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DEPARTMENT OF DEFENSE LAND FALLOUT
PREDICTION SYSTEM. VOLUME II: INITIAL
CONDITIONS, SUPPLEMENT

Hillyer G. Norment

Mount Auburn Research Associates, Incorporated

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VOLUME II
INITIAL CONDITIONS
Supplement

Prepared by

H. G. Norment

MT. AUBURN RESEARCH ASSOCIATES, INC.
385 Elliott Street
Newton, Massachusetts 02164

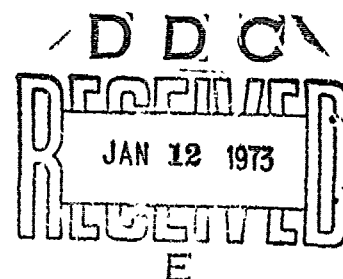
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13. ABSTRACT The DELFIC Initial Conditions Module code has been revised to meet the requirements of the new DELFIC fallout prediction system. This documentation supplement describes the revised code. Discussion of the revised code emphasizes particle size distributions. The code can accept parameters that define lognormal or power-law distributions, or it can accept a distribution in tabular form. Details necessary for use of the code are presented. FORTRAN statement listings of revised subroutines are included.			

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DD FORM 1473

REPLACES DD FORM 1473, 1 JAN 60, WHICH IS OBSOLETE FOR ARMY USE.

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III

1. INTRODUCTION

Since publication of DASA-1800-II⁽¹⁾ in 1966, the Defense Land Fallout Interpretative Code (DELFIIC) has undergone substantial revision in all of its modules. These revisions have created some new demands on the Initial Conditions Module (ICM) and removed some old restrictions. Of most direct consequence to the ICM are changes in the Cloud Rise Module (CRM)⁽²⁾.

The new CRM accounts for wind shear effects on the cloud rise dynamics. Therefore, shot-time winds above ground zero are input via the ICM rather than via the Cloud Rise-Transport Interface Module (CRTIM) as was done originally. The old CRM could accept no more than forty particle size classes, and the size class structure was rigidly prescribed. These restrictions have been relaxed in the new CRM, and the ICM has been revised accordingly. In addition, the ICM has been given a capability to accept parameters that define a power-law particle size distribution function. From these parameters, it constructs a particle size class table with a user-specified number of entries.

Subroutines LINK1 and DSTBN have been revised, and a new subroutine, SHWIND, which is called by LINK1, has been created. Subroutines MASS, TEMP, TIME, and VAPOR remain unchanged.

Subroutine LINK1 is the ICM executive program. Subroutine DSTBN constructs particle size class tables for lognormal and power-law particle distributions. Subroutine SHWIND reads in the shot-time winds above ground zero.

The logic of the ICM consists of a card input, which is described in Table 1, followed by serial exercise of the subordinate subroutines. Adequate detailed documentation is provided by the FORTRAN statement listings.

Use of the ICM is quite simple with one exception: definition of particle size distributions. Therefore, the bulk of this supplement is devoted to discussions of particle size distributions.

2. THE LOGNORMAL DISTRIBUTION

2.1 Fundamentals

A variable x is said to be normally distributed if the probability of its occurrence in the range x to $x + dx$ is given by

$$dN(x|\mu, \sigma^2) = \frac{1}{\sigma\sqrt{2\pi}} \exp \left[-\frac{1}{2} \left(\frac{x - \mu}{\sigma} \right)^2 \right] dx, \quad (1)$$

where μ is the mean value of x and σ^2 is the variance of x . The square root of the variance, σ , is called the standard deviation.

To define a lognormal distribution, we make the transformation

$$x = \ln(y) \quad (2)$$

In terms of the variable y Eq. (1) becomes

$$dN(y|\mu, \sigma^2) = \frac{1}{\sigma\sqrt{2\pi}} \exp \left[-\frac{1}{2} \left(\frac{\ln y - \mu}{\sigma} \right)^2 \right] d(\ln y), \quad (3)$$

and y is said to be lognormally distributed.⁽³⁾

Some statistical properties of y are as follows:

$$\text{mean}(y) = \exp\left(\mu + \frac{1}{2} \sigma^2\right) \quad (4)$$

$$\text{median}(y) = \exp(\mu) \quad (5)$$

$$\text{mode}(y) = \exp(\mu - \sigma^2) \quad (6)$$

$$\text{variance}(y) = \left[\exp(\sigma^2) - 1 \right] \exp(2\mu + \sigma^2). \quad (7)$$

Let $\underline{y}$ and s be the geometric mean and geometric standard deviation of y . Then

$$\underline{y} = \text{median}(y) = \exp(\mu) \quad (8)$$

and

$$s = \exp(\sigma) . \quad (9)$$

Let λ_j' be the j -th moment of $\Lambda(y|\mu, \sigma^2)$ about the origin. Then by definition

$$\lambda_j' = \int_0^{\infty} y^j d\Lambda(y|\mu, \sigma^2) , \quad (10)$$

and from the properties of the normal distribution it follows that

$$\lambda_j' = \exp(j\mu + \frac{1}{2} j^2 \sigma^2) . \quad (11)$$

A feature that distinguishes the lognormal distribution from the normal distribution is the existence of moment distributions. The j -th moment distribution is defined as

$$\Lambda(y|\mu, \sigma^2)_j = \frac{1}{\lambda_j'} \int_0^y t^j d\Lambda(t|\mu, \sigma^2) , \quad (12)$$

which can be shown to be⁽³⁾

$$\Lambda(y|\mu, \sigma^2)_j = \Lambda(y|\mu + j\sigma^2, \sigma^2) . \quad (13)$$

The moment distributions provide simple relationships between lognormal distributions of number, surface area, and volume of particles with respect to their diameters.

