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DAYTON AIRCRAFT CABIN FIRE MODEL

Volume III - Computer Program User's Guide

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Final Report

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16. Abstract

A basic mathematical model and computer simulation program have been developed to assess the smoke and toxic gas emissions resulting from the burning of cabin interior materials of a wide-body transport aircraft in a full-scale fire. The simulation is based on laboratory test data on the cabin materials. This report is a guide for use of the computer simulation program which includes instructions for input data preparation, sample input and output, basic definitions concerning the simulation program and mathematical model, and a brief description of the program structure. This report consists of three volumes: Volume I is entitled "Basic Mathematical Model" and Volume II is entitled "Laboratory Test Program".

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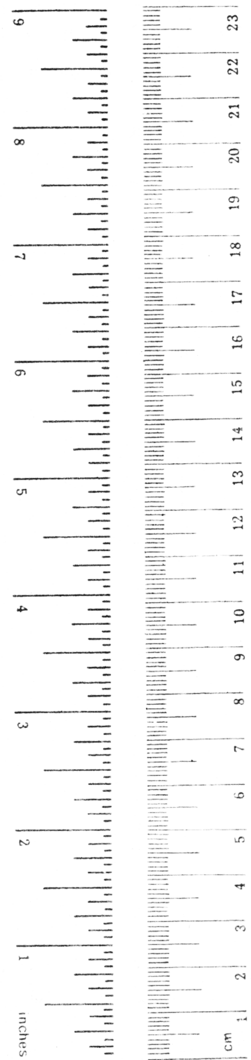
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

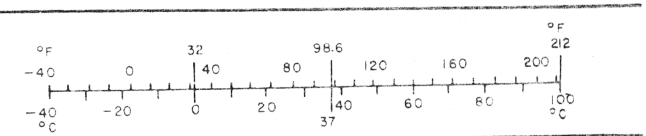
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This contract was prepared by the University of Dayton Research Institute for the Federal Aviation Administration Systems Research and Development Service under Contract FA74WA-3532 during the period July 1974 to March 1976. The report describes the development of a mathematical model of a fire within the cabin of a wide body commercial transport category aircraft. The report is divided into three volumes of which this is the third. Volume I, entitled "Basic Mathematical Model," describes the development and presents example results of the model. Volume II, "Laboratory Test Program," presents the results of a laboratory test and data collection program conducted in support of the development of the model. Volume III. "Computer Program User's Guide," is a guide for use of the computer program which implements the mathematical model.

This contract was administered under the direction of Mr. Robert C. McGuire and Mr. Charles C. Troha of the Systems Research and Development Service, ARD 520. Work was performed at the University of Dayton under the supervision of Mr. Nicholas A. Engler, supervisor of the Applied Systems Analysis Division. Other personnel at the University who have contributed to this program include Mr. James K. Luers, Mr. Jerry B. Reeves, and Mr. Charles D. MacArthur. The author wishes to express his gratitude to all those mentioned for their support, encouragement, and valuable technical contributions. The author also wishes to thank Ms. Jacquelin Aldrich and Ms. Peggy Cummings for their patient assistance in preparing the manuscript.

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SECTION 1
INTRODUCTION

The Dayton Aircraft Cabin Fire (DACFIR) Simulation Program is the computer implementation of the DACFIR Model developed by the University of Dayton Research Institute. The model is a set of equations and logic designed to predict the time history of the build-up of smoke, heat, and toxic gases in the cabin of an aircraft subjected to fire within a period representative of post crash emergency evacuation time. The model provides a means of tracking the development of the fire and the changes in the cabin environment with time. Input to the model includes a description of the cabin geometry and ventilation conditions, a description of the material properties as measured by laboratory tests, and a description of the initial fire situation. The DACFIR Simulation Program as presented in this report applies to a particular cabin geometry, that of a representative wide-body aircraft cabin section. This program has been designated as DACFIR, Version 1, May 1976. A complete description of the DACFIR Model is contained in Volume I, "Basic Mathematical Model".

The intent of this user's guide is to provide instruction for the efficient use of the DACFIR Simulation Program. This documentation contains basic definitions, a flow chart and description of the main program, a description of the program input and output, sample program input and output, program statistical data, and information concerning the availability of the program code. It does not contain a detailed description of the computer program code and thus is not intended as a complete reference source for the computer programmer.

It should be stressed that careful preparation of the input cards is of the utmost importance. A simulation program by its very nature utilizes a relatively large amount of computer time, and seemingly insignificant errors in the input can easily result in serious errors in the results if not cause abnormal termination of the run.

SECTION 2

BASIC DEFINITIONS

An element is the smallest unit of surface area which is utilized in the simulation, and is a square whose dimension is six inches per side. An element may exist, at any specified time, in one of four primary states, virgin, smoldering, flaming or charred or in one of three secondary states which represent temporary conditions intermediate to the primary states.

A surface is defined as consisting of a group of elements all of which lie in the same horizontal or vertical plane and whose material properties are identical. The program recognizes twenty (20) cabin lining surfaces and nine (9) seat groups. The twenty cabin lining surfaces are depicted in Figure 2.1 and are as follows:

1. Carpet
2. Lower Right Sidewall Panel
3. Right Window Reveals and Window Transparencies (considered one surface)
4. Upper Right Sidewall Panel
5. Right Side Passenger Service Unit
6. Right Side Stowage Bin Bottom
7. Right Side Stowage Bin Face
8. Right Ceiling Panel
9. Right Center Stowage Bin Face
10. Right Center Stowage Bin Bottom
11. Left and Right Center Passenger Service Units
12. Left Center Stowage Bin Bottom
13. Left Center Stowage Bin Face
14. Left Ceiling Panel
15. Left Side Stowage Bin Face
16. Left Side Stowage Bin Bottom
17. Left Side Passenger Service Unit
18. Upper Left Sidewall Panel
19. Left Window Reveals and Window Transparencies (considered one surface)
20. Lower Left Sidewall Panel

The seat groups are nine (9) in number and are referenced as shown in Figure 2.2.

1. 1st Row, Left
2. 1st Row, Center
3. 1st Row, Right
4. 2nd Row, Left
5. 2nd Row, Center
6. 2nd Row, Right
7. 3rd Row, Left
8. 3rd Row, Center
9. 3rd Row, Right

The left and right seat groups each contain three individual seats. The center seat groups each contain four individual seats.

Each seat group consists of seven (7) surfaces as shown in Figure 2.3:

1. Cushion Bottom
2. Lower Rear Backrest
3. Upper Rear Backrest
4. Backrest Top
5. Backrest Front
6. Cushion Top
7. Cushion Front

The computer program utilizes seven (7) types of materials:

1. Carpet Material
2. Sidewall Material
3. Window Reveal-Transparency Material
4. PSU Facing Material
5. Stow Bin Material
6. Ceiling Panel Material
7. Seat Upholstery Material with Padding

It is assumed that all materials can yield one or more of the following toxic gases as the material becomes involved in the fire:

1. CO
2. HCl
3. HCN
4. HF
5. SO_2
6. H_2S
7. NH_3
8. NO_x
9. $COCl_2$

Whenever surfaces, seat groups, materials or toxic gases are referenced, the numbering will <u>always</u> be identical with that given above.

