1,270
Jul 1976	1,576	0	0	0	0	97	1,479
Aug 1976	1,787	0	0	0	0	104	1,683
Sep 1976	1,746	0	0	0	0	84	1,662
Oct 1976	1,936	0	0	0	0	94	1,842
Nov 1976	2,243	0	0	3	0	102	2,138
Dec 1976	2,307	0	0	0	0	61	2,246
1977	42,369	0	8,588	10	0	959	32,812
1978	69,023	0	17,916	48	0	1,126	49,933
1979	96,959	0	22,925	191	1,817	1,644	70,382
1980	109,309	0	23,078	406	15,181	1,895	68,749
1981	132,291	0	26,153	387	20,532	1,554	83,665
1982	153,369	2,762	28,471	216	19,923	2,314	99,683
Jan 1983	13,663	664	2,004	12	1,947	206	8,830
Feb 1983	13,258	432	2,223	21	1,973	205	8,404
Mar 1983	14,792	758	2,718	17	2,209	181	8,909
Apr 1983	15,017	667	2,500	18	2,206	213	9,411
Total	675,374	5,283	136,576	1,329	65,788	11,061	455,335

Information obtained from Mr Vincent Clark, AV 876-4948, Norton AFB

TABLE 2 F-15 PRESENT FLEET TOTAL USAGE (FLIGHT HOURS)

F-15 PRESENT FLEET

AREA _{WINDSHIELD}	= 602.5 IN ²
AREA _{CANOPY}	= 280.0 IN ²
\bar{V} _{AIR TO AIR}	= 279.24 Knots (CONUS & Europe)
t_s CONUS	= .1198 based on historical data
t_s EUROPE	= .2307 based on historical data

F-15 RAPID DEPLOYMENT FORCE (RPD)

AREA _{WINDSHIELD}	= 602.5 IN ²
AREA _{CANOPY}	= 280.0 IN ²
\bar{V} _{AIR TO AIR}	= 279.24 Knots (CONUS & Europe)
\bar{V} _{AIR TO GROUND}	= 427.90 Knots (CONUS & Europe)
t_s CONUS AND EUROPE	= Varies 0 - .9

F-15 DUAL ROLE FIGHTER (DRF)

AREA _{WINDSHIELD}	= 602.5 IN ²
AREA _{CANOPY}	= 474.5 IN ²
\bar{V} _{AIR TO AIR}	= 279.24 Knots (CONUS & Europe)
\bar{V} _{AIR TO GROUND}	= 445.91 Knots (CONUS & Europe)
t_s CONUS AND EUROPE	= Varies 0 - .9

TABLE 3 INPUT VARIABLES FOR EQN (5) OIR EXTRAPOLATION

Evaluation of Table 1 reveals a disparity for the Canopy and Windshield OIRs between Conus and Europe. Since the canopy has a lower projected frontal area from the windshield, it would be expected that the OIR on the canopy in Europe would be lower than the windshield OIR, however, this is not the case. Table 4.0-4.5 summarizes the bird impacts for the F-15, F-4 and F-111 by each theatre Conus/Europe and each component windshield/canopy. For Europe, from Table 4.1, 4.3, 4.5 the results are as follows:

	F-15	F-4	F-111
Windshield	3	38	20
Canopy	7	60	15

A possible explanation of this disparity is that a pressure wave is created by the aircraft radome in flight, with a component in the vertical direction strong enough to displace an oncoming bird over the windshield arch and hit the canopy. The pressure force would not be strong enough to displace a 4 lb bird, but it may be sufficient to displace a .1 - .3 lb bird. From Figure 5 (page 37) and 6 (page 51) bird weight distributions, the bird weight range 0 - .3 lbs, represents 35% of the bird population in Conus and 58% in Europe.

The above theory holds a great deal of logical sense, but it is only a crude rationalization of the results and it fails for the F-111. An in-depth analysis is necessary to verify this phenomenon with special consideration in the area of aerodynamic effects over the radome of each of the above aircraft, as well as geometrical similarity. For example, the F-15 and F-4 have basically geometrically similar windshields and canopies but the F-111 does not. It is felt that for the F-111 canopy the pressure wave effects are considerably different than the F-15 and F-4, since the F-111 is a side-by-side seating aircraft. Based on the above the theory would hold in Europe for the F-4 and F-15, but not for the F-111.

F-15 CONUS

ON CANOPY		ON WINDSHIELD	
STRIKE DATE	BASE	STRIKE DATE	BASE
78/04	Langley	78/09	Unknown
80/02	Langley	79/01	Robins
		79/08	Holloman
		79/12	Holloman
		80/02	George
		80/07	Langley
		81/07	Langley
		81/07	Langley
		81/11	Langley
		82/05	Langley
		82/07	Langley
		83/03	Holloman
		83/04	Luke
		83/05	Luke

Time Frame = April 1976-May 1983
 Hours Flown = 473,008
 Total = 2 on Canopy
 14 on Windshield

Data from BASH team computer files, Tyndall AFB

TABLE 4.0 BIRD STRIKES ON CANOPY AND WINDSHIELD

F-15 EUROPE

ON CANOPY		ON WINDSHIELD	
STRIKE DATE	BASE	STRIKE DATE	BASE
78/06	Bitburg	78/07	Bitburg
79/09	Alconbury	81/05	Camp New Amsterdam
80/04	Camp New Amsterdam	81/07	Camp New Amsterdam
80/08	Camp New Amsterdam		
82/08	Spangdahlem		
82/08	Bitburg		
81/09	Camp New Amsterdam		

Time Frame = April 1976-May 1983
 Hours Flown = 136,576
 Total = 7 on Canopy
 3 on Windshield

Data from BASH team computer files, Tyndall AFB

TABLE 4.1 BIRD STRIKES ON CANOPY AND WINDSHIELD

F-111 CONUS

ON CANOPY		ON WINDSHIELD	
STRIKE DATE	BASE	STRIKE DATE	BASE
75/07	Cannon	75/04	Nellis
79/09	Nellis	75/04	Cannon
75/10	Mt Home	76/06	Mt Home
76/08	Mt Home	78/02	Cannon
78/06	Mt Home	78/07	Unknown
78/06	Unknown	78/09	Unknown
78/10	Unknown	79/08	Unknown
78/10	Unknown	79/08	Unknown
78/10	Unknown	79/08	Unknown
79/04	Cannon	79/08	Unknown
79/07	Unknown	79/10	Unknown
79/10	Unknown	79/10	Unknown
79/11	Unknown	79/11	Unknown
79/12	Unknown	82/06	Mt Home
		82/09	Mt Home
		82/09	Mt Home

Time Frame = Jan 1975-Nov 1982
 Hours Flown = Unknown
 Total = 14 on Canopy
 16 on Windshield

Data from BASH team computer files, Tyndall AFB

TABLE 4.2 BIRD STRIKES ON CANOPY AND WINDSHIELD

F-111 EUROPE

ON CANOPY		ON WINDSHIELD	
STRIKE DATE	BASE	STRIKE DATE	BASE
78/07	Unknown	75/11	Upper Heyford
78/09	Unknown	77/10	Upper Heyford
79/08	Unknown	78/08	Lakenheath
79/10	Unknown	78/08	Upper Heyford
80/07	Upper Heyford	78/09	Lakenheath
80/09	Upper Heyford	78/09	Unknown
81/10	Lakenheath	78/09	Unknown
82/04	Incirlik	78/10	Unknown
82/04	Incirlik	79/06	Unknown
82/11	Incirlik	80/10	Lakenheath
82/09	Upper Heyford	80/10	Upper Heyford
82/10	Upper Heyford	80/12	Upper Heyford
82/10	Upper Heyford	81/01	Upper Heyford
82/10	Upper Heyford	81/02	Upper Heyford
82/11	Upper Heyford	81/03	Incirlik
		81/06	Lakenheath
		81/09	Upper Heyford
		81/10	Unknown
		82/06	Lakenheath
		82/07	Upper Heyford

Time Frame = Jan 1975-Nov 1982
 Hours Flown = Unknown
 Total = 15 on Canopy
 20 on Windshield

Data from BASH team computer files, Tyndall AFB

TABLE 4.3 BIRD STRIKES ON CANOPY AND WINDSHIELD

F-4 CONUS

ON CANOPY		ON WINDSHIELD	
STRIKE DATE	BASE	STRIKE DATE	BASE
77/01	Boise (Gowen Fld) ID	75/08	Holloman
78/04	Lincoln MAP NE	77/01	Bergstrom
78/05	Unknown	77/03	Shaw
79/03	Unknown	77/06	Shaw
79/04	Unknown	77/07	Birmingham Muni
79/04	Moody	78/02	Shaw
79/04	Unknown	78/04	Seymour Johnson
79/04	Unknown	78/05	Unknown
79/04	Unknown	78/05	Unknown
79/05	Moody	78/06	George
79/06	Unknown	78/07	Duluth IAP MN
79/07	Unknown	78/08	Moody
79/07	Unknown	78/08	Unknown
79/09	Unknown	78/09	Unknown
79/12	Unknown	78/10	Unknown
80/01	Unknown	78/11	Unknown
80/10	Duluth IAP MN	78/11	Unknown
81/09	MacDill	78/11	Moody
81/01	Lincoln MAP NE	78/11	Homestead
82/07	George	79/03	George
82/05	Shaw	79/05	Homestead
82/06	Birmingham Muni	79/06	Unknown
82/06	Hulman Field IN	79/07	Unknown
82/11	Standiford Field KY	79/09	Luke
82/10	George	79/09	Unknown
		79/10	Duluth IAP MN
		79/10	Key Field MS
		79/10	Unknown
		79/11	Homestead
		79/11	Shaw
		79/12	Moody
		80/03	Homestead
		80/04	Bergstrom
		80/07	Duluth IAP MN
		80/09	George
		80/11	Seymour Johnson
		80/12	Seymour Johnson
		81/05	VDLM
		81/06	MacDill
		81/07	Bergstrom
		81/09	George
		81/10	Kelly
		82/06	Seymour Johnson
		82/08	Duluth IAP MN
		82/10	Edwards
		82/11	Seymour Johnson
		82/10	Seymour Johnson
		82/11	Seymour Johnson

Time Frame = Jan 1975--Jul 1982
Hours Flown = Unknown
Total = 25 on Canopy
 48 on Windshield

Data from BASH team computer files, Tyndall AFB

TABLE 4.4 BIRD STRIKES ON CANOPY AND WINDSHIELD

F-4 EUROPE

ON CANOPY		ON WINDSHIELD	
STRIKE DATE	BASE	STRIKE DATE	BASE
75/03	Bitburg	75/09	Torrejon
76/04	Alconbury	78/02	Bentwaters
78/03	Bitburg	78/03	Bentwaters
78/07	Aviano	78/06	Unknown
78/08	Torrejon	78/07	Hahn
78/09	Unknown	78/07	Unknown
78/09	Unknown	78/08	Unknown
78/10	Unknown	78/09	Hahn
78/10	Unknown	78/09	Unknown
78/10	Unknown	78/09	Unknown
78/12	Zweibrucken	79/06	Unknown
79/01	Hahn	79/06	Unknown
79/03	Unknown	79/06	Unknown
79/06	Unknown	79/07	Unknown
79/06	Spangdahlem	79/10	Hahn
79/07	Unknown	80/07	Torrejon
79/09	Unknown	80/08	Torrejon
80/01	Unknown	80/08	Spangdahlem
80/02	Unknown	80/10	Incirlik
80/03	Unknown	80/11	Incirlik
80/05	Torrejon	81/03	Alconbury
80/07	Zweibrucken	91/03	Ramstein
80/07	Zweibrucken	81/05	Spangdahlem
80/08	Zaragoza	81/06	Ramstein
80/09	Incirlik	81/06	Incirlik
80/09	Ramstein	81/07	Spangdahlem
80/09	Zaragoza	81/07	Spangdahlem
80/09	Hahn	81/07	Hahn
80/09	Hahn	81/09	Torrejon
80/09	Zweibrucken	81/09	Incirlik
80/09	Ramstein	81/10	Zweibrucken
80/10	Zweibrucken	82/09	Ramstein
80/10	Incirlik	82/07	Zweibrucken
80/10	Zaragoza	82/09	Zweibrucken
80/10	Zweibrucken	82/07	Torrejon
80/11	Ramstein	82/08	Torrejon
81/03	Incirlik	82/10	Torrejon
81/03	Incirlik		
81/03	Incirlik		
81/03	Ramstein		
81/04	Incirlik		
81/05	Incirlik		
81/05	Hahn		
81/07	Spangdahlem		

TABLE 4.5 BIRD STRIKES ON CANOPY AND WINDSHIELD

TABLE 4.5 F-4 EUROPE (Cont'd)

81/08	Torrejon
81/08	Alconbury
81/09	Spangdahlem
81/10	Incirklik
82/04	Incirklik
82/05	Zaragoza
82/05	Incirklik
82/05	Spangdahlem
82/06	Incirklik
82/06	Incirklik
82/06	Incirklik
82/09	Ramstein
82/07	Zweibrucken
82/07	Torrejon
82/07	Torrejon
82/08	Torrejon

Time Frame = Jan 1975-Jul 1982

Hours Flown = Unknown

Total = 60 on Canopy

38 on Windshield

Data from BASIL team computer files, Tyndall AFB

Cumulative Probability Distributions

Additional inputs into the model include velocity, bird weight and crew enclosure strength cumulative distributions.

This model assumes that the velocity and bird weight distributions for the majority of the data can be modeled by a Weibull cumulative probability distribution.

The functional form of the cumulative Weibull distribution is given by:

$$F(V) = 1 - \exp \left[- \left(\frac{V - \gamma}{\beta - \gamma} \right)^\alpha \right] \quad (6)$$

Where:

$F(V)$ = cumulative velocity probability distribution

V = velocity

β = characteristic paramter, represents the 63 percentile point of the population sample

α = shape parameter

γ = minimum life parameter, in this analysis it is used only as a correction factor for the Weibull distribution

If portions of the data population do not fit a Weibull distribution, an approximation can be used by the following equation

$$F(V)_{\text{Total}} = F(V)_1 + F(V)_2 + \dots + F(V)_N \quad (7)$$

Equation 7 sums each cumulative distribution to get a total of 1. In this report, $F(V)_{\text{Total}}$ represents a cumulative probability distribution function which is a mixture of Weibull distributions and distributions that are defined by sixth or first order equations, depending on which data population is being analyzed.

The mean values may be obtained by taking the first derivative of each individual cummulative distribution, and applying the following formula

$$\bar{V}_1 = \frac{B}{A} \int V f(V)_1 dV \quad (8)$$

Where:

V = velocity

$f(V)$ = first derivative of $F(V)_1$ probability distribution

and

$$\bar{V}_{\text{Total}} = \bar{V}_1 + \bar{V}_2 + \bar{V}_3 + \dots \quad (9)$$

$$\bar{V}_{\text{Total}} = \int_A^B Vf(V)_1 dV + \int_B^C Vf(V)_2 dV + \int_C^D Vf(V)_3 dV + \dots \quad (10)$$

Before a cumulative distribution can be assigned to a given set of data, it is necessary to reduce the data in a statistical manner. This can be accomplished by the following eqn.

$$\text{RELATIVE FREQUENCY} = \frac{f}{N} \quad (11)$$

where

f = frequency of occurrence

N = total number of occurrences

Eqn. 11 suggests that one can associate with a given event a number, say p, that is equal or approximately equal to that number about which the relative frequency seems to stabilize. The number p, associated with a given event is usually called a probability. Therefore

$$p = \text{PROBABILITY} = \text{RELATIVE FREQUENCY} = \frac{f}{N} \quad (12)$$

Once a given set of data is reduced to a probability form, it is arranged in increasing order to obtain a cumulative probability distribution. To this data, a known cumulative distribution function is fitted. This is done since the statistically reduced data sample contains some level of inaccuracy. The level of inaccuracy is a function of the source and the amount of data. For example, structural recorder data is more realistic and accurate in analyzing the F-15 Air to Air mission than obtaining information from a structural loads report.

A theoretical cumulative distribution such as the Weibull, Gama, Beta or dozens of others, which can be obtained from textbooks are exact, meaning they satisfy all axioms of probability. If a set of data fits any theoretical distribution exactly, the error in that data sample is zero. This occurrence is quite remote due to the inaccuracy in data measuring equipment. Therefore, the data is fitted with a known cumulative distribution, because such a distribution is more exact and represents actual aircraft usage more realistically for a particular mission profile.

This analysis uses primarily the Weibull cumulative probability distribution since this distribution was used exclusively by Dr Halpin and Dr Berens in their work in evaluating the F-16 and T-38 crew enclosure bird impact resistance capabilities. However, one should note that other known cumulative probability distributions could have been used and possibly provided a better fit to any one of the data samples in this report.

VELOCITY DISTRIBUTION FOR F-15 PRESENT FLEET

For the present fleet air to air mission, the velocity distribution was derived from structural recorder data from Kadena, Holloman, and Bitburg for a total of 347.5 flight hours. This data was obtained from McDonnell Douglas and reduced for an altitude range of 0 - 5000 ft AGL. Table 5.0 summarizes the present usage of the F-15 fleet.

Eqn 12 was then used to get the initial probabilities in the altitude range 0 - 5000 ft (Third Column, Table 4.1)

Where

f = # seconds for specific airspeed range

N = total seconds (490,981.8)

From this data, a cumulative probability was obtained (Fourth Column, Table 5.1). This data was then plotted on linear graph paper and fitted with a Weibull cumulative probability distribution.

KADENA + HOLLOMAN + BITBURG CUM

BASED ON 347.5 FLIGHT HOURS

TOTAL USAGE

TRUE ALTITUDE - FEET	SECONDS PER 1000 FLIGHT HOURS														
	0 TO 250	250 TO 500	500 TO 750	750 TO 1000	1000 TO 1500	1500 TO 2000	2000 TO 2500	2500 TO 3000	3000 TO 3500	3500 TO 4000	4000 TO 5000	5000 TO 6000	6000 TO 8000	8000 TO 15000	
0	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
250	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
500	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
750	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
1000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
1500	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
2000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
2500	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
3000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
3500	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
4000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
5000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
6000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
8000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000
15000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000	000000

SECONDS 215623.0275358, 8305176, 3192343, 404038, 5564748, 7530528, 4473653, 0305760, 4220048, 8111215, 7 1505.0

DATA OBTAINED FROM MCDONNELL DOUGLAS
TABLE 5.0 F-15 PRESENT FLEET USAGE

Not Available Copy

DATA FROM KADENA, HOLLOMAN AND BITBURG

TRUE AIRSPEED (KNOTS)	SECONDS	PROB =	$\frac{\text{SECONDS}}{\text{TOTAL SECONDS}}$	CUM PROB
60-90	2.9		.0000	.0000
90-120	54.7		.0001	.0001
120-150	77.7		.0002	.0003
150-180	52193.6		.1063	.1066
180-210	54420.9		.1108	.2174
210-240	54861.1		.1117	.3291
240-270	51977.7		.1059	.4350
270-300	42360.9		.0863	.5213
300-330	56691.3		.1155	.6368
330-360	65813.2		.1340	.7708
360-390	36951.0		.0753	.8461
390-420	41791.1		.0851	.9312
420-450	15386.5		.0313	.9625
450-480	6261.6		.0128	.9753
480-510	2684.7		.0055	.9808
510-540	2681.9		.0055	.9863
540-570	3001.4		.0061	.9924
570-600	1605.7		.0033	.9957
600-630	1047.4		.0021	.9978
630-660	776.9		.0016	.9994
660-690	227.3		.0005	.9999
690-720	112.2		.0002	1.0000
TOTALS	490,981.0		1.0000	

TABLE 5.1 REDUCED DATA FOR 0-5000 FT., FROM TABLE 5.0

To determine the initial parameters for the Weibull distribution, eqn (6), a U vs W transformation was used. This allowed for an initial estimate of the Weibull parameters, α , and β . The transformation was developed as follows:

$$F(V) = 1 - \exp \left[- \left(\frac{V - \gamma}{\beta - \gamma} \right)^\alpha \right]$$

$$1 - F(V) = \exp \left[- \left(\frac{V - \gamma}{\beta - \gamma} \right)^\alpha \right]$$

$$\ln (1 - F(V)) = - \left(\frac{V - \gamma}{\beta - \gamma} \right)^\alpha$$

$$-\ln (1 - F(V)) = \left(\frac{V - \gamma}{\beta - \gamma} \right)^\alpha$$

$$\alpha \ln \left(\frac{V - \gamma}{\beta - \gamma} \right) = \ln \left[-\ln (1 - F(V)) \right]$$

$$\alpha \ln (V - \gamma) - \alpha \ln (\beta - \gamma) = \ln \left[-\ln (1 - F(V)) \right]$$

But the equation of a straight line is

$$u = mW + b$$

where m is the slope of the line

b is the u intercept when W = 0

$$\text{let } W = \ln (V - \gamma)$$

$$\text{and } u = \ln \left[-\ln (1 - F(V)) \right].$$

Therefore;

$$\begin{aligned} u &= \boxed{m} W + \boxed{b} \\ u &= \boxed{\alpha} W + \boxed{-\alpha \ln (\beta - \gamma)} \end{aligned} \quad (13)$$

where α is the slope

and $-\alpha \ln (\beta - \gamma)$ is the u intercept when W = 0

* Any Weibull function in a u vs W domain is a straight line.

Table 5.2 lists the results of the u vs W transformation where the nominal velocities were input for V, and cumulative probabilities, from column 3, were input for F(V). These values were then plotted in the u vs W domain, (Fig 2) and a straight line was drawn through the most significant points that represented individual probabilities, from eqn 12, of greater than .05. From this straight line the parameters were derived as follows:

F-15 PRESENT FLEET

VELOCITY (KTS)	NOMINAL VELOCITY (KTS)	CUM PROB	U	W
90 - 120	105	.0001	-9.2103	4.1744
120 - 150	135	.0003	-8.1116	4.5539
150 - 180	165	.1066	-2.1828	4.8283
180 - 210	195	.2174	-1.4060	5.0434
210 - 240	225	.3291	-.9185	5.2204
240 - 270	255	.4350	-.5605	5.3706
270 - 300	285	.5213	-.3056	5.5013
300 - 330	315	.6368	.0127	5.6168
330 - 360	345	.7708	.3874	5.7203
360 - 390	375	.8461	.6267	5.8141
390 - 420	405	.9312	.9845	5.8999
420 - 450	435	.9625	1.1889	5.9789
450 - 480	465	.9753	1.3086	6.0521
480 - 510	495	.9808	1.3744	6.1203
510 - 540	525	.9863	1.4564	6.1841
540 - 570	555	.9924	1.5851	6.2442
570 - 600	585	.9957	1.6955	6.3008
600 - 630	615	.9978	1.8114	6.3544
630 - 660	645	.9994	1.0040	6.4052
660 - 690	675	.9999	2.2203	6.4536
690 - 720	705	1.0000	2.4435	6.4998

DATA FROM STRUCTURAL RECORDER (HOLLOMAN, BITBURG, KADENA)

TABLE 5.2 WEIBULL U VS W TRANSFORMATION

$$\alpha = \text{slope of line} = 2.81$$

from graph, $u = -15.7002$ when $W = 0$

$\gamma = 40$ established prior to u vs W transformation

Then

$$-15.7002 = 2.81(0) - 2.81 \ln(\beta - 40)$$

$$\beta = 307$$

$$F(V)_1 = 1 - \exp \left[- \left(\frac{V-40}{307-40} \right)^{2.81} \right] \quad \text{for } 200 < V \leq 720$$

The correction factor (γ) in the u vs W domain straightens the data somewhat to represent a straight line. The value for γ was determined by trial and error, as γ was incremented from 0 - 140, and then finally chosen as 40, since it provided the best fit to the data sample.

The above Weibull distribution fitted the data sample exceptionally well from 200 to 720 knots, but was unrealistic below 200 knots. Therefore, the range 110 - 200 was fitted with a sixth order equation.

This distribution was developed by approximating that range by a realistic distribution and intersecting the Weibull at the most common point, which for this case was 200 knots. Then from this distribution, a sixth order least squares fit was accomplished, and the equation checked to insure that the distribution for the specified range was in fact a probability distribution. The following equation was developed:

$$F(V) = \begin{cases} -5.793168 + 2.49687 \times 10^{-1} V - 4.296046 \times 10^{-3} V^2 \\ + 3.774985 \times 10^{-5} V^3 - 1.792476 \times 10^{-7} V^4 \\ + 4.396387 \times 10^{-10} V^5 - 4.371459 \times 10^{-13} V^6 \end{cases} \quad \text{for } 116 \leq V \leq 200$$

Figure 3 summarizes the F-15 present fleet velocity profile in the altitude range of 0 - 5000 ft AGL.

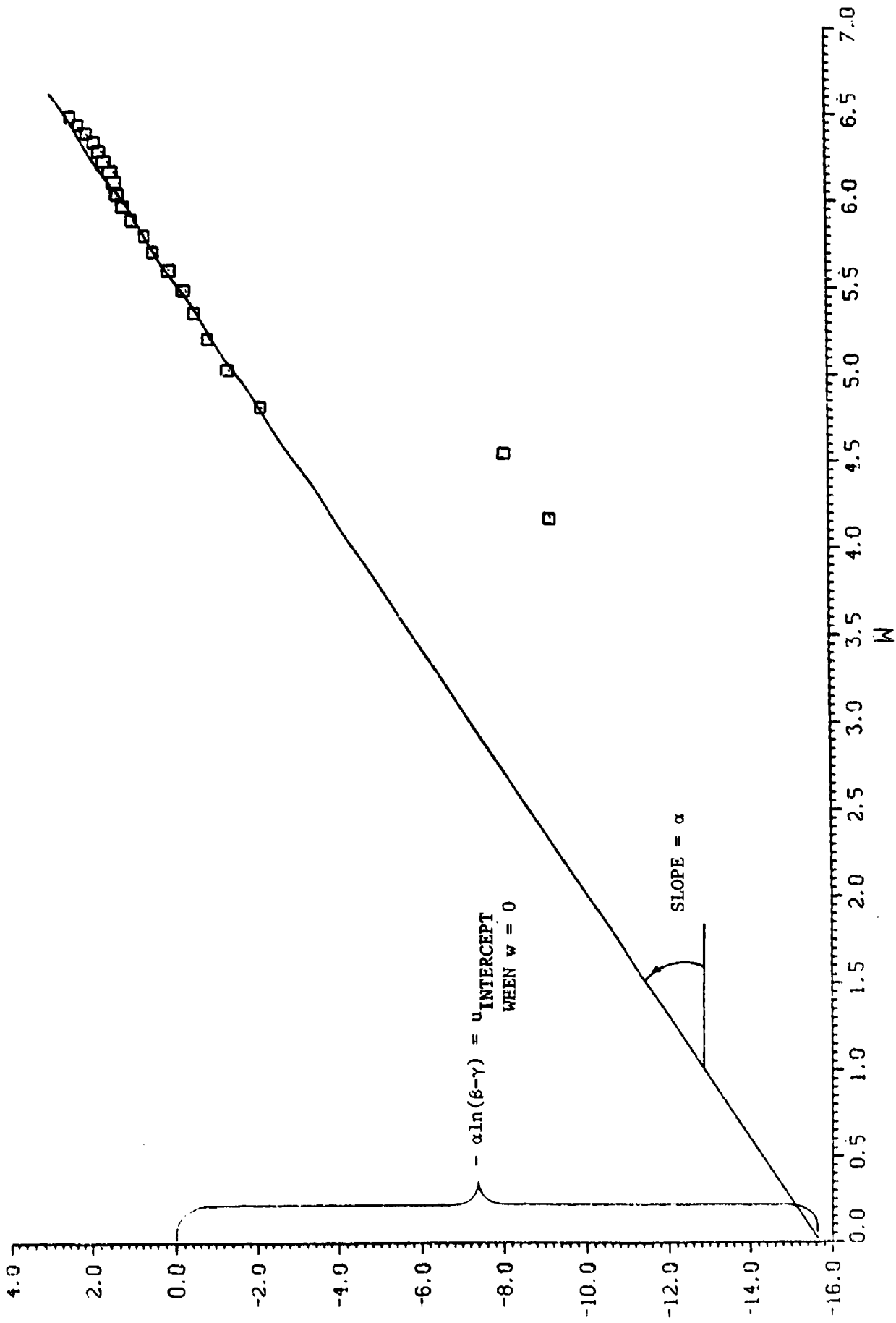


FIG. 2 U VS W TRANSFORMATION
 F-15 PRESENT FLEET, AIR TO AIR MISSION

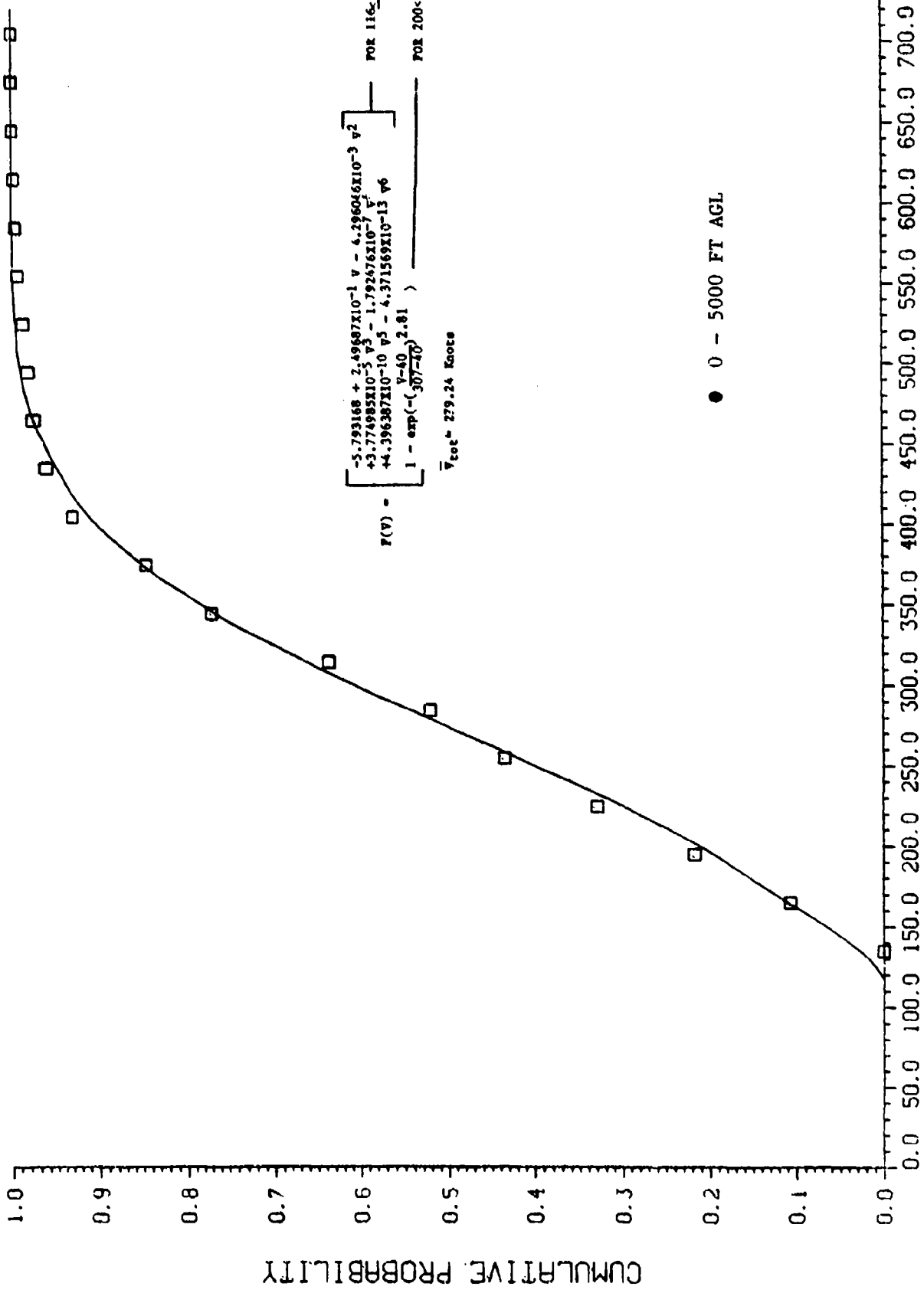


FIG. 3 F-15 PRESENT FLEET VELOCITY DISTRIBUTION
 AIR TO AIR MISSION FROM STRUCTURAL RECORDER DATA

The mean velocity was obtained by applying eqn 9 and 10. By using a numerical integration subroutine on an HP-15C, the mean velocity for the F-15 present fleet was determined to be 279.24 knots.

The proportion of time (t_g) in the range of 0 - 5000 ft AGL for CONUS was obtained from McDonnell Douglas structural loads report (MDC A5318) for all missions other than air to ground. The t_g was determined to be .1198, based on mission mix as specified on pg 3.2.2.1 of the above report. The reason for not using the Holloman t_g was that it was unrealistic and it contradicted a data sample from Langley. The t_g for Holloman was approximately .04 and Langley, .14. Therefore, as a last resort, the structural loads report was used.

Bitburg data was used to determine the t_g for Europe. From Bitburg data for Europe, the t_g was evaluated to be .2307. This represented a realistic value since historically the F-15 fleet has spent considerably more time in Europe between 0 - 5000 ft, and another source of data matched the above t_g within .01 (1%).

An assumption was made that the velocity profile for the present fleet, in the range of 0 - 5000 ft AGL, was the same between CONUS and Europe. This was done considering that the mean velocity would not increase or decrease by more than 10 knots. Such a change in this analysis represents insignificant changes in final results.

F-15 RAPID DEPLOYMENT FORCE (RPD) VELOCITY DISTRIBUTION

For the F-15 RPD, the air to ground velocity profile was derived from McDonnell Douglas structural load report (MDC A5318). This data was used since the F-15 does not fly an air to ground mission at this time. The above report, although not labeled F-15 RPD, is representative of the RPD, since the RPD will be the basic F-15C aircraft with provisions for conformal fuel tanks and a requirement for an air to ground mission (based on conversations with McDonnell Douglas).

Table 6.0-6.3 summarizes the Air to Ground missions for the F-15 RPD. Similar methods were used to reduce the data as in the previous section; however, some reorganization of data was necessary to fit the data with a Weibull curve. For example, if a data point was reduced to be at 443 knots, then this point was assigned to a velocity range of 410 - 460 knots and for Weibull fitting purposes the nominal point between 410 - 460 was used. This approach allowed for some inaccuracy in the source of data. To these boundaries, the Weibull distribution could have been fitted, iterating as necessary to insure most important points are intersected or very closely approached. Important points for this case are defined as points for which eqn 12 shows values of .15 or greater (this value can be established by using one's judgment).

Figure 4 summarizes the F-15 RPD velocity profile for an altitude range of 0 - 5000 ft AGL. An assumption was made that the same velocity profile is flown between CONUS and Europe. Further, it was assumed that for 0 - 5000 ft AGL, the F-15 RPD will fly the same air to air velocity profile in CONUS and Europe as the present fleet (Fig 3). Same rationale as previous section.

F-15C(CFT)
MISSION SUMMARY

MISSION	MISSION HRS PER LIFETIME	HRS PER MISSION	NUMBER OF MISSIONS	COMBAT HRS PER MISSION	COMBAT HRS PER LIFETIME
Air-to-Air 1	310	1.7334	179	.0306	5.5
Air-to-Air 3	545	1.1905	458	.2334	106.9
DOC*	90	.7591	119	.1790	21.3
ESM*	360	2.6054	138	.0732	10.1
Mix { Air-to-Ground 1	665	1.217	546	.499	272.4
Used { Air-to-Ground 2A	300	.912	329	.333	109.6
Air-to-Ground 2B*	385	1.1329	340	.2156	73.3
Formation/Acrobatcs 1A	85	1.2486	68	.1576	10.7
Formation/Acrobatcs 1B*	130	2.2116	59	.1536	9.0
Instrument/Navigation 1A	500	3.789	132	--	--
Instrument/Navigation 1B*	405	5.4035	75	--	--
Ferry*	225	6.5976	34	--	--

*Indicates Missions with Conformal Fuel Tanks

Above missions represent a 400 Hr aircraft lifetime

TOTAL COMBAT TIME PER LIFETIME = 618.8 HR
 AIR-TO-AIR COMBAT TIME PER LIFETIME = 163.5 HR
 AIR-TO-GROUND COMBAT TIME PER LIFETIME = 455.3 HR

DATA OBTAINED FROM MCDONNELL DOUGLAS REPORT #MDC-A5318

TABLE 6.0 F-15 RAPID DEPLOYMENT FORCE MISSION MIX FOR THE AIR TO GROUND MISSION

F-15C

AIR-TO-GROUND I

PAYLOAD: 4 AIM-7F + Internal Gun + Ammo + 4000 lbs. Bombs
 FUEL: Full Internal PEP + Full External @ 600 Gal. Tank

<u>SEGMENT</u>	<u>OPERATION</u>	<u>ALTITUDE (FE)</u>	<u>WEIGHT (LBS)</u>	<u>FUEL (LBS)</u>	<u>DISTANCE (N.M.)</u>	<u>MACH</u>	<u>TIME (HR)</u>
A	Ground Operation and Take-Off	SL	53479	800 300	- 4	- .30	.100 .017
B	Ascent: Climb to 5K Cruise: Speed for Best Range	SL 5000	52379 52219	160	3	.483	.008
D	Combat: Drop Bombs Expend Ammo	5000	50192	2027	100	.562	.274
E	Ascent: Climb to Alt. for Best Cruise	SL	(4282) 33834	12076	-	.70	.499
F	Cruise: Mach for Best Range	48000	32754	1080	51	.841	.103
G	Descent: To SL 70% RPM	48000	32754	None	None	-	-
H	Landing 5% Internal Fuel	SL	32279	475	56	.595	.183
		SL	31597	682	-	-	.003 1.217

DATA OBTAINED FROM MCDONNELL DOUGLAS REPORT #MDC-45318

TABLE 6.1 F-15 RAPID DEPLOYMENT FORCE AIR-TO-GROUND I MISSION

F-15C

AIR-TO-GROUND 2A

PAYLOAD: 4 AIM-7F + Internal Gun + Ammo + 4000 Lbs. Bombs
 FUEL: Full Internal PEP + Full External E 600 Gal. Tank

<u>SEGMENT</u>	<u>OPERATION</u>	<u>ALTITUDE (FT)</u>	<u>WEIGHT (LBS)</u>	<u>FUEL (LBS)</u>	<u>DISTANCE (N.M.)</u>	<u>MACH</u>	<u>TIME (HR)</u>
A	Ground Operation and Takeoff	SL	53479	800 300	- 2	- .3	.100 .017
B	Ascent: Climb to 500 Ft.	SL	52379	53	1	.329	.003
C1	Accelerate: M = .54 - .90	500	52326	421	8	.90	.018
C2	Cruise: M = .90 at 500 Ft.	500	51905	3866	116	.90	.194
D	Combat: 20 Min at Mil Power	SL	48039	8066	-	.70	.333
E	Cruise: M = .90 at 500 Ft.	500	(4282) 35691	3412	127	.90	.214
F	Descent:	500	32279	-	-	.875	-
G	Landing: Fuel Reserve	SL	32279	682	-	-	.033 .912

DATA OBTAINED FROM MCDONNELL DOUGLAS REPORT #MDC-A5318

TABLE 6.2 F-15 RAPID DEPLOYMENT FORCE AIR-TO-GROUND 2A MISSION

F-15 (CFT)

AIR-TO-GROUND 2B

PAYLOAD: 4 AIM-7F + Internal Gun + Ammo + 6000 Lbs. Bombs (MK-82)
 FUEL: Full Internal PEP + Full Conformal Fuel Tanks

<u>SEGMENT</u>	<u>OPERATION</u>	<u>ALTITUDE (FT)</u>	<u>WEIGHT (LBS)</u>	<u>FUEL (LBS)</u>	<u>DISTANCE (N.M.)</u>	<u>MACH</u>	<u>TIME (HR)</u>
A	Ground Operation Take-Off (Mil Power)	SL	63499	920 550	- 1.0	- .53	.100 .0083
B	Ascent: Climb To 500 Ft	SL	62029	75	1.0	.53	.004
CI	Accelerate: M = .54 - .90	500	61954	382	7.6	.72	.0156
C	Cruise: Constant. Alt. @ M = .90	500	61572	7938	220.	.90	.370
D	Combat: Mil Power Drop Bombs, Ammo	500	53634	5218	-	.70	.2156
E	Cruise: Constant Alt. @ M = .90	500	(6282) 42134	7735	229.6	.90	.386
F	Descend: To SL	SL	34399	-	-	.90	-
G	Landing: 5% Fuel Reserve	SL	33717	682	-	-	.0334 1.1329

DATA OBTAINED FROM MCDONNELL DOUGLAS REPORT # MDC-A5318

TABLE 6.3 F-15 RAPID DEPLOYMENT FORCE AIR-TO-GROUND 2B

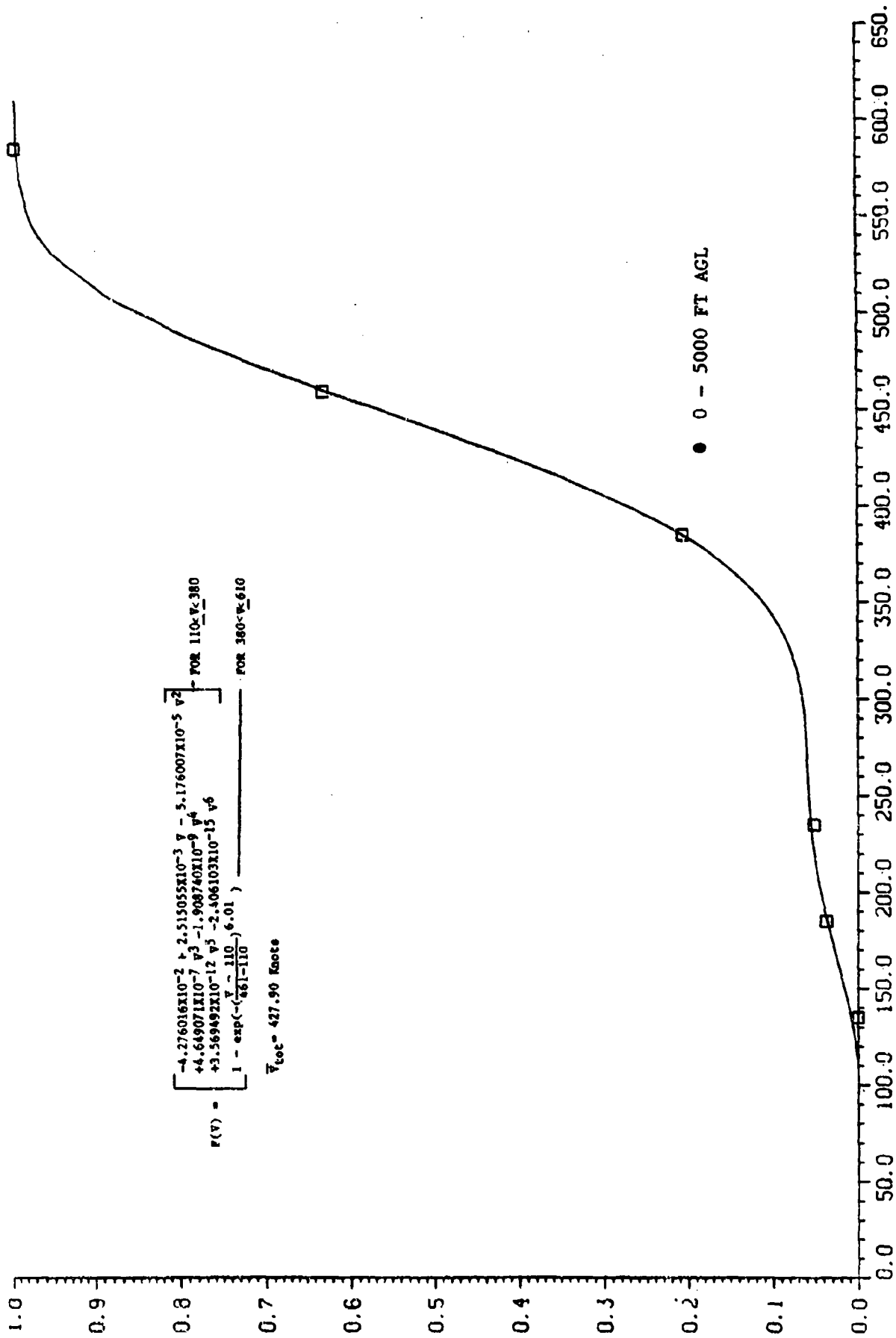


FIG. 4 F-15 RPD VELOCITY DISTRIBUTION
 AIRCRAFT VELOCITY (KTS)
 AIR TO GROUND MISSION FROM STRUCTURAL LOAD REPORT

F-15 DUAL ROLE FIGHTER VELOCITY DISTRIBUTION

The F-15 Dual Role Fighter (DRF), air to ground (0 - 500 ft AGL) velocity profile was derived from McDonnell Douglas Structural Design Criteria, Memorandum 199-DRF-169. This report was used, since it was the best source of this type of information for the DRF.

Mission mix was obtained from the same report and is summarized as follows:

F-15 DRF MISSION MIX			
AIR-TO-AIR	20%	A/A1	2.5%
		A/A2	2.5%
		A/A3	15.0%
AIR-TO-GROUND	75%	A/G1	10.0%
		A/G2	10.0%
		A/G3	55.0%
NON-TACTICAL	5%	N/T1	2.5%
		N/T2	2.5%

NOTE (A) Based on a 4000 hour aircraft lifetime

(B) All percentages are percent of total missions

Table 7.0 - 7.2 lists each air to ground mission. In data reduction, only flight in the altitude range of 0 - 5000 ft is considered. A ratio is used for climbs and descents up to 5000 ft. Same methods were used as in the previous sections to fit the data with a Weibull and sixth order distribution.

Figure 5 summarizes the F-15 DRF velocity profile for an altitude range of 0 - 5000 ft AGL. Similarly as for the F-15 RPD, it was assumed that the DRF will fly the same velocity profile (0 - 5000 ft) between CONUS and Europe. The DRF air to air velocity profile (0 - 5000 ft) was assumed to be equivalent to the F-15 present fleet between CONUS and Europe. Same rationale as previous sections.

