NEWCAS - An Interactive Computer Program for Particle Size Analysis

by
**M. A. Hill
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O. R. Moss**

December 1977

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Battelle
Pacific Northwest Laboratories

ACKNOWLEDGMENTS

NEWCAS has been in use in these laboratories since 1969. As is typical of a useful scientific computer application, it has been modified and revised several times. In the course of converting it to a new computer and re-establishing its interactive use, MARY HILL wrote a USERS GUIDE (Appendix A of this report) which was so well received that we decided to formally document the program as well as its use.

Many people have contributed to the development of NEWCAS. We mention here those whom we remember, with the hope that anyone who has been left out will forgive the frailties of our memories. To help sort out these contributions, we have divided our acknowledgments into three paragraphs covering three time periods.

The development phase of NEWCAS was roughly from late 1969 to 1971. DOUG CRAIG applied the Mercer Cascade Impactor to measurement of aerosol characteristics when he joined Battelle in 1969. He requested help from the biostatistical group in the application of Mercer's computer algorithm for analysis of impactor measurements. JOHN THOMAS adapted the procedure to our laboratory conditions and he and ROSALIE ARGO implemented a computer program - CASPAR - on the UNIVAC 1108. JEFF BUCHANAN supervised its day to day operation. In 1971, DICK OLSON and MAITLAND LEE altered the program substantially and renamed it - NEWCAS.

From 1971 to 1976, NEWCAS was in routine use by the Aerosol Physicists in the Biology Department. RAY BUSCHBOM assumed responsibility for the statistical validity and enhancement of the program late in 1971. He worked closely with MAITLAND LEE who implemented his suggestions and supervised batch operations for those who did not have access to an interactive terminal. In 1973, CHUCK WATSON converted NEWCAS to operate

on the CDC CYBER computer. Due to the new computing environment, the interactive capability was omitted at that time. Batch operations after 1975 were supervised by JACKIE BENDER and for a few months by JESSIE BURNS. In mid 1976, a PDP 11/70 computer was acquired for the Biometrics Center, and NEWCAS was converted again, this time by JACKIE BENDER, DICK HART, and CHUCK WATSON.

By 1977, NEWCAS had become complex and involved because so many programmers had altered it to meet the diverse needs of a growing user community. One of the new users, OWEN MOSS, discovered that the PDP version contained computational inaccuracies. MARY HILL corrected the inaccuracies and completely revised the program using structured programming techniques. In addition, suggestions by BILL CANNON, MIKE ALLEN, ED BLANTON and DOMINIC CATALDO were incorporated into the version of NEWCAS described in this report. Statistical accuracy of the revised program was confirmed by RAY BUSCHBOM.

The body of this report was a joint effort by MARY HILL, who wrote Appendices A,B, and C, and CHUCK WATSON, who supervised the publication details. OWEN MOSS contributed Appendix D and made valuable suggestions while carefully proofreading the body.

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INTRODUCTION

As a result of the growing concern about the quality of the air we breathe, researchers are looking more closely at just how the foreign particles in our air affect us. Their experiments fall primarily into two categories. The first is environmental exposure. Studies in this category involve the effects of air pollutants to which the general public is exposed. The second is industrial exposure. Studies in this category include both worker exposure during the manufacturing of a product and consumer exposure during its use.

Since 1970 and 71, when Congress enacted the Occupational Health and Safety Act (Public Law 91-596) defining clean air standards for industries, this second category of research has flourished. A broad range of industrial exposure studies have been and are presently being conducted. One study at Battelle's Pacific Northwest Laboratories is aimed at finding out whether hydrocarbons which workers in the oil shale processing industry inhale are carcinogenic. Another study involves exposure to transuranic radionuclides in various chemical forms.

Most exposure studies are made by exposing test animals to aerosols containing the particles being studied. To make their experiments valid, the biologists must know what portion of the potentially harmful particles in the aerosol remain in the lungs of the test animals; this is referred to as the respirable fraction. How many particles remain in the lungs is dependent, not only on the concentration of the particles in the aerosol, but also on the size distribution of the particles; certain sizes of particles are more likely to deposit in the lungs than other sizes.

When a study begins, aerosol physicists must make an aerosol with the appropriate size distribution and concentration of particles for the

deposition to be investigated. They use cascade impactors to determine the size distribution. The cascade impactor is a relatively simple instrument made up of a series of jets with decreasing diameters. At each stage, particles too large to follow the airstream are collected on an impaction plate. The activity on each stage (or plate) is then measured and recorded.

Researchers at the Pacific Northwest Laboratories use NEWCAS, a FORTRAN program available on the Biometrics Center PDP 11/70, to help them calculate the respirable fraction of the aerosol from their cascade impactor data.

This report describes how NEWCAS works and how to use it. Included as appendices are a users guide and complete program listings. A novel feature of the program is the method used to display a log-normal probability plot on an ordinary (non-graphics) computer terminal. This is achieved through use of a transparent overlay which the user superimposes on the computer printed plot. One of these overlays is included as the final appendix.

NEWCAS is widely used around the laboratory because its calculations are independent of how the stage activity is measured. Some similar computer programs do not have this flexibility. For example, some which were originally designed for the analysis of radioactive aerosols can only handle count data. NEWCAS does have one drawback, however, in that it always assumes a log-normal distribution. This is valid for about eighty-percent of the work here at the laboratory, but the other twenty-percent seem to follow some other distribution, possibly a combination of several log-normal distributions. When NEWCAS does the Chi-square test, it accepts some of these twenty-percent as log-normal even though they are not. The plot is of value in detecting such occurrences.

Presently, the researcher must calculate the respirable fraction-- the number with which he is most concerned--by hand from the NEWCAS output. This could easily be incorporated into the program; however, the method for calculation of respirable fraction depends on interpretation of the distribution curve. The present procedure encourages each investigator to evaluate his data before making the relatively simple respirable fraction calculation.

NEWCAS is flexible and easy to modify; it is proving to be a valuable tool to aerosol physicists and biologists conducting exposures. It is likely, therefore, that NEWCAS will remain viable as long as air quality continues to be a relevant research subject.

INFORMATION FLOW

The flow of information in analysis of particle size distribution can take one of two paths as shown in Figure 1. After the aerosol has been generated and sampled, the cascade impactor results are recorded on the NEWCAS data collection form (Figure 4). The investigator and/or the technician then must decide how to get this information into the computer. If speed is important, someone can sit at a remote computer terminal and enter the data and edit it in a few minutes. If there is an unusually large amount of data or if rapid turnaround is not important, the forms can be sent to keypunch. The punched cards are then transferred to the computer. This route takes several days and is usually not preferred.

Once the data is on file in the computer, the analysis program, NEWCAS, is invoked. It is interactive in that the user must answer questions regarding the various options available. NEWCAS prints a report which must be evaluated by the aerosol physicist. If appropriate, hand calculated respirable fractions are made and appended to the output which is ready for use by the investigator.

At this point, the user must decide whether or not to save the data file as part of a user maintained data bank. Most users choose to discard the data file since it is so easy to re-enter a specific data set if the need should arise.

FIGURE 1

Information Flow, Block Diagram

ALGORITHM

The FORTRAN program NEWCAS reads data from a file and prints results either on the high-speed line printer or on the user's terminal. The data file may be created from punched cards through the copy utility or the user may save time by interactively entering his data using a BASIC program called INNEWCAS. Either method of data file creation is straightforward and will not be discussed further. A listing of INNEWCAS is included as Appendix B.

The logical flow of NEWCAS is shown in Figure 2. The subroutines referenced in the block diagram are listed in Appendix C. The steps outlined in the diagram are typical of a modularized computer program and do not warrant further discussion here.

The module labeled PROCESS represents the mathematics involved in this particle size analysis. The four major steps in this process are shown in Figure 3 along with their associated subroutines and functions.

● STEP 1

The first step is to calculate the aerodynamic diameters from the jet diameters and the flow rate. The aerodynamic diameter is the diameter of a unit density sphere with the same falling characteristics as an average particle collected on a given stage of the impactor.

For each stage of the impactor, SUBROUTINE JDECD does 3 things. First, it calculates the flow rate through each of the holes in the large multiple hole (Anderson) impactors if one was used to collect this data. Then it calculates the aerodynamic diameter using the equation

FIGURE 2
Logic Flow of NEWCAS

FIGURE 3

Block Diagram of Algorithm to Describe Particle Size Distribution

$$\text{aerodynamic diameter} = 1260 \times \sqrt{\frac{\text{Jet diameter}^3}{\text{flow rate}}}$$

At this point, subroutine CALCD1 is called to perform an iterative slip correction on the aerodynamic diameter. The result is called the effective cut-off diameter.

- STEP 2

The second step is to calculate the cumulative activity and cumulative percent activity up to each stage. This is done in the main program.

- STEP 3

Next, SUBROUTINE REGRES is called to fit the weighted cumulative percent activities to a straight line. To do this SUBROUTINE WTVAl calculates a T-value for the cumulative percent activity at each stage. This involves functions ROOTER and ERFCTN.

The weights are calculated by the equation $W = Z^2N/PQ$ where

W = weight

Z = T-value of the cumulative percent activity

N = total activity

P = fraction of the activity which has been accumulated

$Q = 1-P$.

This is called the combined Mueller-Urban weight of the error in t .¹

Now the regression is performed on the log of the weighted aerodynamic diameters vs. the weighted T-values.

- STEP 4

The final step is performed by SUBROUTINE OTHER, which computes some measures of how well the regression line fits the data. First it computes the predicted values, with the aid of SUBROUTINE RNORM, which correspond to the observed stage activities. A chi-square value is then computed. A table look up retrieves the critical values of chi-square for the proper degrees of freedom for comparison with the calculated value. Finally, the activity per unit mass median aerodynamic diameter, the geometric standard deviation, the mass median and count median aerodynamic diameters are computed.

¹Mueller, G. E., Zur Grundlegung der Psychophysik, Berlin (1878).
Urban, F. M., Arch. ges. Psychol., Vol. 16, p. 168, especially pp. 181-182 (1910).

EXAMPLE

The data shown in Figure 4 was collected in a study using plutonium soil aerosols. A laboratory technician filled out the NEWCAS Data Form (Figure 4) with the appropriate sample identification, machine description, and stage activity values from the impactor. He later submitted this data to the computer interactively via the program INNEWCAS. Details about how to enter data can be found in Appendix A; Appendix B contains a listing of program INNEWCAS. After he entered his data, the laboratory technician ran the program NEWCAS interactively. NEWCAS then printed the three pages of output shown in Figures 5 through 7.

Figure 5 shows the first page of NEWCAS output. The upper part of this page contains various descriptive information entered by the user. Below this are the results of the regression analysis and the accompanying chi-square test.

Figure 6 shows the optional second page of output which contains additional analysis of the distribution. Along with the mode and various medians and means, this page shows the distribution broken down into class intervals and the percent of the activity in each of them.

Figure 7 shows the optional graph of aerodynamic equivalent diameter versus cumulative percent activity. The O's designate observed values and the P's designate the predicted values. The laboratory technician has drawn in the regression line through the predicted values. In order to read values directly from the graph, a log-normal overlay can be placed

NEWCAS DATA FORM

Send output to: M. Hill
 WORK order number: XC1111

CARD ONE (FIXED FIELD)

MACHINE /A/C/T/-/2/ (letters or numbers)
 Card Col 1
 METHOD /E/C/D/ / / / (letters or numbers)
 7
 FLOW RATE /1/7/ / / / / (must be all numbers with
 13 decimal point)
 MONTH /0/6/ DAY /2/0/ YEAR /7/5/ (numbers only)
 19 21 23
 EXPERIMENT /S/N/S/ / / / (letters or numbers)
 25
 TEST (letters or numbers):
/4/4/ / - / 1 / - / 5 / 5 / 1 / 2 / # / 1 / - / 0 / N / 1 / 8 / / /
 31
 AEROSOL /S/O/I/L/- / / / / / / / / (letters or numbers)
 49
 SUSP.NO. /1/ / / / / / (must be all numbers with decimal point)
 61
 SPECIFIC /0/ / / / / / (letters or numbers)
 ACTIVITY 67
 ACTIVITY /1/0/*/* / 0 / (power of ten)
 FACTOR 77

CARD TWO

NO. OF STAGES / / 9 /
 1
 STANDARDS / - / / /
 3
 DENSITY /3/./2/7/0/ / / / / /
 5

CARD THREE

STAGE NO.	STAGE ACTIVITY	(must have decimal)
<u>/1/</u>	<u>4.21</u>	
<u>/2/</u>	<u>1.47</u>	
<u>/3/</u>	<u>1.62</u>	
<u>/4/</u>	<u>2.26</u>	
<u>/5/</u>	<u>1.28</u>	
<u>/6/</u>	<u>1.19</u>	
<u>/7/</u>	<u>.09</u>	
<u>/8/</u>	<u>.01</u>	
<u>9</u>	<u>.00</u>	

FIGURE 4

NEWCAS Data Form

FIGURE 5

DATE = 21-JUN-77 EXPERIMENT = SNS

 INSTRUMENT = ACI-3 TEST = 44-1-SOIL#1-ONLY

 FLOW RATE = 17.420 L/MIN AEROSOL = SOIL-1

 STANDARDS = CALCULATED SUSPENSION = 1.