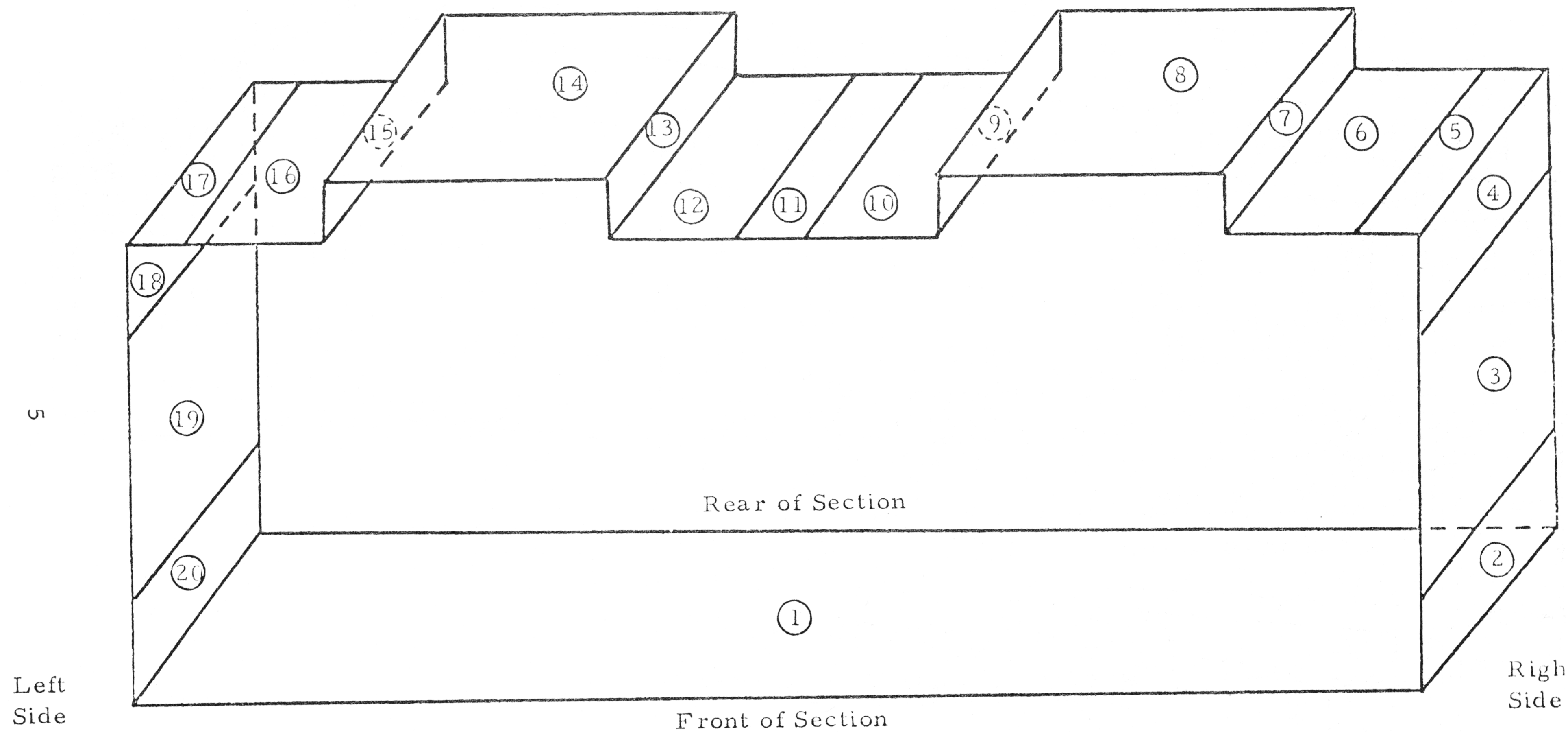


Figure 2.1 Location of Cabin Lining Surfaces

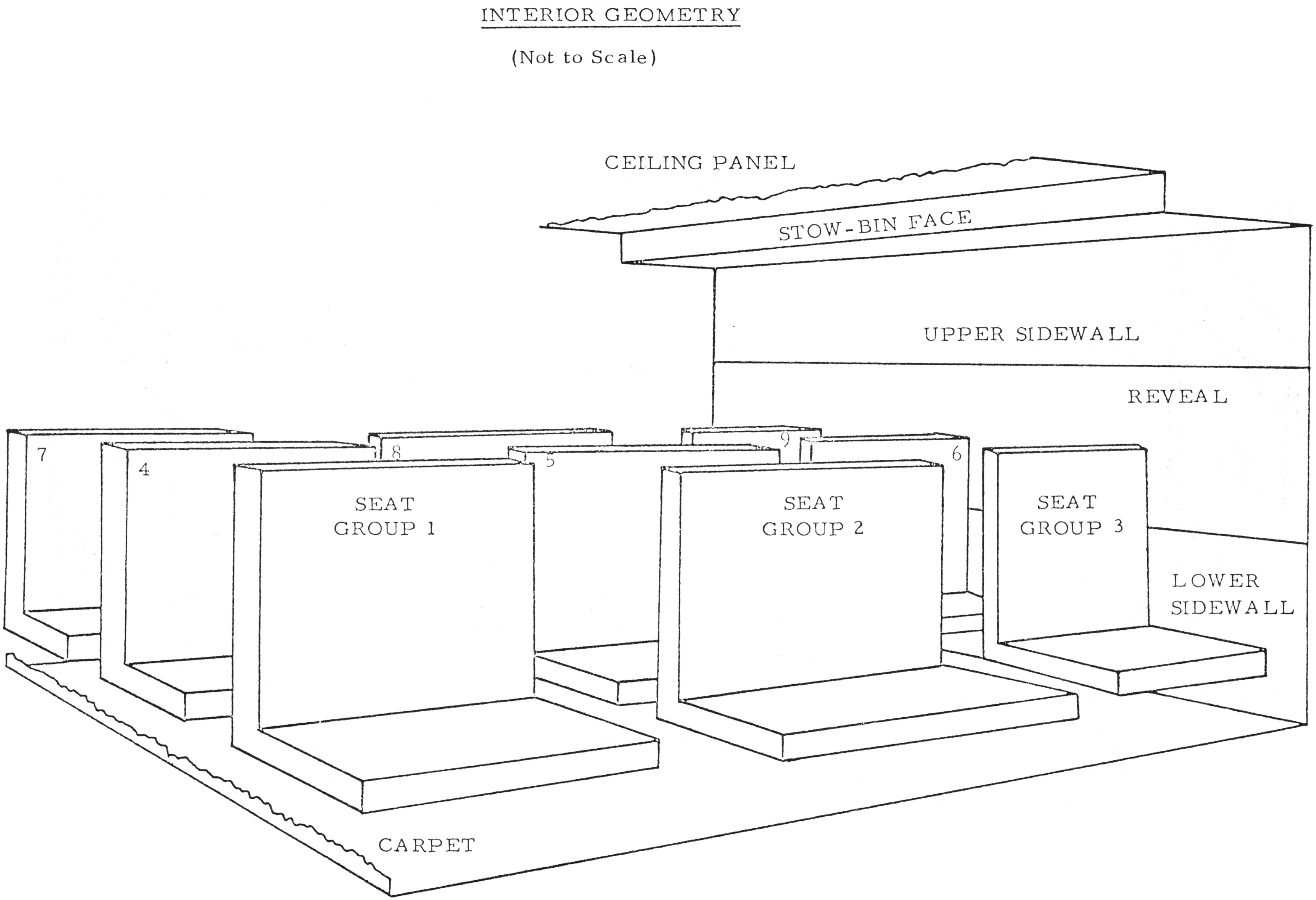


Figure 2.2. Location of Seat Groups

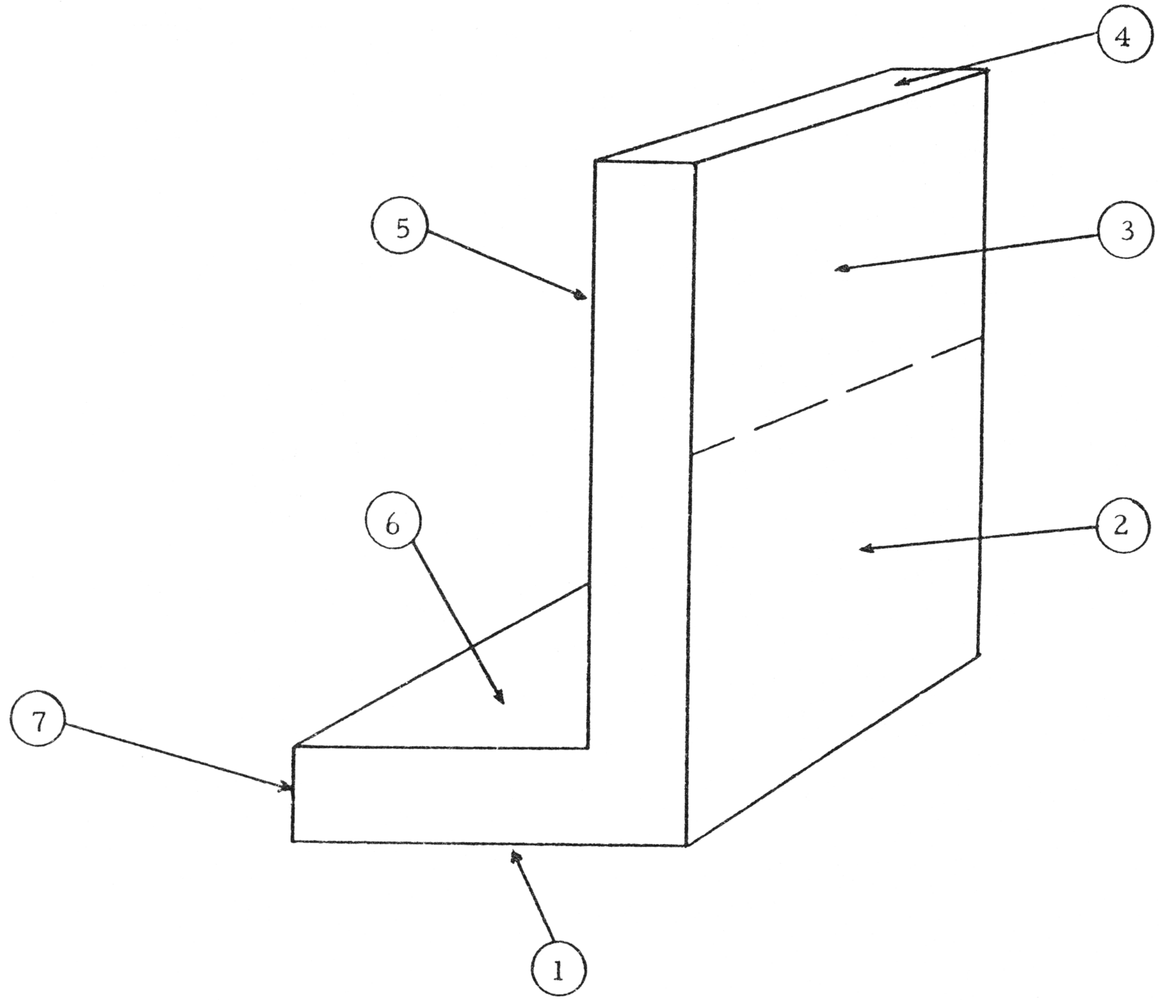


Figure 2.3. Seat Groups - Distinct Surfaces

SECTION 3

PROGRAM CONSTRUCTION

The computer simulation program was written in modular form. That is, each subroutine has as its purpose a specific function or set of computations. These subroutines are linked by means of the coding in the 'Main Program'. The coding in the 'Main Program' then, provides the necessary controls for the logical flow of the sequence of computations.

The following three pages contain a flow diagram of the Main Program. The numbers in the left margin are utilized to reference the diagram to a brief description of each program step or block. This narrative is contained on the pages immediately following the flow charts.

'MAIN PROGRAM' FLOW CHART

Component No.
(see pp. 13-15)