F-15 DRF
AIR-TO-GROUND I

PAYLOAD: 4 AIM-7F + 4 AIM-9L + Internal Gun + Ammo + 5000 lbs. Bombs + LANTIRN
 FUEL: Full Internal + Full CFT + Full E 600 Gal. Tank

SEGMENT	OPERATION	ALTITUDE (FT)	WEIGHT (LBS)	FUEL (LBS)	DISTANCE (N.M.)	MACH	TIME (HR)
		SL	71887				
A	Ground Operation And Take-Off Max AB			800 550	- 2.0	- .30	.100 .017
B	Ascent: Climb to 5K	SL	70537	375	3.0	.483	.008
C	Cruise: Speed for Best Range	5000	70162	9372	305	.625	.7515
D	Dash	5000	60790	2239	50.0	.90	.0856
E	Combat: Drop Bombs Expend Ammo	5000	58551	8200	-	.80	.3333
F	Ascent: Climb to Alt. for Best Cruise	SL	(5120) 45231	1950	80.0	.85	.25
G	Cruise: Mach for Best Range	40000	43281	2234	195	.86	.3944
H	Descent: To SL 70% RPM	40000	41047	540	84.	.595	.200
I	Landing 5% Internal Fuel	SL	40507	664	-	-	.0334
		SL	39843				
							<u>2.1732</u>

DATA OBTAINED FROM MCDONNELL DOUGLAS STRUCTURAL DESIGN CRITERIA, MEMORANDUM 199-DRF-169

TABLE 7.0 F-15 DUAL ROLE FIGHTER AIR-TO-GROUND I MISSION

F-15 DRF
AIR-TO-GROUND 2

SEGMENT	OPERATION	ALTITUDE (FT)	WEIGHT (LBS)	FUEL (LBS)	DISTANCE (N.M.)	MACH	TIME (HR)
A	Ground Operation Takeoff	SL	70082	504 300	- 2.0	- .53	.100 .0167
B	Ascent: Climb to 5000 Ft.	SL	69278	375	3.0	350/.9	.008
C	Cruise: Opt. Speed	5000	68903	2612	85	.625	.2095
D	Descend: to SL No Range or Fuel	5000	66291	-	-	-	.025
E	Dash: Constant Alt. @ .82	SL	66291	4597	100	.82	.1848
F	Combat: Mil Power Drop Bombs	SL	61694 (8000) 45694	8000	-	.80	.3333
G	Dash: Constant Alt. @ .82	SL	41654	4040	100	.82	.1848
H	Ascent: Climb to 5000 Ft.	SL	41654	125	2.0	.90	.0067
I	Cruise: Opt. Speed	5000	41529	1767	84	.48	.2695
J	Descend: to SL	5000	39762	45	4.0	.37	.0167
K	Landing: 5% Fuel Res.	SL	39717	664	-	-	.0334
		SL	39053				<u>1.3884</u>

DATA OBTAINED FROM MCDONNELL DOUGLAS STRUCTURAL DESIGN CRITERIA, MEMORANDUM 119-DRF-169

TABLE 7.1 F-15 DUAL ROLE FIGHTER AIR-TO-GROUND 2 MISSION

F-15 DRF
AIR-TO-GROUND 3

PAYLOAD: 2 AIM-9 + SUU-20 + LANTIRN Pods
FUEL: Full Internal + Full CFT

<u>SEGMENT</u>	<u>OPERATION</u>	<u>ALTITUDE (FT)</u> SL	<u>WEIGHT (LBS)</u> 59203	<u>FUEL (LBS)</u>	<u>DISTANCE (N.M.)</u>	<u>MACH</u>	<u>TIME (HR)</u>
A	Ground Operation Takeoff	SL	58399	504 300	2.0	.53	.100 .0167
B	Ascent: Mil Power Climb to Opt. Alt.	35000	56449	1950	68.0	350/.90	.1367
C	Cruise: Opt: Speed	36000	55814	635	49	.915	.0932
D	Descent: to 500 ft.	500	55604	210	34	.68	.1167
E	Dash: Constant Altitude	500	51299	4305	150.	.727	.3125
F	Combat: Drop Bombs	500	(284) 42815	8200	-	.90	.3333
G	Dash: Constant Altitude	500	38547	4268	150	.727	.3125
H	Ascent: Mil Climb to Opt. Alt.	43000	37172	1375	68	.90	.1233
I	Cruise: Opt. Speed	44000	36814	358	41	.915	.0779
J	Descent: to SL-Idle Thrust	SL	36554	260	44	.80	.1417
K	Landing: 5% Int. Fuel	SL	35890	664	-	-	.0334
							<u>1.7979</u>

DATA OBTAINED FROM MCDONNELL DOUGLAS STRUCTURAL DESIGN CRITERIA, MEMORANDUM 199-DRF-169

TABLE 7.2 F-15 DUAL ROLE FIGHTER AIR-TO-GROUND 3 MISSION

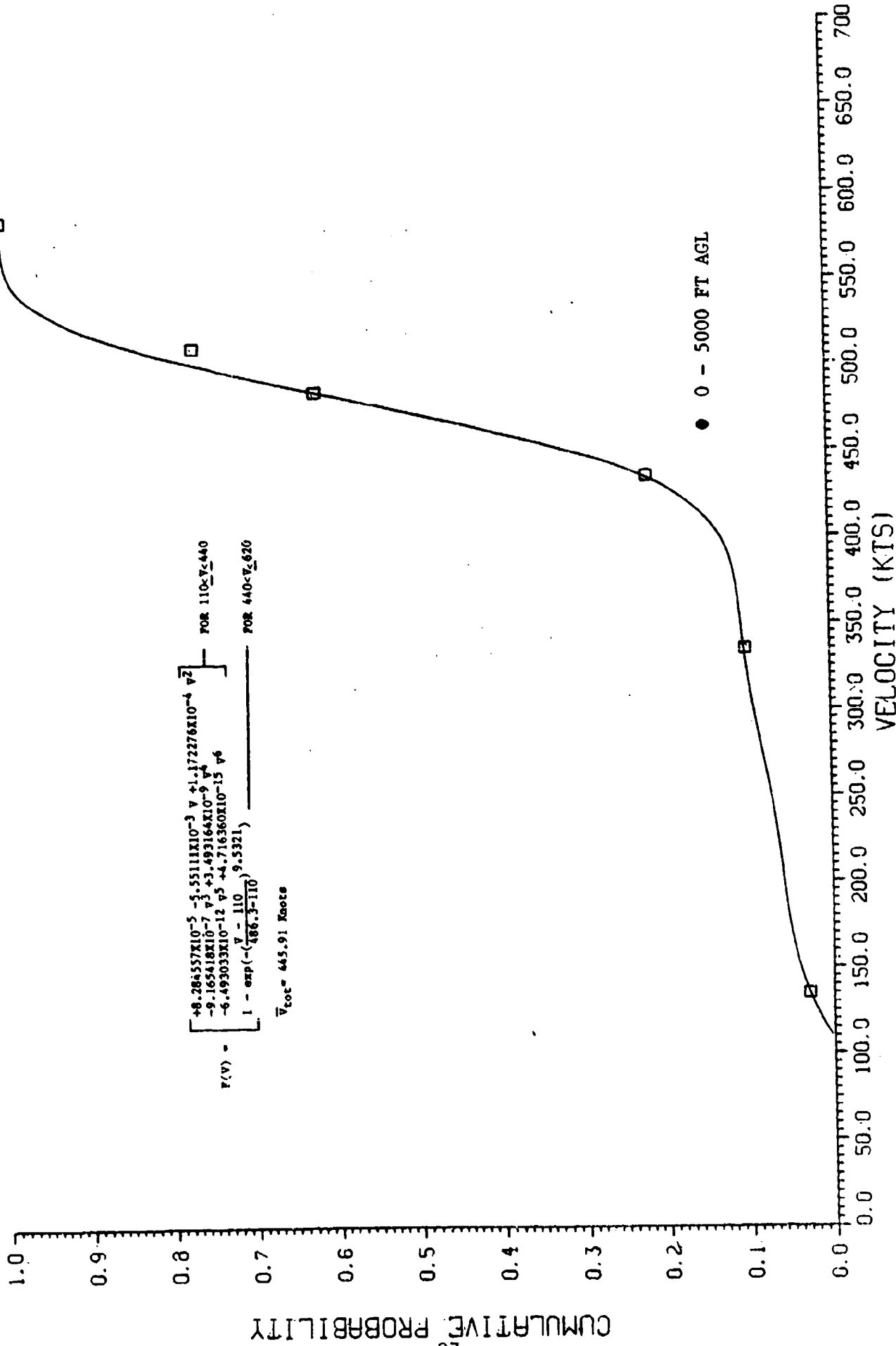


FIG. 5 F-15 DRF VELOCITY DISTRIBUTION
AIR TO GROUND MISSION FROM STRUCTURAL LOAD REPORT

BIRD WEIGHT DISTRIBUTIONS

Bird weight distributions for CONUS and Europe were derived from F-15, F-4 and F-111, (as well as other USAF inventory aircraft, Table 8.0) bird impacts which were identified by species and weight. The above data was obtained from Lt Will (AV 970-6243), BASH Team, Tyndall AFB.

The bird impact data is summarized in Tables 8.0 - 8.6. Table 8.0 lists a composite of several aircraft bird impacts which were identified by the Smithsonian Institute. Some identified bird weights are exact and some are averaged. F-15, F-4, and F-111 impacts were extracted from the log book data and listed in Table 8.1 - 8.6 with remaining computer file bird impacts. All bird impacts are impacts that have been reported anywhere on the aircraft. A bird impacting a wing or engine could have just as well hit the windshield or canopy. The data from computer files was identified by bird type, then Reference 3-5 was used to associate a bird type with a bird weight. Reference 3 was considered to be the most exact source of information, then reference 4 and finally Reference 5 as a last resort.

Based on Tables 8.0 - 8.6 for CONUS and Europe, the data was reduced using eqn 12 and then fitted with a Weibull distribution or a mixture of distributions. Figures 6 and 7 summarize the results with appropriate equations defining each distribution, as well as the mean bird weights.

COMPOSITE OF SEVERAL AIRCRAFT CONUS

BASE	STRIKE DATE	A/C	BIRD TYPE	BIRD WEIGHT
K.I. Sawyer	82/05	B-52H	Horned Lark	1.25 - 1.50 oz
Buckley Field	82/05	A-7D	Red Tailed Hawk	2.5 lbs
Columbus	82/05	T-38	Turkey Vulture	4.5 lbs
MacDill	82/05	F-16	White Ibis	1.5 lbs
Hill	82/05	F-16	White Pelican	17 lbs
Buckley Field	82/06	T-43A	Red Tailed Hawk	2.5 lbs
Williams	82/06	T-38	Horned Lark	1.25 - 1.5 oz
Myrtle Beach	82/06	A-10	Turkey Vulture	4.5 lbs
MacDill	82/07	F-16A	Black Vulture	4.5 lbs
Laughlin	82/07	T-38A	Black Vulture	4.5 lbs
Williams	82/07	T-38	Horned Lark	1.25 - 1.5 oz
K.I. Sawyer	82/07	B-52H	Red Tailed Hawk	2.5 lbs
Patrick	82/08	A-10	Magnificent Frigate Bird	3 lbs
Barnes MAP (ANG)	82/08	A-10	Red Tailed Hawk	2.5 lbs
Columbus	82/07	T-38	Eastern Meadow Lark	4 oz
Ellsworth	82/11	B-52H	Sanderling	1.75 oz
Ellsworth	82/12	B-52H	Golden Eagle	9 lbs
Blytheville	82/04	B-52G	Upland Plover	3 - 3.5 oz
McClellan	82/04	HC-130	Horned Lark	1.25 oz - 1.5 oz
Dyess	82/01	C-130	Robin	3 oz
Minot	82/06	F-106	Horned Lark	1.25 oz - 1.5 oz
Vance	82/06	T-37	Western Meadowlark	4 oz
Luke	82/09	F-104	White Throated Swift	1 oz
Laughlin	82/09	T-38	Black Vulture	4.5 lbs
K.I. Sawyer	82/10	B-52H	Red Winged Blackbird	1.5 oz - 2.0 oz
Columbus	82/09	T-38A	Cattle Egret	12 oz
Columbus	82/09	T-38A	Turkey Vulture	4.5 lbs
Grissom	82/09	KC-135A	Killdeer	3 oz
Norton	82/10	C-141B	Coot	1.25 lbs
Myrtle Beach	82/10	A-10	Red Tailed Hawk	2.5 lbs
Williams	82/10	T-38A	Horned Lark	1.25 oz - 1.5 oz
K.I. Sawyer	82/10	B-52H	Black Vulture	4.5 lbs

TABLE 8.0 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

COMPOSITE OF SEVERAL AIRCRAFT CONUS (Continued)

BASE	STRIKE DATE	A/C	BIRD TYPE	BIRD WEIGHT
Vance	82/11	T-38	Wood Duck	1.5 lbs
Williams	82/11	T-38A	Horned Lark	1.25 oz - 1.5 oz
Williams	82/12	T-38A	American Kestrel	3 oz
Vance	82/12	T-38A	Meadow Lark	4 oz
Rickenbacker (ANG)	82/12	A-7D	Red Tailed Hawk	2.5 lbs
Columbus	82/12	T-38A	Common Grackle	3 - 4 oz
Pope	82/12	C-130E	Ring Necked Duck	1.5 lbs
Myrtle Beach	82/12	A-10A	Ring Necked Duck	1.5 lbs
Des Moines MAP (ANG)	83/01	A-7D	Meadow Lark	4 oz
Williams	83/01	T-38A	Horned Lark	1.25 - 1.5 oz
MacDill	83/01	F-16B	Bald Eagle	8 lbs
Hill	83/01	F-16A	White Pelican	10 - 17 lbs
Myrtle Beach	83/01	A-10A	Laughing Gull	9.1 - 11.50 oz
Williams	83/01	T-38A	Horned Lark	1.25 - 1.5 oz
Savanah MAP (ANG)	83/03	C-130H	Osprey	3.5 lbs
Rickenbacker (ANG)	83/03	A-7D	Red Shouldered Hawk	1.75 lbs
Minot	83/03	B-52H	Pintail Duck	2.2 lbs

DATA OBTAINED FROM LOG BOOK OF IDENTIFIED BIRD TYPE AND WEIGHT BY SMITHSONIUM INSTITUTE, BASH TEAM, TYNDALL AFB; LT WILL (AV 970-6243), LOG BOOK CALL #'s 204-293.

TABLE 8.0 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

F-15 CONUS		F-15 CONUS		F-15 CONUS	
STRIKE DATE	BASE	A/C	COMMAND	BIRD TYPE	BIRD WEIGHT
76/04	Langley	F-15A	TAC	Laughing Gull	9.1 - 11.5 oz
76/08	Langley	F-15A	TAC	Laughing Gull	9.1 - 11.5 oz
76/08	Langley	F-15A	TAC	Laughing Gull	9.1 - 11.5 oz
78/04	Langley	F-15A	TAC	Rough-Legged Hawk	2.0 lbs
79/02	Langley	F-15	TAC	Herring Gull	2.5 lbs
79/03	Langley	F-15	TAC	Herring Gull	2.5 lbs
79/04	Langley	F-15	TAC	Herring Gull	2.5 lbs
79/05	Langley	F-15	TAC	Laughing Gull	9.1 - 11.5 oz
79/08	Langley	F-15	TAC	Laughing Gull	9.1 - 11.5 oz
79/08	Langley	F-15A	TAC	Sparrow Hawk	.5 lbs
79/08	Langley	F-15	TAC	Sparrow	.8 oz
80/02	Eglin	F-15A	TAC	Sparrow	.8 oz
80/02	Langley	F-15	TAC	Red Winged Blackbird	3.3 oz
80/02	Luke	F-15B	TAC	Red Winged Blackbird	3.3 oz
80/03	Langley	F-15	TAC	Ring Billed Gull	1.5 lbs
80/04	Langley	F-15	TAC	Double Crested Cormorant	4.5 lbs
80/07	Luke	F-15B	TAC	Mourning Dove	5.5 oz
81/11	Langley	F-15	TAC	Sandpiper	.125 lbs
81/11	Langley	F-15C	TAC	American Kestrel	3 oz
81/12	Langley	F-15A	TAC	Herring Gull	2.5 lbs
81/12	Langley	F-15A	TAC	Dunlins	.25 lbs
82/02	Langley	F-15C	TAC	Common Grackle	3 - 4 oz
82/07	Langley	F-15C	TAC	Sparrow	.8 oz
82/07	Luke	F-15	TAC	Mourning Dove	5.5 oz
82/07	Langley	F-15D	TAC	Common Grackle	3 - 4 oz
82/08	Langley	F-15A	TAC	Sparrow	.8 oz
82/09	Langley	F-15C	TAC	Common Grackle	3 - 4 oz
82/09	Langley	F-15C	TAC	Common Grackle	3 - 4 oz
82/10	Langley	F-15A	TAC	Common Grackle	3 - 4 oz
82/11	Langley	F-15C	TAC	Herring Gull	2.5 lbs
82/11	Langley	F-15C	TAC	Herring Gull	2.5 lbs
82/12	Luke	F-15	TAC	Water Pipit	.8 oz
83/03	Holloman	F-15B	TAC	Golden Eagle	14 lbs
83/04	Luke	F-15A	TAC	Redwinged Blackbird	3.3 oz

DATA FROM BASH TEAM, TYNDALL AFB, COMPUTER FILES

TABLE 8.1 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

F-15 EUROPE

BASE	STRIKE DATE	A/C	COMMAND	BIRD TYPE	BIRD WEIGHT
Unknown	78/09	F-15A	AFE	Lapwing	8 oz
Unknown	79/06	F-15A	AFE	Kestrel	8 oz
Camp New Amsterdam	80/05	F-15A	AFE	Magpie	7.4 oz
Camp New Amsterdam	80/05	F-15A	AFE	Seagull	8 oz
Camp New Amsterdam	80/05	F-15B	AFE	Magpie	7.4 oz
Camp New Amsterdam	80/06	F-15A	AFE	Hawk	2.0 lbs
Camp New Amsterdam	80/06	F-15A	AFE	Hawk	2.0 lbs
Camp New Amsterdam	80/08	F-15C	AFE	Finch	1.0 oz
Camp New Amsterdam	80/08	F-15C	AFE	Kestrel	8 oz
Camp New Amsterdam	80/09	F-15C	AFE	Kestrel	8 oz
Camp New Amsterdam	80/10	F-15C	AFE	Magpie	7.4 oz
Bitburg	80/10	F-15A	AFE	Raven	8 oz
Bitburg	81/05	F-15C	AFE	Buzzard	1.7 - 2.3 lbs
Bitburg	81/05	F-15C	AFE	Sparrow	.8 oz
Bitburg	81/05	F-15C	AFE	Buzzard	1.7 - 2.3 lbs
Bitburg	81/05	F-15C	AFE	Buzzard	1.7 - 2.3 lbs
Bitburg	81/05	F-15C	AFE	Green Finch	1.0 oz
Unknown	81/07	F-15C	AFE	Sparrow	.8 oz
Camp New Amsterdam	81/09	F-15D	AFE	Magpie	7.4 oz
Camp New Amsterdam	81/09	F-15D	AFE	Magpie	7.4 oz
Bitburg	82/05	F-15C	AFE	Swift	1.3 oz
Camp New Amsterdam	82/09	F-15C	AFE	Lapwing	8 oz
Bitburg	82/09	F-15C	AFE	Lapwing	8 oz

DATA FROM BASH TEAM, TYNDALL AFB, COMPUTER FILES

TABLE 8.2 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

F-4 CONUS

BASE	STRIKE DATE	A/C	COMMAND	BIRD TYPE	BIRD WEIGHT
Bergstrom	75/05	RF-4C	TAC	Turkey Vulture	4.5 lbs
Bergstrom	75/06	RF-4C	TAC	Turkey Vulture	4.5 lbs
Eglin	75/06	F-4E	TAC	Buzzard	1.7 - 2.3 lbs
Bergstrom	75/11	RF-4C	TAC	Gadwall Duck	1 1/2 lbs
Eglin	75/12	F-4C	SYSTEMS	Sparrow Hawk	.5 lbs
Duluth IAP MN	76/03	RF-4C	ANG	Snow Bunting	.8 oz
Bergstrom	76/05	RF-4C	TAC	Turkey Vulture	4.5 lbs
MacDill	76/05	F-4E	TAC	Cattle Egret	12 oz
Hill	76/05	RF-4C	LOG	Cattle Egret	12 oz
Moody	76/06	F-4E	TAC	Cattle Egret	12 oz
Homestead	76/10	F-4E	TAC	Black Buzzard	1.7 - 2.3 lbs
Homestead	77/02	F-4E	TAC	Black Vulture	4.5 lbs
Duluth IAP MN	77/04	RF-4C	ANG	Duck	1 1/2 lbs
Seymour Johnson	77/07	F-4E	TAC	Turkey Buzzard	1.7 - 2.3 lbs
Homestead	77/09	F-4E	TAC	Cattle Egret	12 oz
Homestead	77/09	F-4E	TAC	Cattle Egret	12 oz
Unknown	78/02	F-4E	TAC	Robin	3 oz
MacDill	78/03	F-4E	TAC	Pelican	10 - 17 lbs
Lincoln MAP NE	78/03	RF-4C	ANG	Pintail Duck	1 1/2 lbs
Birmingham Muni	78/04	RF-4C	ANG	Turkey Buzzard	1.7 - 2.3 lbs
Unknown	78/05	RF-4C	ANG	White Pelican	10 - 17 lbs
Homestead	78/06	F-4E	TAC	Turkey Vulture	4.5 lbs
George	78/06	F-4E	TAC	Sparrow	.8 oz
MacDill	78/08	F-4D	TAC	Pelican	10 - 17 lbs
Unknown	78/09	RF-4C	TAC	Thrush	3 oz
Hill	78/09	F-4D	LOG	Lark	1.25 - 1.5 oz
George	78/10	F-4C	SYSTEMS	Sparrow	.8 oz
Unknown	78/10	F-4E	TAC	C Swift	1.0 oz
Shaw	78/10	RF-4C	TAC	Black Vulture	4.5 lbs
Unknown	78/11	RF-4C	TAC	Robin	3 oz
Unknown	78/12	F-4E	TAC	Turkey Vulture	4.5 lbs

TABLE 8.3 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

F-4 CONUS (Continued)

BASE	STRIKE DATE	A/C	COMMAND	BIRD TYPE	BIRD WEIGHT
MacDill	79/03	F-4D	TAC	Pelican	10 - 17 lbs
Duluth IAP MN	79/04	RF-4C	ANG	Raven	1 lb
Unknown	79/04	F-4C	TAC	Sparrow	.8 oz
Seymour Johnson	79/04	F-4E	TAC	Loon	3 1/2 lbs
Unknown	79/05	F-4D	TAC	Sparrow	.8 oz
Hill	79/05	F-4D	TAC	Warbler	.5 oz
Homestead	79/05	F-4C	TAC	Turkey Buzzard	1.7 - 2.3 lbs
Homestead	79/06	F-4E	TAC	Turkey Buzzard	1.7 - 2.3 lbs
Bergstrom	79/07	RF-4C	TAC	Warbler	.5 oz
Bergstrom	79/08	RF-4C	TAC	Red Shouldered Buzzard Hawk	2.5 lbs
MacDill	79/09	F-4D	TAC	Turkey Vulture	4.5 lbs
Unknown	79/09	F-4G	TAC	Sparrow	.8 oz
Key Field MS	79/10	RF-4C	ANG	Buzzard/Turkey Vulture	4.5 lbs
Unknown	79/11	RF-4C	TAC	Mockingbird	3 oz
Homestead	79/11	F-4E	TAC	Turkey Buzzard	1.7 - 2.3 lbs
Unknown	79/11	F-4E	TAC	Cattle Egret	12 oz
Homestead	79/11	F-4C	AFR	Turkey Buzzard	1.7 - 2.3 lbs
George	79/11	F-4E	TAC	Sparrow	.8 oz
George	79/11	F-4E	TAC	Sparrow	.8 oz
George	79/11	F-4E	TAC	Sparrow	.8 oz
George	79/11	F-4E	TAC	Sparrow	.8 oz
Unknown	79/11	F-4C	TAC	Turkey Buzzard	1.7 - 2.3 lbs
Moody	79/12	F-4	TAC	Turkey Vulture	4.5 lbs
Shaw	80/03	F-4C	TAC	Turkey Vulture	4.5 lbs
Lincoln MAP NE	80/04	F-4C	ANG	Common Grackle	3-4 oz
Fort Smith MAP	80/05	F-4C	TAC	Red Tailed Hawk	2.5 lbs
Standiford Field KY	80/05	RF-4C	ANG	Sandpiper	.125 lbs
Homestead	80/06	F-4D	TAC	Turkey Vulture	4.5 lbs
Moody	80/11	F-4E	TAC	Common Loon	3 1/2 lbs
Dannelly Fld	81/01	RF-4C	ANG	Black Buzzard	1.7 - 2.3 lbs
Dannelly Fld	81/03	RF-4C	TAC	Black Buzzard	1.7 - 2.3 lbs
Lincoln MAP NE	81/04	RF-4C	ANG	Plover	.125 lbs

TABLE 8.3 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

F-4 CONUS (Continued)

BASE	STRIKE DATE	A/C	COMMAND	BIRD TYPE	BIRD WEIGHT
MacDill	81/05	F-4D	TAC	Crow	1 lb
Duluth IAP MN	81/05	RF-4C	ANG	Plover	.125 lbs
MacDill	81/06	F-4D	TAC	Turkey Vulture	4.5 lbs
Seymour Johnson	81/07	F-4E	TAC	Black Vulture	4.5 lbs
Shaw	81/07	RF-4C	TAC	Red Tailed Hawk	2.5 lbs
MacDill	81/07	F-4D	TAC	Turkey Buzzards	1.7 - 2.3 lbs
Duluth IAP MN	81/07	RF-4C	ANG	Red Tailed Hawk	2.5 lbs
Hill	81/08	F-4E	LOG	Sparrow Hawk	.5 lbs
Unknown	81/10	F-4D	ANG	Mallard Duck	2 lbs
Duluth IAP MN	81/10	RF-4C	TAC	Sparrow	.8 oz
Kelly	81/10	F-4C	ANG	Turkey Vulture	4.5 lbs
Patrick	81/11	F-4	SYSTEMS	Turkey Buzzard	1.7 - 2.3 lbs
Homestead	81/12	F-4C	AFR	Turkey Buzzard	1.7 - 2.3 lbs
Shaw	81/12	RF-4C	TAC	Black Vulture	4.5 lbs
Lincoln MAP NE	82/01	RF-4C	ANG	Canadian Goose	8 lbs
Lincoln MAP NE	82/01	RF-4C	ANG	Mallard Duck	2 lbs
Langley	82/02	F-4C	TAC	Common Grackle	3 - 4 oz
Boise (Gowen Fld) ID	82/04	RF-4C	ANG	Whistling Swan	13.6 - 15.8
Duluth IAP MN	82/04	RF-4C	ANG	Mallard Duck	2 lbs
Dannelly Fld	82/04	RF-4C	ANG	Turkey Vulture	4.5 lbs
Luke	82/05	F-4C	TAC	Red Tailed Hawk	2.5 lb
Homestead	82/05	F-4C	AFR	Turkey Buzzard	1.7 - 2.3 lbs
Birmingham Muni AL	82/06	RF-4C	ANG	Anhinga or Water Turkey	2.5 - 3 lbs
George	82/06	F-4D	TAC	Red Tailed Hawk	2.5 lbs
Wright-Patterson	82/07	F-4D	AFR	Broad Winged Hawk	15 oz
Dannelly Fld	82/07	RF-4C	ANG	Cattle Egret	12 oz
Bergstrom	82/08	RF-4C	TAC	Turkey Vulture	4.5 lbs
Patrick	82/08	F-4	SYSTEMS	Sparrow	.8 oz
Boise (Gowen Fld) ID	82/09	RF-4C	ANG	Sparrow	.8 oz
Lincoln MAP NE	82/09	RF-4C	ANG	Franklins Gull	1/2 - 1 lb
Standiford Field KY	82/10	RF-4C	ANG	Red Tailed Hawk	2.5 lbs
Edwards	82/10	F-4	SYSTEMS	Sparrow	.8 oz

TABLE 8.3 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

F-4 CONUS (Continued)

BASE	STRIKE DATE	A/C	COMMAND	BIRD TYPE	BIRD WEIGHT
Shaw	82/10	RF-4C	TAC	Sparrow	.8 oz
Birmingham Muni AL	82/11	RF-4C	ANG	American Coot	1 lb
George	82/11	F-4G	TAC	Osprey	3.5 lbs
Moody	82/08	F-4E	TAC	Cattle Egret	12 oz
Moody	82/08	F-4E	TAC	Cattle Egret	12 oz
Moody	82/12	F-4E	TAC	Robin	3 oz
George	82/09	F-4G	TAC	Owl	2 - 4 lbs
McConnell	82/07	F-4	SAC	Killdeer	3 oz
MacDill	83/01	F-4D	TAC	Black Vulture	4.5 lbs
Burlington IAP	83/01	F-4D	ANG	American Kestrel	4 oz
Seymour Johnson	83/02	F-4E	TAC	Raven	2 - 3 lbs

DATA FROM BASH TEAM, TYNDALL AFB, COMPUTER FILES

TABLE 8.3 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

F-4 EUROPE

BASE	STRIKE DATE	A/C	COMMAND	BIRD TYPE	BIRD WEIGHT
Camp New Amsterdam	75/07	F-4E	AFE	Lapwing	8 oz
Torrejon	75/07	F-4C	AFE	Lesser Bustard	1.53 - 2.15 lbs
Camp New Amsterdam	76/07	F-4E	AFE	Magpie	7.4 oz
Torrejon	77/06	F-4C	AFE	Stork	7 lbs
Unknown	78/02	F-4E	AFE	Killdeer	3 oz
Incirlik	79/05	F-4E	AFE	Stork	7 lbs
Torrejon	79/06	F-4D	AFE	Lark	1.25 - 1.5 oz
Unknown	79/06	RF-4C	AFE	Swift	1 oz
Torrejon	79/07	F-4D	AFE	Lesser Bustard	1.53 - 2.15 lbs
Alconbury	79/11	RF-4C	AFE	Crow	8 oz
Unknown	79/12	RF-4C	AFE	Crow	8 oz
Unknown	80/01	F-4D	AFE	Sparrow	.8 oz
Torrejon	80/03	F-4D	AFE	Sparrow	.8 oz
Torrejon	80/03	F-4D	AFE	Sparrow	.8 oz
Torrejon	80/06	F-4D	AFE	Sparrow	.8 oz
Ramstein	80/08	F-4E	AFE	Swift	1 oz
Incirlik	80/09	F-4E	AFE	Sparrow	.8 oz
Incirlik	80/09	F-4E	AFE	Swallow	.5 oz
Incirlik	80/09	F-4D	AFE	Swallow	.5 oz
Incirlik	81/02	F-4D	AFE	Sparrow	.8 oz
Alconbury	81/02	RF-4C	AFE	Crow	8 oz
Zaragoza	81/03	F-4	AFE	Lapwing	8 oz
Incirlik	81/03	F-4G	AFE	Stork	7 lbs
Incirlik	81/03	F-4G	AFE	Woodlark	1.25 - 1.5 oz
Incirlik	81/04	RF-4C	AFE	Lapwing	1.2 lb
Zaragoza	81/05	F-4	AFE	Magpie	7.4 oz
Incirlik	81/05	F-4D	AFE	Alpine Swift	3 oz
Ramstein	81/05	F-4G	AFE	Swift	1 oz
Ramstein	81/06	F-4E	AFE	Sparrow	.8 oz
Zweibrucken	81/06	RF-4C	AFE	Sparrow	.8 oz
Incirlik	81/06	F-4D	AFE	Calandra Lark	1.25 - 1.5 oz
Incirlik	81/06	F-4D	AFE	Common Swift	1 oz

TABLE 8.4 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

F-4 EUROPE (Continued)

BASE	STRIKE DATE	A/C	COMMAND	BIRD TYPE	BIRD WEIGHT
Incirlik	81/06	F-4D	AFE	Common Swift	1 oz
Incirlik	81/07	F-4E	AFE	Calandra Lark	1.25 - 1.5 oz
Hahn	81/07	F-4E	AFE	Common Buzzard	1.75 lbs
Incirlik	81/08	F-4E	AFE	White Stork	7 lbs
Incirlik	81/08	F-4E	AFE	Rock Dove	10 oz
Incirlik	81/08	F-4E	AFE	White Stork	7 lbs
Incirlik	81/08	F-4E	AFE	White Stork	7 lbs
Incirlik	81/09	F-4E	AFE	White Stork	7 lbs
Torrejon	81/10	F-4D	AFE	Rock Dove	10 oz
Zaragoza	82/02	F-4	AFE	Sparrow	.8 oz
Incirlik	82/04	F-4D	AFE	Chough	10 oz
Zaragoza	82/05	F-4E	AFE	Griffon Vulture	12 lbs
Spangdahlem	82/05	F-4G	AFE	Common Buzzard	1.75 lbs
Incirlik	82/05	F-4D	AFE	Swift	1.3 oz
Spangdahlem	82/05	F-4E	AFE	Sparrow Hawk	8 oz
Torrejon	82/05	F-4D	AFE	Sparrow	.8 oz
Torrejon	82/10	F-4D	AFE	Wood Pigeon	17.5 oz
Torrejon	82/11	F-4D	AFE	Sparrow	.8 oz
Unknown	83/01	F-4	AFE	Pigeon	10.5 oz

DATA FROM BASH TEAM, TYNDALL AFB, COMPUTER FILES

TABLE 8.4 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

F-111 CONUS

BASE	STRIKE DATE	A/C	COMMAND	BIRD TYPE	BIRD WEIGHT
Nellis	75/04	F-111A	TAC	Swallow	.5 oz
Mt. Home	76/01	F-111F	TAC	Townsend's Warbler	.5 oz
Mt. Home	78/08	F-111A	TAC	Owl	2 - 4 lbs
Unknown	78/10	F-111D	TAC	Cokoo	12 - 16 oz
Cannon	78/10	F-111D	TAC	Lark	1.25 - 1.5 oz
Mt. Home	78/10	F-111A	TAC	Wren	.3 oz
Cannon	78/11	F-111D	TAC	Lark	1.25 - 1.5 oz
Unknown	79/07	F-111D	TAC	Owl	2-4 lbs
Cannon	79/10	F-111	TAC	Cooper's Hawk	2.5 lbs
Unknown	79/11	F-111A	TAC	Red Winged Blackbird	3.3 oz
Mt. Home	81/12	F-111A	TAC	Rock Dove	10 oz
Mt. Home	82/04	EF-111A	TAC	Golden Eagle	9.5 lbs
Mt. Home	82/08	F-111A	TAC	Golden Eagle	9.5 lbs
Mt. Home	82/10	F-111A	TAC	Horned Lark	1.25 - 1.5 oz

DATA FROM BASH TEAM, TYNDALL AFB, COMPUTER FILES

TABLE 3.5 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

F-111 EUROPE

BASE	STRIKE DATE	A/C	COMMAND	BIRD TYPE	BIRD WEIGHT
Upper Heyford RAF	76/04	F-111E	AFE	Seagull	8 oz
Lakenheath RAF	78/09	F-111F	AFE	Pobin	3 oz
Lakenheath RAF	79/07	F-111F	AFE	Blackhead Seagull	8 oz
Lakenheath RAF	80/07	F-111F	AFE	Herring Gull	2 1/2 lb
Lakenheath RAF	80/10	F-111F	AFE	Lapwing	8 oz
Incirlik	80/12	F-111E	AFE	Rock Dove	10 oz
Incirlik	81/01	F-111F	AFE	Hood Crow	8 oz
Incirlik	81/01	F-111F	AFE	Rock Dove	10 oz
Incirlik	81/02	F-111F	AFE	Chough	9.5 - 13 oz
Upper Heyford RAF	81/10	F-111	AFE	Turkey Buzzard	2.5 lbs
Lakenheath RAF	82/06	F-111F	AFE	Seagull	8 oz
Upper Heyford RAF	82/10	F-111E	AFE	Lapwing	8 oz
Incirlik	82/10	F-111E	AFE	Shorelark	1.25 - 1.5 oz
Lakenheath RAF	82/10	F-111F	AFE	Turkey Buzzard	2.5 lbs
Lakenheath RAF	82/10	F-111F	AFE	Turkey Buzzard	2.5 lbs
Upper Heyford RAF	82/09	F-111E	AFE	Raven	8 oz

DATA FROM BASH TEAM, TYNDALL AFB, COMPUTER FILES

TABLE 8.6 LIST OF IDENTIFIED BIRDS INVOLVED IN BIRD STRIKE

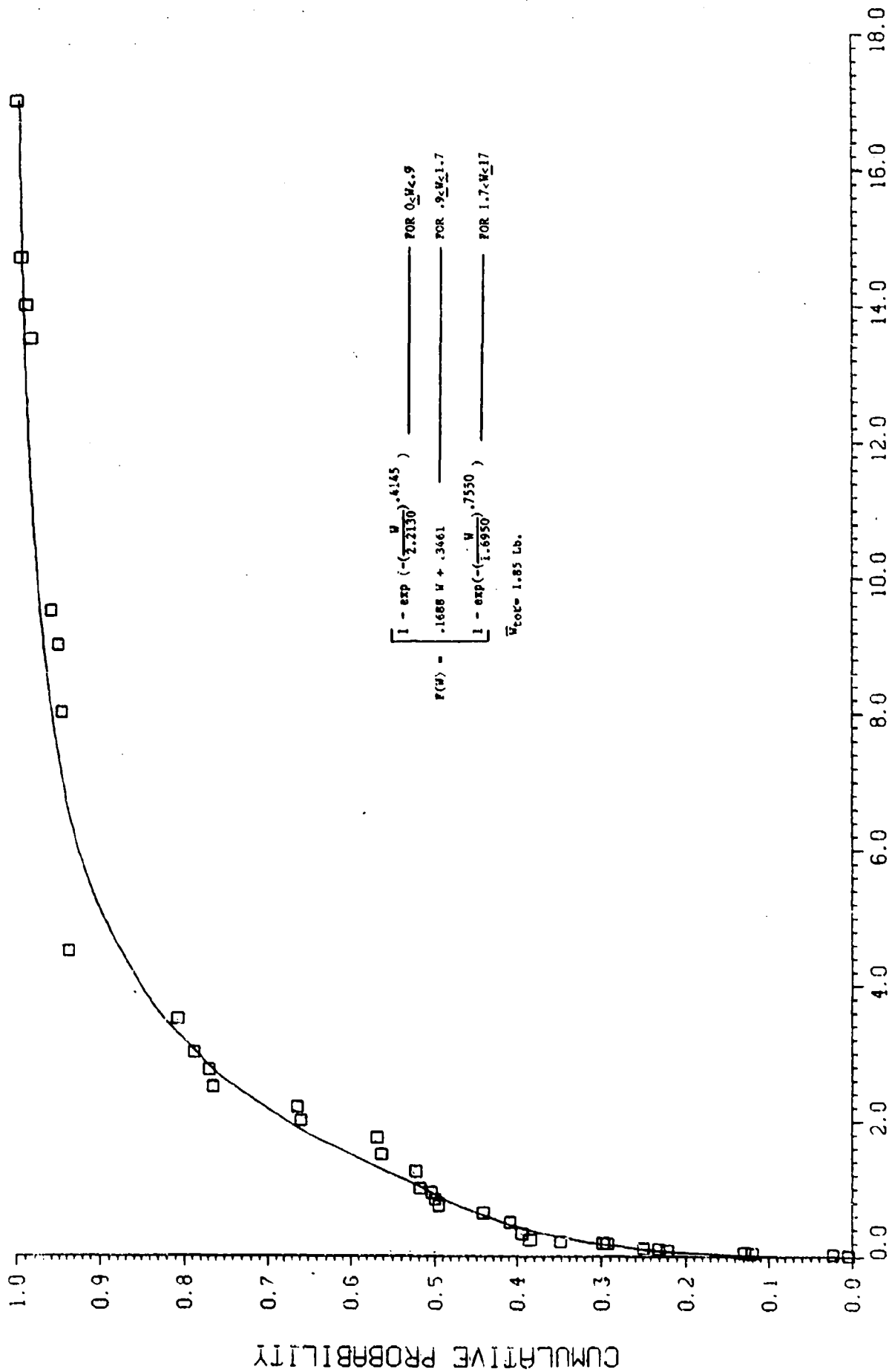


FIG. 6 CONUS BIRD WEIGHT DISTRIBUTION
 BIRD WEIGHT DATA FROM BASH TEAM COMPUTER FILES

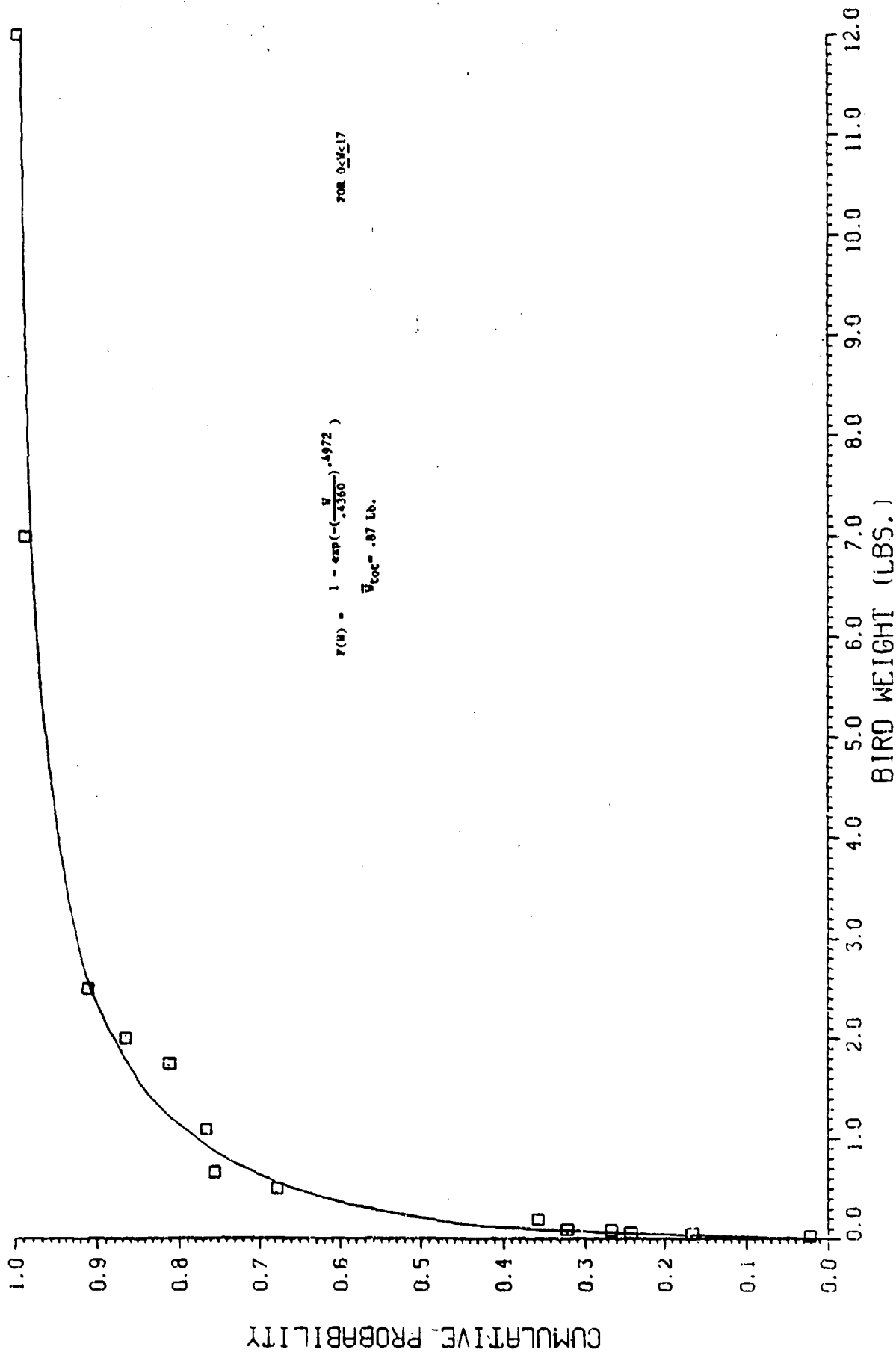


FIG. 7 EUROPE BIRD WEIGHT DISTRIBUTION
 BIRD WEIGHT DATA FROM BASH TEAM COMPUTER FILES

COMPONENT STRENGTH DISTRIBUTIONS

The canopy and windshield strength distributions are the percent area of the component which would be damaged, expressed as a function of impact kinetic energy. Since the majority of USAF bird impact testing is done with an equivalent of a 4 lb bird, the strength distributions have been derived based on the kinetic energy developed by this bird weight.

For example:

$$K.E. = 1/2 mV^2 \quad (14)$$

so, for the impact by a 4 lb bird at 410 Knots:

$$m = \frac{4}{32.2} = .1242 \frac{\text{LBS}}{\text{FT/SEC}^2}$$

$$410 \text{ Knots} \times 1.688 = 692.0800 \text{ ft/sec}$$

$$K.E. = 1/2 (.1242) (692.0800)^2$$

$$K.E. = 29,744.3305 \text{ FT-LBS}$$

Based on Figure 16 for the above kinetic energy, 100% of the present F-15 windshield is critical, meaning that a penetration would occur anywhere on the windshield by a 4 lb bird. At a velocity of 330 knots, an impact by a 4 lb bird (KE = 19,269.23 FT-LBS) makes the windshield 44% critical (44% chance of penetration occurring). Figure 8 shows the F-15 single and two seat model aircraft windshield and canopy profiles. Figures 9 and 10 define the present component capability in terms of penetration/no penetration.

The present capability for the windshield and canopy was obtained from past F-15 bird impact tests (McDonnell Douglas Report, MDC A4888). Since two bird impact points tested were not the most critical locations on the windshield, T-38 data was used to develop the present capability as shown in figures 9 and 10. The T-38 data was extracted from AFWAL report #TR-80-3132, PART I, and it was used since the T-38 had an exhaustive bird impact test program, as well as the T-38 windshield is geometrically similar and made out of the same material (monolithic stretched acrylic) as the F-15 windshield. Percentage of area was determined by using the T-38 percentage distribution (F-15 capability). Figure 15 shows the T-38 penetration values by a 4 lb bird as obtained from the bird impact test program. Using similar ratios, the F-15 capability was obtained and is summarized in Figures 9 and 10.

Example calculation:

From F-15 birdstrike test on windshield, no penetration occurred at 393 kts (severe cracking); at 431 kts, penetration occurred (center impact).

Therefore, $431 - 393 = 38$ KTS

$$\frac{38}{2} = 19$$

$$393 + 19 = 412 \approx 410 \text{ KTS}$$

410 kts represents the predicted penetration value since severe cracking occurred at 393 KTS.

≈ 390 KTS represents no penetration by a 4 lb bird

≈ 410 KTS represents penetration by 4 lb bird

* Δ of 20 KTS from severe cracking to penetration.

Further, additional areas were assessed as follows:

From Fig. 15

$$320 - 210 = 110 \text{ KTS } (\Delta)$$

$$320 - 230 = 90 \text{ KTS } (\Delta).$$

For F-15 same areas,

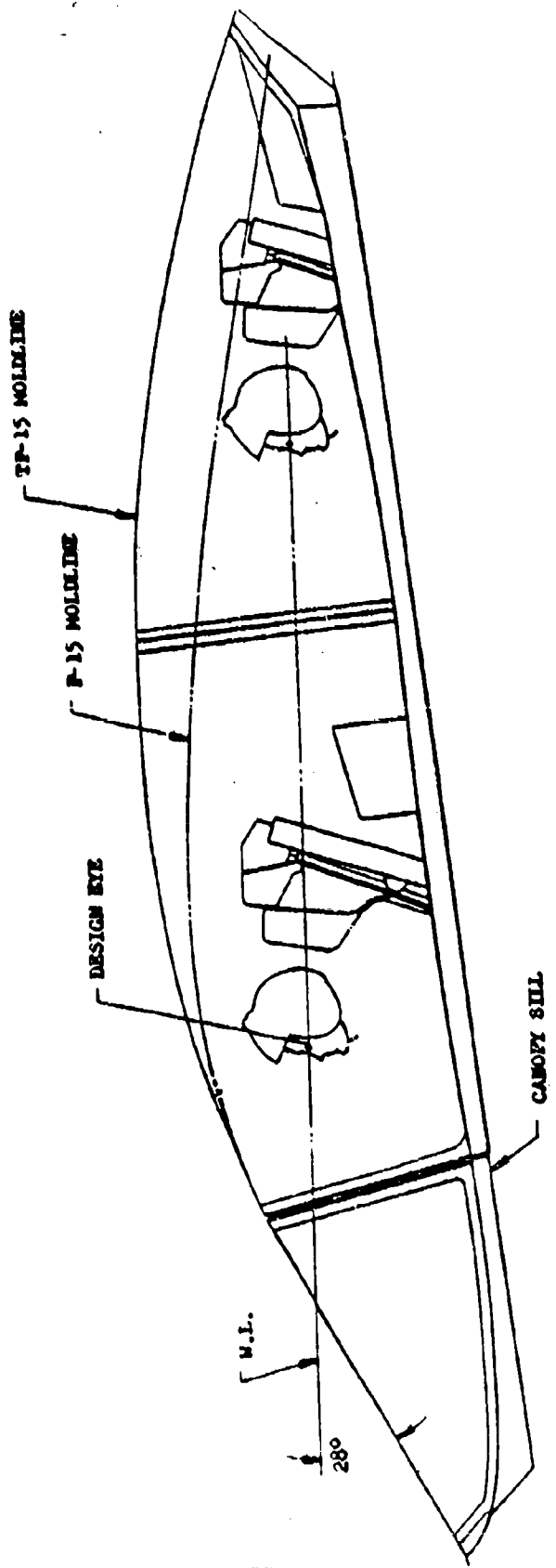
$$410 - 110 = 300 \text{ KTS}$$

$$410 - 90 = 320 \text{ KTS.}$$

Results summarized in figure 10.

For the F-15 canopy only one point was tested, near the canopy arch. At 160 KTS, no penetration occurred, and at 182 KTS, penetration did occur. The transition zone was estimated from 180 to 450 using T-38 percentage areas from Reference 2. The T-38 canopy value of 125 KTS was represented for the F-15 by a range from 180 - 450 KTS, since the F-15 canopy is thicker than the T-38 and it was not felt that decreasing capability exists for the F-15 as it does for the T-38. The zone for the T-38 that is represented by 125 KTS could have easily been a bad shot. Therefore, the F-15 transition zones were estimated as shown in Figure 16. The plotted values were bird penetration values from Figure 10. Similar methods were used to extrapolate increased windshield and canopy capabilities, and these are summarized in Figures 11 - 14. Increased capability component strength distributions are summarized in Figures 17 and 18.