 METHOD = ECD SP. ACT. = 0 UG/ML

 EXP. DATE = 06/20/75 DENSITY = 3.270 G/CM**3

STAGE NO.	STAGE ACTIVITY UCI*10**0	CUMULATIVE ACTIVITY ON STAGE UCI	CUMULATIVE PERCENT LESS THAN	STANDARD P(0.5) UM	PERCENT OBSERVED	INTERVAL PREDICIED	ACTIVITY CHI- SQUARE
=====	=====	=====	=====	=====	=====	=====	=====
9	0.0000	0.0000	0.0000	0.39	0.0000	0.0829	0.0829
8	0.0100	0.0100	0.0824	0.69	0.0824	0.4839	0.3331
7	0.0900	0.1000	0.8244	1.07	0.7420	1.3484	0.2727
6	1.1900	1.2900	10.6348	2.58	9.8104	11.1787	0.1675
5	1.2600	2.5700	21.1871	3.35	10.5523	6.8151	2.0494
4	2.2600	4.8300	39.8186	4.98	18.6315	13.8529	1.6484
3	1.6200	6.4500	53.1739	7.54	13.3553	17.2916	0.8961
2	1.4700	7.9200	65.2927	12.14	12.1167	19.3660	2.7121
1	4.2100	12.1300	100.0000	0.00	34.7073	29.5804	0.8886

TOTAL: 12.1300

ACTIVITY/MASS MEDIAN AERODYNAMIC DIAMETER = 7.357
 GEOMETRIC STANDARD DEVIATION = 2.542
 MASS MEDIAN DIAMETER = 4.069 UM
 COUNT MEDIAN DIAMETER (FOR LOG NORMAL DISTR. = 0.299 UM
 SUM OF CHI-SQUARES = 9.051
 NO. OF DEGREES OF FREEDOM = 6
 CRITICAL VALUES FOR CHI-SQUARE DISTRIBUTION = 10.645(P=.10) 12.592(P=.05) 16.812(P=.01)

IF SUM OF CHI-SQUARES EXCEEDS CRITICAL VALUE FOR LEVEL OF SIGNIFICANCE SELECTED, REJECT AT THAT SIGNIFICANCE LEVEL THE NULL HYPOTHESIS THAT THE DISTRIBUTION IS LOG NORMAL.

MODE OF THE DISTRIBUTION	=	0.1251
ARITHMETIC MEAN OF THE DISTRIBUTION	=	0.4617
MEDIAN OF THE SURFACE AREA DISTRIBUTION	=	1.7038
ARITHMETIC MEAN OF THE SURFACE AREA DISTRIBUTION	=	0.7135
MEDIAN OF THE VOLUME DISTRIBUTION	=	4.0686
ARITHMETIC MEAN OF THE VOLUME DISTRIBUTION	=	1.1026

CLASS INTERVALS	---PREDICTED PERCENT---	
	INTERVAL	CUMULATIVE
0.00 - 0.25	41.8856	41.8856
0.25 - 0.50	30.4051	72.2907
0.50 - 0.75	13.1909	85.4817
0.75 - 1.00	6.2588	91.7404
1.00 - 1.25	3.2526	94.9930
1.25 - 1.50	1.8174	96.8104
1.50 - 1.75	1.0754	97.8859
1.75 - 2.00	0.6665	98.5524
2.00 - 2.25	0.4291	98.9815
2.25 - 2.50	0.2852	99.2667
2.50 - 2.75	0.1947	99.4614
2.75 - 3.00	0.1361	99.5975
3.00 - 3.25	0.0971	99.6946
3.25 - 3.50	0.0705	99.7651
3.50 - 3.75	0.0520	99.8172
3.75 - 4.00	0.0389	99.8561
4.00 - 4.25	0.0295	99.8856
4.25 - 4.50	0.0226	99.9083
4.50 - 4.75	0.0176	99.9258
4.75 - 5.00	0.0137	99.9396
5.00 - 5.25	0.0108	99.9504
5.25 - 5.50	0.0086	99.9591
5.50 - 5.75	0.0069	99.9660
5.75 - 6.00	0.0056	99.9716
6.00 - 6.25	0.0045	99.9761
6.25 - 6.50	0.0037	99.9799
6.50 - 6.75	0.0031	99.9829
6.75 - 7.00	0.0025	99.9855
7.00 - 7.25	0.0021	99.9876
7.25 - 7.50	0.0018	99.9893
7.50 - 7.75	0.0015	99.9908
7.75 - 8.00	0.0012	99.9920
8.00 - 8.25	0.0011	99.9931
8.25 - 8.50	0.0009	99.9940
8.50 - 8.75	0.0008	99.9948
8.75 - 9.00	0.0006	99.9954
9.00 - 9.25	0.0006	99.9960
9.25 - 9.50	0.0005	99.9965
9.50 - 9.75	0.0004	99.9969
9.75 - 10.00	0.0004	99.9972

FIGURE 6

Example of Optional NEWCAS Table of Predicted Percent in Each Size Interval

FIGURE 7

Example of NEWCAS Plot of Aerodynamic Equivalent Diameter vs. Cumulative Percent Activity

FIGURE 8

Example of NEWCAS Plot with Transparent Log-Normal Overlay Superimposed

over the graph as shown in Figure 8.

ADDING NEW IMPACTORS

From time to time new impactors are purchased. They are calibrated by the manufacturer and are often re-calibrated upon receipt. To accommodate new impactors it is necessary to modify subroutine DEFINE of the FORTRAN program NEWCAS by adding the code name of the new impactor and the jet diameters of the various stages. The addition of a new impactor usually requires only the addition of two data statements, but if many more impactors are added, the dimensions of the impactor name and jet diameter arrays will have to be enlarged. This will require editing the common statements and recompiling the program and its subroutines.

A special form (see Appendix A, page A-1) simplifies communication between the aerosol physicist and the computer programmer who is responsible for making the modifications.

APPENDIX A
NEWCAS USERS GUIDE

AN INTERACTIVE PROCEDURE FOR PARTICLE-SIZE ANALYSIS
USING NEWCAS

This booklet contains procedures for the use of NEWCAS, a
program which analyzes particle-size data from cascade impactors.

For statistical background, get in touch with:

Ray Buschbom
946-2380
MATH--Rm.1210/3000 AREA

For help with computer-related difficulties, contact:

Chuck Watson
942-3251 ext. 328
331--TR/300 AREA

Jackie Bender
946-2435
LSL-II--Rm.1237/3000 AREA

Mary Hill
946-3630
LSL-II--Rm.1236/3000 AREA

AN INTERACTIVE PROCEDURE FOR PARTICLE SIZE
ANALYSIS USING NEWCAS

AN INTERACTIVE PROCEDURE FOR PARTICLE
SIZE ANALYSIS USING NEWCAS

I. LOGIN

1. Turn terminal power on.
2. Turn phone coupler on (if you have one).
3. Dial 942-7601 (if you have a phone coupler).
4. Put receiver in phone coupler (if you have one).
5. Depress the control key ("CTRL") and "C" simultaneously.
6. Type LOGIN and your userid.
7. Hit the return (ALWAYS hit return after entering a line).
8. Type your password (won't show up).

(CTRL/C)←←5.

IAS PROGRAM DEVELOPMENT SYSTEM VERSION 1.1
14:06:06 21 SEP-77

PDS> LOGIN CRWA07155←←6.

PASSWORD? ←←8.

USER CRWA07155 UIC E300,1653 TT20: TASK 256 14:06:24 21 SEP 77

```
**** WELCOME TO THE BIOMETRICS COMPUTER CENTER ****
**** REMOTE TERMINALS DIAL 942-7601 ****
**** FOR ASSISTANCE CALL 946-3620 ****
**** BULLETIN 024 14 SEP-77 22:00 ****
```

```
!!!! IAS 1.1 IS NOW ON A NEW SYSTEM DISK !!!!
!!!! SEE BULLETINS 023 AND 024 !!!!
```

II. ENTER YOUR DATA:

1. Type "BASIC".
2. Type "RUN [300,300]INNEWCAS".
3. Enter data as directed.*
4. When finished, type "BYE".

PDS> BASIC ←1.
IAS BASIC V01

READY
RUN [300,300]INNEWCAS ←2.

* * * * * NEWCAS DATA-STOREING PROGRAM * * * * *

NAME YOUR FILE (E.G., NEWCAS.DAT)? MARY.DAT (you may want to use your
name on your file to make
it easy to find)

LINE 1:

1. MACHINE (UP TO 6 LETTERS OR NOS.)? MCI-A2
2. METHOD (UP TO 6 CHARS.)? ECD
3. FLOW RATE (NUMERIC W/ DEC. PT., UP TO 6 CHARS.)? .060
4. DATE (E.G. 013177, MUST BE 6 NUMBERS)? 041177
5. EXPERIMENT (UP TO 6 CHARS.)? 237 42
6. TEST (UP TO 18 CHARS.)?
7. AEROSOL (UP TO 12 CHARS.)? PU02 U02
8. SUSP. NO. (UP TO 6 CHARS.)?
9. SPECIFIC ACTIVITY (UP TO 6 CHARS.)? 11.0
10. ACTIVITY FACTOR (1 OR 2 DIGITS, NO DEC. PT.)?

(Continued)

*Data sheets used for example are at end of procedures.

VERIFY DATA? YES

1. MCI-A2 (user wants to make sure he
2. ECD entered his data correctly)
3. .860
4. 041177
5. 239-42
6.
7. PU02-U02
8.
9. 11.0 (user realizes he typed the wrong date,
10. 10** so he changes it)

CHANGES? YES

NUMBER OF VARIABLE? 4

OLD VALUE: 041177

NEW VALUE? 051177

041177 IS NOW 051177 .

CHANGES? NO

LINE 2:

1. NO. OF STAGES (1 OR 2 DIGITS, NO DEC. PT.)? 8
2. DENSITY (NUMBER WITH DEC. PT., UP TO 10 CHARS.)? 1.0

VERIFY DATA? YES

1. 8
2. 1.0

CHANGES? NO

LINES 3 TO 11 OR 12:

STAGE NO.	STAGE ACTIVITY
1	? .53
2	? 1.77
3	? 5.74
4	? 123.46
5	? 264.07
6	? 177.42
7	? 1.50
8	? .03

VERIFY DATA? NO

(user is sure his data for this line is O.K., so
decides not to verify it)

MORE DATA? YES

(user has another data sheet)

(continued)

LINE 1:

1. MCI-A2
2. ECD
3. .860
4. 051177
5. 239-42
6.
7. PU02-U02
8.
9. 11.0
10. 10**

(user only enters LINE 1 and LINE 2 once, then
modifies them for subsequent data sheets)

CHANGES? YES

NUMBER OF VARIABLE? 1

OLD VALUE: MCI-A2

(user changes machine number)

NEW VALUE? MCI-A6

MCI-A2 IS NOW MCI-A6 .

CHANGES? YES

NUMBER OF VARIABLE? 3

(user changes flow rate)

OLD VALUE: .860

NEW VALUE? .620

.860 IS NOW .620 .

CHANGES? NO

VERIFY DATA? YES

(checks his changes)

1. MCI A6
2. ECD
3. .620
4. 051177
5. 239-42
6.
7. PU02-U02
8.
9. 11.0
10. 10**

CHANGES? NO

LINE 2:

1. 3
2. 1.0

CHANGES? NO

(has no changes to make in LINE 2)

(continued)

LINES 3 TO 11 OR 12:

STAGE NO.	STAGE ACTIVITY	
1	? .40	(enters values of stage activity for second data sheet)
2	? .64	
3	? 2\3.20	
4	? 52.55	
5	? 173.97	
6	? 233.37	
7	? 1.03	
8	? 0.0	

VERIFY DATA? YES (verifies data to make sure No. 3 is right
since he had to use the delete key)

1.	.40
2.	.64
3.	3.20
4.	52.55
5.	173.97
6.	233.37
7.	1.03
8.	0.0

CHANGES? NO

MORE DATA? NO (finished)

DATA HAS BEEN STORED IN MARY.DAT.

READY
BYE ← 4.

14:12:15 TASK TERMINATION
CORE SIZE 18K CPU TIME 01.46

III. CHECK YOUR DATA

1. Type "TYPE filename"
2. If data is not correct, use EDIT to make corrections
or rerun [300,300]INNEWCAS.

PDS> TYPE MARY.DAT ←1.

MCI-A2ECD .860 051177239-42

PU02-U02

11.0 10**

8-11.0

1 .53

2 1.79

3 5.94

4 123.46

5 264.89

6 179.42

7 1.58

8 .03

MCI-A6ECD .620 051177239-42

PU02-U02

11.0 10**

8-11.0

1 .40

2 .64

3 3.20

4 52.55

5 173.97

6 233.37

7 1.83

8 0.0

IV. MAKE THE REPORT

1. If you want your output at your terminal, type "SET TERMINAL WIDTH:130".
2. Type "RUN [300,300]NEWCAS".
3. Enter indicated information.
4. If your output is for the line printer, you will be asked your name, location, and phone number. These will be printed on a banner attached to your output to identify it.

```
[ If your output will be at your terminal
PDS> SET TERMINAL WIDTH:130 ← 1.
PDS> RUN [300,300]NEWCAS ← 2.
14:14:03
```

***** NEWCAS 21-SEP-77 *****

NAME OF YOUR DATA FILE: MARY.DAT

DO YOU WANT SECOND PAGE OF CALCULATIONS (Y OR N)?Y

DO YOU WANT GRAPH (Y OR N)?Y

DO YOU WANT OUTPUT (1) ON LINE PRINTER
OR (2) AT YOUR TERMINAL?2

```
[ If your output will be on the line printer
YOUR NAME? MARY HILL
LOCATION (E.G. 331 BLDG./300 AREA BNW)? LSL2
PHONE? 946-2123
JOB261 -- STOP NORMAL END OF NEWCAS
```

14:33:04 TASK TERMINATION
CORE SIZE 17K CPU TIME 01.23

V. IF YOU DO NOT WISH TO SAVE YOUR DATA FILE, DELETE IT

1. Type "DIR filename;*" to find out what your newest version number is (if you think you have more than one, but only want to delete a certain file).
- 2a. Type "DELETE filename;version" to delete one particular file.
OR
- 2b. Type "DELETE filename;*" to delete all data files with given filename.

PDS> DIR MARY.DAT;* ←1.

DIRECTORY DB0:1300,1653
21-SEP-77 14:33

MARY.DAT;1	1.	21-SEP-77 14:07
MARY.DAT;2	1.	21-SEP-77 14:33

TOTAL OF 2. BLOCKS IN 2. FILES

PDS> DELETE MARY.DAT;2 ←2a.
OR
PDS> DELETE MARY.DAT;* ←2b.