START

↓

1. NPASS = 0
IPR1 = 0
IPR2 = 2

↓

2. CALL INPUTG
(IN)

↓

3. (IN = 0)? —no→ PRINT: 'NORMAL COMPLETION' → STOP
yes

↓

4. PRINT: 'RUN ID'

↓

5. CALL INPUTM

↓

6. CALL INIT

↓

7. CALL INPUTO

↓

8. A → ITIM2 = ITIM2 + ITSPRD
I = 0
K = 0
KPR = 0
ISW = 0
ISAVE = 0
ITIME = ITIME + IDELT

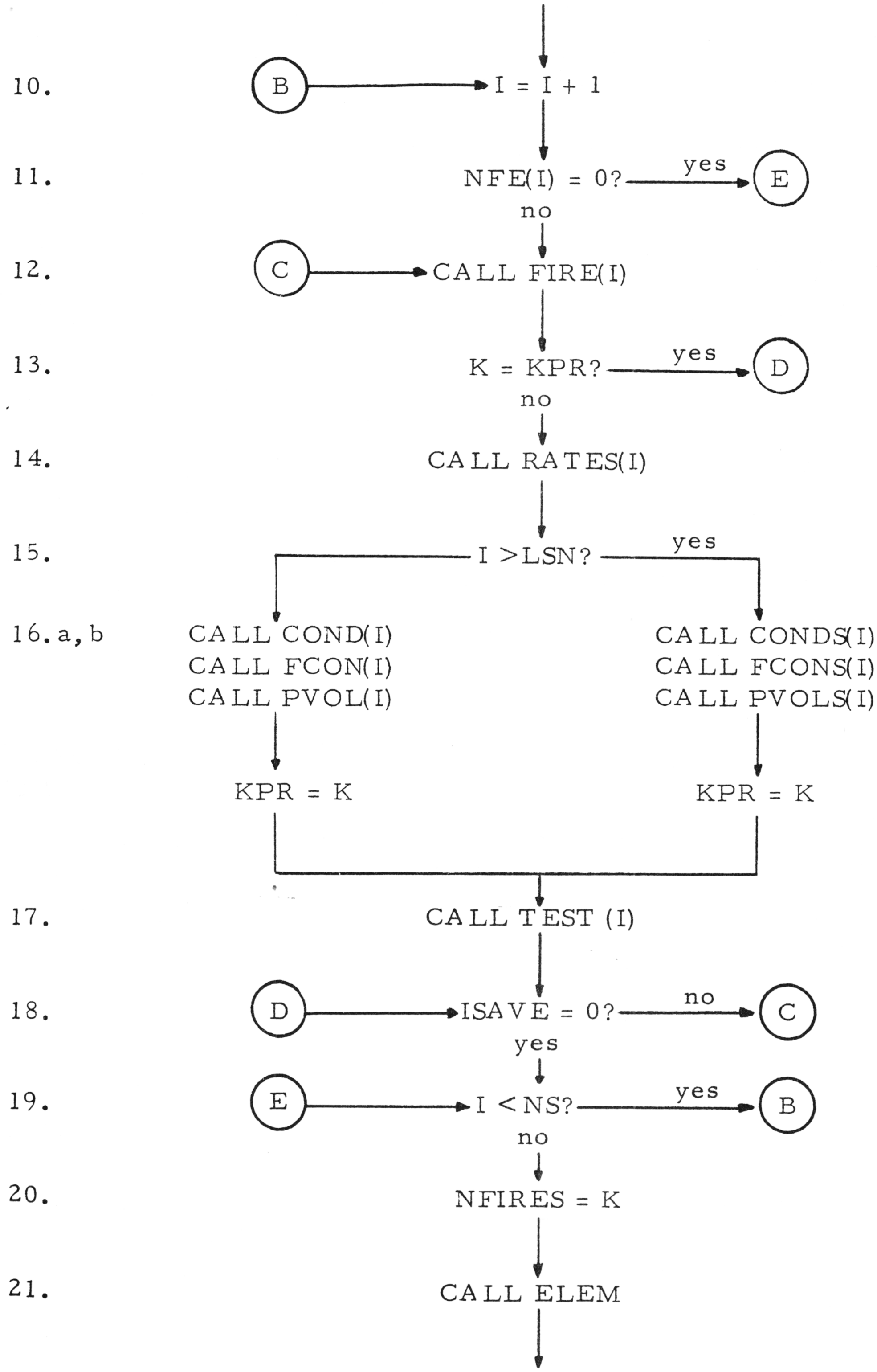
↓

9. TDQ = 0.
TRSF = 0.
TRGF(J) = 0; J = 1,9

↓

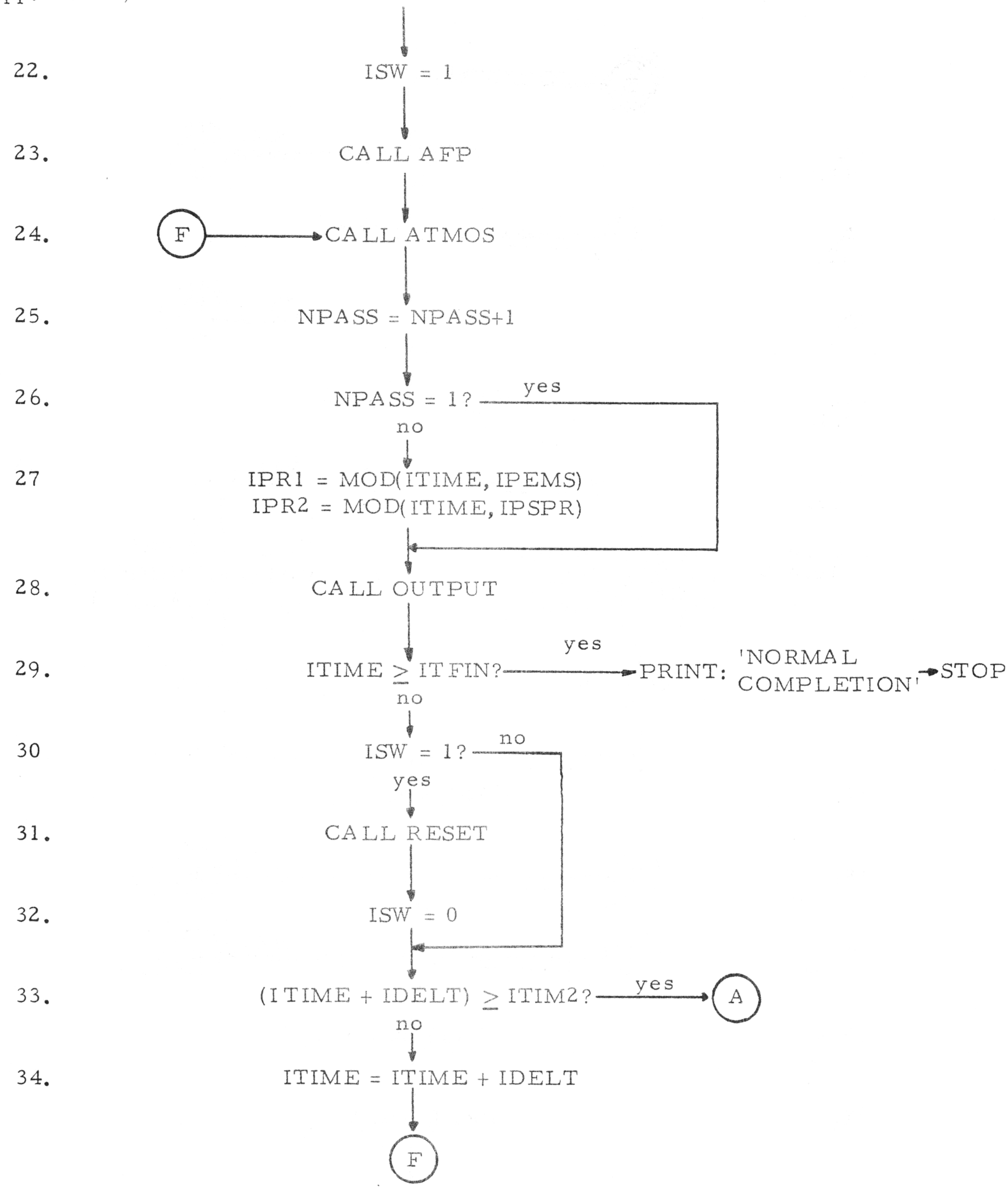
'MAIN PROGRAM' FLOW CHART (Continued)

Component No.
(see pp. 13-15)



'MAIN PROGRAM' FLOW CHART (Continued)

Component No.
(see pp. 13-15)



COMMENTS FOR PROGRAM FLOW CHART

No.

1. 'NPASS' is a counter, initialized at this point, which will contain the number of times the cabin atmosphere computations have been performed. IPR1, IPR2 are print controls.

2. Subroutine 'INPUTG' initializes and defines those variables pertaining to the geometry of the cabin section.

3. Test for run termination (no additional input cards to be read).

4. Eighty characters of run identification are printed.

5. Subroutine 'INPUTM' reads all input data pertaining to the material properties of each surface.

6. Subroutine 'INIT' performs basic computations from the input data and initializes those variables required to start the integration.

7. Subroutine 'INPUTO' reads all data relating to the ignition source.

8. This point is the start of the primary integration loop in the program. 'ITIM2' is the time associated with the flame propagation computations, 'ITIME' is the time associated with the cabin atmosphere computations.

9. Initialize sums which contain emission rates for all fires.

10. 'I' is the surface index (1 through 20 are cabin lining surfaces, 21 through 29 are seat groups).

11. Test: Any flaming elements on surface 'I'? If not, by-pass flame propagation computations for this surface.

12. Subroutine 'FIRE' isolates a fire on the specified surface and performs the computations of the flame properties.

13. If K = KPR at this point, a new fire was not found in subroutine 'FIRE'.

14. Subroutine 'RATES' determines the heat flux at various points associated with one specific fire, and interpolates for material properties as a function of heat flux.

15. If I > LSN, the fire under consideration is located on a seat; otherwise the fire is located on a cabin lining surface.

16. Subroutines 'COND', 'CONDS' determine flame propagation via conduction.

No.

Subroutines 'FCON', 'FCONS' determine flame propagation via flame contact.
Subroutines 'PVOL', 'PVOLS' test for possible elemental change of state due to the pyrolysis (smoldering) of elements in the vicinity of a fire.

17. Subroutine 'TEST' determines if any flaming elements change to the charred state and sums the emission rates for each fire.

18. If 'ISAVE' $\neq 0$; then return control to subroutine 'FIRE' (continue to search surface 'I' for fires).

19. Test: Have all cabin lining surfaces and seat groups been examined this time step? If not, increment for next surface.

20. The variable 'NFIRES' contains the total number of distinct fires in progress during this time interval.

21. Subroutine 'ELEM' updates the time counters and indicators associated with each element.

22. 'ISW' is a switch. When ISW = 1, indicates that the flame propagation computations have been performed this time step.

23. Subroutine 'AFP' determines the total number of flaming and smoldering elements and sums emission rates.

24. Subroutine 'ATMOS' contains all of the equations describing the cabin atmosphere.

25. Add 'one' to the pass counter.

26. Test: If this is the first pass through the program, automatically print flame propagation and cabin atmosphere data.

27. Determine if flame propagation and/or cabin atmosphere data is to be printed this time step.

28. Subroutine 'OUTPUT' consists of the required print and format statements and controls to obtain the output data as required.

29. Test: If simulation time has expired, print appropriate message and terminate the run.

30.- 32. If the flame propagations computations have been performed this pass, reset computer words containing the element states information.

No.

33. If flame propagation computations are to be performed the next time step, re-enter appropriate loop.

34. If flame propagation are not required next time step, increment cabin atmopshere 'Δt' and re-enter cabin atmosphere computations.

SECTION 4

INPUT DATA PREPARATION

This section describes the input requirements of the DACFIR Computer Program. The preparation of each input card is described, and, where necessary, a brief explanation of the input data requirements and options is included. Familiarity with the DACFIR Mathematical Model, as described in Volume I, is assumed. Following the input preparation instructions is a listing of a sample input data deck. The specific set of input data shown in the listing was used to create Case 1 of the sample runs discussed in Section 7, Volume 1.

In the data description shown below, three format types are referenced. They are

Type	Description
A	Alphanumeric, any combination of letters, numbers, and special characters (including blanks) may be entered in the appropriate column.
I	Integer, the entry must be right justified in the field (range of columns). Example: when the number '25' is entered in a five-column field, it must be preceded by three blanks.
F	Floating point, the entry may appear anywhere in the specified field, but the insertion of a decimal point is mandatory.

4.1 INPUT DATA CARDS

Input data cards are to be prepared as described below. Some of the input data for the version of the DACFIR Program described here (Version 1, 30 May 1976) is to be regarded as fixed and not user-defineable. This data consists of various geometric relationships common to all wide-body cabin interiors. The fixed data is indicated in the discussion and users of the program should prepare this data according to the example data set given in Section 4.2. Card Number in the list refers to the number in the sample data set.