2.2 Application to Particle Distributions

In discussions of lognormal particle distributions, confusion frequently arises because distinction is not clearly made between μ and y and between σ and s . Since particular values of μ and σ depend on the base of the logarithms used, we have chosen to confine our discussions in the DELFIC documentation to parameters in the form of y and s .

Suppose that we have plotted cumulative numbers of particles versus diameter on log-probability graph paper and have obtained the curve shown in Figure 1. This straight-line curve indicates that the distribution of particle number with respect to diameter, D , is lognormal. Thus, D is equivalent to y in Eq. (3), and from Eqs. (8) and (9) we have

$$y = D_{50}$$

and

$$s = D_{84.13}/D_{50}$$

These are the quantities DMEAN and SD, respectively, that are required as input to subroutine LINK1, and that are printed by LINK1. DMEAN is expressed in units of micrometers. (In words, DMEAN is the median particle diameter in the distribution of numbers of particles with respect to their diameters.) If the user specifies a lognormal distribution but does not input values for DMEAN and SD, the program supplies the values⁽¹⁾:

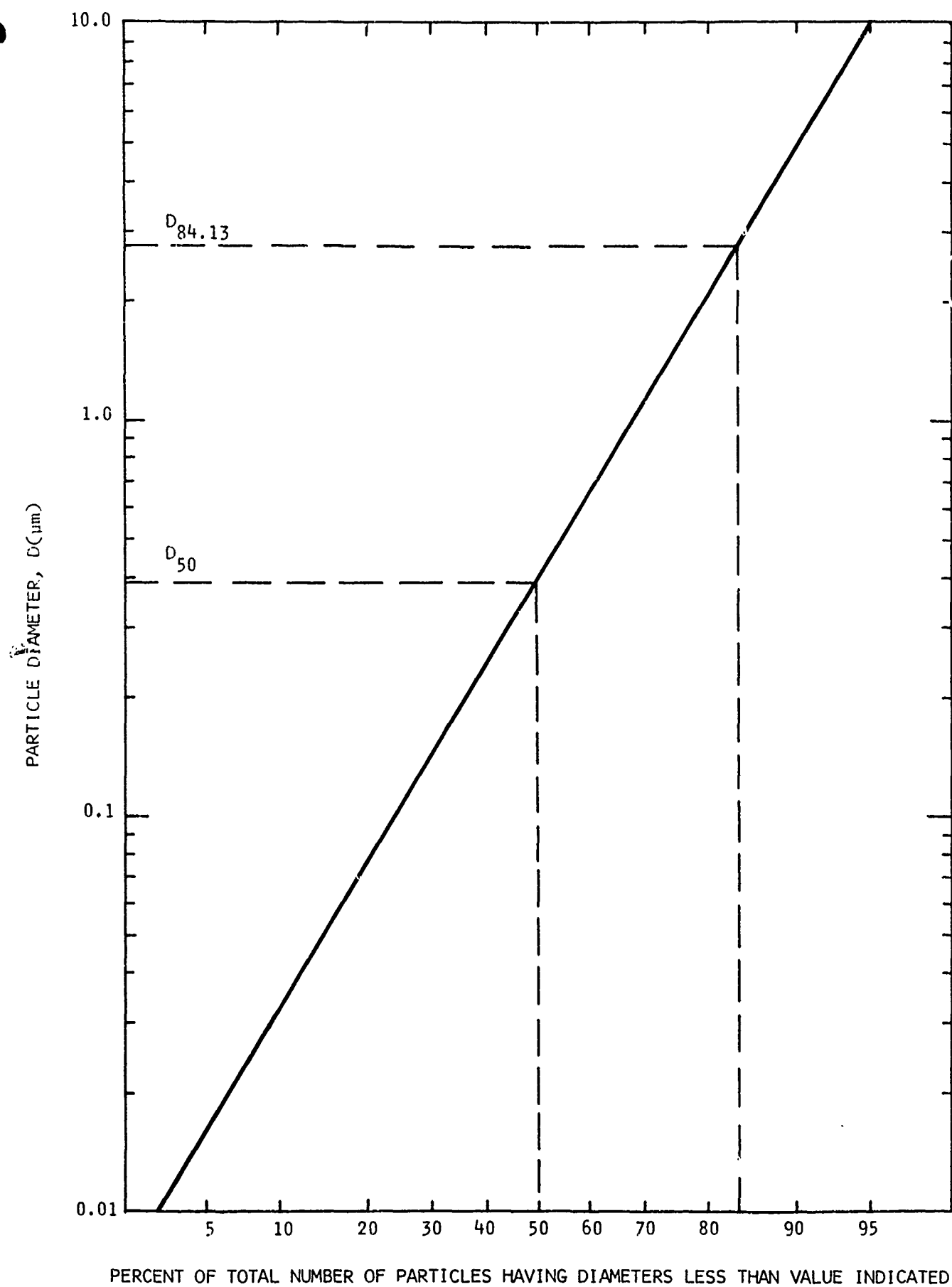


FIGURE 1. CUMULATIVE FREQUENCY GRAPH OF LOGNORMALLY DISTRIBUTED PARTICLES

$$\text{DMEAN} = \bar{y} = 0.407 \text{ } \mu\text{m}$$

$$\text{SD} = s = 4.0$$

As noted above, the properties of the moment distributions are useful in interrelating distributions of particle number, surface area, and volume with respect to particle diameter. This is because the number distribution is the zeroth moment distribution with respect to diameter, surface area is distributed via the second moment distribution, and volume is distributed via the third moment distribution. Thus, if we assume spherical particles and if the parameters μ and σ are known for either the particle number, or particle area, or particle volume distribution with diameter, then the other distributions can be determined from the equations below. The parameter σ is the same for all three distributions. If we use N, S, and V as subscripts to denote number, surface area, and volume, respectively, we have from Eq. (13)

$$\mu_S = \mu_N + 2\sigma^2$$

$$\mu_V = \mu_N + 3\sigma^2$$

where μ and σ are related to $\bar{y}$ and s by Eqs. (8) and (9).

