APPENDIX C

Appendix C

CARB_IMP

UW CASCADE IMPACTOR DATA REDUCTION SYSTEM for IBM and Compatible PC's (Program Documentation)

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CONTENTS

General Overview of The Cascade Impactor Data Reduction System (CARB_IMP)

Although it is possible to reduce data obtained from cascade impactors by hand or with calculators, the number of calculations which must be done to treat the data from just one impactor run make hand calculations impractically laborious. When the treatment of data from multiple runs is considered it becomes obvious that a computer is required. In March 1978 a system of programs known by the acronym "CIDRS" (for Cascade Impactor Data Reduction System) was published for this purpose by the U.S. EPA. CIDRS was written in Fortran for use on large "main-frame" computers and has been adapted since for use on some mini and micro computers. Denver Research Institute released an adaptation of CIDRS written in BASIC for the TRS-80 micro-computer in March 1980. An updated and expanded version of CIDRS, pcCIDRS, for IBM PC compatible microcomputers was released in 1992. The programs which make up the pcCIDRS system were first written in BASIC for the Apple II micro-computer series and were released for that computer in 1983 as "APPLE CIDRS". Versions of the Apple II programs were provided to the ARB in May, 1986 as part of the "Procedures Manual for the Recommended ARB Particle Size Distribution Method (Cascade Impactors)". The IBM PC version, pcCIDRS, was first offered in January 1992. pcCIDRS includes the capability of reducing data from any of the commercially available cascade impactors together with the EPA/SRI series cyclone sampling train and the PM_{10} cyclone. The system described here, CARB_IMP, is an adaptation of pcCIDRS. This adaptation was developed specifically as a means of reducing data obtained with modifications of California ARB Method 501 for sampling high temperature sources and wet sources. The adaptations are based on the use of the University of Washington (Pilat) Mark V impactor and the programs can be used for reducing data from any variant of that impactor under most conceivable sampling circumstances. The Pilat impactor was recommended for ARB use in measuring particle size distributions.

The CARB_IMP package consists of a series of programs which together provide the capabilities to:

1. Generate files containing hardware specifics of UW V impactor configurations used in sampling for later use in reducing particle sizing data.

2. Reduce the data from individual impactor runs and generate size distribution information from that data at a set of standard conditions for a standardized array of particle sizes.

3. Combine and appropriately average the results from multiple sample runs obtained at a single source.

4. Calculate the fractional efficiencies of control devices from samples obtained at the control device inlets and outlets.

5. Plot the size distributions and fractional efficiencies obtained above. The plotting capabilities are provided through the use of templates for any one of several spreadsheet programs. (eg Lotus 123 and Quatro Pro.)

In addition, a program is provided for use in selecting jet plates to use for particular sampling circumstances. The latter also aids in selecting sampling flow rates and nozzle sizes, and can provide the orifice meter pressure differentials needed to sample at the selected flow rate. It can also be used to select nozzles and sampling rates for carrying out PM_{10} sampling.

Distribution Disk Contents and Installation of Programs

CARB_IMP is written to be used with an IBM compatible microcomputer operating under DOS. CARB_IMP is supplied on one disk and is intended to be installed on and run from hard drive, C, D, or E. The entire installed system requires about 1 Mbyte of disk space. The disk is copyable and it is recommended that the original be write protected and preserved as master copy and duplicates be used as working copies. The system is installed by placing the CARB_IMP distribution disk into an appropriate floppy drive and entering "install <drive designation>" where <drive designation> is c, d, or e as appropriate for the target hard drive. INSTALL.BAT will then create the CARB_IMP main directory and subdirectories and then copy the program and data files to them.

Printed output from all programs is directed to LPT1.

Briefly, the programs and files on the CARB_IMP disks are as follow:

EFF - Program to calculate particle control device efficiencies vs. particle size from inlet and outlet impactor data sets.

CARBPRGX - Main cascade impactor data reduction program. Uses hardware information for the impactor configuration used in sampling, stage catch weights, and impactor operating conditions to calculate particle size distribution information.

CARBD50X - Program for calculating stage D_{50}'s at different operating conditions. It allows the user to explore various options such as precollector usage, nozzle diameter, and jet plate selection prior to sampling at a new source. It can also provide the required flow rate for PM_{10} sampling with the EPA PM_{10} cyclone and the metering orifice pressure differential (dH) for sampling at isokinetic or any user selected flow rate including the PM_{10} rate.

MPPRNT10 - Print module used by other programs for producing printed output of results.

BRT70??R - Modules used by other programs in CARB_IMP. These are required forthe system to operate.

STATIS - Program for simple averaging of data from multiple particle sizing runs. Can make corrections for isokinetic sampling errors and can exclude outliers from averages.

SYNTRAV - Program for synthesizing a complete particle sizing traverse of a duct from several partial traverses. Intended for use where significant velocity and particulate stratification would make data from a single point sample or a traverse of a duct during a single impactor run questionable as to being representative. The program also includes provisions to allow corrections to be made for nonisokinetic sampling.

\RESULTS\ Files of reduced results for import into spreadsheets for plotting, for synthesizing a traverse with SYNTRAV, or for averaging by STATIS. ".IT" indicates inlet run and ".OT" indicates outlet run. A "T" in the third position of the extension indicates that the file is a text file formatted like the printed results from the programs. The latter provides a simple way to edit the printed results for reports.

\RUNDATA\ Files of raw data from impactor and cyclone runs for reanalysis at a later time. These also provide a simple way of recalling information which is common to several runs to avoid re-entry of repetitive information. ".IT" indicates an inlet run and ".OT" indicates an outlet run.

UWVGENER- File containing the hardware specific information for the UW (PILAT) Mark V impactor with all stages (Inlet, jet plates 2-13) plus the SRI/EPA RAPC, the PM_{10} cyclone, the ARB High Temperature Precollector, the ARB Liquid Droplet Precollector, the Andersen High Capacity Preseparator, and Method 5 nozzles. The file contains the specific hardware information on the number and sizes of the jets on each stage, calibration values of $\sqrt{\Psi_{50}}$ for each stage, and the jet to plate spacing for each stage. The information in this file is used by CARBPRGX and CARBD50X for calculating the stage D^{50}'s.

XPOINTS- File containing an array of standard diameters. A spline fit is used to generate interpolated or extrapolated values at these diameters for later use in the averaging and efficiency calculation programs.

New impactor operating stage setups can be constructed by selecting the appropriate stages, including precollector, if any, from the generic file described above. Provision is made for this selection process in both the CARBPRGX program and the CARBD50X program. Setups to be used repeatedly can be saved on disk for future use at any time.

\SHEETS\ Spreadsheet templates for various purposes.

INBLANK - Meth 5 field data averaging (meter temp., SQRT(pitot DP), orifice DH, etc) for 27 point traverse.

OUTBLANK- Meth 5 field data averaging (meter temp., SQRT(pitot DP), orifice DH, etc) for 24 point traverse.

IMPOP- Impactor metering orifice DH, flowrate, and nozzle setup.

MTOP- Generates printed version of orifice DH versus pitot DP table for use in Method 5/17 type sampling. Performs all nomograph calculations and prints sheet to use instead of nomograph when sampling.

MTRED- M5/17 data analysis

RUNTIME - time to collect given sample catch weight given particulate concentration and sampler flow rate.

VTPOINT - Calculates distances from the nozzle at which to mark a probe for traverse points.

VTRED - velocity traverse data reduction

WATER - Meth 4 (moisture) data analysis

AVERAGE.W?? Templates into which results from STATIS (".AVG) files can be imported for plotting in selected formats. WR1 for Symphony, WK1 for 123 V2, WK3 for 123 V3, and WQ1 for Quatro Pro.

CIDRS.W?? Templates into which reduced data from CARBPRGX results files can be imported for plotting in selected formats. WR1 for Symphony, WK1 for 123 V2, WK3 for 123 V3, and WQ1 for Quatro Pro.

Descriptions of Key Programs

Stage Size Cuts and Single Run Analysis

CARBPRGX is the main program of the system. It accepts and reduces the raw data from single impactor runs. The program calculates impactor stage D50's, particle concentrations for each stage, provides some information for quality control and data validation, calculates log-normal distribution parameters based on a least squares best fit to measured size distribution, and generates size distribution information for a set of standardized particle sizes through spline fit and interpolation/extrapolation procedures. Raw data may be saved on disk for subsequent reuse and the final results can also be saved for plotting or to be combined with data from other runs.

CARBD50X provides a means of checking out the expected performance of an impactor configuration and playing "what if" games. It allows the user to calculate stage D50s for different sampling flow rates, gas conditions, and impactor stage geometries (no. of jets, jet diameters), etc. The selection of precollectors and jet plates can be changed within the program so the user can determine what effect changing out a stage of the impactor will have. The program operation follows that of CARBPRGX very closely except omitting the entry of stage weights. Old data sets can be retrieved to be used as starting points in CARBD50X and setup files can be written by CARBD50X for subsequent use in analyzing data.

Programs pertaining to combining data from multiple runs are:

STATIS - A program for averaging data from multiple runs made under similar conditions. Simple averages of the differential forms of distributions are made with tests for (and rejection of outliers) being made at the user's option. The average differential distribution is then integrated to obtain the average distribution in the cumulative forms. Standard deviations and 90% confidence limits are calculated for all forms of the distribution. Provision is also made for correcting the data for errors arising from anisokinetic sampling if the user so desires. The results can be written to disk for later plotting and for use in calculating fractional efficiencies of control devices.

SYNTRAV - Similar to STATIS, but performs velocity weighted averaging for properly combining results obtained in ducts having skewed (or non-uniform) velocity distributions.

EFF - Calculates the fractional efficiencies of control devices from control device inlet and outlet data sets. The inlet and outlet data can be from single runs or averaged results from STATIS or SYNTRAV. If both the inlet and outlet data sets are averaged results, confidence limits for the resulting efficiencies are also calculated.

Plotting of Size Distribution Results

Only screen plotting capabilities are included in the system with provision for importing results into spreadsheets for producing graphics hardcopy. Templates with predefined graphics forms for differential, cumulative concentration, cumulative percentage, and log-probability graph formats are provided for most popular spreadsheets. The data to be plotted are imported into the templates as ASCII text files from the \CARB_IMP\RESULTS\ subdirectory with the starting location at cell B1. The Graphics, Name, Use, series of commands for the spreadsheet program will then permit the user to select any one of several preformatted graphical display forms. The spreadsheet's graphical hardcopy function can then be used to generate printed versions of the graphs.

Recommended Reading

Details on the experimental and theoretical foundations on which particle sizing with impactors is based may be found in "Procedures Manual for the Recommended ARB Particle Size Distribution Method (Cascade Impactors). The latter document was written by SRI for the California Air Resources Board in 1986 and is available through NTIS as publication PB 86-218666. Detailed instructions for successful sampling for particle size are provided in the manual. It also includes discussions of problem areas which might compromise the results obtained with impactors and offers some guidance as to how to avoid them. A similar document for series cyclones is available as NTIS publication PB 86-218674. The ARB method for particle size distribution measurement is given in ARB Methods 501, 501a, and 501b.

Operating Instructions for Programs

CARB_IMP.EXE

CARB_IMP.EXE is a program which provides simple selection of the programs in the CARB_IMP system. From DOS type:

```
cd carb_imp <Enter>      (change to directory with the programs)
carb_imp <Enter>         (start menu program)
```

Program Operation

When run, the monitor screen will show MAIN MENU and list descriptors of both the primary program CARBPRGX and the auxiliary programs from which the program to be run can be selected, as shown below:

```
                CARB_IMP Main Menu


Make Program Selection from List below:

1  Impactor D50 Exploration, Define Impactor Configuration,
   and Impactor Flow/Nozzle Selection and Meter Setup

2  Impactor Run Data Analysis

3  Average Data from Selected Runs

4  Synthesize a Complete Isokinetic Traverse from Multiple Runs

5  Calculate Control Device Fractional Efficiencies from Inlet/Outlet Runs


  Enter Selection Number: (0 to Exit)?
```

Figure 1. CARB_IMP (Main Menu)

The user should type a selection of a number 0 through 5 and then press the Enter. This will bring up the selected program. All of the above programs can also be run by simply entering the program name from the DOS prompt. All programs return the user to DOS when exited.

Program Options

1. CARBD50X provides a means of checking out the expected performance of an impactor configuration and playing "what if" games. It allows the user to calculate stage D50s for different sampling flow rates, gas conditions, and impactor stage geometries (no. of jets, jet diameters), etc. The selection of

jet plates included in the impactor setup can be changed within the program so the user can determine what effect changing out a stage of the impactor will have. The program operation follows that of CARBPRGX very closely, omitting the entry of stage weights and adding velocity calculation from pitot data. Old data sets can be retrieved to be used as starting points in CARBD50X and the setups generated in the program can be saved as dummy data files to be used as starting points for data analysis after completing a sampling expedition.

Flow rates are calculated from gas meter volumes and sampling time if both are available. If the meter volume or sampling duration aren't supplied the program will attempt to calculate the flow rate from the orifice meter calibration constant and orifice meter pressure differential. If a flow rate cannot be calculated in either of these two ways, the user will be asked to enter a flow rate directly. If the user simply presses <Enter> when prompted for direct flow rate entry, the program will use the velocity (either from direct entry or calculated from the pitot velocity pressure), and the nozzle size to calculate the isokinetic rate for the nozzle. Alternatively, if the inlet stage is identified as the PM_{10} cyclone, the program will calculate the required sampling rate, based on the gas conditions, to obtain a $10\mu m$ diameter cut. If a metering orifice dH@ was provided by the user, the program will calculate the required orifice dH to obtain the selected flow rate. This can be useful when planning a field sampling program or in setting up to sample.

2. CARBPRGX is the primary data reduction program and will be discussed in detail later.

3. STATIS averages the particle size data from two or more runs. It provides output on cumulative percent, cumulative concentration, and dM/dLogD bases with 90% confidence limits. Runs to average are selected by CARBPRGX test and run numbers. Mixing of "inlet" and "outlet" impactor runs is not permitted. The dM/dLogD values at each particle diameter are averaged and these averaged dM/dLogD values are integrated to provide averages of the cumulative mass concentration and of the cumulative percent less than size distributions. Hardcopy output of the calculated results and disk storage for access by "DATAPLOT" are available as options. Provision is also made for correcting for anisokinetic sampling errors.

4. SYNTRAV is a modification of STATIS which calculates velocity weighted averages rather than simple averages as are done by STATIS. If samples are taken at locations having very different gas velocities, the weighted averages provided by SYNTRAV will more nearly represent the true emission.

5. EFF calculates the fractional particle collection efficiency of control devices from the cascade impactor data taken at the inlet to and the outlet of a control device. The impactor data can come from single runs (CARBPRGX) or from averages of multiple runs (STATIS or SYNTRAV).

With the MAIN MENU program showing on the screen monitor, you will need to select the number that corresponds to program you wish to run and type it in.

CARBPRGX

CARBPRGX is the heart of the entire system and is the longest and most complex program in CARB_IMP. The required inputs are the impactor stage configuration, stage weights from the impactor run, blank corrections to be applied to the stage weights, sampling information regarding the gas volume sampled, the sampling duration, pressures and temperatures at the gas meter, flue gas, and impactor conditions, the particle density to be used if D_{50}'s are to be calculated on a physical (Stokes) diameter basis, the flue gas composition and moisture content, the diameter of the sampling nozzle, and the flue gas velocity.

Options available to the user include:

1) Choice of the diameter basis to be used in the data presentation--Stokes (physical), Classical Aerodynamic, and Impaction Aerodynamic. (The Impaction Aerodynamic diameter basis is seldom used.)

2) Choice of using fixed calibration values for the values of the impactor stage constants or values obtained from theory. The theoretical values include the effects of jet Reynolds number and the jet to plate spacing and are generally superior to the fixed calibration values. If the theoretical values are chosen, the user must also specify the type of substrate used as the use of fibrous substrates will reduce the effective stage constant. The use of the theoretical constants is strongly recommended.

3) Obtaining printed output of the input data and the results.

4) Saving either or both the input data and results to disk for later use.

PROGRAM OPERATION

The program operation proceeds through a number of subroutines which will be described in more detail later. These routines can be broken down into six fundamental operations. The first is related to program initialization and requires no user input or intervention other than at this point the user must select whether fixed calibration stage constants are to be used or if theoretical values of the stage constants are to be calculated and used. The second is data input, which takes place in three screen pages. The third deals with preliminary calculations of such items as gas flow rates, stage pressures, jet velocities, gas viscosity, and isokinetic ratio; this section requires little user intervention other than restarting at program halts for display of intermediate information. The fourth program block is the one in which the stage D_{50}'s are calculated. In the fifth block, a unimodal log-normal fit is made to the measured distribution and a spline fit and interpolation/extrapolation are performed to obtain results at a standard set of particle diameters. The spline fit is independent of the log-normal fit. The final block provides screen and printed displays of the results and handles disk storage of the data and results as desired.

Data Input

To select the CARBPRGX Program from the Main Menu, press 2 and then the Enter key. Then the CARBPRGX program will load and run.

Input to Page 1 of 3. First the user will be asked as to whether theoretical stage constants are to be used. The stage calibration constants, $\sqrt{\Psi_{50}}$, in the UWVGENER.IMP file on the are specific to the conditions under which the calibration data were obtained. These were normal laboratory conditions with standard air in all cases and were not obtained at the same sampling rate for all stages. Because the "constants" are not truly constant for each stage, but depend on the Reynolds Number of the flow through the jet orifices and the jet to plate spacing, it is strongly recommended that the data analysis programs be allowed to use the theoretical values which are calculated by the program for the specific sampling circumstances when reducing impactor data. The latter recommendation is made because the stage "constants" for the D_{50} calculations can change significantly as the jet Reynolds number changes. Consequently the use of fixed calibration constants can lead to significant errors in the calculated stage cut diameters.

Next, an opportunity will be provided for loading an old data set from disk. If so, respond "Y" and a directory of available files will be presented, followed by a prompt for the name of the file to be loaded. These choices are shown below in the sequence in which they will appear. After making these choices, the program will proceed to the data input/change routines. These consist of three menu pages as follow:

```
Use C)alib. OR T)HEO. SQRT PSI For D50 Calculations?
(THEO. recommended)

DO YOU WANT TO RETRIEVE AN OLD
DATA SET? (Y/N)
```

Figure 2. Initial sequence of questions for user upon startup of CARBPRGX.

```
IMPACTOR DATA REDUCTION PROGRAM  VERSION 10.1  - PAGE 1 OF 3

 -->    PART. DIAMETER    CLASS. AERO.
        DATE OF TEST:
        TIME OF TEST:
        LOCATION OF TEST:
        TEST DESIG.:
        TEST TYPE          INLET
        RUN NUMBER:    -FILE NAME:
        RUN REMARKS:
        WATER VAPOR          10.98%
    CO2   7.00%        CO    0.00%
    O2   14.00%        N2   79.00%
        IMPACTOR TYPE:
        PARTICLE DENSITY  2.50 GRAMS/CC
        ORIFICE ID (OPTIONAL):
        SUBSTRATE MATERIAL, G)rease or Bare metal, F)ilter:   G



<Up Arrow> & <Down Arrow> to move pointer.
<PgUp>, <PgDn> for other data entry pages.
<F9> to Calculate,  <Esc> to exit program
```

Figure 3. CARBPRGX, Page 1 of 3, as shown on screen

To enter test data in CARBPRGX, move the pointer (-->) to the desired entry item using the Up and Down arrow cursor keys and type in the information (in the appropriate units) and then press <Enter>, <UpArrow>, <DownArrow>, <PgUp>, <PgDn>, or <F9> as desired. **NOTE: data entry is not through a line editor type of interface. The new characters which are typed and only the newly typed characters will be retained.** However, pressing <Enter> immediately after selecting an item for input or back-spacing over erroneous entries and then pressing enter will preserve the previous information. Pressing the Left and Right arrow keys will usually have the same effect as pressing enter, but they have no specific function in the operation of the program.

The explanation, units, and choices for the variables on Page 1 of 3 of CARBPRGX are as follows:

1) Select one of three types of particle diameters. The diameters are: P (physical or Stokes), C (classical aerodynamic), or I (impaction aerodynamic). Usually "P" will be selected if the data are to be used for such things as electrostatic precipitator diagnostics or

light scattering studies and "C" for most other purposes. The "Impaction Aerodynamic Diameter" is seldom used.

2) Enter date (ALPHA NUMERIC), in the form: 7/18/84.

3) Enter test time (NUMERIC) on a 24 hour basis, such as 1430 for 2:30pm.

4) Enter test location (ALPHA NUMERIC).

5) Enter test series designation, a three character ALPHA string, which is expected to be keyed to major projects.

6) Select test type, either INLET or OUTLET. (Inlet to or outlet from control equipment such as an electrostatic precipitator)

7) Enter the sequence number of the sampling run as one or two NUMERIC digits. The program will generate the FILE NAME from the test designation, the run number, and the test type. <u>Each time a new file name is constructed a directory of names having the same series designation and test type will be shown so the user can verify that the file name has not been used previously.</u>

8) Enter remarks and comments about the cascade impactor source test run (ALPHA NUMERIC). (40 character maximum)

9) The moisture content to be used in reducing the data can be entered directly from the keyboard here (numeric value only). The moisture content can also be calculated from sampling data by entering a condensed water volume on the second data entry page. When exiting the moisture content entry line a prompt will be made regarding changing the dry gas composition. If the dry gas composition is to be changed a response of "Y" should be made and the entry cursor will advance successively through the dry gas composition cells. As is the case with the other entry lines, pressing <Enter> immediately at any of these entries will result in the current value being retained. **Note: the user must provide a dry gas composition before any data analysis can take place.** Data entry here is also numeric only.

10) Entering a new setup name at the impactor type entry line will invoke the stage selection routine in which the user can pick the plates used during a sampling run. The stage selection routine is described in more detail on the next page.

11) Enter the particle density to be used in calculating the particle Stokes (physical) diameter. Be very careful of the value of the particle density you use here. Note that a particle density of 1.0 grams/cc results in calculating the particle aerodynamic diameter (i.e. diameter of sphere of unit density which has aerodynamic properties equal to the actual real particle). If you select

aerodynamic dia. (item 1), the program sets particle density equal to 1.0 when the calculations are carried out.

12) Enter the gas metering orifice identifier. This orifice ID is not required unless the stack gas sampling flow rate is to be calculated from an orifice meter rather than being entered directly or calculated from a dry gas meter volume. If an orifice ID is entered, a prompt will also be made for entry of the orifice meter calibration constant, DH@. DH@ is required if the sampling flow rate is be calculated from the metering orifice DH used in sampling.

13) Select the type of substrate used to collect particle samples on the jet stages (examples are greased stainless steel foil, aluminum foil, quartz fiber filter, Kapton, etc.). "G" for grease or bare metal or similar surfaces and "F" for fiber type substrates. This entry is required if theoretical stage constants are to be used in calculating stage D50's.

Note that the numbers above correspond to the sequence from top to bottom of the entry items (Figure 3). When the user has completed data entry into page 1 of 3, then press "PgDn" the second data entry page will appear.

Stage Selection: The file UWVGENER.IMP contains the hardware information for all jet stages provided with the UW Mark V impactor together with information on various entry stages or precollectors which might be used. This file is loaded automatically when either CARBPRGX or CARBD50X is run.

If a new setup name is entered at the sampler type prompt, the information in the UWVGENER file will appear on the screen. The parameters for each stage will be listed on a single line and identified on the left by a sequence number. The selections are made by entering the sequence numbers from the left side of the table for the desired stages. The selections are to be made in the order in which they are to be used, impactor inlet first through outlet last. An example of the stage selection input screen is provided on the following page. No changes can be made to the stage parameters. Entries in this part of the program require that <Enter> be pressed after typing the desired selection. After the desired stages have been selected, Enter "Q" and the program will proceed to the remaining options and data menus.

PLATE SELECTION

STAGE NO.	NO. JETS	SQR PSI	JET DIA.	J TO P DIST.	ID	Selected as Stage
1	1	0.240	1.2700	0.8500	METH5	
2	1	0.240	1.2700	0.8500	PM10CYC	
3	1	0.240	1.2700	2.2500	RAPC	
4	1	0.240	1.2700	2.7500	HTPC	
5	1	0.240	1.2700	2.6250	LDPC	
6	1	0.240	1.2300	4.7250	And. HiCap.	
7	1	0.240	1.2700	0.8500	Inlet	
8	6	0.331	0.5791	0.5200	P2	
9	12	0.381	0.2438	0.3180	P3	
10	90	0.365	0.0790	0.3180	P4	
11	110	0.371	0.0508	0.3180	P5	
12	110	0.366	0.0390	0.3180	P6	
13	110	0.383	0.0343	0.3180	P7	
14	105	0.347	0.0300	0.3180	P8	
15	105	0.363	0.0262	0.3180	P9	
16	78	0.366	0.0262	0.3180	P10	
17	56	0.369	0.0262	0.3180	P11	
18	40	0.382	0.0262	0.3180	P12	
19	36	0.369	0.0262	0.3180	P13	

TO SELECT A STAGE ENTER ITS STAGE NO. OR Q)UIT WHEN DONE

? 9

FOR STAGE 6 USING STAGE 9 ABOVE

Figure 4. The stage with sequence number 9 has just been selected as Stage 6 of the new impactor configuration.