Card Type	Card Number	Var.	Dim.	Col.	Format Type	Description
1	1	IDENT	20	1-80	A	Run identification
2 - 5	2 - 133	-	-	-	-	Fixed input data (see sample data, pp. 33-35)
6	134	SQD	-	1-10	F	Element square dimension (fixed)
6	134	RFWS	-	11-20	F	Flame spread rate sidewall to seat or seat to sidewall (ft/sec)
6	134	DWS	-	21-30	F	Separation distance outside seats to sidewall (ft)
6	134	CH	-	31-40	F	Cabin floor to ceiling height (ft)
6	134	CL	-	41-50	F	Cabin section length (see Figure 5.1, Volume 1) (ft)
6	134	CW	-	51-60	F	Cabin width (ft)
6	134	SL	-	61-70	F	Detailed section length (see Figure 5.1, Volume 1) (ft)
6	134	SW	-	71-80	F	Section width (must be equal to 1/2 the value of CW)(ft)in columns 51-60
7 - 9	135 - 138	-	-	-	-	Fixed input (see sample data, p. 35)
10	139	IMATL	20	1-2 . . . 39-40	I	Material type for each surface taken in order around the cabin interior (material type denoted by the integers 1-7, see p. 4)
11	140	IMATS	7	1-2 . 13-14	I	Material type for each surface on the seats (see Figure 2.3 & p. 4)

Card Type	Card Number	Var.	Dim.	Col.	Format Type	Description
12	141	GTAB	7	1-10 . . 61-70	F	Stochiometric fuel to oxygen ratio for each combustion of the seven material types (unitless)
12	142	QTAB	7	1-10 . . 61-70	F	Effective heat of combustion for each of the seven material types (Btu/lbm)
12	143	RTAB	7	1-10 . . 61-70	F	Fuel vapor density at base of fire for each of the seven material types (lbm/ft^3)
12	144	UTAB	7	1-10 . . 61-70	F	Fuel vapor flow velocity at base of fire for each of the seven material types (ft/sec)
12	145	TP	7	1-10 . . 61-70	F	Time of transition of an element from the ambient to the smoldering state, each material type (sec)
12	146	TPC	7	1-10 . . . 61-70	F	Time of transition of an element from the smoldering to the charred state, each material type (sec)
12	147	RSS	7	1-10 . . . 61-70	F	The smoke production rate for each of the seven material types in the smoldering state, 'particles'/($ft^2 \cdot sec$) (See Volume 1, Section 5 for discussion of the units 'particles of smoke'.
12	148	RGS(1)	7	1-10 . . 61-70	F	Production rate of CO for each material in the smoldering state, microlbs/ $ft^2 \cdot sec$) (1 microlb = 10^6 lb)

Card Type	Card Number	Var.	Dim.	Col.	Format Type	Description
12	149	RGS(2)	7	1-10 . . 61-70	F	Production rate of HCl for each material in the smoldering state, microlbs/($ft^2 \cdot sec$)
12	150	RGS(3)	7	1-10 . . 61-70	F	Production rate of HCN for each material in the smoldering state, microlbs/($ft^2 \cdot sec$)
12	151	RGS(4)	7	1-10 . . 61-70	F	Production rate of HF for each material in the smoldering state, microlbs/($ft^2 \cdot sec$)
12	152	RGS(5)	7	1-10 . . 61-70	F	Production rate of SO_2 for each material in the smoldering state, microlbs/($ft^2 \cdot sec$)
12	153	RGS(6)	7	1-10 . . 61-70	F	Production rate of H_2S for each material in the smoldering state, microlbs/($ft^2 \cdot sec$)
12	154	RGS(7)	7	1-10 . . 61-70	F	Production rate of NH_3 for each material in the smoldering state, microlbs/($ft^2 \cdot sec$)
12	155	RGS(8)	7	1-10 . . 61-70	F	Production rate of NO for each material in the smoldering state, microlbs/($ft^2 \cdot sec$)
12	156	RGS(9)	7	1-10 . . 61-70	F	Production rate of $COCL_2$ for each material in the smoldering state, microlbs/($ft^2 \cdot sec$)

Card Type 13 (numbers 157 through 275 in the sample deck) consist of tables of various material properties as a function of Q, the heat flux in Btu/($ft^2 \cdot sec$). Each table consists of six X, Y pairs of points -- X being the heat flux, Y the material property. If, during the simulation, a material property value is needed for a heat flux less than Q_1, then the value Y_1 will be used. Linear extrapolation is used to obtain a material property value for a heat flux greater than Q_6. The formats of these tables are as follows.

Cols.	1-5	6-13	14-18	19-26	27-31	32-39	40-44
	Q_1	Y_1	Q_2	Y_2	Q_3	Y_3	Q_4
	45-52	53-57	58-65	66-70	71-78		
	Y_4	Q_5	Y_5	Q_6	Y_6		

It is not necessary that the heat flux values be separated by equal increments. All values are input in 'F' format.

Card Type	Card No.	Table as a Function of Heat Flux (Q)
13	157	Horizontal flame spread rate, material #1, ft/sec
"	158	Horizontal flame spread rate, material #2, ft/sec
"	159	Horizontal flame spread rate, material #3, ft/sec
"	160	Horizontal flame spread rate, material #4, ft/sec
"	161	Horizontal flame spread rate, material #5, ft/sec
"	162	Horizontal flame spread rate, material #6, ft/sec
"	163	Horizontal flame spread rate, material #7, ft/sec
"	164	Vertical upward flame spread rate, material #1, ft/sec
"	165	Vertical upward flame spread rate, material #2, ft/sec
"	166	Vertical upward flame spread rate, material #3, ft/sec
"	167	Vertical upward flame spread rate, material #4, ft/sec
"	168	Vertical upward flame spread rate, material #5, ft/sec
"	169	Vertical upward flame spread rate, material #6, ft/sec
"	170	Vertical upward flame spread rate, material #7, ft/sec
"	171	Vertical downward flame spread rate, material #1, ft/sec
"	172	Vertical downward flame spread rate, material #2, ft/sec
"	173	Vertical downward flame spread rate, material #3, ft/sec
"	174	Vertical downward flame spread rate, material #4, ft/sec
"	175	Vertical downward flame spread rate, material #5, ft/sec
"	176	Vertical downward flame spread rate, material #6, ft/sec

Card Type	Card No.	Table as a Function of Heat Flux (Q)
13	177	Vertical downward flame spread rate, material #7, ft/sec
"	178	Time interval, time lag from the time of flame contact to the time material begins flaming combustion, material #1, sec
"	179	Time interval, time lag from the time of flame contact to the time material begins flaming combustion, material #2, sec
"	180	Time interval, time lag from the time of flame contact to the time material begins flaming combustion, material #3, sec
"	181	Time interval, time lag from the time of flame contact to the time material begins flaming combustion, material #4, sec
"	182	Time interval, time lag from the time of flame contact to the time material begins flaming combustion, material #5, sec
"	183	Time interval, time lag from the time of flame contact to the time material begins flaming combustion, material #6, sec
"	184	Time interval, time lag from the time of flame contact to the time material begins flaming combustion, material #7, sec
"	185	Heat release rate while material #1 is undergoing flaming combustion, $BTU/(ft^2 \cdot sec)$
"	186	Heat release rate while material #2 is undergoing flaming combustion, $BTU/(ft^2 \cdot sec)$
"	187	Heat release rate while material #3 is undergoing flaming combustion, $BTU/(ft^2 \cdot sec)$
"	188	Heat release rate while material #4 is undergoing flaming combustion, $BTU/(ft^2 \cdot sec)$
"	189	Heat release rate while material #5 is undergoing flaming combustion, $BTU/(ft^2 \cdot sec)$
"	190	Heat release rate while material #6 is undergoing flaming combustion, $BTU/(ft^2 \cdot sec)$
"	191	Heat release rate while material #7 is undergoing flaming combustion, $BTU/(ft^2 \cdot sec)$
"	192	Smoke production rate for material #1 in the flaming state, 'particles'/$(ft^2 \cdot sec)$ (A smoke 'particle' is the amount of smoke which if contained in a volume of one cubic foot would cause the light transmission over a one foot path to be reduced by 10%)

Card Type	Card No.	Table as a Function of Heat Flux (Q)
13	193	Smoke production rate for material #2 in the flaming state, 'particles'/($ft^2 \cdot sec$)
"	194	Smoke production rate for material #3 in the flaming state, 'particles'/($ft^2 \cdot sec$)
"	195	Smoke production rate for material #4 in the flaming state, 'particles'/($ft^2 \cdot sec$)
"	196	Smoke production rate for material #5 in the flaming state, 'particles'/($ft^2 \cdot sec$)
"	197	Smoke production rate for material #6 in the flaming state, 'particles'/($ft^2 \cdot sec$)
"	198	Smoke production rate for material #7 in the flaming state, 'particles'/($ft^2 \cdot sec$)
"	199	Production rate of CO for material #1 in the flaming state, microlbs/($ft^2 \cdot sec$) (1 microlb = 10^{-6}lb)
"	200	Production rate of CO for material #2 in the flaming state, microlbs/($ft^2 \cdot sec$)
"	201	Production rate of CO for material #3 in the flaming state, microlbs/($ft^2 \cdot sec$)
"	202	Production rate of CO for material #4 in the flaming state, microlbs/($ft^2 \cdot sec$)
"	203	Production rate of CO for material #5 in the flaming state, microlbs/($ft^2 \cdot sec$)
"	204	Production rate of CO for material #6 in the flaming state, microlbs/($ft^2 \cdot sec$)
"	205	Production rate of CO for material #7 in the flaming state, microlbs/($ft^2 \cdot sec$)
"	206	Production rate of HCl for material #1 in the flaming state, microlbs/($ft^2 \cdot sec$)
"	207	Production rate of HCl for material #2 in the flaming state, microlbs/($ft^2 \cdot sec$)
"	208	Production rate of HCl for material #3 in the flaming state, microlbs/($ft^2 \cdot sec$)
"	209	Production rate of HCl for material #4 in the flaming state, microlbs/($ft^2 \cdot sec$)
"	210	Production rate of HCl for material #5 in the flaming state, microlbs/($ft^2 \cdot sec$)

Card Type	Card No.	Table as a Function of Heat Flux (Q)
13	211	Production rate of HCl for material #6 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	212	Production rate of HCl for material #7 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	213	Production rate of HCN for material #1 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	214	Production rate of HCN for material #2 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	215	Production rate of HCN for material #3 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	216	Production rate of HCN for material #4 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	217	Production rate of HCN for material #5 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	218	Production rate of HCN for material #6 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	219	Production rate of HCN for material #7 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	220	Production rate of HF for material #1 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	221	Production rate of HF for material #2 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	222	Production rate of HF for material #3 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	223	Production rate of HF for material #4 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	224	Production rate of HF for material #5 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	225	Production rate of HF for material #6 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	226	Production rate of HF for material #7 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	227	Production rate of SO_2 for material #1 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	228	Production rate of SO_2 for material #2 in the flaming state, microlbs/($ft^2 \cdot$ sec)