If base 10 logarithms are used instead of natural logarithms, we distinguish the distribution parameters by use of primes, μ'_N and σ' , and the relations become

$$\mu'_S = \mu'_N + 2\ln(10)(\sigma')^2$$

$$\mu'_V = \mu'_N + 3\ln(10)(\sigma')^2$$

where $\ln(10) = 2.3026$.

The distribution of particle mass with respect to diameter is taken to be equivalent to the volume distribution with respect to diameter. This implies that all particles have the same density.

2.3 Particle Size Class Tables

For computation purposes, the continuous lognormal distribution is replaced by a histogram. The computer program, via subroutine DSTBN, does this automatically by use of the distribution parameters and the number of size classes, NDSTR, which is input by the user.

The user specifies parameters DMEAN, SD, and NDSTR. From these, the parameters μ_N , σ , and μ_V are determined via

$$\mu_N = \ln(\text{DMEAN})$$

$$\sigma = \ln(\text{SD})$$

$$\mu_V = \mu_N + 3\sigma^2$$

Define the normal distribution function argument x as

$$x = \frac{\ln(D) - \mu_V}{\sigma}$$

where D is particle diameter. Then

$$N(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^x \exp(-t^2/2) dt$$

Subroutine DSTBN constructs the particle size class table (i.e., histogram) as follows. Each size class contains a constant

volume fraction, ΔN_V , of

$$\Delta N_V = 1/\text{NDSTR} \quad .$$

Let D_i , $i = 1, 2, \dots, \text{NDSTR}$, be the upper (i.e. the larger particle) boundary diameter of the i -th particle size class. The table is ordered with the largest particles in the first size class, and so on. Then, for the i -th size class

$$N(x_i) = i\Delta N_V$$

and

$$\ln(D_{i+1}) = x_i \sigma + \mu_V \quad .$$

The upper boundary of the first size class, D_1 , and the lower boundary of the last size class, $D_{\text{NDSTR}+1}$, are special cases. These are taken to be the diameters at $\Delta N_V/2$ and $1-\Delta N_V/2$, respectively. That is,

$$N(x_1) = \frac{\Delta N_V}{2}$$

and

$$N(x_{\text{NDSTR}+1}) = 1 - \frac{\Delta N_V}{2} \quad .$$

In these calculations x is determined from given $N(x)$ via equation 26.2.23 of Reference 4.

The central particle diameter for the i -th class, d_i , is given by

$$d_i = \sqrt{D_i D_{i+1}} \quad .$$

If NDSTR = 1, a single size class is created with

$$D_1 = (DMEAN) * (5.0 * SD)$$

$$D_2 = (DMEAN) / (5.0 * SD)$$

and

$$d_1 = DMEAN$$

3. THE POWER-LAW DISTRIBUTION

3.1 Fundamentals

Mathematically speaking, power-law distributions are meaningless since distribution functions cannot be defined for them. This is because the power-law function is not properly bounded for zero argument. Freiling has shown that fallout particle distributions that have been represented by power-law functions can equally well be fitted by lognormal distribution functions.⁽⁵⁾ The implication of Freiling's work is that power-law distributions would be more accurately described as truncated lognormal distributions. Nevertheless, power-law distributions frequently are useful in fallout work.

Define the power-law frequency as

$$df(D|k,X) = kD^{-X}dD, \quad (14)$$

where $df(D|k,X)$ is the number of particles in the diameter range D to $D + dD$. If we assume spherical particles with constant density, ρ , we have

$$dF\left(D\left|\frac{\pi\rho k}{6M}, X\right.\right) = \frac{\pi\rho k D^{3-X}}{6M} dD, \quad (15)$$

where $dF\left(D\left|\frac{\pi\rho k}{6M}, X\right.\right)$ is the fraction of the total fallout mass, M , in the diameter range D to $D + dD$.

The mass fraction of particles in the macro-range from D_i to D_j is obtained by integration of Eq. (15) between these limits to give

$$\Delta F = \frac{\pi\rho k}{6M(4-X)} \left(D_j^{4-X} - D_i^{4-X} \right), \quad 0 < X < 4. \quad (16)$$

3.2 Particle Data Analysis

Suppose that we have obtained a sample of fallout particles. We weigh the sample to obtain M (kg), and we size the sample into N fractions, the i -th fraction containing particles in the diameter range ΔD_i centered on D_i (meters). We weigh each fraction and obtain the mass fractions ΔF_i . We determine that the average particle density is ρ (kg/m^3).