VI. LOGOUT

1. Type "LOGO".
2. If you have a phone coupler, hang up and turn power off.
3. Turn terminal power off.

```
FDS> LOGO ←1.  
USER CRWA07155   UIC [300,165] TT16:   TASK 261   14:34:12 21 SEP 7  
CONNECT TIME 15 M   SYSTEM UTILIZATION 3 MCTS
```

DYE

Pacific Northwest Laboratories

NEWCAS DATA FORM

Send output to: _____

WORK order number: _____

CARD ONE (FIXED FIELD)

MACHINE /M/C/I/-/A/2/ (letters or numbers)
Card Col 1

METHOD /E/C/D// (letters or numbers)
7

FLOW RATE /0./8/6/0/ (must be all numbers with
13 decimal point)

MONTH /4/ DAY /1/1/ YEAR /1/1/ (numbers only)
19 21 23

EXPERIMENT /2/3/9/-/4/2/ (letters or numbers)
25

TEST (letters or numbers):

/ / / / / / / / / / / / / / / / / /
31

AEROSOL /P/U/0/2/-/U/0/2// (letters or numbers)
49

SUSP.NO. / / / / / / / / (must be all numbers with decimal point)
61

SPECIFIC /1/1/-/0// (letters or numbers)
ACTIVITY 67

ACTIVITY /1/0/*/*/-/-/ (power of ten)
FACTOR 77

CARD TWO

NO. OF STAGES /0/8/
1

STANDARDS /-/1/
3

DENSITY /1/. / 0 / / / / / / / /
5

CARD THREE

STAGE NO.	STAGE ACTIVITY	(must have decimal)
<u>/1/</u>	0.53	
<u>/2/</u>	1.79	
<u>/3/</u>	5.94	
<u>/4/</u>	123.46	
<u>/5/</u>	264.89	
<u>/6/</u>	179.42	
<u>/7/</u>	1.58	
<u>/8/</u>	0.03	

*SAMPLE DATA FORM 1

Pacific Northwest Laboratories

NEWCAS DATA FORM

Send output to: _____

WORK order number: _____

CARD ONE (FIXED FIELD)

MACHINE M / C / I / - / A / 6 / (letters or numbers)

Card Col 1

METHOD E / C / D / / / / (letters or numbers)

7

FLOW RATE 0 / . / 6 / 2 / 0 / (must be all numbers with decimal point)

13

MONTH 4 DAY 1 / 1 YEAR 7 / 7 (numbers only)

19

21

23

EXPERIMENT 2 / 3 / 9 / - / 4 / 2 / (letters or numbers)

25

TEST (letters or numbers):

/ / / / / / / / / / / / / / / / / /

31

AEROSOL P / U / 0 / 2 / - / U / 0 / 2 / / / / (letters or numbers)

49

SUSP.NO. / / / / / / / / (must be all numbers with decimal point)

61

SPECIFIC 1 / 1 / - / 0 / / / (letters or numbers)

ACTIVITY

67

ACTIVITY 1 / 0 / * / * / / / (power of ten)

FACTOR

77

CARD TWO

NO. OF STAGES 0 / 8 /

1

STANDARDS - / 1 /

3

DENSITY 1 / . / 0 / / / / / / / /

5

CARD THREE

STAGE NO. 1 STAGE ACTIVITY 0.40 (must have decimal)20.6433.20452.555173.976233.3771.8380.00

*SAMPLE DATA FORM 2

NEWCAS, FIRST PAGE, COMPUTED ON 21-SEP-77
 DATE = 21-SEP-77 EXPERIMENT = 239-42

INSTRUMENT = MCI-A2 TEST =

FLOW RATE = 0.860 L/MIN AEROSOL = PU02-U02

STANDARDS = CALCULATED SUSPENSION =

METHOD = ECD SP. ACT. = 11.0 UCI/ML

EXP. DATE = 05/11/77 DENSITY = 1.000 G/CM**3

STAGE NO.	STAGE ACTIVITY UCI*10**	CUMULATIVE ACTIVITY ON STAGE UCI	CUMULATIVE PERCENT LESS THAN	STANDARD P(0.5) UM	PERCENT INTERVAL ACTIVITY OBSERVED	PREDICTED	CHI-SQUARE
8	0.0300	0.0300	0.0052	0.19	0.0052	0.1124	0.1023
7	1.5800	1.6100	0.2787	0.34	0.2735	4.3332	3.8034
6	179.4200	181.0300	31.3396	0.59	31.0609	26.9758	0.6186
5	264.8700	445.9200	77.1769	0.97	45.8573	43.3957	0.1396
4	123.4600	569.3800	98.5700	1.68	21.3732	22.4925	0.0557
3	5.9400	575.3200	99.5984	2.97	1.0203	2.6207	0.9743
2	1.7200	577.1100	99.9082	4.90	0.3079	0.0607	1.0160
1	0.5300	577.6400	100.0000	0.00	0.0918	0.0006	13.5539

TOTAL: 577.6400

ACTIVITY/MASS MEDIAN AERODYNAMIC DIAMETER = 0.725
 GEOMETRIC STANDARD DEVIATION = 1.547
 MASS MEDIAN DIAMETER = 0.725 UM
 COUNT MEDIAN DIAMETER (FOR LOG NORMAL DISTR. = 0.409 UM
 SUM OF CHI-SQUARES = 20.265
 NO. OF DEGREES OF FREEDOM = 5
 CRITICAL VALUES FOR CHI-SQUARE DISTRIBUTION = 9.236(P=.10) 11.071(P=.05) 15.086(P=.01)

IF SUM OF CHI-SQUARES EXCEEDS CRITICAL VALUE FOR LEVEL OF SIGNIFICANCE SELECTED, REJECT AT THAT SIGNIFICANCE LEVEL THE NULL HYPOTHESIS THAT THE DISTRIBUTION IS LOG NORMAL.

*SAMPLE OUTPUT FOR DATA FORM 1 - PAGE 1

A-14

NEWCAS, SECOND PAGE, COMPUTED ON 21-SEP-77

MODE OF THE DISTRIBUTION	=	0.3302
ARITHMETIC MEAN OF THE DISTRIBUTION	=	0.4502
MEDIAN OF THE SURFACE AREA DISTRIBUTION	=	0.5992
ARITHMETIC MEAN OF THE SURFACE AREA DISTRIBUTION	=	0.4252
MEDIAN OF THE VOLUME DISTRIBUTION	=	0.7251
ARITHMETIC MEAN OF THE VOLUME DISTRIBUTION	=	0.5448

CLASS INTERVALS	---PREDICTED PERCENT---	
	INTERVAL	CUMULATIVE
0.00 - 0.25	0.4862	0.4862
0.25 - 0.50	84.8335	85.3196
0.50 - 0.75	14.6060	99.9256
0.75 - 1.00	0.0743	99.9999
1.00 - 1.25	0.0001	100.0000

*SAMPLE OUTPUT FOR DATA FORM 1 - PAGE 2

21-SEP-77 NEWCAS, PLOT PAGE
(10.0) 1 +

EXPT = 239-42 TEST =

CUMULATIVE PERCENT ACTIVITY T-VALUE (%)

*SAMPLE OUTPUT FOR DATA FORM 1 - GRAPH

NEWCAS, FIRST PAGE, COMPUTED ON 21-SEP-77
 DATE = 21-SEP-77 EXPERIMENT = 239-42

INSTRUMENT = MCI-A6 TEST =

FLOW RATE = 0.620 L/MIN AEROSOL = PU02-U02

STANDARDS = CALCULATED SUSPENSION =

METHOD = ECD SP. ACT. = 11.0 UCI/ML

EXP. DATE = 05/11/77 DENSITY = 1.000 G/CM**3

STAGE NO.	STAGE ACTIVITY UCI*10**	CUMULATIVE ACTIVITY ON STAGE UCI	CUMULATIVE PERCENT LESS THAN	STANDARD P(0.5) UM	PERCENT INTERVAL ACTIVITY		CHI-SQUARE
=====	=====	=====	=====	=====	OBSERVED	PREDICTED	=====
8	0.0000	0.0000	0.0000	0.21	0.0000	0.4305	0.4305
7	1.8300	1.8300	0.3927	0.37	0.3927	7.3209	6.5565
6	233.3700	235.2000	50.4764	0.70	50.0837	40.7201	2.1532
5	173.9700	409.1700	87.8123	1.18	37.3358	37.8234	0.0063
4	52.5500	461.7200	99.0700	1.97	11.2778	12.2815	0.0820
3	3.2000	464.9200	99.7768	3.48	0.6868	1.3916	0.3570
2	0.6400	465.5600	99.9142	6.24	0.1374	0.0318	0.3506
1	0.4000	465.9600	100.0000	0.00	0.0853	0.0002	48.7492

TOTAL: 465.9600

ACTIVITY/MASS MEDIAN AERODYNAMIC DIAMETER = 0.714
 GEOMETRIC STANDARD DEVIATION = 1.590
 MASS MEDIAN DIAMETER = 0.714 UM
 COUNT MEDIAN DIAMETER (FOR LOG NORMAL DISTR. = 0.374 UM
 SUM OF CHI-SQUARES = 58.685
 NO. OF DEGREES OF FREEDOM = 5
 CRITICAL VALUES FOR CHI-SQUARE DISTRIBUTION = 9.236(P=.10) 11.071(P=.05) 15.086(P=.01)

IF SUM OF CHI-SQUARES EXCEEDS CRITICAL VALUE FOR LEVEL OF SIGNIFICANCE SELECTED, REJECT AT THAT SIGNIFICANCE LEVEL THE NULL HYPOTHESIS THAT THE DISTRIBUTION IS LOG NORMAL.

NEWCAS, SECOND PAGE, COMPUTED ON 21-SEP-77

MODE OF THE DISTRIBUTION	=	0.3018
ARITHMETIC MEAN OF THE DISTRIBUTION	=	0.4168
MEDIAN OF THE SURFACE AREA DISTRIBUTION	=	0.5755
ARITHMETIC MEAN OF THE SURFACE AREA DISTRIBUTION	=	0.4641
MEDIAN OF THE VOLUME DISTRIBUTION	=	0.7136
ARITHMETIC MEAN OF THE VOLUME DISTRIBUTION	=	0.5168

CLASS INTERVALS	---PREDICTED PERCENT---	
	INTERVAL	CUMULATIVE
0.00 - 0.25	3.0311	3.0311
0.25 - 0.50	88.0601	91.0912
0.50 - 0.75	8.8472	99.9384
0.75 - 1.00	0.0613	99.9997
1.00 - 1.25	0.0003	100.0000

*SAMPLE OUTPUT FOR DATA FORM 2 - PAGE 2

*SAMPLE OUTPUT FOR DATA FORM 2 - GRAPH

Date

To Jackie Bender

From

Subject New Impactors for the Newcas Program

Please add the following:

NEW IMPACTOR CODE _____

<u>Internal Code</u>	<u>Stage Number</u>	<u>Hole Size(cm)</u>
E(2,I)	_____	_____
E(3,I)	_____	_____
E(4,I)	_____	_____
E(5,I)	_____	_____
E(6,I)	_____	_____
E(7,I)	_____	_____
E(8,I)	_____	_____
E(9,I)	_____	_____

APPENDIX B
BASIC PROGRAM
INNEWCAS

```

10 REM ***** PROGRAM FOR ENTERING NEWCAS DATA *****
20 REM
30 REM ----- FORMAT STRINGS -----
40 L1$=" 'LLLLL'LLLLL'LLLLL'RRRRR'LLLLL'LLLLLLLLLLLLLLLLL'LLLLLLLLLLL'LLLLL'LLLLL'LLLLL"
50 L2$=" 'R'R'LLLLLLLLL"
60 L3$="## 'LLLLLLLLL"
70 V$="##. 'LLLLLLLLLLLLLLLLL"
80 REM ---- FORMATS STRINGS -----
90 REM ** INITIALIZE
100 B9=0
110 REM
120 PRINT " * * * * * NEWCAS DATA-STORING PROGRAM * * * * * \ PRINT
130 REM -----
140 REM ** FIND OUT FILENAME USER WANTS AND OPEN IT
150 PRINT "NAME YOUR FILE (E.G., NEWCAS.DAT)";
160 INPUT F$
170 P=POS(F$,'.',1)
180 IF P=0 THEN PRINT "NEED '.' IN FILE NAME."
190 IF P=0 GO TO 160
200 IF LEN(F$)>12 THEN PRINT "FILE NAME TOO LONG."
210 IF LEN(F$)>12 GO TO 160
220 REM -----
230 REM ** DIMENSION DATA ARRAY
240 OPEN F$ FOR OUTPUT AS FILE #1
250 DIM A$(3,10)
260 REM
270 REM ==== BEGINNING OF BIG LOOP FOR EACH DATA COLLECTION SHEET ====
280 REM
290 REM ** GET DATA FOR FIRST LINE OF FILE
300 PRINT\PRINT "LINE 1:"
310 REM -----
320 PRINT \ PRINT " 1. MACHINE (UP TO 6 LETTERS OR NOS.)";
330 INPUT A$(1,1)
340 P=POS(A$(1,1),'-',1)
350 IF P=0 THEN PRINT "NEEDS HYPHEN."
360 IF P=0 GO TO 330
370 IF P<>4 THEN PRINT "HYPHEN IN WRONG PLACE."
380 IF P<>4 GO TO 330
390 IF LEN(A$(1,1))>6 THEN PRINT "TOO LONG."
400 IF LEN(A$(1,1))>6 GO TO 330
410 REM -----
420 PRINT \ PRINT " 2. METHOD (UP TO 6 CHARS.)";
430 INPUT A$(1,2)
440 IF A$(1,2)<>"ECD" THEN PRINT "NEWCAS WORKS ONLY FOR METHOD ECD."