Card Type	Card No.	Table as a Function of Heat Flux (Q)
13	229	Production rate of SO_2 for material #3 in the flaming state, microlbs/(ft^2 · sec)
"	230	Production rate of SO_2 for material #4 in the flaming state, microlbs/(ft^2 · sec)
"	231	Production rate of SO_2 for material #5 in the flaming state, microlbs/(ft^2 · sec)
"	232	Production rate of SO_2 for material #6 in the flaming state, microlbs/(ft^2 · sec)
"	233	Production rate of SO_2 for material #7 in the flaming state, microlbs/(ft^2 · sec)
"	234	Production rate of H_2S for material #1 in the flaming state, microlbs/(ft^2 · sec)
"	235	Production rate of H_2S for material #2 in the flaming state, microlbs/(ft^2 · sec)
"	236	Production rate of H_2S for material #3 in the flaming state, microlbs/(ft^2 · sec)
"	237	Production rate of H_2S for material #4 in the flaming state, microlbs/(ft^2 · sec)
"	238	Production rate of H_2S for material #5 in the flaming state, microlbs/(ft^2 · sec)
"	239	Production rate of H_2S for material #6 in the flaming state, microlbs/(ft^2 · sec)
"	240	Production rate of H_2S for material #7 in the flaming state, microlbs/(ft^2 · sec)
"	241	Production rate of NH_3 for material #1 in the flaming state, microlbs/(ft^2 · sec)
"	242	Production rate of NH_3 for material #2 in the flaming state, microlbs/(ft^2 · sec)
"	243	Production rate of NH_3 for material #3 in the flaming state, microlbs/(ft^2 · sec)
"	244	Production rate of NH_3 for material #4 in the flaming state, microlbs/(ft^2 · sec)
"	245	Production rate of NH_3 for material #5 in the flaming state, microlbs/(ft^2 · sec)
"	246	Production rate of NH_3 for material #6 in the flaming state, microlbs/(ft^2 · sec)

Card Type	Card No.	Table as a Function of Heat Flux (Q)
13	247	Production rate of NH_3 for material #7 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	248	Production rate of NO_x for material #1 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	249	Production rate of NO_x for material #2 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	250	Production rate of NO_x for material #3 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	251	Production rate of NO_x for material #4 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	252	Production rate of NO_x for material #5 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	253	Production rate of NO_x for material #6 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	254	Production rate of NO_x for material #7 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	255	Production rate of $COCl_2$ for material #1 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	256	Production rate of $COCl_2$ for material #2 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	257	Production rate of $COCl_2$ for material #3 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	258	Production rate of $COCl_2$ for material #4 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	259	Production rate of $COCl_2$ for material #5 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	260	Production rate of $COCl_2$ for material #6 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	261	Production rate of $COCl_2$ for material #7 in the flaming state, microlbs/($ft^2 \cdot$ sec)
"	262	Time interval, time required for material #1 to stop smoldering after heat flux falls below the threshold value for this material, sec
"	263	Time interval, time required for material #2 to stop smoldering after heat flux falls below the threshold value for this material, sec

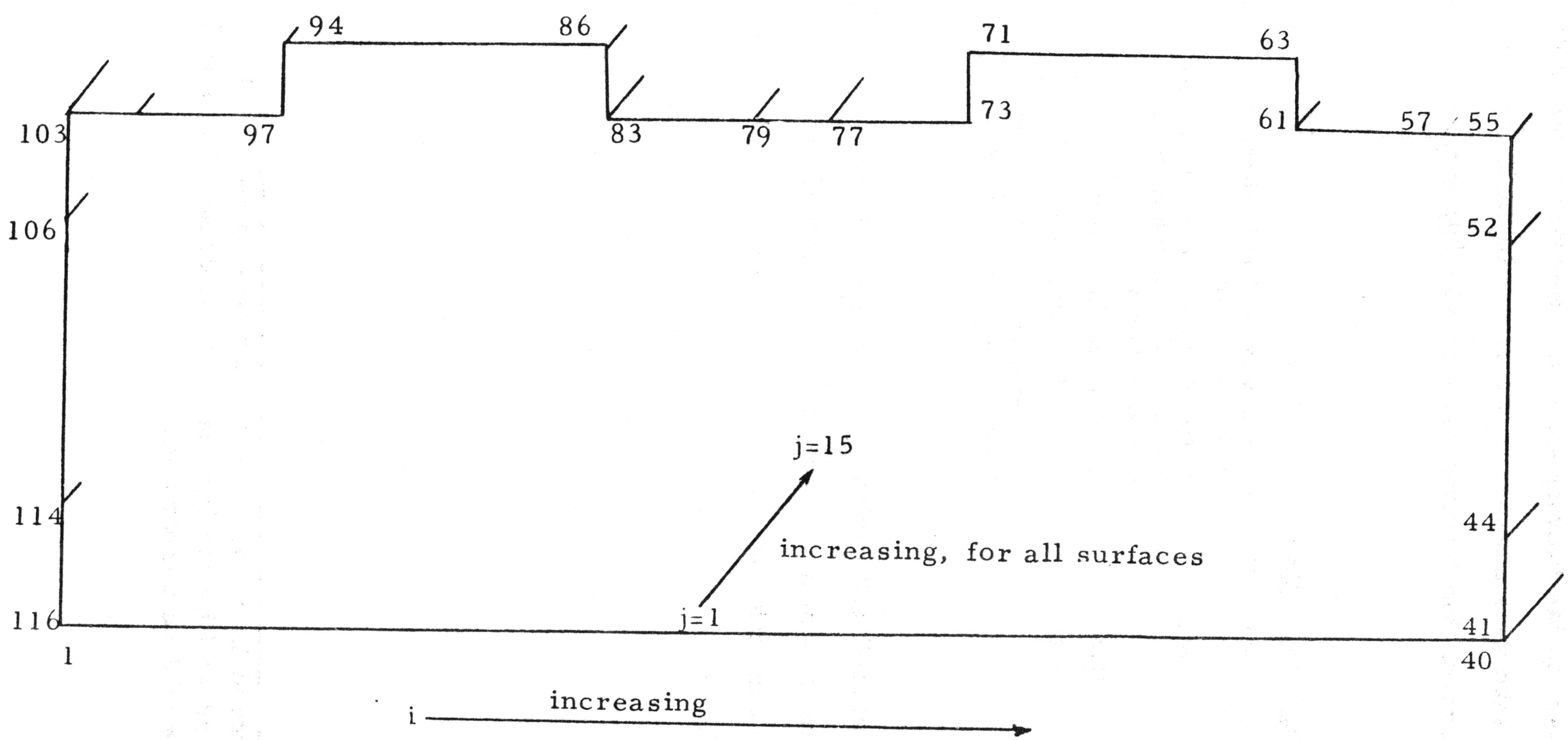
Card Type	Card No.	Table as a Function of Heat Flux (Q)
13	264	Time interval, time required for material #3 to stop smoldering after heat flux falls below the threshold value for this material, sec
"	265	Time interval, time required for material #4 to stop smoldering after heat flux falls below the threshold value for this material, sec
"	266	Time interval, time required for material #5 to stop smoldering after heat flux falls below the threshold value for this material, sec
"	267	Time interval, time required for material #6 to stop smoldering after heat flux falls below the threshold value for this material, sec
"	268	Time interval, time required for material #7 to stop smoldering after heat flux falls below the threshold value for this material, sec
"	269	Time interval, from time material #1 begins flaming combustion to time material becomes charred, sec
"	270	Time interval, from time material #2 begins flaming combustion to time material becomes charred, sec
"	271	Time interval, from time material #3 begins flaming combustion to time material becomes charred, sec
"	272	Time interval, from time material #4 begins flaming combustion to time material becomes charred, sec
"	273	Time interval, from time material #5 begins flaming combustion to time material becomes charred, sec
"	274	Time interval, from time material #6 begins flaming combustion to time material becomes charred, sec
"	275	Time interval, from time material #7 begins flaming combustion to time material becomes charred, sec

Two methods may be used to specify the ignition source for a simulation. The first method is illustrated by the sample data of Section 4. 2 and the data preparation instructions are given immediately below. This first method consists of specifying the amount and location of an ignition source material, such as a flammable liquid. The ignition source material must be located on one of the cabin interior surfaces and must be described by the flammability and combustion toxicity parameters given below. At the start of the simulation, all of the ignition source material is assumed to be on fire and this fire will continue to burn for a period of time determined by the expression $t_{ig} = m_{fi}/\dot{m}_{ft} = m_{fi}/(\rho_{oi}u_{oi}A_{ft})$ where t_{ig} is the burn time in seconds, m_{fi} is the mass of ignition source material in lbm, $\dot{m}_{ft}$ is the material burning rate which is the product of ρ_{oi}, the material fuel vapor density entering the flame base, u_{oi}, the fuel vapor velocity entering the flame base, and A_{fi} the total area of the ignition source material. For further discussion of this method of describing ignition, see Section 7 of Volume I. The second method of specifying ignition is discussed on page 32 of this volume.

Card Type	Card No.	Var.	Dim.	Col.	Type	Definition
14	276	QP	7	1-10 . 61-70	F	Heat flux (threshold value) at which each material type begins to smolder, Btu/(ft^2 · sec)
15	277	CPM	--	1-10	F	Specific heat of materials at ambient conditions, average value, Btu/(lbm · ^{o}R)
		RHOM	--	21-30	F	Bulk density of materials, average value (lbm/ft^3)
		XK	--	21-30	F	Thermal conductivity of materials at ambient conditions, average value, Btu/(ft · sec · ^{o}R)
		XPEN	--	31-40	F	Heat penetration depth of materials, average value, ft
		TO	--	41-50	F	Ambient temperature, ^{o}R

Card Type	Card No.	Var.	Dim.	Col.	Type	Definition
16	278	DELTAT	--	1-10	F	Integration time interval for the cabin atmosphere computations, sec
		TFINAL	--	11-20	F	End time for the simulation run, sec
		IRATIO	--	21-25	I	Ratio: integration time interval of flame spread computations integration time interval of cabin atmosphere computations (must be ≥ 1)
		IPEMS	--	26-30	I	Print interval, cabin atmosphere, sec
		IPSPR	--	31-35	I	Print interval, flame spread data, sec
17	279	NV	--	1-5	I	Number of open doorways (may be = 0)
		BVENT	--	11-20	F	Distance, floor to top of open doorway, ft (same for all doorways)
18	280	WVENT	--	1-10 . 41-50	F	Width of each open doorway, ft *This card must be deleted if NV = 0
19	281	QBKGND	--	1-10	F	Background heat flux, $Btu/(ft^2 \cdot sec)$
20	282	IGSN	--	1-5	I	Surface on which ignition source material resides. If this value is entered as zero, the second method of specifying ignition is indicated. In this case, no cards of type 21, 22, or 23 should appear in this data deck.
		QCI	--	6-15	F	Effective heat of combustion of the ignition source material, Btu/lbm
		GAMI	--	16-25	F	Stochiometric fuel to oxygen ratio of ignition source material
		RHOI	--	26-35	F	Fuel vapor density at base of ignition source, lbm/ft^3
		XMUI	--	36-45	F	Fuel vapor flow velocity at base of ignition source, ft/sec
		XMFI		46-55	F	Mass of ignition source material to be burned, lbm