To obtain the power law distribution parameters k and X , we plot $\log(\Delta F_i / \Delta D_i)$ versus $\log(D_i)$. A straight line is fitted to the data. From Eq. (15), we see that the intercept and slope are

$$\text{intercept} = c = \log\left(\frac{\pi \rho k}{6M}\right) ,$$

and

$$\text{slope} = m = 3 - X .$$

Then

$$X = 3 - m$$

and

$$k = \frac{6M}{\pi \rho} \log^{-1}(c) .$$

When X and k are determined from M expressed in kilograms, D and ΔD in meters, and ρ in kg/m^3 , they can be input to subroutine LINK1 as EXPO and CAY, respectively.

3.3 Particle Size Class Tables

For use in fallout calculations, subroutine DSTBN creates a histogram representation of the power law distribution. The histogram is comprised of NDSTR particle size classes, where NDSTR is

specified by the user. The mass fraction in each size class, ΔF , is the constant

$$\Delta F = 1/\text{NDSTR} \quad .$$

Let D_i be the upper (i.e. larger particle) boundary of the i-th particle size class. The table is ordered with the largest particles in the first class, and so on. Then the smallest particles are contained in the NDSTRth class. If we assume that the smallest particle in this class is much smaller than D_{NDSTR} , we see from Eq. (16) that

$$D_{\text{NDSTR}}^{4-X} = \frac{6M(4-X)}{\pi \rho k} \Delta F \quad .$$

By recursive use of this relation with Eq. (16), we find that

$$D_i = (\text{NDSTR} - i + 1)^{\frac{1}{4-X}} D_{\text{NDSTR}} \quad .$$

Size class central diameters, d_i , are

$$d_i = \sqrt{D_i D_{i+1}} \quad .$$

To establish a central and lower boundary diameter for the NDSTRth class, we say that

$$d_{\text{NDSTR}} = \left(\frac{1}{2}\right)^{\frac{1}{4-X}} D_{\text{NDSTR}}$$

and

$$D_{\text{NDSTR}+1} = (d_{\text{NDSTR}})^2 / D_{\text{NDSTR}} \quad .$$

4. TABULAR DISTRIBUTIONS

4.1 Particle Size Class Tables

If the user so desires, he can input his particle size distribution in histogram form with NDSTR size classes. The table of size classes must be arranged in descending order of particle diameter. Each size class is defined in the input by its upper (i.e. larger particle) boundary diameter, D_i , and mass fraction, ΔF_i . These two data are punched on a separate card for each size class. The last card in the deck contains the lower boundary diameter of the NDSTRth size class. Central particle diameters, d_i , are computed to be

$$d_i = (D_i + D_{i+1})/2 .$$

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5. USER INFORMATION

5.1 Card Input

The ICM card input is described in Table I. This table and the discussions in Sections 2.2, 2.3, 3.2, and 4.1 provide adequate information for use of the code.

5.2 Output

Though the printed output has been modified somewhat, the example output presented in DASA-1800-II is still satisfactory.

Communication with the Cloud Rise Module is via COMMON/SET1/. The contents of COMMON/SET1/ is described in Table 2.2 of DASA-1800-III (Revised).⁽²⁾

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TABLE I

CARD INPUTS TO THE INITIAL CONDITIONS MODULE

Card Number	Contents	Variable Names and FORMATS
1	ICM Run Identifier	DETID(J), J=1,12 (12A6)
2	Control integer to specify particle size distribution type: 1 lognormal 2 power-law 3 tabular	IDISTR (I5)
3	Number of particle size classes	NDSTR (I5)
4(a)*	(For lognormal particle size distribution) Explosion yield (KT), height of burst above GZ(m), soil class indicator: 1.0 for siliceous 2.0 for calcareous, median particle diameter (μm), geometric standard deviation of the particle size distribution, and particle density (g/cm^3). (See Section 2.2.)	W, HEIGHT, USOIL, DMEAN, SD, DNS (6F10.3)
4(b)*	(For power-law particle size distribution) Yield (KT), height of burst (m), soil class indicator (see above), exponent in the particle size distribution frequency function, coefficient in the particle size distribution frequency function, particle density (g/cm^3). (See Section 3.2.)	W, HEIGHT, USOIL, EXPO, CAY, DNS (6F10.3)
4(c)*	(For a tabular particle size distribution) Yield (KT), height of burst (m), soil class indicator (see above), particle density (g/cm^3).	W, HEIGHT, USOIL, DNS (4F10.3)
4(c)** 1	A table of upper boundary particle diameters (μm) and mass fractions	DIAM(J), FMASS(J), J=1,NDSTR (2E12.5)
.	.	.
.	.	.
4(c)** NDSTR+1	The lower boundary diameter (μm) of the last particle size class. (See Section 4.1.)	DIAM(NDSTR+1) (E12.5)

Table I (continued)

Card Number	Contents	Variable Names and FORMATS
5	Number of entires in the wind data table	NHODO (I5)
6***	For each entry in the wind data table: altitude (m, relative to msl), x com- ponent of wind (m/sec), y component of wind (m/sec)	ZV(J), VX(J), VY(J), J=1, NHODO (3F12.3)

* One of the cards 4(a), 4(b), or 4(c) is read according to whether IDISTR is 1, 2, or 3.

** These cards are read only for a tabular distribution.

*** These cards are read only if NHODO > 0.

6. FORTRAN STATEMENT LISTINGS

Complete FORTRAN statement listings are given for the following subroutines. These subroutines are operational on the UNIVAC 1108.

<u>SUBROUTINE</u>	<u>Page</u>
LINK1	22
DSTBN	27
SHVIND	29

The machine used to prepare these listings prints a # symbol to represent a 4-8 punch; this symbol should be an apostrophe ('). In FORMAT and DATA statements, the apostrophe is used to define Hollerith character fields.