```

```

450 IF A$(1,2)<>"ECD" GO TO 430
460 REM -----
470 PRINT \ PRINT " 3. FLOW RATE (NUMERIC w/ DEC. PT., UP TO 6 ChARS.)";
480 INPUT A$(1,3)
490 P=POS(A$(1,3),'.',1)
500 IF P=0 THEN PRINT "NEEDS DEC. PT."
510 IF P=0 GO TO 480
520 IF LEN(A$(1,3))>6 THEN PRINT "TOO LONG."
530 REM -----
540 IF LEN(A$(1,3))>6 GO TO 480
550 PRINT \ PRINT " 4. DATE (E.G. 013177, MUST BE 6 NUMBERS)";
560 INPUT A$(1,4)
570 P=POS(A$(1,4),'/',1)
580 IF P<>0 THEN PRINT "NO '/'S."
590 IF P<>0 GO TO 560
600 P=POS(A$(1,4),'-',1)
610 IF P<>0 THEN PRINT "NO '-'S."
620 IF P<>0 GO TO 560
630 IF LEN(A$(1,4))<>6 THEN PRINT "MUST BE 6 NUMBERS."
640 IF LEN(A$(1,4))<>6 GO TO 560
650 REM -----
660 PRINT \ PRINT " 5. EXPERIMENT (UP TO 6 ChARS.)";
670 INPUT A$(1,5)
680 IF LEN(A$(1,5))>6 THEN PRINT "TOO LONG."
690 IF LEN(A$(1,5))>6 GO TO 670
700 REM -----
710 PRINT \ PRINT " 6. TEST (UP TO 18 ChARS.)";
720 INPUT A$(1,6)
730 IF LEN(A$(1,6))>18 THEN PRINT "TOO LONG."
740 IF LEN(A$(1,6))>18 GO TO 720
750 REM -----
760 PRINT \ PRINT " 7. AEROSOL (UP TO 12 ChARS.)";
770 INPUT A$(1,7)
780 IF LEN(A$(1,7))>12 THEN PRINT "TOO LONG."
790 IF LEN(A$(1,7))>12 GO TO 770
800 REM -----
810 PRINT \ PRINT " 8. SUSP. NO. (UP TO 6 ChARS.)";
820 INPUT A$(1,8)
830 IF LEN(A$(1,8))>6 THEN PRINT "TOO LONG."
840 IF LEN(A$(1,8))>6 GO TO 820
850 REM -----
860 PRINT \ PRINT " 9. SPECIFIC ACTIVITY (UP TO 6 ChARS.)";
870 INPUT A$(1,9)
880 IF LEN(A$(1,9))>6 THEN PRINT "TOO LONG."

```

```

890 IF LEN(A$(1,9))>9 GO TO 870
900 REM -----
910 PRINT \ PRINT "10. ACTIVITY FACTOR (1 OR 2 DIGITS, NO DEC. PT.)";
920 INPUT A$(1,10)
930 P=POS(A$(1,10),'.',1)
940 IF P<>0 THEN PRINT "JUST EXPONENT."
950 IF P<>0 GO TO 920
960 IF LEN(A$(1,10))>2 THEN PRINT "TOO LONG."
970 IF LEN(A$(1,10))>2 GO TO 920
980 A$(1,10)="10**"+A$(1,10)
990 REM -----
1000 REM ** VERIFY DATA IF USER DESIRES TO DO SO
1010 T=1
1020 M=10
1030 Q=0
1040 GOSUB 1880
1050 REM -----
1060 REM ** GET DATA FOR SECOND LINE OF FILE
1070 PRINT \ PRINT "LINE 2:"
1080 REM
1090 PRINT \ PRINT " 1. NO. OF STAGES (1 OR 2 DIGITS, NO DEC. PT.)";
1100 INPUT A$(2,1)
1110 P=POS(A$(2,1),'.',1)
1120 IF P<>0 THEN PRINT "NO DEC. PT."
1130 IF P<>0 GO TO 1100
1140 IF LEN(A$(2,1))>2 THEN PRINT "TOO LONG."
1150 IF LEN(A$(2,1))>2 GO TO 1100
1160 A1$="-1"
1170 REM -----
1180 PRINT \ PRINT " 2. DENSITY (NUMBER WITH DEC. PT., UP TO 10 CHARS.)";
1190 INPUT A$(2,2)
1200 P=POS(A$(2,2),'.',1)
1210 IF P=0 THEN PRINT "NEED DEC. PT."
1220 IF P=0 GO TO 1190
1230 IF LEN(A$(2,2))>10 THEN PRINT "TOO LONG."
1240 IF LEN(A$(2,2))>10 GO TO 1190
1250 REM -----
1260 REM ** VERIFY IF USER DESIRES
1270 T=2
1280 M=2
1290 Q=0
1300 GOSUB 1880
1310 REM -----
1320 REM ** GET DATA FOR NEXT 8 OR 9 LINES OF FILE

```

```

1330 REM
1340 PRINT \ PRINT "LINES 3 TO 11 OR 12:"
1350 PRINT \ PRINT "STAGE NO.  STAGE ACTIVITY"
1360 FOR I=1 TO VAL(A$(2,1))
1370 PRINT I;" "; \ INPUT A$(3,I)
1380 P=POS(A$(3,I),".",1)
1390 IF P=0 THEN PRINT "NEEDS DEC. PT."
1400 IF P=0 GO TO 1370
1410 IF LEN(A$(3,I))>10 THEN PRINT "TOO LONG."
1420 IF LEN(A$(3,I))>10 GO TO 1370
1430 NEXT I
1440 REM -----
1450 REM ** VERIFY IF USER DESIRES
1460 T=3
1470 M=VAL(A$(2,1))
1480 Q=0
1490 GOSUB 1580
1500 REM -----
1510 REM ** PRINT DATA ONTO FILE
1520 PRINT #1,USING L1$,A$(1,1),A$(1,2),A$(1,3),A$(1,4),A$(1,5),A$(1,6),A$(1,7),A$(1,8),A$(1,9),A$(1,10)
1530 PRINT #1,USING L2$,A$(2,1),A1$,A$(2,2)
1540 FOR I=1 TO VAL(A$(2,1))
1550 PRINT #1,USING L3$,I,A$(3,I)
1560 NEXT I
1570 REM ===== GET NEXT SET OF DATA OR QUIT =====
1580 PRINT \ PRINT "MORE DATA"; \ INPUT Y$
1590 PRINT
1600 REM ** IF MORE DATA, JUST MAKE CHANGES IN LINES 1 AND 2, DON'T RE-ENTER
1610 IF Y$="NO" GO TO 1830
1620 IF Y$<>"YES" GO TO 1580
1630 PRINT \ PRINT "LINE 1:"
1640 T=1
1650 M=10
1660 Q=99
1670 GOSUB 1880
1680 IF B9=0 GO TO 1720
1690 Q=0
1700 GOSUB 1880
1710 REM -----
1720 PRINT \ PRINT "LINE 2:"
1730 T=2
1740 M=2
1750 Q=99
1760 GOSUB 1880

```



```

1770 IF B9=0 GO TO 1820
1780 C=0
1790 GOSUB 1880
1800 REM -----
1810 REM ** GET THIRD LINE OF DATA
1820 GO TO 1340
1830 PRINT "DATA HAS BEEN STORED IN ";F$;"."
1840 CLOSE #1
1850 GO TO 2100
1860 REM
1870 REM
1880 REM :::::::::::::::::::: SUBROUTINE FOR DATA VERIFICATION ::::::::::::::::::::
1890 IF C=99 GO TO 1930
1900 PRINT \ PRINT "VERIFY DATA"; \ INPUT Y$
1910 IF Y$="NO" THEN RETURN
1920 IF Y$<>"YES" GO TO 1900
1930 B9=0
1940 FOR I=1 TO M
1950 PRINT USING V$,I,A$(T,I)
1960 NEXT I
1970 PRINT \ PRINT "CHANGES"; \ INPUT Y$
1980 IF Y$="NO" THEN RETURN
1990 IF Y$<>"YES" GO TO 1970
2000 B9=99
2010 PRINT "NUMBER OF VARIABLE"; \ INPUT N
2020 Q$=A$(T,N)
2030 PRINT "OLD VALUE: ";Q$
2040 PRINT "NEW VALUE"; \ INPUT A$(T,N)
2050 PRINT Q$," IS NOW ";A$(T,N);" ."
2060 GO TO 1970
2070 REM :::::::::::::::::::: SUBROUTINE FOR DATA VERIFICATION ::::::::::::::::::::
2080 REM
2090 REM
2100 END

```


APPENDIX C
FORTRAN PROGRAM
NEWCAS

PROGRAM NEWCAS

+++++++NEWCAS+++++

BATTELLE-NORTHWEST
BIOMETRICS CENTER

COST OF RUN: ABOUT \$.70 PER DATA SHEET

ABSTRACT:

NEWCAS IS A PARTICLE SIZE DISTRIBUTION CALCULATOR. IT USES CASCADE IMPACTOR DATA, INCLUDING FLOW RATE (INPUT), STAGE ACTIVITY (INPUT), AND JET DIAMETER (STORED), IN ITS CALCULATIONS. IT CALCULATES CUMULATIVE PERCENT ACTIVITIES AND ECD'S, THEN DOES A WEIGHTED LINEAR REGRESSION AND CHI-SQUARE TEST ON THE RESULTS. IF DESIRED, IT CAN GIVE ADDITIONAL INFORMATION ON THE DISTRIBUTION (E.G. ARITHMETIC MEAN, MODE,...) AND CAN GRAPH ECD VS. CUM. % ACTIVITY.

HISTORY:

NEWCAS WAS FIRST DEVELOPED BY RAY BUSCHBOM. CYBER VERSION WAS COMPLETED 9/21/73 BY MAITLAND LEE. FIRST PDP VERSION WAS COMPLETED 10/76 BY CHUCK WATSON AND MAITLAND LEE. NEW IMPACTORS HAVE BEEN ADDED AT VARIOUS TIMES BY JACKIE WALLACE AND CHUCK WATSON. PRESENT INTERACTIVE VERSION WAS COMPLETED 5/11/77 BY MARY HILL.

REFERENCES:

HATCH, THEODORE.
DETERMINATION OF 'AVERAGE PARTICLE SIZE' FROM THE SCREEN-ACCUMULATION OF NON UNIFORM PARTICULATE SUBSTANCES.
JOURNAL OF THE FRANKLIN INSTITUTE, JANUARY, 1933. P27-37.
MERCER, T.T., TILLERY, M.I., AND NEWTON, G.J.
A MULTI-STAGE, LOW FLOW RATE CASCADE IMPACTOR.
AEROSOL SCIENCE. 1970, VOL.1. P9-15.
GREAT BRITAIN: PERGAMON PRESS.

INPUT:

NEWCAS ASKS THE USER FOR THE NAME OF HIS DATA FILE. THIS FILE CAN BE MADE EITHER BY RUNNING THE BASIC PROGRAM [300,300]INNEWCAS, WHICH ASKS THE USER FOR EACH PIECE OF INFORMATION, OR FROM PUNCHED CARDS.

FIRST LINE OF INPUT--

NAME OF MACHINE USED (COLS. 1-6, LEFT ADJUSTED) (2A3)
METHOD OF CALCULATION (COLS. 7-12, LEFT ADJUSTED) (2A3)
NOTE!!! MUST BE 'ECD'
FLOW RATE (IN LITERS) (COLS. 13-18, USE DECIMAL) (F6.0)
EXPERIMENT DATE (COLS. 19-24) (6A1)
EXPERIMENT NUMBER (COLS. 25-30) (6A1)
TEST NUMBER (COLS. 31-48) (18A1)
AEROSOL (COLS. 49-60) (12A1)
SUSP. NO. (COLS. 61-66) (6A1)
SP. ACT. (COLS. 67-72, USE DECIMAL) (F6.0)

```

C      ACTIVITY FACTOR (COLS. 73-78) (6A1)    (10**XX)
C
C      SECOND LINE OF INPUT--
C      NUMBER OF STAGES (COLS. 1-2, RIGHT ADJUSTED)    (I2)
C      NOTE!! UP TO 10 STAGES
C      STANDARDS (IE)    (COLS. 3-4, RIGHT ADJUSTED)    (I2)
C      -1 = USE STANDARDS IN PROGRAM
C      0 = STANDARDS WILL FOLLOW DATA
C      NOTE!! THIS VERSION ONLY WORKS FOR IE = -1
C      DENSITY (COLS. 5-14, USE DECIMAL)    (F10.0)
C
C      NEXT "MAX" LINES OF INPUT--
C      STAGE NUMBER (COLS. 1-2, RIGHT ADJUSTED)    (I2)
C      STAGE ACTIVITY (COLS. 3-12, USE DECIMALS)    (F10.0)
C
C      NECESSARY SUBROUTINES:
C
C      ALL NECESSARY SUBROUTINES ARE ON THE OBJECT LIBRARY [300,14]NEWCAS.OLB.
C
C      DEFINE--DICTIONARIES OF IMPACTOR NAMES AND JET DIAMETERS
C      AND CRITICAL VALUES OF CHI-SQUARES
C      START--ASKS USER NAME OF DATA FILE AND WHAT OPTIONS HE DESIRES
C      BANNER--CALLED FROM START TO PRINT BANNER AT TOP OF OUTPUT IF
C      IT GOES TO THE LINE PRINTER
C      READER--READS DATA; FINDS IMPACTOR NAME AND CORRESPONDING JET
C
C      JDECD--ADJUSTS FOR MULTIPLE HOLES; THEN CALCULATES ECD'S
C      CALCDI--CALLED FROM JDECD TO GET SLIP CORRECTIONS
C      REGRES--DOES LINEAR WEIGHTED REGRESSION, Y=T-VALUE OF CUM.%ACTIVITY
C      AND X=LN(ECD)    (LOG-NORMAL DISTRIBUTION)
C      WIVAL--CALLED FROM REGRES TO GET T-VALUES AND WEIGHTS
C      ROOTER--CALLED BY CALCX TO GET ROOT OF EQUATION
C      MODIFIED VERSION OF 'SOUSA'
C      ERFCIN--CALLED BY ROOTLR TO GET ERF
C      OTHER--CALCULATES CHI-SQUARES, AMAD, ... (REST OF PAGE 1)
C      RNROR--CALLED FROM OTHER TO COMPUTE T-VALUE
C      WRITER--PRINTS FIRST AND SECOND PAGE OF CALCULATIONS
C      SECOND--DOES SECOND PAGE OF CALCULATIONS (MODE, ARITH. MEAN, ...)
C      GRAPH--MAKES AND PRINTS GRAPH
C
C      IMPORTANT VARIABLES:
C
C      E--JET DIAMETER
C      ECD--EFFECTIVE CUT-OFF DIAMETER (AFTER SLIP CORRECTION)
C      ELOG--NATURAL LOG OF ECD
C      ELOG10--LOG, BASE 10, OF ECD (USED IN GRAPH)
C      IST--STAGE NUMBER
C      TOTA--TOTAL ACTIVITY
C      A--STAGE ACTIVITY
C      CA--CUMULATIVE ACTIVITY
C      CPA--CUMULATIVE PERCENT ACTIVITY
C      TA--T-VALUE OF ACTIVITY
C      ETA--EXPECTED T-VALUE OF ACTIVITY
C      ECA--EXPECTED CUMULATIVE ACTIVITY
C      PNT--PERCENT INTERVAL ACTIVITY
C      PCONT--PERCENT INTERVAL ACTIVITY, OBSERVED
C      PCPNT--PERCENT INTERVAL ACTIVITY, PREDICTED
C      CHS--CHI-SQUARE FOR EACH STAGE
C      CSTOT--TOTAL CHI-SQUARE
C
C      + + + + +

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C      INCLUDE 'NEWCAS.COM'
C      DATA DONE,BAD,PGIWO,PLOT/4*.FALSE./
C      DATA INU,LUN/1,2/
C      DATA MIN/1/
C
C      ** INITIALIZE ARRAYS WHICH DESCRIBE IMPACTORS
C      CALL DEFINE
C
C      ** FIND OUT WHAT OPTIONS THE USER DESIRES
C      CALL START
C
C      ***** BEGIN BIG LOOP FOR EACH SET OF DATA
C
100  CONTINUE
C
C      ** SET NECESSARY ARRAYS TO ZERO
C      DO 200 I=1,10
C          CA(I) = 0.0
200  CONTINUE
C
C      ** READ DATA FOR THIS CASE
C      CALL READER
C      IF (BAD) STOP 'SOMETHING IS WRONG WITH DATA.'
C      IF (DONE) WRITE (LUN,1001)
C      IF (DONE) CLOSE (UNIT=INU)          !FINISHED WITH INPUT
C      IF (DONE) CLOSE (UNIT=LUN)
C      IF (DONE) STOP 'NORMAL EN OF NEWCAS'
C
C      ** CALCULATE ECO'S FROM JET DIAMETERS AND CORRECT FOR MULTIPLE HOLES IF NECESSARY
C      CALL JDECD
C
C      ** CALCULATE CUMULATIVE ACTIVITIES AND CUM. % ACTIVITIES
C      CA(MIN) = A(MIN)
C      DO 300 I=MIN,MAX-1
C          CA(I+1) = CA(I) + A(I+1)
300  CONTINUE
C      TOTA = CA(MAX)
C      DO 400 I=MIN,MAX
C          CPA(I) = CA(I)/TOTA * 100.
C          IST(I) = MAX - I + 1
400  CONTINUE
C
C      ** DO WEIGHTED STRAIGHT-LINE REGRESSION
C      CALL REGRES
C
C      ** DO THE REST OF THE PAGE-ONE CALCULATIONS (INCLUDING CHI-SQUARES)
C      CALL OTHER
C
C      ** PRINT FIRST PAGE
C      CALL WRITE1
C
C      ** IF USER DESIRES SECOND PAGE OF CALCULATIONS, DO THEM.
C      IF (PGIWO) CALL SECOND
C
C      ** IF GRAPH IS DESIRED, MAKE IT
C      IF (PLOT) CALL GRAPH
C
C      GO TO 100          !NEXT CASE
C
C      - - - - - FORMAT - - - - -
1001 FORMAT (1H1)
C      - - - - - FORMAT - - - - -
C
C      END