If the first stage is the SRI/EPA Right Angle PreCollector select the line identified as "RAPC" as the first stage of the impactor setup. If the first stage is the "wet source" ARB precollector select "LDPC". Similarly select "HTPC" if the precollector is the ARB "high temperature" precollector/probe. This will invoke the routine in CARBPRGX that accounts for the nozzle tip size used on the performance of the precollector. Similarly, the PM10 cyclone must be identified as "PM10CYC". Figure 5 illustrates the dependence of $\sqrt{\Psi_{50}}$ for the RAPC on nozzle tip size. Both Pollution Control Systems, the manufacturer of the UW (Pilat) impactors, and Graseby/Andersen market versions of the RAPC. The RAPC should not be confused with the UW "Right Angle Inlet" or the Andersen "High Capacity Preseparator" (And. HiCap. in the setup file). Both of the UW "Right Angle Inlet" and the standard UW first stage when used with a straight nozzle will behave much like the RAPC. Although detailed calibration data for the latter are not available, it is expected that their performance would be very close to that of the SRI/EPA RAPC and the routine used for calculating the D50 of the latter should be acceptable for either of them and superior to any other way of handling them. The aerodynamic behavior that results in the nozzle tip size effect on the performance of the SRI/EPA RAPC will have similar effects on the performance of any entry stage to any impactor.

If a Method 5 type "gooseneck" or similar right angle (90°) nozzle is used, a dummy stage should be entered as Stage 1 of the impactor with the entry line identified as "METH5" selected for it. This will result in the calculation of the nozzle D50, the diameter above which the nozzle affects the sizing data, based on the actual nozzle tip size that is entered when the run data are reduced. Such a nozzle acts as a poorly behaved first stage of the impactor and the measured size distribution should not be expected to be valid for diameters larger than the D_{50} of the nozzle.

If a straight nozzle is used with the UW impactor (no precollector) the first stage D50 will be very close to that of the Right Angle Precollector operating under the same conditions. Under this circumstance, the first stage should be selected as the being the RAPC and the "Inlet" stage should be omitted in setting up for data analysis. Upon completion of impactor stage selection, press "Q" and "Enter" to proceed.

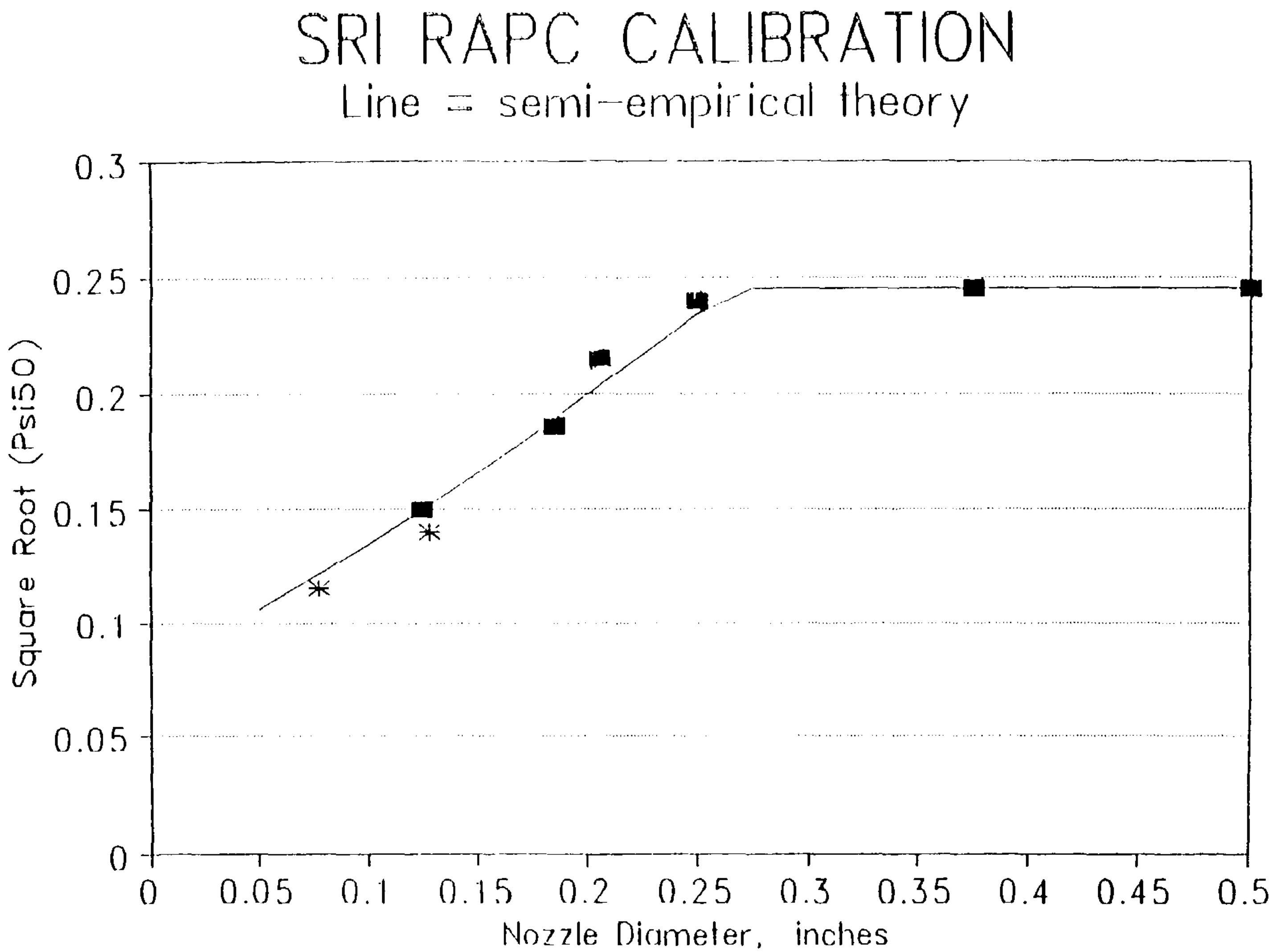


Figure 5. SRI RAPC Calibration

Input to Page 2 of 3 - page 2 of 3 will appear on the monitor screen as shown below. Data entry is performed as it was for page 1.

```
IMPACTOR DATA REDUCTION PROGRAM  VERSION 10.1 - PAGE 2 OF 3

       SAMPLING SYS. TYPE:    M5
 -->   GAS METER VOL        0.000 CUBIC FEET
       IMPACTOR DELTA P     0.00 IN. HG. (0 for calc. from theory)
       ORIFICE DELTA P      0.00 INCHES H2O
       STACK PRESSURE       0.0  INCHES H2O
       BAROMETRIC PRES     29.50 INCHES HG
       STACK TEMP           0    DEGREES F
       METER TEMP           0    DEGREES F
       IMPACTOR TEMP        0    DEGREES F
       SAMPLE TIME          0.00 MINUTES
       AVG GAS VEL          0.00 FEET/SEC
       NOZZLE DIA           0.000 INCHES
       MAX PART DIA      1000     MICRONS
       WATER VOLUME        0.0  CC
       METER FACTOR        1.0000


For direct entry of flowrate leave METER VOL & ORI DP = 0

<Up arrow> & <Down arrow> to move pointer.
<PgUp>, <PgDn> for other data entry pages.
<F9> to Calculate,  <Esc> to exit program
```

Figure 6. CARBPRGX, Page 2 of 3 as shown on screen

The explanation for the variables on page 2 of 3 of CARBPRGX are as follows:

1) Two types of sampling systems are commonly used. The first is the standard Method 5 type for which the data entry page is illustrated above. The second type does not rely on a leakless pump but places the dry gas meter, if used, and an orifice meter upstream of the pump. The pressure at which the meter(s) operate must be provided for flow rate and sampled gas volume calculations. This entry toggles between the two types of train. If the second type (herein called an "impactor train") is used, an additional entry line for the needed orifice meter inlet pressure differential to ambient will appear at the bottom of the entry list. The sampling train is assumed to follow the sequence: impactor, condenser, drier, orifice meter, dry gas meter (if used), and pump. Enter the orifice meter inlet differential pressure to ambient. If the pressure at the orifice meter inlet is below atmospheric, the entry should be a negative value.

2) Enter dry gas meter volume in cubic feet. Set equal to zero (0) if the sample gas flow is to be calculated from the orifice meter or is to be entered directly by the user. If <Enter> is pressed immediately at this entry line without typing a meter volume, prompts will be given for the gas meter starting volume and then the gas meter ending volume. The program will then take the difference as the net volume.

3) Enter the overall impactor gas pressure drop. If left at 0, the program will calculate the jet stage pressure drop for each stage using standard orifice equations and the impactor geometry, gas composition, temperature, pressure, and gas sampling flow rate. Normally it should be left at zero because the impactor pressure drop will not generally be measured by the user.

4) Enter the gas flow rate metering orifice pressure drop (DH).

5) Enter the static pressure of stack gas (negative if stack is below ambient atmospheric pressure). This stack pressure is the pressure difference (inches water gauge) between the stack gas and the atmospheric barometric pressure.

6) Enter the atmospheric barometric pressure (inches of mercury absolute) at the elevation of the stack sampling location.

7) Enter the stack gas temperature (degrees F).

8) Enter the dry gas meter temperature (degrees F).

9) Enter the impactor temperature (degrees F). This may differ from the stack gas temperature. (For example, if the impactor was heated when sampling a high moisture gas stream as in ARB Method 501a or was run at a lower temperature than the stack gas as in the high temperature variant of ARB Method 501, Method 501b.)

10) Enter the total time of gas sampling through impactor (minutes).

11) Enter the stack gas velocity (ft/sec). This is optional but needed if the isokinetic ratio is to be calculated and if correction for non-isokinetic sampling is desired.

12) Enter the sampling nozzle diameter (inches). Optional, but needed if the isokinetic ratio is to be calculated or correction for non-isokinetic sampling is desired.

13) Enter the maximum particle diameter (typically about 60 microns for controlled sources, and 1000 microns for uncontrolled sources).

14) Enter the volume of condensed water collected if a moisture content specific to this run is to be calculated. If left zero, the value from data entry page one will be used.

15) Enter the dry gas meter correction factor if different from 1.000.

16) If the "Impactor" type sampling train is selected in (1) above, a prompt will appear at the bottom of the previous list. The pressure differential to ambient at the orifice meter inlet in inches of mercury should be entered at this point. (Negative value if the orifice inlet is below atmospheric pressure.)

When the entry of data into page 2 of CARBPRGX is complete, press <PgDn> and page 3 of 3 will appear.

Input to Page 3 of 3

The page 3 of 3 of CARBPRGX data entry is shown below:

```
IMPACTOR DATA REDUCTION PROGRAM  VERSION 10.1 - PAGE 3 OF 3

 -->  MASS GAIN OF STAGE    1      0.00 MG  RAPC
      MASS GAIN OF STAGE    2      0.00 MG  Inlet
      MASS GAIN OF STAGE    3      0.00 MG  P3
      MASS GAIN OF STAGE    4      0.00 MG  P4
      MASS GAIN OF STAGE    5      0.00 MG  P6
      MASS GAIN OF STAGE    6      0.00 MG  P8
      MASS GAIN OF FILTER          0.00 MG
      MASS GAIN OF  BLANK SUBST.   0.00 MG
      MASS GAIN OF  BLANK FILTER   0.00 MG




<Up arrow> & <Down arrow> to move pointer.
<PgUp>, <PgDn> for other data entry pages.
<F9> to Calculate,  <Esc> to exit program
```

Figure 7. CARBPRGX, Page 3 of 3, as shown on screen

Note that the number of stages shown on the monitor screen is dependent upon the configuration of cascade impactor setup specified in item #10 on page 1 of 3 of CARBPRGX. For example a Mark V/III configuration consisting of the inlet and six jet plates has 7 stage weights, 1 filter weight, 1 blank substrate weight, and 1 blank outlet filter weight (10 weights in total).

To select an entry line for the mass gains of the particles on the substrates under the jet stages, on the impactor outlet filter, and on the blanks, use the <Up arrow> or <Dn arrow> keys until the pointer is on the appropriate line and enter the net weight gain. If a net weight is not entered, but <Enter> is pressed immediately at each any line, sequential prompts for initial and final weights will be given and the net gain will be calculated by the program.

Note that the program will subtract the blank weights from the measured stage and outlet filter weights to correct for interferences and systematic weighing errors. Negative or zero net stage weights after correction are not allowed - they will cause fatal errors. Therefore, if a weight is zero, the program will give it an infinitesimally small positive value. At this point data entry for the run is complete.

Check Filename

The user should now check page 1 of 3 (press <PgDn>) for the file name (Item #7 on page 1 of 3). This is a alpha numeric filename (name composed of letters and numbers). This filename is generated by CARBPRGX from the impactor test designation, the impactor run number, and the test type (inlet to control equipment or outlet of control equipment). An example of a filename is TNEFR2.OT (corresponds to outlet run number 2 of a test program with a series identifier, NEF.

Processing the Data

After completing the data entry, press "<F9>" to begin processing. (NOTE: at some entry lines <Enter> may have to be pressed once or twice as well.) Several intermediate results will be shown on the screen. The performance of the first internal stage (NOT PRECOLLECTORS) of most (or all) impactors differs substantially from theory.

NOTE: THE CALIBRATION VALUES OF THE STAGE CONSTANTS THAT WERE LOADED FROM DISK ARE OVERWRITTEN IF THE THEORETICAL CONSTANTS OPTION WAS SELECTED. Therefore if new calculations using the calibration values of the constants are desired after once having used theoretical values, the impactor hardware information must be re-established through the stage selection process.

The value of the D_{50} of each stage will be checked relative to those of the preceding stages during processing . Any which are too close to one another will result in one (or more) being skipped in the log-normal and spline fitting procedures. Flags regarding the omission of any skipped stage in the distribution fitting procedures are provided in the results.

After the stage D50's are calculated and the relative spacings have been checked, the reduced size distribution will be printed on the screen in cumulative percent by mass form and the log-normal and spline fits will be made. The user will then be given prompts regarding whether hardcopy of the results is desired and if the results or raw data are to be saved to disk. If a number of runs are to be reduced with many of the input variables remaining constant, it will probably be convenient to save the raw data to be used later, with changes being made as needed, for reducing other runs. This can save considerable time in data input. Finally the choice of returning to the main menu or continuing with the reduction of more runs in this program will be made.

Calculation Sequence

Upon completion of data entry, the calculations take place in the following sequence:

1) The gas viscosity and wet and dry molecular weights are calculated in a subroutine by a method in which the viscosity of a gas mixture is calculated from the viscosities of its constituents (Wilke, 19). The individual component viscosities are calculated from an approximation by Reid and Sherwood (1958) using data from Weast (1968) and are good to about 3%. Viscosities are separately calculated for the first stage and the remainder of the impactor to account for the possibility that the first stage is at stack conditions while the remainder may be at a different temperature. For instance the sampler might be heated when sampling wet sources.

2) The impactor flow rate at standard conditions and at impactor conditions (which will usually be stack conditions) and stack conditions and the isokinetic ratio are calculated from either the gas meter or orifice meter data depending on the information entered by the user. If insufficient information is available to permit a flow rate to be calculated the user will be prompted to enter the flow rate at <u>impactor</u> conditions. Rates are calculated separately for the nozzle/precollector using stack temperature conditions and for the remainder of the system using the impactor temperature.

3) Stage pressure drops, jet velocities, and Reynolds numbers are then calculated. The pressure drops of individual stages are calculated by treating the stages as orifice plates having approach ratios of 0.2. The latter value is close to that for the stages of the Pilat impactors and for most other multi-jet impactors as well. The coefficient of discharge is estimated based on the Reynolds number from a fit to a curve given in Brown (19). Gas compressibility is accounted for by a correction factor given by Considine (1957). Some pressure recovery takes place which lessens the permanent pressure loss from the jets from that calculated by the orifice equations. This recovery is accounted for by an empirical correction factor which has been optimized for the Pilat (UW) impactors. It is expected that the same correction should be suitable for most commercial multi-jet impactors. The results of these calculations will scroll by rapidly but <Pause> can be used to halt the scrolling if the user wishes to see the stage by stage results.

Tests of the pressure drops predicted by the program against measured values for various combinations of stages of Pilat Mark III, V, and 10 impactors have been made. Impactor configurations with six to fourteen stages were used in these tests. The impactors were operated at flow rates which produced total pressure drops ranging from a fraction of an inch of mercury to nineteen inches of mercury. The average signed error in the predicted total pressure drop was -2.6 percent. The average unsigned error was 8.0 percent and the maximum error was 28 percent. The inlet pressure to each stage is the important factor in calculating stage D50's. Because much of the total pressure drop, and the error in the calculated total pressure drop, occurs at the last stage, the accuracy of the pressure drop calculations is believed to be adequate for the purpose. If the actual overall pressure drop through the stages, exclusive of the backup filter is known, it can be entered and will be apportioned through the stages by scaling from the calculated pressure drops.

4) Theoretical stage constants for D50 calculations are calculated, if desired. The stage constants are calculated from curve fits to theoretical values of $\sqrt{\Psi_{50}}$ versus Re and S/W (Farthing, 1983). The basic fitting equations reproduce Farthing's theoretical values over the range of Reynolds number from 10 to 3000 and S/W (jet to plate distance relative to jet diameter) from 2 to 11 with a maximum error of +/- 3.5% and an average error of -0.2%. The fitting equations have been adjusted to account for a systematic bias of +7% in the theoretical values as compared to laboratory calibrations. Corrections to the theoretical stage constants can be made for the shifts which result from using fibrous substrates. These corrections are based on comparisons of calibrations of a number of Brink and Pilat impactor stages which were done at SRI with both glass fiber and greased substrates. The use of the theoretical stage constants is strongly recommended because the constants are functions of gas conditions and sampling rates and can change quite a lot as for different values of the latter parameters and calibration values for the actual conditions of use of impactors are seldom available.

5) Stage D_{50}s are then calculated in an iterative loop. In the loop an initial estimate of the value of the Cunningham correction factor, CC, is made and value of the D50 is calculated using the estimate. A new value of CC is then calculated using this D_{50} value and the process is repeated until successive estimates of CC differ by less than 0.02%, at which time the loop is terminated. The last pair of values of D_{50} and CC are retained as the final results.

6) The stage weights are used to form cumulative percentages smaller than consecutive D50s beginning at the final stage and proceeding toward the inlet. Corrections for blank weight gains are made in the process. The total measured mass concentration in at dry normal conditions is also calculated at this time.

NOTE: In many cases the entry stage undercuts one or more of the first few succeeding stages. If this is the case, the weight gain of the first stage downstream of the entry stage should generally be taken to result from particles that were re-entrained from the entry stage and its weight gain should be combined with that of the entry stage in the analysis. The user will be given a prompt regarding this which should be answered affirmatively unless the user has some compelling reason to believe that no bounce-off or blow-off could have occurred from the entry stage, including precollectors other than the PM10 cyclone.

7) Transformations to log-probability coordinates from linear diameters and cumulative percentages are made preparatory to the spline and best log-normal fits. Data from stages that cut too close to the previous stage for the D50 analysis method of constructing a size distribution to be valid are dropped in the spline fit. A stage is dropped from the fit if the last retained D50 is less than 1.4 times the value of the last D50 accepted. The data to be fit are then reordered so that the stage index increases from the filter to the impactor inlet rather than the entry order from inlet to filter. If problems are encountered that would lead to a fatal error, an error flag is set and the program will return to the data input pages.

8) A least squares fit of the best log-normal approximation to the distribution is then made.

9) A cubic spline is fit to the data for use in generating distribution parameters at a set standard diameters at this time (Lawless, 1978). A modified version of the cubic spline described by Lawless is used. One modification insures that no negative slopes will be generated. Two other changes were made to Lawless's algorithms to provide improved extrapolations for particle sizes outside the span of the stage D_{50}s. Interpolation along the spline curve is used to generate distribution values at the standard diameters which fall between the stage D_{50}s and to extrapolate for those which fall below the smallest D50 or above the largest. The extrapolations are carried to diameters far removed from the range of the stage D_{50}s for later use in averaging results from multiple runs. However, they should not be expected to be very good, quantitatively, much farther than a factor of two in diameter from the smallest and largest of the stage D_{50}s.

Examples of the display screens for a typical data set are given on the following pages. Only the very end of the pressure drop calculations are shown as this will be the normal way in which the screens are viewed.

```
CALCULATIONS

FLOW RATES
VISCOSITY
mw = 28.51976
VIS =  226.8638  UP
QI =  .545437    QS=  .3281456
Qnoz = .545437  ISO=  65.04447
% WATER =  10.12638

PRESS ANY KEY TO CONTINUE
```

Figure 8. Wet molecular weight, viscosity (micro-poise), flowrates (QI=impactor, QS=dry standard), isokinetic ratio, and moisture content. These are the first intermediate results given by the program.

```
DP EST.= .4256872
Y= .9963445
DP= .4278743

STAGE VJET,CM/S RE. NO.     DP  P IN
   1  2.03E+02  9.03E+02  0.0  29.28
   2  4.60E+02  3.92E+02  0.0  29.28
   3  5.84E+02  1.61E+02  0.0  29.27
   4  1.16E+03  2.05E+02  0.0  29.27
   5  2.54E+03  3.04E+02  0.1  29.24
   6  4.57E+03  4.17E+02  0.4  29.11
 TOTAL DP=  .5944488


STAGE          SQRT PSI50
 1              .2346375
 2              .3431979
 3              .3904492
 4              .4234134
 5              .4263941
 6              .3942163

PRESS ANY KEY TO CONTINUE
```

Figure 9. Jet velocities, Stage pressures and pressure drops, and $\sqrt{\Psi_{50}}$ results.

```
STAGE  C.CORR   CUMFR   D50 CA    D50 IA
   1   1.021   96.848  11.7296  11.8535
   2   1.051   89.989   4.9286   5.0516
   3   1.090   79.422   2.7811   2.9030
   4   1.149   65.146   1.6741   1.7944
   5   1.284   47.164   0.8844   1.0021
   6   1.536   25.473   0.4866   0.6030



PRESS ANY KEY TO CONTINUE
```

Figure 10. Stage Cunningham corrections, cumulative weight percentages, and D50 results.

```
CALCULATIONS
FIT - INIT
LOG-NORMAL SIZE DISTRIBUTION
MMD=  1.027916  SIG G=  3.55069  R2=  .9966239

PRESS ANY KEY TO CONTINUE
```

Figure 11. Least squares unimodal log-normal fit to measured distribution.

DIA.	CUM%	CONC.	DM/DLOGD
0.100	0.22	5.32E-02	1.10E+00
0.158	2.78	6.73E-01	5.32E+00
0.251	9.12	2.20E+00	1.01E+01
0.398	19.56	4.73E+00	1.53E+01
0.631	34.95	8.45E+00	2.10E+01
1.000	51.00	1.23E+01	1.65E+01
1.585	63.60	1.54E+01	1.54E+01
2.512	76.79	1.86E+01	1.50E+01
3.981	86.83	2.10E+01	9.37E+00
6.310	92.74	2.24E+01	5.27E+00
10.000	96.07	2.32E+01	3.01E+00
15.849	97.71	2.36E+01	1.38E+00
25.119	98.64	2.39E+01	9.00E-01
39.811	99.23	2.40E+01	5.65E-01
63.096	99.60	2.41E+01	3.38E-01
100.000	99.82	2.41E+01	1.89E-01
158.489	99.93	2.42E+01	9.37E-02
251.189	99.98	2.42E+01	3.63E-02
398.107	100.00	2.42E+01	7.62E-03
630.957	100.00	2.42E+01	2.21E-04
1000.000	100.00	2.42E+01	5.76E-11

DO YOU WANT TO SAVE THE RESULTS (Y/N)

Figure 12. Summary of spline fit and extrapolation results.

10) The results are also shown in three graphical forms: dM/dLogD, cumulative concentration, and log-probability.

11) Prompts will be given regarding saving the results, saving the raw data, and printing the results and printing the results to disk as a text file for editing with a word processor.

CARBD50X

CARBD50X provides a means of checking out the expected performance of an impactor configuration and playing "what if" games. It allows the user to calculate stage D50s for different sampling flow rates, gas conditions, and selected impactor stages. The program operation follows that of MPPROGPC very closely except omitting the entry of stage weights. Old data sets can be retrieved to be used as starting points in CARBD50X and setup files can be written by CARBD50X for subsequent use in analyzing data. Flow rates are calculated from gas meter volumes and sampling time if both are available. In addition, inputs have been added for velocity presures from pitot tubes and pitot calibration constants. If the meter volume or sampling duration aren't supplied the program will attempt to calculate the flow rate from the orifice meter calibration constant and orifice meter pressure differential. If a flow rate cannot be calculated in either of these two ways, the user will be asked to enter a flow rate directly. If the user simply presses <Enter> when prompted for direct flow rate entry, the program will use the velocity, either from direct entry or calculated from the pitot velocity pressure, and the nozzle size to calculate the isokinetic rate for the nozzle. (Note: if the isokinetic flow rate is to be calculated from the nozzle tip size and either an input gas velocity or velocity pressure, or pitot dp, the gas meter volume and orifice meter dH or dH@ must be zero.) Also, if the inlet stage is the PM10 cyclone, the program will calculate the required sampling rate, based on the gas conditions, to obtain a 10μm diameter cut. If a metering orifice dH@ was also provided by the user, the program will calculate the required orifice dH to obtain the selected flow rate (isokinetic, or PM10 as chosen by the user). This can be useful when planning a field sampling program or in setting up to perform measurements.

STATIS and SYNTRAV

STATIS and SYNTRAV are programs for combining data from multiple runs. STATIS provides results by forming simple averages of the data from the selected runs, while SYNTRAV provides velocity weighted averages. If the runs to be combined were taken at different locations in a duct in which the velocity distribution was badly skewed or non-uniform, the averaging should be done using SYNTRAV as the velocity weighted average will more nearly represent the true average emissions. SYNTRAV is intended to be used to combine results from several partial traverses of the duct to form one full traverse. Each partial traverse is expected to cover a defined portion of the duct with no overlap among them. Both programs will provide corrections for errors resulting from anisokinetic sampling to be made by particle size if the user so desires. A maximum of 20 runs can be averaged by the programs as they are currently dimensioned.