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SUBROUTINE LINK1	LINK1 1
INITIAL CONDITIONS (FIREBALL) MODULE	LINK1 2
MT. AUBURN RESEARCH ASSOCIATES	LINK1 3
JANUARY 1972	LINK1 4
*****	LINK1 5
PROGRAM TO DETERMINE THE INITIAL CONDITIONS SPECIFICATIONS OF	LINK1 6
TIME, TEMPERATURE, TOTAL SOIL MASS, FRACTION OF THE SOIL BURDEN IN	LINK1 7
THE VAPOR PHASE, AND THE SIZE FREQUENCY DISTRIBUTION OF THE	LINK1 8
CONDENSED PHASE SOIL	LINK1 9
	LINK1 10
	LINK1 11
THE FIRST CARD CONTAINS ANY ARBITRARY ALPHANUMERIC IDENTIFICATION.	LINK1 12
	LINK1 13
OTHER INPUT PARAMETERS ARE - TEST PARAMETER (IDISTR) TO DETERMINE	LINK1 14
IF THE PARTICLE SIZE FREQUENCY DISTRIBUTION IS LOG-NORMAL, POWER	LINK1 15
LAW, OR TABULAR, YIELD IN KILOTONS, HEIGHT (DEPTH) OF BURST IN	LINK1 16
METERS, A SOIL TYPE INDICATOR, FALLOUT PARTICLE DENSITY (GM/CM**3),	LINK1 17
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C	TMP2 AVERAGE TEMPERATURE OF CONDENSED PHASE MATERIAL IN	LINK1 74
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C	4TMP2 ,T2M ,USOIL ,VPR ,W ,HEIGHT ,LINK1 95	
C	5ZSCL ,NH0DO ,ZV(200) ,VX(200) ,VY(200)	LINK1 96
C		LINK1 97
C		LINK1 98
C	*****	LINK1 99
C		LINK1100
1	FORMAT(12A6)	LINK1101
2	FORMAT(/3X,60H THE SPECIFIED STANDARD DEVIATION IS NEGATIVE HENCE	LINK1102
	INCORRECT///)	LINK1103
3	FORMAT(7F10.3)	LINK1104
4	FORMAT(///25X26H**** INPUT PARAMETERS ****/20X,5HYIELD,40X,E12.5	LINK1105
	1,2X,2HKT/20X,24HHEIGHT OR DEPTH OF BURST,21X,E12.5,2X,6HMETERS/20X	LINK1106
	2,13H SOIL CATEGORY)	LINK1107
5	FORMAT(1H+,65X,9HSILICEOUS)	LINK1108
6	FORMAT(1H+,65X,10HCALCAREOUS)	LINK1109
7	FORMAT(/20X, 36HPARTICLE SIZE FREQUENCY DISTRIBUTION/	LINK1110
	125X32HA LOG-NORMAL DISTRIBUTION WITH -/30X,15H MEDIAN DIAMETER,20	LINK1111
	2E12.5,2X,11HMICROMETERS/30X,28HGEOMETRIC STANDARD DEVIATION, 7X,	LINK1112
	3E12.5/25X, 34H THIS DISTRIBUTION WAS SPECIFIED BY)	LINK1113
8	FORMAT(1H+,65X,11H THE PROGRAM)	LINK1114
9	FORMAT(1H+,65X,8H THE USER)	LINK1115
10	FORMAT(I5)	LINK1116