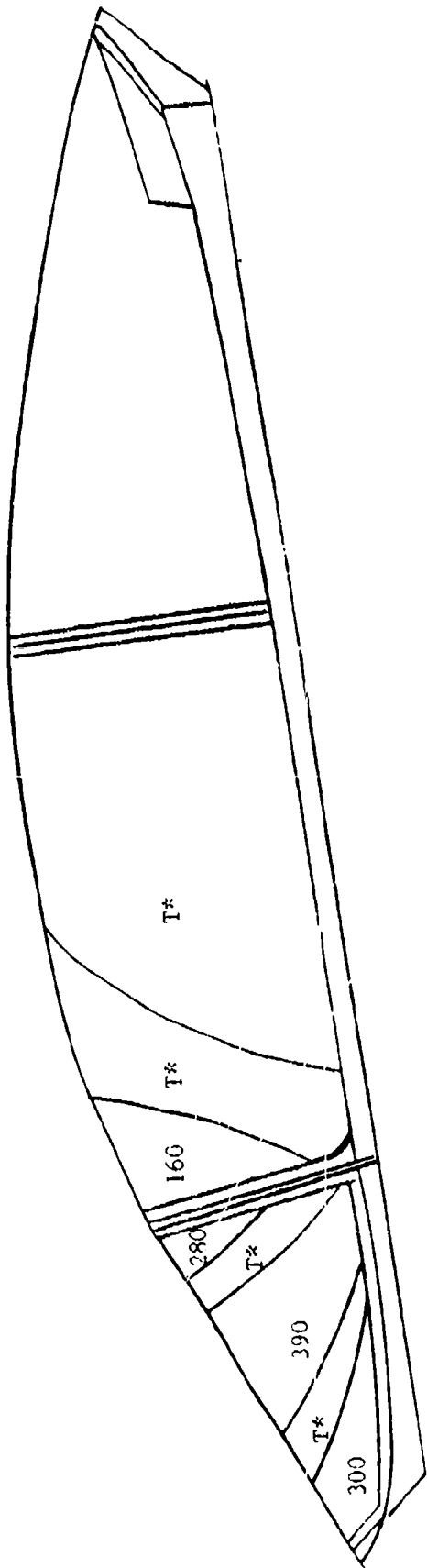
The above approach was recommended by Mr Blaine West from University of Dayton Research Institute, since it was representative of realistic component capability. The above component strength capabilities were estimated using the above estimation process.



F = SINGLE SEAT F-15

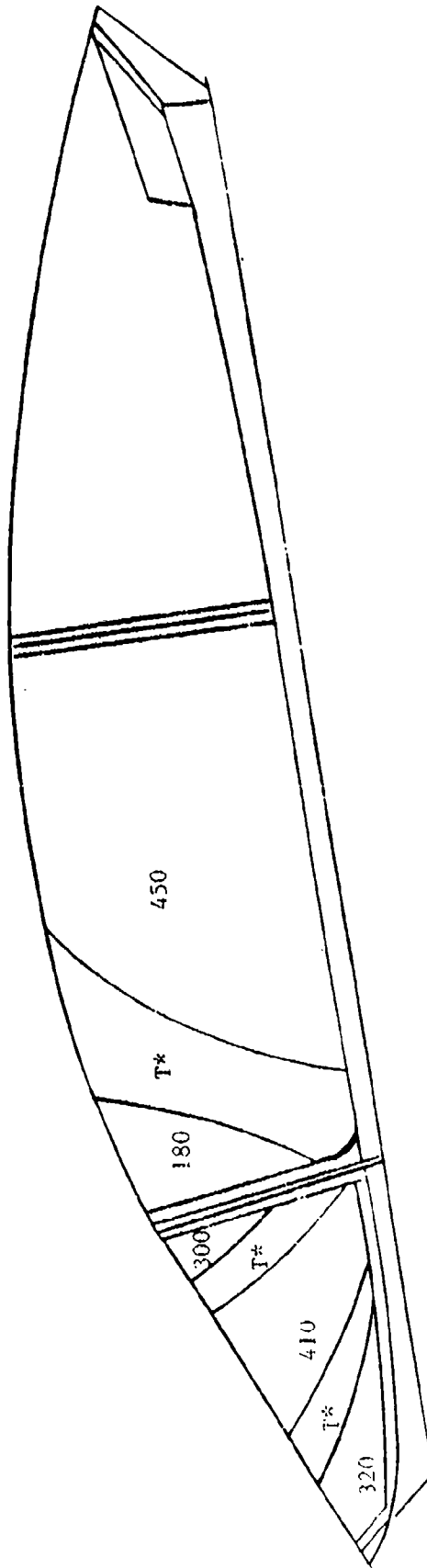
TF = 2 SEAT F-15

FIGURE 8 PROFILE OF F-15F AND TF WINDSHIELD AND CANOPY



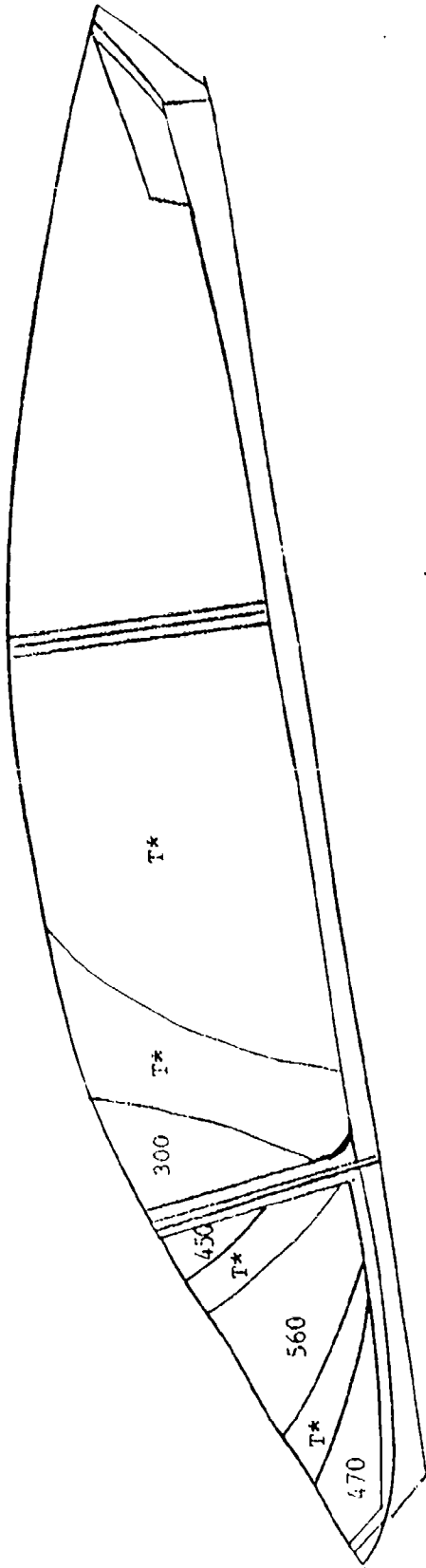
*TRANSITION ZONE
IMPACT VELOCITY KNOTS

FIGURE 9 EXISTING F-15 TRANSPARENCY CAPABILITY
(NO PENETRATION BY A 4 LB BIRD)



*TRANSITION ZONE
IMPACT VELOCITY KNOTS

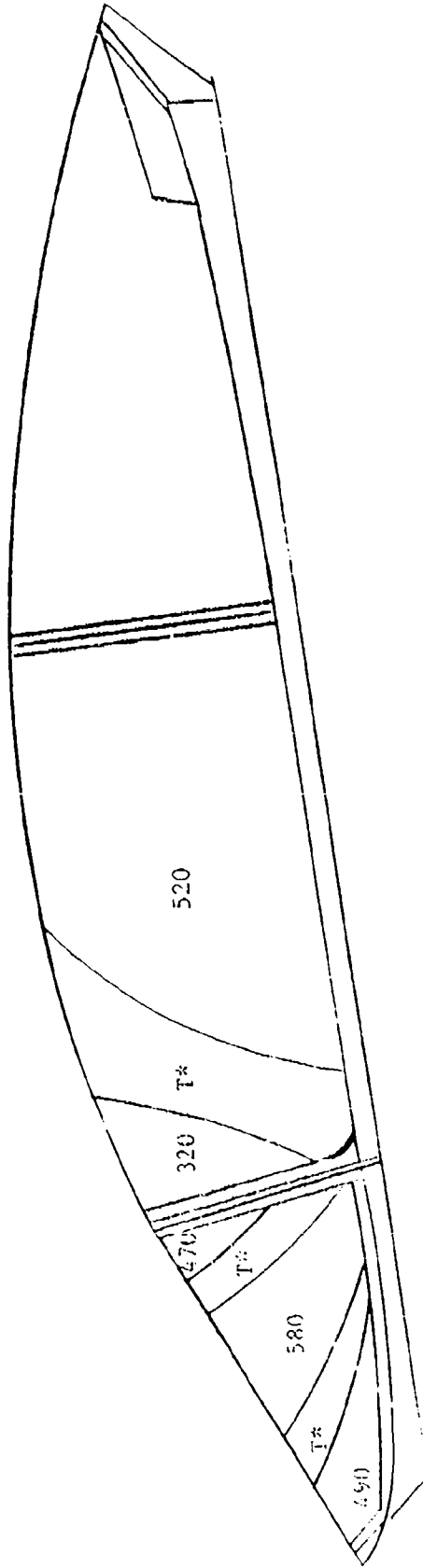
FIGURE 10 EXISTING F-15 TRANSPARENCY PENETRATION VALUES BY A 4 LB BIRD



*TRANSITION ZONE
IMPACT VELOCITY KNOTS

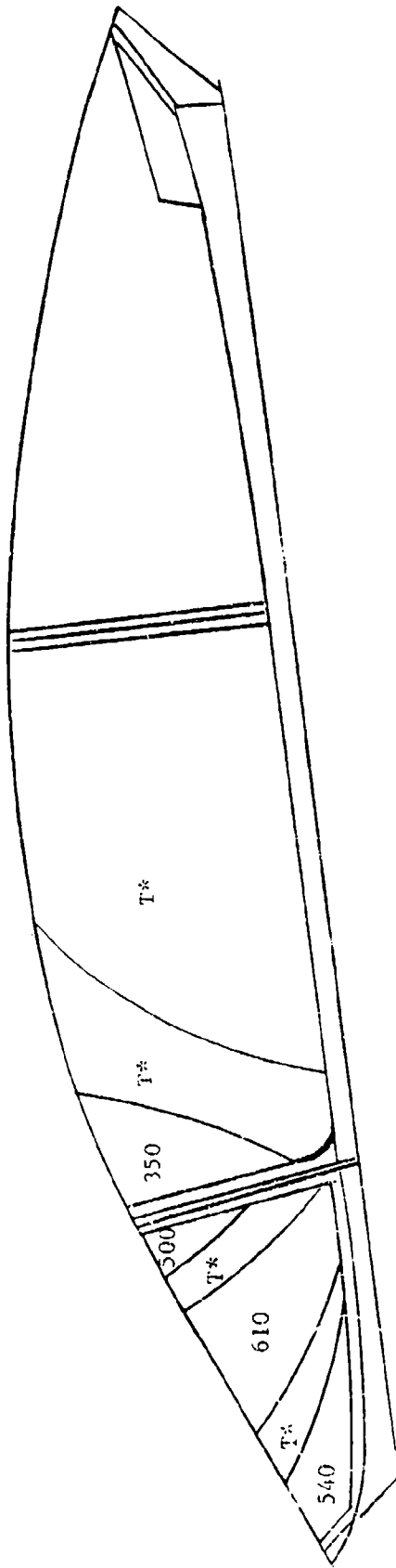
FIGURE 11. 450 KT WINDSHIELD/300 KT CANOPY CAPABILITY

(NO PENETRATION BY A 4 LB BIRD)



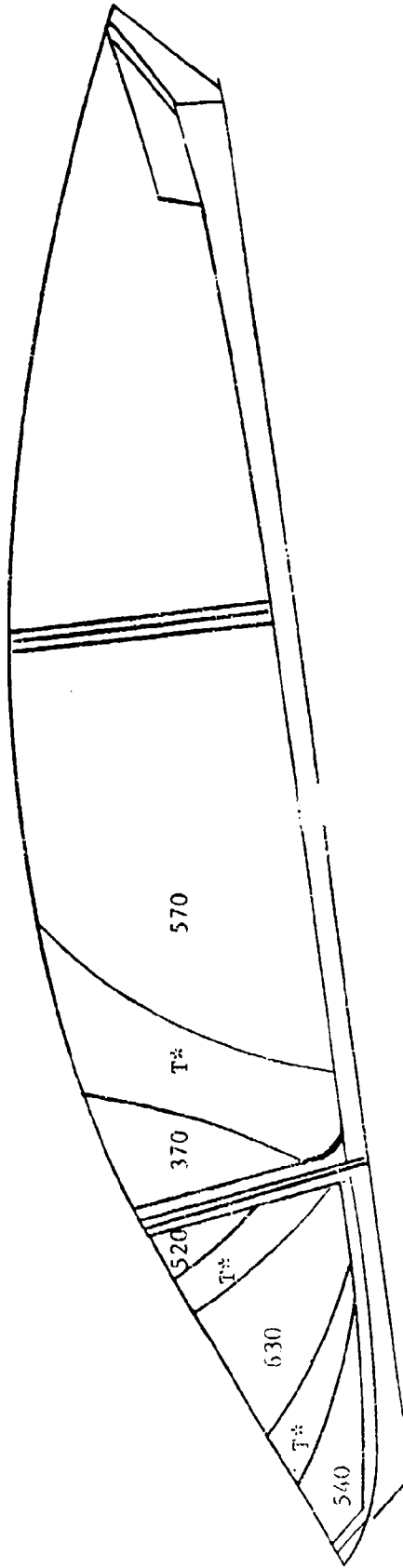
*TRANSITION ZONE
IMPACT VELOCITY KNOTS

FIGURE 12. 450 KT WINDSHIELD/300 KT CANOPY CAPABILITY PENETRATION VALUES BY A 4 LB BIRD



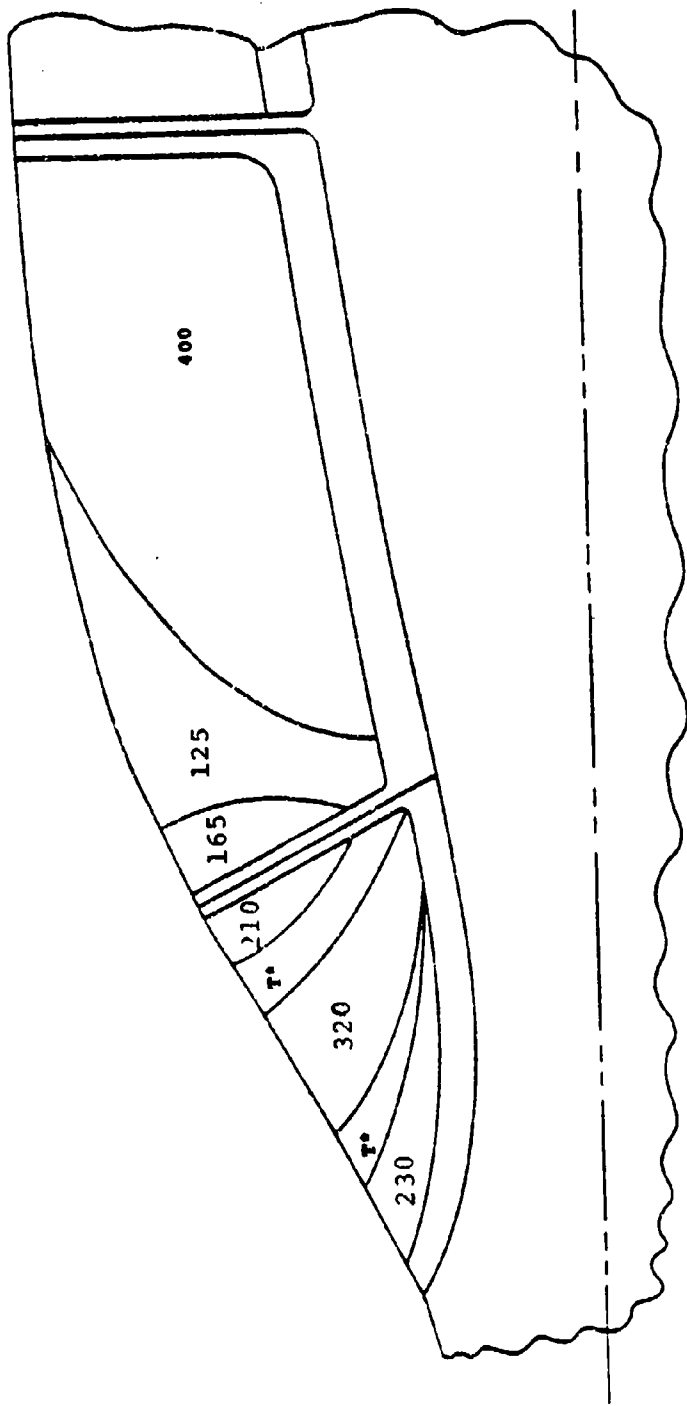
*TRANSITION ZONE
IMPACT VELOCITY KNOTS

FIGURE 13 500 KT WINDSHIELD/350 KT CANOPY CAPABILITY
(NO PENETRATION BY A 4 LB BIRD)



*TRANSITION ZONE
IMPACT VELOCITY KNOTS

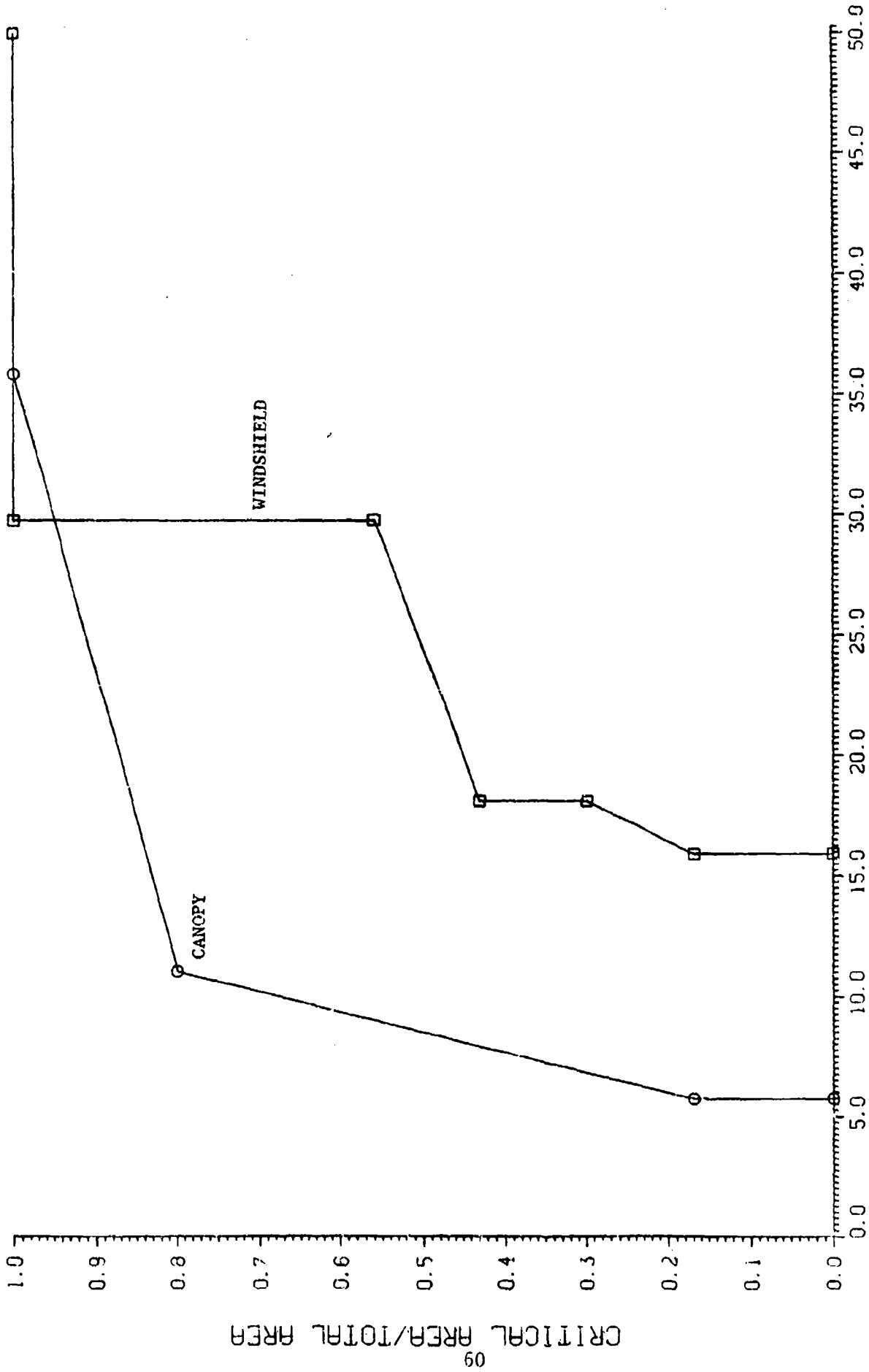
FIGURE 14 500 KT WINDSHIELD/350 KT CANOPY CAPABILITY PENETRATION VALUES BY A 4 LB BIRD



* Transition Zone
Impact Velocity in Knots

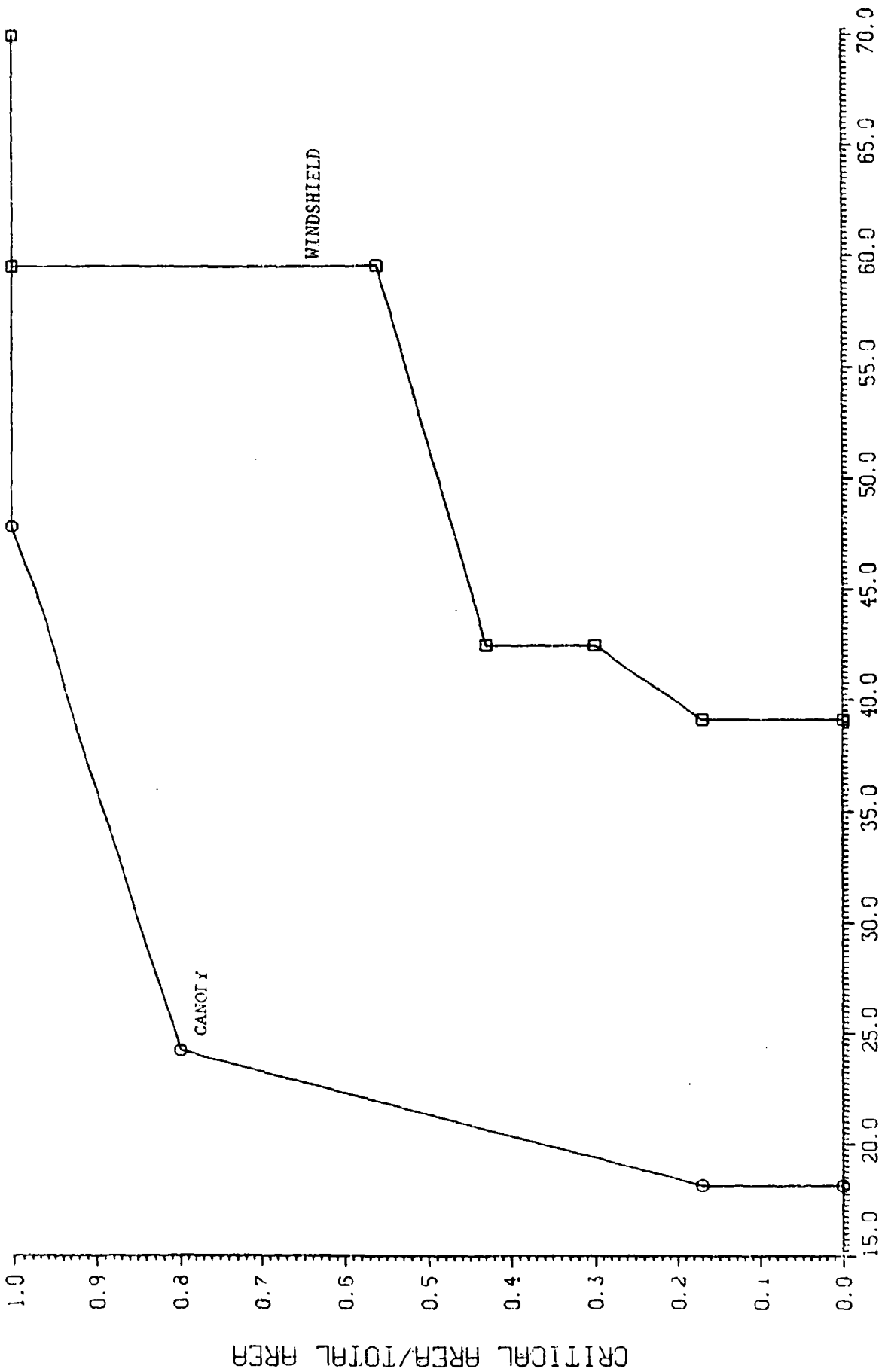
FROM AFVAL REPORT #TR-80-3132, PART I

FIGURE 15 EXISTING T-38 TRANSPARENCY PENETRATION VALUES BY A 4 LB BIRD



KINETIC ENERGY (X 1000 FT.-LBS.)

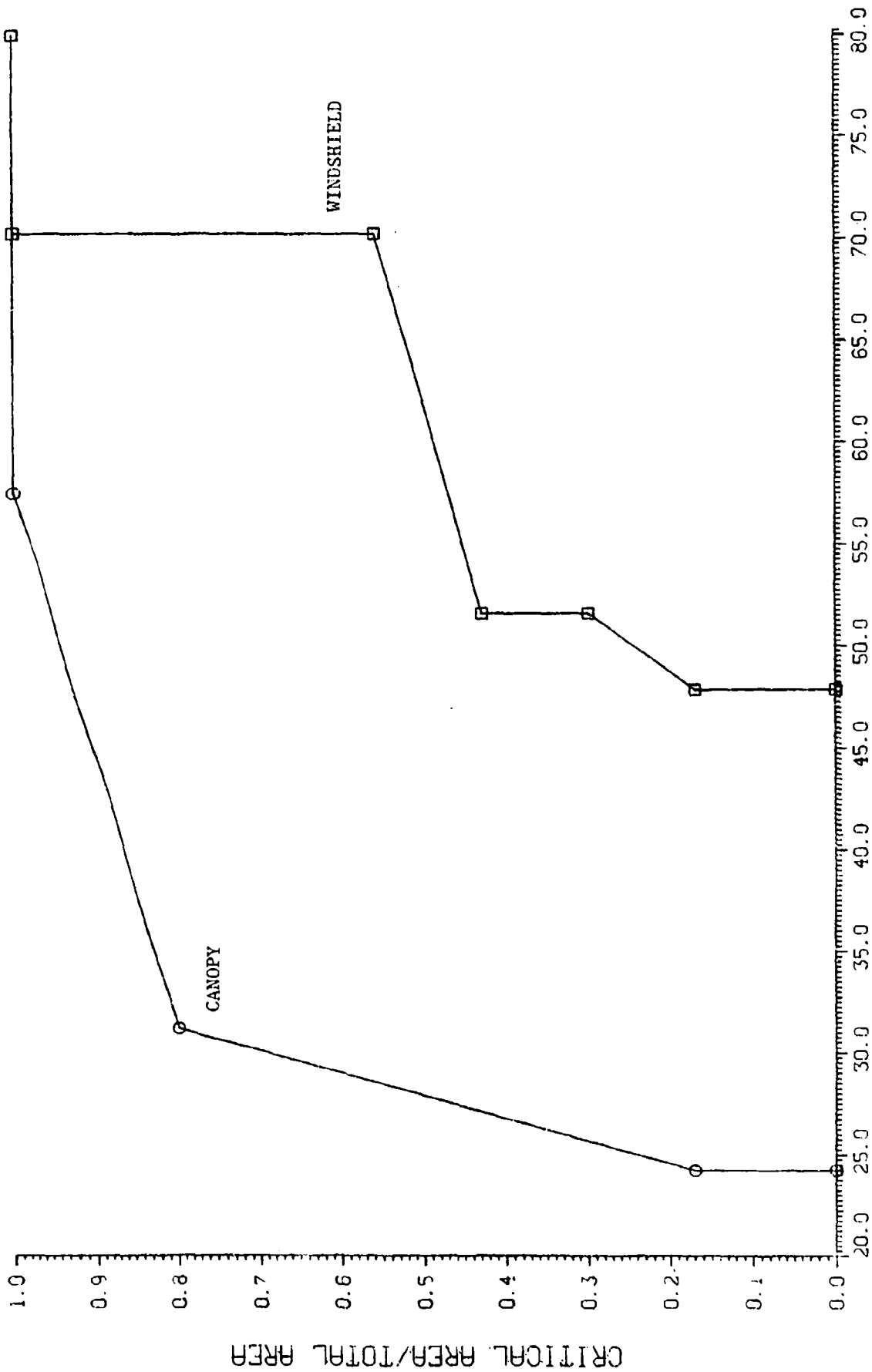
FIG. 16 CRITICAL AREA DISTRIBUTION
F-15 PRESENT WINDSHIELD AND CANOPY CAPABILITY



KINETIC ENERGY (X 1000 FT. -LBS.)

FIG. 17 CRITICAL AREA DISTRIBUTION

INCREASED CAPABILITY, 450 KI. WINDSHIELD AND 300 KI. CANOPY



KINETIC ENERGY (X 1000 FT.-LBS.)

FIG. 18 CRITICAL AREA DISTRIBUTION INCREASED CAPABILITY, 500 KT. WINDSHIELD AND 350 KT. CANOPY

MODEL APPLICATION

Since all inputs have been already derived, the number of penetrations on a specific component, windshield or canopy, can be obtained by the product of:

$$\#PENETRATIONS = OIR \times FORCE \text{ USAGE} \times \Delta P(V) \times \Delta P(W) \times CRITICAL \text{ AREA}$$

$$OIR = OPERATIONAL \text{ IMPACT RATE PER } 10^6 \text{ HRS} \quad (15)$$

FORCE USAGE = TOTAL Flight Hours for specific mission air-to-air or air-to-ground

$\Delta P(V)$ = aircraft velocity probability

$\Delta P(W)$ = bird weight probability

Critical area = Windshield or canopy area capability

$\Delta P(V)$ and $\Delta P(W)$ values are obtained by evaluating the respective cumulative probability distribution function for a desired range (Table 9.0 - 9.6). The critical area values are obtained first by developing a kinetic energy matrix (Table 10.0).

Eqn 14 is used to determine each element of the matrix.

Example:

For velocity range 310 - 360 → Nominal 335 KTS and bird weight

4 - 5 → Nominal 4.5 LBS

$$KE = 1/2 m v^2$$

$$KE = 22,344 \text{ Ft Lbs}$$

For velocity range 160 - 210 → Nominal 185 KTS and bird weight

1 - 2 → Nominal 1.5 Lbs

$$KE = 2271 \text{ Ft Lbs}$$

From Table 10.0 for each kinetic energy value (each element), figures 16 - 18 are used to obtain proportion of component critical area. Table 10.1 and 10.2 lists the results in the 12 by 15 matrix, for the present capability windshield and canopy. The use of eqn 15 obtains the number of penetrations that exceed the kinetic energy of the specific subsystem. A summation is then taken of all incremental bird penetration values from the 12 by 15 matrix, and a total number of penetrations for a specific usage profile is obtained.

AIR/AIR + INST/NAV + All Missions Flown (except AIR TO GROUND)

CONUS & EUROPE

CUM. PROB	VELOCITY (KTS)	VELOCITY (KTS)	AP(V)
.0001	116	110 - 160	.0948
.0949	160	160 - 210	.1501
.2450	210	210 - 260	.1950
.4400	260	260 - 310	.2040
.6440	310	310 - 360	.1660
.8100	360	360 - 410	.1080
.9180	410	410 - 460	.0540
.9720	460	460 - 510	.0210
.9930	510	510 - 560	.0060
.9990	560	560 - 610	.0010
1.0000	610	610 - 660	0
1.0000	660	660 - 710	0
1.0000	710		

$$F(v) = \begin{cases} \left[\begin{aligned} &-5.793168 + 2.49687 \times 10^{-1} v - 4.296046 \times 10^{-3} v^2 \\ &+ 3.774985 \times 10^{-5} v^3 - 1.792476 \times 10^{-7} v^4 \\ &+ 4.396387 \times 10^{-10} v^5 - 4.371569 \times 10^{-13} v^6 \end{aligned} \right] & \text{FOR } 116 \leq v \leq 200 \\ 1 - \exp\left(-\left(\frac{v-40}{307-40}\right)^{2.81}\right) & \text{FOR } 200 < v \leq 720 \end{cases}$$

$$\bar{v}_{tot} = 279.24 \text{ Knots}$$

TABLE 9.0 F-15 PRESENT FLEET

AIR TO GROUND MISSION

CONUS & EUROPE

CUM PROB	VELOCITY (KTS)	VELOCITY (KTS)	AP(V)
.0002	110	110 - 160	.0217
.0219	160	160 - 210	.0257
.0476	210	210 - 260	.0111
.0587	260	260 - 310	.0102
.0689	310	310 - 360	.0626
.1315	360	360 - 410	.1905
.3220	410	410 - 460	.3040
.6260	460	460 - 510	.2540
.8880	510	510 - 560	.1000
.9880	560	560 - 610	.0120
1.0000	610		

$$F(V) = \begin{cases} -4.276016 \times 10^{-2} + 2.515055 \times 10^{-3} V - 5.176007 \times 10^{-5} V^2 & \text{FOR } 110 \leq V \leq 380 \\ +4.649071 \times 10^{-7} V^3 - 1.908740 \times 10^{-9} V^4 & \\ +3.569492 \times 10^{-12} V^5 - 2.406103 \times 10^{-15} V^6 & \\ 1 - \exp\left(-\frac{V - 110}{461 - 110}\right)^{6.01} & \text{FOR } 380 < V < 610 \end{cases}$$

$$\bar{V}_{\text{tot}} = 427.90 \text{ Knots}$$

TABLE 9.1 F-15 RAPID DEPLOYMENT FORCE

AIR TO AIR + INST/NAV + All Missions Flown (except AIR TO GROUND)

CONUS & EUROPE

CUM PROB	VELOCITY (KTS)	VELOCITY (KTS)	A P(V)
.0001	116	110 - 160	.0948
.0949	160	160 - 210	.1501
.2450	210	210 - 260	.1950
.4400	260	260 - 310	.2040
.6440	310	310 - 360	.1660
.8100	360	360 - 410	.1080
.9180	410	410 - 460	.0540
.9720	460	460 - 510	.0210
.9930	510	510 - 560	.0060
.9990	560	560 - 610	.0010
1.0000	610	610 - 660	.0000
1.0000	660	660 - 710	.0000
1.0000	710		

$$F(V) = \left[\begin{array}{l} -5.793168 + 2.49687 \times 10^{-1} v - 4.296046 \times 10^{-3} v^2 \\ + 3.774985 \times 10^{-5} v^3 - 1.792476 \times 10^{-7} v^4 \\ + 4.396387 \times 10^{-10} v^5 - 4.371569 \times 10^{-13} v^6 \end{array} \right] \text{--- FOR } 116 \leq v < 200$$

$$1 - \exp\left(-\left(\frac{v-40}{307-40}\right)^{2.81}\right) \text{--- FOR } 200 \leq v < 720$$

$$\bar{V}_{tot} = 279.24 \text{ Knots}$$

TABLE 9.2 F-15 RAPID DEPLOYMENT FORCE

AIR TO AIR + INST/NAV + All Missions Flown (except AIR TO GROUND)

CONUS & EUROPE

CUM PROB	VELOCITY (KTS)	VELOCITY (KFS)	AP(V)
.0001	116	110 - 160	.0948
.0949	160	160 - 210	.1501
.2450	210	210 - 260	.1950
.4400	260	260 - 310	.2040
.6440	310	310 - 360	.1660
.8100	360	360 - 410	.1080
.9180	410	410 - 460	.0540
.9720	460	460 - 510	.0210
.9930	510	510 - 560	.0060
.9990	560	560 - 610	.0010
1.0000	610	610 - 660	.0000
1.0000	660	660 - 710	.0000
1.0000	710		

$$F(V) = \begin{cases} -5.793168 + 2.49687 \times 10^{-1} v - 4.296046 \times 10^{-3} v^2 \\ + 3.774985 \times 10^{-5} v^3 - 1.792476 \times 10^{-7} v^4 \\ + 4.396387 \times 10^{-10} v^5 - 4.371569 \times 10^{-13} v^6 \end{cases} \text{ FOR } 116 \leq v < 200$$

$$1 - \exp\left(-\left(\frac{v-40}{307-40}\right)^{2.81}\right) \text{ FOR } 200 < v < 720$$

$$\bar{V}_{tot} = 279.24 \text{ Knots}$$

TABLE 9.3 F-15 DUAL ROLE FIGHTER

AIR TO GROUND MISSION

CONUS & EUROPE

CUM PROB	VELOCITY (KTS)	VELOCITY (KTS)	ΔP(V)
.0032	110	110 - 160	.0431
.0463	160	160 - 210	.0159
.0522	210	210 - 260	.0153
.0775	260	260 - 310	.0195
.0970	310	310 - 360	.0125
.1095	360	360 - 410	.0375
.1470	410	410 - 460	.2470
.3940	460	460 - 410	.4390
.8330	510	510 - 560	.1630
.9960	560	560 - 610	.0040
1.0000	610		

$$F(V) = \begin{cases} \left[\begin{aligned} &+8.284557 \times 10^{-5} - 5.55111 \times 10^{-3} V + 1.172276 \times 10^{-4} V^2 \\ &- 9.165418 \times 10^{-7} V^3 + 3.493164 \times 10^{-9} V^4 \\ &- 6.493033 \times 10^{-12} V^5 + 4.716360 \times 10^{-15} V^6 \end{aligned} \right] & \text{FOR } 110 < V < 440 \\ 1 - \exp\left(-\left(\frac{V - 110}{486.3 - 110}\right)^{9.5321}\right) & \text{FOR } 440 < V < 620 \end{cases}$$

$$\bar{V}_{tot} = 445.91 \text{ Knots}$$

TABLE 9.4 F-15 DUAL ROLE FIGHTER

CONUS

WEIGHT (LBS)	$\Delta P(W)$	CUM. PROB	WEIGHT (LBS)
0 - 1	.5149	0	0
1 - 2	.1631	.5149	1
2 - 3	.1074	.6780	2
3 - 4	.0668	.7854	3
4 - 5	.0438	.8522	4
5 - 6	.0295	.8960	5
6 - 7	.0204	.9255	6
7 - 8	.0144	.9459	7
8 - 9	.0103	.9603	8
9 - 10	.0075	.9706	9
10 - 11	.0054	.9781	10
11 - 12	.0040	.9835	11
12 - 13	.0030	.9875	12
13 - 14	.0022	.9905	13
14 - 15	.0017	.9927	14
		.9944	15

$$F(W) = \begin{cases} 1 - \exp\left(-\left(\frac{W}{2.2130}\right)^{.4145}\right) & \text{FOR } 0 \leq W < .9 \\ .1688 W + .3461 & \text{FOR } .9 \leq W < 1.7 \\ 1 - \exp\left(-\left(\frac{W}{1.6950}\right)^{.7550}\right) & \text{FOR } 1.7 < W < 17 \end{cases}$$

$$\bar{W}_{\text{tot}} = 1.85 \text{ Lb.}$$

TABLE 9.5 BIRD WEIGHT DISTRIBUTION

EUROPE

WEIGHT (LBS)	$\Delta P(W)$	CUM. PROB	WEIGHT (LBS)
0 - 1	.7793	0	0
1 - 2	.1022	.7793	1
2 - 3	.0449	.8815	2
3 - 4	.0243	.9264	3
4 - 5	.0147	.9507	4
5 - 6	.0094	.9654	5
6 - 7	.0064	.9748	6
7 - 8	.0045	.9812	7
8 - 9	.0032	.9857	8
9 - 10	.0024	.9889	9
10 - 11	.0018	.9913	10
11 - 12	.0014	.9931	11
12 - 13	.0010	.9945	12
13 - 14	.0008	.9955	13
14 - 15	.0007	.9963	14
		.9970	15

$$F(W) = 1 - \exp\left(-\left(\frac{W}{.4360}\right)^{.4972}\right)$$

FOR $0 < W < 17$

$$\bar{W}_{tot} = .87 \text{ Lb.}$$

TABLE 9.6 BIRD WEIGHT DISTRIBUTION

KINETIC ENERGY (FT-LBS X 1000)

VELOCITY (KNOTS)	BIRD WEIGHT (LBS)														
	.500	1.500	2.500	3.500	4.500	5.500	6.500	7.500	8.500	9.500	10.500	11.500	12.500	13.500	14.500
110-150	403.	1210.	2016.	2822.	3629.	4435.	5241.	6048.	6854.	7660.	8467.	9273.	10079.	10886.	11692.
160-210	757.	2271.	3786.	5300.	6814.	8328.	9843.	11357.	12871.	14386.	15900.	17414.	18928.	20443.	21957.
210-260	1222.	3665.	6109.	8552.	10995.	13439.	15882.	18326.	20769.	23212.	25656.	28099.	30543.	32986.	35429.
260-310	1797.	5391.	8984.	12578.	16172.	19766.	23359.	26953.	30547.	34141.	37734.	41328.	44922.	48516.	52109.
310-360	2483.	7448.	12413.	17379.	22344.	27309.	32275.	37240.	42205.	47171.	52136.	57101.	62067.	67032.	71997.
360-410	3279.	9837.	16395.	22953.	29512.	36070.	42628.	49186.	55744.	62302.	68860.	75419.	81977.	88535.	95093.
410-460	4186.	12558.	20930.	29303.	37675.	46047.	54419.	62791.	71163.	79535.	87908.	96280.	104652.	113024.	121396.
460-510	5204.	15611.	26019.	36426.	46833.	57241.	67648.	78055.	88463.	98870.	109278.	119685.	130093.	140500.	150907.
510-560	6312.	19296.	31660.	44024.	56387.	68751.	81115.	93479.	105843.	118207.	130571.	142935.	155298.	167662.	180025.
560-610	7571.	22717.	37854.	52993.	68137.	83279.	98420.	113562.	128703.	143845.	158986.	174128.	189270.	204411.	219553.
610-660	8920.	26761.	44601.	62442.	80282.	98123.	115963.	133804.	151644.	169485.	187325.	205165.	223006.	240846.	258687.
660-710	10380.	31141.	51902.	72662.	93423.	114183.	134944.	155705.	176465.	197226.	217986.	238747.	259508.	280268.	301029.

TABLE 10.0 KINETIC ENERGY MATRIX

CRITICAL AREA/TOTAL AREA

VELOCITY (KNOTS)	BIRD WEIGHT (LBS)														
	.500	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5
110-160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
160-210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
210-260	0	0	0	0	0	0	0	0	0	0	0	.258	.439	.456	.473
260-310	0	0	0	0	.184	.448	.488	.529	1.0	1.0	.514	.542	1.0	1.0	1.0
310-360	0	0	0	.256	.477	.533	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
360-410	0	0	.198	.484	.557	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
410-460	0	0	.461	.555	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
460-510	0	0	.518	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
510-560	0	.440	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
560-610	0	.481	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
610-660	0	.527	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
660-710	0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

TABLE 10.1 WINDSHIELD CRITICAL AREA/TOTAL AREA, PRESENT CAPABILITY

VELOCITY (KNOTS)	BIRD WEIGHT (LBS)														
	.500	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5
110-160	0	0	0	0	0	0	0	.207	.302	.398	.493	.588	.684	.779	.805
160-210	0	0	0	0	.298	.477	.656	.802	.814	.826	.839	.851	.863	.875	.888
210-260	0	0	.214	.503	.792	.819	.838	.858	.878	.898	.918	.937	.957	.977	.997
260-310	0	0	.554	.812	.841	.870	.899	.928	.957	.986	1.0	1.0	1.0	1.0	1.0
310-360	0	.373	.810	.851	.891	.931	.971	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
360-410	0	.655	.843	.896	.949	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
410-460	0	.812	.879	.947	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
460-510	0	.836	.921	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
510-560	.241	.864	.966	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
560-610	.387	.894	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
610-660	.547	.927	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
660-710	.719	.962	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

TABLE 10.2 CANOPY CRITICAL AREA/TOTAL AREA, PRESENT CAPABILITY

USE OF COMPUTER PROGRAM FOR MODEL APPLICATION

Appendix A lists an interactive computer program which was used to obtain the number of bird penetrations for each component varying t_H . Program BAAPP evaluates the present fleet air-to-air mission. The inputs for the program are in line number 140 - 740 and can be changed to evaluate the RPD and DRF air-to-air/air-to-ground missions. In the above program lines, the following are input parameters:

- (140) PWC - $\Delta P(W)$ bird weight probability for CONUS. From Table 9.5 (Does not change when evaluating F-15 Present Fleet, F-15 RPD, F-15 DRF).
- (160) PWE - $\Delta P(W)$ bird weight probability for Europe. From Table 9.6 (Does not change when evaluating F-15 Present Fleet, F-15 RPD, F-15 DRF).
- (230) PVI - $\Delta P(V)$ velocity probability. From Table 9.0 - 9.5 (changes for air-to-air and air-to-ground missions)
- (250 - 740) Windshield and Canopy Critical area Proportions. From Table 10.1 and 10.2 for present Windshield and Canopy Capability. (These values change for increased capability. By using Figures 17 and 18, a similar Table to 10.1 and 10.2 can be obtained).

Appendix B contains the results, after running the program BAAPP, for the F-15 present fleet (air-to-air mission). The first matrix, expected number of birdstrikes (uncorrected), is not corrected for critical area. The second matrix, expected number of birdstrikes, is corrected for critical area, and the summation of all elements of this matrix is the total number of penetrations for a specific, component, theatre, OIR, Force Usage, or mission. The Appendix C program lists only the results, the total number of bird penetrations.

EVALUATION OF RESULTS

To date, the F-15 fleet has had one bird penetration on the windshield, and two incidents resulting in two cracked windshields and one cracked canopy. Of these two incidents, no penetration into the cockpit has occurred. Table 11 summarizes the results of this model's simulation of the F-15 present fleet based on the number of hours flown to date in CONUS and Europe and on the present windshield/canopy capability. It is important to note that any value other than an integer value for a penetration is meaningless; however, since this simulation is a numerical solution, fractional values will occur. For example, for CONUS, the model predicts 0.45 bird penetrations on the canopy and to date there have been none. Since this is a numerical solution, one can imagine a counter starting when the F-15 fleet started flying. The 0.45 penetrations implies we have not had a penetration on the canopy to this date, but given more time, we will.

The model simulated past history very well, the same methodology was used to evaluate the F-15 RPD and DRF. The results are presented in Figures 19 - 70 for different missions with varying T_g and force usage (flight hours). A realistic usage profile is summarized in Table 12.0 - 12.7 for the RPD and DRF over a 15 year flying period. These graphs can also be used to evaluate other and possibly more realistic usage profiles.

Evaluation of Table 12.7 indicates that, even with a 500 kt windshield and 350 kt canopy, bird penetrations into the cockpit will still occur; however, there is little that can be done to prevent an 8 lb bird from penetrating at 480 knots. To dissipate the energy resulting from an impact of such a severe condition could require structural considerations that would interfere with the capability and function of the aircraft, as well as make the design cost prohibitive based on latest state of the art technology in transparency design.

The number of penetrations that are represented in either the tables or the graphs do not imply aircraft losses. Based on McAir's initial analyses of historical data, one out of every three penetrations resulted in an aircraft loss, fatality, or pilot major injury. This ratio was used to assess the results in terms of aircraft losses, fatalities or pilot major injuries. However, one should note that this type of ratio is based on a small data sample and has not been verified against all existing data from which a more realistic ratio might be inferred.

Figures 19 through 70 can be used to predict the number of bird penetrations for a change in T_g if the force usage shown in Tables 12.0, 12.4, and 12.5 remains the same. From Table 12.3, it is found that the F-15 RPD air to ground missions predicts 9.5 windshield bird penetrations for a T_g of 0.8056 and the present windshield capability in CONUS. What is the expected number of windshield bird penetrations if the time spent in the bird threat environment is reduced to a T_g of 0.6? First find the right graph, in this case, Figure 27, "F-15 RPD, Present Windshield Capability, CONUS, Air to Ground." Then from Table 12.0, "F-15 RPD Force Usage," the number of flight hours for the CONUS and air to ground case, 141,750 hours, is used in Figure 27. Since Figure 27 doesn't have a line for a T_g of 0.6, the value is interpolated between T_g of 0.5 and 0.7. From the graph:

At	Flight Hours	T _s	Windshield Bird Penetrations (WBP)
	141,750	.5	WBP.5 = 5.6
	141,750	.6	WBP.6 = ?
	141,750	.7	WBP.7 = 8.3

Using a ratio to interpolate

$$\frac{WBP.7 - WBP.6}{T_{s.7} - T_{s.6}} = \frac{WBP.7 - WBP.5}{T_{s.7} - T_{s.5}}$$

Solving for WBP.6

$$WBP.6 = - \left[\left(\frac{8.3 - 5.6}{.7 - .5} \right) (.7 - .6) \right] - 8.3$$

WBP.6 = 6.95 windshield bird penetrations

CONCLUSIONS

A statistical simulation was used to evaluate the F-15 present windshield and canopy capability with respect to the number of bird penetrations into the cockpit. The results of this simulation as applied to the present fleet recreated past history very precisely. Similar methodology was used to evaluate the F-15 RPD and DRF. The results indicate that the model, using the assumptions and parameters of this analysis, predicts that the present windshield and canopy need improvement for the air-to-ground mission of the RPD and DRF.