The programs actually average only the differential form of the distributions. The values of dM/dLogD for the standardized set of diameters generated and stored on disk by CARBPRGX are picked up from the data disk for averaging as the runs are selected. If three or more runs are being averaged, outliers can be identified and removed from the averaging process at the user's option. Outliers can be omitted at either the 90% or 95% significance level. Average cumulative forms of the distribution are generated by integrating the average differential distribution. The average distribution in the cumulative concentration form is obtained directly by the integration. The average distribution in the cumulative percent by mass form is obtained by normalizing the average cumulative concentration form. By constructing the averaged cumulative forms of the distribution in this way the effect of errors in the original data for single stages can be removed from the results if outliers are removed without discarding valid data from other stages. If the cumulative distributions were averaged directly, an error at any one stage of a run would propagate forward through the remainder of the distribution if the erroneous data were not dropped; but if outliers were dropped directly, the information from all stages beyond the one at which the problem was manifested would also be lost. Outliers can be removed at either the 90% or 95% significance level at the user's discretion. The program also provides 90% confidence limits for the results if three or more runs are averaged.

Program Operation

As startup, the user is asked if correction for anisokinetic sampling is desired. If so, the values of dM/dLogD will be corrected for each selected run as it is read into memory.

The runs to be averaged are selected by specifying the test type (Inlet or Outlet), the test designation, and the run number. Mixing of test types is not permitted. It is anticipated that a single test designator will be used to identify a major test program or series of tests, consequently all the runs to be averaged will probably share a common test designator and only the run identifiers will be different. If this is the case, once the test designator is entered and the type is specified, only the run number must be specified to read it into memory. Runs with different test designators can be averaged however.

The data entry options and program operation are controlled by entering a number, 1, 2, or 3, the letter "C", or the letter "Q". These result in the following actions:

1) Toggle the test type between Inlet and Outlet.

2) Selects entry of the Test Designator.

3) Select entry of the next run to be used by entry of the run identifier (the characters between the "R" and the ".IT" or ".OT" in the run file name).

C) Display a directory of runs of the type selected by (1) above having the test designator entered at (2) above.

Q) Quit the selection process and proceed with the averaging.

Each time a run is selected the Test Designator, Run Number, and Test Type are combined to form the run (result) file name. This name is checked against the data directory and if the name is valid, the file is read. As the file is read, the diameters at which the spline interpolations were made in CARBPRGX are checked to be certain that they are consistent from run to run, and the diameter basis on which the fits were made are checked for consistency. If a run is selected for which either the diameters or diameter basis is not the same as that of the first run entered, it is rejected for inclusion in the average and a message to that effect is written on the screen. If correction for anisokinetic sampling was selected, a run will be rejected for which the gas velocity and/or nozzle diameter was omitted in the CARBPRGX data entry. A message to this effect will be given in such a case. Once a run is read into memory and accepted, a counter for the sequence number of the next run to be entered, if any, will be advanced and a new prompt line for input option "3" will be added.

If the sampling areas covered by the runs being combined in SYNTRAV were not equal, the user will be asked to enter appropriate values after the data for each run has been read from disk and validated. The value entered may be the actual area spanned by the run or the fraction of the total duct area represented by the run, but must be consistent for all runs in the set. Sample screens to this point in the operation of the program are illustrated below.

```
DO YOU WANT THE DATA CORRECTED FOR
ISOKINETIC SAMPLING ERRORS (Y/N)?
```

Figure 13. Initial screen for STATIS and SYNTRAV.

```
STAT V2.1 Page 1 of 1

1) TEST TYPE INLET
2) TEST DESIG.  1s
3)RUN  1  T1sR1.IT
3)RUN  2  T1sR2.IT
3)RUN  3



         C)AT. OF RUNS, Q)UIT, OR NUMBER OF ITEM TO ENTER/CHANGE:

             RUN Number = ? 3
```

Figure 14. STATIS and SYNTRAV run selection (data file) selection screen. Screen is shown as the third run is being selected.

After all runs to be averaged have been selected and "Q" is entered, the user will be asked if outliers are to be dropped and, if so, what significance level is to be used in the test. Once this question is answered the calculations will proceed. Upon completion of the calculations the results will be displayed on the screen. A value of 3.0 E+33 is used for the confidence interval as a flag if insufficient runs were averaged for a meaningful confidence interval to be calculated. The tabular display of the results will be followed by graphical screen displays with both the individual run and averaged results shown in the dM/dLogD format graph. Following the screen display the user will be given prompts regarding whether printed copy and saving the results to disk are desired. If the results are to be saved to disk, a prompt for a file name will be given. If plots of the averaged results are desired or if they are to be used for calculating fractional efficiencies, they must be saved on the disk. Examples of typical screens from the remainder of the program are given below.

The tabular results include the particle diameter, average value of dM/dLogD at each diameter, the standard deviation for each average dM/dLogD, the 90% confidence interval for each dM/dLogD, the cumulative mass concentration to each diameter, the confidence interval for the cumulative concentration, and the cumulative percent by mass to each diameter. A final entry line in the table provides the straight average of the total concentrations of all runs that were averaged and the standard deviation for the total concentration. This average total concentration is based on the raw results with no correction for isokinetic errors and with no outlier removal.

```
COMPUTING STATISTICS
REMOVE OUTLIERS ? (Y/N)y
 Use (A) 90% or (B) 95% significance for outlier removal?
```

Figure 15. Prompts following the completion of selecting the runs to be combined.

```
 CLASS. AERO DIA.

   DIA. dM/dLogD STD DEV     90%CON.INT    Cum.Conc      Cum.%
   0.00 0.99E-01  0.71E-01    0.32E+00    0.00E+00      0.00
 <PRESS SPACE BAR FOR MORE>
   DIA. Dm/Dlogd  STD DEV     90%CON.INT    Cum.Conc      Cum.%
   0.10 0.24E+01  0.16E+01    0.72E+01    0.99E-01      0.00
   0.13 0.22E+02  0.23E+02    0.39E+02    0.17E+01      0.04
   0.16 0.32E+02  0.27E+02    0.45E+02    0.42E+01      0.09
   0.20 0.38E+02  0.23E+02    0.39E+02    0.78E+01      0.17
   0.25 0.41E+02  0.16E+02    0.26E+02    0.12E+02      0.26
   0.32 0.48E+02  0.59E+00    0.26E+01    0.16E+02      0.36
   0.40 0.40E+02  0.62E+00    0.28E+01    0.21E+02      0.45
   0.50 0.50E+02  0.15E+02    0.26E+02    0.25E+02      0.56
   0.63 0.57E+02  0.23E+02    0.38E+02    0.31E+02      0.67
   0.79 0.67E+02  0.31E+02    0.53E+02    0.37E+02      0.81
 <PRESS SPACE BAR FOR MORE>

  31.62 0.36E+04  0.80E+03    0.14E+04    0.38E+04     83.14
  39.81 0.28E+04  0.61E+03    0.10E+04    0.41E+04     90.47
  50.12 0.15E+04  0.11E+02    0.51E+02    0.43E+04     94.77
  63.10 0.84E+03  0.16E+03    0.73E+03    0.45E+04     97.61
  79.43 0.42E+03  0.18E+03    0.80E+03    0.45E+04     98.84
 <PRESS SPACE BAR FOR MORE>

   DIA. dM/dLogD  STD DEV     90%CON.INT    Cum.Conc      Cum.%
 100.00 0.19E+03  0.13E+03    0.57E+03    0.46E+04     99.58
 125.89 0.75E+02  0.68E+02    0.30E+03    0.46E+04     99.83
 158.49 0.26E+02  0.29E+02    0.13E+03    0.46E+04     99.96
 199.53 0.74E+01  0.92E+01    0.41E+02    0.46E+04     99.99
 251.19 0.15E+01  0.20E+01    0.90E+01    0.46E+04    100.00
 316.23 0.18E+00  0.25E+00    0.11E+01    0.46E+04    100.00
 398.11 0.75E-02  0.11E-01    0.47E-01    0.46E+04    100.00
 501.19 0.29E-04  0.41E-04    0.18E-03    0.46E+04    100.00
 630.96 0.79E-10  0.11E-09    0.50E-09    0.46E+04    100.00
 794.33 0.14E-33  0.20E-33    0.88E-33    0.46E+04    100.00
<PRESS SPACE BAR FOR MORE>

   DIA. dM/dLogD  STD DEV     90%CON.INT    Cum.Conc      Cum.%
1000.00 0.00E+00  0.00E+00    0.00E+00    0.46E+04    100.00
<PRESS SPACE BAR TO CONTINUE>

 DO YOU WANT HARDCOPY ? (Y / N)
```

Figure 16. Screen summary of the results from STATIS.

Program Description

The corrections for anisokinetic sampling are made using an equation developed by Beleyev and Levin (19).

The outlier tests are performed as described in Appendix F of EPA Publication 600/9-76-005 (Quality Assurance Handbook for Air Pollution Measurement Systems. Volume I - Principles). The integration for calculation of the average cumulative concentration is done from dM/dLogDs by a modification of Simpson's method. The values of the cumulative concentrations smaller than the first standard particle diameter from the CARBPRGX data files are averaged and used as a constant of integration for the starting point for the cumulative concentration.

EFF

EFF is a program for calculating the fractional efficiencies of control devices from cascade impactor data. The data from which the efficiencies are to be calculated may represent information from single impactor runs or from combined runs for either, or both, the inlet and outlet data sets. Efficiencies are calculated for each of the diameters in the standardized array used in CARBPRGX. If the inlet and outlet data sets represent averages, confidence intervals at the 90% level will be calculated as well. The results will be displayed on the screen and, at the user's option can be printed and/or saved to disk for plotting.

Program Operation

When run, the user will first be prompted for the source of the inlet data - a single run file from CARBPRGX or data for combined runs from STATIS (or SYNTRAV). If the data source selected was CARBPRGX, a listing of the available CARBPRGX files will be printed on the screen and the user will be prompted to enter the test number and run designation of the desired file. The file name will be displayed for verification and, if accepted, the data will be read into memory. If data from STATIS or SYNTRAV is selected, a catalog of the RESULTS directory will be displayed after which the user will be asked to enter the file name. The data in the selected file will be read into memory after the file name has been provided. Once the inlet data has been gathered from the disk, the same sequence of steps will be followed to load the desired outlet data.

After both sets of data have been loaded, a check will be made to verify that both files are on the same diameter basis. If so, the efficiencies will be calculated and displayed. The display will include the fractional efficiency based on the inlet and outlet total concentration. The use will then be given prompts regarding the desirability of printed output and saving the results to disk. Finally, a choice of doing another set of efficiencies or returning to the MAIN MENU will be offered.

Plotting via. Spreadsheets

Templates for plotting results from CARBPRGX (CIDRS.W??) and STATIS or SYNTRAV (AVERAGE.W??) can be found in the \CARB_IMP\SHEETS\ subdirectory. The results themselves are found in the \CARB_IMP\RESULTS\ subdirectory with extensions of ".IT" or ".OT" if from CARBPRGX or ".AVG" if from STATIS or SYNTRAV. With your spreadsheet program (Lotus, Quattro, ..) up and running "Retrieve" or "Open" the appropriate template from within the \CARB_IMP\SHEETS subdirectory and place the cursor in cell B1. Then use the text file import function of the spreadsheet program to load the data file to be plotted. The spreadsheet should automatically recalculate the variables within it based on the new data, but to be sure it advisable to force a recalculation (F9 in Quattro).

After the recalculation the data are ready to be plotted. First, invoke the Graph module of the spreadsheet. Then use the graph NAME select or display subfunction to pick the desired format. These are dM/dLogD vs. Dia. with linear concentration axes, dM/dLogD vs. Dia. with log concentration axes, Cumulative Concentration vs. Dia. with log concentration axes, Cumulative Percent by weight vs. Dia. with a linear percentage scale, and Cumulative Percent by weight vs. Dia. on a probability scale. The X axis is logarithmic in all cases. The area under the linear dM/dlogD presentation between two sizes equals the particulate concentration on a weight basis between those sizes. Log-normal distributions will appear as straight lines in the cumulative percent plot which uses the probability scale. The Mass Median Diameter (MMD) of the distribution is the diameter at which the cumulative percent curves reach 50%. If a printer with graphics capability is installed in the spreadsheet, the Graph Print function of the spreadsheet can be used to obtain printed graphs for reports, etc.

APPENDIX D

Raw and Reduced Data from SRI Trials and ARB Demo Runs

D1

SRI Trials

CARB UW IMPACTOR DATA REDUCTION PROGRAM, VERSION X R4

INPUT DATA

```
PART. DIAMETER    CLASSICAL AERODYNAMIC
DATE OF TEST:  2/25/94
TIME OF TEST:  1600
LOCATION OF TEST:  SRI combustor @ windbox inlet
TEST DESIG.:  cmb
TEST TYPE          INLET
RUN NUMBER:  1-FILE NAME:TcmbR1.IT
RUN REMARKS:
IMPACTOR TYPE: cmobl
  HTPC Inlet 4 5 7 9 11 13

WATER VAPOR            7.00%
 CO2  13.00%          CO    0.00%
 O2    7.00%          N2   80.00%
ORIFICE ID (OPTIONAL):  ntl
SUBSTRATE MATERIAL, G)rease or Bare metal, F)ilter:   F

GAS METER VOL          0.000 cf
IMPACTOR DELTA P       0.00 IN. HG. (0 for calc. from theory)
ORIFICE DELTA P        0.06 INCHES H2O
STACK PRESSURE        -2.0  INCHES H2O
BAROMETRIC PRES       29.50 INCHES HG
STACK TEMP          1110    DEGREES F
METER TEMP            84    DEGREES F
IMPACTOR TEMP        350    DEGREES F
SAMPLE TIME            5.00 MINUTES
AVG GAS VEL           13.00 FEET/SEC
ORI P WRT PBAR        -0.01 INCHES HG
NOZZLE DIA             0.250 INCHES
MAX PART DIA        1000    MICRONS
WATER VOLUME         0.0  CC
METER FACTOR         1.0000

MASS GAIN OF STAGE  1  47.50 MG
MASS GAIN OF STAGE  2  34.40 MG
MASS GAIN OF STAGE  3  21.50 MG
MASS GAIN OF STAGE  4   5.20 MG
MASS GAIN OF STAGE  5   2.40 MG
MASS GAIN OF STAGE  6   1.70 MG
MASS GAIN OF STAGE  7   1.10 MG
MASS GAIN OF STAGE  8   0.80 MG
MASS GAIN OF FILTER    2.80 MG

MASS GAIN OF BLANK SUBSTRATE    0.00
MASS GAIN OF BLANK FILTER       0.00
```

RESULTS

TEST DESIG.: cmb RUN NUMBER: 1
HTPC Inlet 4 5 7 9 11 13

ACTUAL FLOW RATE 0.215 CFM
FLOW RATE AT STANDARD CONDITIONS 0.128 CFM
PERCENT ISOKINETIC 156.840 %
VISCOSITY 233.5E-06 GM/CM-SEC
CALCULATED IMPACTOR DELTA P = 0.88 IN. HG

STAGE	CUNN. CORR.	D50 (CLAS AERO)	D50 (IMP AERO)	CUM FREQ.	RE. NO.	V*D50 UM-M/S	
1	1.032	17.754	18.034	59.5400	217	27.6	
2	1.009	27.226	27.355	30.2385	342	21.8	skip
3	1.044	5.859	5.986	11.9250	61	13.5	
4	1.068	3.787	3.914	7.4957	78	17.2	
5	1.126	2.038	2.163	5.4514	115	20.4	
6	1.239	1.083	1.205	4.0034	158	19.4	
7	1.470	0.567	0.687	3.0664	296	19.1	
8	1.799	0.351	0.471	2.3850	461	18.6	

STAGE CUT DIAMETERS BASED ON THEORETICAL VALUES OF STAGE CONSTANTS

PARTICLE DENSITY = 1

TOTAL MASS CONCENTRATION = 6.48E+03 MG/DRY NORMAL CUBIC METER
= 1.99E+03 MG/ACTUAL CUBIC METER
= 2.83E+00 GRAINS/DRY STD CUBIC FOOT
= 8.69E-01 GRAINS/ACTUAL CUBIC FOOT

TEST DESIG.: cmb RUN NUMBER: 1

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMFR (STDDEV)	CUMFR (PERCENT)	CUM.MASS (MG/DRY	DM/DLOGD N.CU.METER)
0.100	-3.0517	0.11	7.40E+00	7.22E+01
0.126	-2.7733	0.28	1.80E+01	1.45E+02
0.158	-2.5283	0.57	3.72E+01	2.41E+02
0.200	-2.3196	1.02	6.60E+01	3.33E+02
0.251	-2.1502	1.58	1.02E+02	3.81E+02
0.316	-2.0231	2.15	1.40E+02	3.50E+02
0.398	-1.9407	2.62	1.69E+02	2.43E+02
0.501	-1.8918	2.93	1.90E+02	1.72E+02
0.631	-1.8537	3.19	2.07E+02	1.80E+02
0.794	-1.8132	3.49	2.26E+02	2.13E+02
1.000	-1.7679	3.85	2.50E+02	2.62E+02
1.259	-1.7162	4.31	2.79E+02	3.22E+02
1.585	-1.6609	4.84	3.13E+02	3.60E+02
1.995	-1.6076	5.40	3.50E+02	3.59E+02
2.512	-1.5589	5.95	3.86E+02	3.82E+02
3.162	-1.5020	6.65	4.31E+02	5.60E+02
3.981	-1.4190	7.79	5.05E+02	9.61E+02
5.012	-1.2940	9.78	6.34E+02	1.68E+03
6.310	-1.1145	13.25	8.59E+02	2.91E+03
7.943	-0.8775	19.01	1.23E+03	4.62E+03
10.000	-0.5936	27.64	1.79E+03	6.58E+03
12.589	-0.2747	39.18	2.54E+03	8.28E+03
15.849	0.0675	52.69	3.41E+03	9.02E+03
19.953	0.4212	66.32	4.30E+03	8.44E+03
25.119	0.7805	78.25	5.07E+03	6.90E+03
31.623	1.1449	87.39	5.66E+03	4.92E+03
39.811	1.5139	93.50	6.06E+03	3.05E+03
50.119	1.8874	97.04	6.29E+03	1.64E+03
63.096	2.2650	98.82	6.40E+03	7.55E+02
79.433	2.6463	99.59	6.45E+03	2.99E+02
100.000	3.0311	99.88	6.47E+03	1.01E+02
125.893	3.4190	99.97	6.48E+03	2.91E+01
158.489	3.8098	99.99	6.48E+03	7.15E+00
199.526	4.2030	100.00	6.48E+03	1.49E+00
251.189	4.5985	100.00	6.48E+03	2.62E-01
316.228	4.9959	100.00	6.48E+03	3.92E-02
398.107	5.3948	100.00	6.48E+03	4.95E-03
501.187	5.7950	100.00	6.48E+03	5.28E-04
630.957	6.1962	100.00	6.48E+03	4.78E-05
794.328	6.5979	100.00	6.48E+03	3.66E-06
1000.000	7.0000	100.00	6.48E+03	2.38E-07

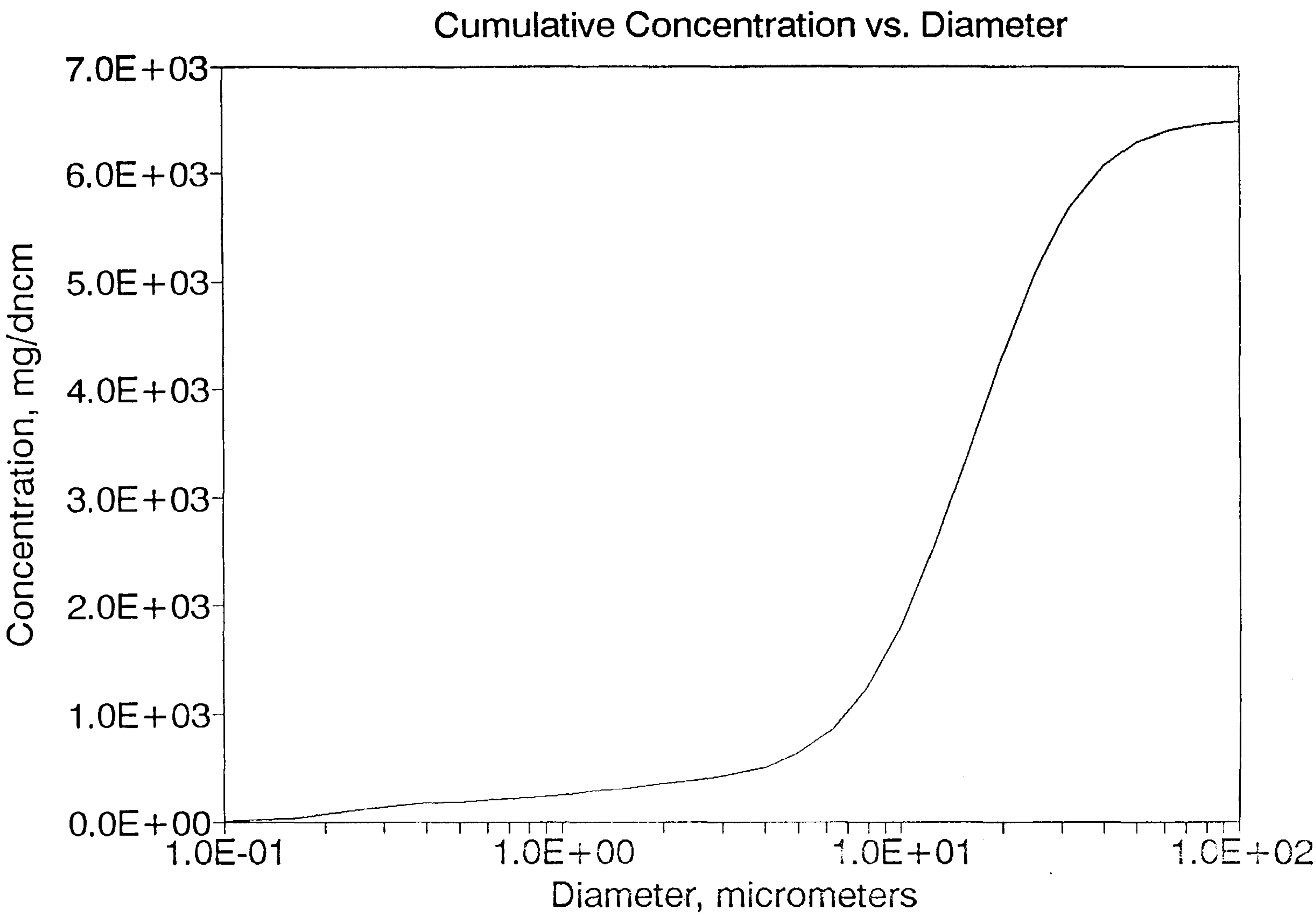
INHALABLE PARTICULATE MATTER

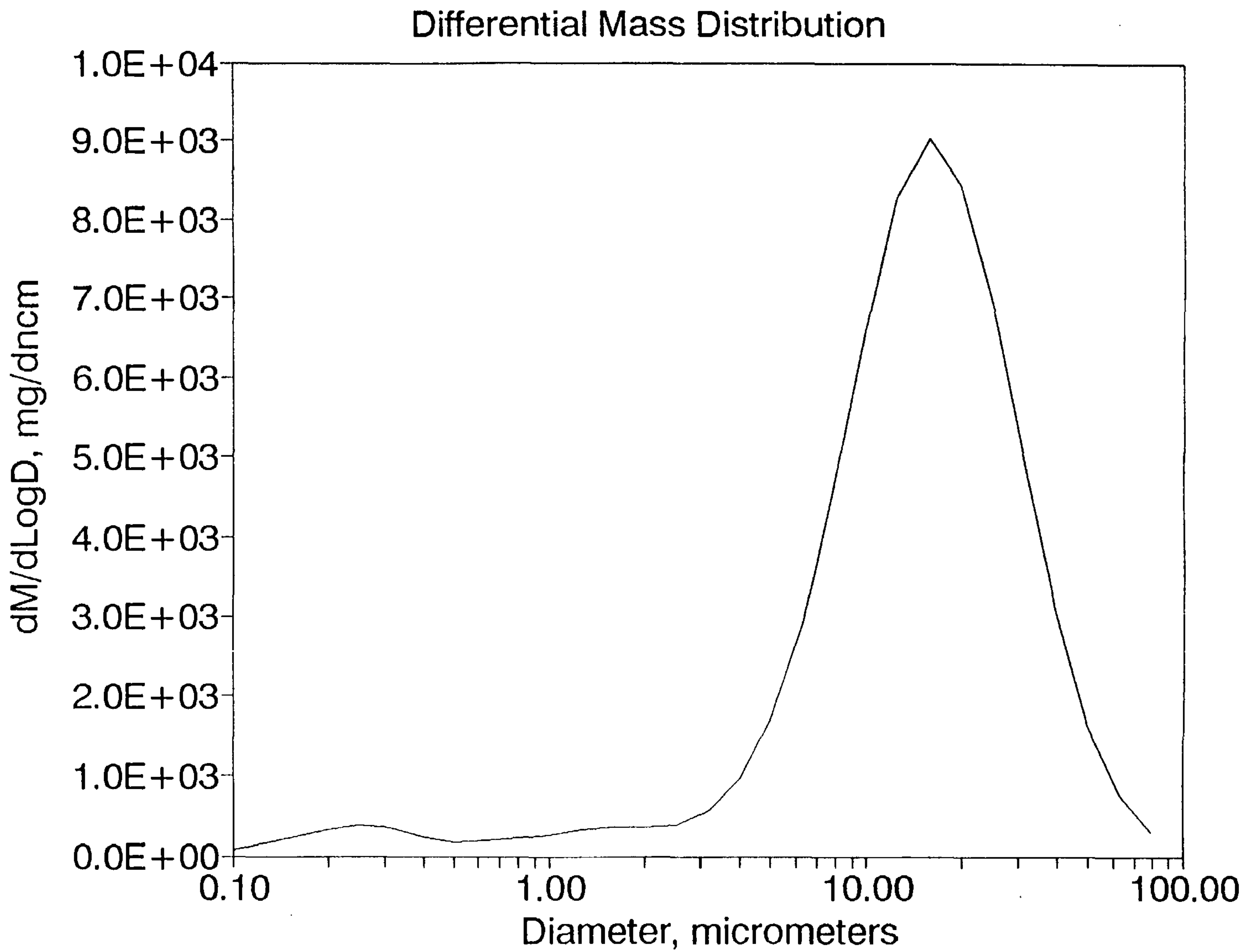
CUM MASS LESS THAN 1.000 MICRON: 249.75 3.8544 %
CUM MASS LESS THAN 2.512 MICRON: 385.61 5.9511 %
CUM MASS LESS THAN 10.000 MICRON: %1790.93 27.6395 %
CUM MASS LESS THAN 15.849 MICRON: %3414.15 52.6908 %
NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE ON CLASSICAL AERODYNAMIC BASIS.