```

NEWCAS COMMON

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C LOGICAL BAD,DONE,PGTWO,PLOT
C
C BYTE EXPDAT(6),EXPNO(6),TSINO(16),ALRSOL(12),
1 SUSPNO(6),STACTN(6),SPACT(6),TODAY(10)
C
C REAL FMD
C
C INTEGER*4 MACH(2),METH(2),MCNE(100,2)
C
COMMON MACH,MCNE,METH,
1 EXPDAT,EXPNO,TSINO,ALRSOL,SUSPNO,STACTN,SPACT,
2 FLO,DENS,TODAY,
3 MIN,MAX,INU,EON,JROW,
4 E(10,100),ECD(10),ELG10(10),ELG(10),
5 A(10),TA(10),CA(10),CPA(10),
6 ECA(10),ETA(10),FNT(10),PCONT(10),PCPNT(10),CHS(10),IST(10),
7 CHA(48),CHB(48),CHC(48),
8 TOTA,B0,B1,
9 GMEAN,CSD,FMD,CMD,CSTOT,NDOF,CSP10,CSP05,CSP01,
1 BAD,DONE,PGTWO,PLOT,
2 DM,DBAR,DS,DBARS,DV,DVARV,AG,BG,XK,ZK

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SUBROUTINE DEFINE

----- DEFINES CASCADE IMPACTOR NAMES AND JET DIAMETERS -----
AND DEFINES CRITICAL VALUES OF CHI-SQUARE

INCLUDE 'NEWCAS.COM'