BIRD PENETRATIONS*

	MODEL SIMULATION		HISTORICAL	
	CONUS	EUROPE	CONUS	EUROPE
Windshield	1.10	0.08	1	0
Canopy	0.45	0.62	0	0
Hours Flown	473008	136576	473008	136576
Ts	.1198	.2307	.1198	.2307

*with present windshield and canopy capability

TABLE 11 F-15 PRESENT FLEET AJR TO AIR MISSION

Number of aircraft available = 150 aircraft

Average number of hours flown per month = 25 hours

The total number of flying hours for 15 years is:

$$15 \text{ years} \times 150 \text{ A/C} \times \frac{25 \text{ hrs}}{\text{month}} \times \frac{12 \text{ months}}{\text{year}} = 675,000 \text{ hrs}$$

Aircraft's distribution: 1 - Conus = 70% of aircraft

2 - Europe = 30% of aircraft

The mission mix is: 1 - 30% air to ground (A/G)

2 - 70% air to air (A/A)

Mission mix data obtained from HQ TAC message 221715Z July 1982

For 15 Years of F-15 RPD Force Usage

	Combined	Conus (70%)	Europe (30%)	Ts Conus	Ts Europe
Total hours	675,000	472,500	202,500		
A/G Hours (30%)		141,750	60,750	.8056	.8056
A/A Hours (70%)		330,750	141,750	.1198	.2307

TABLE 12.0 F-15 RPD FORCE USAGE

WINDSHIELD BIRD PENETRATIONS

	Present Capability	450 Knots Capability	500 Knots Capability
Conus	.75	.15	.09
Europe	.08	.016	.009

CANOPY BIRD PENETRATIONS

	Present Capability	300 Knots Capability	350 Knots Capability
Conus	.30	.11	.07
Europe	.65	.19	.05

TABLE 12.2 F-15 RPD AIR TO AIR MISSION

WINDSHIELD BIRD PENETRATIONS

	Present Capability	450 Knots Capability	500 Knots Capability
Conus	9.50	3.20	2.40
Europe	.60	.17	.12

CANOPY BIRD PENETRATIONS

	Present Capability	300 Knots Capability	350 Knots Capability
Conus	2.60	1.40	1.05
Europe	3.50	1.50	1.0

TABLE 12.3 F-15 RPD AIR TO GROUND MISSION

Production schedule obtained from HQ USAF message 082200Z Apr 83

Years of Production	Number of A/C	Cumulative Number of A/C	Flight hours per car
1st	16	16	4,800
2nd	72	88	26,400
3rd	72	160	48,000
4th	72	232	69,600
5th	72	304	91,200
6th	60	364	109,200
7th	36	400	<u>120,000</u>
Total flight hours for the first 7 years:			447,648

Sample Calculation: for the first year:

$$16 \text{ A/C} \times 25 \frac{\text{flight hours}}{\text{month}} \times 12 \frac{\text{month}}{\text{year}} = 4800 \text{ flight hours}$$

For the remaining 8 years, the number of flight hours is:

$$400 \text{ A/C} \times 25 \frac{\text{flight hours}}{\text{month}} \times 12 \frac{\text{month}}{\text{year}} \times 8 \text{ years} = 960,000 \text{ hours}$$

The total flight hours for 15 years is:

$$447,648 \text{ hours} + 960,000 \text{ hours} = 1,407,648 \text{ hours}$$

TABLE 12.4 F-15 DRF FORCE USAGE

Aircraft distribution: 1 - Conus = 70% of aircraft
 2 - Europe = 30% of aircraft

The mission mix is: 1 - 75% Air to ground (A/G)
 2 - 25% Air to air (A/A)

For 15 years of F-15 DRF Force Usage

	Combined	Conus	Europe	Ts Conus	Ts Europe
Total Hours	1,407,648	985,353	422,294		
A/G Hours (75%)		739,015	316,720	.6360	.6360
A/A Hours (25%)		246,338	105,573	.1198	.2307

TABLE 12.5 F-15 DRF FORCE USAGE

WINDSHIELD BIRD PENETRATIONS

	Present Capability	450 Knots Capability	500 Knots Capability
Conus	.55	.10	.06
Europe	.06	.01	0

CANOPY BIRD PENETRATIONS

	Present Capability	300 Knots Capability	350 Knots Capability
Conus	.40	.13	.08
Europe	.80	.25	.15

TABLE 12.6 F-15 DRF AIR TO AIR MISSION

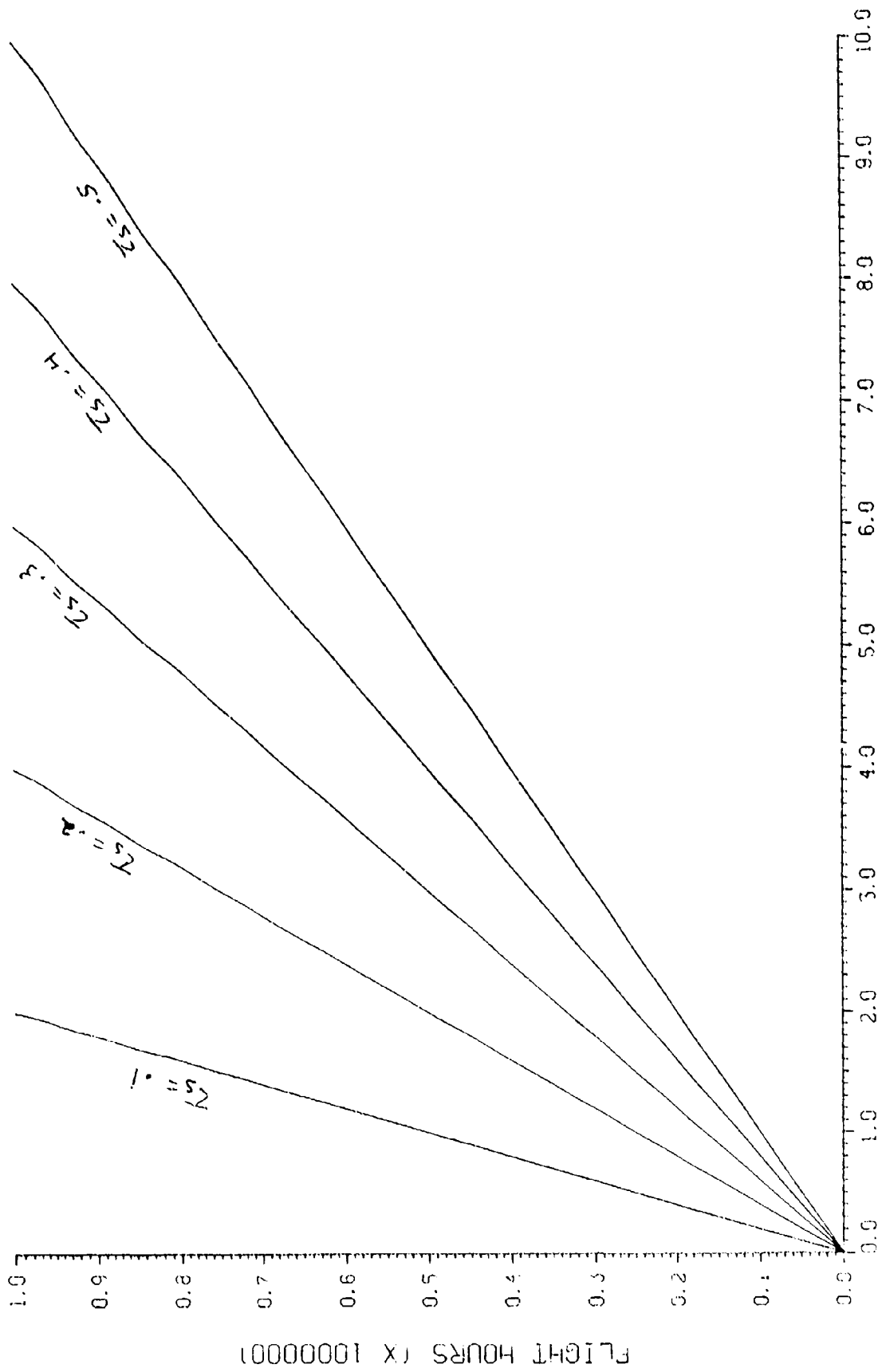
WINDSHIELD BIRD PENETRATION

	Present Capability	450 Knots Capability	500 Knots Capability
Conus	45.5	17.0	10.9
Europe	2.8	.9	.6

CANOPY BIRD PENETRATIONS

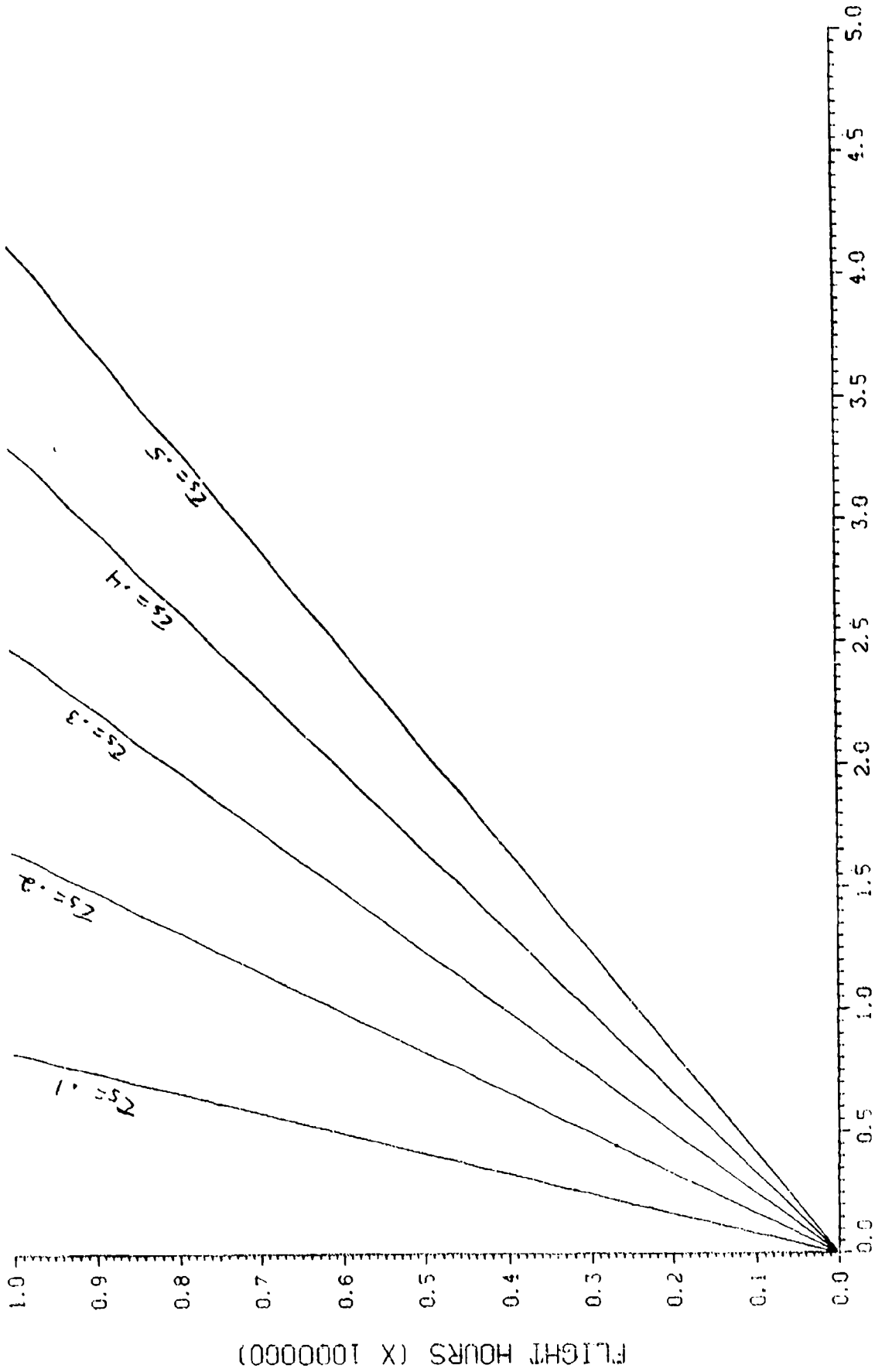
	Present Capability	300 Knots Capability	350 Knots Capability
Conus	19.2	10.7	8.9
Europe	25.5	11.5	8.5

TABLE 12.7 F-15 DRF, AIR TO GROUND MISSION

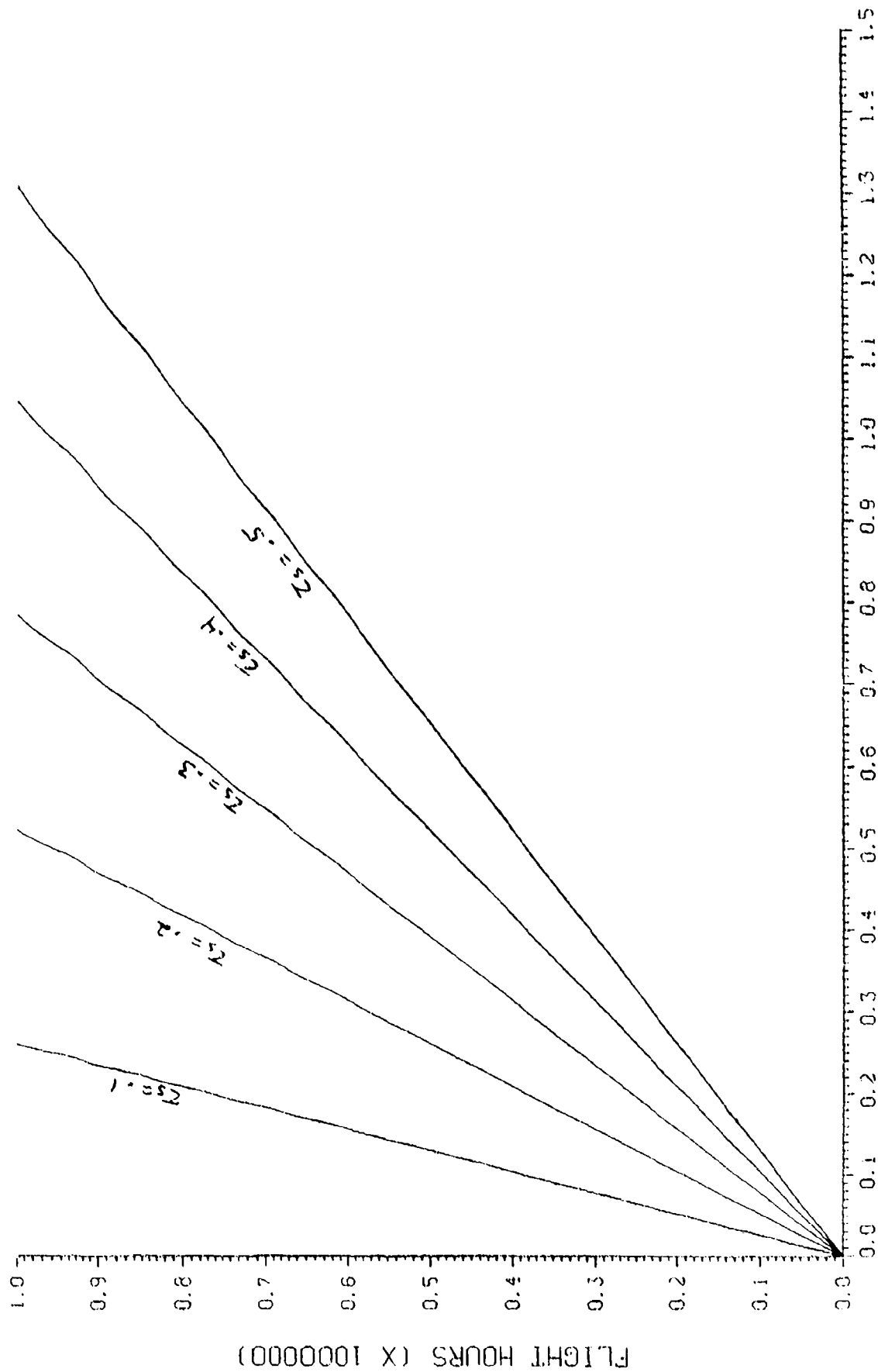


WINDSHIELD BIRD PENETRATIONS

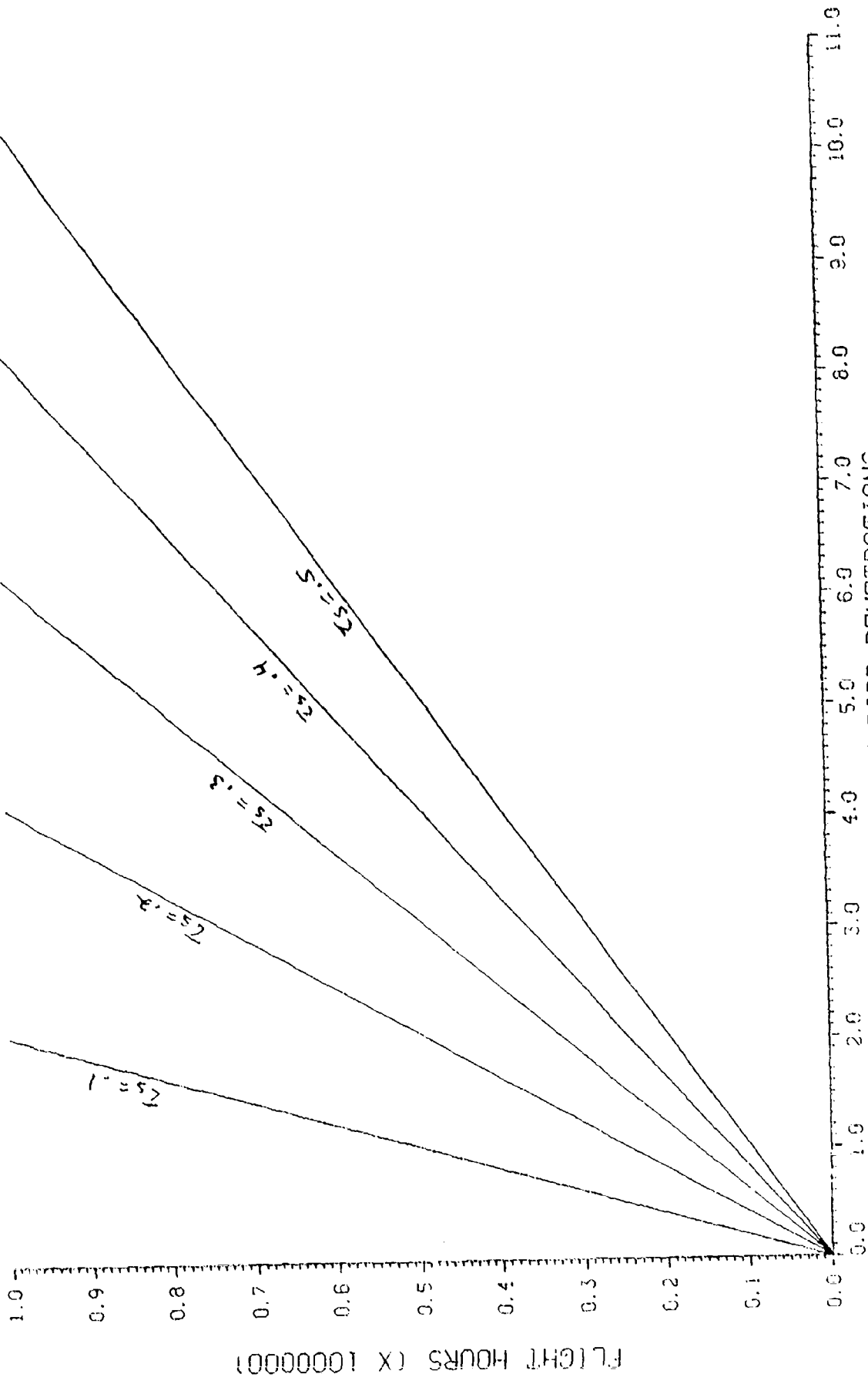
FIG. 19 F-15 PRESENT FLEET, PRESENT WINDSHIELD CAPABILITY
CONUS, AIR TO AIR (0-5000 FT. AGL)



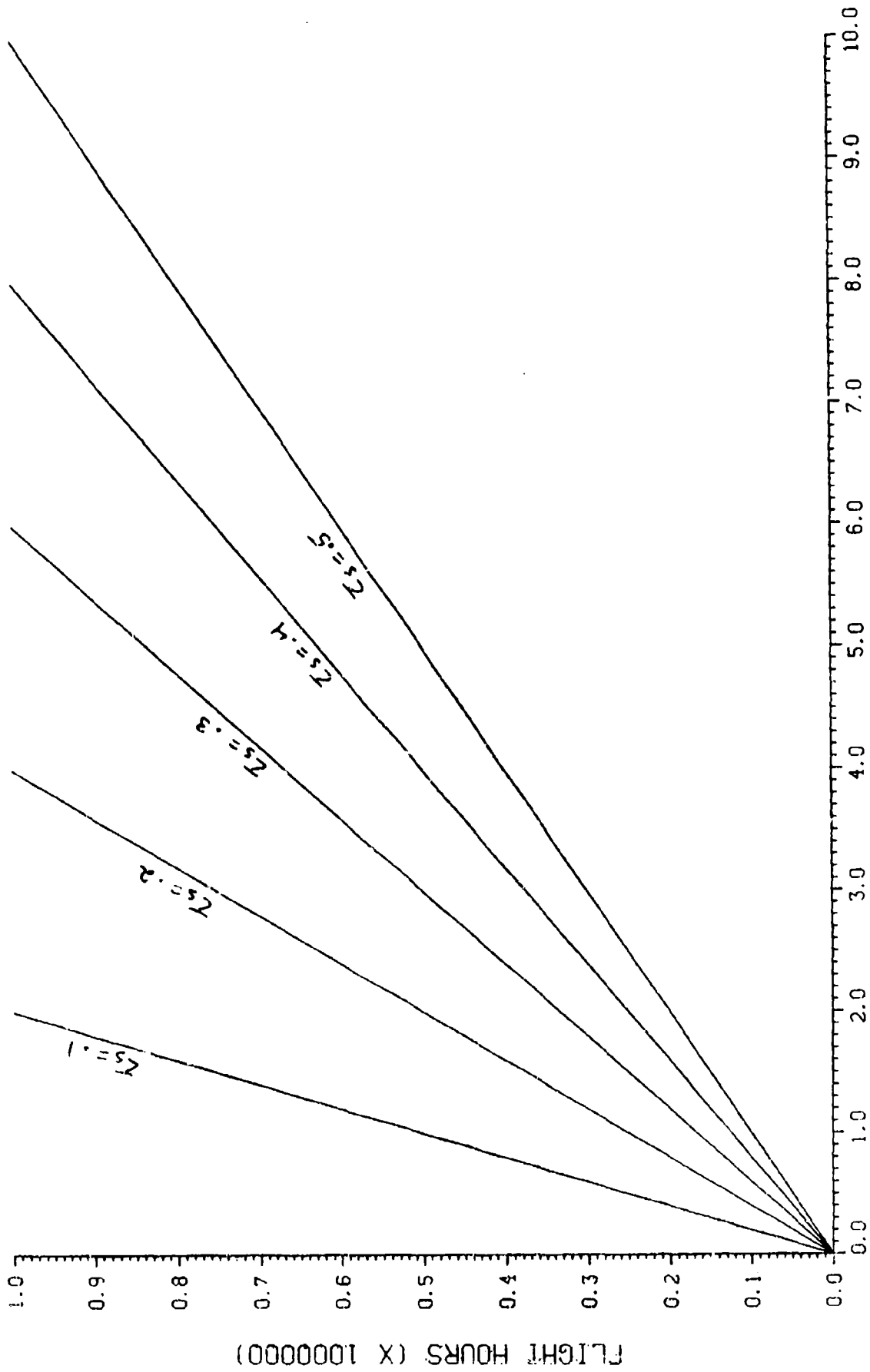
CANOPY BIRD PENETRATIONS
 FIG. 20 F-15 PRESENT FLEET, PRESENT CANOPY CAPABILITY
 CONUS, AIR TO AIR (0-5000 FT. AGL)



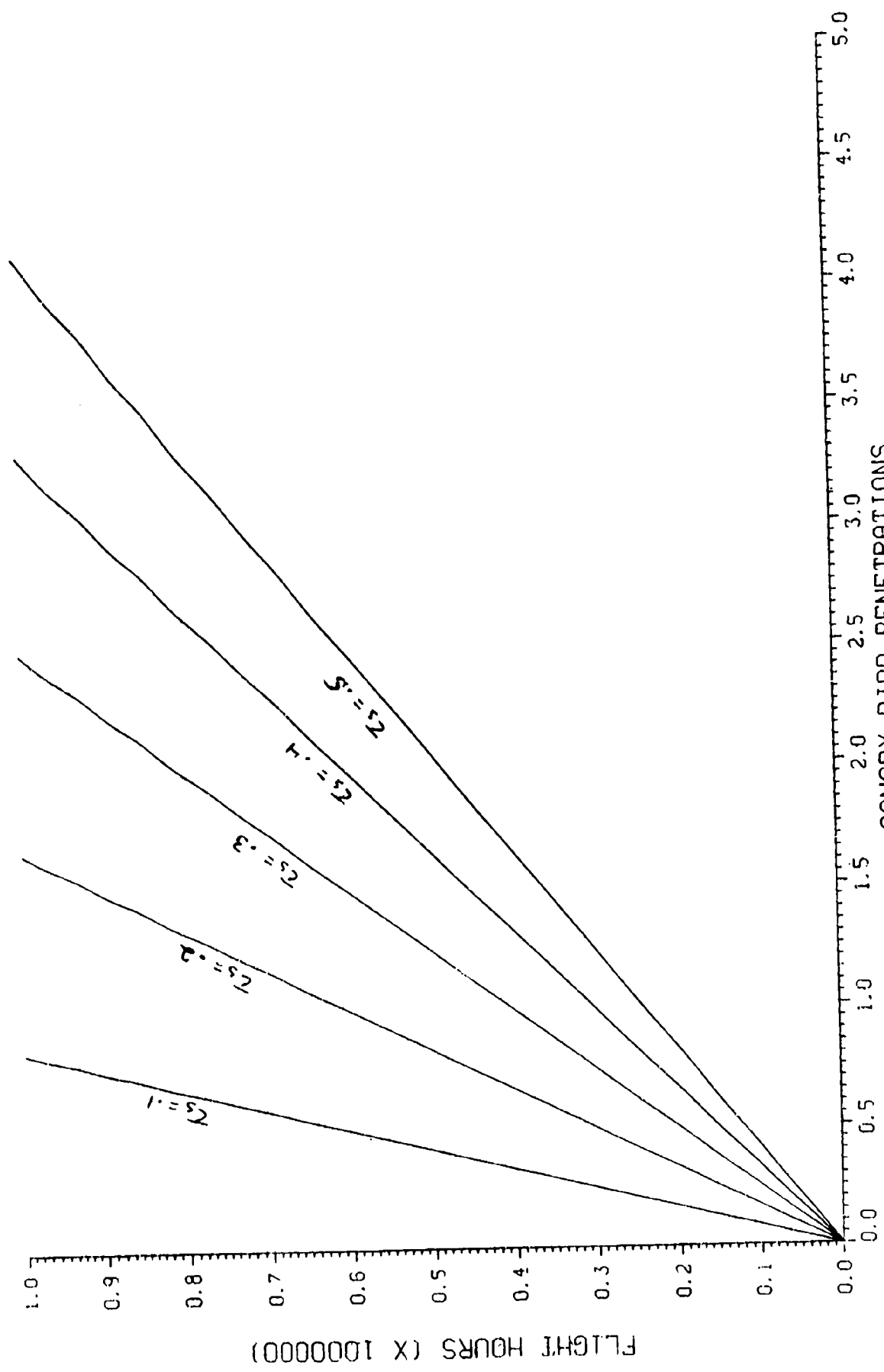
WINDSHIELD BIRD PENETRATIONS
 FIG. 21 F-15 PRESENT FLEEI, PRESENT WINDSHIELD CAPABILITY
 EUROPE, AIR TO AIR (0-5000 FT. AGL)



CANOPY BIRD PENETRATIONS
 FIG. 22 F-15 PRESENT FLEET, PRESENT CANOPY CAPABILITY
 EUROPE, AIR TO AIR (0-5000 FT. AGL)

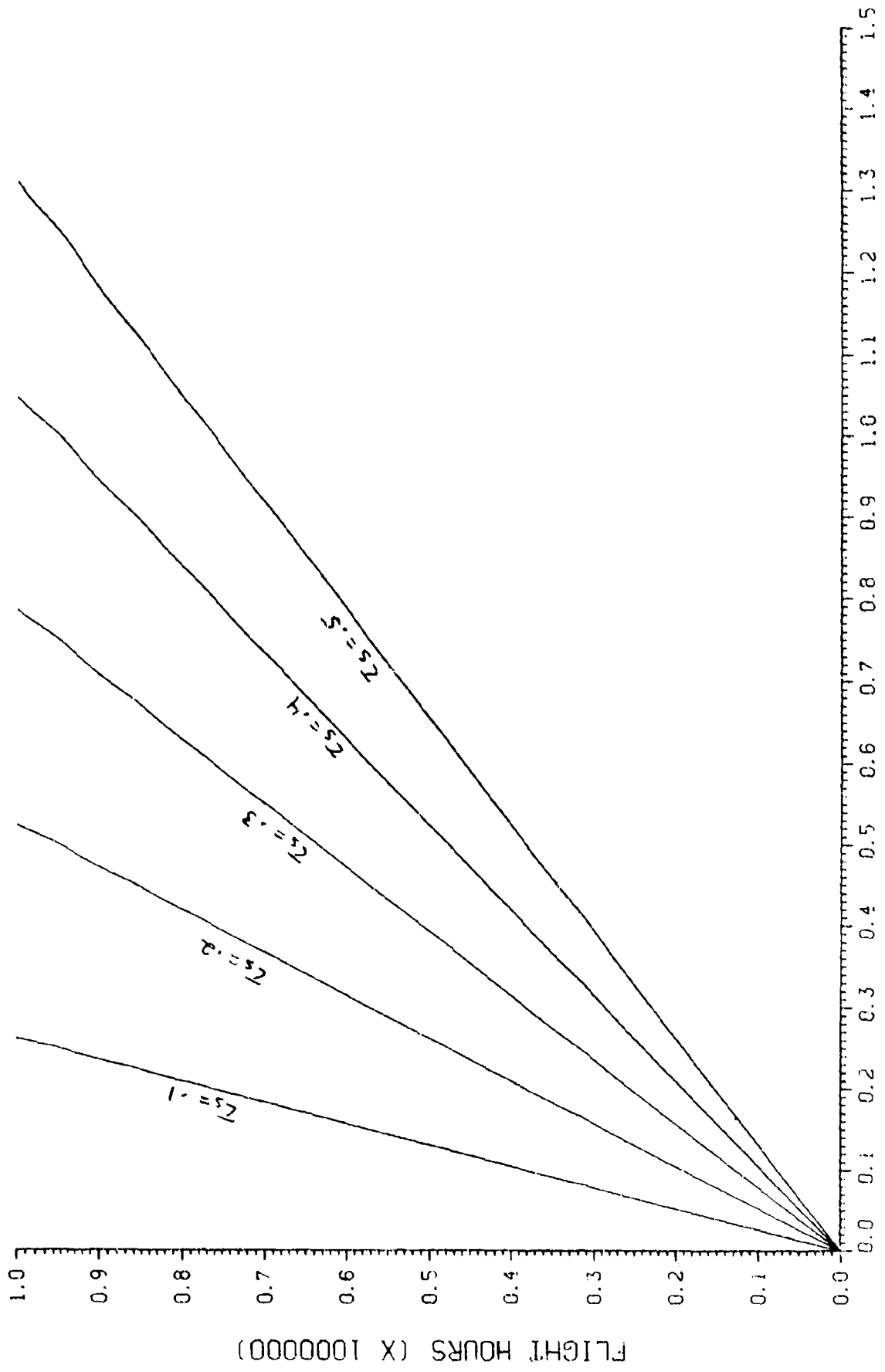


WINDSHIELD BIRD PENETRATIONS
 FIG. 23 F-15 RPD, PRESENT WINDSHIELD CAPABILITY
 CONUS, AIR TO AIR (0-5000 FT. AGL)



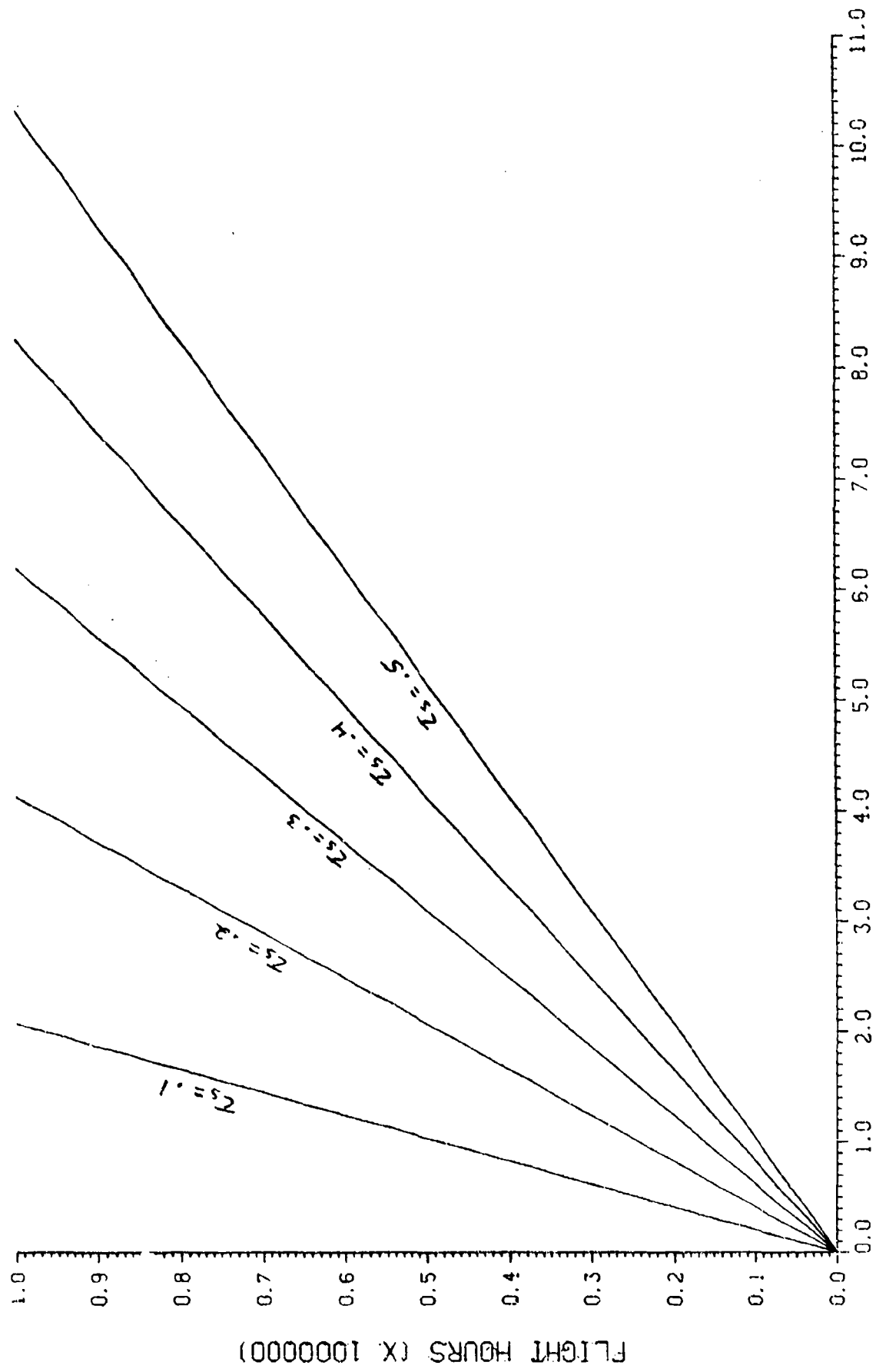
CANOPY BIRD PENETRATIONS

FIG. 24 F-15 RPD, PRESENT CANOPY CAPABILITY
CONUS, AIR TO AIR (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS

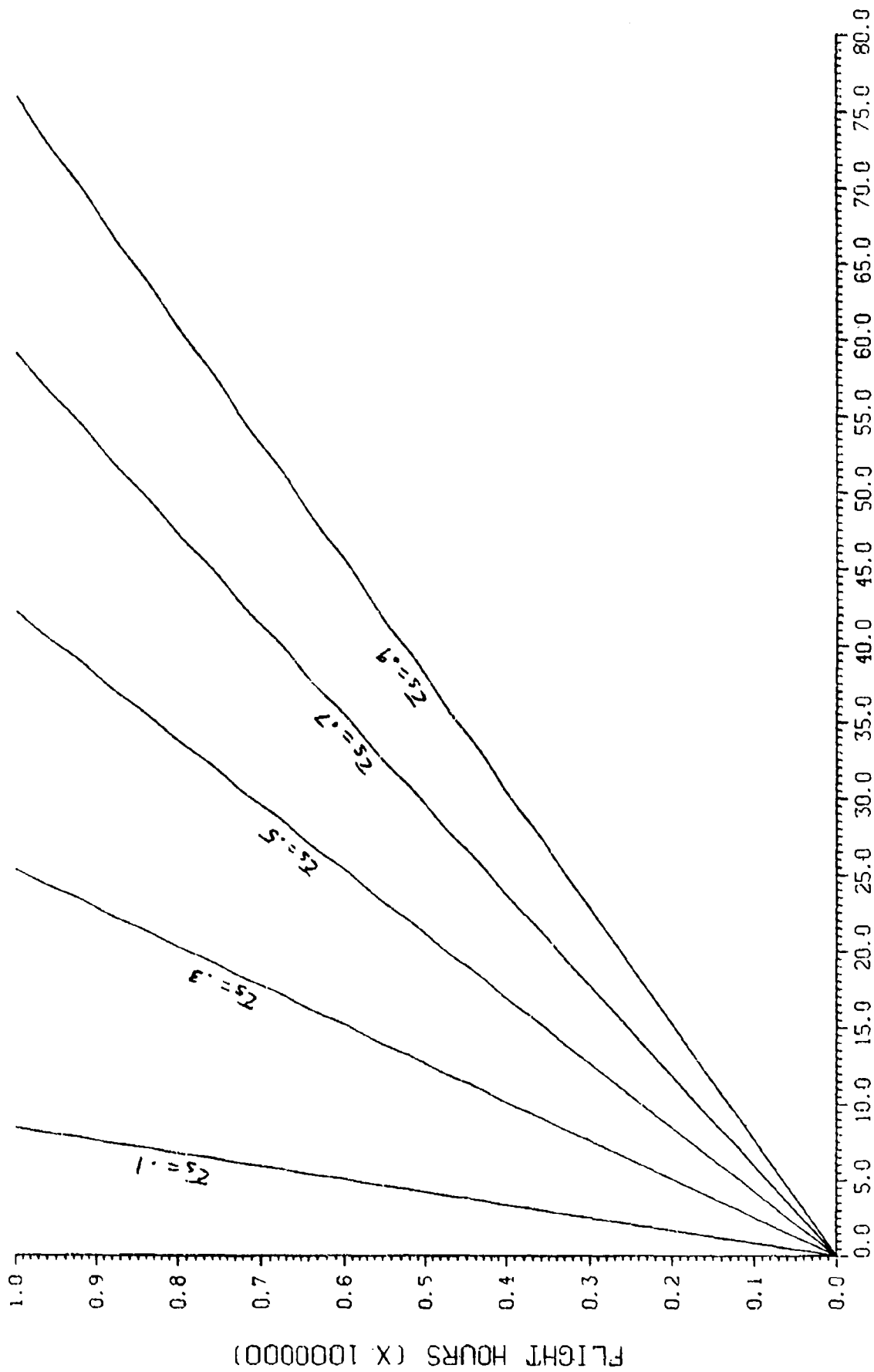
FIG. 25 F-15 RPD, PRESENT WINDSHIELD CAPABILITY
EUROPE, AIR TO AIR 10-5000 FT. AGL)



CANOPY BIRD PENETRATIONS

FIG. 26 F-15 RPD, PRESENT CANOPY CAPABILITY

EUROPE, AIR TO AIR (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS
 FIG. 27 F-15 RPD, PRESENT WINDSHIELD CAPABILITY
 CONUS, AIR TO GROUND (0-5000 FT. AGL)

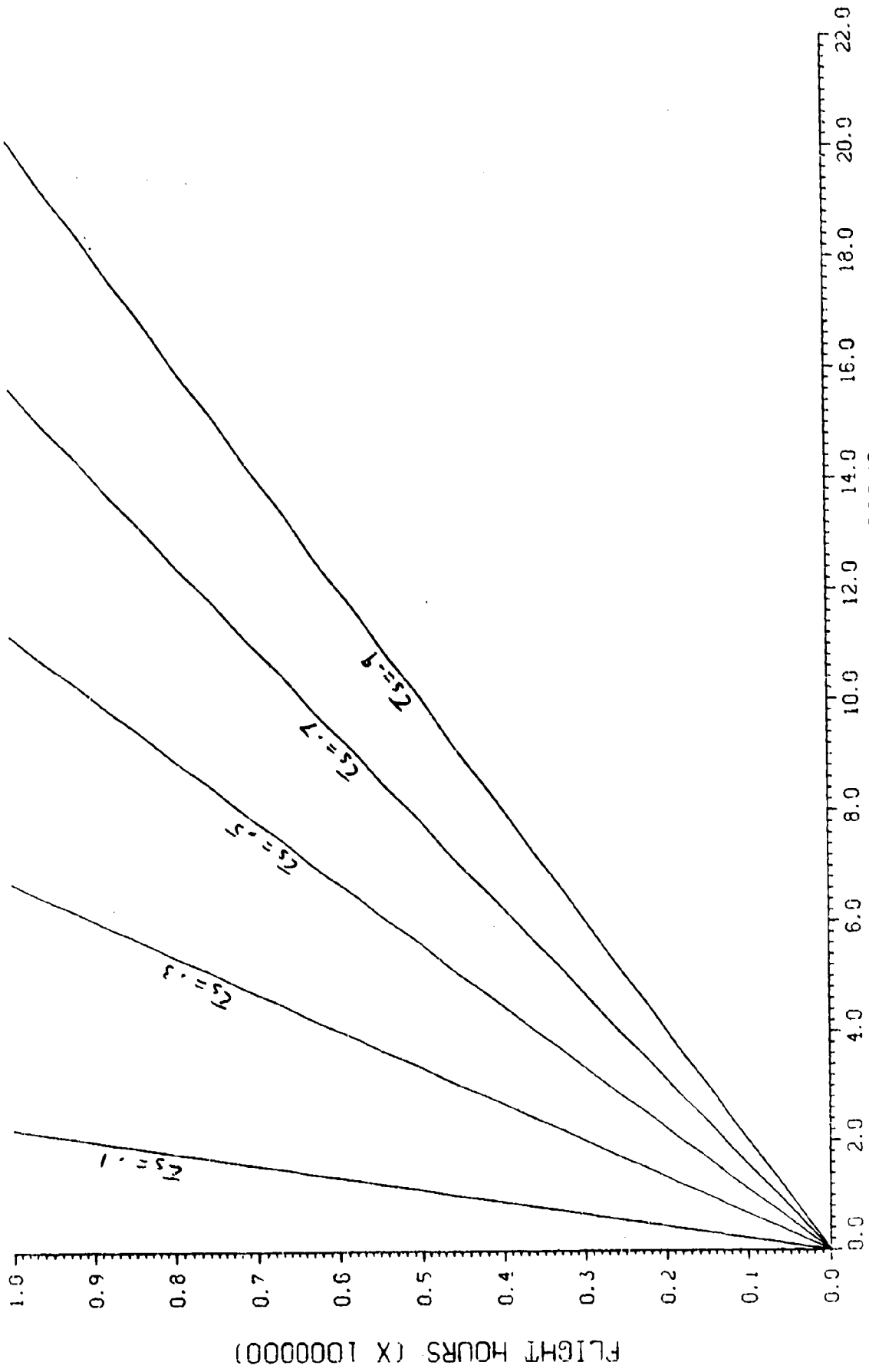
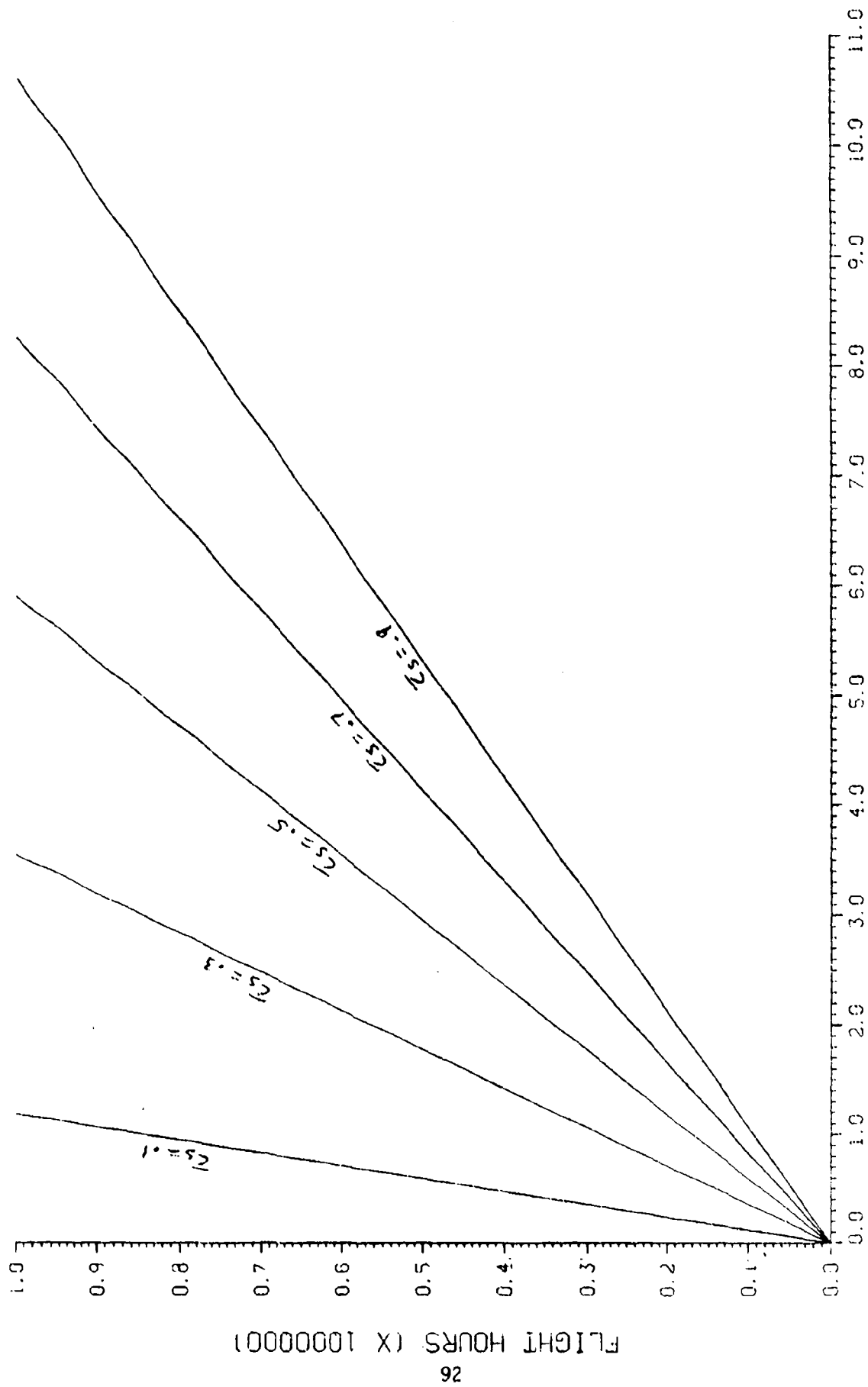
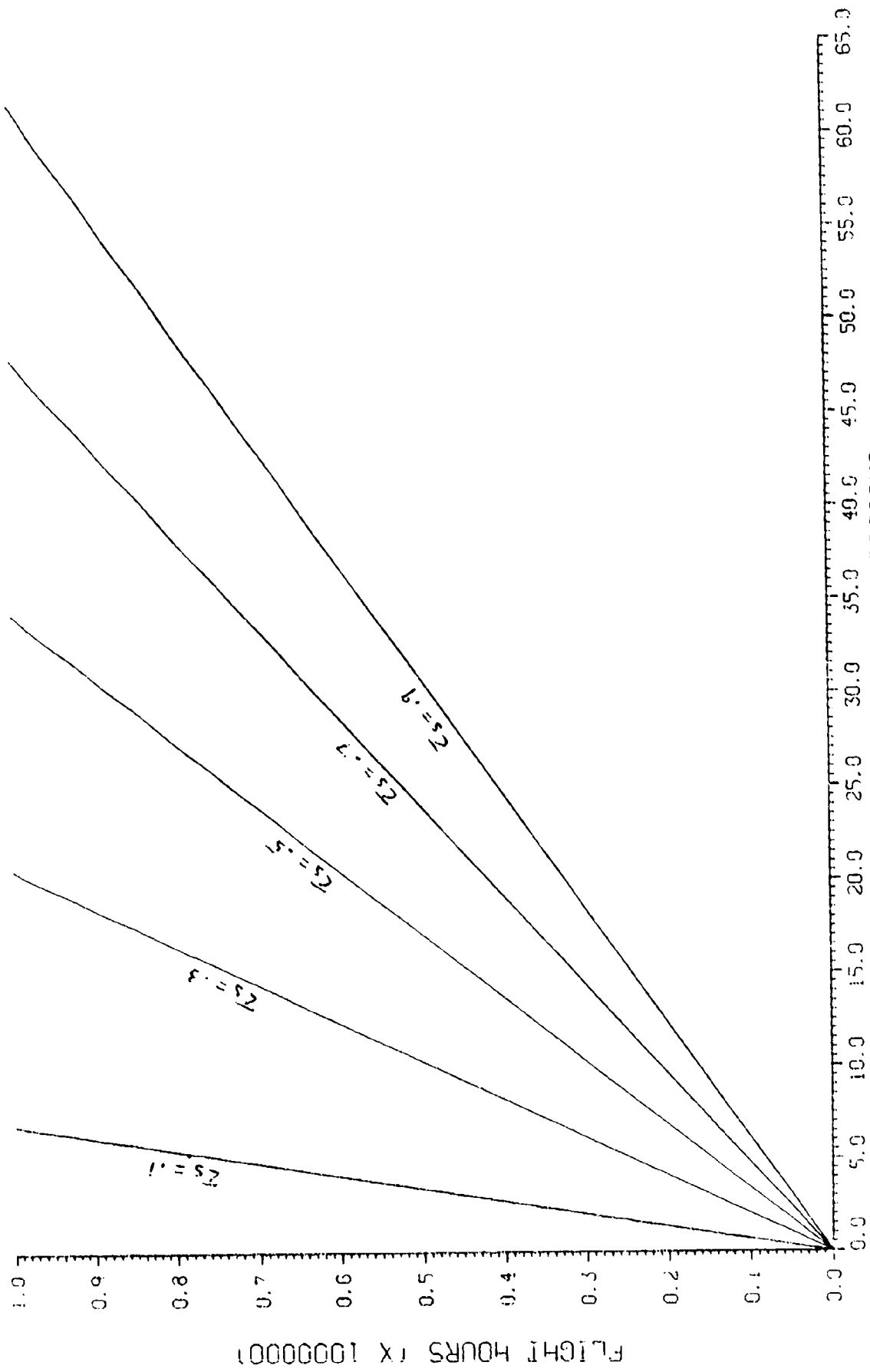