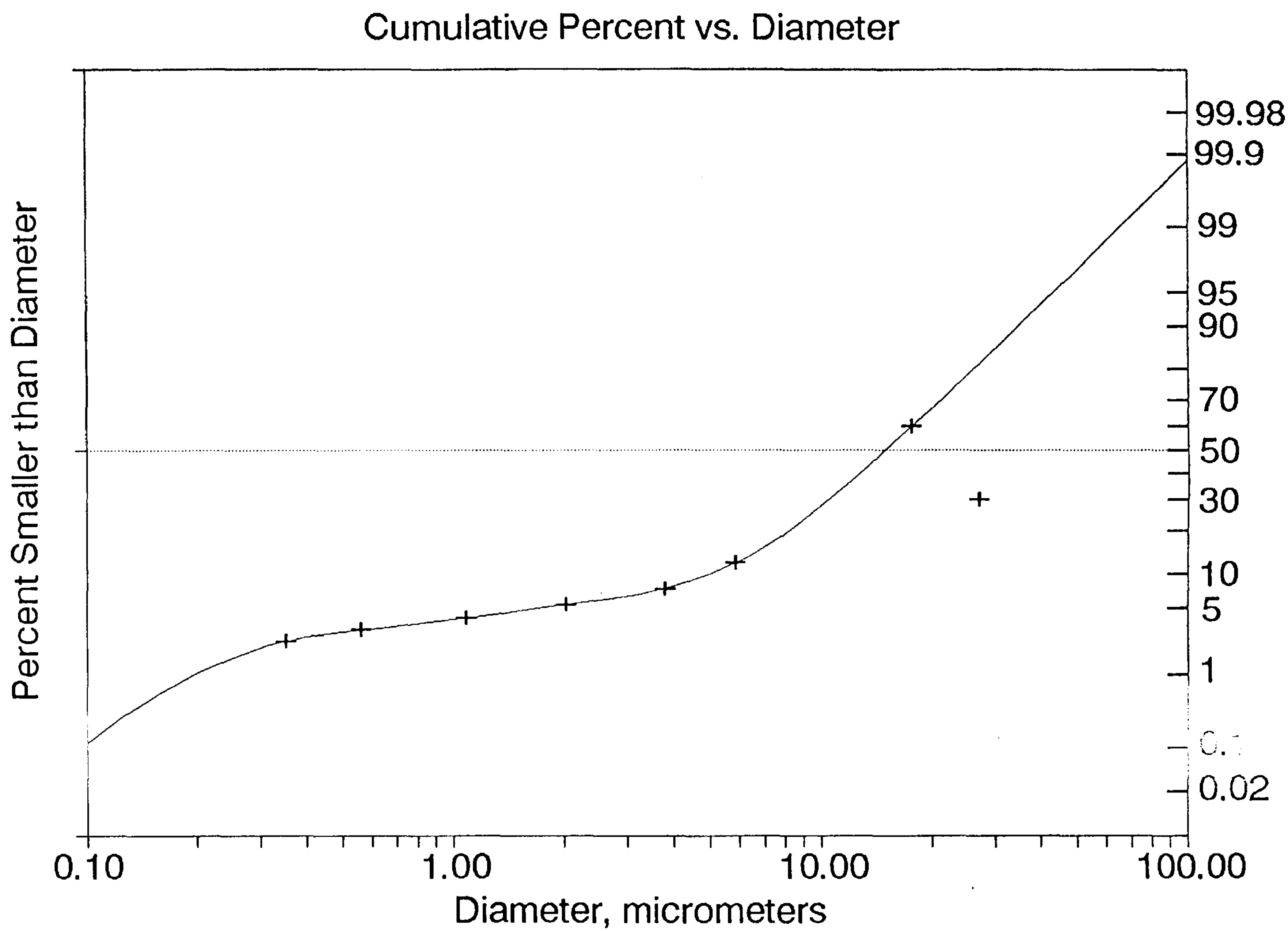
LOG-NORMAL APPROXIMATION

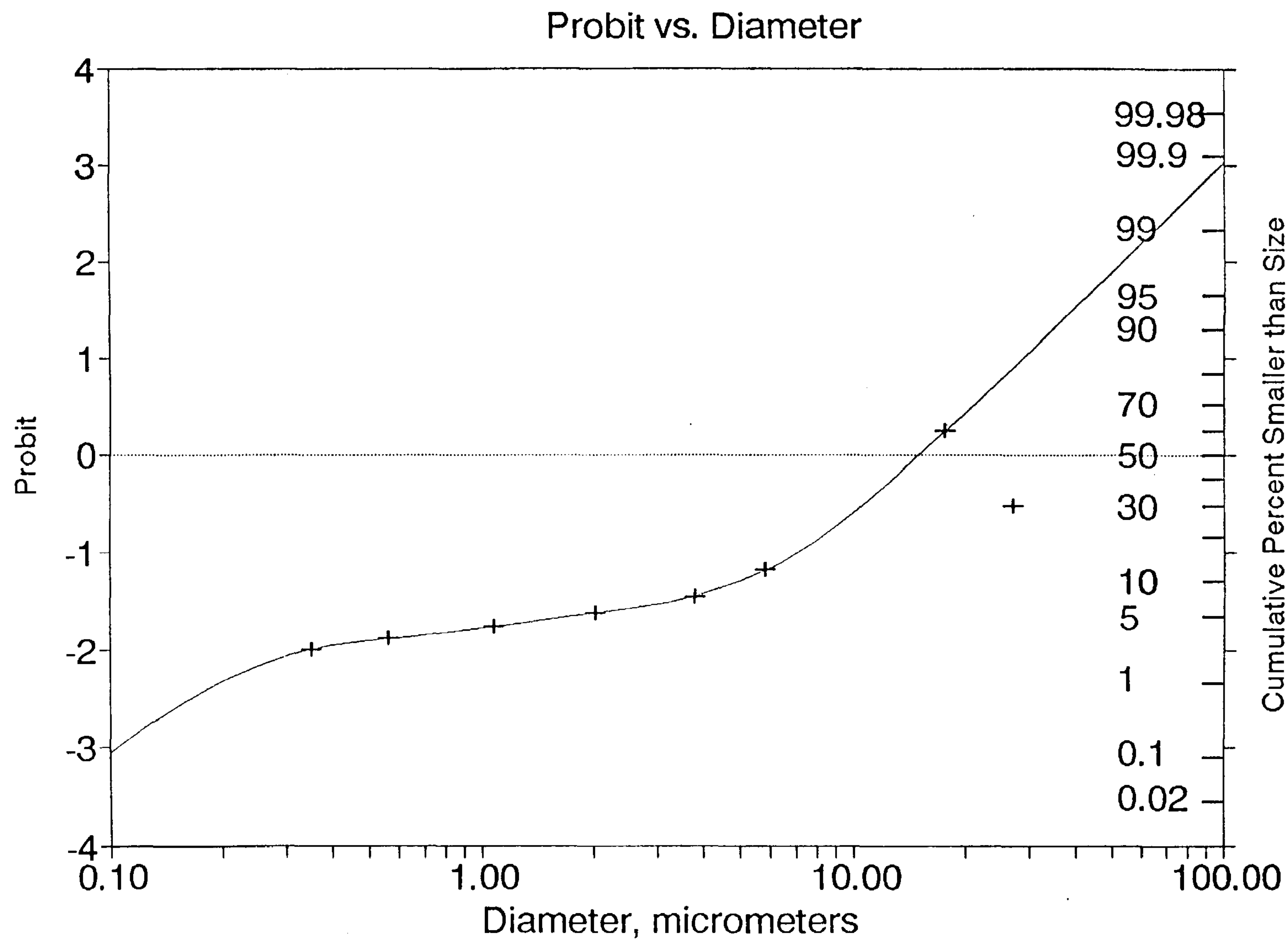
LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: Y=-1.73 + 1.14X
MASS MEDIAN DIAMETER: 33.150
GEOMETRIC STANDARD DEVIATION: 7.535
CORRELATION COEFFICIENT: 0.802

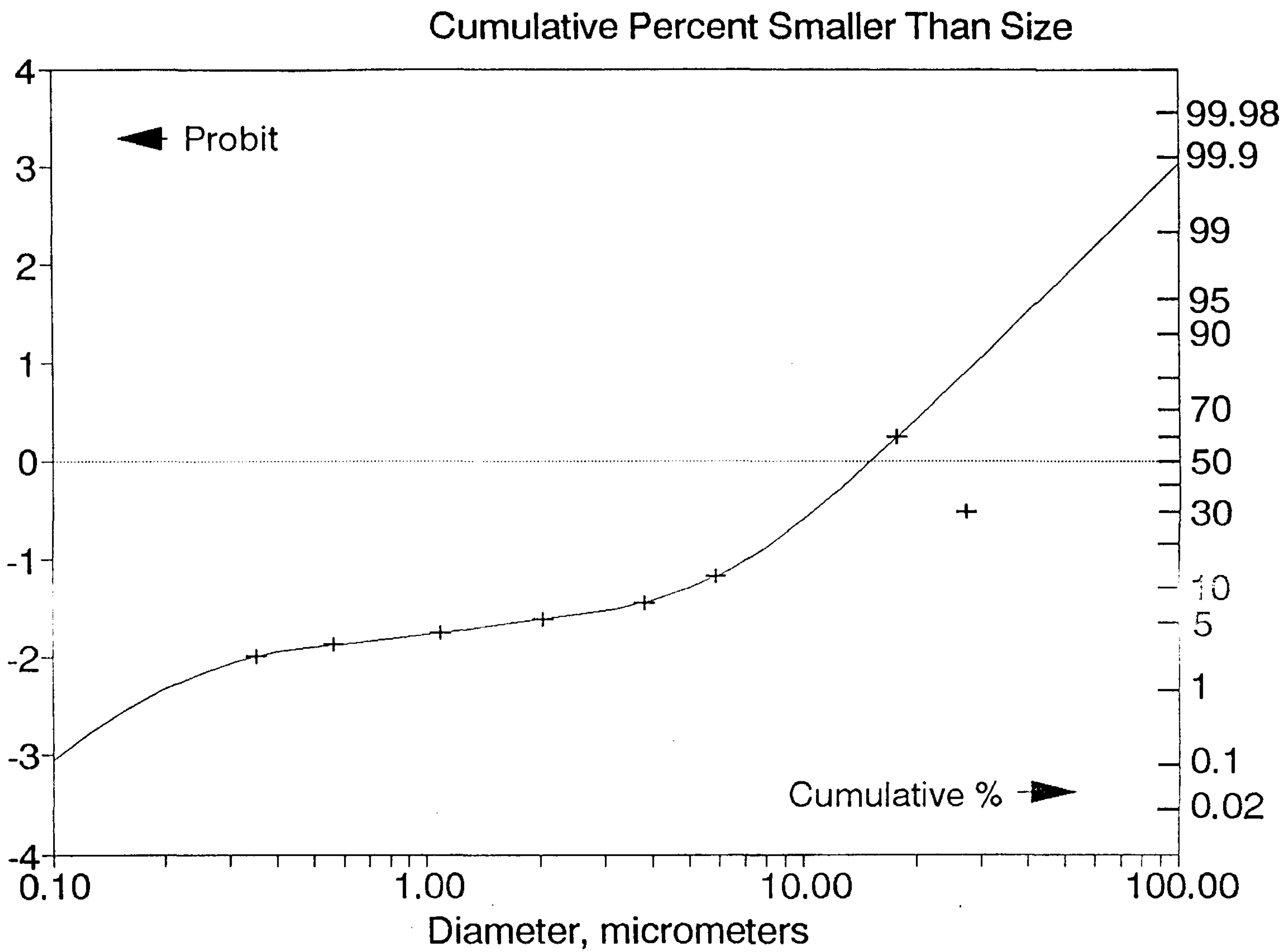

Cumulative Concentration vs. Diameter
7.0E+03
6.0E+03
5.0E+03
4.0E+03
3.0E+03
2.0E+03
1.0E+03
0.0E+00
Concentration, mg/dncm
1.0E-01
1.0E+00
1.0E+01
1.0E+02
Diameter, micrometers

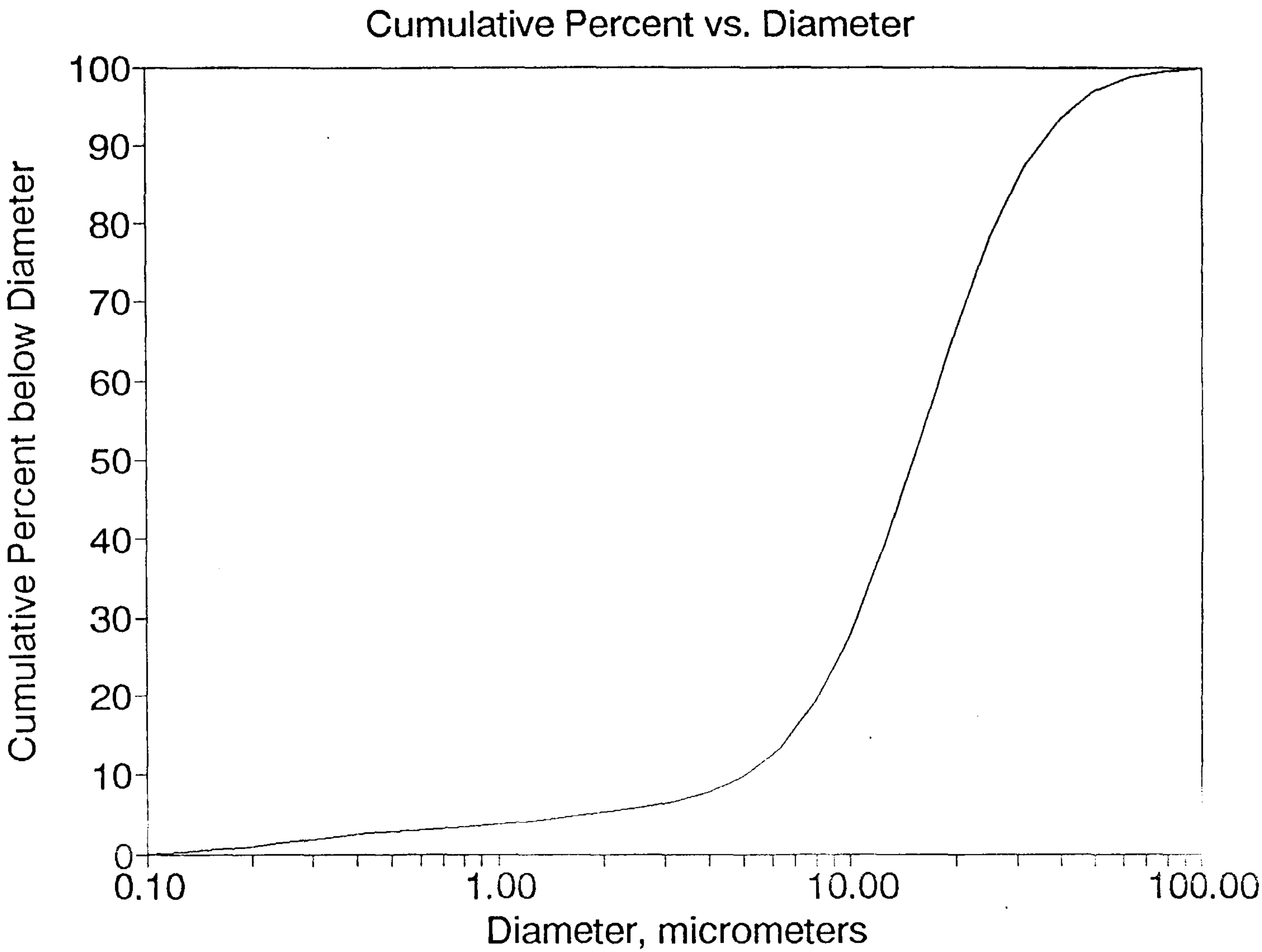

Differential Mass Distribution
dM/dLogD, mg/dncm
1.0E+04
9.0E+03
8.0E+03
7.0E+03
6.0E+03
5.0E+03
4.0E+03
3.0E+03
2.0E+03
1.0E+03
0.0E+00
0.10
1.00
10.00
100.00
Diameter, micrometers


Cumulative Percent vs. Diameter
Percent Smaller than Diameter
99.98
99.9
99
95
90
70
50
30
10
5
1
0.1
0.02
0.10
1.00
10.00
100.00
Diameter, micrometers



Probit vs. Diameter
Probit
4
3
2
1
0
-1
-2
-3
-4
0.10
1.00
10.00
100.00
Diameter, micrometers
99.98
99.9
99
95
90
70
50
30
10
5
1
0.1
0.02
Cumulative Percent Smaller than Size


Cumulative Percent Smaller Than Size
Probit
Cumulative %
4
3
2
1
0
-1
-2
-3
-4
99.98
99.9
99
95
90
70
50
30
10
5
1
0.1
0.02
0.10
1.00
10.00
100.00
Diameter, micrometers


Cumulative Percent vs. Diameter
Cumulative Percent below Diameter
100
90
80
70
60
50
40
30
20
10
0
0.10
1.00
10.00
100.00
Diameter, micrometers

CARB UW IMPACTOR DATA REDUCTION PROGRAM, VERSION X R4

INPUT DATA

PART. DIAMETER   CLASSICAL AERODYNAMIC
DATE OF TEST: 1/26/94
TIME OF TEST: 1830
LOCATION OF TEST: SRI Comb. between tube banks
TEST DESIG.: cmb
TEST TYPE   INLET
RUN NUMBER: 2-FILE NAME:TcmbR2.IT
RUN REMARKS:
IMPACTOR TYPE: Comb2
HTPC Inlet 3 4 5 7 9 11

WATER VAPOR	7.00%		
CO_2 14.00%		CO	0.00%
O_2 6.00%		N_2	80.00%

ORIFICE ID (OPTIONAL): NT#1
SUBSTRATE MATERIAL, G)rease or Bare metal, F)ilter: F

GAS METER VOL	1.748	cf
IMPACTOR DELTA P	0.00	IN. HG. (0 for calc. from theory)
ORIFICE DELTA P	0.08	INCHES H2O
STACK PRESSURE	-1.0	INCHES H2O
BAROMETRIC PRES	29.50	INCHES HG
STACK TEMP	1500	DEGREES F
METER TEMP	100	DEGREES F
IMPACTOR TEMP	350	DEGREES F
SAMPLE TIME	10.00	MINUTES
AVG GAS VEL	29.00	FEET/SEC
ORI P WRT PBAR	-0.01	INCHES HG
NOZZLE DIA	0.250	INCHES
MAX PART DIA	1000	MICRONS
WATER VOLUME	0.0	CC
METER FACTOR	1.0000	

MASS GAIN OF STAGE 1	276.20	MG
MASS GAIN OF STAGE 2	102.60	MG
MASS GAIN OF STAGE 3	65.60	MG
MASS GAIN OF STAGE 4	30.00	MG
MASS GAIN OF STAGE 5	17.70	MG
MASS GAIN OF STAGE 6	9.00	MG
MASS GAIN OF STAGE 7	5.40	MG
MASS GAIN OF STAGE 8	2.50	MG
MASS GAIN OF FILTER	6.20	MG

MASS GAIN OF BLANK SUBSTRATE	0.10
MASS GAIN OF BLANK FILTER	0.20

RESULTS

TEST DESIG.: cmb RUN NUMBER: 2
HTPC Inlet 3 4 5 7 9 11

ACTUAL FLOW RATE 0.272 CFM
FLOW RATE AT STANDARD CONDITIONS 0.162 CFM
PERCENT ISOKINETIC 111.123 %
VISCOSITY 233.0E-06 GM/CM-SEC
CALCULATED IMPACTOR DELTA P = 0.51 IN. HG

STAGE	CUNN. CORR.	D50 (CLAS AERO)	D50 (IMP AERO)	CUM FREQ.	RE. NO.	V*D50 UM-M/S	
1	1.048	15.016	15.373	46.3049	241	36.9	
2	1.011	24.117	24.244	26.3711	437	24.5	skip
3	1.036	7.020	7.147	13.6328	190	16.1	
4	1.054	4.747	4.873	7.8180	78	13.8	
5	1.085	3.019	3.144	4.3952	99	17.4	
6	1.159	1.606	1.730	2.6643	147	20.3	
7	1.305	0.847	0.968	1.6336	202	19.3	
8	1.613	0.441	0.560	1.1669	378	18.9	

STAGE CUT DIAMETERS BASED ON THEORETICAL VALUES OF STAGE CONSTANTS

PARTICLE DENSITY = 1

TOTAL MASS CONCENTRATION = 1.12E+04 MG/DRY NORMAL CUBIC METER
= 2.75E+03 MG/ACTUAL CUBIC METER
= 4.88E+00 GRAINS/DRY STD CUBIC FOOT
= 1.20E+00 GRAINS/ACTUAL CUBIC FOOT

TEST DESIG.: cmb RUN NUMBER: 2

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMFR (STDDEV)	CUMFR (PERCENT)	CUM.MASS (MG/DRY	DM/DLOGD N.CU.METER)
0.100	-3.4388	0.03	3.29E+00	3.33E+01
0.126	-3.1754	0.08	8.40E+00	7.22E+01
0.158	-2.9384	0.17	1.85E+01	1.33E+02
0.200	-2.7303	0.32	3.55E+01	2.07E+02
0.251	-2.5535	0.53	5.97E+01	2.74E+02
0.316	-2.4104	0.80	8.92E+01	3.06E+02
0.398	-2.3034	1.06	1.19E+02	2.77E+02
0.501	-2.2342	1.27	1.42E+02	1.93E+02
0.631	-2.1910	1.42	1.59E+02	1.53E+02
0.794	-2.1505	1.58	1.76E+02	2.07E+02
1.000	-2.0916	1.82	2.04E+02	3.49E+02
1.259	-2.0158	2.19	2.45E+02	4.65E+02
1.585	-1.9374	2.64	2.95E+02	5.12E+02
1.995	-1.8659	3.10	3.47E+02	5.59E+02
2.512	-1.7878	3.69	4.13E+02	7.96E+02
3.162	-1.6826	4.62	5.17E+02	1.35E+03
3.981	-1.5411	6.16	6.89E+02	2.11E+03
5.012	-1.3783	8.40	9.40E+02	2.91E+03
6.310	-1.1962	11.58	1.29E+03	4.39E+03
7.943	-0.9657	16.71	1.87E+03	7.30E+03
10.000	-0.6798	24.83	2.78E+03	1.09E+04
12.589	-0.3556	36.11	4.04E+03	1.41E+04
15.849	-0.0108	49.57	5.54E+03	1.56E+04
19.953	0.3419	63.38	7.08E+03	1.50E+04
25.119	0.7009	75.83	8.48E+03	1.26E+04
31.623	1.0659	85.68	9.58E+03	9.29E+03
39.811	1.4364	92.46	1.03E+04	5.93E+03
50.119	1.8121	96.50	1.08E+04	3.27E+03
63.096	2.1926	98.58	1.10E+04	1.54E+03
79.433	2.5776	99.50	1.11E+04	6.23E+02
100.000	2.9667	99.85	1.12E+04	2.14E+02
125.893	3.3594	99.96	1.12E+04	6.23E+01
158.489	3.7555	99.99	1.12E+04	1.54E+01
199.526	4.1546	100.00	1.12E+04	3.19E+00
251.189	4.5563	100.00	1.12E+04	5.58E-01
316.228	4.9602	100.00	1.12E+04	8.21E-02
398.107	5.3659	100.00	1.12E+04	1.01E-02
501.187	5.7731	100.00	1.12E+04	1.05E-03
630.957	6.1815	100.00	1.12E+04	9.19E-05
794.328	6.5905	100.00	1.12E+04	6.75E-06
1000.000	7.0000	100.00	1.12E+04	4.18E-07