***** IMPACTOR DICTIONARY

```
DATA MCNE(1,1),MCNE(1,2)/'MCI','-1A'/
DATA E(2,1),E(3,1),E(4,1),E(5,1),E(6,1),E(7,1),E(8,1)/
+ .2195,.1786,.1401,.1184,.0892,.0681,.0409/
DATA MCNE(2,1),MCNE(2,2)/'MCI','-2A'/
DATA E(2,2),E(3,2),E(4,2),E(5,2),E(6,2),E(7,2),E(8,2)/
+ .2214,.1779,.1396,.1190,.0906,.0671,.0330/
DATA MCNE(3,1),MCNE(3,2)/'MCI','-1B'/
DATA E(2,3),E(3,3),E(4,3),E(5,3),E(6,3),E(7,3),E(8,3)/
+ .2466,.1718,.1269,.0847,.0643,.0419,.0314/
DATA MCNE(4,1),MCNE(4,2)/'MCI','-2B'/
DATA E(2,4),E(3,4),E(4,4),E(5,4),E(6,4),E(7,4),E(8,4)/
+ .2438,.1778,.1194,.0813,.0584,.0381,.0318/
DATA MCNE(5,1),MCNE(5,2)/'MCI','-1C'/
DATA E(2,5),E(3,5),E(4,5),E(5,5),E(6,5),E(7,5),E(8,5)/
+ .1346,.0851,.0622,.0419,.0318,.0203,.0140/
DATA MCNE(6,1),MCNE(6,2)/'ACI','-1'/
DATA E(2,6),E(3,6),E(4,6),E(5,6),E(6,6),E(7,6),E(8,6)/
+ .118,.0914,.0711,.0533,.0343,.0254,.0254/
DATA MCNE(7,1),MCNE(7,2)/'ACI','-2'/
DATA E(2,7),E(3,7),E(4,7),E(5,7),E(6,7),E(7,7),E(8,7)/
+ .118,.0914,.0711,.0533,.0343,.0254,.0254/
DATA MCNE(11,1),MCNE(11,2)/'MCI','-AC'/
DATA E(2,11),E(3,11),E(4,11),E(5,11),E(6,11),E(7,11),E(8,11)/
+ .2413,.1702,.1194,.0864,.0610,.0432,.0305/
DATA MCNE(12,1),MCNE(12,2)/'MCI','-BC'/
DATA E(2,12),E(3,12),E(4,12),E(5,12),E(6,12),E(7,12),E(8,12)/
+ .2388,.1702,.1194,.0864,.0610,.0406,.0330/
DATA MCNE(13,1),MCNE(13,2)/'MCI','-CC'/
DATA E(2,13),E(3,13),E(4,13),E(5,13),E(6,13),E(7,13),E(8,13)/
+ .2438,.1702,.1168,.0864,.0610,.0406,.0305/
DATA MCNE(14,1),MCNE(14,2)/'MCI','-DC'/
DATA E(2,14),E(3,14),E(4,14),E(5,14),E(6,14),E(7,14),E(8,14)/
+ .2438,.1702,.1194,.0864,.0635,.0457,.0305/
DATA MCNE(15,1),MCNE(15,2)/'MCI','-EC'/
DATA E(2,15),E(3,15),E(4,15),E(5,15),E(6,15),E(7,15),E(8,15)/
+ .2438,.1702,.1194,.0864,.0610,.0406,.0305/
DATA MCNE(16,1),MCNE(16,2)/'MCI','-FC'/
DATA E(2,16),E(3,16),E(4,16),E(5,16),E(6,16),E(7,16),E(8,16)/
+ .2362,.1727,.1194,.0889,.0610,.0406,.0305/
DATA MCNE(17,1),MCNE(17,2)/'MCI','-GC'/
DATA E(2,17),E(3,17),E(4,17),E(5,17),E(6,17),E(7,17),E(8,17)/
+ .2362,.1727,.1194,.0889,.0610,.0406,.0305/
DATA MCNE(18,1),MCNE(18,2)/'MCI','-HC'/
DATA E(2,18),E(3,18),E(4,18),E(5,18),E(6,18),E(7,18),E(8,18)/
+ .2388,.1727,.1219,.0889,.0610,.0406,.0305/
DATA MCNE(19,1),MCNE(19,2)/'MCI','-IC'/
DATA E(2,19),E(3,19),E(4,19),E(5,19),E(6,19),E(7,19),E(8,19)/
+ .2337,.1727,.1219,.0889,.0610,.0406,.0305/
DATA MCNE(20,1),MCNE(20,2)/'MCI','-JC'/
DATA E(2,20),E(3,20),E(4,20),E(5,20),E(6,20),E(7,20),E(8,20)/
+ .2337,.1727,.1194,.0889,.0610,.0406,.0305/
DATA MCNE(21,1),MCNE(21,2)/'MCI','-LC'/
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DATA E(2,21),E(3,21),E(4,21),E(5,21),E(6,21),E(7,21),E(8,21)/
+ .2337,.1651,.1143,.0838,.0610,.0432,.0305/
DATA MCNE(22,1),MCNE(22,2)/'MCI','-MC'/
DATA E(2,22),E(3,22),E(4,22),E(5,22),E(6,22),E(7,22),E(8,22)/
+ .2337,.1651,.1143,.0813,.0610,.0432,.0305/
DATA MCNE(23,1),MCNE(23,2)/'MCI','-NC'/
DATA E(2,23),E(3,23),E(4,23),E(5,23),E(6,23),E(7,23),E(8,23)/
+ .2337,.1651,.1143,.0813,.0610,.0432,.0305/
DATA MCNE(24,1),MCNE(24,2)/'MCI','-OC'/
DATA E(2,24),E(3,24),E(4,24),E(5,24),E(6,24),E(7,24),E(8,24)/
+ .2337,.1651,.1143,.0838,.0610,.0432,.0305/
DATA MCNE(25,1),MCNE(25,2)/'MCI','-PC'/
DATA E(2,25),E(3,25),E(4,25),E(5,25),E(6,25),E(7,25),E(8,25)/
+ .2337,.1676,.1143,.0813,.0610,.0432,.0305/
DATA MCNE(26,1),MCNE(26,2)/'MCI','-QC'/
DATA E(2,26),E(3,26),E(4,26),E(5,26),E(6,26),E(7,26),E(8,26)/
+ .2438,.1676,.1143,.0838,.0610,.0432,.0305/
DATA MCNE(27,1),MCNE(27,2)/'MCI','-RC'/
DATA E(2,27),E(3,27),E(4,27),E(5,27),E(6,27),E(7,27),E(8,27)/
+ .2438,.1651,.1143,.0838,.0610,.0432,.0305/
DATA MCNE(28,1),MCNE(28,2)/'MCI','-SC'/
DATA E(2,28),E(3,28),E(4,28),E(5,28),E(6,28),E(7,28),E(8,28)/
+ .2438,.1651,.1143,.0813,.0610,.0432,.0305/
DATA MCNE(29,1),MCNE(29,2)/'MCI','-TC'/
DATA E(2,29),E(3,29),E(4,29),E(5,29),E(6,29),E(7,29),E(8,29)/
+ .2438,.1651,.1143,.0838,.0610,.0432,.0305/
DATA MCNE(30,1),MCNE(30,2)/'MCI','-UC'/
DATA E(2,30),E(3,30),E(4,30),E(5,30),E(6,30),E(7,30),E(8,30)/
+ .2438,.1651,.1143,.0838,.0610,.0432,.0305/
DATA MCNE(32,1),MCNE(32,2)/'MCI','-KC'/
DATA E(2,32),E(3,32),E(4,32),E(5,32),E(6,32),E(7,32),E(8,32)/
+ .2388,.1651,.1118,.0838,.0584,.0432,.0305/
DATA MCNE(33,1),MCNE(33,2)/'MCI','-VC'/
DATA E(2,33),E(3,33),E(4,33),E(5,33),E(6,33),E(7,33),E(8,33)/
+ .2388,.1651,.1143,.0838,.0584,.0406,.0305/
DATA MCNE(34,1),MCNE(34,2)/'MCI','-WC'/
DATA E(2,34),E(3,34),E(4,34),E(5,34),E(6,34),E(7,34),E(8,34)/
+ .2413,.1651,.1118,.0813,.0584,.0406,.0305/
DATA MCNE(35,1),MCNE(35,2)/'MCI','-XC'/
DATA E(2,35),E(3,35),E(4,35),E(5,35),E(6,35),E(7,35),E(8,35)/
+ .2413,.1651,.1118,.0838,.0584,.0432,.0305/
DATA MCNE(36,1),MCNE(36,2)/'MCI','-YC'/
DATA E(2,36),E(3,36),E(4,36),E(5,36),E(6,36),E(7,36),E(8,36)/
+ .2413,.1651,.1143,.0838,.0584,.0406,.0305/
DATA MCNE(37,1),MCNE(37,2)/'MCI','-ZC'/
DATA E(2,37),E(3,37),E(4,37),E(5,37),E(6,37),E(7,37),E(8,37)/
+ .2388,.1651,.1118,.0813,.0584,.0406,.0305/
DATA MCNE(38,1),MCNE(38,2)/'MCI','-AD'/
DATA E(2,38),E(3,38),E(4,38),E(5,38),E(6,38),E(7,38),E(8,38)/
+ .2388,.1651,.1143,.0838,.0584,.0432,.0305/
DATA MCNE(39,1),MCNE(39,2)/'MCI','-BD'/
DATA E(2,39),E(3,39),E(4,39),E(5,39),E(6,39),E(7,39),E(8,39)/
+ .2413,.1626,.1118,.0838,.0584,.0432,.0279/
DATA MCNE(40,1),MCNE(40,2)/'MCI','-CD'/
DATA E(2,40),E(3,40),E(4,40),E(5,40),E(6,40),E(7,40),E(8,40)/
+ .2362,.1651,.1118,.0838,.0584,.0432,.0305/
DATA MCNE(41,1),MCNE(41,2)/'MCI','-DD'/
DATA E(2,41),E(3,41),E(4,41),E(5,41),E(6,41),E(7,41),E(8,41)/
+ .2388,.1651,.1118,.0813,.0584,.0406,.0305/
DATA MCNE(42,1),MCNE(42,2)/'MCI','-ED'/
DATA E(2,42),E(3,42),E(4,42),E(5,42),E(6,42),E(7,42),E(8,42)/
+ .2388,.1549,.1194,.0838,.0584,.0406,.0279/
DATA MCNE(43,1),MCNE(43,2)/'MCI','-FD'/
DATA E(2,43),E(3,43),E(4,43),E(5,43),E(6,43),E(7,43),E(8,43)/

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+ .2388,.1574,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(44,1),MCNE(44,2)/'MCI','GD'/
DATA E(2,44),E(3,44),E(4,44),E(5,44),E(6,44),E(7,44),E(8,44)/
+ .2388,.1574,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(45,1),MCNE(45,2)/'MCI','HD'/
DATA E(2,45),E(3,45),E(4,45),E(5,45),E(6,45),E(7,45),E(8,45)/
+ .2388,.1574,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(46,1),MCNE(46,2)/'MCI','ID'/
DATA E(2,46),E(3,46),E(4,46),E(5,46),E(6,46),E(7,46),E(8,46)/
+ .2388,.1549,.1168,.0838,.0584,.0406,.0305/
DATA MCNE(47,1),MCNE(47,2)/'MCI','JD'/
DATA E(2,47),E(3,47),E(4,47),E(5,47),E(6,47),E(7,47),E(8,47)/
+ .2362,.1575,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(48,1),MCNE(48,2)/'MCI','KD'/
DATA E(2,48),E(3,48),E(4,48),E(5,48),E(6,48),E(7,48),E(8,48)/
+ .2362,.1575,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(49,1),MCNE(49,2)/'MCI','LD'/
DATA E(2,49),E(3,49),E(4,49),E(5,49),E(6,49),E(7,49),E(8,49)/
+ .2362,.1549,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(50,1),MCNE(50,2)/'MCI','MD'/
DATA E(2,50),E(3,50),E(4,50),E(5,50),E(6,50),E(7,50),E(8,50)/
+ .2388,.1575,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(51,1),MCNE(51,2)/'MCI','ND'/
DATA E(2,51),E(3,51),E(4,51),E(5,51),E(6,51),E(7,51),E(8,51)/
+ .2362,.1575,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(52,1),MCNE(52,2)/'MCI','OD'/
DATA E(2,52),E(3,52),E(4,52),E(5,52),E(6,52),E(7,52),E(8,52)/
+ .2388,.1575,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(53,1),MCNE(53,2)/'MCI','PD'/
DATA E(2,53),E(3,53),E(4,53),E(5,53),E(6,53),E(7,53),E(8,53)/
+ .2388,.1575,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(54,1),MCNE(54,2)/'MCI','QD'/
DATA E(2,54),E(3,54),E(4,54),E(5,54),E(6,54),E(7,54),E(8,54)/
+ .2388,.1549,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(55,1),MCNE(55,2)/'MCI','RD'/
DATA E(2,55),E(3,55),E(4,55),E(5,55),E(6,55),E(7,55),E(8,55)/
+ .2362,.1575,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(56,1),MCNE(56,2)/'MCI','SD'/
DATA E(2,56),E(3,56),E(4,56),E(5,56),E(6,56),E(7,56),E(8,56)/
+ .2388,.1549,.1168,.0838,.0584,.0406,.0305/
DATA MCNE(57,1),MCNE(57,2)/'MCI','TD'/
DATA E(2,57),E(3,57),E(4,57),E(5,57),E(6,57),E(7,57),E(8,57)/
+ .2388,.1575,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(58,1),MCNE(58,2)/'MCI','UD'/
DATA E(2,58),E(3,58),E(4,58),E(5,58),E(6,58),E(7,58),E(8,58)/
+ .2388,.1600,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(59,1),MCNE(59,2)/'MCI','VD'/
DATA E(2,59),E(3,59),E(4,59),E(5,59),E(6,59),E(7,59),E(8,59)/
+ .2388,.1600,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(60,1),MCNE(60,2)/'MCI','WD'/
DATA E(2,60),E(3,60),E(4,60),E(5,60),E(6,60),E(7,60),E(8,60)/
+ .2388,.1600,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(61,1),MCNE(61,2)/'MCI','XD'/
DATA E(2,61),E(3,61),E(4,61),E(5,61),E(6,61),E(7,61),E(8,61)/
+ .2388,.1600,.1194,.0838,.0584,.0406,.0305/
DATA MCNE(62,1),MCNE(62,2)/'ACT','3'/
DATA E(2,62),E(3,62),E(4,62),E(5,62),E(6,62),E(7,62),E(8,62),
1 E(9,62)/
+ .15002,.11684,.08890,.06858,.05800,.03302,.02540,.02286/
DATA MCNE(63,1),MCNE(63,2)/'ACT','4'/
DATA E(2,63),E(3,63),E(4,63),E(5,63),E(6,63),E(7,63),E(8,63),
1 E(9,63)/
+ .15748,.11684,.09144,.06858,.05800,.03302,.02540,.02540/
DATA MCNE(64,1),MCNE(64,2)/'ACT','5'/

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DATA E(2,64),E(3,64),E(4,64),E(5,64),E(5,64),E(7,64),E(8,64),
1 E(9,64)/
+ .1626,.1168,.0914,.0686,.0533,.0330,.0254,.0254/
DATA MCNE(65,1),MCNE(65,2)/'MCI','A2'/
DATA E(2,65),E(3,65),E(4,65),E(5,65),E(6,65),E(7,65),E(8,65)/
+ .2378,.1717,.1191,.0843,.0622,.0459,.0337/
DATA MCNE(66,1),MCNE(66,2)/'MCI','A6'/
DATA E(2,66),E(3,66),E(4,66),E(5,66),E(6,66),E(7,66),E(8,66)/
+ .250,.1704,.1181,.0856,.0620,.0427,.0318/
DATA MCNE(67,1),MCNE(67,2)/'MCI','A7'/
DATA E(2,67),E(3,67),E(4,67),E(5,67),E(6,67),E(7,67),E(8,67)/
+ .249,.171,.118,.085,.062,.042,.033/
DATA MCNE(68,1),MCNE(68,2)/'MCI','A1'/
DATA E(2,68),E(3,68),E(4,68),E(5,68),E(6,68),E(7,68),E(8,68)/
+ .2372,.1714,.1188,.0850,.0617,.0459,.0332/
DATA MCNE(69,1),MCNE(69,2)/'MCI','A3'/
DATA E(2,69),E(3,69),E(4,69),E(5,69),E(6,69),E(7,69),E(8,69)/
+ .2387,.1709,.1183,.0850,.0619,.0452,.0340/
DATA MCNE(70,1),MCNE(70,2)/'MCI','A4'/
DATA E(2,70),E(3,70),E(4,70),E(5,70),E(6,70),E(7,70),E(8,70)/
+ .2369,.1714,.1193,.0848,.0622,.0452,.0340/
DATA MCNE(71,1),MCNE(71,2)/'MCI','A5'/
DATA E(2,71),E(3,71),E(4,71),E(5,71),E(6,71),E(7,71),E(8,71)/
+ .2379,.1711,.1188,.0845,.0622,.0462,.0337/
DATA MCNE(72,1),MCNE(72,2)/'MCI','A8'/
DATA E(2,72),E(3,72),E(4,72),E(5,72),E(6,72),E(7,72),E(8,72)/
+ .247,.172,.118,.086,.061,.042,.032/
DATA MCNE(73,1),MCNE(73,2)/'MCI','B2'/
DATA E(2,73),E(3,73),E(4,73),E(5,73),E(6,73),E(7,73),E(8,73)/
+ .2362,.1778,.1397,.1168,.0889,.0686,.0381/
DATA MCNE(74,1),MCNE(74,2)/'MCI','B3'/
DATA E(2,74),E(3,74),E(4,74),E(5,74),E(6,74),E(7,74),E(8,74)/
+ .2380,.1791,.1415,.1181,.0894,.0709,.0419/
DATA MCNE(75,1),MCNE(75,2)/'MCI','B4'/
DATA E(2,75),E(3,75),E(4,75),E(5,75),E(6,75),E(7,75),E(8,75)/
+ .2372,.1791,.1405,.1181,.0902,.0699,.0414/
DATA MCNE(76,1),MCNE(76,2)/'MCI','B5'/
DATA E(2,76),E(3,76),E(4,76),E(5,76),E(6,76),E(7,76),E(8,76)/
+ .2380,.1803,.1422,.1181,.0902,.0691,.0406/
DATA MCNE(77,1),MCNE(77,2)/'MCI','B6'/
DATA E(2,77),E(3,77),E(4,77),E(5,77),E(6,77),E(7,77),E(8,77)/
+ .2380,.1783,.1417,.1179,.0889,.0691,.0414/
DATA MCNE(78,1),MCNE(78,2)/'MCI','B7'/
DATA E(2,78),E(3,78),E(4,78),E(5,78),E(6,78),E(7,78),E(8,78)/
+ .2380,.1798,.1422,.1181,.0907,.0700,.0409/
DATA MCNE(79,1),MCNE(79,2)/'MCI','B8'/
DATA E(2,79),E(3,79),E(4,79),E(5,79),E(6,79),E(7,79),E(8,79)/
+ .2372,.1783,.1422,.1181,.0907,.0686,.0406/
DATA MCNE(80,1),MCNE(80,2)/'MCI','B9'/
DATA E(2,80),E(3,80),E(4,80),E(5,80),E(6,80),E(7,80),E(8,80)/
+ .2327,.1778,.1417,.1179,.0902,.0699,.0404/
DATA MCNE(81,1),MCNE(81,2)/'MCI','C1'/
DATA E(2,81),E(3,81),E(4,81),E(5,81),E(6,81),E(7,81),E(8,81)/
+ .2380,.1783,.1405,.1194,.0907,.0691,.0406/
DATA MCNE(82,1),MCNE(82,2)/'MCI','C2'/
DATA E(2,82),E(3,82),E(4,82),E(5,82),E(6,82),E(7,82),E(8,82)/
+ .2372,.1783,.1422,.1181,.0907,.0686,.0406/
DATA MCNE(83,1),MCNE(83,2)/'MCI','C3'/
DATA E(2,83),E(3,83),E(4,83),E(5,83),E(6,83),E(7,83),E(8,83)/
+ .2372,.1791,.1405,.1181,.0902,.0699,.0414/
DATA MCNE(84,1),MCNE(84,2)/'MCI','C4'/
DATA E(2,84),E(3,84),E(4,84),E(5,84),E(6,84),E(7,84),E(8,84)/
+ .2380,.1798,.1422,.1181,.0907,.0700,.0409/
DATA MCNE(85,1),MCNE(85,2)/'MCI','C5'/

```

```

DATA E(2,85),E(3,85),E(4,85),E(5,85),E(6,85),E(7,85),E(8,85)/
+ .2372,.1791,.1405,.1181,.0902,.0699,.0414/
DATA MCNE(86,1),MCNE(86,2)/'MCI','-C6'/
DATA E(2,86),E(3,86),E(4,86),E(5,86),E(6,86),E(7,86),E(8,86)/
+ .2372,.1783,.1422,.1181,.0907,.0686,.0406/
DATA MCNE(87,1),MCNE(87,2)/'MCI','-C7'/
DATA E(2,87),E(3,87),E(4,87),E(5,87),E(6,87),E(7,87),E(8,87)/
+ .2372,.1791,.1405,.1181,.0902,.0699,.0414/
DATA MCNE(88,1),MCNE(88,2)/'MCI','-C8'/
DATA E(2,88),E(3,88),E(4,88),E(5,88),E(6,88),E(7,88),E(8,88)/
+ .2380,.1788,.1414,.1181,.0904,.0699,.0414/
DATA MCNE(89,1),MCNE(89,2)/'ACT','-6'/
DATA E(2,89),E(3,89),E(4,89),E(5,89),E(6,89),E(7,89),E(8,89),
1 E(9,89)/
+ .1600,.1168,.0904,.0711,.0508,.0330,.0229,.0229/

```

C
C
C
C
C
C
C
C

***** CHI-SQUARE DICTIONARIES

** CRITICAL VALUES FOR P.10

```

DATA CHA /02.706,4.605,6.251,7.779,9.236,10.645,12.017
A,13.362,14.684,15.987,17.275,18.549,19.812,21.064,22.307,23.542,24
B,7.69,25.989,27.204,28.412,29.615,30.813,32.007,33.196,34.382,35.56
C,36.741,37.916,39.087,40.256,41.422,42.585,43.745,44.903,46.059,4
D,7.212,48.363,49.513,50.660,51.805,52.949,54.090,55.230,56.369,57.5
E,5,58.641,59.774,60.907/

```

C
C ** CRITICAL VALUES FOR P.05
C

```

DATA CHB /3.841,5.991,7.815,9.488,11.071,12.592,14.067,
A,15.507,16.919,18.307,19.675,21.026,22.362,23.685,24.996,26.296,27.
B,5.87,28.869,30.144,31.410,32.671,33.924,35.172,36.415,37.652,38.865
C,40.113,41.337,42.557,43.773,44.985,46.194,47.400,48.602,49.802,50
D,9.98,52.192,53.384,54.572,55.758,56.942,58.124,59.304,60.481,61.65
E,6,62.830,64.001,65.171/

```

C
C ** CRITICAL VALUES FOR P.01
C

```

DATA CHC /6.635,9.210,11.345,13.277,15.086,16.812,18.47
A,20.090,21.666,23.209,24.725,26.217,27.688,29.141,30.578,32.000,
B,33.409,34.805,36.191,37.566,38.932,40.289,41.638,42.980,44.314,45.
C,64.2,46.963,48.278,49.588,50.892,52.191,53.486,54.776,56.061,57.342
D,58.619,59.892,61.162,62.428,63.691,64.950,66.206,67.459,68.710,69
E,9.57,71.201,72.443,73.683/