Card Type	Card No.	Var.	Dim.	Col.	Type	Description
21	283	RSI	--	1-10	F	Smoke production rate, ignition source material, 'particles'/$ft^2 \cdot$ sec
		RTGI(1)	--	11-20	F	Production rate of CO, ignition source material, microlb/($ft^2 \cdot$ sec) (1 microlb = 10^{-6} lbm)
		RTGI(2)	--	21-30	F	Production rate of HCl, ignition source material, microlb/($ft^2 \cdot$ sec)
		RTGI(3)	--	31-40	F	Production rate of HCN, ignition source material, microlb/($ft^2 \cdot$ sec)
		RTGI(4)	--	41-50	F	Production rate of HF, ignition source material, microlb/($ft^2 \cdot$ sec)
		RTGI(5)	--	51-60	F	Production rate of SO_2, ignition source material, microlb/($ft^2 \cdot$ sec)
		RTGI(6)	--	61-70	F	Production rate of H_2S, ignition source material, microlb/($ft^2 \cdot$ sec)
		RTGI(7)	--	71-80	F	Production rate of NH_3, ignition source material, microlb/($ft^2 \cdot$ sec)
21	284	RTGI(8)	--	1-10	F	Production rate of NO_x, ignition source material, microlb/($ft^2 \cdot$ sec)
		RTGI(9)	--	11-20	F	Production rate of $COCl_2$, ignition source material, microlb/($ft^2 \cdot$ sec)
22	285	NIJSQ	--	1-5	I	The number of elements covered by the ignition source
		PIGN	--	6-15	F	Perimeter of ignition source fire, ft
23	286 thru 301	ICNIJ	(2100)	1-5	I	i index of ignition source element
				6-10	I	j index of ignition source element
						Enter one pair of i, j indices per card (total number of cards will be equal to the value of NIJSQ) For numbering of elements, see Figure 4.1.
24	302	NIJC	--	1-5	I	Number of elements (on any surface) to be set to the charred (inert) state at the start of the simulation. If the value = zero, do not include cards of type 25 in the deck.
25	(not shown)	I, J	--	1-5		i index of inert element
				6-10		j index of inert element
						Enter one pair of i, j indices per card (total number of cards will be equal to the value of NIJC



i progresses counterclockwise around the cabin lining facing toward the rear of the cabin

j progresses from the front edge to the back edge of the cabin section of interest

Figure 4.1. Numbering of Elements

The second method for specifying the ignition source is somewhat more simple than the first. In this method, any number of elements on one or more surfaces can be set to the flaming state at the start of the simulation. To indicate this method, a zero is entered in column 5 of card type 20. Initialization of the elements to the flaming state is done by entering values on card types 26 and 27.

Card Type	Card No.	Var.	Dim.	Col.	Type	Description
26	303	NOFL	--	1-5	I	*Total number of flaming elements on surface ISFL.
		ISFL	--	6-10		Surface number on which the elements identified on the following type 27 cards are located.
27	(not shown)	I, J	--	1-5	I	i index of flaming element
				6-10		j index of flaming element
						Enter one pair of i, j indices per card to a total of NOFL cards.

If elements are to be initialized to flaming on additional surfaces, the deck should continue with groups of cards of types 26 and 27 arranged as above until all desired elements are initialized. No further cards are necessary following the last type 27 card.

*If the value of NOFL entered is zero, a zero must be entered for the variable ISFL and this card will be the last card in the deck. No initialization to the flaming state will be performed.

4.2 SAMPLE INPUT

The following six pages present a sample input data deck.

Card Type	Card No.	Col. 1									
1	1	WIDE-BODY CASE 1 S O A MATERIALS, FLOOR SPILL FIRE									
2		20	9	7	22						
3		0.	0.	1.0							
"		1.0	0.	0.							
"	5	1.0	0.	0.							
"		1.0	0.	0.							
"		0.	0.	-1.0							
"		0.	0.	-1.0							
"		1.0	0.	0.							
"	10	0.	0.	-1.0							
"		-1.0	0.	0.							
"		0.	0.	-1.0							
"		0.	0.	-1.0							
"		0.	0.	-1.0							
"	15	1.0	0.	0.							
"		0.	0.	-1.0							
"		-1.0	0.	0.							
"		0.	0.	-1.0							
"		0.	0.	-1.0							
"	20	-1.0	0.	0.							
"		-1.0	0.	0.							
3		-1.0	0.	0.							
4		1	9	1	40	1	15	0.0			
5		21	1	10	2	5	1	0	1	-1	0
5	25	22	14	27	1	4	1	-13	1	0	0
5		23	31	40	2	5	1	-30	1	-1	0
5		24	1	10	7	10	1	0	1	-6	0
5		25	14	27	6	9	1	-13	1	-5	3
5		26	31	40	7	10	1	-30	1	-6	0
5	30	27	1	10	12	15	1	0	1	-11	0
5		28	14	27	11	14	1	-13	1	-10	0
5		29	31	40	12	15	1	-30	1	-11	0
4		0	4	41	43	1	15	0.0			
5		5	41	54	1	15	0	55	1	0	0
5	35	-23	43	43	2	4	0	10	-1	23	0
5		-26	43	43	7	9	0	10	-1	28	0
5		-29	43	43	12	14	0	10	-1	33	0
4		0	7	44	51	1	15	0.0			
5		5	41	54	1	15	0	55	1	0	0
5	40	-23	44	49	5	5	0	10	-1	62	1
5		-23	44	49	5	5	0	10	1	-38	1
5		-26	44	49	10	10	0	10	-1	62	1
5		-26	44	49	10	10	0	10	1	-39	1
5		-29	44	49	15	15	0	10	-1	62	1
5	45	-29	44	49	15	15	0	10	1	-38	1
4		0	1	52	54	1	15	0.0			

Card Type	Card No.	Col. 5									
5	47	5	41	54	1	15	0	55	1	0	0
4		0	0	55	56	1	15	7.0			
4		0	0	57	60	1	15	7.0			
4	50	1	1	61	62	1	15	0.0			
5		8	61	62	1	15	0	63	1	0	0
4		0	0	63	71	1	15	8.0			
4		0	1	72	73	1	15	0.0			
5		8	72	73	1	15	0	71	1	0	0
4	55	0	0	74	77	1	15	7.0			
4		0	0	78	79	1	15	7.0			
4		0	0	80	83	1	15	7.0			
4		0	1	84	85	1	15	0.0			
5		14	84	85	1	15	0	86	1	0	0
4	60	0	0	86	94	1	15	8.0			
4		0	1	95	96	1	15	0.0			
5		14	95	96	1	15	0	94	1	0	0
4		0	0	97	100	1	15	7.0			
4		0	0	101	102	1	15	7.0			
4	65	0	1	103	105	1	15	0.0			
5		17	103	116	1	15	0	102	1	0	0
4		0	7	106	113	1	15	0.0			
5		17	103	116	1	15	0	102	1	0	0
5		-21	108	113	5	5	0	1	1	-95	1
5	70	-21	108	113	5	5	0	1	-1	119	1
5		-24	108	113	10	10	0	1	1	-95	1
5		-24	108	113	10	10	0	1	-1	119	1
5		-27	108	113	15	15	0	1	1	-95	1
5		-27	108	113	15	15	0	1	-1	119	1
4	75	0	4	114	116	1	15	0.0			
5		17	103	116	1	15	0	102	1	0	0
5		-21	114	114	2	4	0	1	-1	23	0
5		-24	114	114	7	9	0	1	-1	28	0
5		-27	114	114	12	14	0	1	-1	33	0
4	80	1	6	1	10	1	22	1.0			
5		16	3	6	5	18	-1	103	0	5	0
5		17	1	2	5	18	-1	103	0	5	0
5		-19	1	1	5	11	-1	119	0	5	1
5		-19	1	1	13	18	1	95	0	4	1
5	85	-20	1	1	1	4	0	114	1	1	0
5		-20	1	1	19	21	0	114	-1	23	0
4		1	3	1	14	1	22	1.0			
5		12	3	6	5	18	-1	86	0	4	0
5		11	7	8	5	18	-1	86	0	4	0
5	90	10	9	12	5	18	-1	86	0	4	0
4		1	6	1	10	1	22	1.0			
5		5	9	10	5	18	-1	65	0	5	0
5		6	5	8	5	18	-1	65	0	5	0
5		-3	10	10	5	11	1	38	0	5	1
5	95	-3	10	10	13	18	-1	62	0	4	1
5		-2	10	10	1	4	0	43	1	1	0
5		-2	10	10	19	21	0	43	-1	23	0
4		1	6	1	10	1	22	1.0			

Card Type	Card No.	Col. 5															
5		16	3	6	5	18	-1	103	0	10	0						
5	100	17	1	2	5	18	-1	103	0	10	0						
5		-19	1	1	5	11	-1	119	0	10	1						
5		-19	1	1	13	18	1	95	0	9	1						
5		-20	1	1	1	4	0	114	1	6	0						
5		-20	1	1	19	21	0	114	-1	28	0						
4	105	1	3	1	14	1	22	1.0									
5		12	3	6	5	18	-1	86	0	9	0						
5		11	7	8	5	18	-1	86	0	9	0						
5		10	9	12	5	18	-1	86	0	9	0						
4		1	6	1	10	1	22	1.0									
5	110	5	9	10	5	18	-1	65	0	10	0						
5		6	5	8	5	18	-1	65	0	10	0						
5		-3	10	10	5	11	1	38	0	10	1						
5		-3	10	10	13	18	-1	62	0	9	1						
5		-2	10	10	1	4	0	43	1	6	0						
5	115	-2	10	10	19	21	0	43	-1	28	0						
4		1	6	1	10	1	22	1.0									
5		16	3	6	5	18	-1	103	0	15	0						
5		17	1	2	5	18	-1	103	0	15	0						
5		-19	1	1	5	11	-1	119	0	15	1						
5	120	-19	1	1	13	18	1	95	0	14	1						
5		-20	1	1	1	4	0	114	1	11	0						
5		-20	1	1	19	21	0	114	-1	33	0						
4		1	3	1	14	1	22	1.0									
5		12	3	6	5	18	-1	86	0	14	0						
5	125	11	7	8	5	18	-1	86	0	14	0						
5		10	9	12	5	18	-1	86	0	14	0						
4		1	6	1	10	1	22	1.0									
5		5	9	10	5	18	-1	65	0	15	0						
5		6	5	8	5	18	-1	65	0	15	0						
5	130	-3	10	10	5	11	1	38	0	15	1						
5		-3	10	10	13	18	-1	62	0	14	1						
5		-2	10	10	1	4	0	43	1	11	0						
5		-2	10	10	19	21	0	43	-1	33	0						
6		0.5		0.2		0.1		8.0		30.0		20.		7.5		10.	
7	135	1	1	1	1	2	2	2	2	3	3	3	4	5	5	5	5
7		5	5	6	6	6	7										
8		0	0	0	0	0	12	11	10	9	8	7	6	5	1	1	
9		0	0	0	0	0	12	13	14	15	16	17	21	22	22	22	