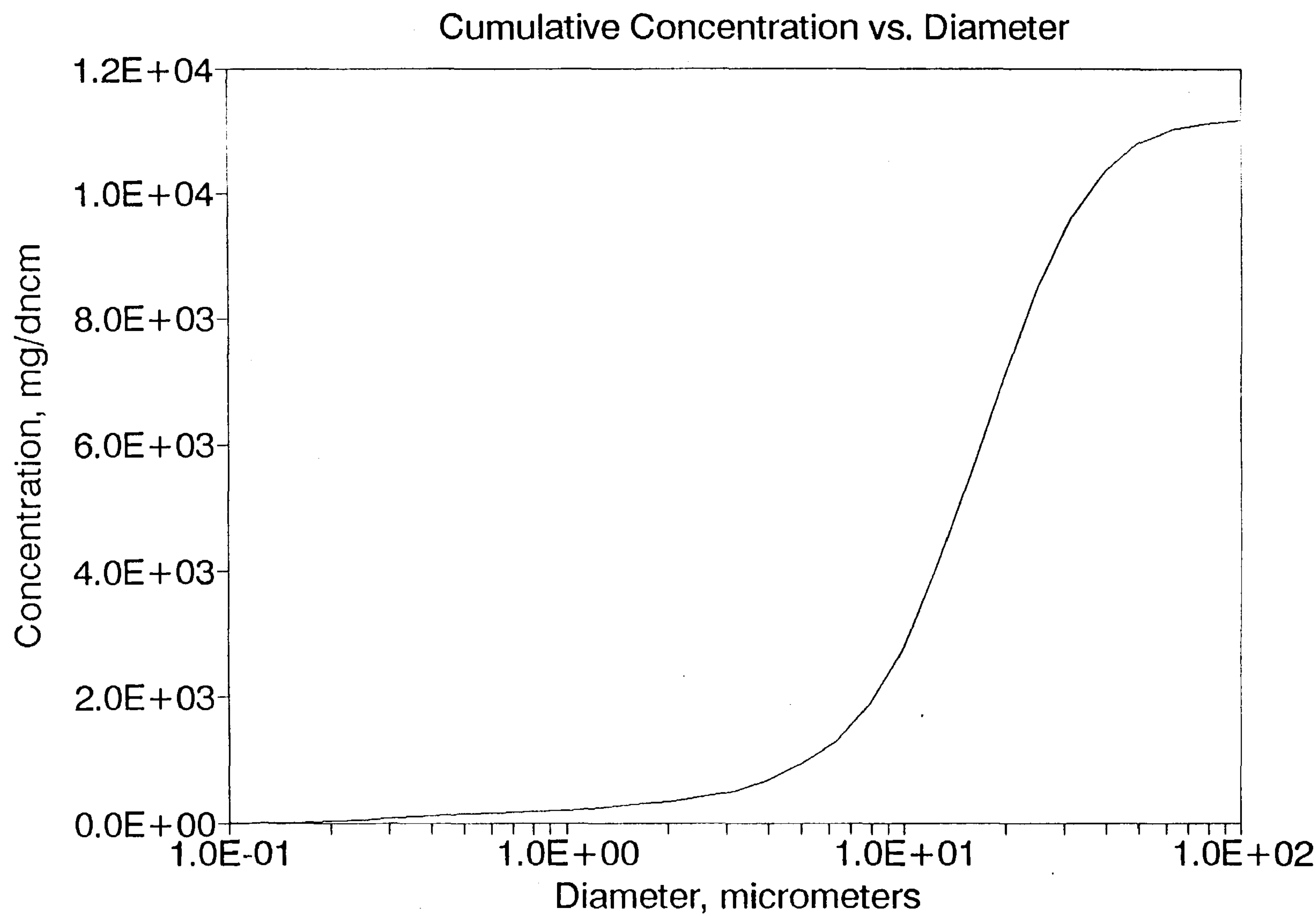
INHALABLE PARTICULATE MATTER

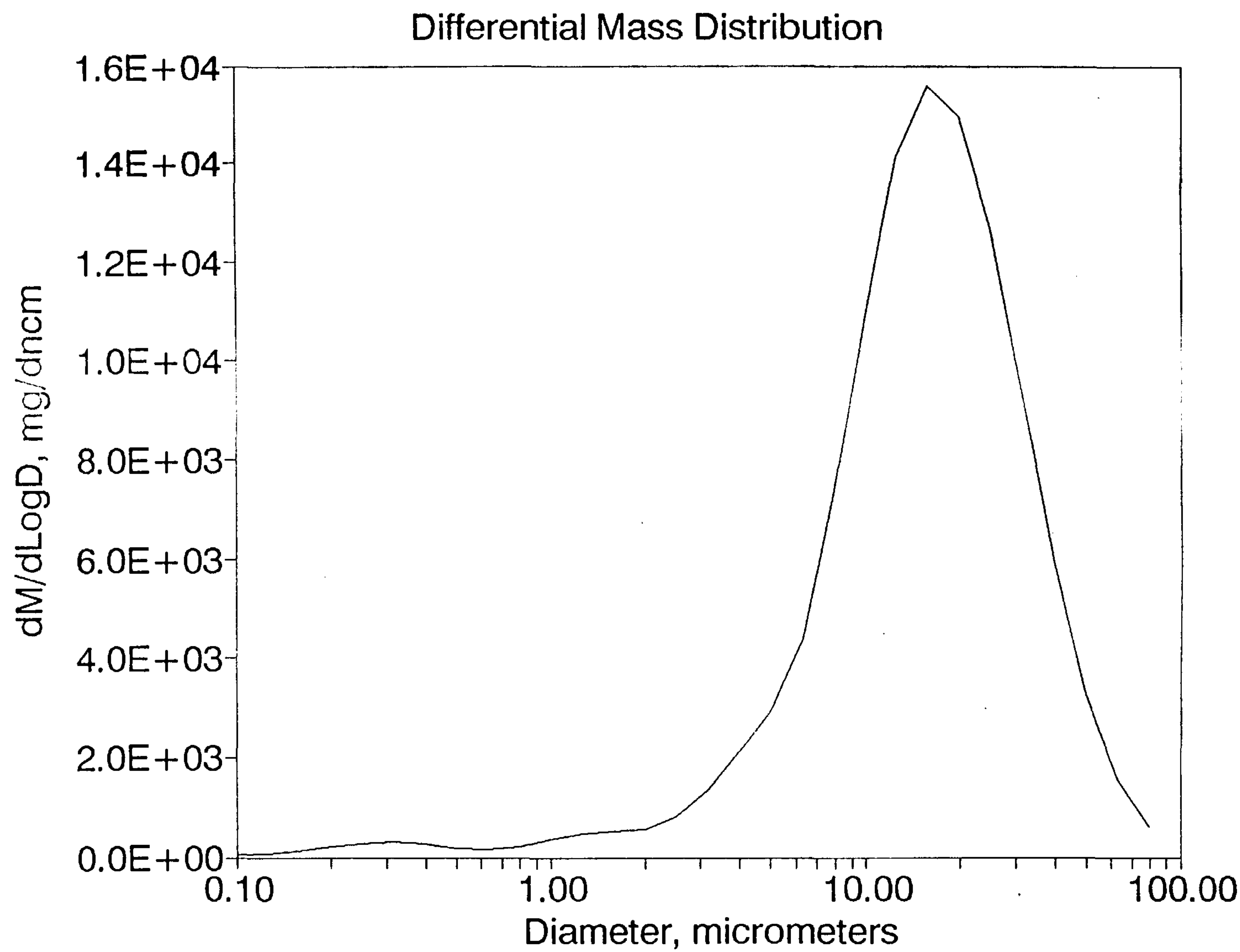
CUM MASS LESS THAN 1.000 MICRON: 203.97 1.8247 %
CUM MASS LESS THAN 2.512 MICRON: 412.61 3.6911 %
CUM MASS LESS THAN 10.000 MICRON: %2775.86 24.8324 %
CUM MASS LESS THAN 15.849 MICRON: %5540.87 49.5678 %
NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE
ON CLASSICAL AERODYNAMIC BASIS.

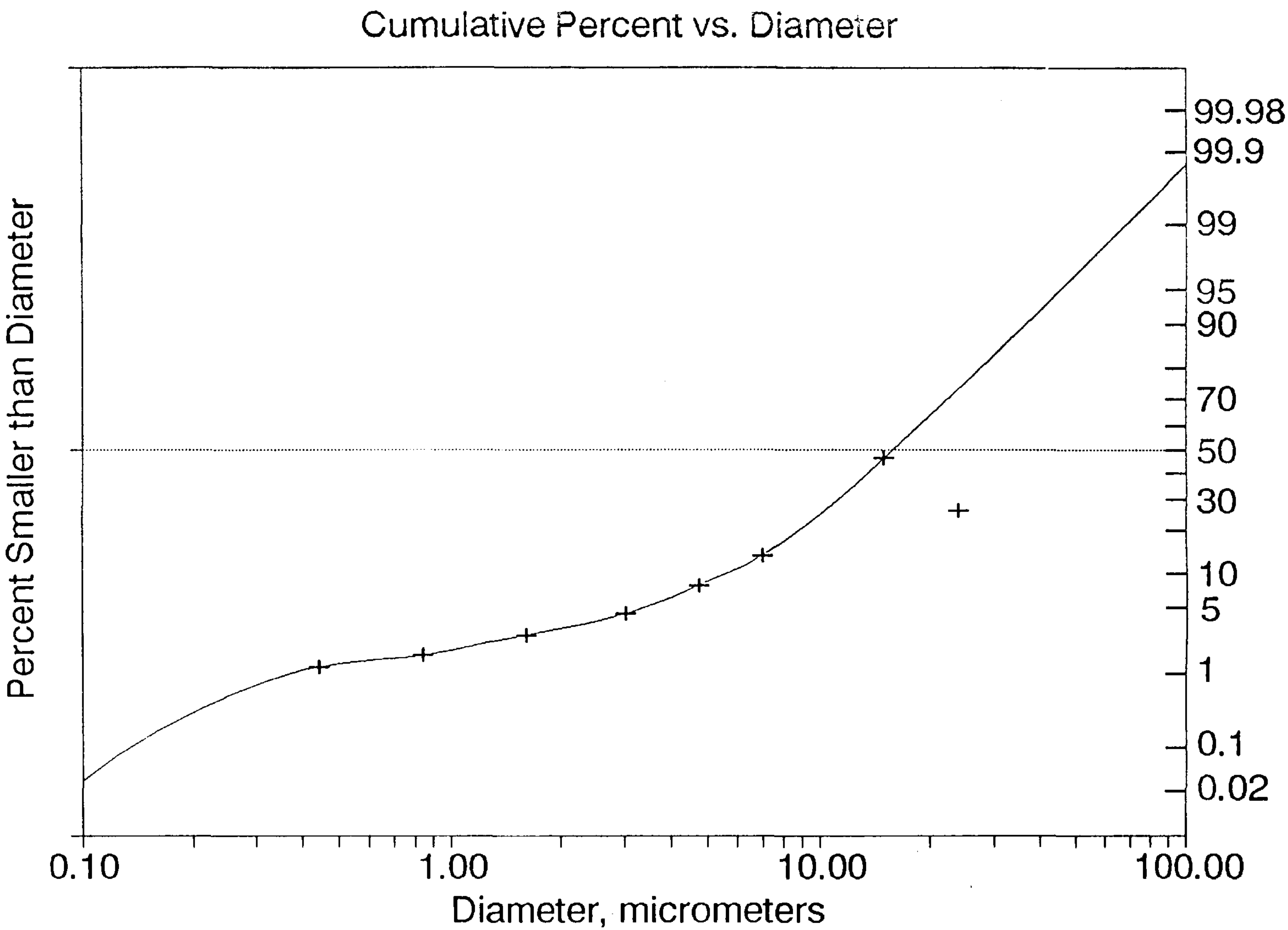
LOG-NORMAL APPROXIMATION

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

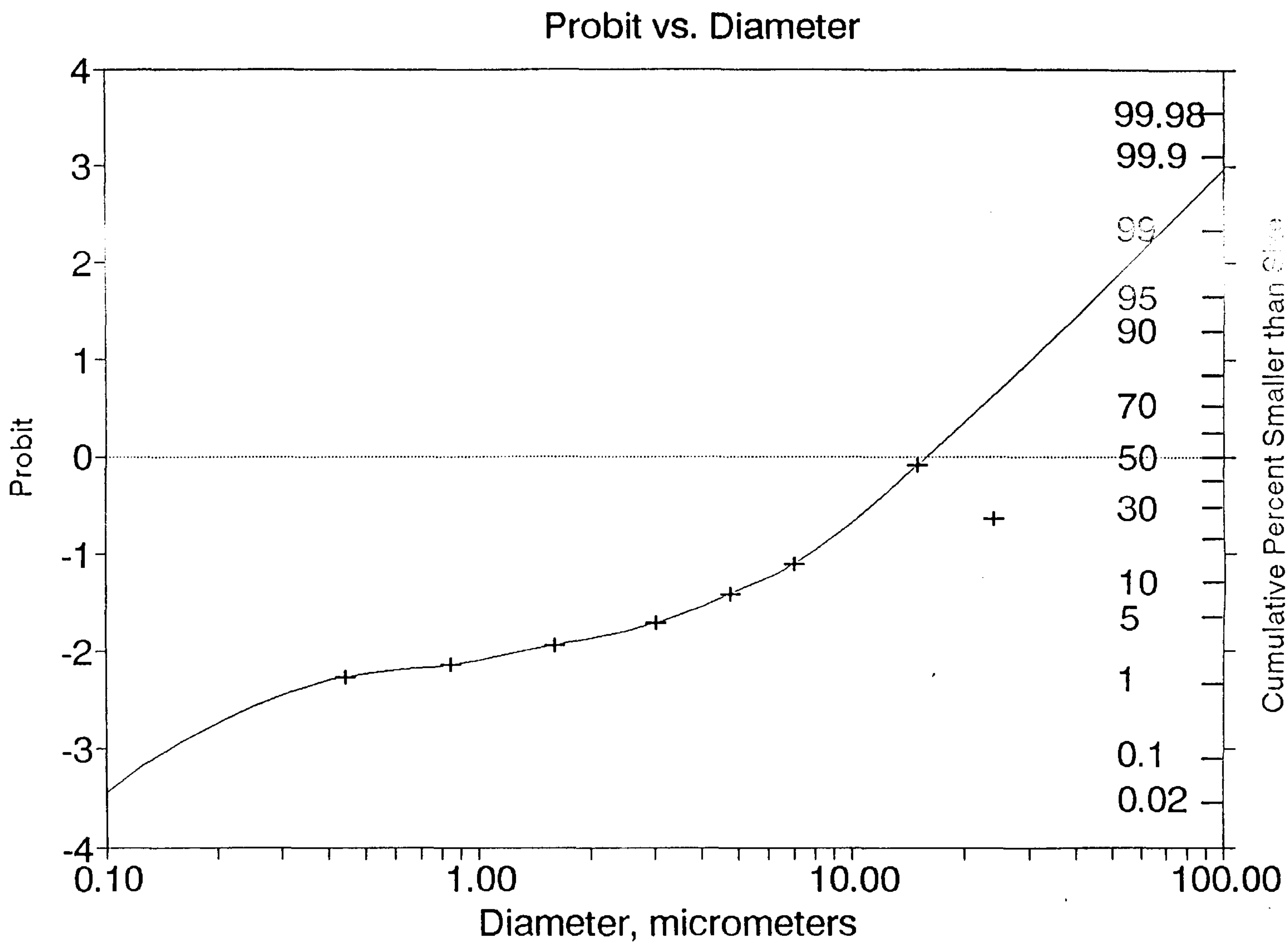
LEAST SQUARES LINE: Y=-2.08 + 1.31X
MASS MEDIAN DIAMETER: 38.230
GEOMETRIC STANDARD DEVIATION: 5.785
CORRELATION COEFFICIENT: 0.874


Cumulative Concentration vs. Diameter
1.2E+04
1.0E+04
8.0E+03
6.0E+03
4.0E+03
2.0E+03
0.0E+00
Concentration, mg/dncm
1.0E-01
1.0E+00
1.0E+01
1.0E+02
Diameter, micrometers

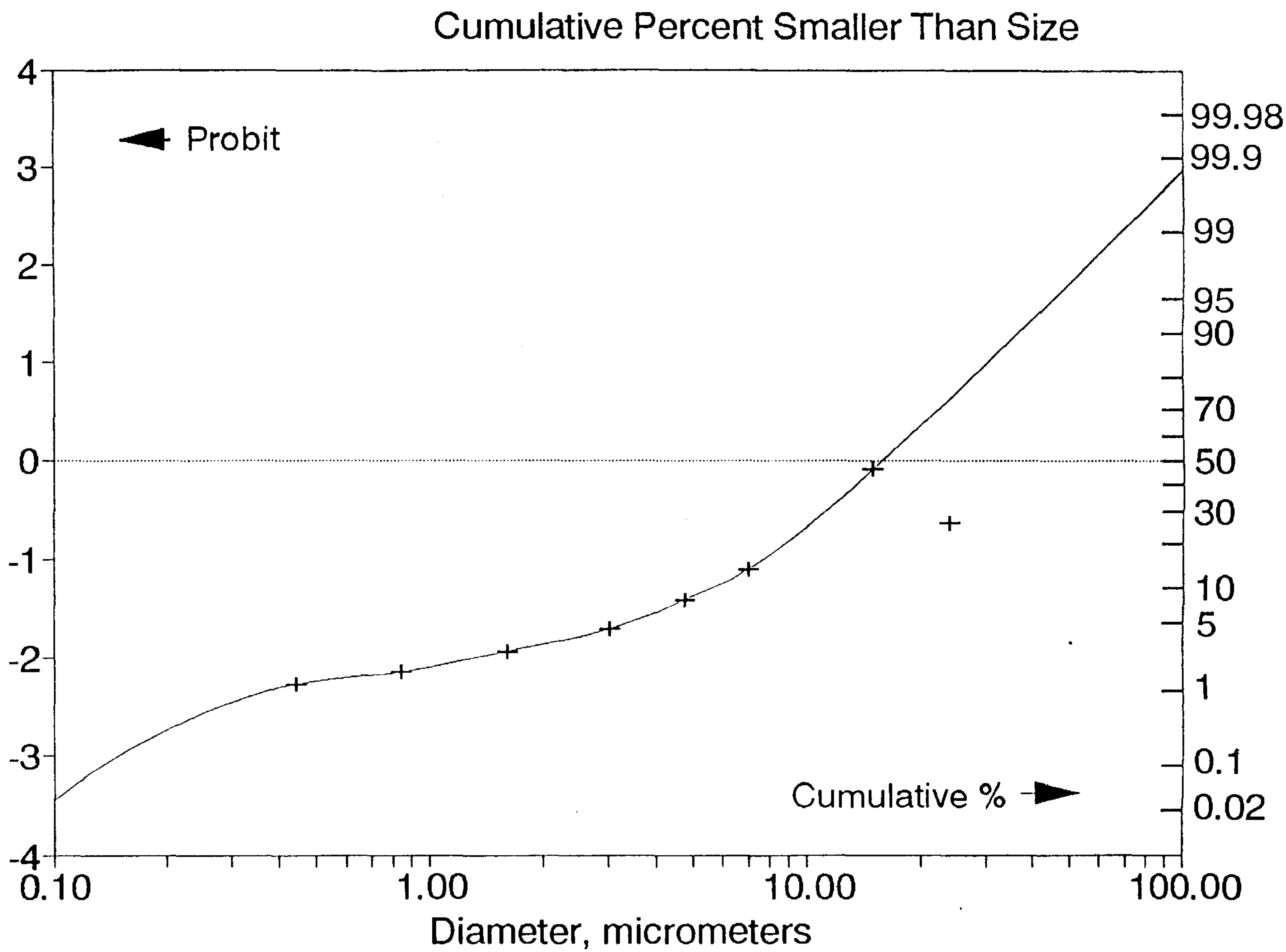

Differential Mass Distribution
1.6E+04
1.4E+04
1.2E+04
1.0E+04
8.0E+03
6.0E+03
4.0E+03
2.0E+03
0.0E+00
dM/dLogD, mg/dncm
0.10
1.00
10.00
100.00
Diameter, micrometers

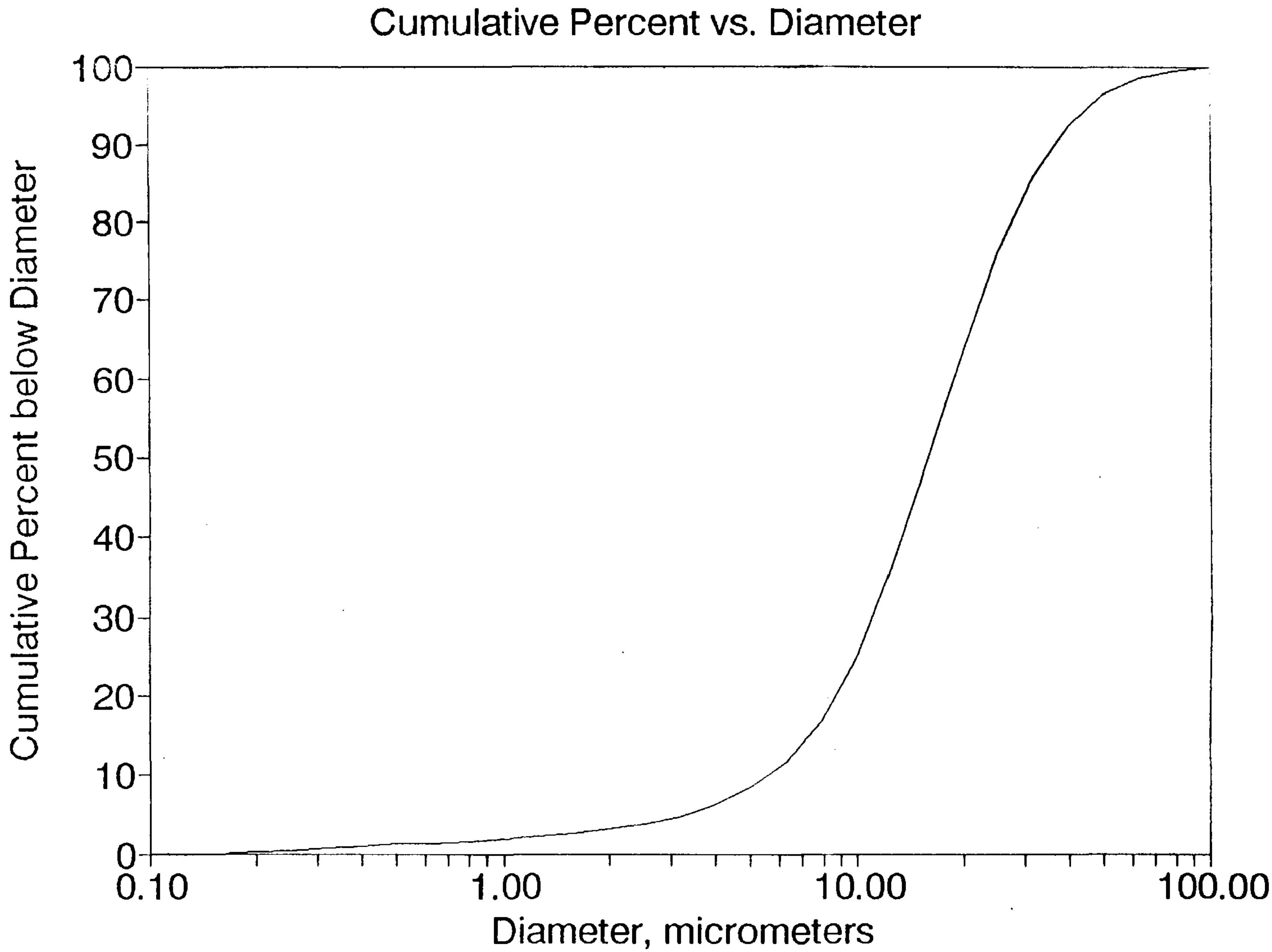


Cumulative Percent vs. Diameter
Percent Smaller than Diameter
99.98
99.9
99
95
90
70
50
30
10
5
1
0.1
0.02
0.10
1.00
10.00
100.00
Diameter, micrometers



Probit vs. Diameter
Probit
4
3
2
1
0
-1
-2
-3
-4
0.10
1.00
10.00
100.00
Diameter, micrometers
99.98
99.9
99
95
90
70
50
30
10
5
1
0.1
0.02
Cumulative Percent Smaller than Size


Cumulative Percent Smaller Than Size
Probit
Cumulative %
Diameter, micrometers
4
3
2
1
0
-1
-2
-3
-4
0.10
1.00
10.00
100.00
99.98
99.9
99
95
90
70
50
30
10
5
1
0.1
0.02



Cumulative Percent vs. Diameter
Cumulative Percent below Diameter
100
90
80
70
60
50
40
30
20
10
0
0.10
1.00
10.00
100.00
Diameter, micrometers

D2

ARB Demos

Wet Demo 1								
	Final grams	Initial grams	Diff. grams		Total mg		Correction mg	Corrected Net, mg
pc	1.4984	1.4974	-0.0010					
	1.5338	1.5355	0.0017		0.7	x	-0.3	1.0
tube	1.5392	1.5405	0.0013		3.6	x	-0.4	4.0
	1.5228	1.524	0.0012					
	1.5574	1.5585	0.0011					
Wet Demo 2								
pc	1.5599	1.5621	0.0022					
	1.5583	1.5589	0.0006		2.8	x	-0.3	3.1
tube	1.5555	1.5555	0.0000		2.5	x	-0.4	2.9
	1.5192	1.5202	0.0010					
	1.5534	1.5549	0.0015					
Wet Demo 3								
pc	1.5631	1.5636	0.0005					
	1.5481	1.5492	0.0011		1.6	x	-0.3	1.9
tube	1.5519	1.5525	0.0006		2.0	x	-0.4	2.4
	1.5535	1.554	0.0005					
	1.548	1.5489	0.0009					

Flare 1								
pc	1.5411	1.5415	0.0004		0.4		-0.1	0.5
tube	1.5433	1.5435	0.0002					
	1.5508	1.5513	0.0005		1.5	x	-0.5	2.0
	1.5618	1.5621	0.0003					
	1.5432	1.5439	0.0007					
control	1.5227	1.5227	0.0000		-0.4			
	1.5422	1.542	-0.0002					
Flare 2								
pc	1.5371	1.5372	0.0001		0.1		-0.1	0.2
tube	1.5361	1.5358	-0.0003					
	1.5248	1.5248	0.0000		-0.6		-0.5	-0.1
	1.5278	1.5279	0.0001					
	1.5426	1.5424	-0.0002					
control	1.5264	1.5262	-0.0002		-0.4			
	1.5601	1.5601	0.0000					
Flare 3								
pc	1.5464	1.5462	-0.0002		-0.2		-0.5	0.3
tube	1.543	1.5424	-0.0006					
	1.5523	1.5515	-0.0008		-2.8		-2.2	-0.6
	1.5476	1.5468	-0.0008					
	1.5267	1.5261	-0.0006					
control	1.5287	1.5281	-0.0006		-2.2			
	1.5414	1.5409	-0.0005					