```

C
C
C
C

RETURN

END


```

C      SUBROUTINE READER
C
C      ----- READS DATA -----
C
C      INCLUDE 'NEWCAS.COM'
C
C      ***** READ FIRST DATA CARD AND MATCH MACHINE NUMBER WITH DICTIONARY
C
C      READ (INU,1001,END=50,ERR=95)
C      1      MACH(1),MACH(2),METH(1),METH(2),FLO,
C      2      EXPDAT,EXPNO,TSTNO,AERSOL,SUSPNO,SPACT,STACTN
C      GO TO 95
C
C 50    CONTINUE
C      DONE = .TRUE.  !ONLY GETS HERE WHEN NO MORE DATA
C      RETURN
C
C 95    CONTINUE
C
C      FLO = FLO * 1000.
C
C ** FIND RIGHT MACHINE NUMBER
C      DO 100 I=1,100
C      IF (MACH(1).NE.MCNE(I,1).OR.MACH(2).NE.MCNE(I,2)) GO TO 100
C      JROW = I  !FOUND IT, SO SAVE IT AND EXIT LOOP
C      GO TO 200
C 100   CONTINUE
C      WRITE (LUN,1002) MACH  !ERROR: NO MATCH
C      BAD = .TRUE.
C      RETURN
C
C 200   CONTINUE
C
C ** MAKE SURE METHOD = ECD
C      IF (METH(1).EQ.'ECD'.AND.METH(2).EQ.' ') GO TO 300
C      WRITE (LUN,1003)
C      BAD = .TRUE.
C      RETURN
C
C 300   CONTINUE
C
C ***** READ SECOND DATA CARD AND MAKE SURE IE = -1 (STANDARDS)
C
C      READ (INU,1004) MAX,IE,DENS
C      IF (IE.EQ.-1) GO TO 400
C      WRITE (LUN,1005)
C      BAD = .TRUE.
C      RETURN
C
C 400   CONTINUE
C
C ***** READ DATA CARDS WHICH CONTAIN STAGE ACTIVITIES
C
C      DO 500 I=MIN,MAX
C      READ (INU,1006) II,ATMP
C      IF (II.GE. MIN .AND. II.LE. MAX) GO TO 500
C      WRITE (LUN,1007)
C      BAD = .TRUE.
C      RETURN
C 500   CONTINUE
C

```

```

      A(MAX-II+1) = ATMP      !SWITCH STAGES UPSIDE DOWN
      CONTINUE
C
C
C      RETURN
C
C
C  ----- FORMATS -----
1001 FORMAT (4A3,F5.0,6A1,6A1,18A1,12A1,6A1,6A1,6A1)
1002 FORMAT (///,5X,'NO MATCH IN DICTIONARY FOR ',2A3)
1003 FORMAT (///,5X,'NEWCAS WORKS ONLY FOR METHOD = ECD. ')
1004 FORMAT (212,F10.0)
1005 FORMAT (///,5X,'NEWCAS WORKS ONLY FOR DEFINED STANDARDS. ')
1006 FORMAT (12,F10.0)
1007 FORMAT (///,5X,'STAGE NUMBER UNREASONABLE. ')
C
C  ----- FORMATS -----
C
C
C
      END

```



```

C      SUBROUTINE JDECD
C      - - - - - CORRECTS FLOW ON MULTIPLE-HOLE MACHINES, CALCULATES ECD,
C                  AND DOES SLIP CORRECTION - - - - -
C      INCLUDE 'NEWCAS.COM'
C      ----- START LOOP FOR EACH STAGE EXCEPT THE LAST -----
C      DO 100 I=MIN,MAX-1
C          TFLO = FLO      !PUT FLOW IN TEMP STORAGE SO IT DOESN'T GET
C                          DIVIDED AT EACH STAGE
C      ***** CORRECT FLOW FOR MULTIPLE HOLES
C      ** FIRST SEVEN STAGES OF MOST ACI'S HAVE 400 HOLES
C          IF(I.NE.MAX-1.AND.((MACH(1).EQ.MCNE(6,1).AND.MACH(2).EQ.MCNE(6,2))
C      1              .OR.(MACH(1).EQ.MCNE(7,1).AND.MACH(2).EQ.MCNE(7,2))
C      2              .OR.(MACH(1).EQ.MCNE(62,1).AND.MACH(2).EQ.MCNE(62,2))
C      3              .OR.(MACH(1).EQ.MCNE(63,1).AND.MACH(2).EQ.MCNE(63,2))
C      4              .OR.(MACH(1).EQ.MCNE(64,1).AND.MACH(2).EQ.MCNE(64,2))))
C      5              TFLO = FLO/400.
C      ** FIRST SIX STAGES OF ACI-6 HAS 400 HOLES
C          IF(I.LE.MAX-3.AND.MACH(1).EQ.MCNE(89,1).AND.MACH(2).EQ.MCNE(89,2))
C      1              TFLO = FLO/400.
C      ** SEVENTH STAGE OF ACI-6 HAS 399 HOLES
C          IF(I.EQ.MAX-2.AND.MACH(1).EQ.MCNE(89,1).AND.MACH(2).EQ.MCNE(89,2))
C      1              TFLO = FLO/399.
C      ** EIGHTH STAGE OF ACI-3, ACI-4, ACI-5, AND ACI-6 HAVE 201 HOLES
C          IF(I.EQ.MAX-1.AND.((MACH(1).EQ.MCNE(62,1).AND.MACH(2).EQ.MCNE(62,2))
C      1              .OR.(MACH(1).EQ.MCNE(63,1).AND.MACH(2).EQ.MCNE(63,2))
C      2              .OR.(MACH(1).EQ.MCNE(64,1).AND.MACH(2).EQ.MCNE(64,2))
C      3              .OR.(MACH(1).EQ.MCNE(89,1).AND.MACH(2).EQ.MCNE(89,2))))
C      4              TFLO = FLO/201.
C      ** EIGHTH STAGE OF ACI-1 AND ACI-2 HAVE 215 HOLES
C          IF(I.EQ.MAX-1.AND.((MACH(1).EQ.MCNE(6,1).AND.MACH(2).EQ.MCNE(6,2))
C      1              .OR.(MACH(1).EQ.MCNE(7,1).AND.MACH(2).EQ.MCNE(7,2))))
C      2              TFLO = FLO/215.
C      ***** CALCULATE ECD FOR THIS STAGE
C          TDI = SQRT(E(I+1,JROW)**3./TFLO) * 1260.
C      ***** DO SLIP CORRECTION
C          CALL CALCDI (TDI,DI)
C      ***** STORE CORRECTED ECD (JPSIDE DOWN)
C          ECD(MAX-I) = DI
C      100 CONTINUE      !NEXT STAGE
C      ----- BOTTOM OF LOOP -----
C          ECD(MAX) = 0.0      ! LAST STAGE IS ALWAYS ZERO
C      RETURN
C      END

```

```

      SUBROUTINE CALCDI(TDI,DI)
C
C
C - - - - CALLED BY JDECD TO CALCULATE NEW ECD WITH SLIP CORRECTION - - - -
C
      A1 = 1
      I = 13
      X = 2**I
C
C
C * * * * * ITERATES THROUGH 50 MAXIMUM OF 13 TIMES
C * * * * * RETURNS EITHER AFTER MAXIMUM ITERATIONS
C
C
C
50    CONTINUE
      I = I - 1
      IF (I .LT. -1) RETURN
      DI = X / 1000.0
      B = 74.93 * DI
      A2 = 12.64 / B
      A3 = (4.02/3) * EXP(-.1095*B)
      C = A1 + A2 + A3
      Y = SQRT(C) * DI
      Q = Y - TDI
      IF (ABS(Q) .LT. .00001) RETURN
      IF (Q .GT. 0) X = X - 2**I
      IF (Q .LT. 0) X = X + 2**I
      GO TO 50
C
C
      END

```

```

C      SUBROUTINE REGRES
C
C      - - - - - DOES WEIGHTED LINEAR REGRESSION - - - - -
C      X = ALOG (ECD)
C      Y = T-VALUE OF CUM. % OF STAGE ACTIVITIES
C
C      INCLUDE 'NEWCAS.COM'
C
C      ***** SET SUMS BACK TO ZERO
C
C      SW = 0.0
C      SWX = 0.0
C      SWY = 0.0
C      SWXY = 0.0
C      SWX2 = 0.0
C
C      DO 10 I = MIN,MAX-1
C      TA(I) = 0.0
C      ELOG(I) = 0.0
C      CONTINUE
10
C
C      ***** GET WEIGHT AND T-VALUE FOR EACH STAGE AND DO NECESSARY SUMS
C
C      DO 100 I = MIN,MAX-1
C
C      CALL WTVAL (CPA(I),TOTTA,TA(I),W)
C      W = AMAX1 (W, 0.1E-6)
C
C      ELOG(I) = ALOG(ECD(I))
C      ELOG10(I) = ALOG10(ECD(I))
C
C      SW = SW + W
C      SWX = SWX + W * ELOG(I)
C      SWY = SWY + W * TA(I)
C      SWXY = SWXY + W * ELOG(I) * TA(I)
C      SWX2 = SWX2 + W * ELOG(I)**2
C
C      100 CONTINUE
C
C      ***** CALCULATE COEFFICIENTS (Y = B0 + B1*X)
C
C      YBAR = SWY / SW
C      B1 = (SWXY - SWX*SWY/SW) / (SWX2 - SWX**2/SW)
C      B0 = YBAR - B1 * SWX/SW
C
C      ***** CALCULATE EXPECTED Y'S (T-VALUES OF CUM. % ACTIVITIES)
C
C      DO 200 I=MIN,MAX-1
C      ETA(I) = B0 + B1 * ELOG(I)
C      CONTINUE
200
C
C      RETURN
C
C      END

```

```

C      SUBROUTINE WTVAL(XCPA,XIUTA,XTA,XW)
C
C      - - - - - COMPUTES T-VALUES AND WEIGHTS FOR WEIGHTED LINEAR REGRESSION
C
C      ** CALCULATE T-VALUE
C      IF (XCPA .GE. 99.9999) XCPA = 99.9999
C      IF (XCPA .LE. 0.00001) XCPA = 0.00001
C
C      CPFRAC = XCPA/100.0
C
C      IF (CPFRAC .GT. 0.5) SIGN = 1.
C      IF (CPFRAC .LT. 0.5) SIGN = -1.
C      IF (CPFRAC .LT. 0.5) CPFRAC = 1.0 - CPFRAC
C      IF (CPFRAC .NE. 0.5) XTA = SIGN * 1.4142 * ROOTER(CPFRAC,2.0,0.01)
C      IF (CPFRAC .EQ. 0.5) XTA = 0.0
C
C      ** CALCULATE WEIGHT
C
C      THIS WEIGHT (W = Z**2 * N / (P*Q) IS CALLED THE COMBINED
C      MOELLER-URBAN WEIGHT OF THE ERROR IN T.
C
C      REFERENCES:
C
C      MUELLER,G.E.  ZUR GRUNDLEGUNG DER PSYCHOPHYSIK.  BERLIN, 1878.
C
C      URBAN,F.M.  ARCH. GES. PSYCHOL.  VOL. 16, P.168.  1910.
C      ESPECIALLY PP.181-182.
C
C      ZZ = EXP(-XTA**2/2.0) / 2.50663
C      XW = ZZ**2 * XIUTA / (CPFRAC * (1.0-CPFRAC))
C
C      RETURN
C
C      END
C
C      = = = = =
C
C      FUNCTION ROOTER (CPFRAC, X, DX)
C
C      THIS ROUTINE FINDS A ZERO OF THE FUNCTION F IN A NEIGHBORHOOD OF X.
C      IF NO CHANGE OF SIGN IS FOUND FOR F IN 200 STEPS OF DX,
C      A RETURN IS EXECUTED.  IF A ROOT IS LOCATED, IT IS RETURNED
C      AS X.
C      DX MAY BE EITHER POSITIVE OR NEGATIVE, BUT NOT ZERO.
C      (THIS IS A MODIFIED VERSION OF SOUSA.)
C
C      ** THIS IS THE FUNCTION USED BY NEWCAS
C      FCTN(X) = 0.5 * ERFCTN(X,EXP(-X**2)) + 0.5 - CPFRAC

```

```

C      DEL=DX
      Y=X
      I=0
      K=0
      A=Y
      FA = FCTN(A)
C      DEFINE LIMITS OF INTERVAL CONTAINING ZERO.
1     B=A+DEL
      FB = FCTN(B)
      IF (FA) 3,2,10
2     Y=A
      GO TO 22
3     IF (FB) 5,4,13
4     Y=B
      GO TO 22
5     IF (FA-FB) 6,7,8
6     FA=FB
7     A=B
      GO TO 9
C      ABOUT FACE
8     DEL=-DEL
C      MAKE A COUNT OF NUMBER OF ABOUT FACES. A LOOP IS POSSIBLE IF F
C      HAS A LOCAL MAXIMUM OR MINIMUM WITH NO ROOT.
      K=K+1
      IF (K-5) 9,23,23
C      COUNT NUMBER OF STEPS TAKEN
9     I=I+1
      IF (I .LE. 200) GO TO 1
      GO TO 22
C
10    IF (FB) 12,4,11
11    IF (FA-FB) 8,7,6
C      CASE I (B-A)*DEL IS NEGATIVE
12    ASSIGN 16 TO KASE
      GO TO 14
C      CASE II (B-A)*DEL IS POSITIVE
13    ASSIGN 18 TO KASE
C      CONVERGING MARCH BEGAN
C      DOUBLE TIME
14    DEL=DEL/2.
      Y=A+DEL
      IF (ABS(DEL/Y) -.5E-7) 19,19,15
15    CONTINUE
      FY = FCTN(Y)
      GO TO KASE, (16,18)
C      CASE I (B-A)*DEL IS NEGATIVE
16    IF (FY) 14,22,17
17    A=Y
      GO TO 14
C      CASE II (B-A)*DEL IS POSITIVE
18    IF (FY) 17,22,14
C      IF Y=0. WE REQUIRE DEL TO BE ZERO FOR A ROOT TO BE ASSUMED THERE.
19    CONTINUE
      IF (Y .NE. 0.0) GO TO 22
      IF (DEL .NE. 0.0) GO TO 14
      GO TO 22
C
C * * * * * MORE THAN 5 ABOUT FACES
23    K=0
      DEL=DEL/2.
      IF (ABS(DEL/(AMAX1(ABS(A),ABS(B)))) -.5E-7) 24,24,9
24    Y=(A+B)/2.
22    CONTINUE