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11  FORMAT(/3X,50)THE SCALED DEPTH OF BURST IS BEYOND THE SCOPE OF THE LINK1117
1  MODEL(//) LINK1118
12  FORMAT(/3X,11)THE SCALED HEIGHT OF BURST IS SUCH THAT THERE IS NO LINK1119
1  SOIL MASS ENTRAINED IN THE CLOUD AND HENCE NO LOCAL FALLOUT(//) LINK1120
13  FORMAT(///25X37H**** INITIAL CLOUD PROPERTIES AT H+E12.5,14H SECLINK1121
1  ONDS ****//20X,23HAVERAGE GAS TEMPRATURE38X,E12.5,2X,14HDEGRFES LINK1122
2  KELVIN//20X,56HAVERAGE TEMPERATURE OF CONDENSED PHASE MATERIAL IN LINK1123
3  CLOUD,5X,E12.5,2X,14HDEGRFES KELVIN//20X,31HMASS OF VAPORIZED SOIL LINK1124
4  IN CLCUD,30X,E12.5,2X,9HKILOGRAMS//20X41HMASS OF CONDENSED PHASE LINK1125
5  MATERIAL IN CLOUD,20X,E12.5,2X,9HKILOGRAMS) LINK1126
15  FORMAT(1X,14HLEAVING LINK 1) LINK1127
16  FORMAT(#1#//51X,#* * * * * * * * * *//12X,#T H F  D E P A R T M LINK1128
1  E N T  O F  D E F E N S E  F A L L O U T  P R E D I C T I O N LINK1129
2  S Y S T E M#//51X,#* * * * * * * * * *//43X,#INITIAL CONDITILINK1130
3  ONS (FIREBALL) MODULE#,//55X,#PREPARED BY#/46X,#MT. AUBURN RESEARLINK1131
4  CH ASSOCIATES#/55X,#NEWTON, MASS.#///25X,**** INITIAL CONDITIONLINK1132
5  S IDENTIFICATION ****//25X,12A6) LINK1133
17  FORMAT(/3X,60)THE SPECIFIED MEAN PARTICLE SIZE IS NEGATIVE HENCE TLINK1134
1  INCORRECT(//) LINK1135
18  FORMAT(/20X,36HPARTICLE SIZE FREQUENCY DISTRIBUTION/ LINK1136
1  125X41HA TABULATED EMPIRICAL DISTRIBUTION WITH -/30X12,2X,21HPARTICLINK1137
2  LE SIZE CLASSES) LINK1138
192  FORMAT(/51X,19H* * * * * * * * * *//) LINK1139
193  FORMAT(#1#,9X,#PARTICLE SIZE, LOWER SIZE INTERVAL BOUNDARY,MASS FRLINK1140
1  EQUENCY, AND UPPER SIZE INTERVAL BOUNDARY#/10X,#FOR USE IN PSXP,TRLINK1141
2  ANSPORT, AND ACTIVITY CALCULATIONS (DIAMETERS IN METERS)#//20X,#DILINK1142
3  AMETER#,4X,#LOWER BCUNDARY#,3X,#MASS FRACTION#,3X,#UPPER BOUNDARY#LINK1143
4  //) LINK1144
197  FORMAT(/20X,#PARTICLE SIZE FREQUENCY DISTPIRIBUTION#/25X,#POWER LAWLINK1145
1  DISTRIBUTION WITH - #/30X,I3,1X,#PARTICLE SIZE CLASSES#/30X,#THE LINK1146
2  SPECIFIED PARAMETERS ARE#/30X,#CAY =#,2X,E12.5/30X,#EXPO =#,2X,E12LINK1147
3  .5) LINK1148
194  FORMAT(12X,I3,4(3X,E12.5)) LINK1149
195  FORMAT(2E12.5) LINK1150
198  FORMAT(/3X,58)THE PARTICLE SIZE DISTRIBUTION TABLE IS IMPROPERLY OLINK1151
2  RDERED(//) LINK1152
C LINK1153
C ***** LINK1154
C ***** LINK1155
C ***** LINK1156
C READ INITIAL CONDITIONS RUN IDENTIFIER LINK1157
C READ (ISIN,1) (DETID(J),J=1,12) LINK1158
C LINK1159
C WRITE OVERALL TITLE LINK1160
C WRITE (ISOUT,16) (DETID(J),J=1,12) LINK1161
20 READ (ISIN,10) IDISTR LINK1162
READ (ISIN,10) NDSTR LINK1163
IF (NDSTR) 401,401,402 LINK1164
401 NDSTR=100 LINK1165
402 GO TO (210,220,211),IDISTR LINK1166
210 READ (ISIN,3) W,HEIGHT,USOIL,DMEAN,SD,ONS LINK1167
C WAS A PRESHOT PARTICLE LOG-NORMAL DISTRIBUTION SPECIFIED BY LINK1168
C THE USER YES TO 22 LINK1169
IF (DMEAN) 21,21,22 LINK1170
21 IS=0 LINK1171
GO TO 23 LINK1172
22 IS=1 LINK1173
GO TO 23 LINK1174

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220	READ(ISIN,3)W,HEIGHT,USOTL,EXPO,CAY,DNS	LNK1175
	GO TO 23	LNK1176
211	READ(ISIN,3)W,HEIGHT,USOIL,DNS	LNK1177
	READ(ISIN,195)(DIAM(I),FMASS(I),I=1,NDSTR)	LNK1178
	LD=NDSTR+1	LNK1179
	READ(ISIN,195)DIAM(LD)	LNK1180
C		LNK1181
C	CHECK ORDERING OF THE HISTOGRAM TABLE	LNK1182
	DO 215 I=2,LD	LNK1183
	IF(DIAM(I).LT. DIAM(I-1)) GO TO 215	LNK1184
	WRITE(ISOUT,198)	LNK1185
	GO TO 190	LNK1186
215	CONTINUE	LNK1187
C		LNK1188
C	23 CONVERT HOB - DOB FROM METERS TO FEET	LNK1189
	23 HEIGHT=HEIGHT/0.3048	LNK1190
C	ZSCL IS THE SCALED FOR - DOB	LNK1191
	60 ZSCL=HEIGHT/((W)**(1.0/3.4))	LNK1192
C		LNK1193
C	TEST THE DATA TO SEE IF THE MODEL IS APPROPRIATE	LNK1194
	IF(HEIGHT)66,66,63	LNK1195
	63 IF(ZSCL-190.0)70,70,150	LNK1196
	66 IF(ZSCL+20.0)143,70,70	LNK1197
70	CALL TIME	LNK1198
	CALL TEMP	LNK1199
	CALL MASS	LNK1200
	CALL VAPOR	LNK1201
	GO TO (90,95,95),IDISTR	LNK1202
C		LNK1203
C	TEST FOR ACCEPTABLE SPECIFICATIONS OF PRE-SHOT PARTICLE SIZE	LNK1204
C	FREQUENCY DISTRIBUTION.	LNK1205
90	IF(SD)91,92,92	LNK1206
91	WRITE (ISOUT,2)	LNK1207
	GO TO 190	LNK1208
92	IF(DMEAN)94,95,95	LNK1209
94	WRITE (ISOUT,17)	LNK1210
	GO TO 190	LNK1211
C		LNK1212
95	CALL DSTBN	LNK1213
C		LNK1214
C	CONVERT HOB - DOB BACK TO METERS FROM FEET	LNK1215
	HEIGHT=HEIGHT*0.3048	LNK1216
C		LNK1217
C	CONVERT VPR AND SSAM FROM GRAMS TO KILOGRAMS	LNK1218
	VPR=VPR/1000.0	LNK1219
C	DURING COMPUTATION SSAM CONTAINS THE VALUE OF THE TOTAL MASS OF	LNK1220
C	GAS AND CONDENSED PHASE MATERIAL IN THE CLOUD.	LNK1221
	SSAM=SSAM/1000.0-VPR	LNK1222
C		LNK1223
C	WRITE INITIAL CONDITIONS RESULTS	LNK1224
	WRITE(ISOUT,4)W,HEIGHT	LNK1225
	IF(USOIL-1.0)301,301,302	LNK1226
301	WRITE (ISOUT,5)	LNK1227
	GO TO 305	LNK1228
302	WRITE (ISOUT,6)	LNK1229
305	GO TO (309,310,311),IDISTR	LNK1230
309	WRITE(ISOUT,7)DMEAN,SD	LNK1231
	IF (IS)102,103,102	LNK1232