Pooled Controls								
	1.5528	1.5534	0.0006					
	1.5227	1.5227	0.0000					
	1.5422	1.542	-0.0002					
	1.5264	1.5262	-0.0002					
	1.5601	1.5601	0.0000					
	1.5287	1.5281	-0.0006		Avg		Std dev	
	1.5414	1.5409	-0.0005		-0.13		0.37	
				2 X avg. blank	-0.3			
				3 X avg. blank	-0.4			
				4 X avg. blank	-0.5			
Flare Blank Washes								
pc	1.539	1.5392	0.0002		0.2			
tube	1.5352	1.5353	0.0001		-0.6			
	1.5537	1.5533	-0.0004					
	1.5318	1.5316	-0.0002					
	1.5437	1.5436	-0.0001					

INPUT DATA

PART. DIAMETER   CLASSICAL AERODYNAMIC
DATE OF TEST: 3/14
TIME OF TEST: 1505
LOCATION OF TEST: Incinerator stack
TEST DESIG.: arb
TEST TYPE   OUTLET
RUN NUMBER: 1-FILE NAME:TarbR1.OT
RUN REMARKS: Probe residue combined with Inlet stage.
IMPACTOR TYPE: wetl
LDPC Inlet 2 3 4 5 7 9

WATER VAPOR   29.24%
CO_2 14.00%   CO   0.00%
O_2 6.00% N_2 80.00%
ORIFICE ID (OPTIONAL): arb
SUBSTRATE MATERIAL, G)rease or Bare metal, F)ilter: F

GAS METER VOL	21.631	cf
IMPACTOR DELTA P	0.00	IN. HG. (0 for calc. from theory)
ORIFICE DELTA P	0.50	INCHES H2O
STACK PRESSURE	-1.0	INCHES H2O
BAROMETRIC PRES	29.50	INCHES HG
STACK TEMP	158	DEGREES F
METER TEMP	60	DEGREES F
IMPACTOR TEMP	264	DEGREES F
SAMPLE TIME	61.00	MINUTES
AVG GAS VEL	0.00	FEET/SEC
ORI P WRT PBAR	-0.07	INCHES HG
NOZZLE DIA	0.250	INCHES
MAX PART DIA	1000	MICRONS
WATER VOLUME	204.0	CC
METER FACTOR	1.0800	

MASS GAIN OF STAGE 1	1.00	MG
MASS GAIN OF STAGE 2	4.00	MG
MASS GAIN OF STAGE 3	0.30	MG
MASS GAIN OF STAGE 4	0.50	MG
MASS GAIN OF STAGE 5	0.40	MG
MASS GAIN OF STAGE 6	0.70	MG
MASS GAIN OF STAGE 7	2.00	MG
MASS GAIN OF STAGE 8	2.70	MG
MASS GAIN OF FILTER	10.60	MG

MASS GAIN OF BLANK SUBSTRATE   0.00
MASS GAIN OF BLANK FILTER   0.20

RESULTS

TEST DESIG.: arb RUN NUMBER: 1
LDPC Inlet 2 3 4 5 7 9

ACTUAL FLOW RATE 0.753 CFM
FLOW RATE AT STANDARD CONDITIONS 0.382 CFM
PERCENT ISOKINETIC 0.000 %
VISCOSITY 201.4E-06 GM/CM-SEC
CALCULATED IMPACTOR DELTA P = 1.19 IN. HG

STAGE	CUNN. CORR.	D50 (CLAS AERO)	D50 (IMP AERO)	CUM FREQ.	RE. NO.	V*D50 UM-M/S	
1	1.018	9.967	10.056	77.2727	1618	23.9	
2	1.016	13.370	13.479	77.2727	1417	37.5	skip
3	1.022	10.084	10.193	75.9091	518	22.7	skip
4	1.058	3.787	3.895	73.6364	615	24.0	
5	1.111	1.986	2.093	71.8182	253	16.0	
6	1.196	1.123	1.228	68.6364	322	17.9	
7	1.413	0.545	0.648	59.5455	477	19.1	
8	1.913	0.265	0.367	47.2728	654	16.8	

STAGE CUT DIAMETERS BASED ON THEORETICAL VALUES OF STAGE CONSTANTS

PARTICLE DENSITY = 1

TOTAL MASS CONCENTRATION = 3.33E+01 MG/DRY NORMAL CUBIC METER
= 1.98E+01 MG/ACTUAL CUBIC METER
= 1.46E-02 GRAINS/DRY STD CUBIC FOOT
= 8.66E-03 GRAINS/ACTUAL CUBIC FOOT

TEST DESIG.: arb RUN NUMBER: 1

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMFR (STDDEV)	CUMFR (PERCENT)	CUM.MASS (MG/DRY	DM/DLOGD N.CU.METER)
0.100	-1.3116	9.48	3.16E+00	2.30E+01
0.126	-0.9271	17.69	5.90E+00	3.11E+01
0.158	-0.5953	27.58	9.19E+00	3.38E+01
0.200	-0.3210	37.41	1.25E+01	3.08E+01
0.251	-0.1089	45.66	1.52E+01	2.37E+01
0.316	0.0384	51.53	1.72E+01	1.58E+01
0.398	0.1374	55.46	1.85E+01	1.10E+01
0.501	0.2140	58.47	1.95E+01	9.63E+00
0.631	0.2925	61.50	2.05E+01	1.06E+01
0.794	0.3760	64.66	2.16E+01	1.02E+01
1.000	0.4529	67.47	2.25E+01	8.34E+00
1.259	0.5114	69.55	2.32E+01	5.52E+00
1.585	0.5501	70.89	2.36E+01	3.61E+00
1.995	0.5776	71.82	2.39E+01	2.80E+00
2.512	0.6010	72.61	2.42E+01	2.41E+00
3.162	0.6205	73.25	2.44E+01	1.85E+00
3.981	0.6343	73.71	2.46E+01	1.17E+00
5.012	0.6445	74.04	2.47E+01	1.21E+00
6.310	0.6601	74.54	2.48E+01	2.33E+00
7.943	0.6915	75.54	2.52E+01	4.46E+00
10.000	0.7487	77.30	2.58E+01	7.39E+00
12.589	0.8398	79.95	2.67E+01	1.01E+01
15.849	0.9650	83.27	2.78E+01	1.18E+01
19.953	1.1225	86.92	2.90E+01	1.23E+01
25.119	1.3105	90.50	3.02E+01	1.14E+01
31.623	1.5271	93.66	3.12E+01	9.55E+00
39.811	1.7707	96.17	3.21E+01	7.11E+00
50.119	2.0393	97.93	3.26E+01	4.66E+00
63.096	2.3313	99.01	3.30E+01	2.66E+00
79.433	2.6447	99.59	3.32E+01	1.30E+00
100.000	2.9779	99.85	3.33E+01	5.40E-01
125.893	3.3290	99.96	3.33E+01	1.87E-01
158.489	3.6963	99.99	3.33E+01	5.38E-02
199.526	4.0779	100.00	3.33E+01	1.26E-02
251.189	4.4720	100.00	3.33E+01	2.42E-03
316.228	4.8769	100.00	3.33E+01	3.73E-04
398.107	5.2908	100.00	3.33E+01	4.64E-05
501.187	5.7118	100.00	3.33E+01	4.64E-06
630.957	6.1382	100.00	3.33E+01	3.75E-07
794.328	6.5682	100.00	3.33E+01	2.46E-08
1000.000	7.0000	100.00	3.33E+01	1.32E-09

INHALABLE PARTICULATE MATTER

CUM MASS LESS THAN	1.000 MICRON:	22.49	67.4673 %
CUM MASS LESS THAN	2.512 MICRON:	24.20	72.6079 %
CUM MASS LESS THAN	10.000 MICRON:	25.77	77.2966 %
CUM MASS LESS THAN	15.849 MICRON:	27.76	83.2741 %

NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL APPROXIMATION

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: Y= 0.35 + 0.50X
MASS MEDIAN DIAMETER: 0.202
GEOMETRIC STANDARD DEVIATION: 101.731
CORRELATION COEFFICIENT: 0.898

CARB UW IMPACTOR DATA REDUCTION PROGRAM, VERSION X R4

INPUT DATA

```
PART. DIAMETER    CLASSICAL AERODYNAMIC
DATE OF TEST:  3/15
TIME OF TEST:  0955
LOCATION OF TEST:  Incinerator stack
TEST DESIG.:  arb
TEST TYPE          OUTLET
RUN NUMBER:  2-FILE NAME:TarbR2.OT
RUN REMARKS:  Probe residue combined with Inlet stage
IMPACTOR TYPE: arbl
  LDPC Inlet 2 3 4 5 7 9

WATER VAPOR          34.94%
 CO2   14.00%        CO     0.00%
 O2     6.00%        N2    80.00%
ORIFICE ID (OPTIONAL):  arb
SUBSTRATE MATERIAL, G)rease or Bare metal, F)ilter:   F

GAS METER VOL        21.617 cf
IMPACTOR DELTA P      0.00 IN. HG. (0 for calc. from theory)
ORIFICE DELTA P       0.50 INCHES H2O
STACK PRESSURE       -1.0  INCHES H2O
BAROMETRIC PRES      29.50 INCHES HG
STACK TEMP          166    DEGREES F
METER TEMP           60    DEGREES F
IMPACTOR TEMP       278    DEGREES F
SAMPLE TIME          60.00 MINUTES
AVG GAS VEL           0.00 FEET/SEC
ORI P WRT PBAR       -0.07 INCHES HG
NOZZLE DIA            0.250 INCHES
MAX PART DIA      1000     MICRONS
WATER VOLUME       265.0  CC
METER FACTOR         1.0800

MASS GAIN OF STAGE  1   3.10 MG
MASS GAIN OF STAGE  2   2.90 MG
MASS GAIN OF STAGE  3   0.10 MG
MASS GAIN OF STAGE  4   0.30 MG
MASS GAIN OF STAGE  5   0.70 MG
MASS GAIN OF STAGE  6   1.80 MG
MASS GAIN OF STAGE  7   4.60 MG
MASS GAIN OF STAGE  8   7.70 MG
MASS GAIN OF FILTER   20.40 MG

MASS GAIN OF BLANK SUBSTRATE    0.10
MASS GAIN OF BLANK FILTER      -0.10
```

RESULTS

TEST DESIG.: arb RUN NUMBER: 2
LDPC Inlet 2 3 4 5 7 9

ACTUAL FLOW RATE 0.848 CFM
FLOW RATE AT STANDARD CONDITIONS 0.388 CFM
PERCENT ISOKINETIC 0.000 %
VISCOSITY 202.0E-06 GM/CM-SEC
CALCULATED IMPACTOR DELTA P = 1.45 IN. HG

STAGE	CUNN. CORR.	D50 (CLAS AERO)	D50 (IMP AERO)	CUM FREQ.	RE. NO.	V*D50 UM-M/S	
1	1.019	9.395	9.485	85.8191	1747	25.2	
2	1.018	12.594	12.706	85.8191	1520	39.8	skip
3	1.024	9.496	9.608	85.8191	556	24.0	skip
4	1.063	3.555	3.666	85.3301	660	25.4	
5	1.122	1.845	1.955	83.8631	271	16.7	
6	1.219	1.031	1.139	79.7066	345	18.5	
7	1.475	0.491	0.596	68.7041	512	19.4	
8	2.101	0.231	0.334	50.1222	702	16.5	

STAGE CUT DIAMETERS BASED ON THEORETICAL VALUES OF STAGE CONSTANTS

PARTICLE DENSITY = 1

TOTAL MASS CONCENTRATION = 6.20E+01 MG/DRY NORMAL CUBIC METER
= 3.35E+01 MG/ACTUAL CUBIC METER
= 2.71E-02 GRAINS/DRY STD CUBIC FOOT
= 1.46E-02 GRAINS/ACTUAL CUBIC FOOT

TEST DESIG.: arb RUN NUMBER: 2

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMFR (STDDEV)	CUMFR (PERCENT)	CUM.MASS (MG/DRY	DM/DLOGD N.CU.METER)
0.100	-1.1768	11.96	7.42E+00	5.23E+01
0.126	-0.7789	21.80	1.35E+01	6.80E+01
0.158	-0.4337	33.23	2.06E+01	7.15E+01
0.200	-0.1459	44.20	2.74E+01	6.30E+01
0.251	0.0798	53.18	3.30E+01	4.80E+01
0.316	0.2491	59.83	3.71E+01	3.53E+01
0.398	0.3815	64.86	4.02E+01	2.78E+01
0.501	0.4978	69.07	4.28E+01	2.51E+01
0.631	0.6126	72.99	4.53E+01	2.33E+01
0.794	0.7222	76.49	4.74E+01	1.99E+01
1.000	0.8193	79.37	4.92E+01	1.56E+01
1.259	0.8978	81.53	5.06E+01	1.14E+01
1.585	0.9578	83.09	5.15E+01	8.10E+00
1.995	1.0023	84.19	5.22E+01	5.59E+00
2.512	1.0325	84.91	5.27E+01	3.36E+00
3.162	1.0484	85.28	5.29E+01	1.20E+00
3.981	1.0532	85.39	5.30E+01	7.25E-01
5.012	1.0583	85.51	5.30E+01	7.21E-01
6.310	1.0634	85.62	5.31E+01	1.37E-01
7.943	1.0685	85.74	5.32E+01	3.13E+00
10.000	1.0860	86.13	5.34E+01	7.63E+00
12.589	1.1593	87.68	5.44E+01	1.15E+01
15.849	1.2668	89.74	5.56E+01	1.38E+01
19.953	1.4068	92.03	5.71E+01	1.43E+01
25.119	1.5773	94.26	5.85E+01	1.32E+01
31.623	1.7767	96.22	5.97E+01	1.09E+01
39.811	2.0031	97.74	6.06E+01	7.96E+00
50.119	2.2546	98.79	6.13E+01	5.13E+00
63.096	2.5296	99.43	6.17E+01	2.89E+00
79.433	2.8262	99.76	6.19E+01	1.40E+00
100.000	3.1427	99.92	6.20E+01	5.78E-01
125.893	3.4771	99.97	6.20E+01	2.01E-01
158.489	3.8277	99.99	6.20E+01	5.83E-02
199.526	4.1927	100.00	6.20E+01	1.40E-02
251.189	4.5703	100.00	6.20E+01	2.76E-03
316.228	4.9588	100.00	6.20E+01	4.45E-04
398.107	5.3562	100.00	6.20E+01	5.85E-05
501.187	5.7609	100.00	6.20E+01	6.27E-06
630.957	6.1709	100.00	6.20E+01	5.49E-07
794.328	6.5846	100.00	6.20E+01	3.95E-08
1000.000	7.0000	100.00	6.20E+01	2.36E-09

INHALABLE PARTICULATE MATTER

CUM MASS LESS THAN 1.000 MICRON: 49.22 79.3702 %
CUM MASS LESS THAN 2.512 MICRON: 52.65 84.9100 %
CUM MASS LESS THAN 10.000 MICRON: 53.41 86.1269 %
CUM MASS LESS THAN 15.849 MICRON: 55.65 89.7404 %
NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE
ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL APPROXIMATION

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: Y= 0.65 + 0.65X
MASS MEDIAN DIAMETER: 0.103
GEOMETRIC STANDARD DEVIATION: 33.960
CORRELATION COEFFICIENT: 0.821

CARB UW IMPACTOR DATA REDUCTION PROGRAM, VERSION X R4

INPUT DATA

```
PART. DIAMETER    CLASSICAL AERODYNAMIC
DATE OF TEST:  3/15
TIME OF TEST:  1320
LOCATION OF TEST:  Incinerator Stack
TEST DESIG.:  arb
TEST TYPE          OUTLET
RUN NUMBER:  3-FILE NAME:TarbR3.OT
RUN REMARKS:  Probe residue combined with Inlet stage
IMPACTOR TYPE: arb3
  LDPC Inlet 3 4 5 7 9 11

WATER VAPOR         35.16%
 CO2  14.00%        CO    0.00%
 O2    6.00%        N2   80.00%
ORIFICE ID (OPTIONAL):  arb
SUBSTRATE MATERIAL, G)rease or Bare metal, F)ilter:   F

GAS METER VOL       12.605 cf
IMPACTOR DELTA P     0.00 IN. HG. (0 for calc. from theory)
ORIFICE DELTA P      0.50 INCHES H2O
STACK PRESSURE      -1.0  INCHES H2O
BAROMETRIC PRES     29.50 INCHES HG
STACK TEMP         166    DEGREES F
METER TEMP          60    DEGREES F
IMPACTOR TEMP      276    DEGREES F
SAMPLE TIME         35.00 MINUTES
AVG GAS VEL          0.00 FEET/SEC
ORI P WRT PBAR      -0.07 INCHES HG
NOZZLE DIA           0.250 INCHES
MAX PART DIA      1000    MICRONS
WATER VOLUME     156.0  CC
METER FACTOR       1.0800

MASS GAIN OF STAGE  1   1.90 MG
MASS GAIN OF STAGE  2   2.20 MG
MASS GAIN OF STAGE  3  -0.10 MG
MASS GAIN OF STAGE  4   0.40 MG
MASS GAIN OF STAGE  5   0.70 MG
MASS GAIN OF STAGE  6   2.00 MG
MASS GAIN OF STAGE  7   4.70 MG
MASS GAIN OF STAGE  8   6.00 MG
MASS GAIN OF FILTER    4.20 MG

MASS GAIN OF BLANK SUBSTRATE   -0.10
MASS GAIN OF BLANK FILTER      -0.10
```

RESULTS

TEST DESIG.: arb RUN NUMBER: 3
LDPC Inlet 3 4 5 7 9 11

ACTUAL FLOW RATE 0.848 CFM
FLOW RATE AT STANDARD CONDITIONS 0.388 CFM
PERCENT ISOKINETIC 0.000 %
VISCOSITY 201.4E-06 GM/CM-SEC
CALCULATED IMPACTOR DELTA P = 5.65 IN. HG

STAGE	CUNN. CORR.	D50 (CLAS AERO)	D50 (IMP AERO)	CUM FREQ.	RE. NO.	V*D50 UM-M/S	
1	1.019	9.379	9.468	81.2227	1752	25.2	
2	1.018	12.575	12.687	81.2227	1527	39.7	skip
3	1.063	3.550	3.661	81.2227	663	25.4	
4	1.122	1.842	1.951	79.0393	.273	16.7	
5	1.219	1.029	1.136	75.5459	347	18.5	
6	1.474	0.490	0.594	66.3756	514	19.3	
7	2.099	0.230	0.333	45.4149	705	16.5	
8	4.416	0.085	0.178	18.7773	1322	11.8	

STAGE CUT DIAMETERS BASED ON THEORETICAL VALUES OF STAGE CONSTANTS

PARTICLE DENSITY = 1

TOTAL MASS CONCENTRATION = 5.95E+01 MG/DRY NORMAL CUBIC METER
= 3.20E+01 MG/ACTUAL CUBIC METER
= 2.60E-02 GRAINS/DRY STD CUBIC FOOT
= 1.40E-02 GRAINS/ACTUAL CUBIC FOOT

TEST DESIG.: arb RUN NUMBER: 3

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMFR (STDDEV)	CUMFR (PERCENT)	CUM.MASS (MG/DRY	DM/DLOGD N.CU.METER)
0.100	-0.6876	24.58	1.46E+01	4.53E+01
0.126	-0.4839	31.43	1.87E+01	3.62E+01
0.158	-0.3333	36.95	2.20E+01	3.04E+01
0.200	-0.2018	42.00	2.50E+01	3.10E+01
0.251	-0.0561	47.76	2.84E+01	3.81E+01
0.316	0.1140	54.54	3.25E+01	4.14E+01
0.398	0.2861	61.26	3.65E+01	3.76E+01
0.501	0.4358	66.85	3.98E+01	2.82E+01
0.631	0.5464	70.76	4.21E+01	1.90E+01
0.794	0.6255	73.42	4.37E+01	1.31E+01
1.000	0.6849	75.33	4.49E+01	1.00E+01
1.259	0.7351	76.89	4.58E+01	8.60E+00
1.585	0.7802	78.24	4.66E+01	7.54E+00
1.995	0.8216	79.43	4.73E+01	6.70E+00
2.512	0.8574	80.44	4.79E+01	5.08E+00
3.162	0.8810	81.08	4.83E+01	2.44E+00
3.981	0.8860	81.22	4.84E+01	1.00E-26
5.012	0.8860	81.22	4.84E+01	1.00E-26
6.310	0.8860	81.22	4.84E+01	1.00E-26
7.943	0.8860	81.22	4.84E+01	2.32E+00
10.000	0.8983	81.55	4.86E+01	7.85E+00
12.589	0.9666	83.31	4.96E+01	1.29E+01
15.849	1.0713	85.80	5.11E+01	1.64E+01
19.953	1.2106	88.70	5.28E+01	1.78E+01
25.119	1.3824	91.66	5.46E+01	1.71E+01
31.623	1.5849	94.35	5.62E+01	1.47E+01
39.811	1.8162	96.53	5.75E+01	1.12E+01
50.119	2.0743	98.10	5.84E+01	7.49E+00
63.096	2.3573	99.08	5.90E+01	4.35E+00
79.433	2.6634	99.61	5.93E+01	2.17E+00
100.000	2.9905	99.86	5.95E+01	9.15E-01
125.893	3.3368	99.96	5.95E+01	3.22E-01
158.489	3.7004	99.99	5.95E+01	9.38E-02
199.526	4.0793	100.00	5.95E+01	2.23E-02
251.189	4.4716	100.00	5.95E+01	4.31E-03
316.228	4.8754	100.00	5.95E+01	6.70E-04
398.107	5.2888	100.00	5.95E+01	8.37E-05
501.187	5.7099	100.00	5.95E+01	8.39E-06
630.957	6.1367	100.00	5.95E+01	6.77E-07
794.328	6.5674	100.00	5.95E+01	4.42E-08
1000.000	7.0000	100.00	5.95E+01	2.35E-09

INHALABLE PARTICULATE MATTER

CUM MASS LESS THAN 1.000 MICRON: 44.85 75.3276 %
CUM MASS LESS THAN 2.512 MICRON: 47.90 80.4379 %
CUM MASS LESS THAN 10.000 MICRON: 48.56 81.5488 %
CUM MASS LESS THAN 15.849 MICRON: 51.09 85.7998 %
NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL APPROXIMATION

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: Y= 0.41 + 0.86X
MASS MEDIAN DIAMETER: 0.332
GEOMETRIC STANDARD DEVIATION: 14.553
CORRELATION COEFFICIENT: 0.830

******* [illegible]

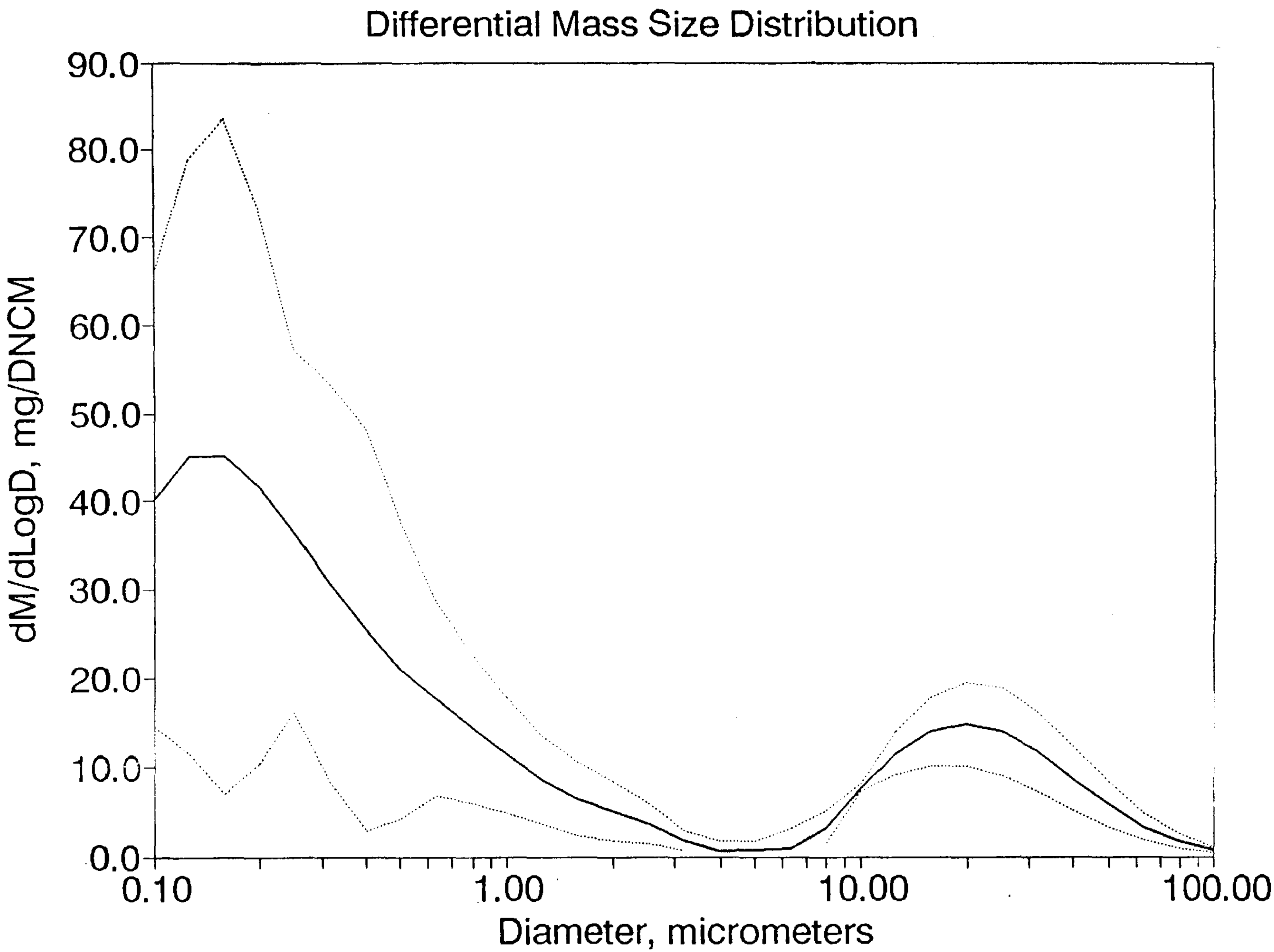
RESULTS OF AVERAGES FOR RUNS :
TarbR1.OT
TarbR2.OT
TarbR3.OT