Card Type	Card No.	Col. 1											
10		1 2 3 2 4 5 5 6 5 5 4 5 5 6 5 5 4 2 3 2											
11	140	7 7 7 7 7 7 7											
12		2.5	2.5	2.5	2.5	2.5	2.5	2.5					
12		7000.	7000.	7000.	7000.	7000.	7000.	7000.					
12		0.0935	0.0935	0.0935	0.0935	0.0935	0.0935	0.0935					
12		0.0374	0.0374	0.0374	0.0374	0.0374	0.0374	0.0374					
12	145	8.	20.	12.	10.	14.	7.	8.					
12		500.	67.	150.	150.	130.	120.	600.					
12		10.	25.	25.	25.	25.	75.	10.					
12		2.	30.	16.	16.	30.	4.	10.					
12		0.7	4.	0.1	0.2	4.	0.74	0.84					
12	150	0.32	0.05	0.	0.	0.05	0.	0.62					
12		0.	6.	0.	0.	6.	2.	0.					
12		3.0	0.	0.	0.	0.	0.	0.					
12		0.	0.	0.	0.	0.	0.	0.					
12		0.	0.	0.	0.	0.	0.	0.					
12	155	0.	0.	0.	0.	0.	0.	0.					
12		0.	0.	0.	0.	0.	0.	0.					
13		.3	0.	1.23	.017	1.94	.0464	2.82	.139	3.96	.417	4.3	.5
"		0.	0.	1.	0.	2.2	.0093	3.08	.0161	4.0	.0275	5.0	.038
"		1.	0.	2.2	.002	3.08	.0042	4.41	.0083	4.6	.0094	5.0	.012
"	160	1.32	0.	2.2	.0018	3.08	.0034	4.41	.0075	4.6	.0086	5.0	.011
"		0.	0.	1.32	0.	2.82	.0155	3.08	.0181	4.0	.0275	5.0	.038
"		0.	0.	1.	0.	1.94	.0106	2.82	.0213	3.96	.0415	4.20	.045
"		0.5	0.	1.23	.004	1.94	.0115	3.50	.0660	4.0	.097	5.0	.17
"		0.	0.	1.0	0.	2.0	0.	3.	0.	4.	0.	5.	0.
"	165	0.4	0.	1.	0.	2.2	.0192	3.08	.03	3.5	.035	4.	.041
"		0.	0.	1.	0.	2.	.003	3.08	.0065	4.41	.0133	5.	.0175
"		0.	0.	1.32	0.	2.2	.0035	3.08	.0044	4.41	.0113	5.	.015
"		0.	0.	1.	0.	2.2	0.0192	3.08	0.030	3.5	0.035	4.0	0.041
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"	170	0.5	0.	1.23	0.006	1.94	.0173	3.	.045	3.96	.0834	5.	.15
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.2	.00776	3.08	.0187	3.5	.024	4.	.0305
"		0.	0.	1.	0.	2.2	.0116	3.08	.0038	4.41	.0083	5.	.0011
"		0.	0.	1.32	0.	2.2	.0.14	3.08	.0034	4.41	.0075	5.	.0097
"	175	0.0	0.	1.	0.	2.2	0.0078	3.08	0.0187	3.5	0.024	4.0	0.0305
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.5	0.	1.23	.0032	1.94	.0092	3.	.024	3.96	.0445	5.	.08
"		0.	9000.	1.	10.	2.	5.	3.	2.	4.	1.	50.	0.
"		0.	9000.	0.5	5.	2.2	1.92	3.08	1.44	6.	0.5	50.	0.
"	180	0.	9000.	1.	50.	2.2	21.6	3.08	10.8	4.41	2.40	50.	0.
"		0.	9000.	1.	50.	2.2	21.6	3.08	10.8	4.41	2.40	50.	0.
"		0.	9000.	1.	10.	2.	5.	3.	2.	4.	1.	50.	0.
"		0.	9000.	0.5	5.	2.2	1.92	3.08	1.44	6.	0.5	50.	0.
"		0.	9000.	1.	10.	2.2	4.	4.	1.	8.	0.5	50.	0.
"	185	0.	0.	0.4	0.	1.94	3.33	2.82	7.08	5.	10.	6.	10.4
"		0.	0.	0.5	0.	2.2	2.75	3.08	4.42	4.5	6.	5.	6.3
"		0.	0.	0.4	0.	2.2	7.67	4.41	11.61	5.	11.61	6.	11.61
"		0.	0.	0.4	0.	2.2	7.67	4.41	11.61	5.	11.61	6.	11.61
"		0.	0.	0.4	0.	2.82	5.43	4.4	8.	5.	8.45	6.	9.00
"	190	0.2	0.	0.4	0.3	1.23	2.78	1.94	6.31	2.6	8.1	3.9	9.95
"		0.	0.	0.2	0.	1.23	2.03	1.94	2.59	4.	3.2	5.	3.2
"		0.	0.	0.4	1.	1.94	18.18	2.82	35.6	4.	45.	5.	47.5
13		0.	0.	0.5	0.	2.2	23.15	3.08	59.23	4.	90.	5.	98.

Card Type	Card No.	Col. 1											
13		0.	0.	0.4	0.	2.2	37.29	4.41	55.	5.	55.	6.	55.
"	195	0.	0.	0.4	0.	2.2	37.29	4.41	70.	5.	73.	6.	77.5
"		0.	0.	0.5	0.	2.2	23.15	3.08	59.23	4.	90.	5.	98.
"		0.2	0.	0.4	5.0	1.23	46.74	1.63	73.0	1.94	83.85	2.80	99.0
"		0.2	0.	1.23	10.25	1.94	17.06	2.82	17.89	3.96	7.09	5.0	7.09
"		0.5	0.	2.2	24.6	3.70	200.0	4.41	259.0	5.	270.0	6.61	244.8
"	200	0.5	0.0	2.20	208.0	3.30	170.0	4.41	92.0	5.00	150.0	6.61	631.6
"		0.4	0.0	2.2	87.2	3.7	240.0	4.41	266.8	5.4	290.0	6.61	281.8
"		0.4	0.0	2.2	0.0	3.40	70.0	4.41	150.4	5.20	180.0	6.61	168.1
"		0.5	0.0	2.2	69.8	3.00	65.0	4.41	31.1	4.90	50.0	6.61	213.2
"		0.2	0.0	2.2	305.1	3.84	800.0	4.41	872.4	5.32	800.0	6.61	505.3
"	205	0.2	0.0	2.2	78.7	3.40	103.0	4.41	105.2	5.40	110.0	6.61	151.8
"		0.0	0.0	2.2	8.5	3.5	30.0	4.41	40.4	5.06	30.0	6.61	0.0
"		0.0	0.0	0.5	0.0	2.2	25.2	3.1	34.0	4.41	35.3	6.61	0.0
"		0.0	0.0	0.4	0.0	2.2	3.7	3.3	8.5	4.41	9.8	6.61	0.0
"		0.0	0.0	0.4	0.0	2.2	1.1	3.3	1.8	4.41	2.0	6.61	0.0
"	210	0.0	0.0	0.4	0.0	2.2	8.4	3.0	11.0	4.41	11.9	6.61	0.0
"		0.2	0.0	2.2	13.0	3.6	28.5	4.41	31.5	4.9	28.0	6.61	3.9
"		0.0	0.0	0.2	0.0	2.2	5.1	3.1	10.0	4.41	11.7	6.61	0.0
"		0.0	0.0	0.4	0.0	2.2	3.9	3.18	5.6	4.41	6.2	6.61	5.6
"		0.0	0.0	0.5	0.0	2.2	0.5	4.41	1.8	5.70	4.6	6.61	8.7
"	215	0.0	0.0	1.0	0.0	2.2	0.0	4.41	0.0	6.0	0.1	6.61	0.2
"		0.0	0.0	1.0	0.0	2.2	0.0	4.41	0.1	5.40	0.1	6.61	0.0
"		0.0	0.0	0.5	0.0	2.2	0.1	4.41	0.6	5.56	1.4	6.61	2.9
"		0.0	0.0	0.2	1.0	2.2	1.0	3.2	3.0	4.41	8.3	6.61	13.4
"		0.0	0.0	0.2	0.0	2.2	3.7	2.8	3.9	4.41	3.4	6.61	1.7
"	220	0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.5	0.0	2.2	63.2	3.20	80.0	4.41	82.8	5.6	62.5	6.61	9.3
"		0.0	0.0	1.5	0.0	2.2	2.0	2.8	0.0	5.0	0.0	6.0	0.0
"		0.0	0.0	1.5	0.0	2.2	1.5	2.8	0.0	5.0	0.0	6.0	0.0
"		0.5	0.0	2.2	21.2	3.30	27.0	4.41	28.0	5.6	20.	6.61	3.1
"	225	0.20	0.0	2.2	31.6	3.90	195.0	4.41	207.1	5.0	175.0	6.61	5.7
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.0	0.0	2.2	31.2	3.5	90.0	4.41	118.3	5.30	100.0	6.61	67.1
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"	230	0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"	235	0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"	240	0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"	245	0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"	250	0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.

Card Type	Card No.	Col. 1											
13		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"	255	0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"	260	0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	0.	1.	0.	2.	0.	3.	0.	4.	0.	5.	0.
"		0.	10.	1.	10.	2.	10.	3.	10.	4.	10.	5.	10.
"		0.	13.5	1.	13.5	2.	13.5	3.	13.5	4.	13.5	5.	13.5
"		0.	1.8	1.	1.8	2.	1.8	3.	1.8	4.	1.8	5.	1.8
"	265	0.	1.2	1.	1.2	2.	1.2	3.	1.2	4.	1.2	5.	1.2
"		0.	2.4	1.	2.4	2.	2.4	3.	2.4	4.	2.4	5.	2.4
"		0.	6.6	1.	6.6	2.	6.6	3.	6.6	4.	6.6	5.	6.6
"		0.	2.4	1.	2.4	2.	2.4	3.	2.4	4.	2.4	5.	2.4
"		0.	9000.	1.	930.	1.94	632.	2.82	326.	5.	60.	50.	10.
"	270	0.	9000.	1.	75.	2.2	51.36	3.08	42.36	4.41	29.4	50.	5.
"		0.	9000.	1.	750.	2.	525.	3.	395.	4.41	265.	50.	15.
"		0.	9000.	1.	1000.	2.	700.	3.	550.	4.41	355.2	50.	20.
"		0.	9000.	1.	225.	2.2	153.	3.08	128.4	4.41	87.	50.	15.
"		0.	9000.0	1.0	75.0	2.2	51.36	3.08	42.36	4.41	29.4	50.0	5.0
"	275	0.	9000.	1.23	720.0	1.94	720.	2.82	720.0	4.41	720.0	50.	150.
14		2.	2.2	5.4	5.4	2.8	4.	2.5					
15		0.25	35.0	0.000084	0.00833	530.0							
16		1.0	730.	10	10	10							
17		4	7.0										
18	280	5.	5.	7.	7.								
19		0.											
20		1	13000.	3.5	0.2045	0.0480	6.73						
21		0.	0.	0.	0.	0.	0.	0.	0.				
21		0.	0.										
22	285	16	8.0										
23		9	5										
23		10	5										
23		11	5										
23		12	5										
23	290	9	6										
23		10	6										
23		11	6										
23		12	6										
23		9	7										
23	295	10	7										
23		11	7										
23		12	7										
23		9	8										
23		10	8										
23	300	11	8										
23		12	8										
24		0											
26	303	0	0										

SECTION 5

PROGRAM OUTPUT

5.1 OUTPUT OPTIONS

The user has the capability of specifying the frequency of the output for both the cabin atmosphere and the flame spread data. Input card type 16 contains the required parameters, IPEMS and IPSPR. 'IPEMS', the print time interval for the cabin atmosphere data, is ordinarily set to correspond to every tenth pass through the program therefore, if the integration time step is one second, set 'IPEMS' = 10 seconds. 'IPSPR', the print time interval for the flame spread data, is ordinarily set to either 'IPEMS' or 3X IPEMS. The maximum flame spread rate utilized in the computer run should be considered in determining a value for 'IPSPR'. Note - Both outputs will always be printed upon the completion of the first pass through the program, regardless of the values of 'IPEMS' and 'IPSPR'.