103	WRITE (ISOUT,9)	LINK1233
	GO TO 315	LINK1234
102	WRITE (ISOUT,9)	LINK1235
	GO TO 315	LINK1236
311	WRITE(ISOUT,19)NDSTR	LINK1237
C		LINK1238
C	PRINT FINAL PARTICLE SIZE CLASS	LINK1239
C		LINK1240
315	WRITE(ISOUT,193)	LINK1241
	DO 602 J=1,NDSTR	LINK1242
	J0=J+1	LINK1243
	DM1=DIAM(J0)*1.0E-6	LINK1244
	DM2=DIAM(J)*1.0E-6	LINK1245
602	WRITE(ISOUT,194)J,PS(J),DM1,FMASS(J),DM2	LINK1246
	GO TO 106	LINK1247
310	WRITE(ISOUT,197)NDSTR,CAY,EXPO	LINK1248
	GO TO 315	LINK1249
106	WRITE(ISOUT,13)TME,TMP1,TMP2,VPR,SSAM	LINK1250
118	WRITE(ISOUT,192)	LINK1251
200	CALL SHWINO	LINK1252
	WRITE(ISOUT,15)	LINK1253
	RETURN	LINK1254
143	WRITE (ISOUT,11)	LINK1255
	GO TO 190	LINK1256
150	WRITE (ISOUT,12)	LINK1257
190	CALL EXIT	LINK1258
	END	LINK1259

	SUBROUTINE DSTRN	DSTRN 1
	COMMON /SET1/	DSTRN 2
	1CAY ,DEFID(12) ,DIAM(201) ,DMEAN ,DNS ,EXPO ,DSTRN 3	
	2FMASS(200) ,IDISTR ,IEXEC ,IRISE ,ISIN ,ISOUT ,DSTRN 4	
	3NDSTR ,PS(200) ,SD ,SSAM ,TME ,TMP1 ,DSTRN 5	
	4TMP2 ,T2M ,USOIL ,VPR ,W ,HEIGHT ,DSTRN 6	
	5ZSCL ,NHONO ,ZV(200) ,VX(200) ,VY(200) ,DSTRN 7	
C		DSTRN 8
C	LOGNORMAL DISTRIBUTION TO 100	DSTRN 9
C	POWER FUNCTION DISTRIBUTION TO 200	DSTRN 10
C	TABULAR DISTRIBUTION TO 300	DSTRN 11
C		DSTRN 12
C	EQUATION 26.2.23 OF NBS-AMS 55 HANDBOOK IS USED TO COMPUTE THE	DSTRN 13
C	PROBABILITY FUNCTION ARGUMENT FROM THE RATIONAL POLYNOMIAL	DSTRN 14
C	APPROXIMATION TO THE NORMAL PROBABILITY FUNCTION.	DSTRN 15
C	TA(X)=SQRT(ALOG(1.0/X**2))	DSTRN 16
	APX(X)=TA(X)-(2.515517+0.802853*TA(X)+0.010323*TA(X)**2)/	DSTRN 17
	1(1.0+1.432798*TA(X)+0.149269*TA(X)**2+0.001308*TA(X)**3)	DSTRN 18
	LD=NDSTR+1	DSTRN 19
	GO TO (100,200,300),IDISTR	DSTRN 20
100	IF(DMEAN)111,111,112	DSTRN 21
111	DMEAN=0.407	DSTRN 22
	SD=4.0	DSTRN 23
112	IF(NDSTR-1)101,101,102	DSTRN 24
101	PS(1)=DMEAN*1.0E-6	DSTRN 25
	C5=SD**5	DSTRN 26
	DIAM(1)=DMEAN*C5	DSTRN 27
	DIAM(2)=DMEAN/C5	DSTRN 28
	FMASS(1)=1.0	DSTRN 29
	GO TO 400	DSTRN 30
102	BARMU=ALOG(DMEAN)	DSTRN 31
	SIGMA=ALOG(SD)	DSTRN 32
	BARMU=BARMU+3.*SIGMA**2	DSTRN 33
	FRAC=1.0/FLOAT(NDSTR)	DSTRN 34
	DO 103 ND=1,NDSTR	DSTRN 35
103	FMASS(ND)=FRAC	DSTRN 36
	NH=NDSTR/2	DSTRN 37
	DO 104 I=1,NH	DSTRN 38
	PRB=FLOAT(I)*FRAC	DSTRN 39
	DIAM(I+1)=BARMU+APX(PRB)*SIGMA	DSTRN 40
	J=NDSTR-I+1	DSTRN 41
104	DIAM(J)=BARMU-APX(PRB)*SIGMA	DSTRN 42
C		DSTRN 43
C	FOR THE 2 EXTREME INTERVALS THE AVERAGE DIAMETER IS	DSTRN 44
C	ASSUMED TO BE AT HALF A MASS FRACTION FROM ZERO AND ONE	DSTRN 45
C		DSTRN 46
	PRB=FRAC/2.0	DSTRN 47
	PS(1)=BARMU+APX(PRB)*SIGMA	DSTRN 48
	PS(NDSTR)=BARMU-APX(PRB)*SIGMA	DSTRN 49
	DIAM(1)=2.*PS(1)-DIAM(2)	DSTRN 50
	DIAM(LD)=2.*PS(NDSTR)-DIAM(NDSTR)	DSTRN 51
C		DSTRN 52
C	CALCULATE MEAN DIAMETERS FROM BOUNDARY VALUES.	DSTRN 53
C		DSTRN 54
	J=NDSTR-1	DSTRN 55
	IF(J-1)107,107,105	DSTRN 56
105	DO 106 I=2,J	DSTRN 57
106	PS(I)=0.5*(DIAM(I)+DIAM(I+1))	DSTRN 58