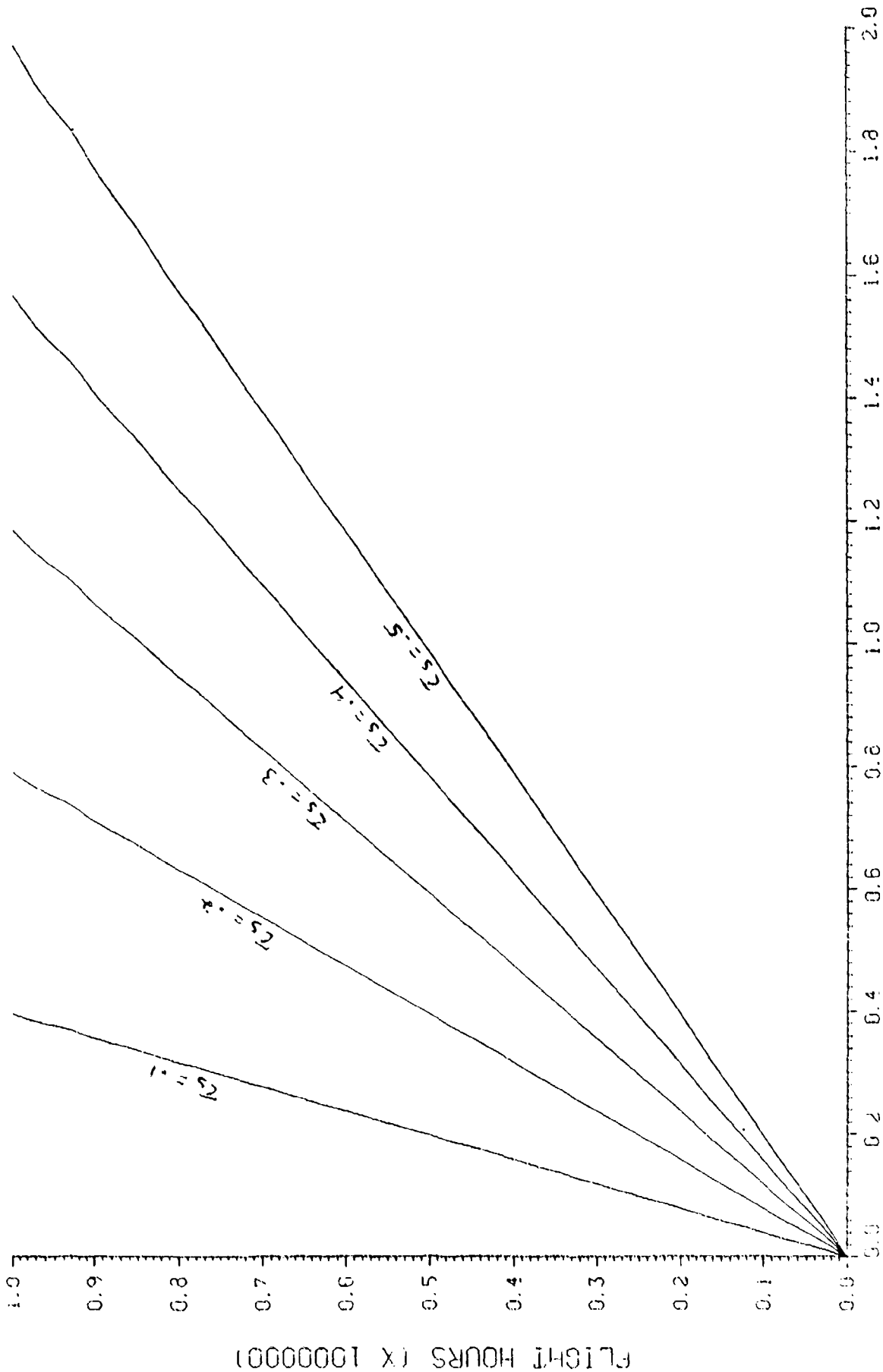
FIG. 28 F-15 RPD, PRESENT CANOPY CAPABILITY
 CONUS, AIR TO GROUND (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS
 FIG. 29 F-15 RPD, PRESENT WINDSHIELD CAPABILITY
 EUROPE, AIR TO GROUND (0-5000 FT. AGL)



CANOPY FIRE PENETRATIONS
 FIG. 30 F-15 RPD, PRESENT CANOPY CAPABILITY
 EUROPE, AIR TO GROUND (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS
 FIG 31 F-15 RPD, 450 KT. WINDSHIELD CAPABILITY
 CONUS, AIR TO AIR (0-5000 FT. AGL)

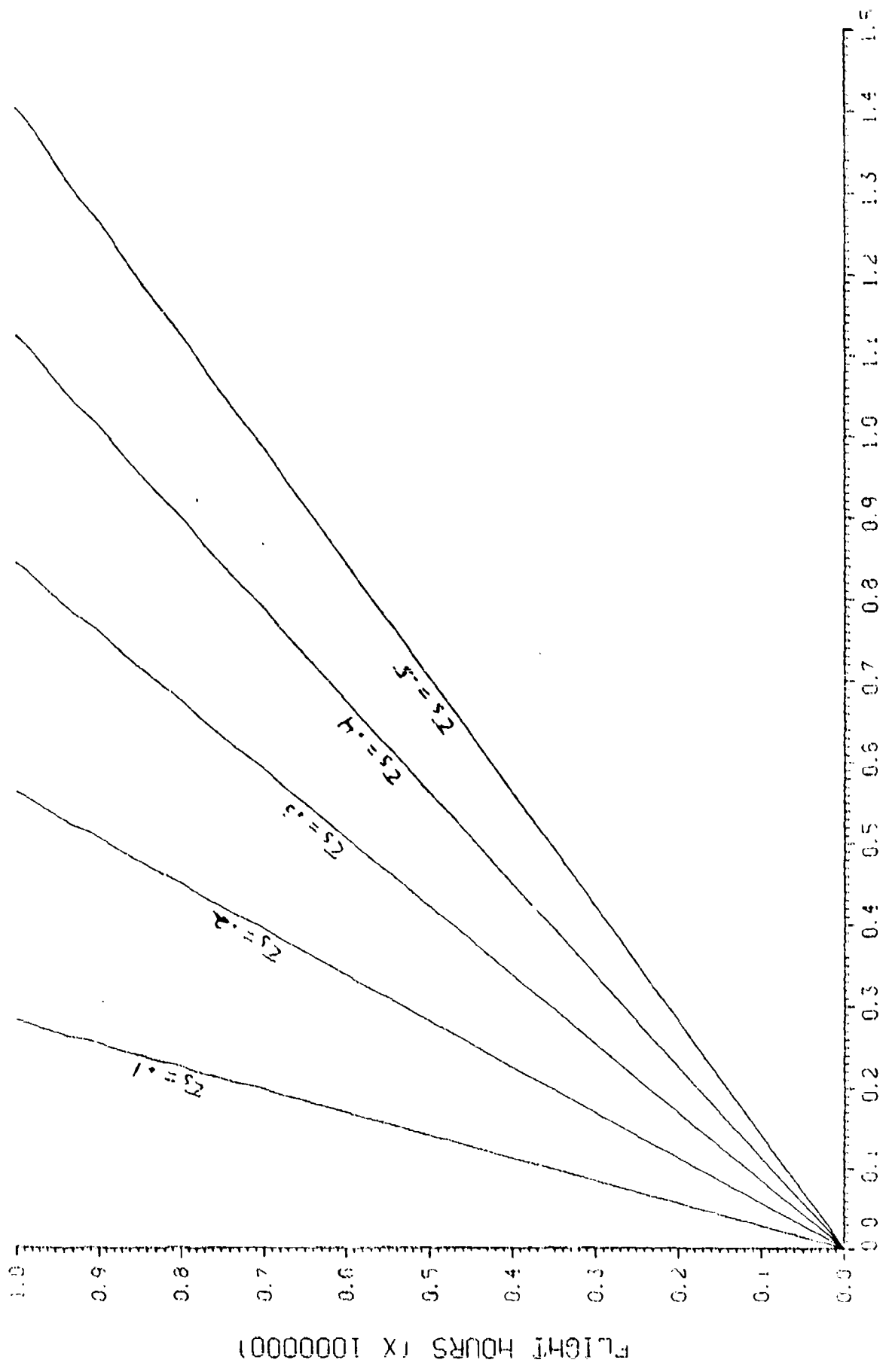
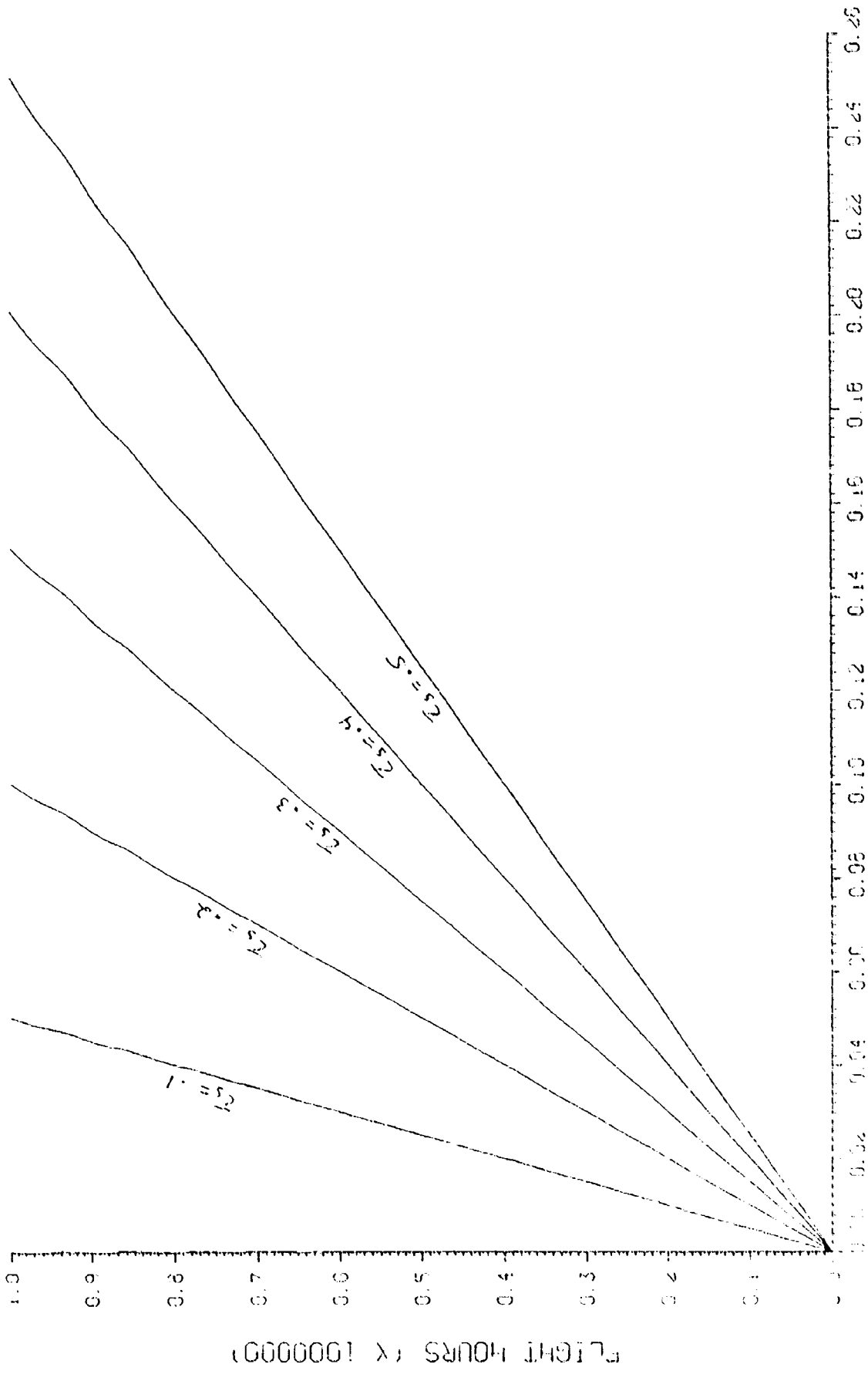


FIG. 32 F-15 RPD, 300 KT. CANOPY CAPABILITY
 CONUS, AIR TO AIR (0-5000 FT, AGL)



WINDSHIELD BIRD PENETRATIONS
 FIG 33 C 15 RPD, 450 KT. WINDSHIELD CAPABILITY
 EUROPE, AIR TO AIR TO 5000 FT. AGL

FLIGHT HOURS (X 100000)

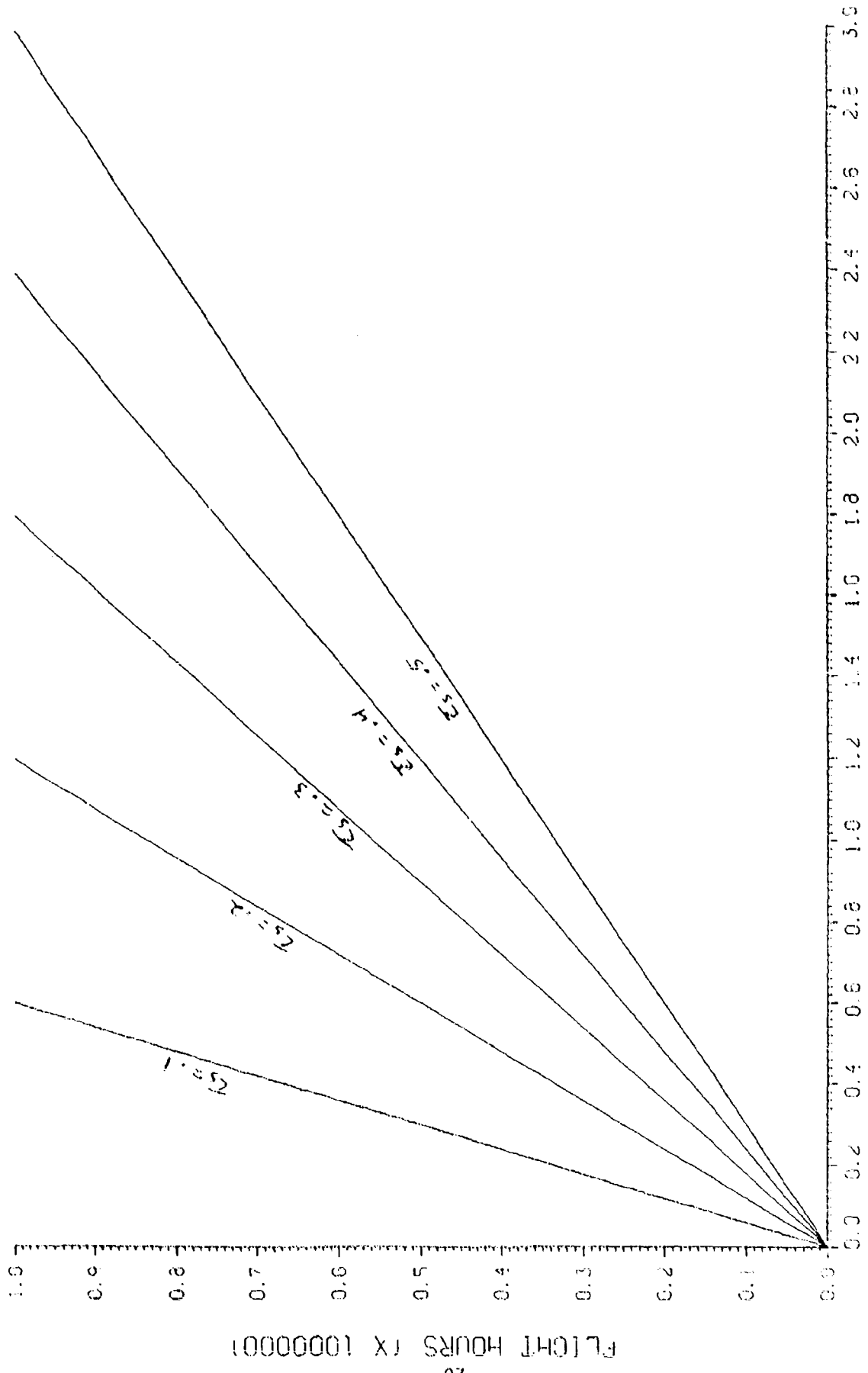
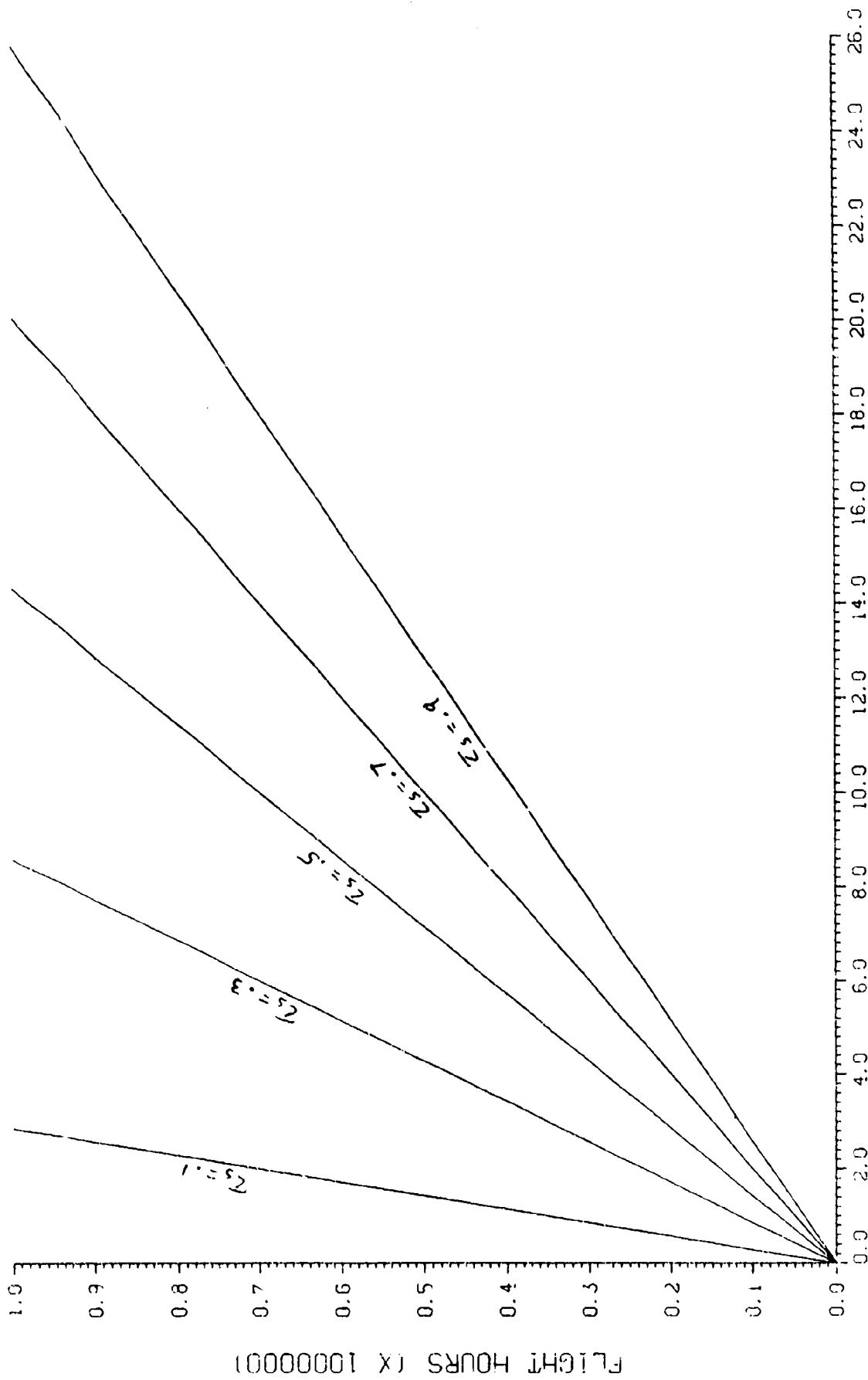
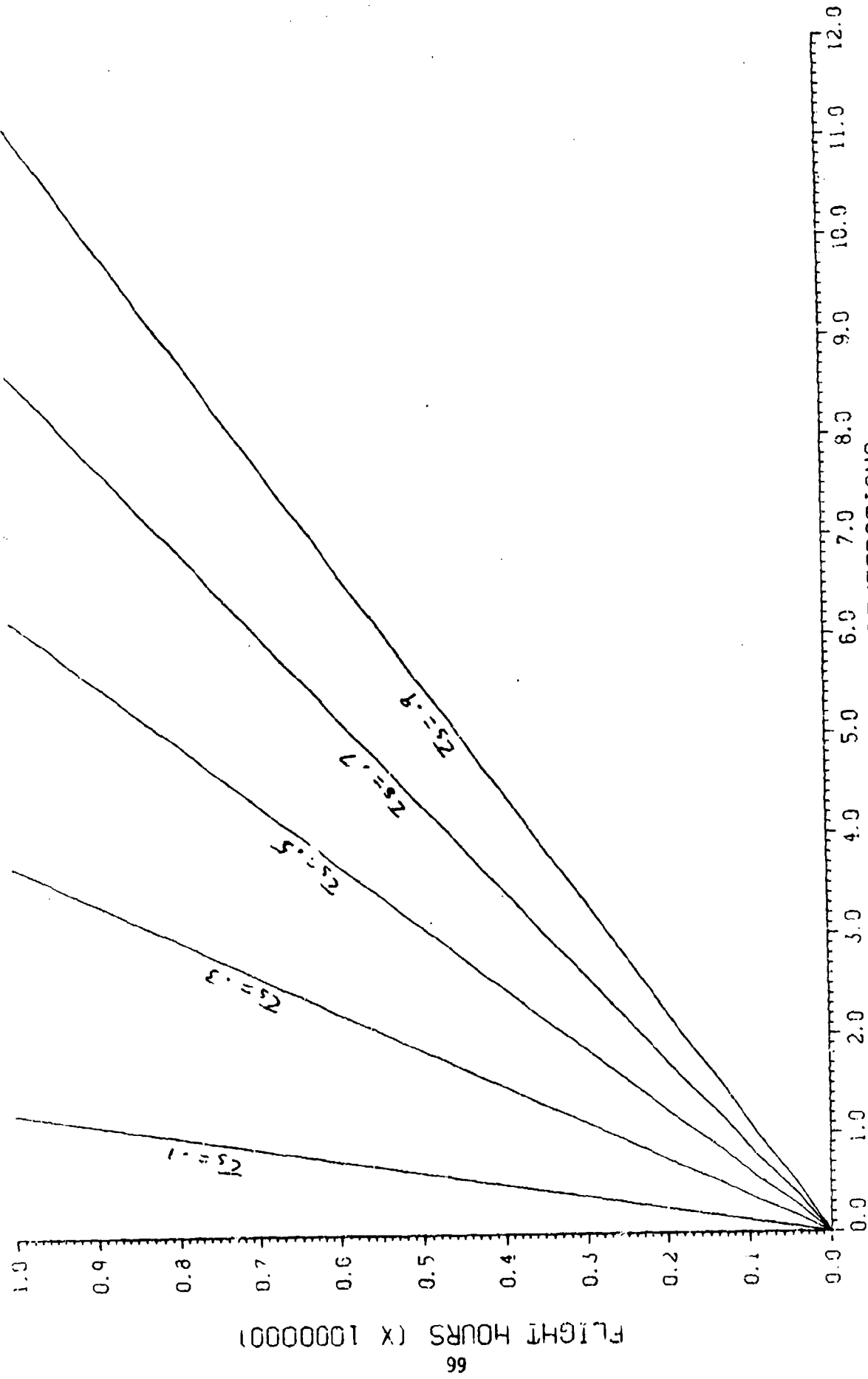


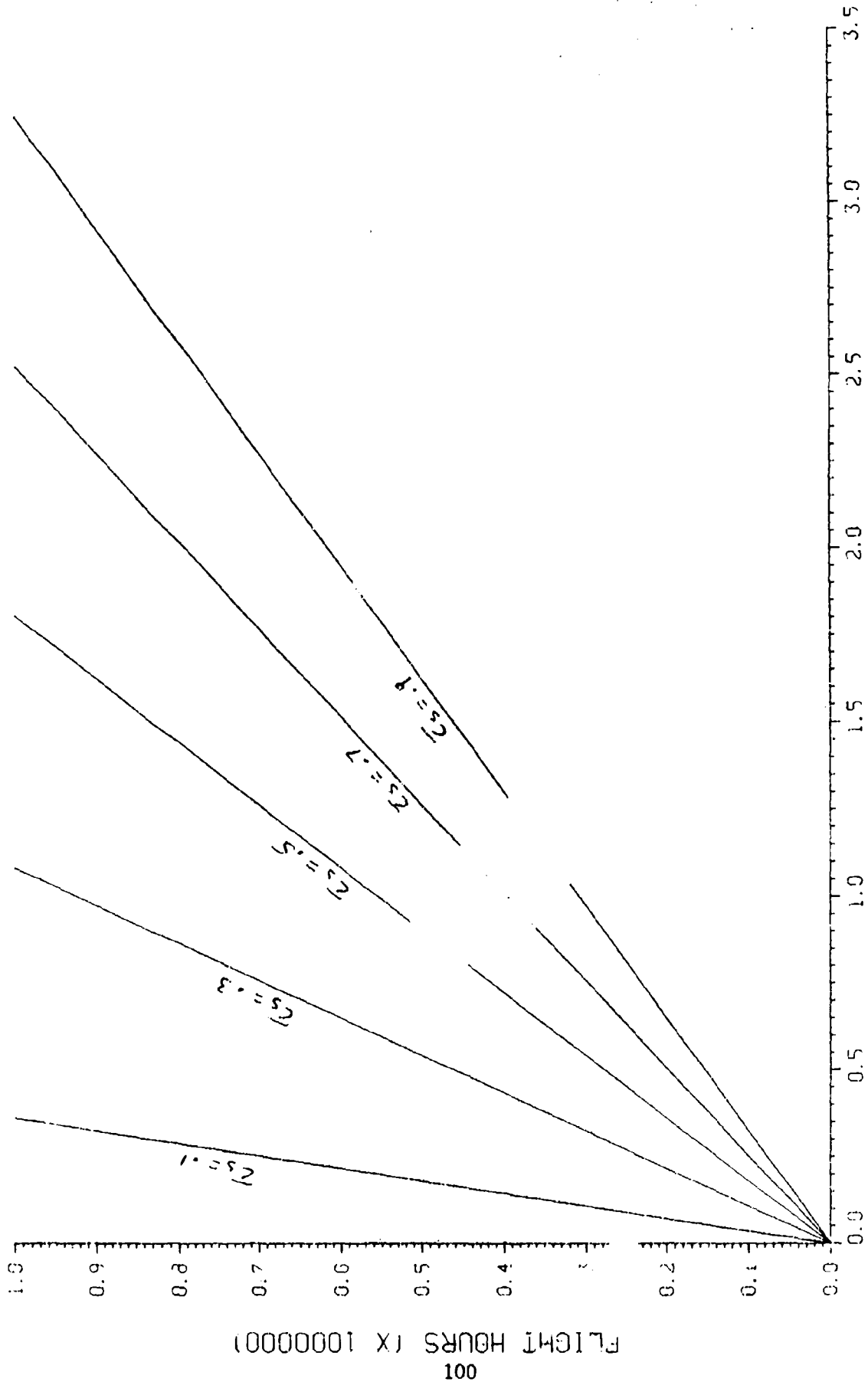
FIG. 34 F-15 RPD, 300 KT. CANOPY CAPABILITY
 EUROPE, AIR TO AIR (0-5000 FT. AGL)



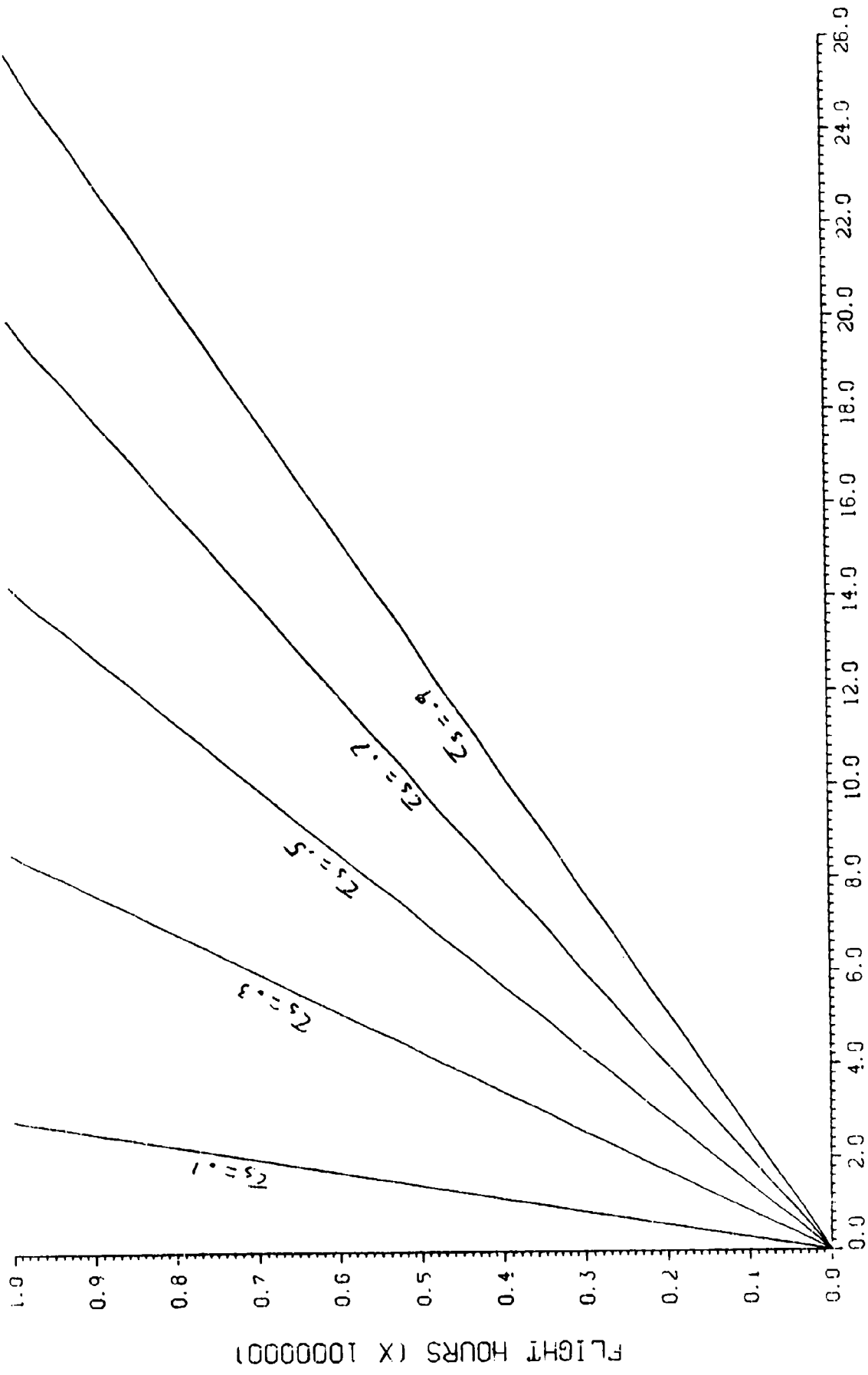
WINDSHIELD BIRD PENETRATIONS
 FIG. 35 F-15 RPD, 450 KT. WINDSHIELD CAPABILITY
 CONUS, AIR TO GROUND (0-5000 FT. AGL)



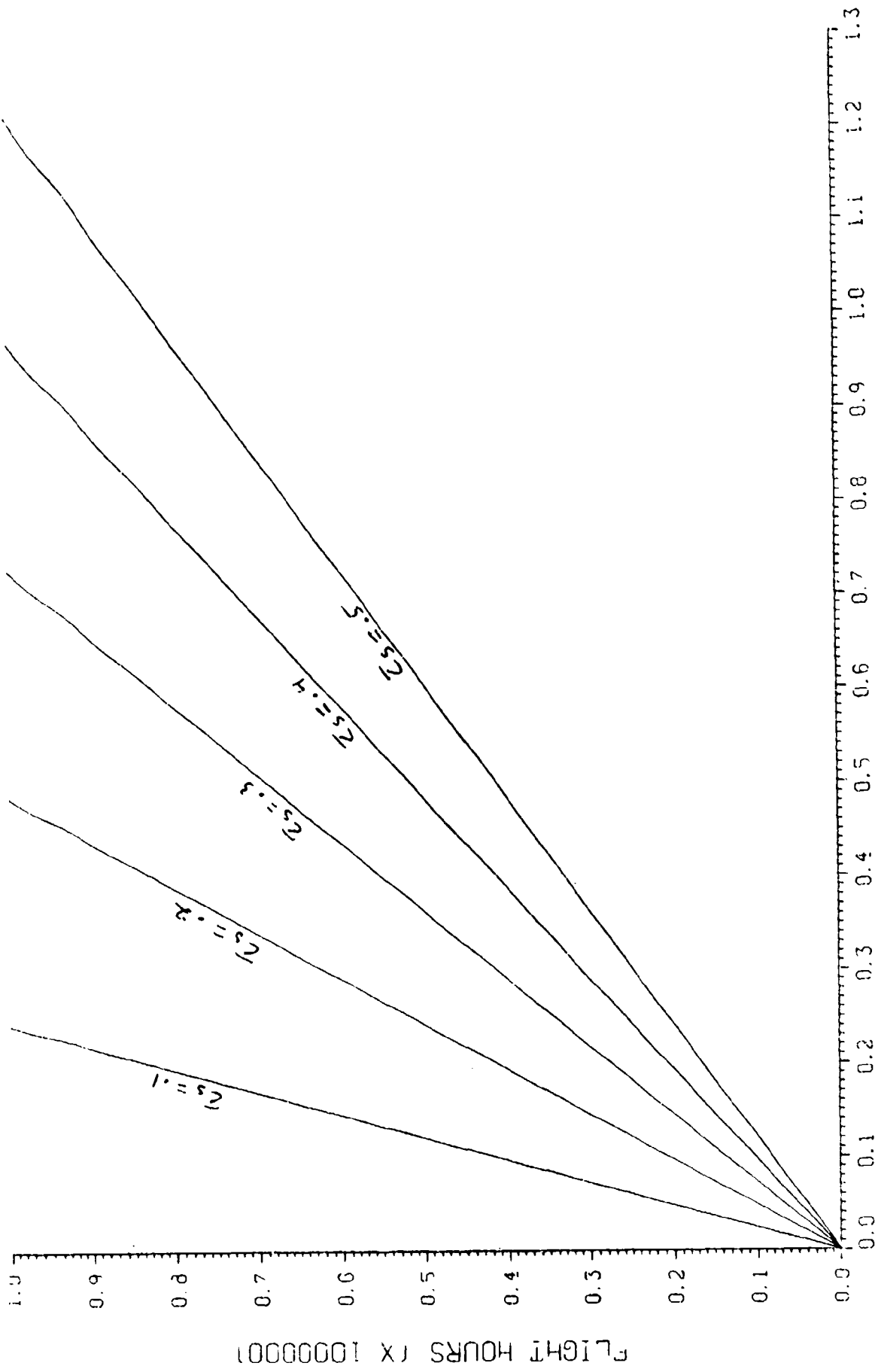
CANOPY BIRD PENETRATIONS
 FIG. 36 F-15 RPD, 300 KI. CANOPY CAPABILITY
 CONUS, AIR TO GROUND (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS
 FIG. 37 F-15 RPD, 450 KT. WINDSHIELD CAPABILITY
 EUROPE, AIR TO GROUND (0-5000 FT. AGL)



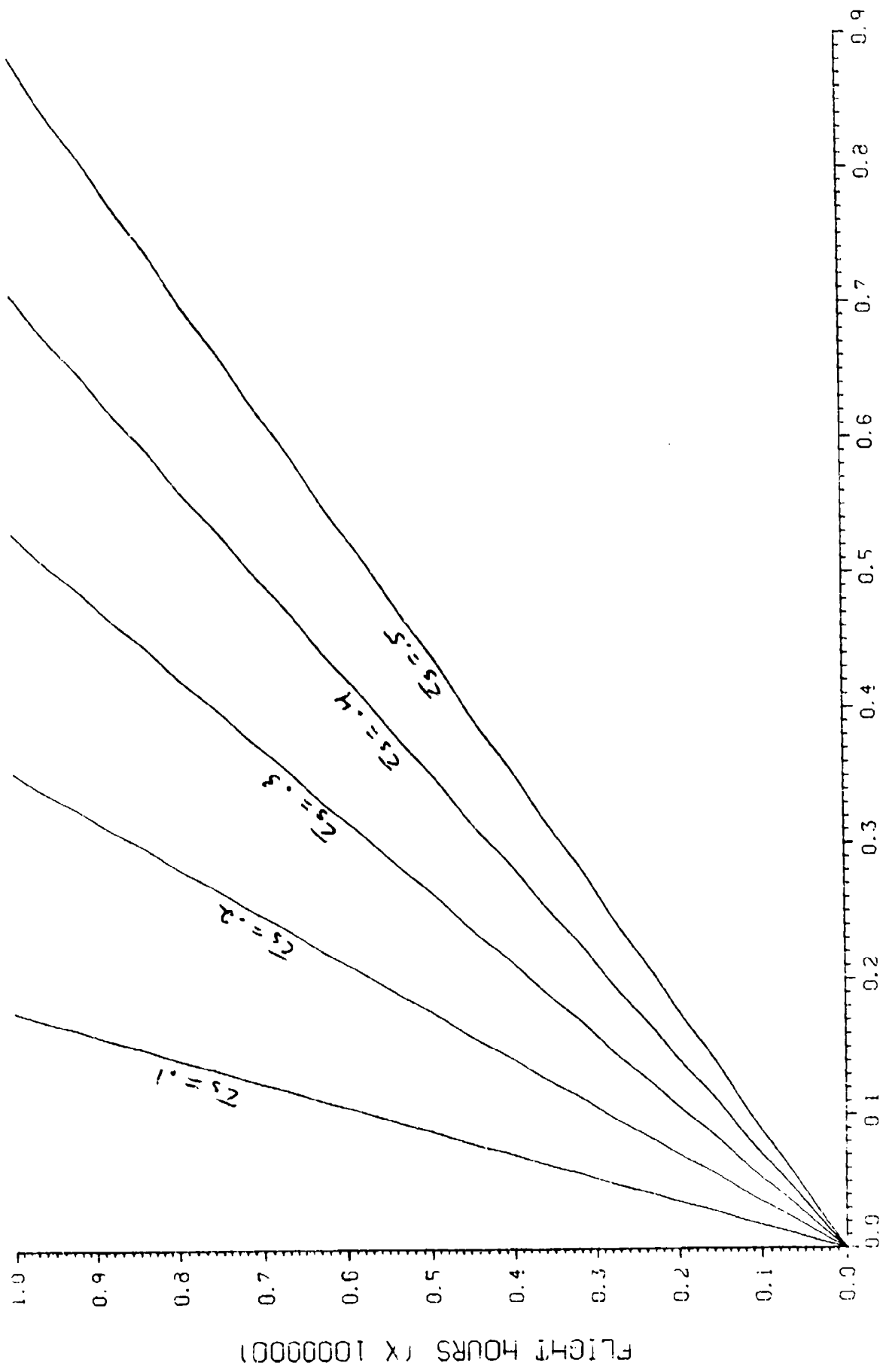
CANOPY BIRD PENETRATIONS
 FIG. 38 F-15 RPD, 300 KI. CANOPY CAPABILITY
 EUROPE, AIR TO GROUND (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS

FIG. 39 F-15 RPD, 500 KT. WINDSHIELD CAPABILITY

CONUS, AIR TO AIR 10-5000 FT. AGL



CANOPY BIRD PENETRATIONS
 FIG. 40 F-15 RPD, 350 KT. CANOPY CAPABILITY
 CONUS AIR TO AIR (0-5000 FT. ACL)

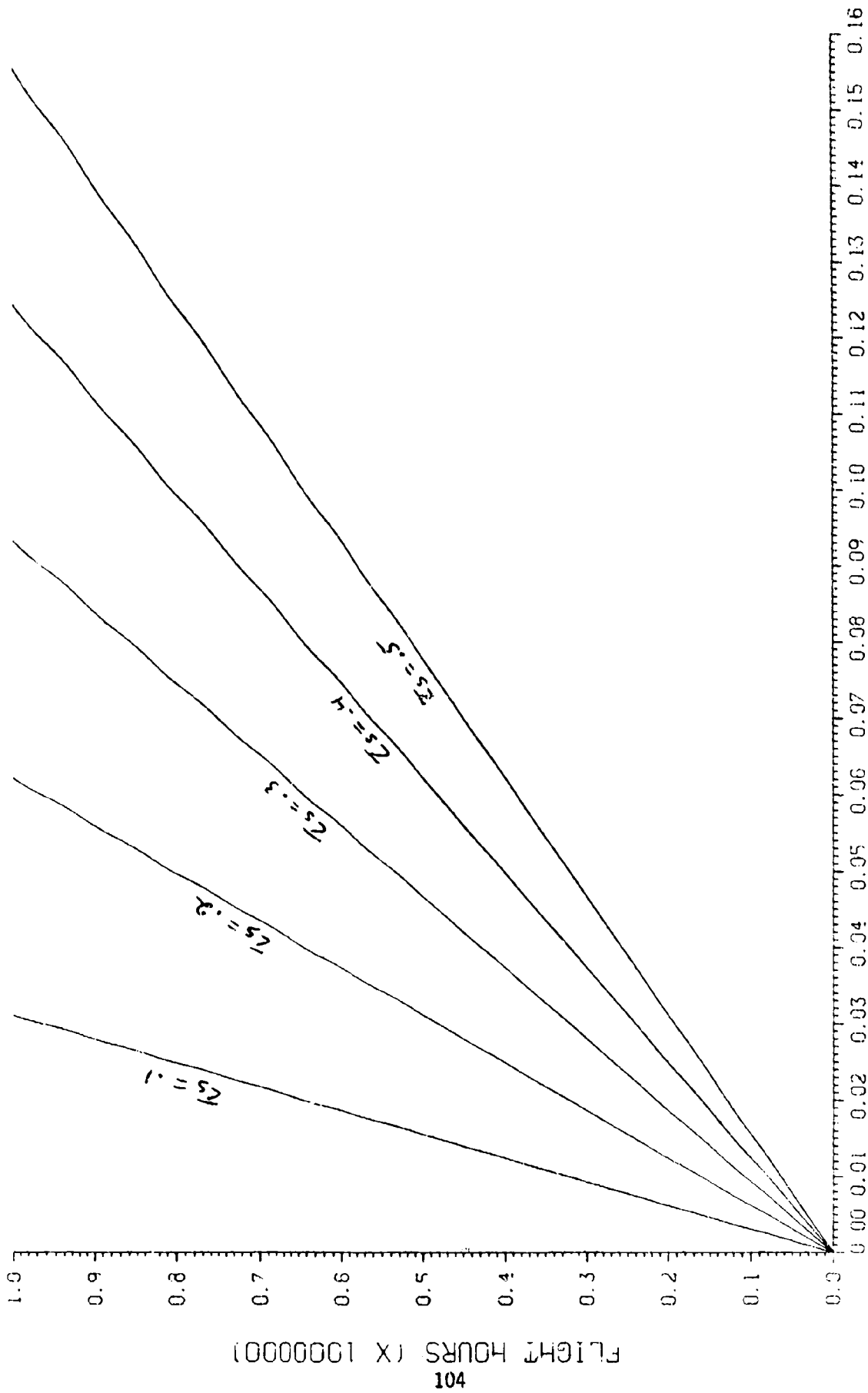
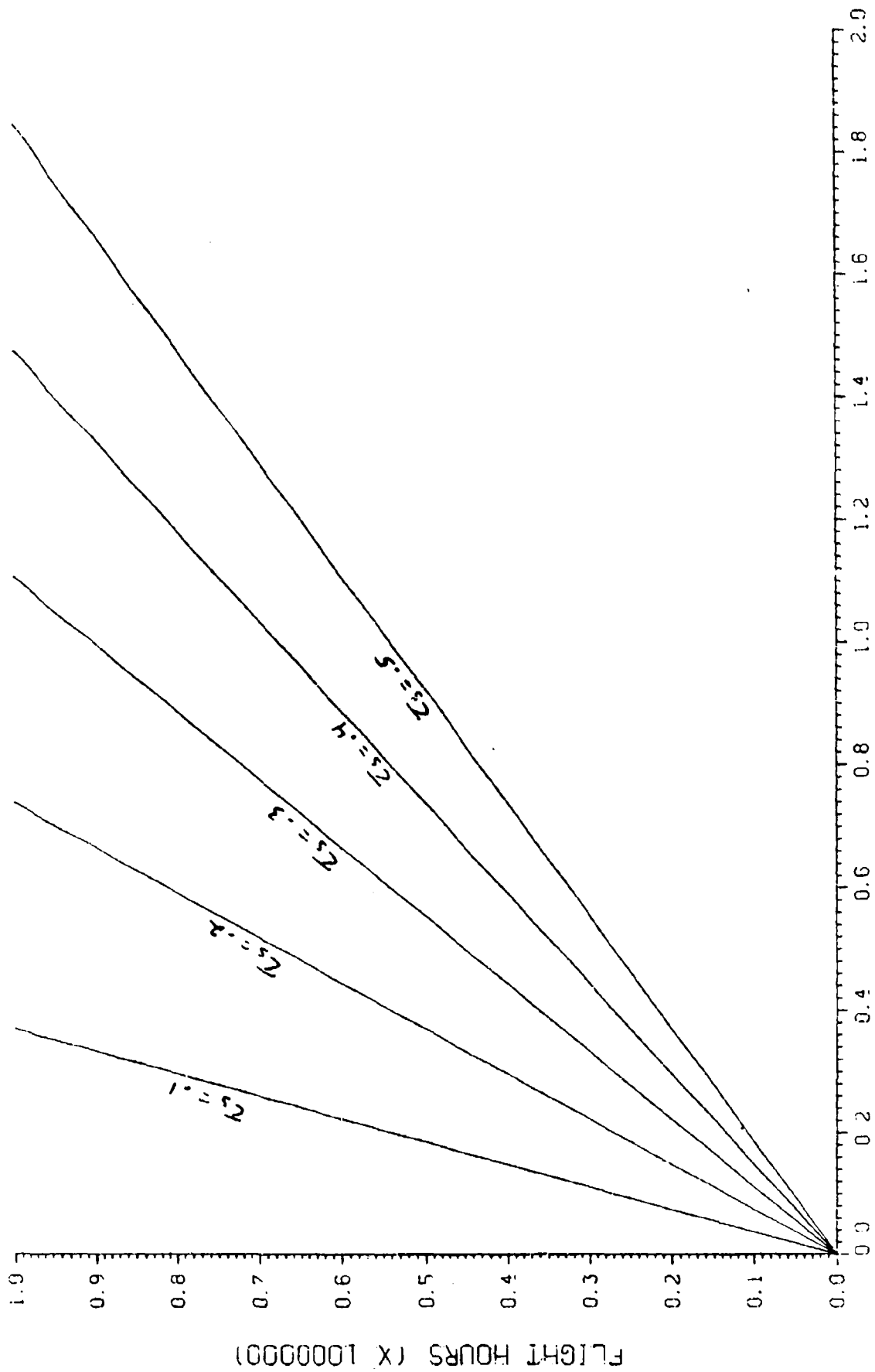
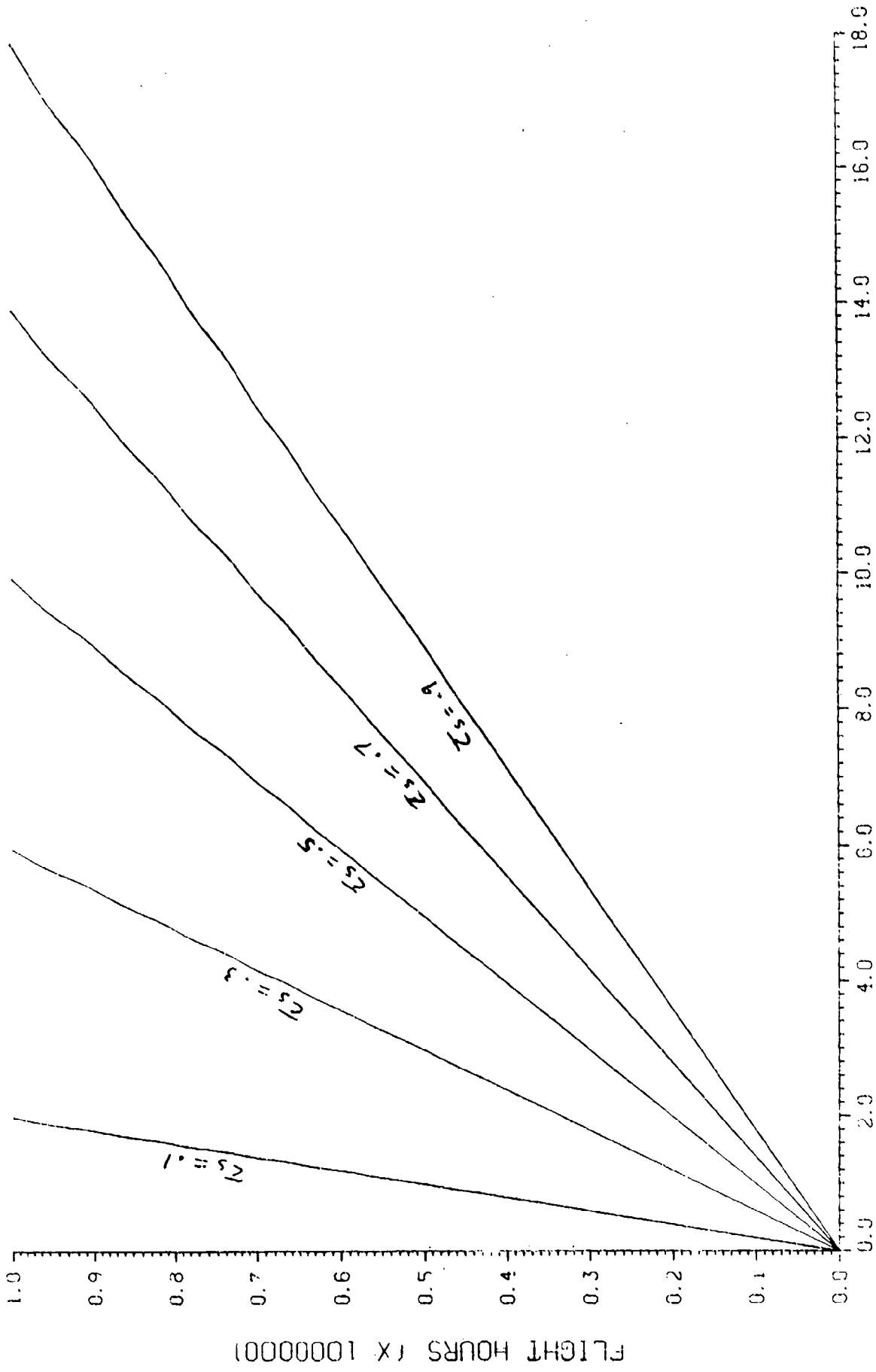