5.2 OUTPUT FORMATS

1. The following will appear in the upper left corner of each page of output.

TIME = XXXX SEC AFTER IGNITION

where XXXX is the number of seconds.

2. Cabin Atmosphere Summary (one page of output)

   The cabin atmosphere summary consists of zone depth, gas density, gas temperature, material surface temperature, and the heat rate to the surface. These variables are printed for both the upper and lower zones.

   The flow rate (in and out) through open doorways is presented along with the upward gas flow resulting from all fires in the cabin section.

   The smoke concentration and toxic gas concentrations (for nine toxic gases) are presented in two forms: the values computed assuming that all smoke and toxic gases are contained within the upper gas layer, "stratified", and values computed assuming that the smoke and toxic gases are uniformly mixed over the entire cabin section volume, "uniform mixing".

The values reported for the stratified condition should be regarded as the best estimate of the actual concentrations achieved. These values are computed by the methods described in Volume I. The uniform mixing values are computed within the output subroutine by multiplying the stratified values by the ratio of the upper zone depth to the cabin height. These values represent a possible lower limit on the concentrations which would result if the air-borne materials are uniformly distributed over the entire available volume.

Two columns of information to the right of each toxic gas concentration indicate whether the concentration has exceeded a present short exposure irritation (IR) level or short exposure life danger (LD) level. A value of 1 in the appropriate column indicates that the level has been exceeded. The preset levels used are

	Irritation (ppm)	Life Danger (ppm)
CO	1.0	10,000.
HCl	35.0	1,000.
HCN	30.0	200.
HF	30.0	100.
SO_2	20.0	500.
H_2S	10.0	400.
NH_2	500.0	2,000.
NO_x	25.0	200.
$COCl_2$	5.0	50.

These levels, obtained from the open literature, have been selected as estimates only for the purposes of exercising the computer simulation using these levels and are not intended to constitute a conclusion about the actual toxicological effects of these gases.

To further compare the results of various simulation runs, a rough estimate of the combined effect of the toxic gas concentrations is made by summing the ratios of each gas concentrations to the corresponding irritation or life danger levels given above. If the sum of the ratios for the irritation level exceeds one, the indication is that the combined effect of the two or more toxic gases may cause short exposure irritation even though no single concentration exceeds its irritation level. If such a condition occurs, a "1" is printed to the right of the statement, "SE IR COMB EFF", below the report of the concentrations for each gas distribution condition. An analogous computation is done for the life danger levels and is reported as "SE LD COMB EFF". Again, it must be emphasized that these computations are for comparison purposes only and should not be used for any other purpose.

3. Flame Spread Data

The characteristics of each distinct fire are printed as they appeared prior to the flame spread calculations for this time interval. The remainder of the data represents conditions as they existed after flame spread calculations. This data includes the number of flaming and smoldering elements on each surface, and a summary by material type of the area in the flaming and smoldering states. In addition, a two dimensional diagram of each surface is included which enables the user to picture the state of each element on the surfaces involved.

SAMPLE OUTPUT: The following five (5) pages contain sample output from a simulation run in which IPEMS = IPSPR = 10 seconds. This output resulted from the sample input data presented in Section 4.2.

TIME= 40 SEC AFTER IGNITION

CABIN ATMOSPHERE SUMMARY

STRATIFIED GAS MODEL	ZONE DEPTH (FT)	GAS DENSITY (LBM/CU FT)	GAS TEMP (DEG F)	MATL SURF TEMP (DEG F)	HEAT RATE TO SURF (BTU/SQ FT-SEC)
UPPER ZONE	3.459	.0628	240.8	75.5	.112
LOWER ZONE	4.541	.0830	70.2	73.9	.078

	TOTAL FLOW RATE THRU VENTS (LBM/SEC)	UPWD GAS FLOW,ALL FIRES (LBM/SEC)
OUT	9.741	12.666
IN	9.651	

SMOKE CONCENTRATION
(OPTICAL DENSITY)

STRATIFIED	UNIFORM MIXING
.033	.014

TOXIC GAS CONCENTRATION
(PPM)

GAS	STRATIFIED CONCENTRATION	IR	LD	UNIFORM MIXING CONCENTRATION	IR	LD
CO	.80353E+02	1	0	.34741E+02	1	0
HCL	.44251E+01	0	0	.19132E+01	0	0
HCN	.18372E+01	1	0	.78431E+00	0	0
HF	0.	0	0	0.	0	0
SO2	.90704E+01	0	0	.39216E+01	0	0
H2S	0.	0	0	0.	0	0
NH3	0.	0	0	0.	0	0
NO(X)	0.	0	0	0.	0	0
COCL2	0.	0	0	0.	0	0

SE IR COMB EFF 1	SE IR COMB EFF 1
SE LD COMB EFF 0	SE LD COMB EFF 0

TIME=   40 SEC AFTER IGNITION

DISTINCT FIRES AT START OF FLAME SPREAD CALCULATICNS

FIRE NC	ZONE	DIST-FIRE BASE FROM FLCOR(FT)	FLAME HEIGHT(FT)	FIRE BASE AREA(SQ FT)	BASE RADIUS,FLAME VOL(FT)
1	LWR	C.00	7.02	4.00	1.00
2	LWR	0.00	3.37	4.00	.40
3	LWR	1.00	2.18	1.25	.50
4	LWR	1.00	2.75	2.00	.67

TIME= 40 SEC AFTER IGNITION

ELEMENT STATE SUMMARY - CONDITIONS ON ALL SURFACES AT END OF FLAME SPREAD CALCULATIONS

	LEFT SIDEWALL UPPER	REVEALS	LOWER	FLOOR	RIGHT SIDEWALL LOWER	REVEALS	UPPER
NO ELEM AFLAME	0	0	0	32	0	0	0
NO ELEM SMLDRG	0	0	0	0	0	0	0

	CEILING,LEFT SIDE PSU	SB BOTT	SB FACE	PANELS
NO ELEM AFLAME	0	0	0	0
NO ELEM SMLDRG	0	0	0	0

	CEILING,CENTER SB FACE,LFT	SB BOTT	PSU	SB BOTT	SB FACE,RGT
NO ELEM AFLAME	0	0	0	0	0
NO ELEM SMLDRG	0	0	0	0	0

	CEILING,RIGHT SIDE PANELS	SB FACE	SB BOTT	PSU
NO ELEM AFLAME	0	0	0	0
NO ELEM SMLDRG	0	0	0	0

SEAT GROUPS	1ST ROW LEFT	CTR	RGT	2ND ROW LEFT	CTR	RGT	3RD ROW LEFT	CTR	RGT
NO ELEM AFLAME	5	0	0	8	0	0	0	0	0
NO ELEM SMLDRG	0	0	0	0	0	C	0	0	0

FLAMING AND SMOLDERING AREAS BY MATERIAL TYPE (SQ FT)

	CARPET	SIDEWALL	REVEALS	PSU	STOW BIN	CEIL PANEL	SEATS
AREA AFLAME	8.00	0.00	0.00	0.00	0.00	0.00	3.25
AREA SMLDRG	0.00	0.00	0.00	0.00	0.00	0.00	0.00

```
TIME=    40 SEC AFTER IGNITION

DISTRIBUTION OF FLAMING(F),SMOLDERING(S),AND CHARRED(C) ELEMENTS AT END OF FLAME SPREAD CALCULATIONS

     FLOOR FIRES
     X                   REAR                     X




              FFFF
             FFFFFF
             FFFFFF
             FFFFFF
             FFFFFF
              FFFF


     X                   FRONT                    X

     SEAT GROUP,ROW 1

     X  LEFT  X    X    MIDDLE    X    X RIGHT    X
                                                    CF
                                                    CT
                                                    CT
                                                    CT
                                                    BF
                                                    BF
                                                    BF
                                                    BF
                                                    BF
                                                    BF
                                                    BT
                                                    BU
                                                    BU
                                                    BU
                                                    BL
                                                    BL
                                                    BL
                                                    BL
                                                    CB
              FFF                                   CB
               FF                                   CB
                                                    CB
```

```
TIME=   40 SEC AFTER IGNITION

     SEAT GROUP,ROW 2

     X   LEFT  X    X    MIDDLE    X    X RIGHT  X
                                                  CF
                                                  CT
                                                  CT
                                                  CT
                                                  BF
                                                  BF
                                                  BF
                                                  BF
                                                  BF
                                                  BF
                                                  BT
                                                  BU
                                                  BU
                                                  BU
                                                  BL
                                                  BL
                                                  BL
                                                  BL
                                                  CB
             FF                                   CB
            FFF                                   CB
            FFF                                   CB
```

SECTION 6

PROGRAM STATISTICS

The following program data pertains to runs made on the Control Data 6600 Computer System installed at Area B, Wright-Patterson Air Force Base, Dayton, Ohio (Building 676).

Programming Language:	FORTRAN IV
Operating System:	NOS/BE
Computer Storage Required:	120,000 words (octal)
Compile Time (CPU seconds):	18 seconds
Execution Time (for sample input run to 730 sec. simulated time):	360 seconds
Number of Cards, Program Source:	approx. 3000
Number of Cards, Input:	approx. 150

SECTION 7

PROGRAM AVAILABILITY

Because of the length of the code of the DACFIR program, a listing of the code has not been included in this volume. Copies of the program code and sample input data may be obtained from any of the organizations listed below.

University of Dayton Research Institute
Applied Systems Analysis Section
Attn: Mr. C.D. MacArthur
300 College Park
Dayton, Ohio 45469
(513) 229-3921

Department of Transportation
Federal Aviation Administration
Cabin Fire Safety Research & Development Program
Attn: Mr. C.C. Troha ARD 520
Trans Point Building
2100 Second Street, S.W., Room 1400
Washington, D.C. 20591
(202) 426-8416

Department of Transportation
Federal Aviation Administration
Aeronautical Center
P.O. Box 25082
Attn: Mr. James Gillespie AAC210
Oklahoma City, Oklahoma 73125
(405) 686-4374