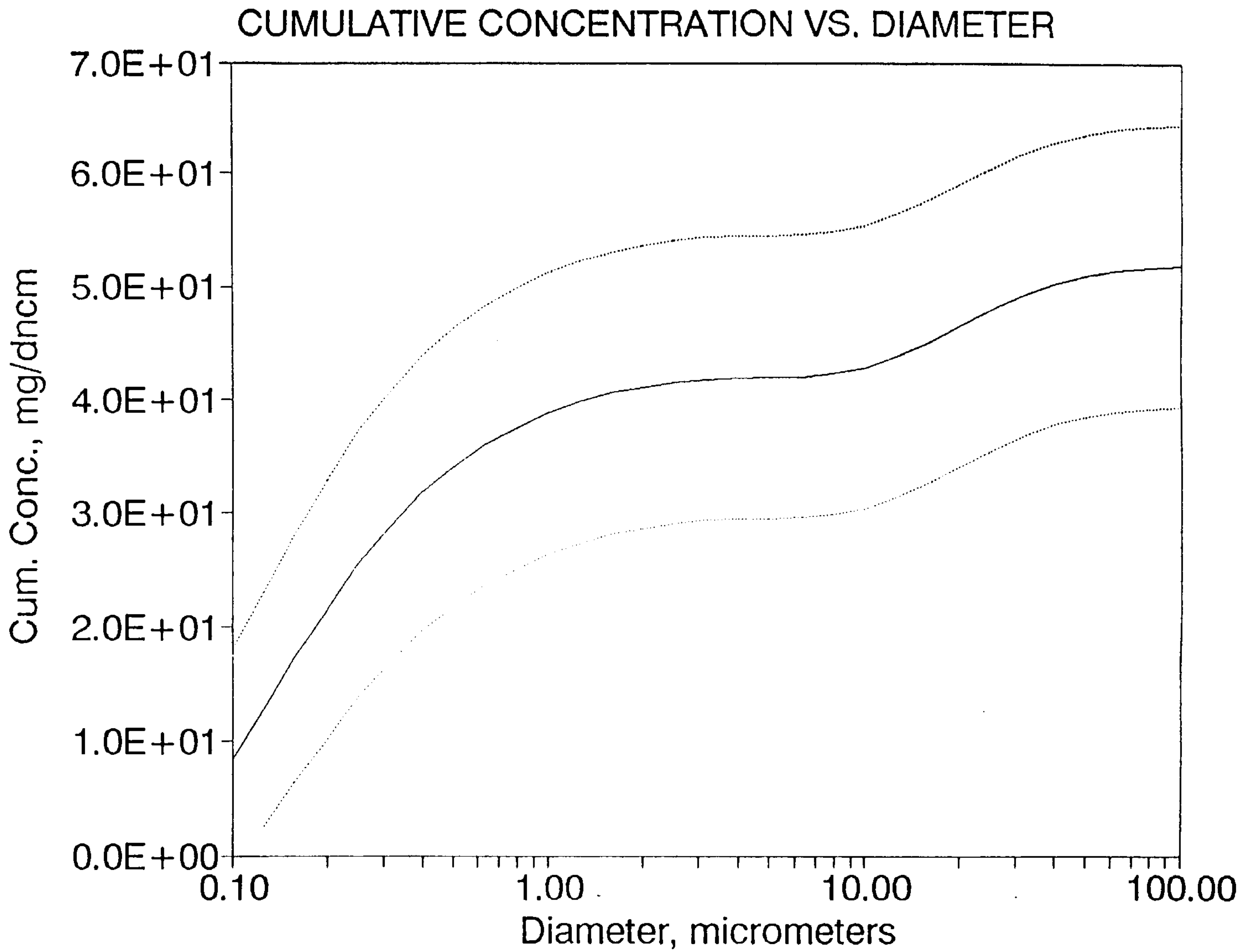
CLASS. AERO DIA.

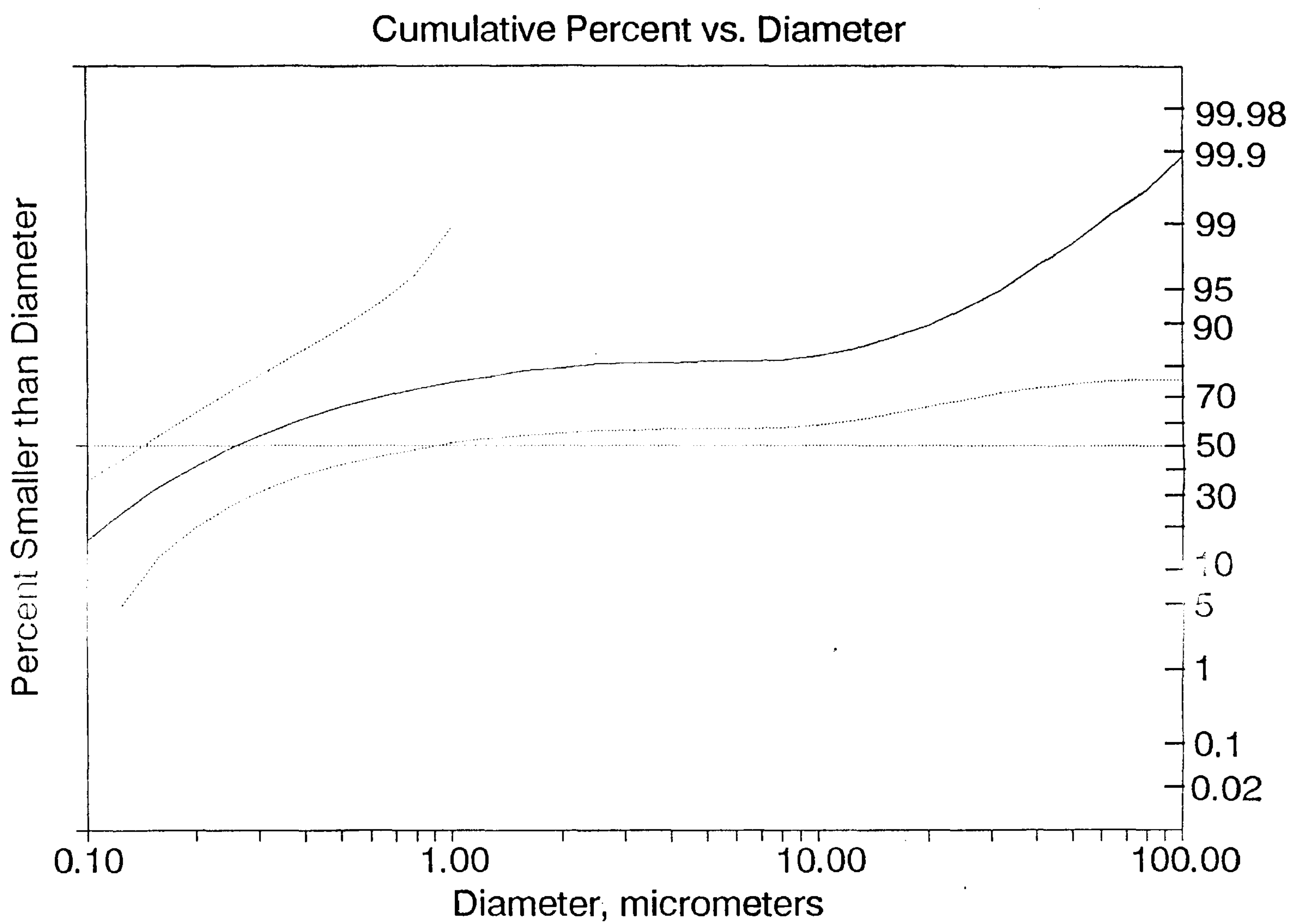
DIA. MICRON	DM/DLOGD MG/DNM3	STD DEV	90% CON INT	CUM LOAD. MG/DNM3	90% CON INT	CUM%
0.10	4.02E+01	1.53E+01	2.58E+01	8.41E+00	9.78E+00	16.21
0.13	4.51E+01	2.00E+01	3.37E+01	1.28E+01	1.02E+01	24.59
0.16	4.52E+01	2.28E+01	3.84E+01	1.73E+01	1.09E+01	33.29
0.20	4.16E+01	1.85E+01	3.12E+01	2.16E+01	1.14E+01	41.55
0.25	3.66E+01	1.22E+01	2.06E+01	2.55E+01	1.17E+01	49.25
0.32	3.08E+01	1.34E+01	2.25E+01	2.88E+01	1.19E+01	55.56
0.40	2.55E+01	1.35E+01	2.27E+01	3.17E+01	1.21E+01	61.16
0.50	2.10E+01	9.95E+00	1.68E+01	3.40E+01	1.23E+01	65.49
0.63	1.76E+01	6.46E+00	1.09E+01	3.60E+01	1.24E+01	69.32
0.79	1.44E+01	5.00E+00	8.42E+00	3.75E+01	1.24E+01	72.31
1.00	1.13E+01	3.82E+00	6.44E+00	3.88E+01	1.24E+01	74.89
1.26	8.50E+00	2.93E+00	4.94E+00	3.98E+01	1.24E+01	76.71
1.58	6.42E+00	2.45E+00	4.12E+00	4.06E+01	1.24E+01	78.21
2.00	5.03E+00	2.01E+00	3.39E+00	4.11E+01	1.24E+01	79.27
2.51	3.61E+00	1.35E+00	2.28E+00	4.16E+01	1.25E+01	80.15
3.16	1.83E+00	6.20E-01	1.05E+00	4.18E+01	1.25E+01	80.62
3.98	6.32E-01	5.91E-01	9.97E-01	4.20E+01	1.25E+01	80.90
5.01	6.44E-01	6.09E-01	1.03E+00	4.20E+01	1.25E+01	81.02
6.31	8.23E-01	1.31E+00	2.21E+00	4.21E+01	1.25E+01	81.16
7.94	3.30E+00	1.08E+00	1.82E+00	4.23E+01	1.25E+01	81.63
10.00	7.62E+00	2.30E-01	3.87E-01	4.28E+01	1.25E+01	82.55
12.59	1.15E+01	1.40E+00	2.35E+00	4.38E+01	1.25E+01	84.52
15.85	1.40E+01	2.28E+00	3.84E+00	4.51E+01	1.25E+01	86.89
19.95	1.48E+01	2.80E+00	4.72E+00	4.65E+01	1.25E+01	89.69
25.12	1.39E+01	2.92E+00	4.93E+00	4.80E+01	1.25E+01	92.49
31.62	1.17E+01	2.67E+00	4.50E+00	4.92E+01	1.25E+01	94.89
39.81	8.75E+00	2.15E+00	3.62E+00	5.03E+01	1.25E+01	96.95
50.12	5.76E+00	1.51E+00	2.55E+00	5.10E+01	1.25E+01	98.26
63.10	3.30E+00	9.18E-01	1.55E+00	5.15E+01	1.25E+01	99.21
79.43	1.62E+00	4.75E-01	8.01E-01	5.17E+01	1.25E+01	99.63
100.00	6.78E-01	2.06E-01	3.48E-01	5.18E+01	1.25E+01	99.88
125.89	2.37E-01	7.43E-02	1.25E-01	5.18E+01	1.25E+01	99.96
158.49	6.87E-02	2.19E-02	3.70E-02	5.19E+01	1.25E+01	99.99
199.53	1.63E-02	5.24E-03	8.84E-03	5.19E+01	1.25E+01	100.00
251.19	3.16E-03	1.01E-03	1.70E-03	5.19E+01	1.25E+01	100.00
316.23	4.96E-04	1.55E-04	2.61E-04	5.19E+01	1.25E+01	100.00
398.11	6.28E-05	1.90E-05	3.21E-05	5.19E+01	1.25E+01	100.00
501.19	6.43E-06	1.88E-06	3.17E-06	5.19E+01	1.25E+01	100.00
630.96	5.34E-07	1.52E-07	2.55E-07	5.19E+01	1.25E+01	100.00
794.33	3.61E-08	1.02E-08	1.73E-08	5.19E+01	1.25E+01	100.00
1000.00	2.01E-09	6.00E-10	1.01E-09	5.19E+01	1.25E+01	100.00

FOR TOTAL MASS: (UNCORRECTED)

9999.00	5.16E+01	1,59E+01	2.68E+01


Differential Mass Size Distribution
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
dM/dLogD, mg/DNCM
0.10
1.00
10.00
100.00
Diameter, micrometers


CUMULATIVE CONCENTRATION VS. DIAMETER
7.0E+01
6.0E+01
5.0E+01
4.0E+01
3.0E+01
2.0E+01
1.0E+01
0.0E+00
Cum. Conc., mg/dncm
0.10
1.00
10.00
100.00
Diameter, micrometers



Cumulative Percent vs. Diameter
Percent Smaller than Diameter
99.98
99.9
99
95
90
70
50
30
10
5
1
0.1
0.02
0.10
1.00
10.00
100.00
Diameter, micrometers

CARB UW IMPACTOR DATA REDUCTION PROGRAM, VERSION X R4

INPUT DATA

```
PART. DIAMETER    CLASSICAL AERODYNAMIC
DATE OF TEST:  3/17
TIME OF TEST:  1230
LOCATION OF TEST:  Flare
TEST DESIG.:  flr
TEST TYPE           INLET
RUN NUMBER:  1-FILE NAME:TflrR1.IT
RUN REMARKS:
IMPACTOR TYPE: flr
  HTPC Inlet 2 3 4 5 7 9

WATER VAPOR          7.12%
 CO2  14.00%        CO    0.00%
 O2    6.00%        N2   80.00%
ORIFICE ID (OPTIONAL):  arb
SUBSTRATE MATERIAL, G)rease or Bare metal, F)ilter:   F

GAS METER VOL       44.597 cf
IMPACTOR DELTA P     0.00 IN. HG. (0 for calc. from theory)
ORIFICE DELTA P      0.55 INCHES H2O
STACK PRESSURE      -1.0  INCHES H2O
BAROMETRIC PRES     29.50 INCHES HG
STACK TEMP        1700    DEGREES F
METER TEMP          60    DEGREES F
IMPACTOR TEMP      360    DEGREES F
SAMPLE TIME        120.00 MINUTES
AVG GAS VEL          0.00 FEET/SEC
ORI P WRT PBAR      -0.08 INCHES HG
NOZZLE DIA           0.250 INCHES
MAX PART DIA      1000    MICRONS
WATER VOLUME      78.0  CC
METER FACTOR       1.0800

MASS GAIN OF STAGE  1   0.90 MG
MASS GAIN OF STAGE  2   2.30 MG
MASS GAIN OF STAGE  3   0.10 MG
MASS GAIN OF STAGE  4   0.00 MG
MASS GAIN OF STAGE  5   0.00 MG
MASS GAIN OF STAGE  6  -0.10 MG
MASS GAIN OF STAGE  7  -0.10 MG
MASS GAIN OF STAGE  8   0.00 MG
MASS GAIN OF FILTER    0.20 MG

MASS GAIN OF BLANK SUBSTRATE   -0.20
MASS GAIN OF BLANK FILTER       0.10
```

RESULTS

TEST DESIG.: flr RUN NUMBER: 1
HTPC Inlet 2 3 4 5 7 9

ACTUAL FLOW RATE 0.680 CFM
FLOW RATE AT STANDARD CONDITIONS 0.400 CFM
PERCENT ISOKINETIC 0.000 %
VISCOSITY 235.0E-06 CM/CM-SEC
CALCULATED IMPACTOR DELTA P = 0.92 IN. HG

STAGE	CUNN. CORR.	D50 (CLAS AERO)	D50 (IMP AERO)	CUM FREQ.	RE. NO.	V*D50 UM-M/S	
1	1.087	9.212	9.606	77.0833	559	61.5	
2	1.017	15.197	15.326	25.0000	1069	38.5	skip
3	1.023	11.471	11.600	18.7500	391	23.3	skip
4	1.060	4.310	4.438	14.5833	464	24.7	
5	1.111	2.345	2.472	10.4167	191	17.1	
6	1.192	1.356	1.480	8.3333	243	19.5	
7	1.399	0.665	0.786	6.2500	360	21.0	
8	1.883	0.323	0.443	2.0833	493	18.5	

STAGE CUT DIAMETERS BASED ON THEORETICAL VALUES OF STAGE CONSTANTS

PARTICLE DENSITY = 1

TOTAL MASS CONCENTRATION = 3.53E+00 MG/DRY NORMAL CUBIC METER
= 7.88E-01 MG/ACTUAL CUBIC METER
= 1.54E-03 GRAINS/DRY STD CUBIC FOOT
= 3.44E-04 GRAINS/ACTUAL CUBIC FOOT

TEST DESIG.: flr RUN NUMBER: 1

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMFR (STDDEV)	CUMFR (PERCENT)	CUM.MASS (MG/DRY N.CU.METER)	DM/DLOGD
0.100	-3.3860	0.04	1.26E-03	1.42E-02
0.126	-3.0833	0.10	3.63E-03	3.58E-02
0.158	-2.7974	0.26	9.11E-03	7.79E-02
0.200	-2.5298	0.57	2.02E-02	1.48E-01
0.251	-2.2821	1.13	3.97E-02	2.47E-01
0.316	-2.0557	1.99	7.03E-02	3.66E-01
0.398	-1.8533	3.19	1.13E-01	4.75E-01
0.501	-1.6834	4.62	1.63E-01	5.13E-01
0.631	-1.5562	5.98	2.11E-01	4.29E-01
0.794	-1.4792	6.95	2.45E-01	2.62E-01
1.000	-1.4360	7.55	2.66E-01	1.79E-01
1.259	-1.3986	8.10	2.86E-01	2.32E-01
1.585	-1.3426	8.97	3.17E-01	3.68E-01
1.995	-1.2824	9.98	3.52E-01	3.07E-01
2.512	-1.2558	10.46	3.69E-01	1.77E-02
3.162	-1.2452	10.65	3.76E-01	2.53E-01
3.981	-1.1367	12.78	4.51E-01	1.46E+00
5.012	-0.8178	20.67	7.30E-01	4.37E+00
6.310	-0.2991	38.24	1.35E+00	7.91E+00
7.943	0.3263	62.79	2.22E+00	8.64E+00
10.000	0.9649	83.27	2.94E+00	5.47E+00
12.589	1.5602	94.06	3.32E+00	2.39E+00
15.849	2.1104	98.26	3.47E+00	8.02E-01
19.953	2.6177	99.56	3.51E+00	2.23E-01
25.119	3.0847	99.90	3.53E+00	5.41E-02
31.623	3.5136	99.98	3.53E+00	1.21E-02
39.811	3.9069	100.00	3.53E+00	2.57E-03
50.119	4.2669	100.00	3.53E+00	5.39E-04
63.096	4.5960	100.00	3.53E+00	1.15E-04
79.433	4.8965	100.00	3.53E+00	2.51E-05
100.000	5.1709	100.00	3.53E+00	5.77E-06
125.893	5.4216	100.00	3.53E+00	1.40E-06
158.489	5.6508	100.00	3.53E+00	3.60E-07
199.526	5.8611	100.00	3.53E+00	9.85E-08
251.189	6.0547	100.00	3.53E+00	2.87E-08
316.228	6.2340	100.00	3.53E+00	8.86E-09
398.107	6.4015	100.00	3.53E+00	2.89E-09
501.187	6.5594	100.00	3.53E+00	9.84E-10
630.957	6.7103	100.00	3.53E+00	3.48E-10
794.328	6.8563	100.00	3.53E+00	1.26E-10
1000.000	7.0000	100.00	3.53E+00	4.62E-11

INHALABLE PARTICULATE MATTER

CUM MASS LESS THAN 1.000 MICRON:	0.27	7.5492 %
CUM MASS LESS THAN 2.512 MICRON:	0.37	10.4577 %
CUM MASS LESS THAN 10.000 MICRON:	2.94	83.2710 %
CUM MASS LESS THAN 15.849 MICRON:	3.47	98.2576 %

NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL APPROXIMATION

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: Y=-1.46 + 1.57X
MASS MEDIAN DIAMETER: 8.527
GEOMETRIC STANDARD DEVIATION: 4.328
CORRELATION COEFFICIENT: 0.767

INPUT DATA

PART. DIAMETER   CLASSICAL AERODYNAMIC
DATE OF TEST: 3/18
TIME OF TEST: 1016
LOCATION OF TEST: Flare
TEST DESIG.: flr
TEST TYPE   INLET
RUN NUMBER: 2-FILE NAME:TflrR2.IT
RUN REMARKS:
IMPACTOR TYPE: flr
HTPC Inlet 2 3 4 5 7 9

WATER VAPOR 7.55%
CO2 14.00%   CO 0.00%
O2 6.00%   N2 80.00%
ORIFICE ID (OPTIONAL): arb
SUBSTRATE MATERIAL, G)rease or Bare metal, F)ilter: F

GAS METER VOL	46.184	cf
IMPACTOR DELTA P	0.00	IN. HG. (0 for calc. from theory)
ORIFICE DELTA P	0.55	INCHES H2O
STACK PRESSURE	-1.0	INCHES H2O
BAROMETRIC PRES	29.50	INCHES HG
STACK TEMP	1680	DEGREES F
METER TEMP	60	DEGREES F
IMPACTOR TEMP	375	DEGREES F
SAMPLE TIME	120.00	MINUTES
AVG GAS VEL	0.00	FEET/SEC
ORI P WRT PBAR	-0.08	INCHES HG
NOZZLE DIA	0.250	INCHES
MAX PART DIA	1000	MICRONS
WATER VOLUME	86.0	CC
METER FACTOR	1.0800	

MASS GAIN OF STAGE 1	0.10	MG
MASS GAIN OF STAGE 2	0.00	MG
MASS GAIN OF STAGE 3	0.10	MG
MASS GAIN OF STAGE 4	0.00	MG
MASS GAIN OF STAGE 5	0.20	MG
MASS GAIN OF STAGE 6	-0.20	MG
MASS GAIN OF STAGE 7	-0.40	MG
MASS GAIN OF STAGE 8	0.00	MG
MASS GAIN OF FILTER	0.10	MG

MASS GAIN OF BLANK SUBSTRATE -0.50
MASS GAIN OF BLANK FILTER -0.10

RESULTS

TEST DESIG.: flr RUN NUMBER: 2
HTPC Inlet 2 3 4 5 7 9

ACTUAL FLOW RATE 0.721 CFM
FLOW RATE AT STANDARD CONDITIONS 0.414 CFM
PERCENT ISOKINETIC 0.000 %
VISCOSITY 237.9E-06 GM/CM-SEC
CALCULATED IMPACTOR DELTA P = 1.02 IN. HG

STAGE	CUNN. CORR.	D50 (CLAS AERO)	D50 (IMP AERO)	CUM FREQ.	RE. NO.	V*D50 UM-M/S
1	1.088	9.044	9.435	85.0000	584	62.2
2	1.018	14.843	14.975	72.5000	1096	39.9 skip
3	1.024	11.202	11.334	57.5000	401	24.1 skip
4	1.063	4.203	4.333	45.0000	476	25.5
5	1.117	2.275	2.404	27.5000	196	17.5
6	1.203	1.308	1.435	20.0000	249	20.0
7	1.429	0.636	0.760	17.5000	369	21.3
8	1.969	0.304	0.426	5.0000	506	18.4

STAGE CUT DIAMETERS BASED ON THEORETICAL VALUES OF STAGE CONSTANTS

PARTICLE DENSITY = 1

TOTAL MASS CONCENTRATION = 2.84E+00 MG/DRY NORMAL CUBIC METER
= 6.37E-01 MG/ACTUAL CUBIC METER
= 1.24E-03 GRAINS/DRY STD CUBIC FOOT
= 2.78E-04 GRAINS/ACTUAL CUBIC FOOT

TEST DESIG.: flr RUN NUMBER: 2

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMFR (STDDEV)	CUMFR (PERCENT)	CUM.MASS (MG/DRY	DM/DLOGD N.CU.METER)
0.100	-3.1989	0.07	1.97E-03	2.37E-02
0.126	-2.8552	0.22	6.12E-03	6.51E-02
0.158	-2.5220	0.58	1.66E-02	1.54E-01
0.200	-2.2000	1.39	3.95E-02	3.18E-01
0.251	-1.8904	2.94	8.34E-02	5.75E-01
0.316	-1.5941	5.55	1.57E-01	9.19E-01
0.398	-1.3192	9.35	2.66E-01	1.22E+00
0.501	-1.0912	13.76	3.91E-01	1.22E+00
0.631	-0.9380	17.41	4.94E-01	7.77E-01
0.794	-0.8752	19.07	5.42E-01	2.18E-01
1.000	-0.8635	19.39	5.51E-01	3.45E-02
1.259	-0.8482	19.82	5.63E-01	2.78E-01
1.585	-0.7826	21.69	6.16E-01	7.73E-01
1.995	-0.6714	25.10	7.13E-01	1.14E+00
2.512	-0.5393	29.49	8.37E-01	1.35E+00
3.162	-0.3865	34.96	9.93E-01	1.81E+00
3.981	-0.1837	42.71	1.21E+00	2.65E+00
5.012	0.0957	53.81	1.53E+00	3.57E+00
6.310	0.4402	67.01	1.90E+00	3.77E+00
7.943	0.8191	79.36	2.25E+00	3.13E+00
10.000	1.2024	88.54	2.51E+00	2.08E+00
12.589	1.5734	94.22	2.68E+00	1.20E+00
15.849	1.9319	97.33	2.76E+00	6.18E-01
19.953	2.2786	98.86	2.81E+00	2.88E-01
25.119	2.6142	99.55	2.83E+00	1.23E-01
31.623	2.9392	99.83	2.84E+00	4.82E-02
39.811	3.2544	99.94	2.84E+00	1.76E-02
50.119	3.5604	99.98	2.84E+00	6.04E-03
63.096	3.8578	99.99	2.84E+00	1.95E-03
79.433	4.1474	100.00	2.84E+00	5.96E-04
100.000	4.4297	100.00	2.84E+00	1.73E-04
125.893	4.7054	100.00	2.84E+00	4.81E-05
158.489	4.9753	100.00	2.84E+00	1.28E-05
199.526	5.2399	100.00	2.84E+00	3.24E-06
251.189	5.4999	100.00	2.84E+00	7.89E-07
316.228	5.7559	100.00	2.84E+00	1.84E-07
398.107	6.0087	100.00	2.84E+00	4.12E-08
501.187	6.2588	100.00	2.84E+00	8.80E-09
630.957	6.5070	100.00	2.84E+00	1.79E-09
794.328	6.7538	100.00	2.84E+00	3.47E-10
1000.000	7.0000	100.00	2.84E+00	6.38E-11