107 DO 108 I=1,NDSTR	DSTRN 59
DIAM(I)=EXP(DIAM(I))	DSTRN 60
108 PS(I)=EXP(PS(I))*1.0E-6	DSTRN 61
DIAM(LD)=EXP(DIAM(LC))	DSTRN 62
GO TO 400	DSTRN 63
200 IF(EXPO-4.0)201,202,202	DSTRN 64
202 WRITE(ISOUT,2001)	DSTRN 65
CALL EXIT	DSTRN 66
2001 FORMAT(1X,1X,EXPONENT OF POWER LAW POWER LAW PARTICLE SIZE FREQUENCY DISTRIBUTION GT. OR EQ. 4.0)	DSTRN 67
201 IF(NDSTR-1)203,204,204	DSTRN 68
203 NDSTR=10	DSTRN 69
204 AN=FLCAT(NDSTR)	DSTRN 70
FRAC=1.0/AN	DSTRN 71
DO 205 I=1,NDSTR	DSTRN 72
205 FMASS(I)=FRAC	DSTRN 73
POW=1.0/(4.0-EXPO)	DSTRN 74
DMIN=(6.0*SSAM*FRAC/(POW*CAY*DNS*3.14159E6))**POW	DSTRN 75
DO 206 IJ=1,NDSTR	DSTRN 76
AJ=FLOAT(IJ)-1.0	DSTRN 77
206 DIAM(IJ)=(AN-AJ)**PCW*DMIN	DSTRN 78
PS(NDSTR)=DMIN*0.5**POW	DSTRN 79
DIAM(LD)=PS(NDSTR)**2/DIAM(NDSTR)	DSTRN 80
ND=NDSTR-1	DSTRN 81
DO 207 IJ=1,ND	DSTRN 82
207 PS(IJ)=SQRT(DIAM(IJ)*DIAM(IJ+1))	DSTRN 83
DO 208 IJ=1,LD	DSTRN 84
208 DIAM(IJ)=1.0E+6*DIAM(IJ)	DSTRN 85
GO TO 400	DSTRN 86
300 DO 301 I=1,NDSTR	DSTRN 87
301 PS(I)=0.5*(DIAM(I)+DIAM(I+1))*1.0E-6	DSTRN 88
400 RETURN	DSTRN 89
END	DSTRN 90
	DSTRN 91

	SUBROUTINE SHWIND	SHWIND 1
C		SHWIND 2
C	READS IN SHOT TIME WIND DATA ABOVE GROUND ZERO	SHWIND 3
C		SHWIND 4
	COMMON /SET1/	SHWIND 5
	1CAY ,DETID(12) ,DIAM(201) ,DMEAN ,DNS ,EXPO ,	SHWIND 6
	2FMASS(200) ,IDISTR ,IFXEC ,IRISE ,ISIN ,ISOUT ,	SHWIND 7
	3NDSTP ,PS(200) ,SD ,SSAM ,TME ,TMP1 ,	SHWIND 8
	4TMP2 ,T24 ,USOIL ,VPR ,W ,HEIGHT ,	SHWIND 9
	5ZSCL ,NHODD ,ZV(200) ,VX(200) ,VY(200)	SHWIND 10
	READ(ISIN,1)NHODD	SHWIND 11
	IF(NHODD)100,100,200	SHWIND 12
100	WRITE(ISOUT,5)	SHWIND 13
	GO TO 300	SHWIND 14
200	READ(ISIN,2)(ZV(J),VX(J),VY(J),J=1,NHODD)	SHWIND 15
	WRITE(ISOUT,3)NHODD	SHWIND 16
	WRITE(ISOUT,4)(ZV(J),VX(J),VY(J),J=1,NHODD)	SHWIND 17
300	RETURN	SHWIND 18
C		SHWIND 19
	1 FORMAT(I5)	SHWIND 20
	2 FORMAT(F12.3, 2F12.3)	SHWIND 21
	3 FORMAT(#1#,9X,#WIND HODDGRAPH AT GROUND ZERO#,10X,#NHODD = #,I5//1	SHWIND 22
	11X,#VECTOR ALTITUDE, ZV(J)#,16X,#VX(J)#,24X,#VY(J)#)	SHWIND 23
	4 FORMAT(3(16X,E13.6))	SHWIND 24
	5 FORMAT(#1#,9X,#SHOT-TIME WINDS HAVE NOT BEEN SPECIFIED#)	SHWIND 25
	END	SHWIND 26

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