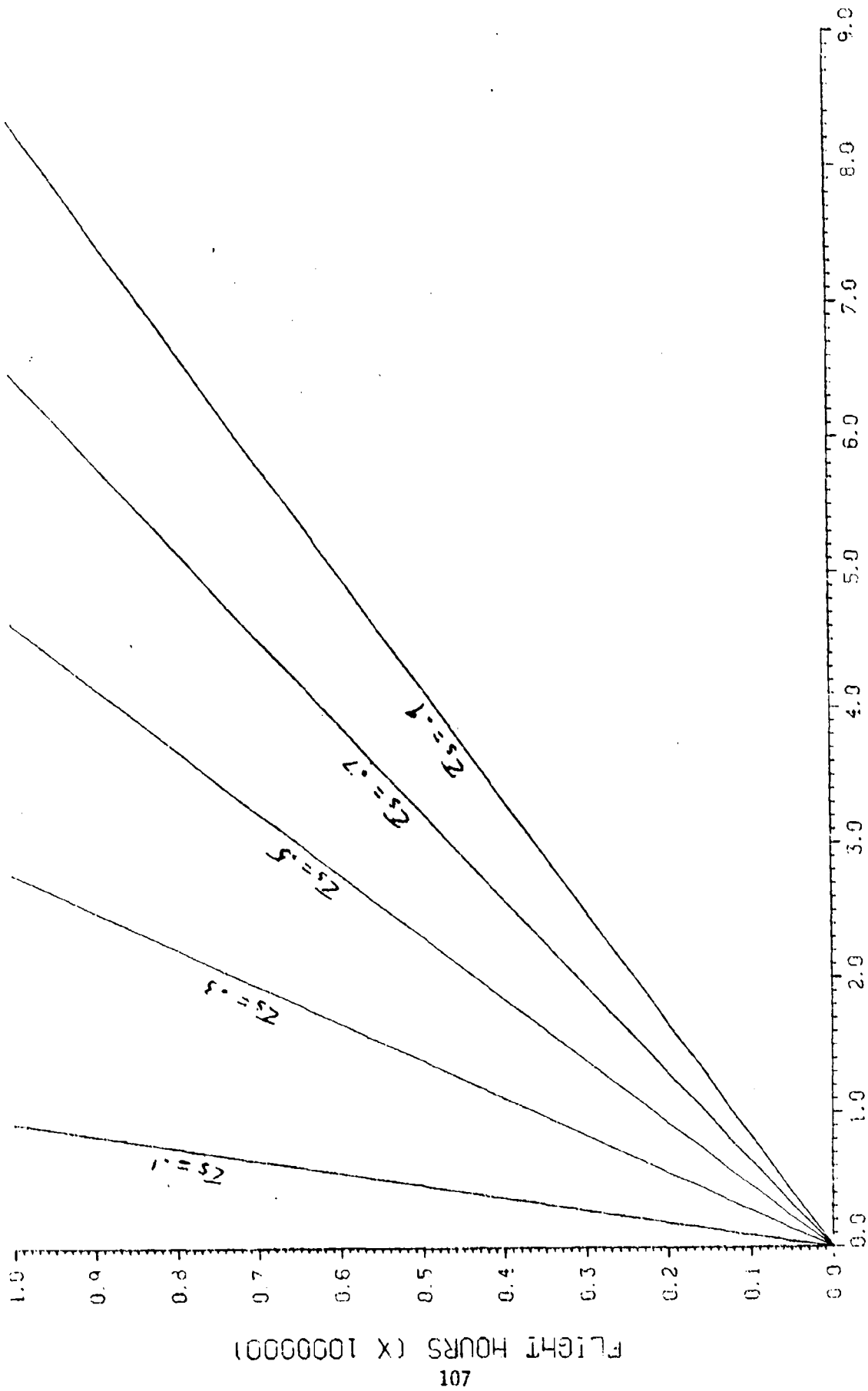
FIG 41 F-15 RPD, 500 KT. WINDSHIELD CAPABILITY
 WINDSHIELD BIRD PENETRATIONS
 EUROPE, AIR TO AIR 10-5000 FT. AGL



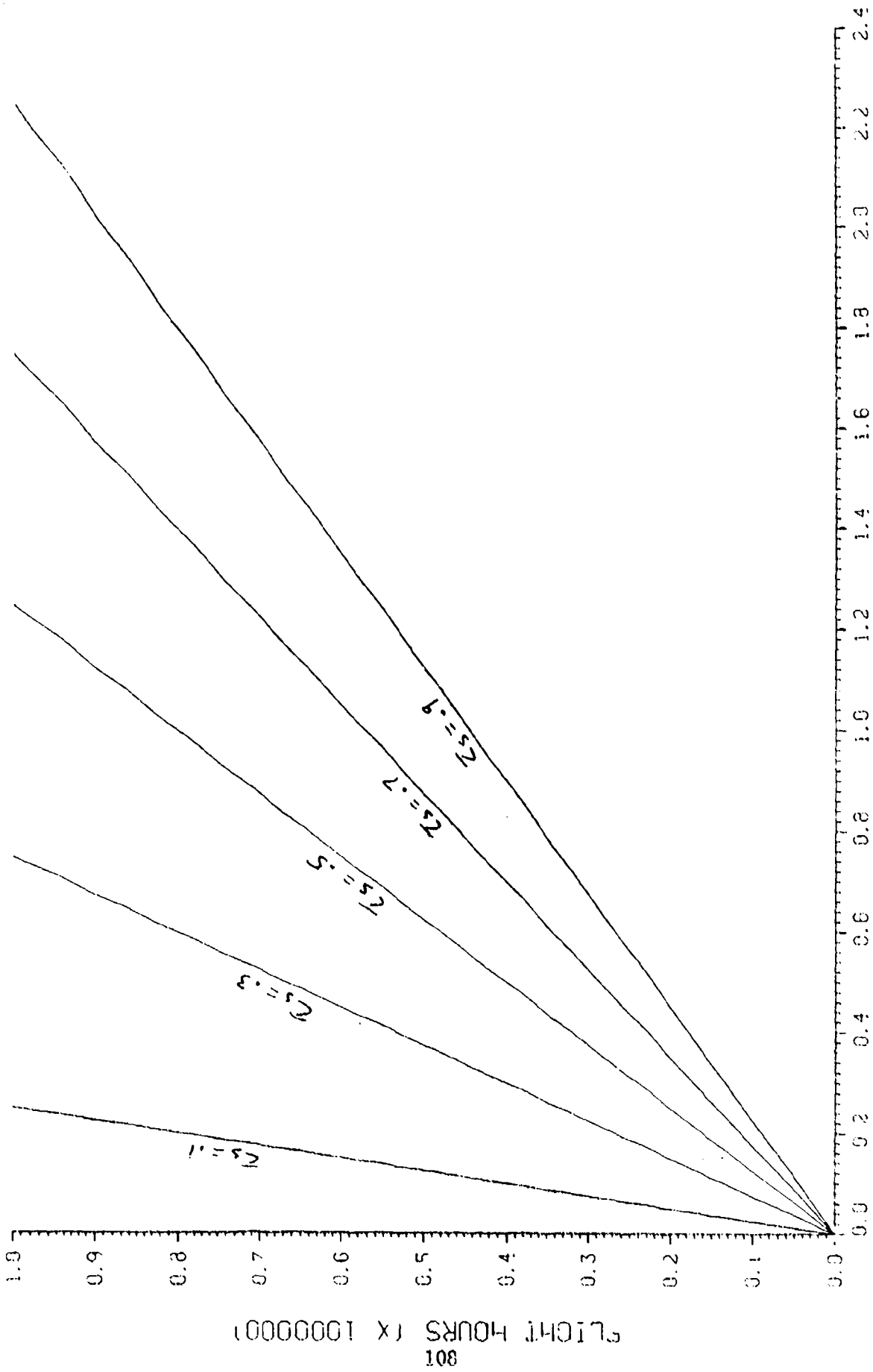
CANOPY BIRD PENETRATIONS
 FIG. 42 F-15 RPD, 350 KI. CANOPY CAPABILITY
 EUROPE, AIR TO AIR (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS
 FIG. 43 F-15 RPD, 500 KT. WINDSHIELD CAPABILITY
 CONUS, AIR TO GROUND (0-5000 FT. AGL)



CANOPY BIRD PENETRATIONS
 FIG 44 F-15 APD, 350 KT. CANOPY CAPABILITY
 CONUS, ATR TO GROUND (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS
 FIG. 45 F-15 RPD, 500 KT. WINDSHIELD CAPABILITY
 EUROPE, AIR TO GROUND (0-5000 FT. AGL)

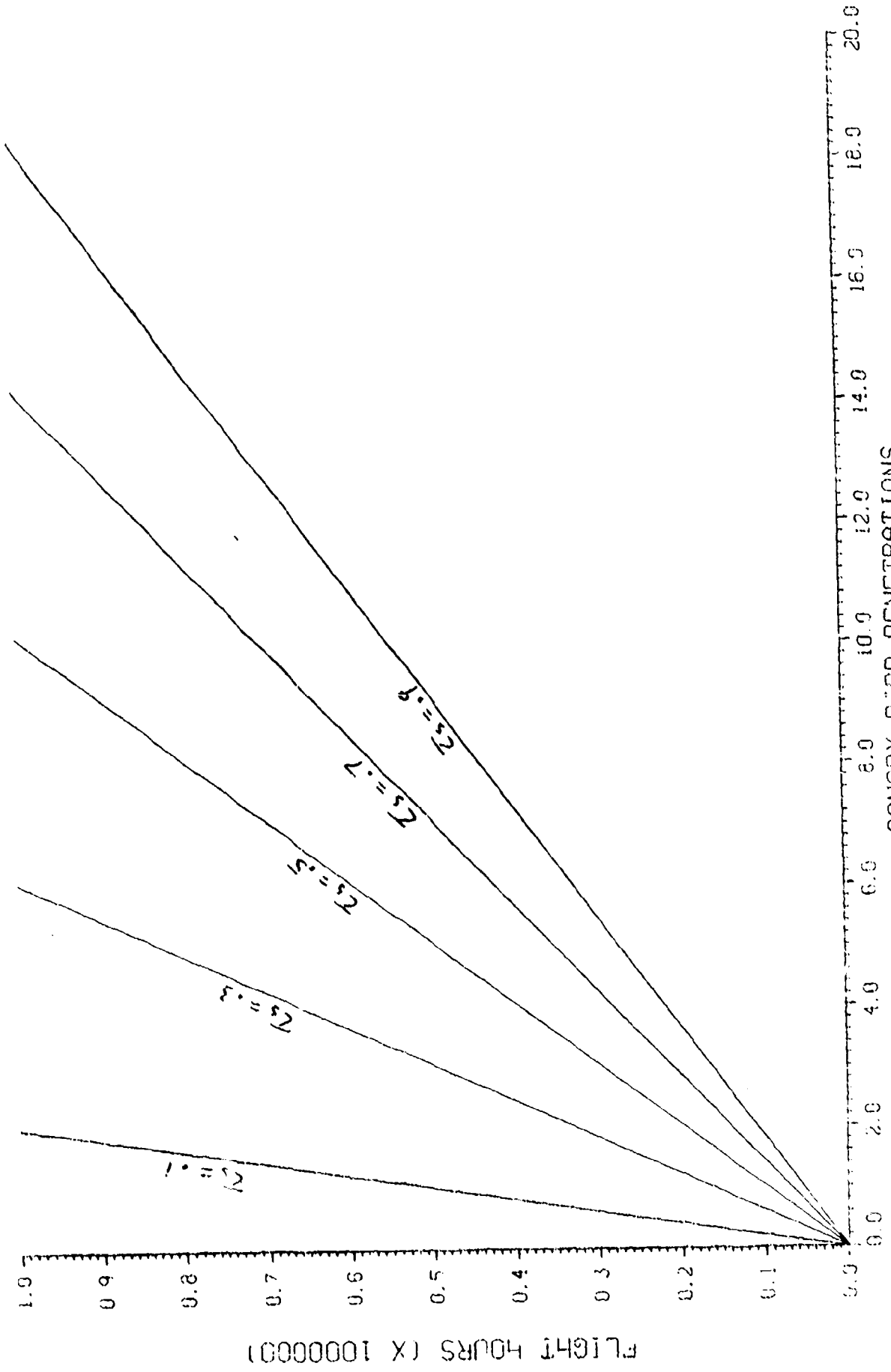
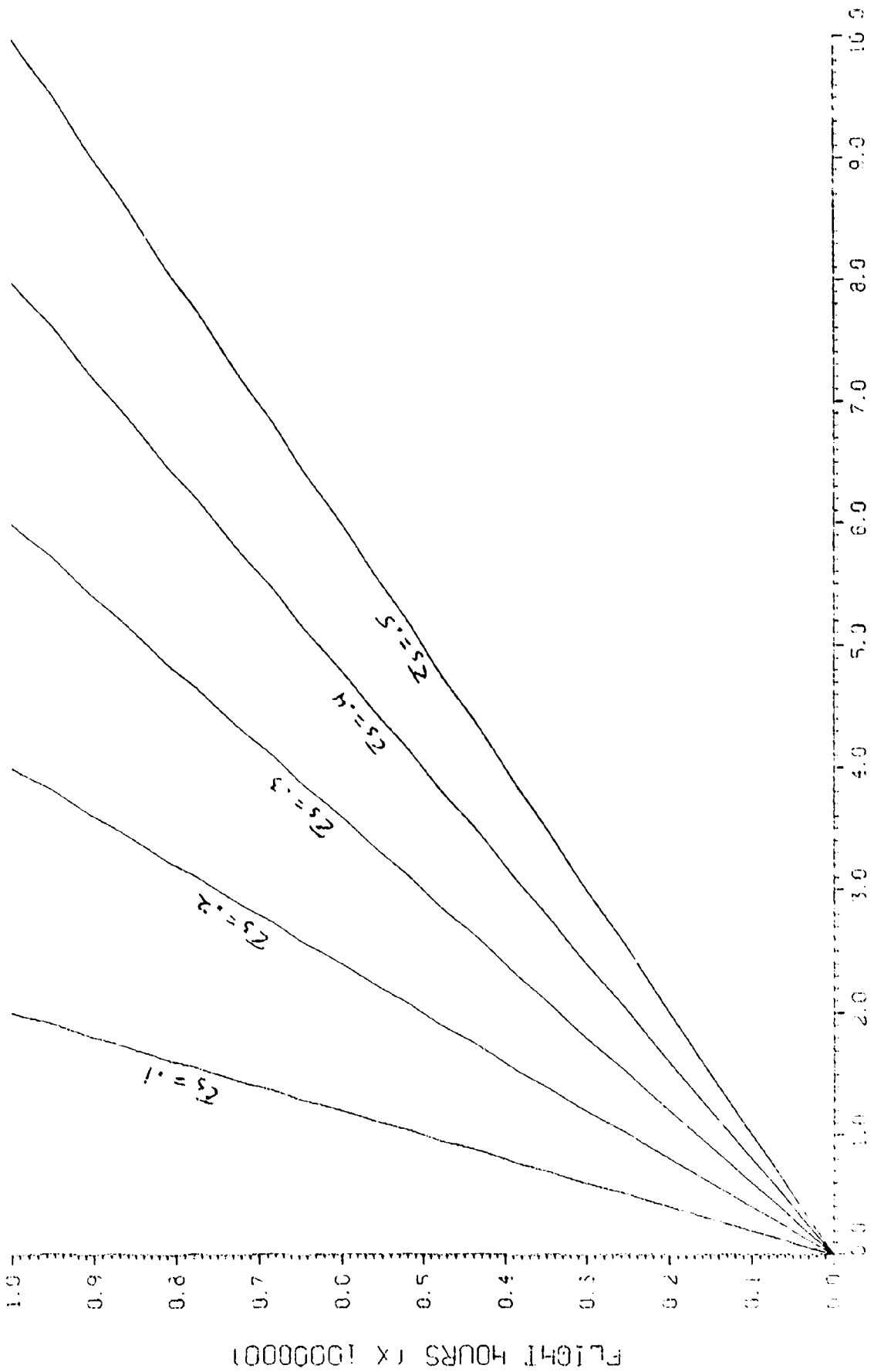


FIG. 46 F-15 RPD, 350 KT. CANOPY CAPABILITY
 CARGO AIR TO GROUND (0-5000 FT AGL)

FLIGHT HOURS (X 1000000)



WINDSHIELD BIRD PENETRATIONS
 FIG 47 F-15 DRG PRESENT WINDSHIELD CAPABILITY
 COND. AIR TO AIR (0-5000 FT. AGL)

FLIGHT HOURS (X 1000000)

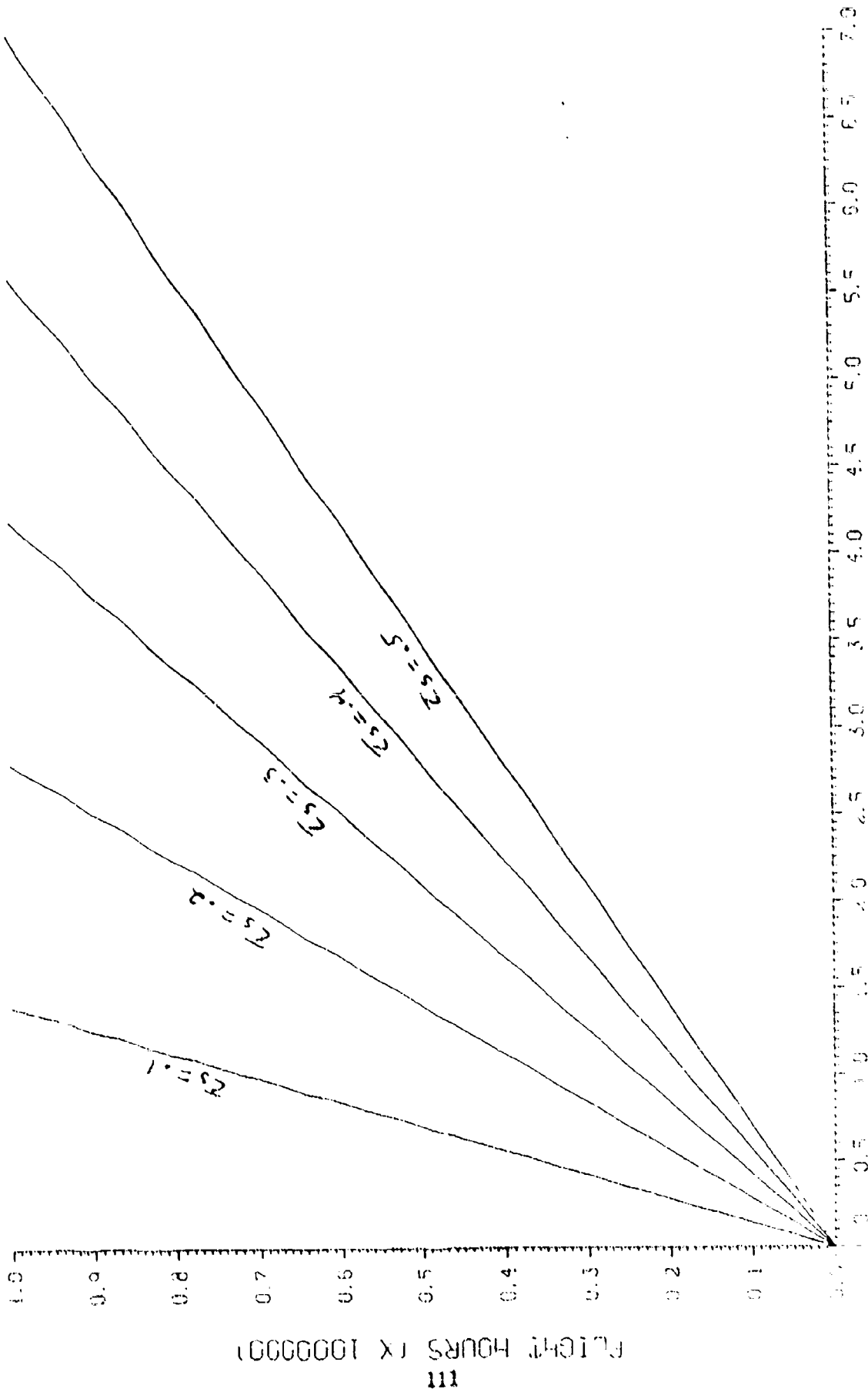
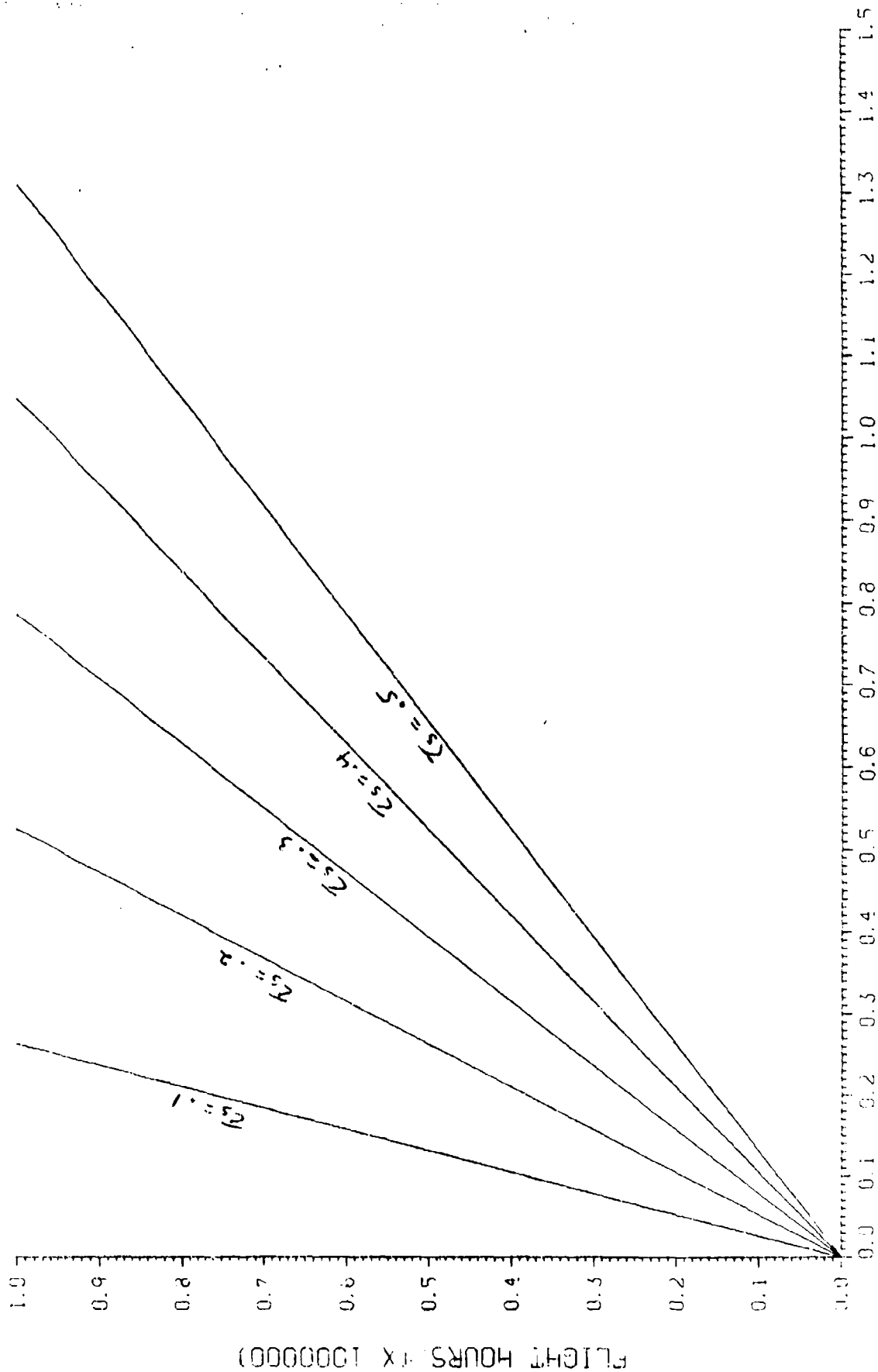
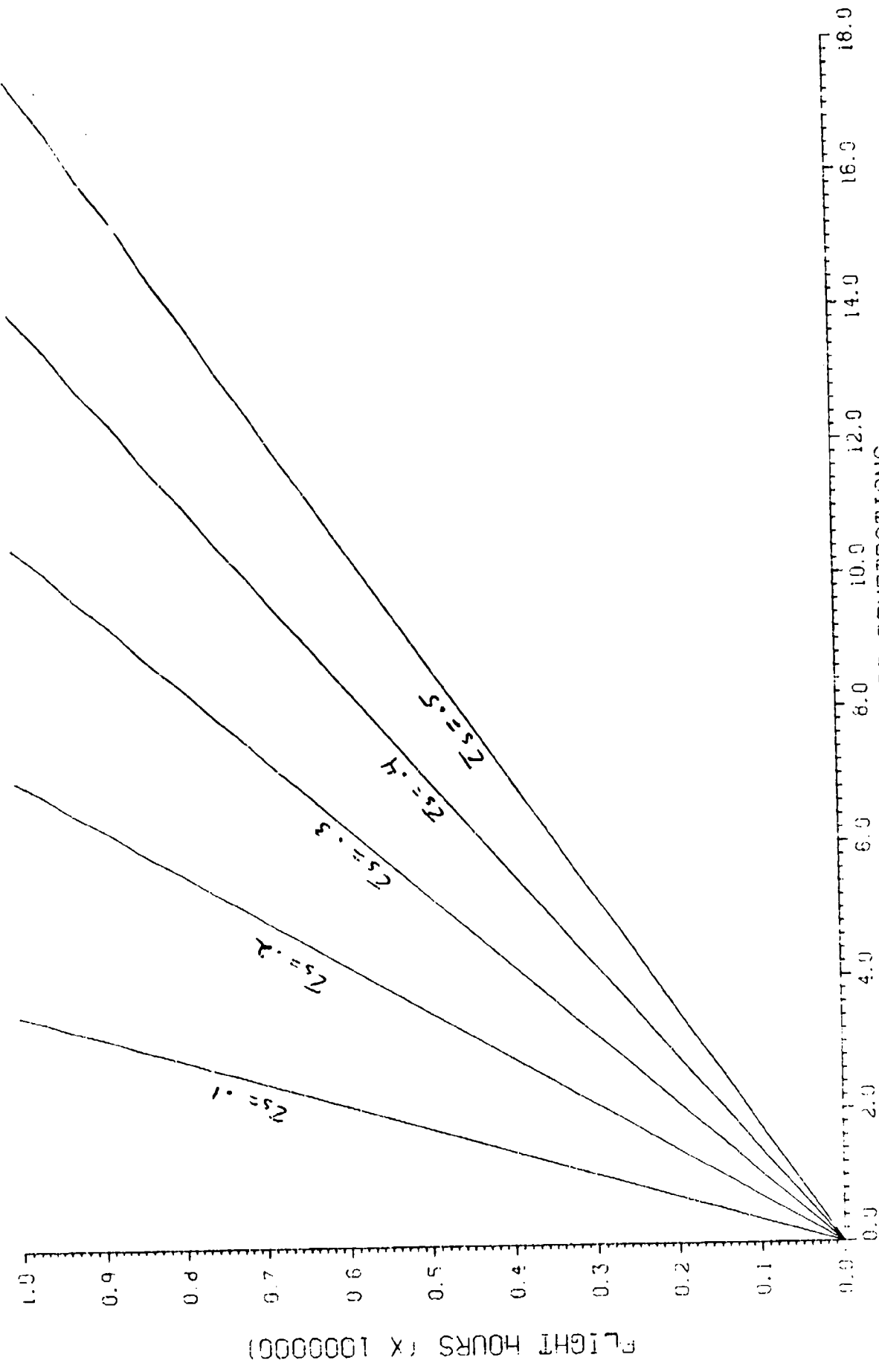


FIG 48 CANOPY BIRD PENETRATIONS
 CANOPY BIRD PENETRATIONS
 CANOPY BIRD PENETRATIONS
 CANOPY BIRD PENETRATIONS
 CANOPY BIRD PENETRATIONS

FLIGHT HOURS (X 100000)

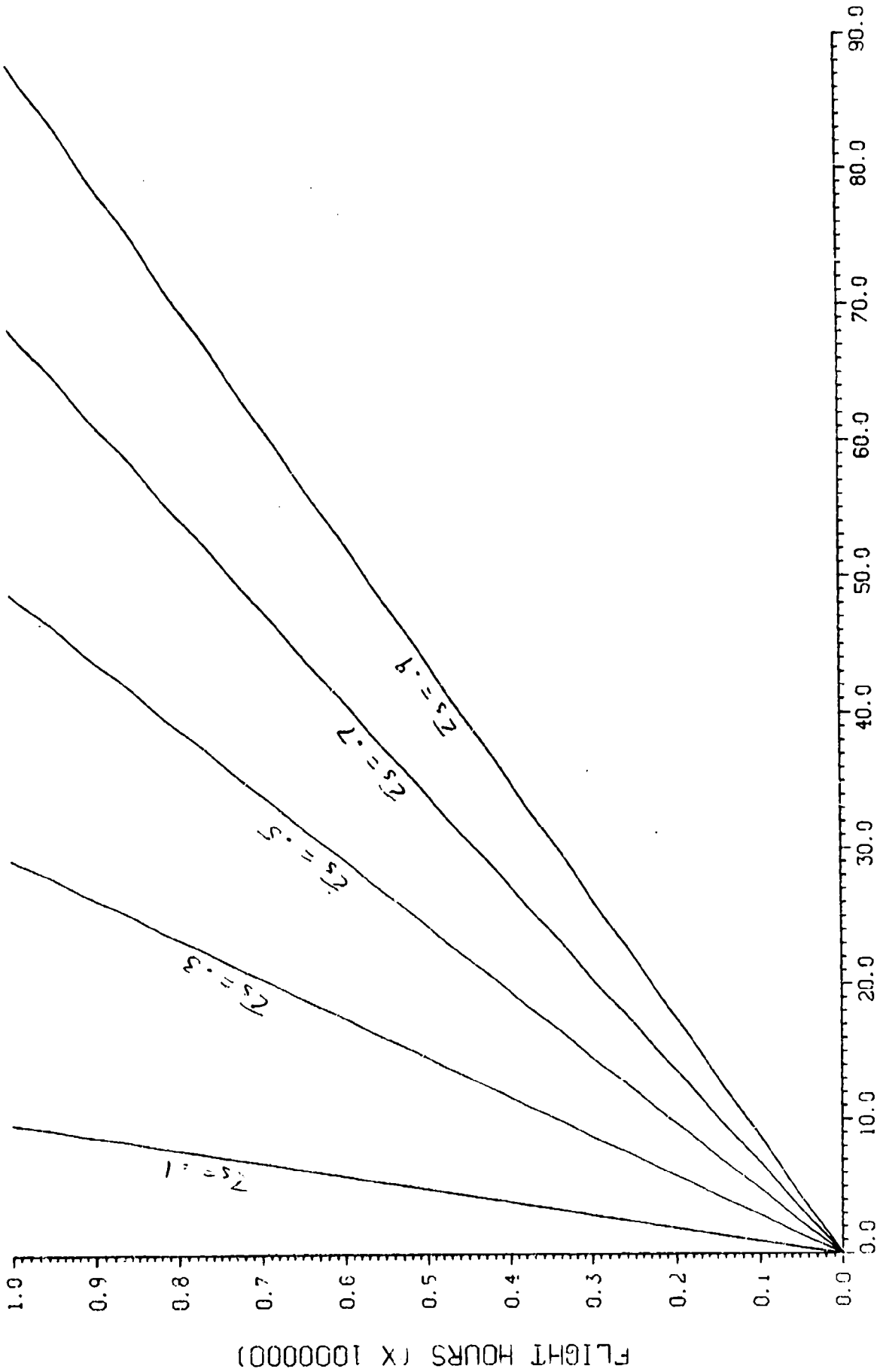


WINDSHIELD BIRD PENETRATIONS
 FIG. 49 F-15 DRF, PRESENT WINDSHIELD CAPABILITY
 CUTOFF AIR TO AIR (0-5000 FT. AGL)



CANOPY BIRD PENETRATIONS
 FIG 50 F-15 DRF, PRESENT CANOPY CAPABILITY
 EUROPE, AIR TO AIR (0-5000 FT. AGL)

FLIGHT HOURS (X 1000000)



WINDSHIELD BIRD PENETRATIONS
 FIG. 51 F-15 DRF, PRESENT WINDSHIELD CAPABILITY
 CONUS, AIR TO GROUND (0-5000 FT. AGL)

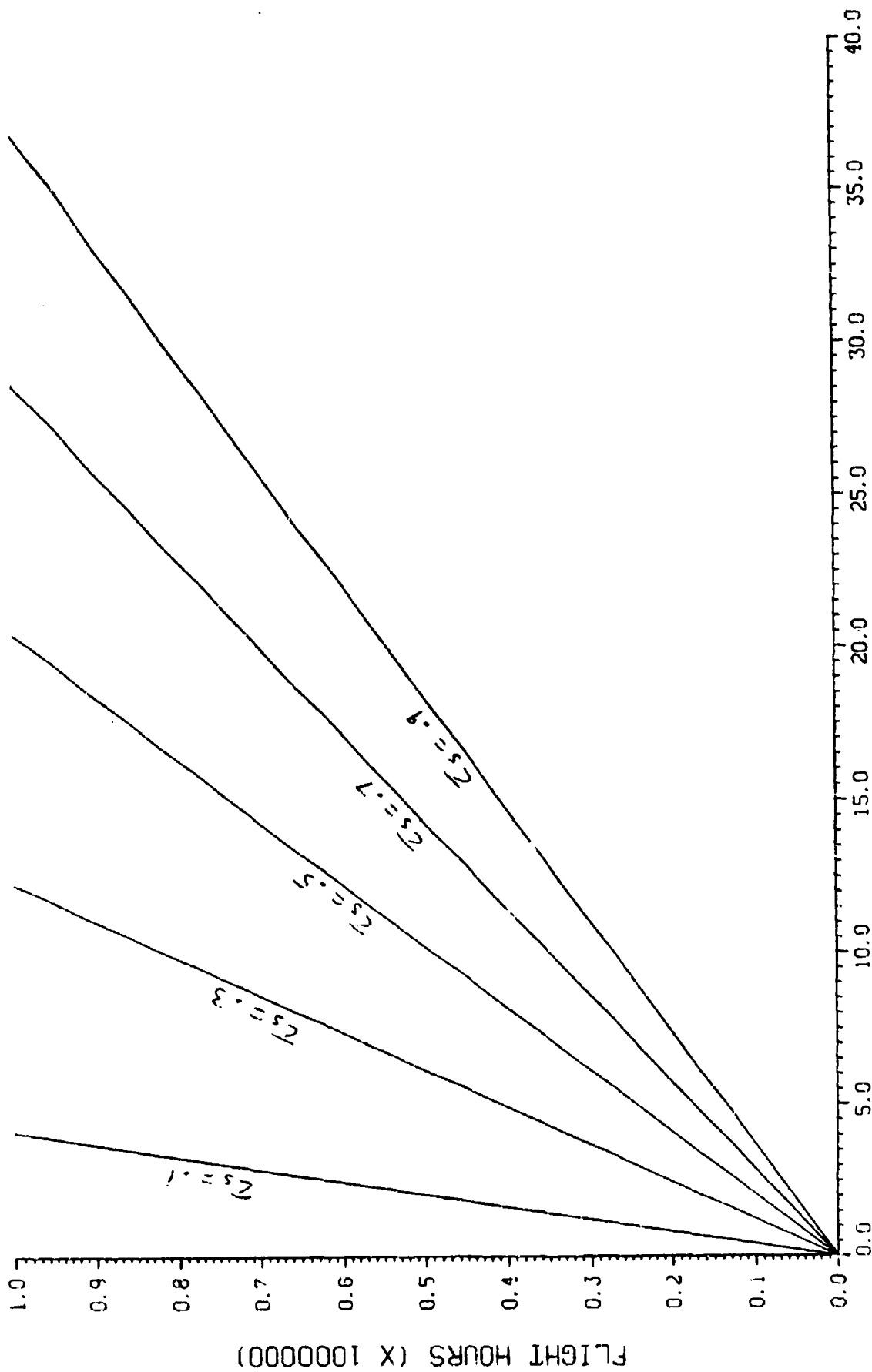
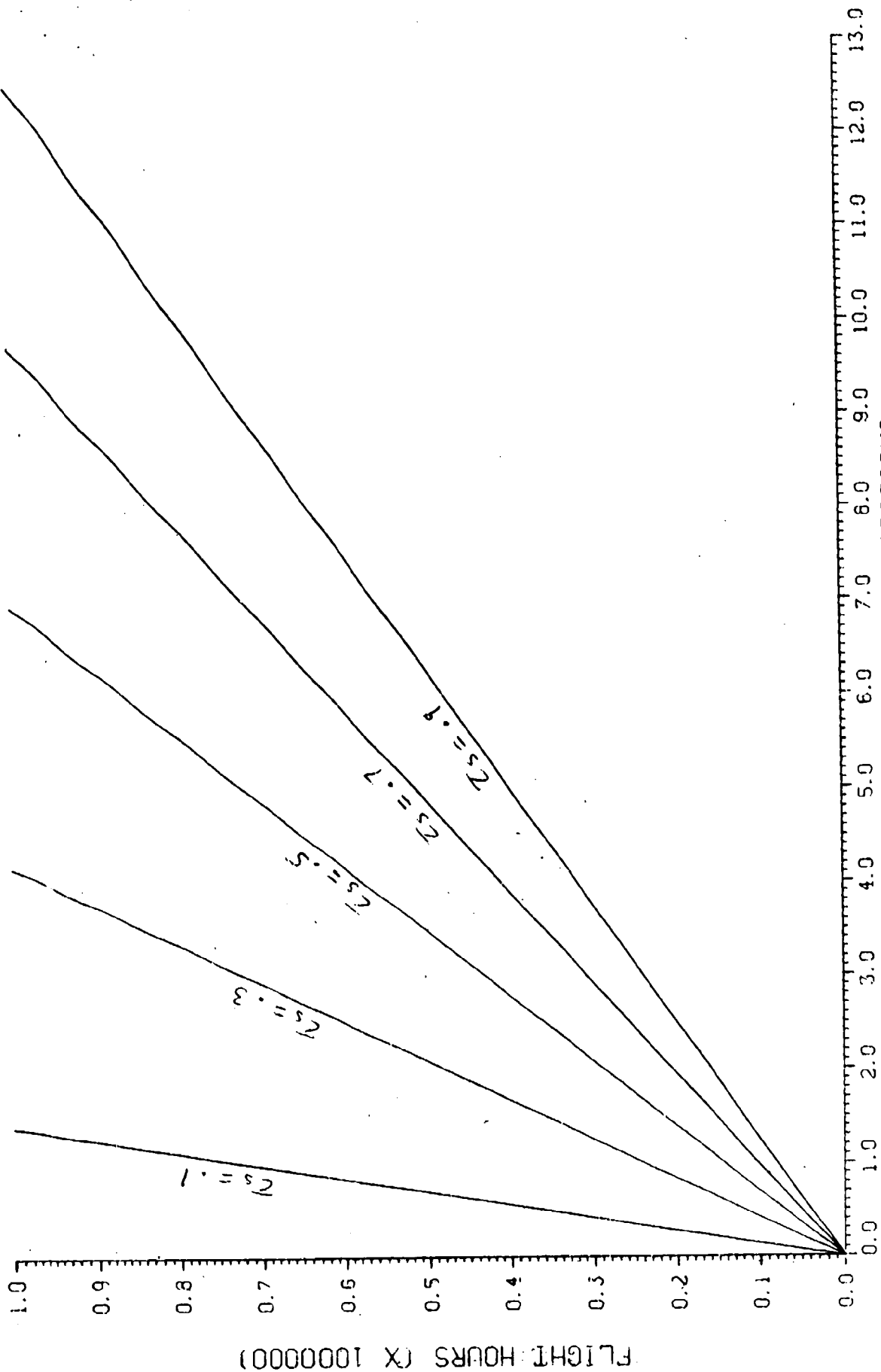


FIG. 52 F-15 DRF, PRESENT CANOPY CAPABILITY
 CONUS, AIR TO GROUND (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS
 FIG. 53 F-15 DRF, PRESENT WINDSHIELD CAPABILITY
 EUROPE, AIR TO GROUND (0-5000 FT. AGL)