```



```

C      SUBROUTINE OTHER
C      - - - - - DOES OTHER CALCULATIONS FOR FIRST PAGE - - - - -
C      INCLUDING CHI-SQUARES AND AMAD
C      INCLUDE 'NEWCAS.COM'
C
C      ***** CALCULATE % INTERVAL ACTIVITIES -- OBSERVED AND PREDICTED
C      AND CHI-SQUARES
C
C      CPREV = 0.0
C      CSTOT = 0.0
C
C      DO 100 I=MIN,MAX
C
C      ** ECA = PRED.CUM.ACT.      ETA = PRED. T-VALUE
C      IF (I .NE. MAX) ECA(I) = TOTA * RNORM(ETA(I))
C      IF (I .EQ. MAX) ECA(I) = TOTA
C
C      IF (I .NE. 1) CPREV = ECA(I-1)
C      PNT(I) = ECA(I) - CPREV      ! PREDICTED INTERVAL ACTIVITY
C      PCONT(I) = A(I)/TOTA * 100.    ! % OBS. INT. ACT.
C      PCPNT(I) = PNT(I)/TOTA * 100.  ! % PRED. INT. ACT.
C
C      CHS(I) = (A(I) - PNT(I))**2./PNT(I) * 100./TOTA
C      CSTOT = CSTOT + CHS(I)
C
C 100    CONTINUE
C
C      ***** GET CRITICAL VALUES OF CHI-SQUARE
C
C      NDOF = MAX -3
C      CSP10 = CHA(NDOF)
C      CSP05 = CHB(NDOF)
C      CSP01 = CHC(NDOF)
C
C      ***** CALCULATE ACTIVITY/MASS MEDIAN AERODYNAMIC DIAMETER
C
C      GMEAN = EXP(-B0/B1)
C
C      ***** CALCULATE GEOMETRIC STANDARD DEVIATION
C
C      GSD = EXP(1./B1)
C
C      ***** CALCULATE MASS MEDIAN DIAMETER AND COUNT MEAN DIAMETER
C      IF DENSITY IS GREATER THAN .00001
C
C      IF (DENS .LT. .00001) GO TO 200
C      MMD = GMEAN / SQRT(DENS)
C      CMD = 10.** (ALOG10(MMD) - 6.9078*(ALOG10(GSD))**2.)
C
C 200    CONTINUE
C
C      RETURN
C
C      END

```

```

C      FUNCTION RNORM(X)
C
C      - - - - - COMPUTES A RATIONAL FUNCTION APPROXIMATION TO THE NORMAL DIST.
C
C      DIMENSION A(7)
C      DATA A / .430638E-4, .2765672E-3, .1520143E-3, .92705272E-2,
C      +.422820123E-1, .705230784E-1, 1.0/
C
C      Y = ABS(X) / 1.41421356
C      RNORM = 0.0
C      DO 1 I=1,7
C          RNORM = RNORM * Y + A(I)
1      CONTINUE
C      RNORM = .5 * (((((1.0/RNORM)**2)**2)**2)**2)
2      IF (X .GT. 0.0) RNORM = 1.0 - RNORM
C
C      RETURN
C
3      RNORM = 0.0
C      GO TO 2
C
C      END

```



```

SUBROUTINE WRITER
C
C
C - - - - - WRITES PAGES ONE AND TWO - - - - -
C
C INCLUDE 'NEWCAS.COM'
C
C * * * * * WRITE1 * * * * *
C
C ENTRY WRITE1
C ** PRINT PRELIMINARY RESULTS
C
C WRITE (LUN,1001) TODAY,EXPNO,MACH,TSTNO,FLO/1000.,AERSOL,
1 SUSPNO,METH,SPACT,EXPDAT,DENS
C
C ** PRINT COLUMN HEADINGS
C
C WRITE (LUN,1002) STACTN
C
C ** PRINT COLUMNS
C
C DO 100 I=MIN,MAX
C WRITE (LUN,1003) IST(I),A(I),CA(I),CPA(I),ECD(I),
1 PCONT(I),PCPNT(1),CHS(I)
100 CONTINUE
C WRITE (LUN,1004) TOTA
C
C ** PRINT REST OF FIRST PAGE: AMAD, CHI-SQUARE RESULTS, ETC.
C
C WRITE (LUN,1005) GMEAN,GSD
C IF (DENS.LT..00001) GO TO 200
C WRITE (LUN,1006) MMD,CMD
C WRITE (LUN,1007) CSTOT,NDOF,CSP10,CSP05,CSP01
C WRITE (LUN,1008)
200 CONTINUE
C
C RETURN
C
C * * * * * WRITE 2 * * * * *
C
C ENTRY WRITE2
C
C WRITE (LUN,2001) DM, DBAR, DS, DBARS, DV, DBARV
C WRITE (LUN,2002)
C
C RETURN
C
C * * * * * WRITE 3 * * * * *
C
C ENTRY WRITE3
C
C WRITE (LUN,3001) AG, EG, XK, ZK
C
C RETURN
C
C
C
C

```

```

C
C - - - - - FORMAT STATEMENTS - - - - -
C
1001 FORMAT (1H1,
1      T8, 'DATE = ',10A1,T28, 'EXPERIMENT = ',6A1/
2      T15,10(' '),T41,6(' ')//
3      T2, 'INSTRUMENT = ',2A3,T34, 'TEST = ',18A1/
4      T15,6(' '),T41,18(' ')//
5      T3, 'FLOW RATE = ',F6.3, ' L/MIN',T31, 'AEROSOL = ',12A1/
7      T3, 'STANDARDS = ', 'CALCULATED',T28, 'SUSPENSION = ',6A1/
8      T15,10(' '),T41,6(' ')//
9      T6, 'METHOD = ',2A3,T30, 'SP. ACT. = ',6A1, ' UG/ML'/
1     T15,6(' '),T41,6(' ')//
2     T3, 'EXP. DATE = ',2A1, '/',2A1, '/',2A1,T31, 'DENSITY = ',
3         F6.3, ' G/CM**3'//
4     T15,8(' '),T41,6(' ')//)
C
1002 FORMAT (T2, 'STAGE',T11, 'STAGE',T20, 'CUMULATIVE',T35, 'CUMULATIVE',
1     T50, 'STANDARD',T62, 'PERCENT INTERVAL ACTIVITY',T93, 'CHI-'/
2     T3, 'NO.',T10, 'ACTIVITY',T20, 'ACTIVITY ON',T37, 'PERCENT',
3     T51, 'P(0.5)',T92, 'SQUARE'//
4     T10, 'UCI*',6A1, ' STAGE UCI',T36, 'LESS THAN',
5     T52, 'UM',T63, 'OBSERVED',T77, 'PREDICTED'//
6     T2,5(' '),T10,8(' '),T20,11(' '),T35,11(' '),
7     T50,8(' '),T62,11(' '),T76,11(' '),T91,8(' ')//)
C
1003 FORMAT (T2,I3,F13.4,F13.4,F14.4,F12.2,3F14.4)
C
1004 FORMAT (' TOTAL:',T21,F10.4)
C
1005 FORMAT (('/' ACTIVITY/MASS MEDIAN AERODYNAMIC DIAMETER',
1     T49, '=',F10.3/
2     ' GEOMETRIC STANDARD DEVIATION',T49, '=',F10.3)
C
1006 FORMAT (' MASS MEDIAN DIAMETER',T49, '=',F10.3, ' UM'/
1     ' COUNT MEDIAN DIAMETER (FOR LOG NORMAL DISTR.',
2     T49, '=',F10.3, ' UM')
1007 FORMAT (' SUM OF CHI-SQUARES',T49, '=',F10.3/
1     ' NO. OF DEGREES OF FREEDOM',T49, '=',I10/
2     '$ CRITICAL VALUES FOR CHI-SQUARE DISTRIBUTION',
3     T49, '=',F10.3, '(P=.10)',F10.3, '(P=.05)',F10.3, '(P=.01)')
C
1008 FORMAT ('/T4, 'IF SUM OF CHI-SQUARES EXCEEDS CRITICAL VALUE FOR LEVE
1L OF SIGNIFICANCE SELECTED, REJECT AT THAT'/T4, 'SIGNIFICANCE LEVE
2L THE NULL HYPOTHESIS THAT THE DISTRIBUTION IS LOG NORMAL.')
C
2001      FORMAT (1H1//' MODE OF THE DISTRIBUTION',T53, '=',F10.4/
1      ' ARITHMETIC MEAN OF THE DISTRIBUTION',T53, '=',F10.4/
2      ' MEDIAN OF THE SURFACE AREA DISTRIBUTION',T53, '=',F10.4/
3      ' ARITHMETIC MEAN OF THE SURFACE AREA DISTRIBUTION',T53, '=',
4      4F10.4/
5      ' MEDIAN OF THE VOLUME DISTRIBUTION',T53, '=',F10.4/
6      ' ARITHMETIC MEAN OF THE VOLUME DISTRIBUTION',T53, '=',F10.4)
C
2002 FORMAT (('/T20, '---PREDICTED PERCENT---'/
1      ' CLASS INTERVALS', T33, 'CUMULATIVE', T20, 'INTERVAL'/
2      2T2, 41(' ') )
C
3001 FORMAT (T3,F5.2, ' - ', F5.2, T18,2F12.4)
C
C - - - - - FORMAT STATEMENTS - - - - -
C
      END

```

```

C      SUBROUTINE SECOND
C      ----- SECOND PAGE OF OUTPUT -----
C
C      INCLUDE 'NEWCAS.COM'
C      -----
C      ADDITIONS FOR BUSCHBOM/CATALDO, SEPT. 1976
C      MODIFICATIONS MADE BY MATTLAND LEE
C      SECOND PAGE OF OUTPUT:
C      MODE OF DISTRIBUTION
C      ARITHMETIC MEAN OF THE DISTRIBUTION
C      MEDIAN OF THE SURFACE AREA DISTRIBUTION
C      ARITHMETIC MEAN OF THE SURFACE AREA DISTRIBUTION
C      MEDIAN OF THE VOLUME DISTRIBUTION
C      ARITHMETIC MEAN OF THE VOLUME DISTRIBUTION
C
C      ALCMD=ALOG(CMD)
C      ALGSD=(ALOG(GSD))**2
C      DM=ALCMD - ALGSD
C      DM=EXP(DM)
C      DEAR=ALCMD + 0.5 * ALGSD
C      DEAR=EXP(DEAR)
C      DS=ALCMD + 2.0 * ALGSD
C      DS=EXP(DS)
C      DEARS=ALCMD + ALGSD
C      DEARS=EXP(DEARS)
C      DV=ALCMD + 3.0 * ALGSD
C      DEARV=ALCMD + 1.5 * ALGSD
C      DEARV=EXP(DEARV)
C      DV=EXP(DV)
C
C      CALL WRITE2
C
C      AG=0.0
C      BG=0.0
C      XK=0.0
C      IHUND = 0
C      DO 400 IM=1,40
C      IF (IHUND .EQ. 1 ) GO TO 400
C      BG=BG+0.25
C      AG=BG-0.25
C      ZK=(ALOG(BG) - ALCMD) / ALGSD
C      ZK=RNORM(ZK) * 100.
C      XK=ZK - XK
C      IF (ZK .GE.100.0) IHUND = 1
C
C      CALL WRITE3
C
C      XK=ZK
C      400      CONTINUE
C      -----
C      RETURN
C      END

```

```

C      SUBROUTINE GRAPH
C
C      - - - - - PLOTS ECD VS. % CUM. ACTIVITY - - - - -
C
C      INCLUDE 'NEWCAS.COM'
C
C      BYTE SQUARE(57,57)
C
C      DO 200 I=1,57
C          DO 100 J=1,57
C              SQUARE(I,J) = ' '
C          CONTINUE
C      CONTINUE
C
C      ** PUT P'S, O'S, AND *'S IN THE RIGHT SQUARES OF THE GRAPH
C
C      DO 300 I=MIN,MAX-1
C          IY = NINT(28. * (ELG10(I)+1.) + 1.)
C          IX1 = NINT(7. * (ETA(I) + 4.) + 1.)
C          IX2 = NINT(7. * (TA(I) + 4.) + 1.)
C          IF (IY .GT. 57 .OR. IY .LT. 1
C              .OR. IX1 .GT. 57 .OR. IX1 .LT. 1)
C              GO TO 260
C          SQUARE(IY,IX1) = 'P'
C      260 IF (IY .GT. 57 .OR. IY .LT. 1
C              .OR. IX2 .GT. 57 .OR. IX2 .LT. 1)
C              GO TO 300
C          IF (SQUARE(IY,IX2) .EQ. ' ') SQUARE(IY,IX2) = 'O'
C          IF (SQUARE(IY,IX2) .EQ. 'P') SQUARE(IY,IX2) = '*'
C      300 CONTINUE
C
C      ** PRINT Y-AXIS AND GRAPH
C
C      WRITE (LUN,80)
C
C      DO 500 I=57,1,-1
C          DO 400 J=1,57 !DON'T PRINT BLANK LINES (FOR TERMINAL OUTPUT)
C              IF (SQUARE(I,J) .NE. ' ') GO TO 450
C          CONTINUE
C      400 IF ((I-1)/7 .EQ. FLOAT(I-1)/7.) WRITE (LUN,881)
C          IF ((I-1)/7 .NE. FLOAT(I-1)/7.) WRITE (LUN,882)
C          GO TO 470
C
C      450 IF ((I-1)/7 .EQ. FLOAT(I-1)/7.)
C          1 WRITE (LUN,81) (SQUARE(I,J),J=1,57)
C          IF ((I-1)/7 .NE. FLOAT(I-1)/7.)
C          1 WRITE (LUN,82) (SQUARE(I,J),J=1,57)
C
C      ** WRITE Y-AXIS LABELS
C
C      470 IF (I .EQ. 57) WRITE (LUN,57)
C          IF (I .EQ. 50) WRITE (LUN,50)
C          IF (I .EQ. 43) WRITE (LUN,43)
C          IF (I .EQ. 36) WRITE (LUN,36)
C          IF (I .EQ. 29) WRITE (LUN,29)
C          IF (I .EQ. 22) WRITE (LUN,22)
C          IF (I .EQ. 15) WRITE (LUN,15)

```


APPENDIX D
TRANSPARENT LOG-NORMAL
PLOT OVERLAY

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