INHALABLE PARTICULATE MATTER

CUM MASS LESS THAN 1.000 MICRON: 0.55 19.3940 %
CUM MASS LESS THAN 2.512 MICRON: 0.84 29.4858 %
CUM MASS LESS THAN 10.000 MICRON: 2.51 88.5400 %
CUM MASS LESS THAN 15.849 MICRON: 2.76 97.3308 %
NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE
ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL APPROXIMATION

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: Y=-0.88 + 1.60X
MASS MEDIAN DIAMETER: 3.515
GEOMETRIC STANDARD DEVIATION: 4.198
CORRELATION COEFFICIENT: 0.907

CARB UW IMPACTOR DATA REDUCTION PROGRAM, VERSION X R4

INPUT DATA

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PART. DIAMETER    CLASSICAL AERODYNAMIC
DATE OF TEST:  3/19
TIME OF TEST:  1030
LOCATION OF TEST:  Flare
TEST DESIG.:  flr
TEST TYPE          INLET
RUN NUMBER:  3-FILE NAME:TflrR3.IT
RUN REMARKS:
IMPACTOR TYPE: flr
  HTPC Inlet 2 3 4 5 7 9

WATER VAPOR          8.91%
 CO2  14.00%        CO     0.00%
 O2    6.00%        N2    80.00%
ORIFICE ID (OPTIONAL):  arb
SUBSTRATE MATERIAL, G)rease or Bare metal, F)ilter:   F

GAS METER VOL       45.680 cf
IMPACTOR DELTA P     0.00 IN. HG. (0 for calc. from theory)
ORIFICE DELTA P      0.55 INCHES H2O
STACK PRESSURE      -1.0  INCHES H2O
BAROMETRIC PRES     29.50 INCHES HG
STACK TEMP        1750    DEGREES F
METER TEMP          60    DEGREES F
IMPACTOR TEMP      348    DEGREES F
SAMPLE TIME        120.00 MINUTES
AVG GAS VEL          0.00 FEET/SEC
ORI P WRT PBAR      -0.08 INCHES HG
NOZZLE DIA           0.250 INCHES
MAX PART DIA      1000    MICRONS
WATER VOLUME     102.0  CC
METER FACTOR       1.0800

MASS GAIN OF STAGE  1   0.80 MG
MASS GAIN OF STAGE  2  -0.50 MG
MASS GAIN OF STAGE  3   0.20 MG
MASS GAIN OF STAGE  4  -0.10 MG
MASS GAIN OF STAGE  5  -0.10 MG
MASS GAIN OF STAGE  6  -0.20 MG
MASS GAIN OF STAGE  7   0.10 MG
MASS GAIN OF STAGE  8  -0.30 MG
MASS GAIN OF FILTER    0.00 MG

MASS GAIN OF BLANK SUBSTRATE   -0.30
MASS GAIN OF BLANK FILTER      -0.30
```

RESULTS

TEST DESIG.: flr RUN NUMBER: 3
HTPC Inlet 2 3 4 5 7 9

ACTUAL FLOW RATE 0.700 CFM
FLOW RATE AT STANDARD CONDITIONS 0.410 CFM
PERCENT ISOKINETIC 0.000 %
VISCOSITY 231.3E-06 GM/CM-SEC
CALCULATED IMPACTOR DELTA P = 0.99 IN. HG

STAGE	CUNN. CORR.	D50 (CLAS AERO)	D50 (IMP AERO)	CUM FREQ.	RE. NO.	V*D50 UM-M/S	
1	1.093	8.951	9.356	57.6923	572	63.9	
2	1.017	14.858	14.984	65.3846	1126	38.8	skip
3	1.023	11.213	11.339	46.1538	411	23.4	skip
4	1.060	4.211	4.336	38.4615	489	24.8	
5	1.112	2.273	2.397	30.7692	201	17.0	
6	1.195	1.308	1.429	26.9231	256	19.4	
7	1.408	0.639	0.758	11.5385	379	20.8	
8	1.906	0.309	0.427	11.5385	520	18.2	

STAGE CUT DIAMETERS BASED ON THEORETICAL VALUES OF STAGE CONSTANTS

PARTICLE DENSITY = 1

TOTAL MASS CONCENTRATION = 1.87E+00 MG/DRY NORMAL CUBIC METER
= 3.99E-01 MG/ACTUAL CUBIC METER
= 8.16E-04 GRAINS/DRY STD CUBIC FOOT
= 1.75E-04 GRAINS/ACTUAL CUBIC FOOT

TEST DESIG.: flr RUN NUMBER: 3

SPLINE FIT ON CLASSICAL AERODYNAMIC DIAMETER BASIS

PARTICLE DIA. (MICRONS)	CUMFR (STDDEV)	CUMFR (PERCENT)	CUM.MASS (MG/DRY	DM/DLOGD N.CU.METER)
0.100	-2.0564	1.99	3.71E-02	2.90E-01
0.126	-1.7609	3.91	7.30E-02	4.23E-01
0.158	-1.5221	6.40	1.19E-01	4.88E-01
0.200	-1.3453	8.93	1.67E-01	4.34E-01
0.251	-1.2356	10.83	2.02E-01	2.58E-01
0.316	-1.1982	11.54	2.15E-01	1.00E-26
0.398	-1.1985	11.53	2.15E-01	1.00E-26
0.501	-1.1985	11.53	2.15E-01	1.00E-26
0.631	-1.1985	11.53	2.15E-01	3.62E-01
0.794	-1.0464	14.77	2.76E-01	8.69E-01
1.000	-0.8292	20.35	3.80E-01	1.15E+00
1.259	-0.6379	26.18	4.89E-01	9.10E-01
1.585	-0.5429	29.36	5.48E-01	3.21E-01
1.995	-0.5148	30.34	5.66E-01	1.17E-01
2.512	-0.4846	31.40	5.86E-01	3.23E-01
3.162	-0.4178	33.81	6.31E-01	5.70E-01
3.981	-0.3204	37.44	6.99E-01	7.77E-01
5.012	-0.2003	42.06	7.85E-01	9.50E-01
6.310	-0.0599	47.61	8.89E-01	1.12E+00
7.943	0.1015	54.04	1.01E+00	1.27E+00
10.000	0.2844	61.19	1.14E+00	1.38E+00
12.589	0.4885	68.74	1.28E+00	1.42E+00
15.849	0.7129	76.20	1.42E+00	1.35E+00
19.953	0.9565	83.06	1.55E+00	1.19E+00
25.119	1.2182	88.84	1.66E+00	9.59E-01
31.623	1.4970	93.28	1.74E+00	6.97E-01
39.811	1.7917	96.34	1.80E+00	4.52E-01
50.119	2.1014	98.22	1.83E+00	2.59E-01
63.096	2.4249	99.23	1.85E+00	1.30E-01
79.433	2.7612	99.71	1.86E+00	5.63E-02
100.000	3.1093	99.91	1.86E+00	2.09E-02
125.893	3.4679	99.97	1.87E+00	6.62E-03
158.489	3.8362	99.99	1.87E+00	1.77E-03
199.526	4.2131	100.00	1.87E+00	3.96E-04
251.189	4.5973	100.00	1.87E+00	7.43E-05
316.228	4.9880	100.00	1.87E+00	1.16E-05
398.107	5.3840	100.00	1.87E+00	1.50E-06
501.187	5.7843	100.00	1.87E+00	1.62E-07
630.957	6.1877	100.00	1.87E+00	1.46E-08
794.328	6.5933	100.00	1.87E+00	1.10E-09
1000.000	7.0000	100.00	1.87E+00	6.94E-11

INHALABLE PARTICULATE MATTER

CUM MASS LESS THAN 1.000 MICRON:	0.38	20.3502 %
CUM MASS LESS THAN 2.512 MICRON:	0.59	31.3977 %
CUM MASS LESS THAN 10.000 MICRON:	1.14	61.1939 %
CUM MASS LESS THAN 15.849 MICRON:	1.42	76.2047 %

NOTE: DIAMETERS FOR INHALABLE PARTICULATE MATTER ARE ON CLASSICAL AERODYNAMIC BASIS.

LOG-NORMAL APPROXIMATION

LOG-NORMAL SIZE DISTRIBUTION PARAMETERS

LEAST SQUARES LINE: Y=-0.82 + 0.98X
MASS MEDIAN DIAMETER: 6.892
GEOMETRIC STANDARD DEVIATION: 10.469
CORRELATION COEFFICIENT: 0.950

******* RESULTS OF STATIS(TICS) *******

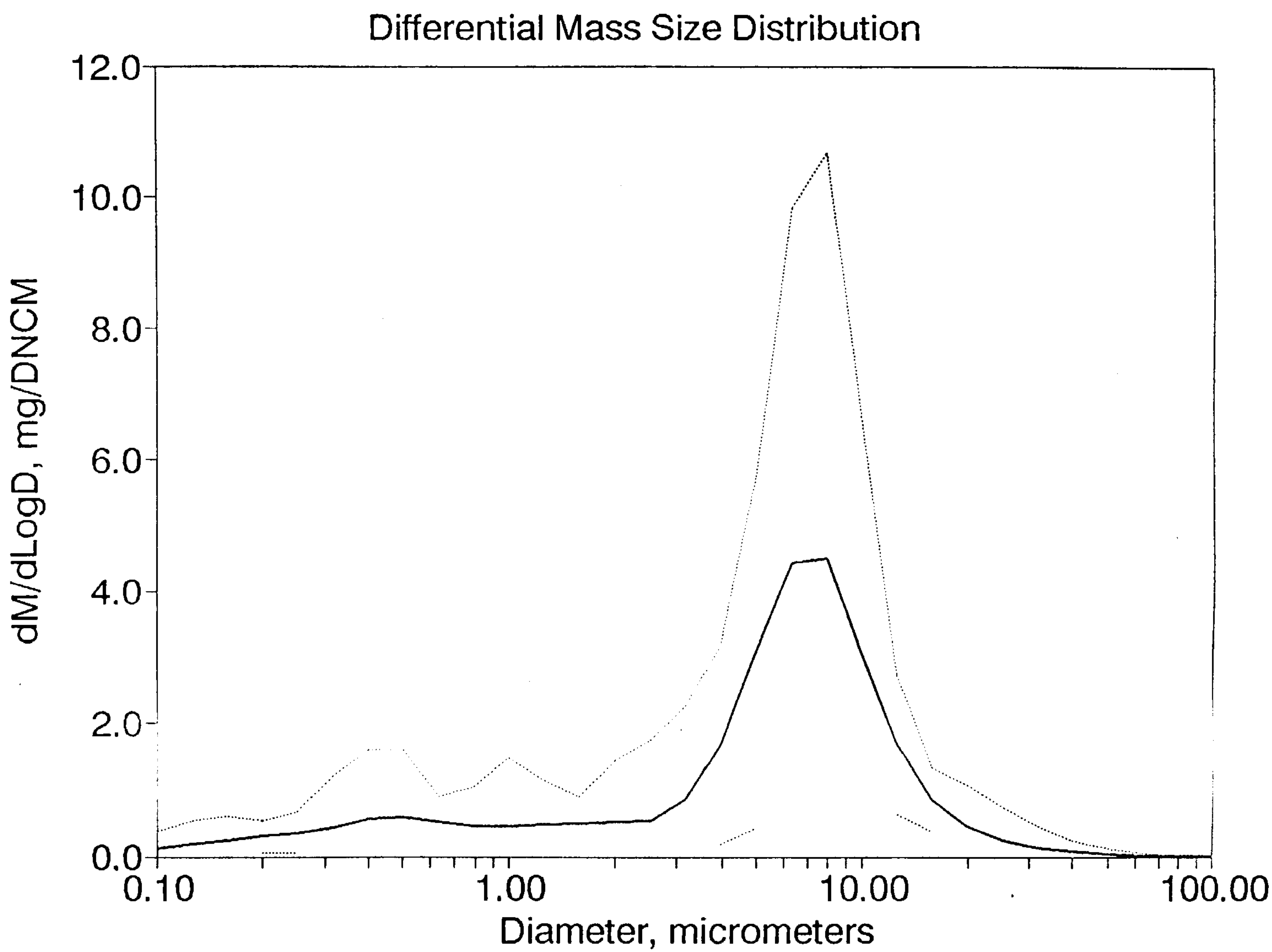
RESULTS OF AVERAGES FOR RUNS :
TflrR1.IT
TflrR2.IT
TflrR3.IT

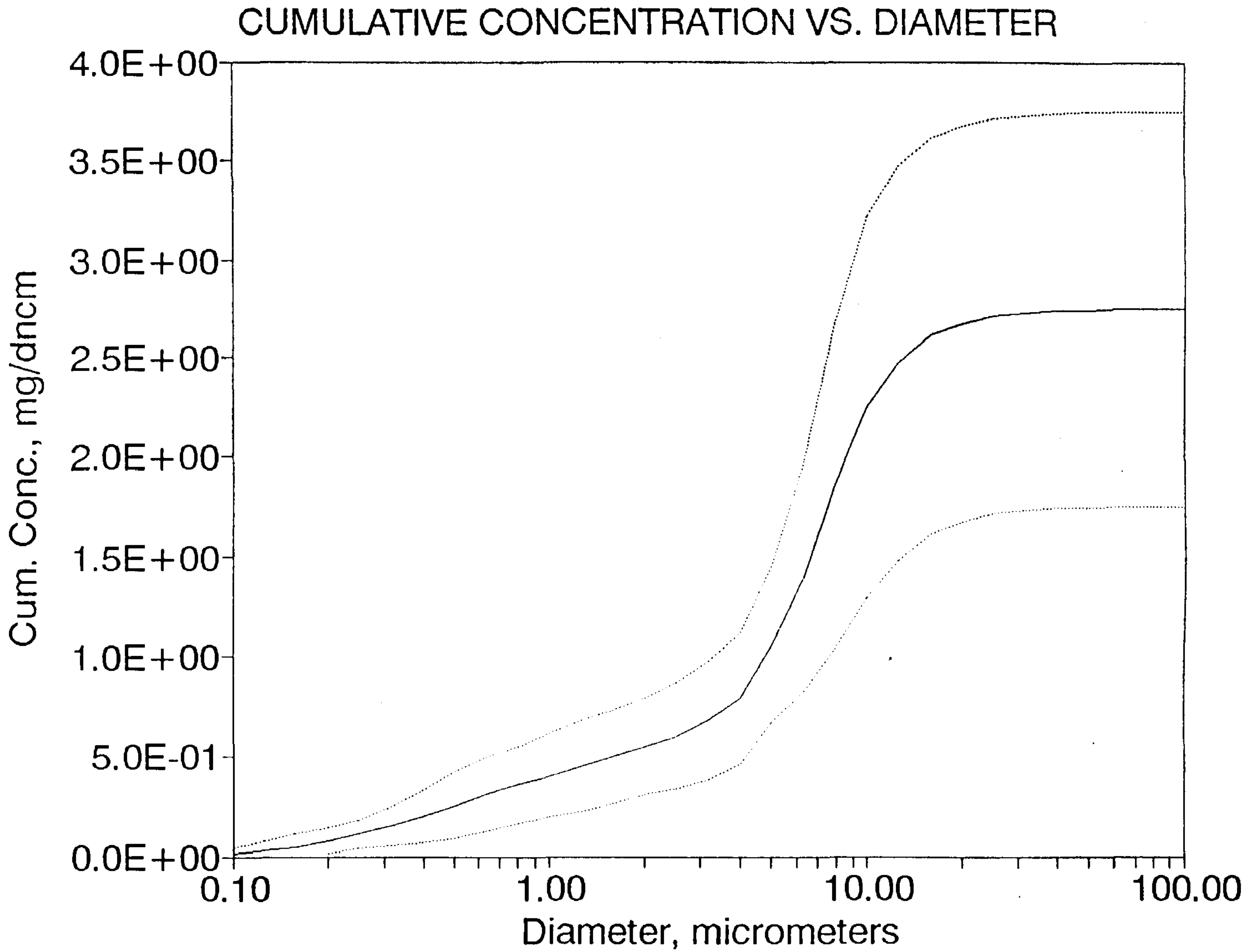
CLASS. AERO DIA.

DIA. MICRON	DM/DLOGD MG/DNM3	STD DEV	90% CON INT	CUM LOAD. MG/DNM3	90% CON INT	CUM%
0.10	1.09E-01	1.56E-01	2.63E-01	1.34E-02	3.45E-02	0.49
0.13	1.75E-01	2.16E-01	3.64E-01	2.87E-02	4.69E-02	1.04
0.16	2.40E-01	2.18E-01	3.67E-01	4.83E-02	5.94E-02	1.76
0.20	3.00E-01	1.44E-01	2.43E-01	7.64E-02	6.71E-02	2.78
0.25	3.60E-01	1.86E-01	3.14E-01	1.08E-01	7.27E-02	3.94
0.32	4.29E-01	4.62E-01	7.80E-01	1.49E-01	9.39E-02	5.42
0.40	5.63E-01	6.13E-01	1.03E+00	1.96E-01	1.31E-01	7.14
0.50	5.78E-01	6.12E-01	1.03E+00	2.54E-01	1.67E-01	9.22
0.63	5.22E-01	2.23E-01	3.77E-01	3.09E-01	1.84E-01	11.25
0.79	4.48E-01	3.62E-01	6.09E-01	3.57E-01	1.91E-01	12.97
1.00	4.55E-01	6.08E-01	1.03E+00	4.02E-01	2.09E-01	14.61
1.26	4.77E-01	3.85E-01	6.49E-01	4.49E-01	2.26E-01	16.31
1.58	4.92E-01	2.43E-01	4.10E-01	4.97E-01	2.32E-01	18.07
2.00	5.15E-01	5.47E-01	9.22E-01	5.48E-01	2.43E-01	19.91
2.51	5.42E-01	7.12E-01	1.20E+00	6.00E-01	2.65E-01	21.82
3.16	8.70E-01	8.31E-01	1.40E+00	6.76E-01	2.96E-01	24.58
3.98	1.68E+00	8.89E-01	1.50E+00	7.90E-01	3.29E-01	28.72
5.01	3.09E+00	1.58E+00	2.66E+00	1.05E+00	3.94E-01	38.25
6.31	4.44E+00	3.19E+00	5.38E+00	1.41E+00	5.79E-01	51.12
7.94	4.51E+00	3.64E+00	6.14E+00	1.86E+00	8.17E-01	67.43
10.00	3.07E+00	2.08E+00	3.51E+00	2.26E+00	9.58E-01	82.08
12.59	1.68E+00	6.23E-01	1.05E+00	2.47E+00	9.93E-01	89.89
15.85	8.68E-01	2.88E-01	4.86E-01	2.61E+00	9.96E-01	95.02
19.95	4.62E-01	3.58E-01	6.04E-01	2.67E+00	9.98E-01	97.19
25.12	2.55E-01	2.90E-01	4.88E-01	2.71E+00	9.99E-01	98.61
31.62	1.39E-01	1.89E-01	3.19E-01	2.73E+00	1.00E+00	99.26
39.81	7.14E-02	1.06E-01	1.79E-01	2.74E+00	1.00E+00	99.68
50.12	3.37E-02	5.27E-02	8.88E-02	2.75E+00	1.00E+00	99.85
63.10	1.43E-02	2.30E-02	3.88E-02	2.75E+00	1.00E+00	99.95
79.43	5.42E-03	8.85E-03	1.49E-02	2.75E+00	1.00E+00	99.98
100.00	1.82E-03	2.99E-03	5.05E-03	2.75E+00	1.00E+00	99.99
125.89	5.37E-04	8.88E-04	1.50E-03	2.75E+00	1.00E+00	100.00
158.49	1.39E-04	2.30E-04	3.88E-04	2.75E+00	1.00E+00	100.00
199.53	3.17E-05	5.21E-05	8.78E-05	2.75E+00	1.00E+00	100.00
251.19	6.33E-06	1.03E-05	1.73E-05	2.75E+00	1.00E+00	100.00
316.23	1.11E-06	1.75E-06	2.96E-06	2.75E+00	1.00E+00	100.00
398.11	1.71E-07	2.59E-07	4.37E-07	2.75E+00	1.00E+00	100.00
501.19	2.37E-08	3.29E-08	5.54E-08	2.75E+00	1.00E+00	100.00
630.96	3.05E-09	3.50E-09	5.90E-09	2.75E+00	1.00E+00	100.00
794.33	3.91E-10	2.89E-10	4.86E-10	2.75E+00	1.00E+00	100.00
1000.00	5.70E-11	9.47E-12	1.60E-11	2.75E+00	1.00E+00	100.00

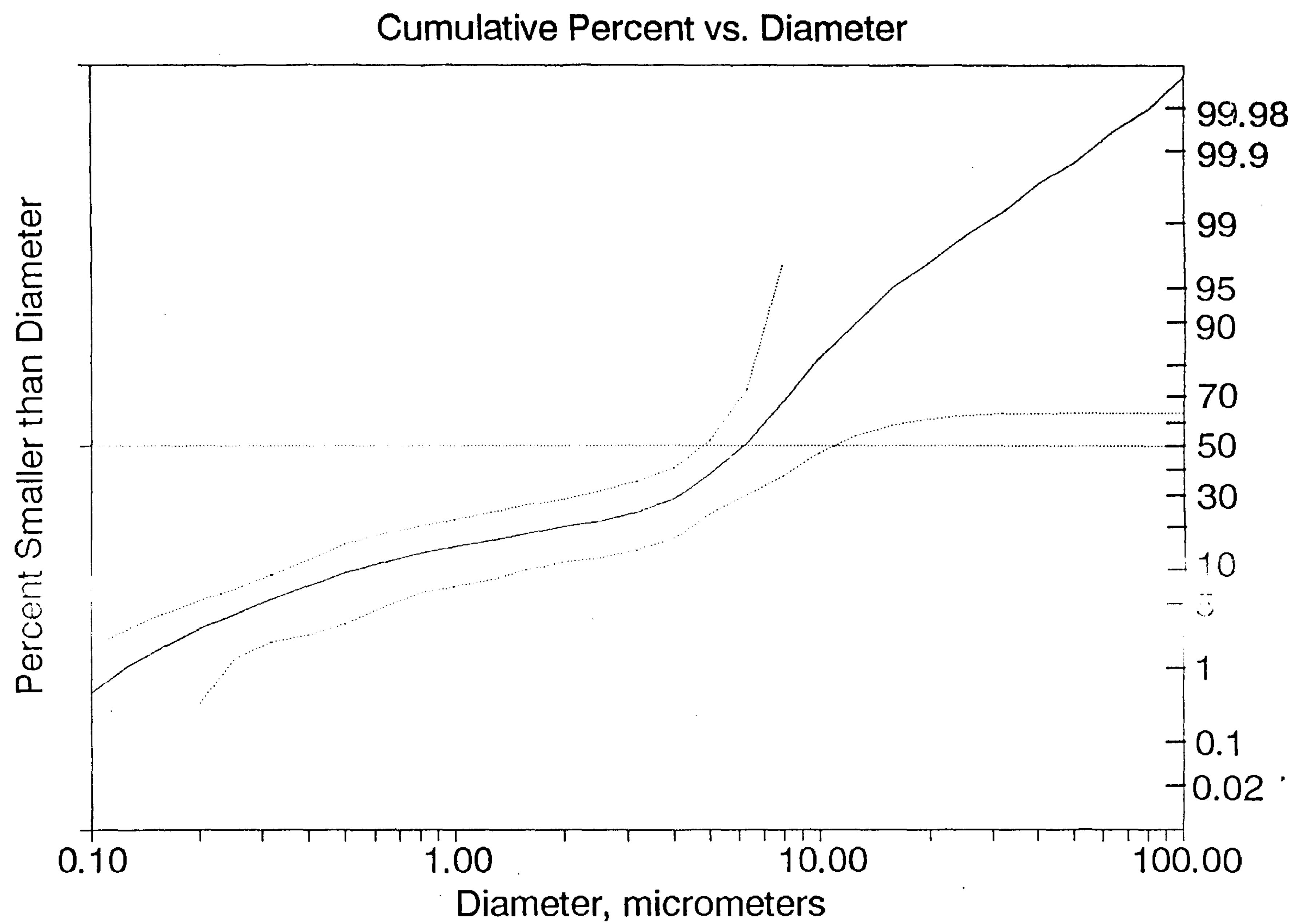
FOR TOTAL MASS: (UNCORRECTED)

9999.00	2.74E+00	8.35E-01	1.41E+00


Differential Mass Size Distribution
dM/dLogD, mg/DNCM
0.0
2.0
4.0
6.0
8.0
10.0
12.0
0.10
1.00
10.00
100.00
Diameter, micrometers



CUMULATIVE CONCENTRATION VS. DIAMETER
4.0E+00
3.5E+00
3.0E+00
2.5E+00
2.0E+00
1.5E+00
1.0E+00
5.0E-01
0.0E+00
Cum. Conc., mg/dncm
0.10
1.00
10.00
100.00
Diameter, micrometers



Cumulative Percent vs. Diameter
Percent Smaller than Diameter
99.98
99.9
99
95
90
70
50
30
10
5
1
0.1
0.02
0.10
1.00
10.00
100.00
Diameter, micrometers