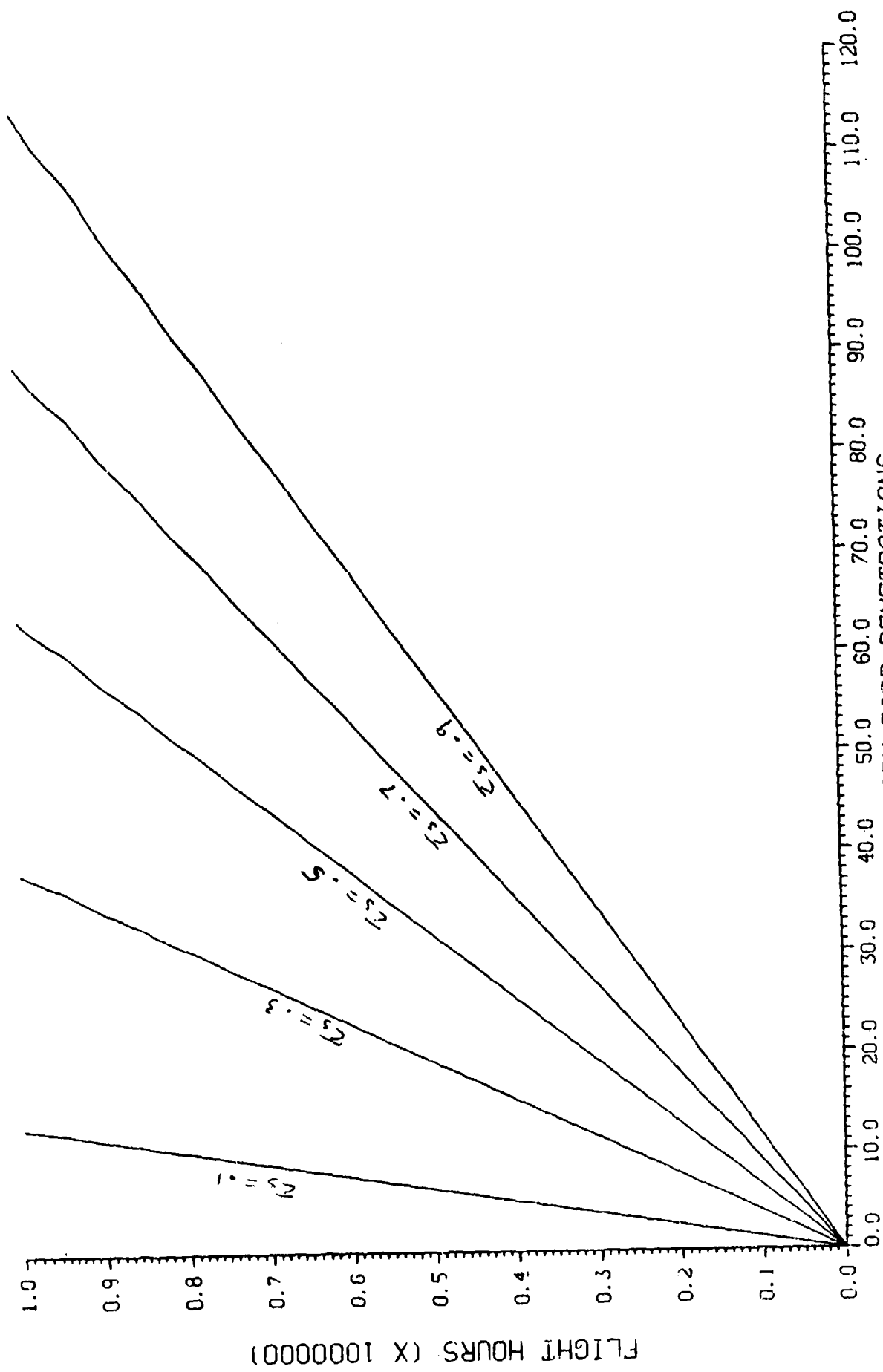
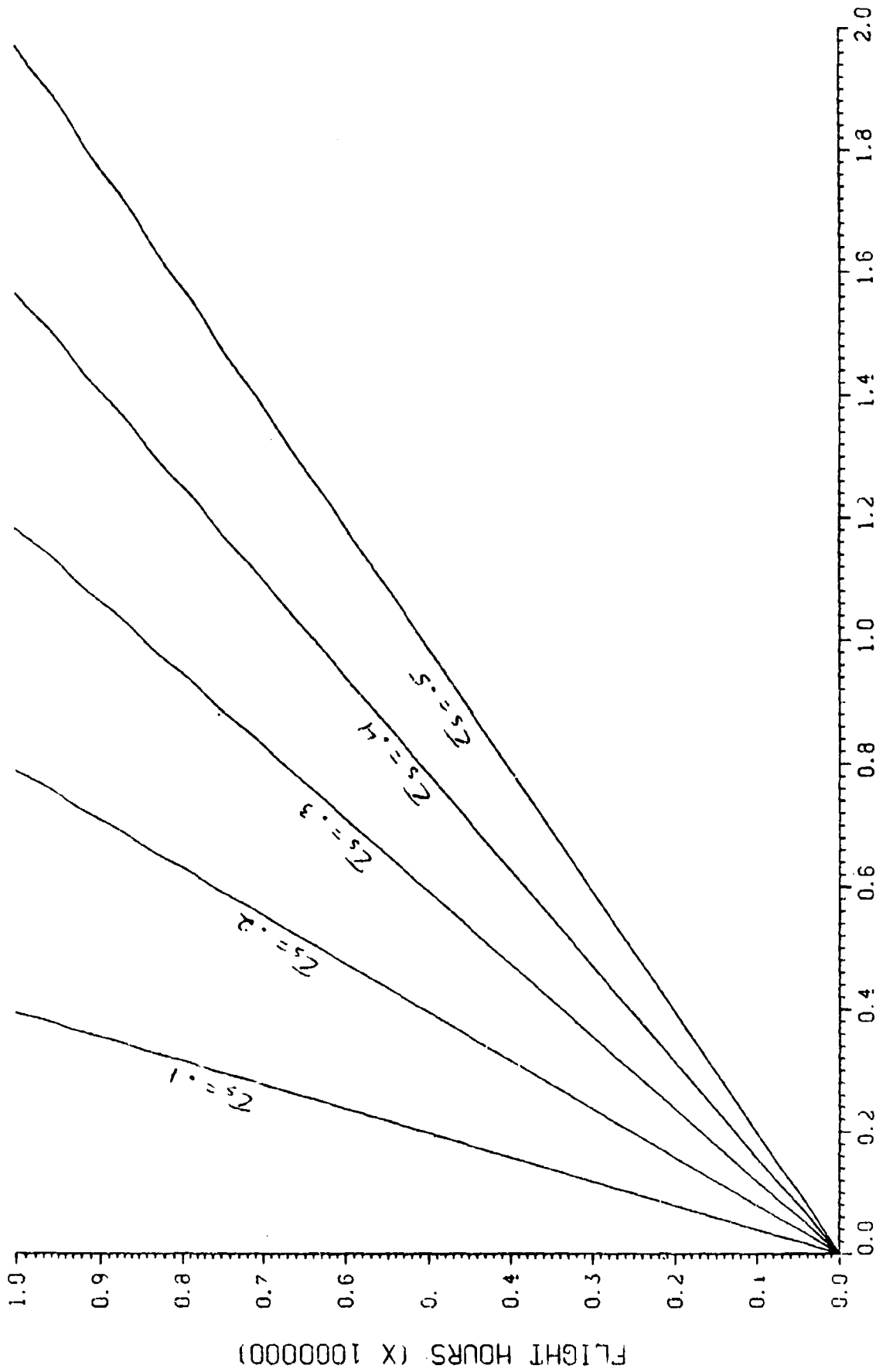
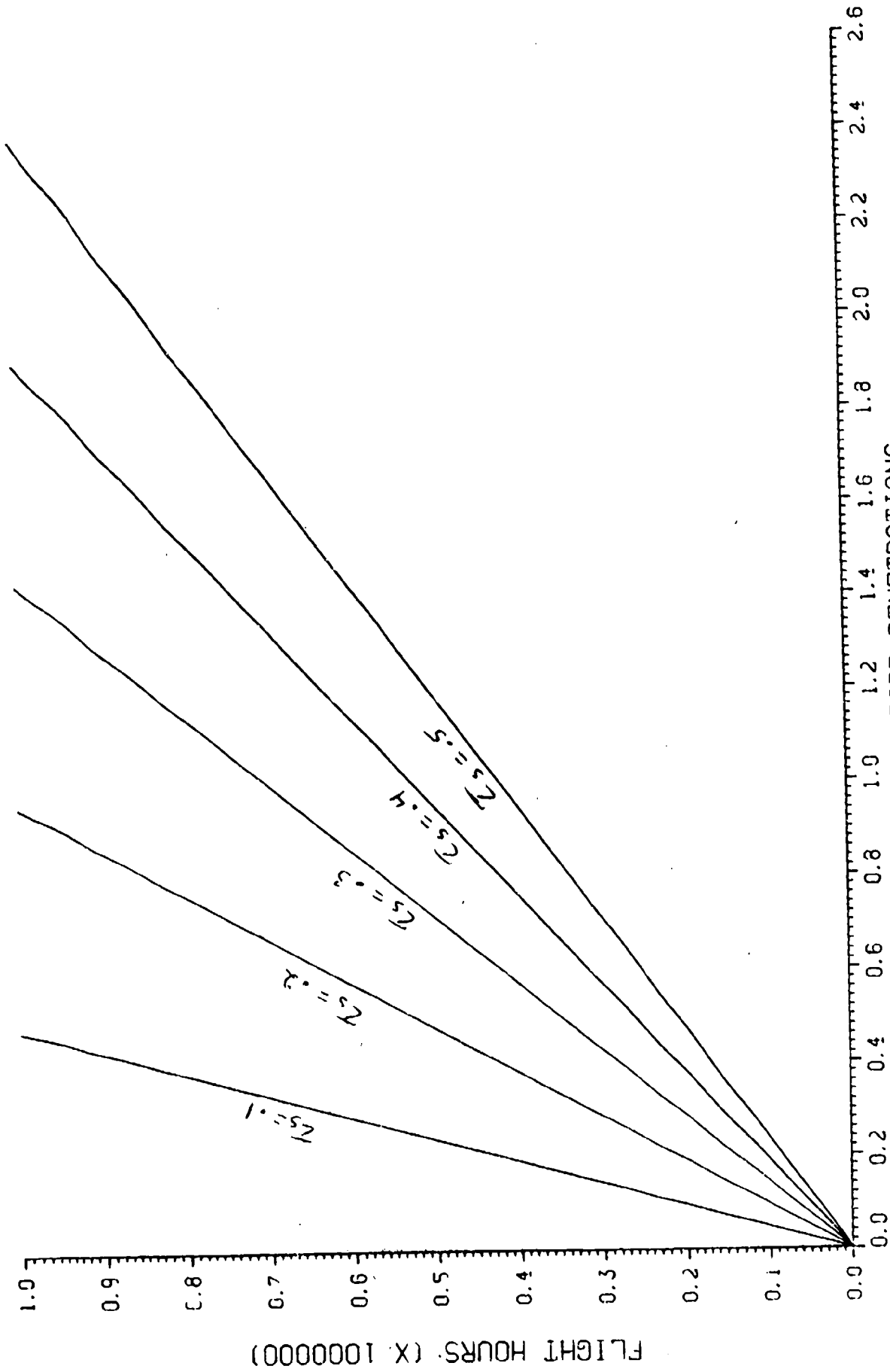


FIG. 54 F-15 DRF, PRESENT CANOPY CAPABILITY
 EUROPE, AIR TO GROUND (0-5000 FT. AGL)

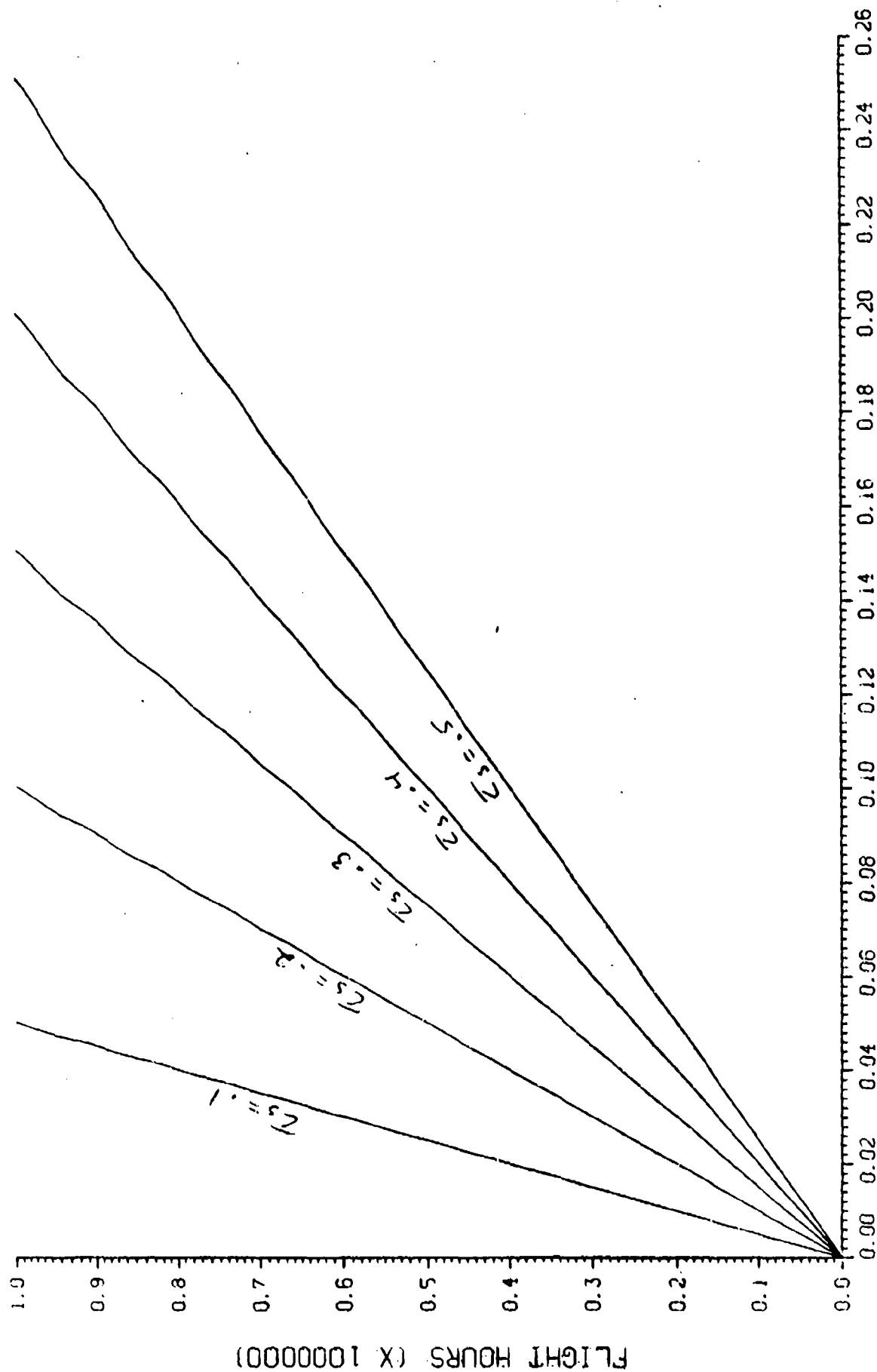


WINDSHIELD BIRD PENETRATIONS

FIG. 55 F-15 DRF, 450 KT. WINDSHIELD CAPABILITY
CONUS, AIR TO AIR (0-5000 FT. AGL)



CANOPY BIRD PENETRATIONS
 FIG. 56 F-15 DRF, 300 KT. CANOPY CAPABILITY
 CONUS, AIR TO AIR (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS

FIG. 57 F-15 DRF, 450 KT. WINDSHIELD CAPABILITY
EUROPE, AIR TO AIR (0-5000 FT. AGL)

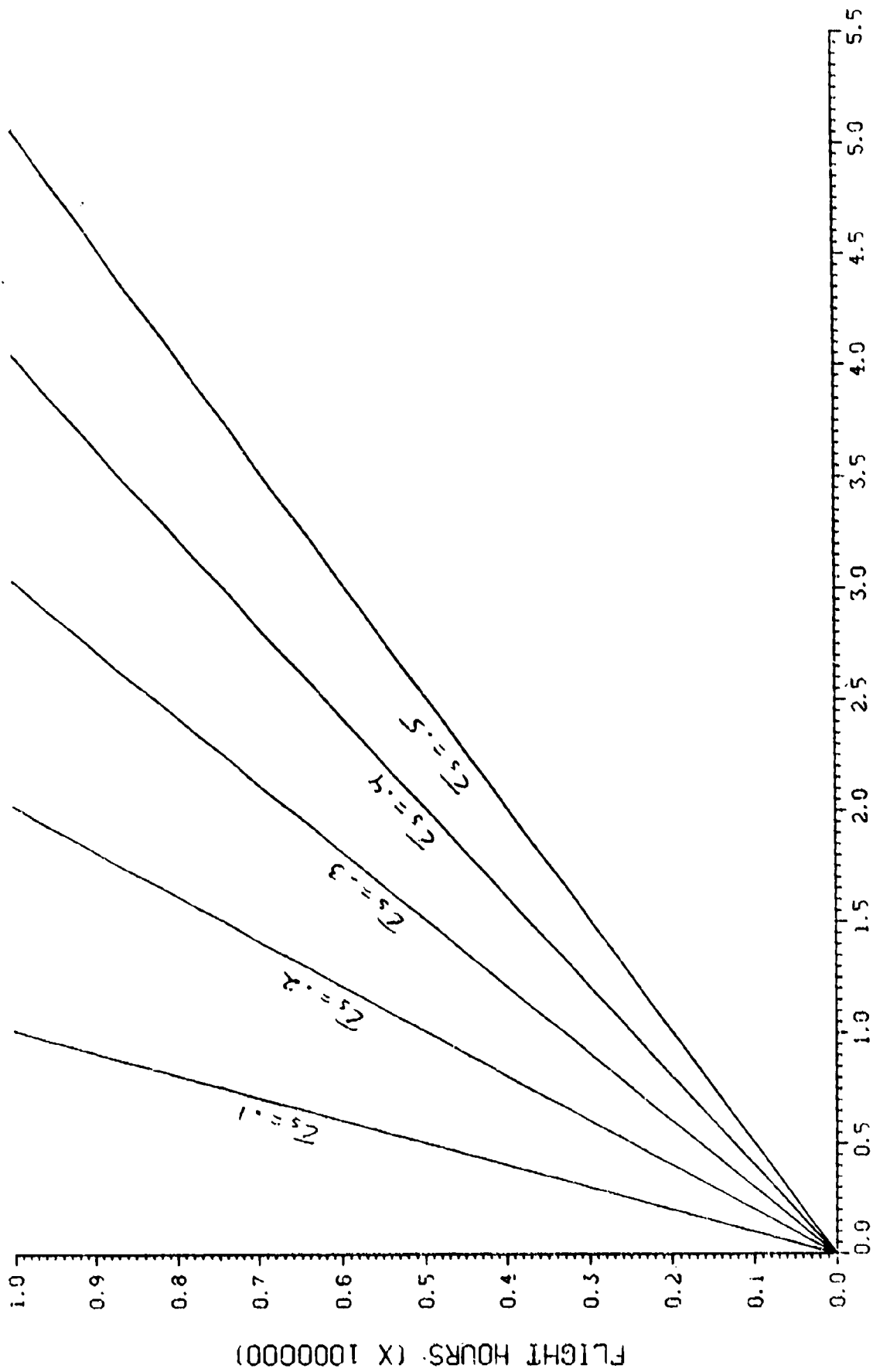
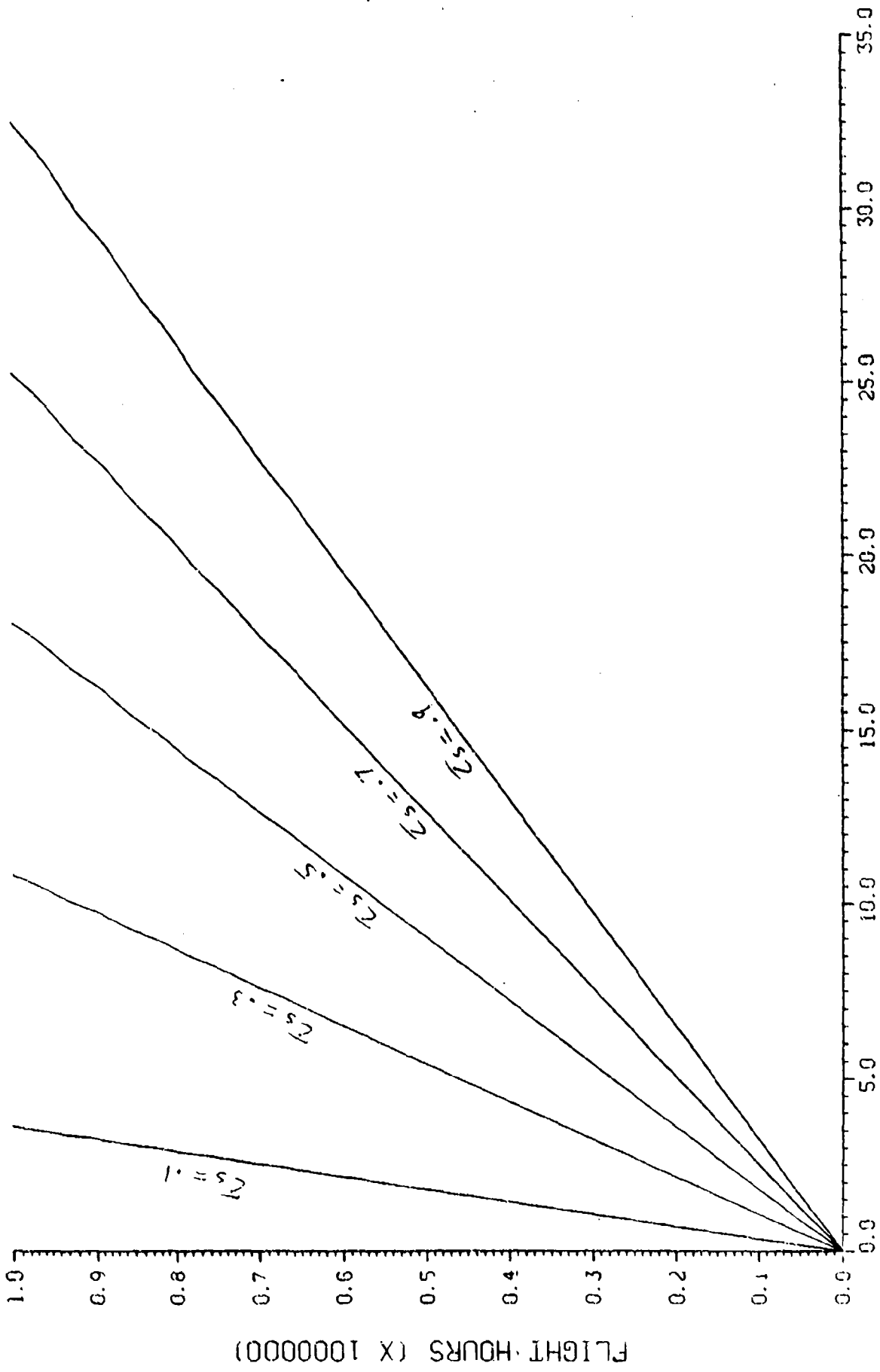
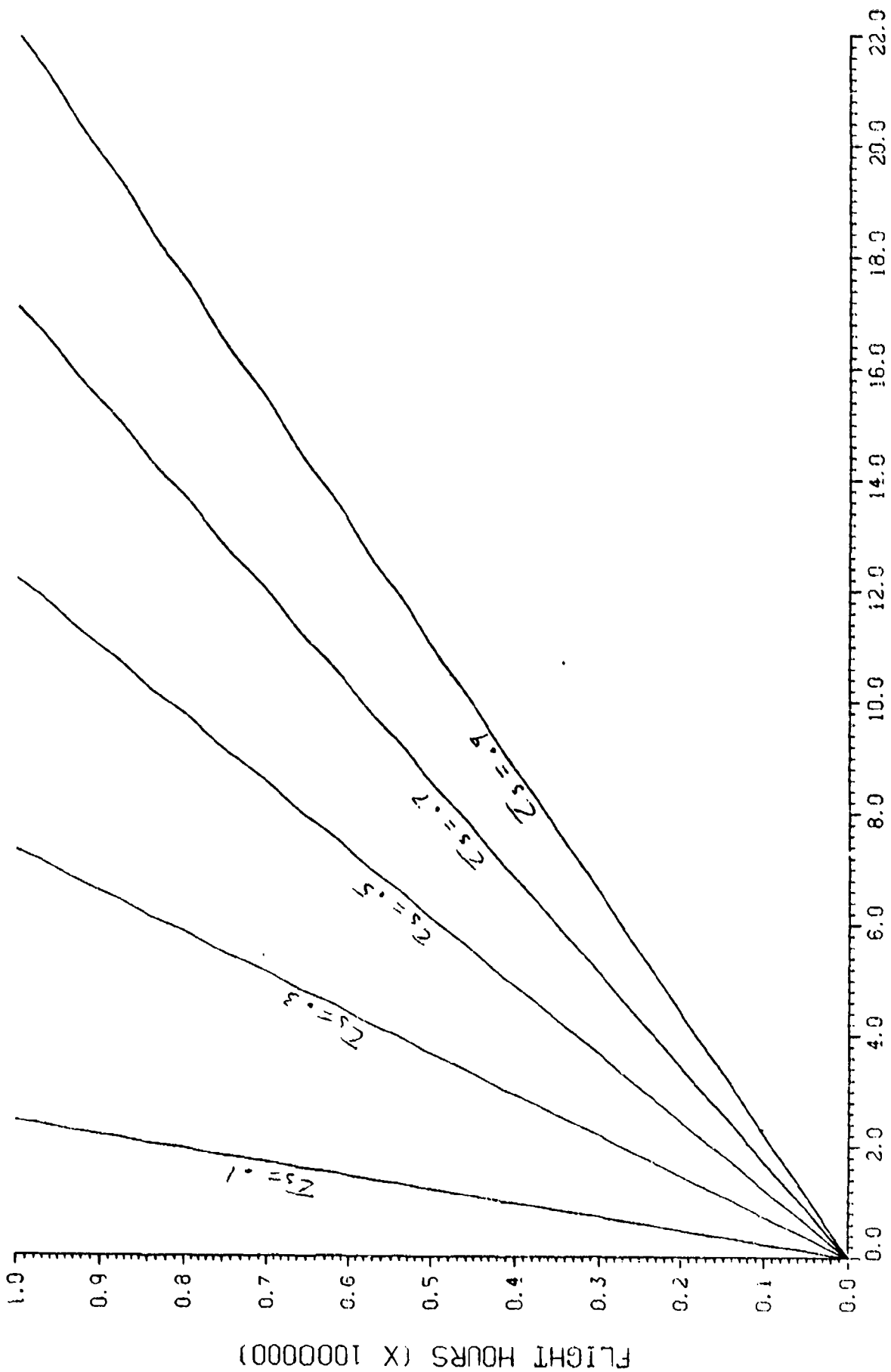


FIG. 58 F-15 DRF, 300 KT. CANOPY CAPABILITY
EUROPE, AIR TO AIR (0-5000 FT. AGL)

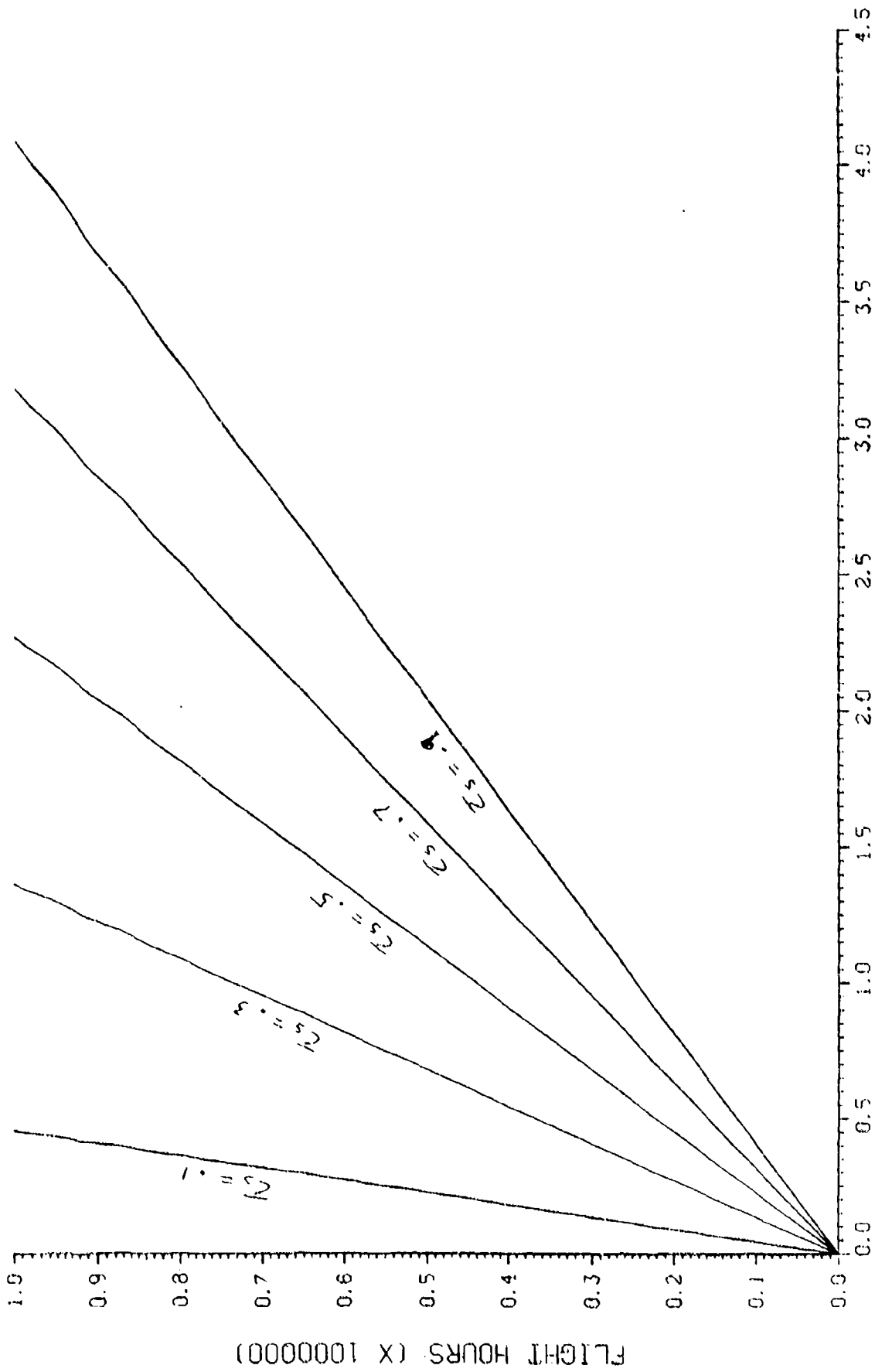


WINDSHIELD BIRD PENETRATIONS
 FIG. 59 F-15 DRF, 450 KT. WINDSHIELD CAPABILITY
 CONUS, AIR TO GROUND (0-5000 FT. AGL)



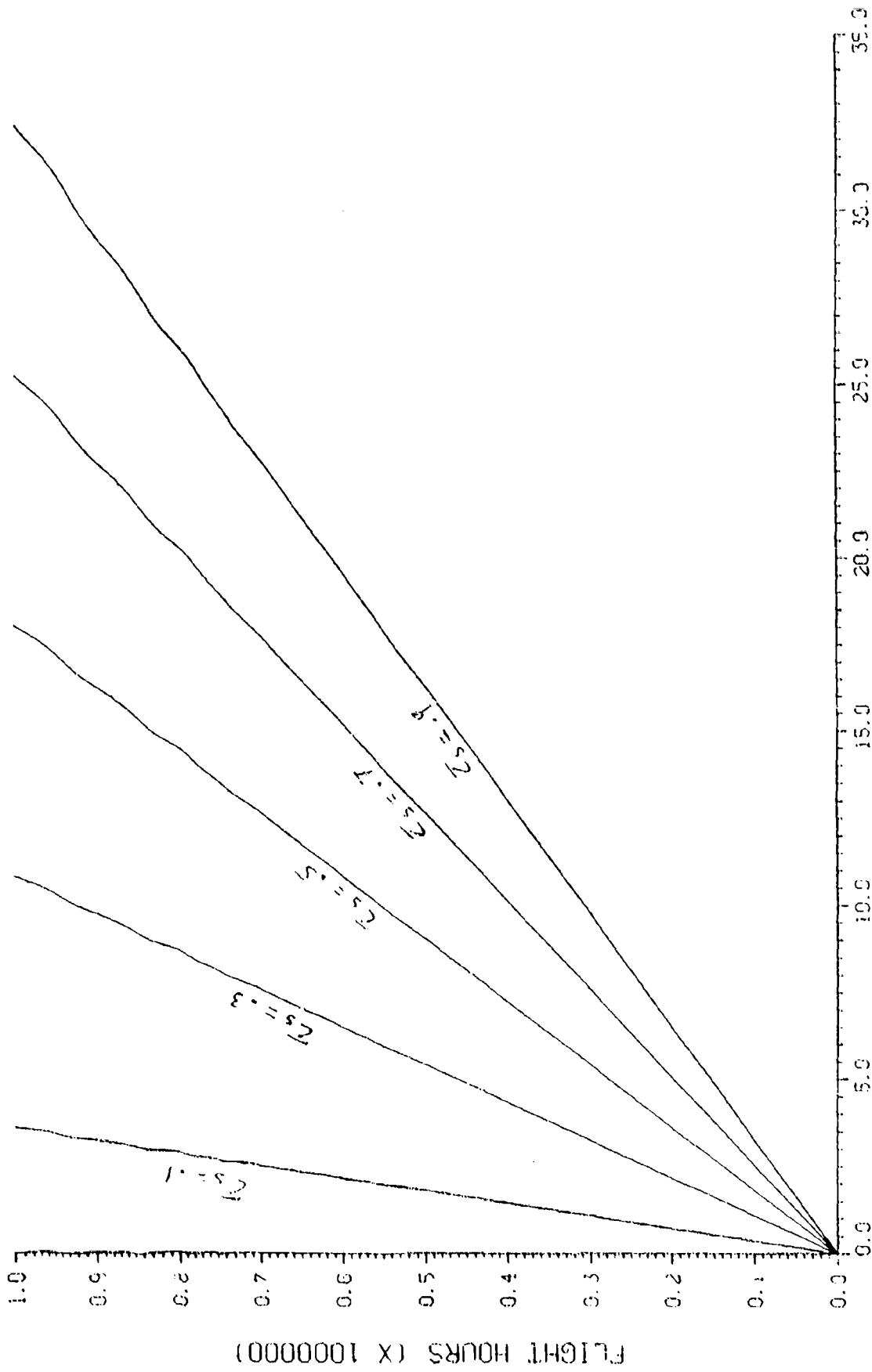
CANOPY BIRD PENETRATIONS

FIG. 60 F-15 DRF, 300 KT. CANOPY CAPABILITY
CONUS, AIR TO GROUND (0-5000 FT. AGL)

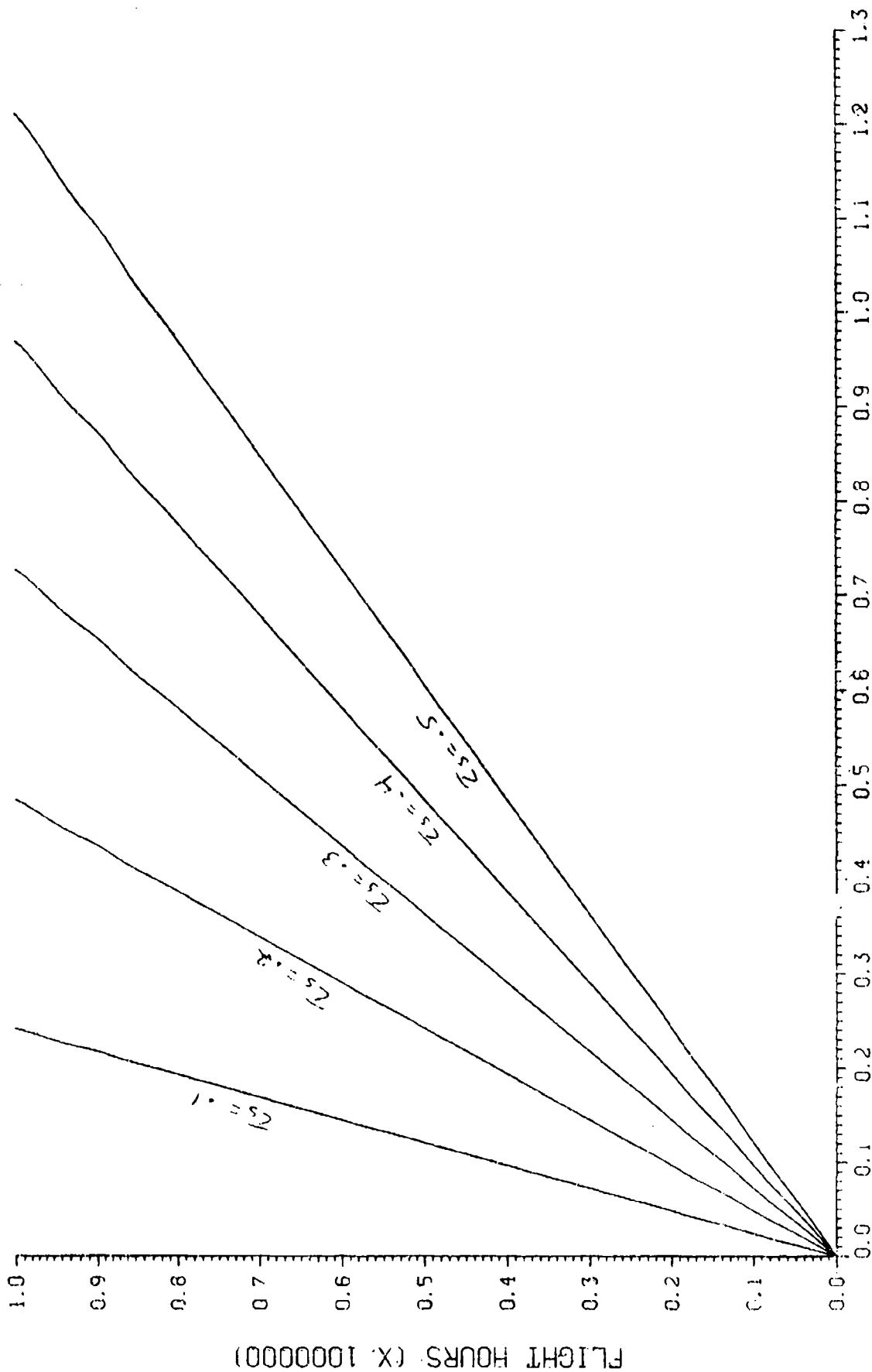


WINDSHIELD BIRD PENETRATIONS

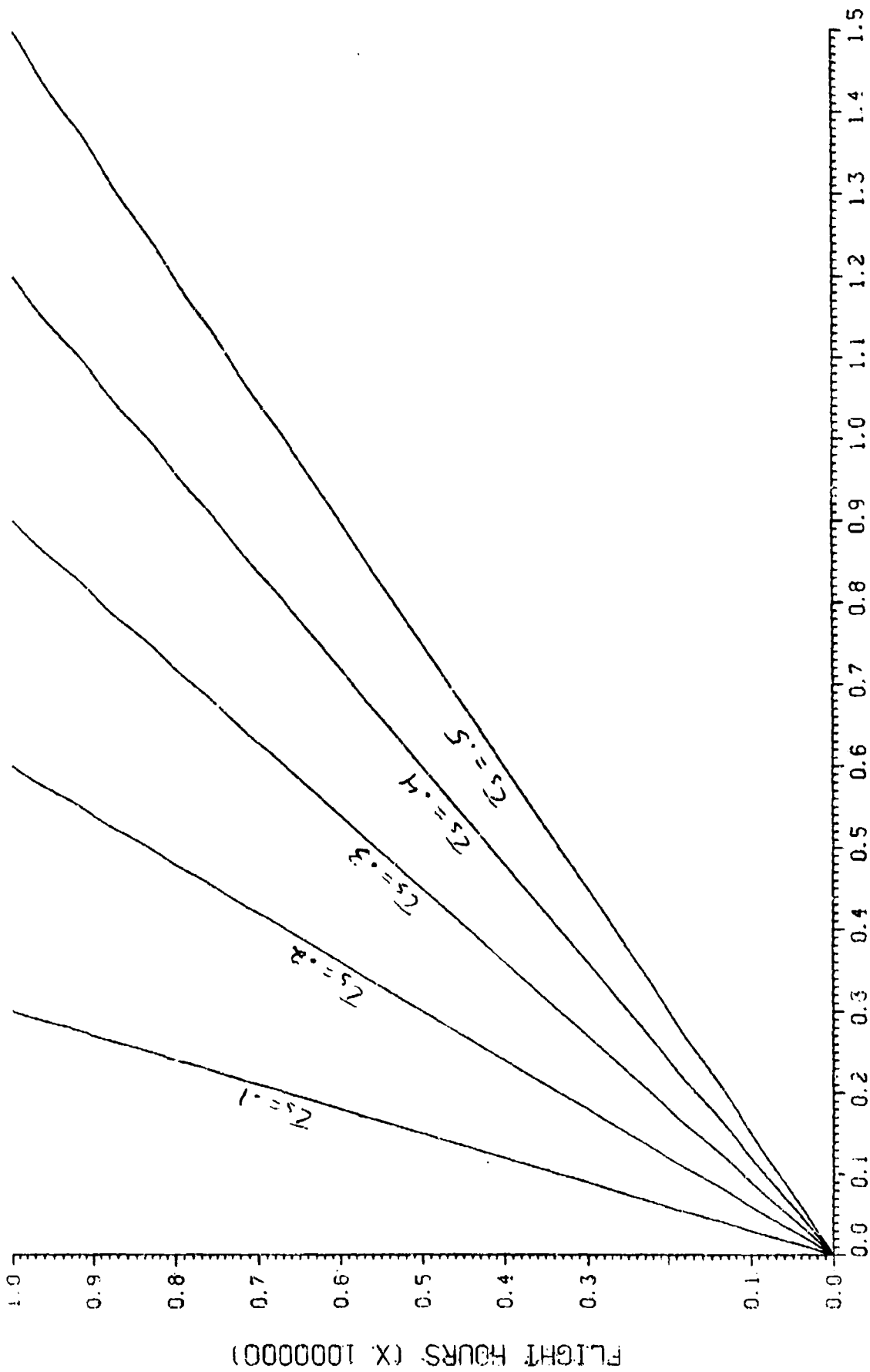
FIG. 61 F-15 DRF, 450 KT. WINDSHIELD CAPABILITY
EUROPE, AIR TO GROUND (0-5000 FT. AGL)



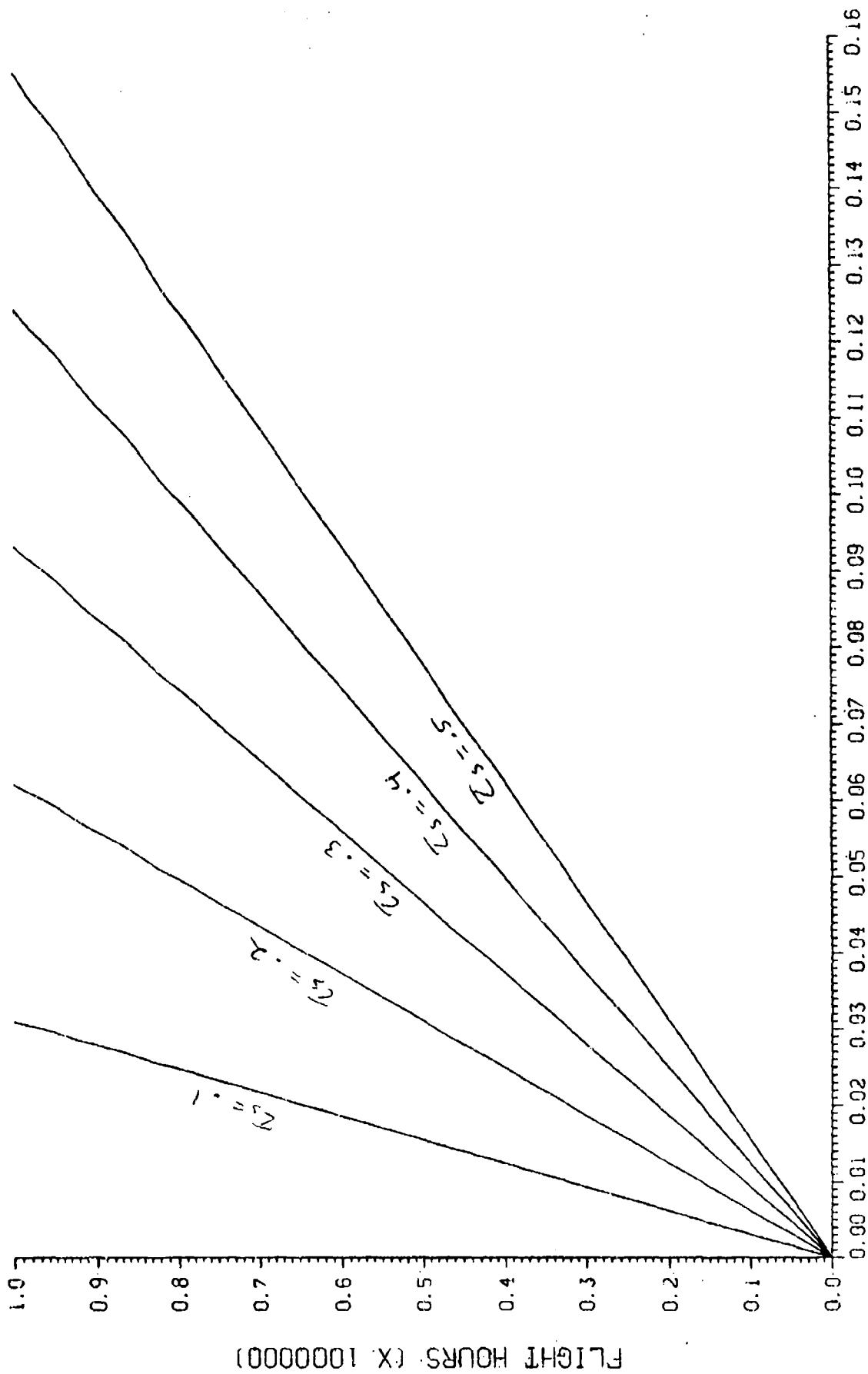
WINDSHIELD BIRD PENETRATIONS
 FIG. 62 F-15 DRF, 450 KT. WINDSHIELD CAPABILITY
 CONUS, AIR TO GROUND (0-5000 FT. ACL)



WINDSHIELD BIRD PENETRATIONS
 FIG. 63 F-15 DRF, 500 KT. WINDSHIELD CAPABILITY
 CONUS, AIR TO AIR (0-5000 FT. AGL)

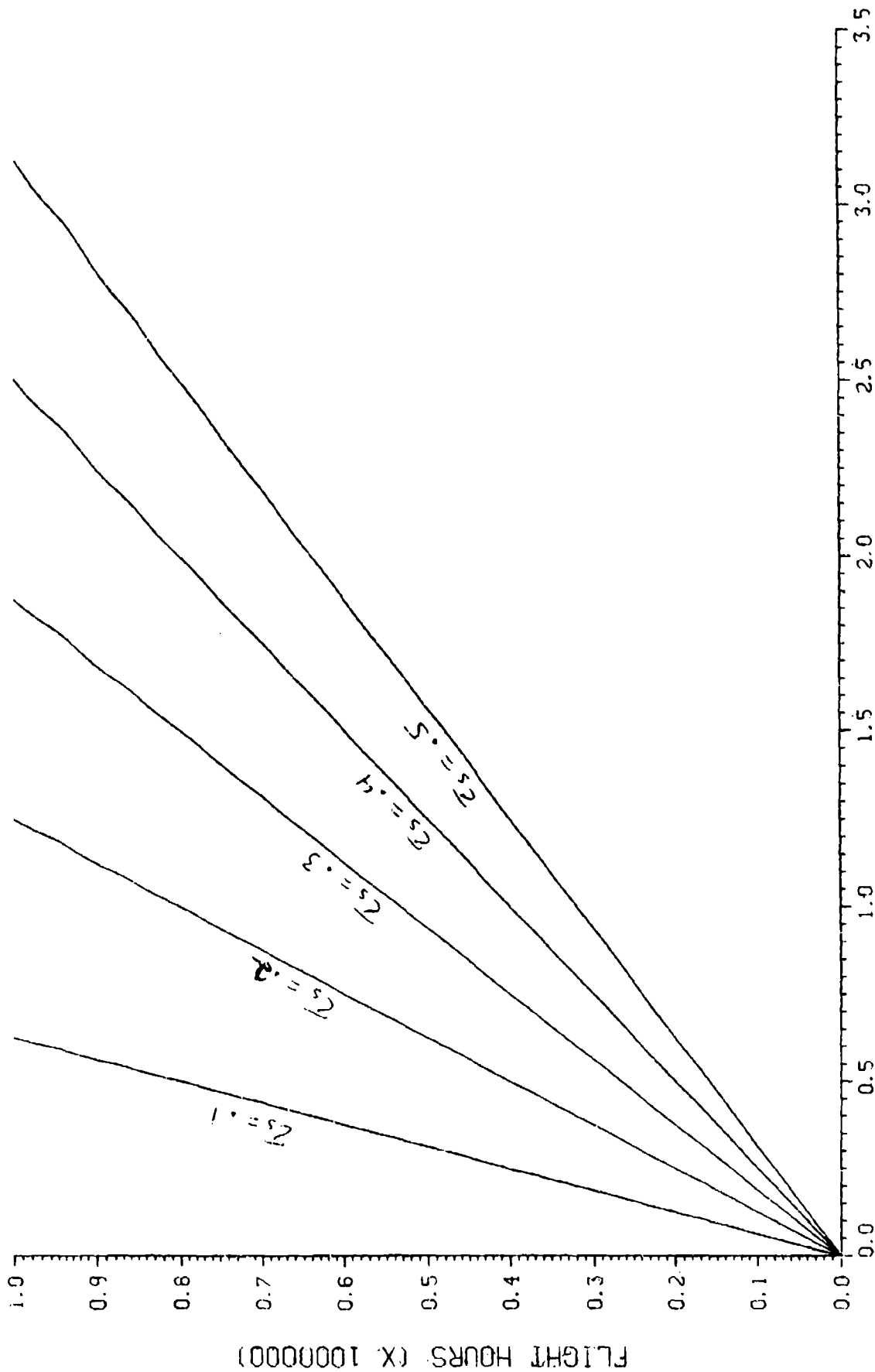


CANOPY BIRD PENETRATIONS
 FIG. 64 F-15 DRF, 350 KT. CANOPY CAPABILITY
 CONUS, AIR TO AIR (0-5000 FT. AGL)



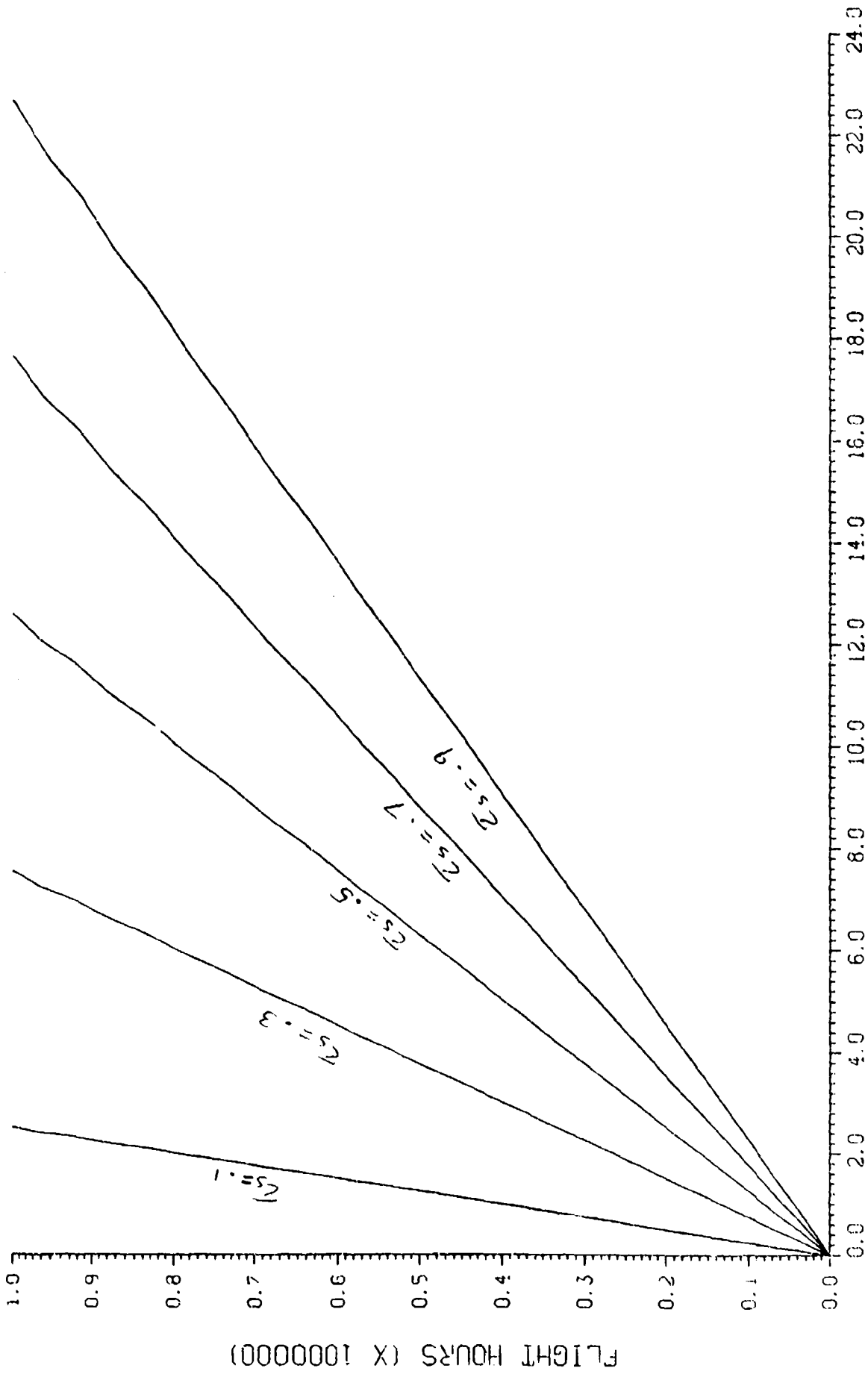
WINDSHIELD BIRD PENETRATIONS

FIG. 65 F-15 DRF, 500 KT. WINDSHIELD CAPABILITY
EUROPE, AIR TO AIR (0-5000 FT. AGL)



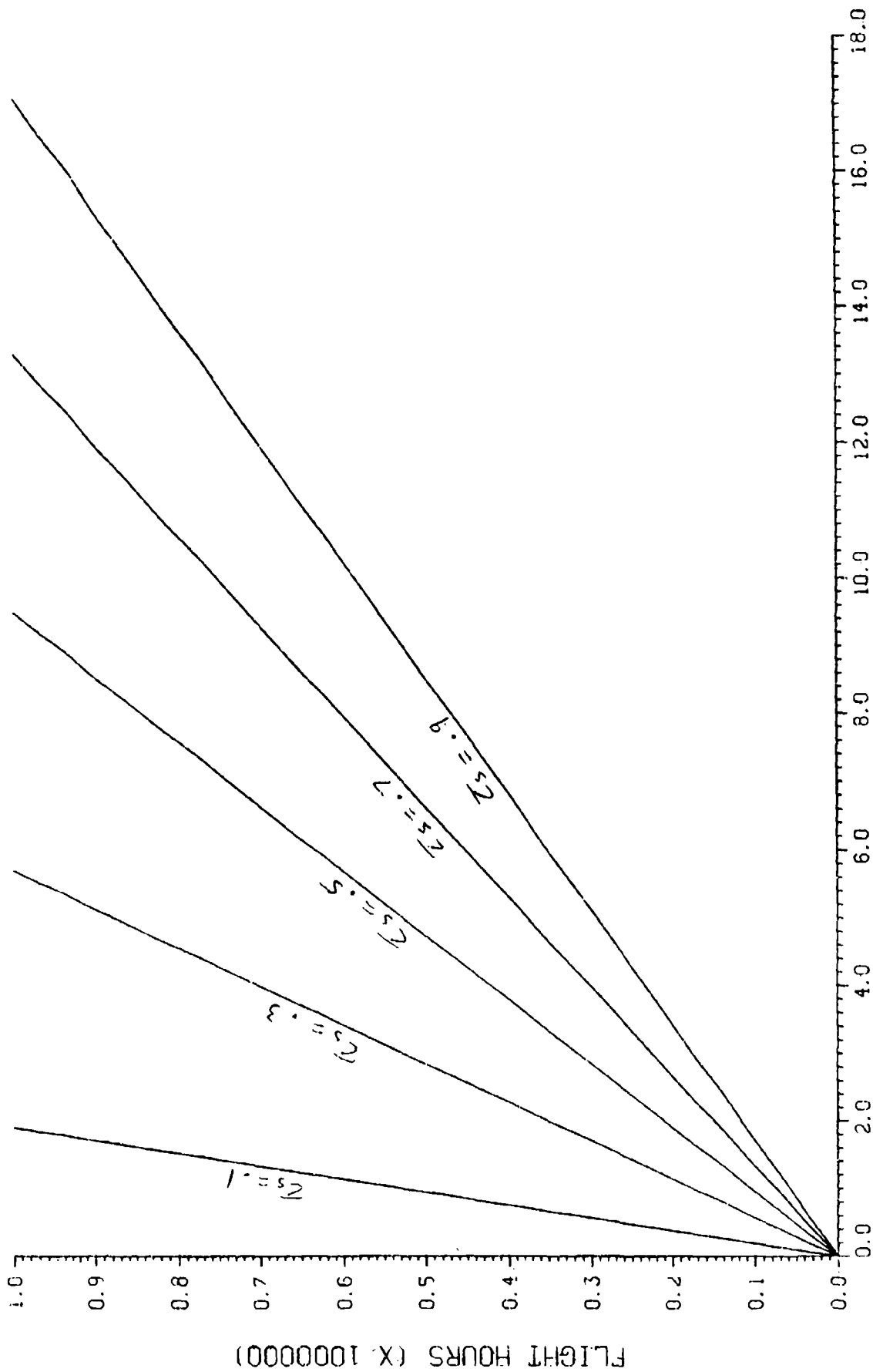
CANOPY BIRD PENETRATIONS

FIG. 66 F-15 DRF, 350 KT. CANOPY CAPABILITY
EUROPE, AIR TO AIR (0-5000 FT. AGL)



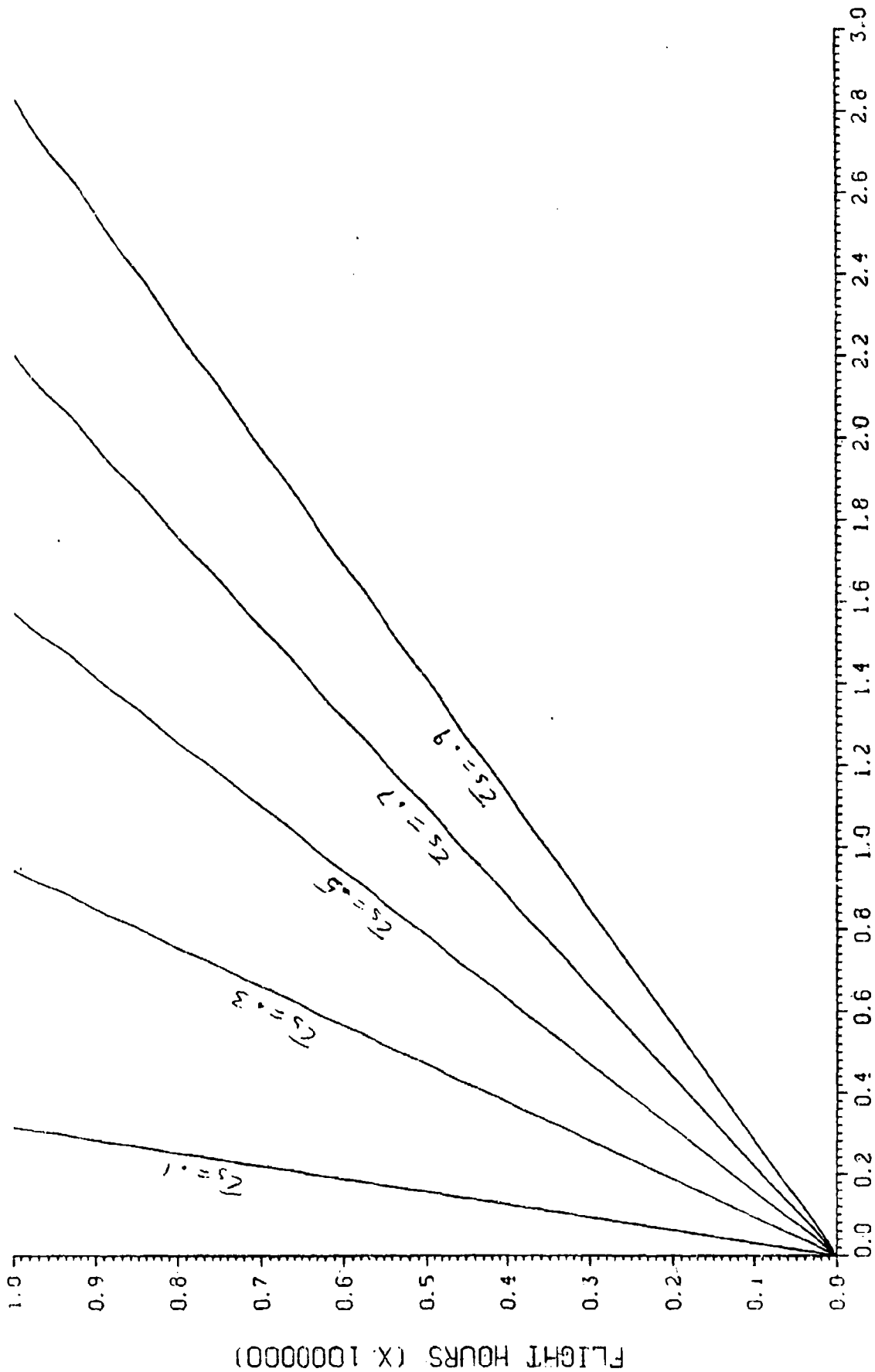
WINDSHIELD BIRD PENETRATIONS
 FIG. 67 F-15 DRF, 500 KT. WINDSHIELD CAPABILITY
 CONUS, AIR TO GROUND (0-5000 FT. AGL)

FLIGHT HOURS (X 100000)

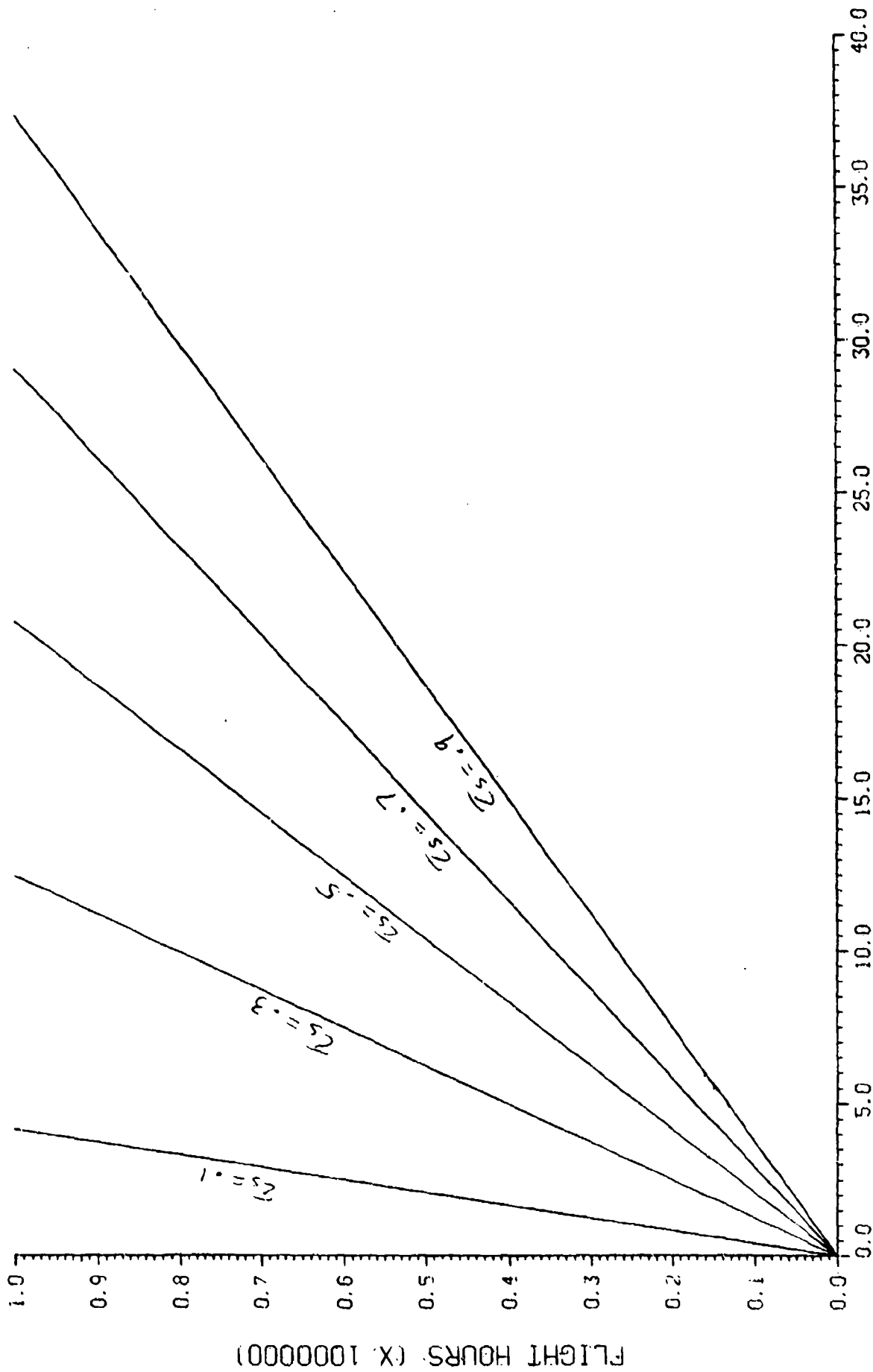


CANOPY BIRD PENETRATIONS

FIG. 68 F-15 DRF, 350 KI. CANOPY CAPABILITY
CONUS, AIR TO GROUND (0-5000 FT. AGL)



WINDSHIELD BIRD PENETRATIONS
 FIG. 69 F-15 DRF, 500 KT. WINDSHIELD CAPABILITY
 EUROPE, AIR TO GROUND (0-5000 FT. AGL)



CANOPY BIRD PENETRATIONS
 FIG. 70 F-15 DRF, 350 KT. CANOPY CAPABILITY
 EUROPE, AIR TO GROUND (0-5000 FT. AGL)

APPENDIX A

```

100= PROGRAM BAAPF(INPUT,OUTPUT)
110= DIMENSION PW(15),PWC(15),PWE(15),BWGT(15)
120= DIMENSION VEL(12),PV(12),PV1(12),ENOB(12,15)
130= DIMENSION ACA(12,15),ACAW(12,15),ACAC(12,15)
140= DATA PWC/.5149,.1631,.1074,.0668,.0438,.0295,.0204,.0144,
150= 1.0103,.0075,.0054,.0040,.0030,.0022,.0017/
160= DATA PWE/.7793,.1022,.0449,.0243,.0147,.0094,.0064,.0045,
170= 1.0032,.0024,.0018,.0014,.0010,.0008,.0007/
180= DATA BWGT/.5,1.5,2.5,3.5,4.5,5.5,6.5,7.5,8.5,9.5,10.5,
190= 111.5,12.5,13.5,14.5/
200= DATA VEL/"110-160","160-210","210-260","260-310","310-360",
210= "360-410","410-460","460-510","510-560","560-610",
220= "610-660","660-710"/
230= DATA PV1/.0948,.1501,.1950,.2040,.1660,.1080,.0540,.0210,.0060,
240= 1.0010,0.0,0.0/
250=C WINDSHIELD AC/A
260= DATA (ACAW(1,J),J=1,15)/0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,
270= 10.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
280= DATA (ACAW(2,J),J=1,15)/0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,
290= 10.,0.,0.,.258,.439,.456,.473/
300= DATA (ACAW(3,J),J=1,15)/0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,.432,
310= 1.459,.487,.514,.542,1.0,1.0,1.0/
320= DATA (ACAW(4,J),J=1,15)/0.,0.,0.,0.,.184,.448,.488,.529,
330= 11.,1.,1.,1.,1.,1.,1./
340= DATA (ACAW(5,J),J=1,15)/0.,0.,0.,.256,.477,.533,1.0,1.0,
350= 11.,1.,1.,1.,1.,1.,1./
360= DATA (ACAW(6,J),J=1,15)/0.,0.,.198,.484,.557,1.0,1.0,1.0,
370= 11.,1.,1.,1.,1.,1.,1./
380= DATA (ACAW(7,J),J=1,15)/0.,0.,.461,.555,1.0,1.0,1.0,1.0,
390= 11.,1.,1.,1.,1.,1.,1./
400= DATA (ACAW(8,J),J=1,15)/0.,0.0,.518,1.,1.,1.,1.,1.,
410= 11.,1.,1.,1.,1.,1.,1./
420= DATA (ACAW(9,J),J=1,15)/0.,.440,1.0,1.0,1.0,1.0,1.0,1.0,
430= 11.,1.,1.,1.,1.,1.,1./
440= DATA (ACAW(10,J),J=1,15)/0.,.481,1.0,1.0,1.0,1.0,1.0,1.0,
450= 11.,1.,1.,1.,1.,1.,1./
460= DATA (ACAW(11,J),J=1,15)/0.,.527,1.0,1.0,1.0,1.0,1.0,1.0,
470= 11.,1.,1.,1.,1.,1.,1./
480= DATA (ACAW(12,J),J=1,15)/0.0,1.,1.,1.,1.,1.,1.,1.0,
490= 11.,1.,1.,1.,1.,1.,1./
500=C CANOPY AC/A
510= DATA (ACAC(1,J),J=1,15)/0.,0.,0.,0.,0.,0.,0.,0.,.207,
520= 1.302,.398,.493,.588,.684,.779,.805/
530= DATA (ACAC(2,J),J=1,15)/0.,0.,0.,0.,.298,.477,.656,.802,
540= 1.814,.826,.839,.851,.863,.875,.888/
550= DATA (ACAC(3,J),J=1,15)/0.,0.,.214,.503,.792,.819,.838,.858,
560= 1.878,.898,.918,.937,.957,.977,.997/
570= DATA (ACAC(4,J),J=1,15)/0.,0.,.554,.812,.841,.870,.899,.928,
580= 1.957,.986,1.0,1.0,1.0,1.0,1.0/
590= DATA (ACAC(5,J),J=1,15)/0.,.373,.810,.851,.891,.931,.971,1.0,
600= 11.0,1.0,1.0,1.0,1.0,1.0,1.0/
610= DATA (ACAC(6,J),J=1,15)/0.,.655,.843,.896,.949,1.0,1.0,1.0,
620= 11.0,1.0,1.0,1.0,1.0,1.0,1.0/
630= DATA (ACAC(7,J),J=1,15)/0.,.812,.879,.947,1.0,1.0,1.0,1.0,
640= 11.0,1.0,1.0,1.0,1.0,1.0,1.0/
650= DATA (ACAC(8,J),J=1,15)/0.,.836,.921,1.0,1.0,1.0,1.0,1.0,
660= 11.0,1.0,1.0,1.0,1.0,1.0,1.0/
670= DATA (ACAC(9,J),J=1,15)/.241,.864,.966,1.0,1.0,1.0,1.0,1.0,
680= 11.0,1.0,1.0,1.0,1.0,1.0,1.0/
690= DATA (ACAC(10,J),J=1,15)/.387,.894,1.0,1.0,1.0,1.0,1.0,1.0,
700= 11.0-1.0,1.0-1.0,1.0,1.0,1.0,1.0/

```

Copy available to DTIC does not
 permit fully legible reproduction

```

710= DATA (ACAC(11,J),J=1,15)/.547,.927,1.0,1.0,1.0,1.0,1.0,1.0,1.0,
720= 1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0/
730= DATA (ACAC(12,J),J=1,15)/.719,.982,1.0,1.0,1.0,1.0,1.0,1.0,1.0,
740= 1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0/
750= 1 PRINT *, "WINDSHIELD OR CANOPY ? "
760= READ 1010, PART
770= IF (PART.EQ. "WINDSHIELD") GOTO 810
780= IF (PART.EQ. "CANOPY") GOTO 830
790= PRINT *, "PLEASE ENTER 'WINDSHIELD' OR 'CANOPY'"
800= GOTO 1
810= 810 DO 820 I=1,12
820= DO 820 J=1,15
830= 820 ACA(I,J)=ACAW(I,J)
840= GOTO 5
850= 830 DO 840 I=1,12
860= DO 840 J=1,15
870= 840 ACA(I,J)=ACAC(I,J)
880= 5 PRINT *, "OPERATIONAL IMPACT RATE ( PER 10**6 ) * "
890= READ *, OIR
900= 10 PRINT *, "CONUS OR EUROPE? --- "
910= READ 1010, WHERE
920= PRINT *, "ENTER FORCE USAGE --- "
930= READ *, FU
940= IF (WHERE.EQ. "CONUS") GOTO 20
950= IF (WHERE.EQ. "EUROPE") GOTO 40
960= PRINT *, "PLEASE ENTER 'CONUS' OR 'EUROPE'"
970= GOTO 10
980= 20 DO 30 I=1,15
990= 30 PW(I)=PWC(I)
1000= GOTO 90
1010= 40 DO 50 I=1,15
1020= 50 PW(I)=PWE(I)
1030= 60 PRINT *, "ENTER % F-15 ="
1040= READ *, P15
1050= IF (P15.EQ. 100.) GOTO 70
1060= PRINT *, "WARNING THE MIX DID NOT TOTAL 100%"
1070= 70 F15=P15/100.
1080= DO 80 I=1,12
1090= 80 PV(I)=F15*PV1(I)
1100= IP15=P15
1110= PRINT 1020, WHERE, IP15, PART, OIR, FU
1120= PRINT 1025, BMGT
1130= DO 100 I=1,12
1140= DO 90 J=1,15
1150= ENOB(I,J)=OIR*FU*PV(I)*PW(J)
1160= 90 CONTINUE
1170= 100 PRINT 1030, VEL(I), (ENOB(I,J), J=1,15)
1180= PRINT 1040
1190= PRINT 1025, BMGT
1200= B=0
1210= DO 120 I=1,12
1220= DO 110 J=1,15
1230= ENOB(I,J)=ENOB(I,J)*ACA(I,J)
1240= B=ENOB(I,J) +B
1250= 110 CONTINUE
1260= 120 PRINT 1030, VEL(I), (ENOB(I,J), J=1,15)
1270= PRINT 1060, B
1280= 1010 FORMAT(A10)
1290= 1020 FORMAT(1H1,
1300= 1 10X,A10,I3," F-15 MIX (" ,A10," )",

```

```
1310=      2 //,10X,"DIR =",F10.2," / 10**6  FU = ",F10.4," * 10**6",
1320=      3 ////,25X,"EXPECTED NUMBER OF BIRDSTRIKE (UNCORRECTED)"
1330= 1025 FORMAT(/,3X,"VELOCITY   ",25X,"BIRD WEIGHT (LBS)",
1340=      1 /,3X,"(KNOTS,   ",15F8.3)
1350= 1030 FORMAT(/,3X,A10,15F8.4)
1360= 1040 FORMAT(////,25X,"EXPECTED NUMBER OF BIRDSTRIKES (CORRECTED)"
1370= 1060 FORMAT(/,25X,"THE TOTAL EXPECTED NUMBER OF PENETRATIONS = ",F10.4)
1380=      END
1390=*EOR
```

430008 CM STORAGE USED
 .494 CP SECONDS COMPILATION TIME
 WINDSHIELD OR CANOPY WINDSHIELD
 OPERATIONAL IMPACT RATE (PER 10**6) =29.6
 CONUS OR EUROPE? ---CONUS
 ENTER FORCE USAGE ----.473008
 ENTER % F-15 =100

CONUS 100 F-15 MIX (WINDSHIELD)

DIR = 29.60 / 10**6 FU = .4730 * 10**8

EXPECTED NUMBER OF BIRDBSTRIKE (UNCORRECTED)

VELOCITY (KNOTS)	BIRD WEIGHT (LBS)														
	.500	1.500	2.500	3.500	4.500	5.500	6.500	7.500	8.500	8.500	10.500	11.500	12.500	13.500	14.500
110-160	.6834	.2165	.1426	.0887	.0581	.0392	.0271	.0181	.0137	.0100	.0072	.0053	.0040	.0029	.0023
160-210	1.0821	.3428	.2257	.1404	.0920	.0620	.0429	.0303	.0218	.0158	.0113	.0084	.0063	.0048	.0036
210-260	1.4058	.4453	.2932	.1824	.1186	.0805	.0557	.0393	.0281	.0205	.0147	.0108	.0082	.0060	.0048
260-310	1.4707	.4858	.3068	.1908	.1251	.0843	.0583	.0411	.0294	.0214	.0154	.0114	.0088	.0063	.0049
310-360	1.1967	.3791	.2496	.1553	.1018	.0688	.0474	.0335	.0239	.0174	.0128	.0093	.0070	.0051	.0040
360-410	.7788	.2486	.1824	.1010	.0682	.0448	.0308	.0218	.0156	.0113	.0082	.0060	.0043	.0033	.0026
410-460	.3893	.1233	.0812	.0505	.0331	.0223	.0154	.0103	.0078	.0057	.0041	.0030	.0023	.0017	.0013
460-510	.1514	.0480	.0316	.0186	.0129	.0087	.0080	.0042	.0030	.0022	.0018	.0012	.0009	.0006	.0005
510-560	.0433	.0137	.0090	.0056	.0037	.0025	.0017	.0012	.0008	.0006	.0005	.0003	.0003	.0002	.0001
560-610	.0072	.0023	.0015	.0008	.0006	.0004	.0003	.0002	.0001	.0001	.0001	.0001	.0000	.0000	.0000
610-660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
660-710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

APPENDIX B

EXPECTED NUMBER OF BIRDSTRIKES (CORRECTED)

VELOCITY (KNOTS)	.500	1.500	2.500	3.500	4.500	5.500	6.500	7.500	8.500	9.500	10.500	11.500	12.500	13.500	14.500
110-160	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
160-210	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0022	.0028	.0021	.0017
210-260	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0170	.0128	.0100	.0078	.0059	.0082	.0060	.0048
260-310	0.0000	0.0000	0.0000	0.0000	.0230	.0377	.0264	.0218	.0234	.0214	.0154	.0114	.0088	.0063	.0049
310-360	0.0000	0.0000	0.0000	.0397	.0486	.0365	.0474	.0335	.0238	.0174	.0128	.0083	.0070	.0051	.0040
360-410	0.0000	0.0000	.0322	.0488	.0369	.0448	.0308	.0218	.0158	.0113	.0082	.0060	.0045	.0033	.0026
410-460	0.0000	0.0000	.0374	.0280	.0321	.0223	.0154	.0108	.0078	.0057	.0041	.0030	.0023	.0017	.0013
460-510	0.0000	0.0000	.0164	.0196	.0129	.0087	.0060	.0042	.0030	.0022	.0018	.0012	.0008	.0006	.0005
510-560	0.0000	0.0060	.0090	.0056	.0037	.0025	.0017	.0012	.0008	.0006	.0005	.0003	.0003	.0002	.0001
560-610	0.0000	.0011	.0015	.0008	.0008	.0004	.0003	.0002	.0001	.0001	.0001	.0001	.0000	.0000	.0000
610-660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
660-710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

THE TOTAL EXPECTED NUMBER OF PENETRATIONS * 1.1298

END BAAPF
020200 MAXIMUM EXECUTION FL.
0.088 CP SECONDS EXECUTION TIME.

400008 CM STORAGE USED
 499 CP SECONDS COMPILATION TIME
 WINDSHIELD OR CANOPY CANOPY
 OPERATIONAL IMPACT RATE (PER 10**6) = 4.23
 LUNDS GR EUROPE) ---CONUS
 FINDER FORCE USAGE ---473008
 ENRIP % F-15 *100

CONUS 100 F-15 MIX (CANOPY)
 CIP * 4.23 / 10**6 FU * .4730 * 10**5

EXPECTED NUMBER OF BIRDSTRIKE (UNCORRECTED)

VELOCITY (KNOTS)	BIRD WEIGHT (LBS)													
	1.500	2.500	3.500	4.500	5.500	6.500	7.500	8.500	9.500	10.500	11.500	12.500	13.500	14.500
110-150	.0977	.0305	.0204	.0127	.0083	.0056	.0039	.0027	.0020	.0014	.0010	.0008	.0006	.0003
160-210	.1546	.0450	.0323	.0201	.0132	.0089	.0061	.0043	.0031	.0023	.0015	.0012	.0009	.0005
210-250	.2009	.0656	.0419	.0261	.0171	.0115	.0080	.0056	.0040	.0029	.0021	.0016	.0012	.0007
260-310	.2302	.0655	.0438	.0273	.0179	.0120	.0083	.0059	.0042	.0031	.0022	.0018	.0012	.0007
310-350	.1710	.0542	.0357	.0222	.0145	.0099	.0069	.0049	.0034	.0025	.0019	.0013	.0010	.0005
360-410	.1113	.0352	.0232	.0144	.0095	.0064	.0044	.0031	.0022	.0016	.0012	.0009	.0005	.0004
410-450	.0555	.0175	.0116	.0072	.0047	.0032	.0022	.0016	.0011	.0008	.0005	.0003	.0002	.0002
460-510	.0215	.0093	.0045	.0028	.0018	.0012	.0009	.0005	.0004	.0003	.0002	.0001	.0001	.0001
510-560	.0062	.0020	.0013	.0008	.0005	.0004	.0002	.0002	.0001	.0001	.0000	.0000	.0000	.0000
560-610	.0010	.0003	.0002	.0001	.0001	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
610-660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
660-710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

EXPECTED NUMBER OF BIRDSTRIKES (CORRECTED)

VELOCITY (KNOTS)	BIRD WEIGHT (LBS)														
	.500	1.500	2.500	3.500	4.500	5.500	6.500	7.500	8.500	9.500	10.500	11.500	12.500	13.500	14.500
110-160	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0006	0.0006	0.0005	0.0004	0.0004	0.0003	0.0003
160-210	0.0000	0.0000	0.0000	0.0000	0.0035	0.0042	0.0040	0.0035	0.0025	0.0019	0.0014	0.0010	0.0008	0.0006	0.0005
210-260	0.0000	0.0000	0.0090	0.0131	0.0135	0.0094	0.0067	0.0048	0.0035	0.0026	0.0019	0.0015	0.0011	0.0008	0.0007
260-310	0.0000	0.0000	0.0243	0.0221	0.0150	0.0105	0.0075	0.0055	0.0040	0.0030	0.0022	0.0016	0.0012	0.0009	0.0007
310-360	0.0000	0.0202	0.0289	0.0189	0.0130	0.0091	0.0066	0.0048	0.0034	0.0025	0.0018	0.0013	0.0010	0.0007	0.0006
360-410	0.0000	0.0231	0.0196	0.0129	0.0090	0.0054	0.0044	0.0031	0.0022	0.0016	0.0012	0.0009	0.0006	0.0005	0.0004
410-460	0.0000	0.0143	0.0102	0.0068	0.0047	0.0032	0.0022	0.0016	0.0011	0.0008	0.0006	0.0004	0.0003	0.0002	0.0002
460-510	0.0000	0.0057	0.0042	0.0028	0.0018	0.0012	0.0006	0.0006	0.0004	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001
510-560	0.0015	0.0017	0.0012	0.0008	0.0005	0.0004	0.0002	0.0002	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
560-610	0.0004	0.0003	0.0002	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
610-660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
660-710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

THE TOTAL EXPECTED NUMBER OF PENETRATIONS = .4673

END BAAPF
020200 MAXIMUM EXECUTION FL.
0.078 CP SECONDS EXECUTION TIME.

430008 CM STORAGE USED
 .487 CP SECONDS COMPILATION TIME
 WINDSHIELD OR CANOPY WINDSHIELD
 OPERATIONAL IMPACT RATE (PER 10**6) =21.97
 CONJUS OR EUROPE? ---EUROPE
 ENTER FORCE USAGE ----.136576
 ENTER % F-15 =100

EUROPE 100 F-15 MIX (WINDSHIELD)

DIR = 21.97 / 10**6 FU = .1366 * 10**6

EXPECTED NUMBER OF BIRDSTRIKE (UNCORRECTED)

VELOCITY (KNOTS)	BIRD WEIGHT (LBS)													
	1.500	2.500	3.500	4.500	5.500	6.500	7.500	8.500	9.500	10.500	11.500	12.500	13.500	14.500
110-150	.2217	.0291	.0128	.0042	.0027	.0018	.0013	.0009	.0007	.0005	.0004	.0003	.0002	.0002
160-210	.3510	.0480	.0202	.0088	.0042	.0028	.0020	.0014	.0011	.0008	.0006	.0005	.0004	.0003
210-260	.4560	.0398	.0263	.0142	.0088	.0037	.0026	.0019	.0014	.0011	.0008	.0008	.0003	.0004
260-310	.4770	.0626	.0275	.0148	.0050	.0039	.0028	.0020	.0015	.0011	.0008	.0008	.0003	.0004
310-360	.3882	.0509	.0224	.0121	.0073	.0032	.0022	.0015	.0012	.0009	.0007	.0005	.0004	.0003
360-410	.2525	.0331	.0148	.0079	.0048	.0021	.0015	.0010	.0008	.0006	.0005	.0003	.0003	.0002
410-460	.1283	.0188	.0073	.0039	.0024	.0010	.0007	.0005	.0004	.0003	.0002	.0002	.0001	.0001
460-510	.0491	.0084	.0028	.0015	.0009	.0004	.0003	.0002	.0002	.0001	.0001	.0001	.0001	.0000
510-560	.0140	.0018	.0008	.0004	.0003	.0001	.0001	.0001	.0000	.0000	.0000	.0000	.0000	.0000
560-610	.0023	.0003	.0001	.0001	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
610-660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
660-710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

EXPECTED NUMBER OF BIRDSTRIKES (CORRECTED)

VELOCITY (KNOTS)	BIRD HEIGHT (LBS)														
	.500	1.500	2.500	3.500	4.500	5.500	6.500	7.500	8.500	9.500	10.500	11.500	12.500	13.500	14.500
110-160	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
160-210	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0002	.0002	.0002	.0001
210-260	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.0011	.0008	.0007	.0005	.0004	.0006	.0005	.0004
260-310	0.0000	0.0000	0.0000	0.0000	.0017	.0026	.0019	.0015	.0020	.0015	.0011	.0009	.0008	.0003	.0004
310-360	0.0000	0.0000	0.0000	.0031	.0035	.0025	.0032	.0022	.0018	.0012	.0009	.0007	.0005	.0004	.0003
360-410	0.0000	0.0000	.0029	.0038	.0027	.0030	.0021	.0015	.0010	.0008	.0006	.0005	.0003	.0003	.0002
410-460	0.0000	0.0000	.0034	.0022	.0024	.0015	.0010	.0007	.0005	.0004	.0003	.0002	.0002	.0002	.0001
460-510	0.0000	0.0000	.0015	.0015	.0009	.0008	.0004	.0003	.0002	.0002	.0001	.0001	.0001	.0001	.0000
510-560	0.0000	.0008	.0008	.0004	.0003	.0002	.0001	.0001	.0001	.0000	.0000	.0000	.0000	.0000	.0000
560-610	0.0000	.0001	.0001	.0001	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
610-660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
660-710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

THE TOTAL EXPECTED NUMBER OF PENETRATIONS = .0824

END BAAPF
 020200 MAXIMUM EXECUTION FL.
 0.084 CP SECONDS EXECUTION TIME.

430008 CM STORAGE USED
 .508 CP SECONDS COMPILATION TIME
 WINDSHIELD OR CANOPY ?CANOPY
 OPERATIONAL IMPACT RATE (PER 10**6) =51.25
 CONUS OR EUROPE? ---EUROPE
 ENTER FORCE USAGE ----.136578
 ENTER % F-15 =100

EUROPE 100 F-15 MIX (CANOPY)

DIR = 51.25 / 10**6 FU = .1366 * 10**8

EXPECTED NUMBER OF BIRDSTRIKE (UNCORRECTED)

VELOCITY (KNOTS)	.500	1.500	2.500	3.500	4.500	5.500	6.500	7.500	8.500	9.500	10.500	11.500	12.500	13.500	14.500
	BIRD HEIGHT (LBS)														
110-160	.5171	.0878	.0298	.0181	.0098	.0062	.0042	.0030	.0021	.0018	.0012	.0008	.0007	.0005	.0005
160-210	.8188	.1074	.0472	.0255	.0154	.0089	.0067	.0047	.0034	.0025	.0019	.0015	.0011	.0008	.0007
210-260	1.0637	.1383	.0813	.0332	.0201	.0128	.0087	.0061	.0044	.0033	.0025	.0018	.0014	.0011	.0010
260-310	1.1128	.1458	.0841	.0347	.0210	.0134	.0081	.0064	.0048	.0034	.0028	.0020	.0014	.0011	.0010
310-360	.9055	.1187	.0522	.0282	.0171	.0108	.0074	.0052	.0037	.0028	.0021	.0016	.0012	.0009	.0008
360-410	.5891	.0773	.0338	.0184	.0111	.0071	.0048	.0034	.0024	.0018	.0014	.0011	.0008	.0006	.0005
410-460	.2948	.0386	.0170	.0092	.0058	.0038	.0024	.0017	.0012	.0008	.0007	.0005	.0004	.0003	.0003
460-510	.1145	.0150	.0088	.0038	.0022	.0014	.0009	.0007	.0005	.0004	.0003	.0002	.0001	.0001	.0001
510-560	.0327	.0043	.0019	.0010	.0006	.0004	.0003	.0002	.0001	.0001	.0001	.0001	.0000	.0000	.0000
560-610	.0055	.0007	.0003	.0002	.0001	.0001	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
610-660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
660-710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

EXPECTED NUMBER OF BIRDSTRIKES (CORRECTED)

VELOCITY (KNOTS)	BIRD WEIGHT (LBS)														
	.500	1.500	2.500	3.500	4.500	5.500	6.500	7.500	8.500	9.500	10.500	11.500	12.500	13.500	14.500
110-160	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0006	0.0008	0.0008	0.0005	0.0005	0.0004	0.0004
160-210	0.0000	0.0000	0.0000	0.0000	0.0046	0.0047	0.0044	0.0038	0.0027	0.0021	0.0016	0.0013	0.0009	0.0007	0.0007
210-260	0.0000	0.0000	0.0131	0.0167	0.0159	0.0105	0.0073	0.0053	0.0038	0.0029	0.0023	0.0018	0.0013	0.0011	0.0010
260-310	0.0000	0.0000	0.0355	0.0282	0.0177	0.0117	0.0082	0.0080	0.0044	0.0034	0.0026	0.0020	0.0014	0.0011	0.0010
310-360	0.0000	0.0443	0.0423	0.0240	0.0152	0.0102	0.0072	0.0052	0.0037	0.0028	0.0021	0.0018	0.0012	0.0009	0.0008
360-410	0.0000	0.0506	0.0286	0.0185	0.0105	0.0071	0.0048	0.0034	0.0024	0.0018	0.0014	0.0011	0.0008	0.0006	0.0005
410-460	0.0000	0.0314	0.0149	0.0087	0.0058	0.0038	0.0024	0.0017	0.0012	0.0009	0.0007	0.0005	0.0004	0.0003	0.0003
460-510	0.0000	0.0128	0.0061	0.0038	0.0022	0.0014	0.0009	0.0007	0.0005	0.0004	0.0003	0.0002	0.0001	0.0001	0.0001
510-560	0.0079	0.0037	0.0018	0.0010	0.0006	0.0004	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
560-610	0.0021	0.0006	0.0003	0.0002	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
610-660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
660-710	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

THE TOTAL EXPECTED NUMBER OF PENETRATIONS = .6508

END BAAPF
020200 MAXIMUM EXECUTION FL.
0.071 CP SECONDS EXECUTION TIME.

APPENDIX C

```

100= PROGRAM RAAPF(INPUT,OUTPUT)
110= DIMENSION PW(15),PWC(15),PWE(15),BWGT(15)
120= DIMENSION VEL(12),PV(12),PV1(12),ENOB(12,15)
130= DIMENSION ACA(12,15),ACAW(12,15),ACAC(12,15)
140= DATA PWC/.5149,.1631,.1074,.0668,.0438,.0295,.0204,.0144,
150= 1.0103,.0075,.0054,.0040,.0030,.0022,.0017/
160= DATA PWE/.7793,.1022,.0449,.0243,.0147,.0094,.0064,.0045,
170= 1.0032,.0024,.0018,.0014,.0010,.0008,.0007/
180= DATA BWGT/.5,1.5,2.5,3.5,4.5,5.5,6.5,7.5,8.5,9.5,10.5,
190= 11.5,12.5,13.5,14.5/
200= DATA VEL/"110-160","160-210","210-260","260-310","310-360",
210= 1"360-410","410-460","460-510","510-560","560-610",
220= 1"610-660","660-710"/
230= DATA PV1/.0948,.1501,.1950,.2040,.1680,.1080,.0540,.0210,.0060,
240= 1.0010,0.0,0.0,0.0/
250=C WINDSHIELD AC/A
260= DATA (ACAW(1,J),J=1,15)/0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,
270= 10.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
280= DATA (ACAW(2,J),J=1,15)/0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,
290= 10.,0.,0.,.258,.438,.458,.473/
300= DATA (ACAW(3,J),J=1,15)/0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,.432,
310= 1.459,.487,.514,.542,1.0,1.0,1.0/
320= DATA (ACAW(4,J),J=1,15)/0.,0.,0.,0.,.184,.448,.488,.529,
330= 11.,1.,1.,1.,1.,1.,1.,1./
340= DATA (ACAW(5,J),J=1,15)/0.,0.,0.,.256,.477,.533,1.0,1.0,
350= 11.,1.,1.,1.,1.,1.,1.,1./
360= DATA (ACAW(6,J),J=1,15)/0.,0.,.198,.484,.557,1.0,1.0,1.0,
370= 11.,1.,1.,1.,1.,1.,1.,1./
380= DATA (ACAW(7,J),J=1,15)/0.,0.,.461,.555,1.0,1.0,1.0,1.0,
390= 11.,1.,1.,1.,1.,1.,1.,1./
400= DATA (ACAW(8,J),J=1,15)/0.,0.,.518,1.,1.,1.,1.,1.,1.,
410= 11.,1.,1.,1.,1.,1.,1.,1./
420= DATA (ACAW(9,J),J=1,15)/0.,.440,1.0,1.0,1.0,1.0,1.0,1.0,
430= 11.,1.,1.,1.,1.,1.,1.,1./
440= DATA (ACAW(10,J),J=1,15)/0.,.481,1.0,1.0,1.0,1.0,1.0,1.0,
450= 11.,1.,1.,1.,1.,1.,1.,1./
460= DATA (ACAW(11,J),J=1,15)/0.,.527,1.0,1.0,1.0,1.0,1.0,1.0,
470= 11.,1.,1.,1.,1.,1.,1.,1./
480= DATA (ACAW(12,J),J=1,15)/0.0,1.,1.,1.,1.,1.,1.,1.,1.0,
490= 11.,1.,1.,1.,1.,1.,1.,1./
500=C CANOPY AC/A
510= DATA (ACAC(1,J),J=1,15)/0.,0.,0.,0.,0.,0.,0.,0.,.207,
520= 1.302,.398,.493,.588,.684,.779,.805/
530= DATA (ACAC(2,J),J=1,15)/0.,0.,0.,0.,.298,.477,.658,.802,
540= 1.814,.828,.838,.851,.863,.875,.888/
550= DATA (ACAC(3,J),J=1,15)/0.,0.,.214,.503,.792,.818,.838,.858,
560= 1.878,.898,.918,.937,.957,.977,.997/
570= DATA (ACAC(4,J),J=1,15)/0.,0.,.554,.812,.841,.870,.899,.928,
580= 1.957,.986,1.0,1.0,1.0,1.0,1.0/
590= DATA (ACAC(5,J),J=1,15)/0.,.373,.810,.851,.891,.931,.971,1.0,
600= 11.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0/
610= DATA (ACAC(6,J),J=1,15)/0.,.855,.843,.898,.949,1.0,1.0,1.0,
620= 11.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0/
630= DATA (ACAC(7,J),J=1,15)/0.,.812,.879,.947,1.0,1.0,1.0,1.0,
640= 11.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0/
650= DATA (ACAC(8,J),J=1,15)/0.,.836,.921,1.0,1.0,1.0,1.0,1.0,
660= 11.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0/
670= DATA (ACAC(9,J),J=1,15)/.241,.864,.986,1.0,1.0,1.0,1.0,1.0,
680= 11.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0/
690= DATA (ACAC(10,J),J=1,15)/.387,.894,1.0,1.0,1.0,1.0,1.0,1.0,
700= 11.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0/

```

```

710= DATA (ACAC(11,J),J=1,15)/.547,.927,1.0,1.0,1.0,1.0,1.0,1.0,1.0,
720= 11.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0/
730= DATA (ACAC(12,J),J=1,15)/.719,.962,1.0,1.0,1.0,1.0,1.0,1.0,1.0,
740= 11.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0/
750= 1 PRINT *,"WINDSHIELD OR CANOPY (W OR C) ? -"
760= READ 1010,PART
770= IF(PART.EQ."W")GOTO 810
780= IF(PART.EQ."C")GOTO 830
790= PRINT *,"PLEASE ENTER 'W' FOR WINDSHIELD OR 'C' FOR CANOPY"
800= GOTO 1
810= 810 DO 820 I=1,12
820= DO 820 J=1,15
830= 820 ACA(I,J)=ACAW(I,J)
840= GOTO 5
850= 830 DO 840 I=1,12
860= DO 840 J=1,15
870= 840 ACA(I,J)=ACAC(I,J)
880= 5 PRINT *,"OPERATIONAL IMPACT RATE ( PER 10**6 ) = "
890= READ *,OIR
900= 10 PRINT *,"CONUS OR EUROPE? ('C' OR 'E') ---"
910= READ 1010,WHERE
920= IF(WHERE.EQ."C".OR.WHERE.EQ."E") GO TO 15
930= PRINT *,"PLEASE ENTER 'C' FOR CONUS OR 'E' FOR EUROPE ---"
940= GOTO 10
950= 15 PRINT *,"ENTER FORCE USAGE --- "
960= READ *,FU
970= IF(WHERE.EQ."E") GO TO 40
980= 20 DO 30 I=1,15
990= 30 PW(I)=PWC(I)
1000= GO TO 60
1010= 40 DO 50 I=1,15
1020= 50 PW(I)=PWE(I)
1030= 60 P15=100
1040= IF(P15.EQ.100.)GOTO 70
1050= PRINT *,"WARNING THE MIX DID NOT TOTAL 100%"
1060= 70 F15=P15/100.
1070= DO 80 I=1,12
1080= 80 PV(I)=F15*PV1(I)
1090= IP15=P15
1100= DO 100 I=1,12
1110= DO 90 J=1,15
1120= ENOB(I,J)=OIR*FU*PV(I)*PW(J)
1130= 90 CONTINUE
1140= 100 CONTINUE
1150= B=0
1160= DO 120 I=1,12
1170= DO 110 J=1,15
1180= ENOB(I,J)=ENOB(I,J)*ACA(I,J)
1190= B=ENOB(I,J)+B
1200= 110 CONTINUE
1210= 120 CONTINUE
1220= PRINT 1080,B
1230= 1010 FORMAT(A10)
1240= 1020 FORMAT(1H1,
1250= 1 10X,A10,I3," F-15 MIX (" ,A10," )",
1260= 2 //,10X,"OIR = ",F10.2," / 10**6 FU = ",F10.4," * 10**6",
1270= 3 ////,25X,"EXPECTED NUMBER OF BIRDSTRIKE (UNCORRECTED)")
1280= 1025 FORMAT(/,3X,"VELOCITY ",25X,"BIRD WEIGHT (LBS)",
1290= 1 //,3X,"(KNOTS) ",15F8.3)
1300= 1030 FORMAT(/,3X,A10,15F8.4)
1310= 1040 FORMAT(////,25X,"EXPECTED NUMBER OF BIRDSTRIKES (CORRECTED)")
1320= 1080 FORMAT(/,25X,"THE TOTAL EXPECTED NUMBER OF PENETRATIONS = ",F10.4)
1330= END

```

REFERENCES

1. "An Analytical Methodology to Predict Potential Aircraft Losses Due to Canopy Birdstrikes," April 1980, Dr John C. Halpin and John M. Griffin, Aeronautical Systems Division, Wright-Patterson Air Force Base, Dayton, Ohio.
2. "Evaluation of the Birdstrike Threat to T-38 Transparencies," UDR-TM-79-12, July 1979, A. Berens, University of Dayton Research Institute, Dayton, Ohio.
3. "List of Identified Birds Involved in Bird Strikes," Logbook Call #204-293, May 1982 - March 1983, obtained from Lt Will, Bird Aircraft Strike Hazard Team, Tyndall AFB.
4. "List of Identified Birds Involved in Birdstrikes," March 1976 - September 1977, Obtained from Lt Will, Bird Aircraft Strike Hazard Team, Tyndall AFB.
5. "Weights of a Number of Birds," May 1970, G. Kaiser, Canadian Wildlife Service.
6. "F-15C/D Structural Loads Report for Production Eagle Package," MDC A5318, October 1978, McDonnell Aircraft Company.
7. "Final Report Windshield/Canopy Bird Impact Resistance," August 1977, McDonnell Aircraft Company.
8. "F-15 DRF Structural Design Criteria," Memorandum 199-DRF-169, September 1982, McDonnell Aircraft Company.