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TITLE: INTERMEDIATE RESULTS OF A ONE-YEAR STUDY OF A LASER SPECTROMETER IN THE DOE FILTER TEST FACILITIES

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INTERMEDIATE RESULTS OF A ONE-YEAR STUDY OF A LASER SPECTROMETER IN THE DOE FILTER TEST FACILITIES*

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Abstract

A 1-year study of the model LAS-X (Particle Measuring Systems, Inc.) laser spectrometer in the Department of Energy (DOE) Filter Test Facilities (FTFs) was begun on August 1, 1983. The principal objectives of the study were to gain operational experience with the LAS-X/diluter/HP-85 particle size measurement system in the FTF environment, acquire size distribution data to quantify the consistency of the Q107 aerosol size distribution at each FTF and among FTFs, and compare the FTF test aerosols to current and proposed standards. Results of the first 9 months of the study are summarized and discussed. Major conclusions based on these data are: 1) the LAS-X system can be operated successfully in the FTF environment, 2) each FTF would require a back-up LAS-X to be able to continue filter testing during the (at least) once each year removal of a LAS-X from service for major recalibration and repair, 3) the FTF test aerosols are not monodisperse, as assumed in the military standard MIL-STD-282, and do not all meet the new DOE Nuclear Standard NE-F-3-43, which a replacement aerosol would be required to meet, 4) the test aerosol at each FTF is quite consistent over time, and 5) the test aerosols at the three FTFs differ consistently. Final conclusions and recommendations from this study will be developed after analysis of the full 12 months of data.

I. Introduction

Los Alamos has undertaken a program "Filter Test Facility Support Laboratory" for DOE. One aspect of this program, a laboratory evaluation of a proposed new filter penetration test system, was discussed elsewhere in this meeting.⁽¹⁾ Another part of this DOE program is to evaluate a laser spectrometer particle size measurement system [consisting of a model LAS-X laser spectrometer (Particle Measuring Systems, Inc.), a diluter, a model HP-85 (Hewlett-Packard) microcomputer, and Los Alamos software] as a possible replacement for the Owl in sizing the aerosols used at the three DOE FTFs for quality assurance testing of size 5 (1000 cfm) high efficiency particulate air (HEPA) filters. Some initial results related to this effort were presented at the 17th DOE Nuclear Air Cleaning Conference.⁽²⁾

Based on the initial evaluations, Los Alamos recommended to DOE that the LAS-X particle size measurement system receive an intensive evaluation in the FTFs for 1 year. The 1-year study was begun August 1, 1983. This report presents intermediate results of the study based on data collected during the first nine months.

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18th DOE NUCLEAR AIRBORNE WASTE MANAGEMENT AND AIR CLEANING CONFERENCE

II. Objectives

The objectives of the 1-year study were to:

1. Evaluate the impact of the LAS-X particle size measurement system on FTF operations including (a) additional costs in time, materials, and equipment, (b) ability of FTF personnel to efficiently operate the system, (c) ability of the equipment to operate reliably in the FTF environment, and (d) benefits due to more complete particle size characterizations.
2. Determine the relationship of the test aerosols at the three FTFs to relevant Standards.(3,4)
3. Provide data on daily variations of the test aerosols produced at each FTF including possible seasonal changes.
4. Compare the test aerosols produced at the three FTFs.

III. Equipment and Procedures

The LAS-X owned by each FTF nominally sizes particles with diameters between 0.09 and 3 μm using four overlapping size ranges. Size is determined by measuring the amount of light scattered into a detector by individual particles. Salzman, et al. have described the operation of the LAS-X, including refractive index corrections.(2) Since it is a single-particle counter, errors occur if the aerosol concentration is as high as that found in the model Q107 penetrometer used at each FTF for testing size 5 (1000 cfm) HEPA filters. During this study, the test aerosol in the Q107 was passed through a capillary diluter prior to entering the LAS-X. A capillary diluter works by passing a small portion of the incoming aerosol stream through a controlled "leak" consisting of a capillary tube and allowing it to mix with the bulk of the incoming stream which was passed through a HEPA filter. The diluter provided by Los Alamos was designed to operate at a flow of approximately 140 L/min (5 cfm).(5) Data acquisition and analysis was accomplished with an HP-85 microcomputer system and software developed at Los Alamos. A detailed description of the equipment and software will be provided in the final report of this study.

Conducting the study at the FTFs did not alter the way in which HEPA filters were tested. All normal procedures were followed, including adjusting the Q107 to obtain an Owl reading of 29%. No Q107 adjustments were made based on the LAS-X size distribution results. Each FTF reviewed its operations prior to the start of the study to ascertain that all normal procedures were being followed and that all equipment was operating properly. Los Alamos provided detailed descriptions of the equipment and procedures associated with the study and visited each FTF prior to the start of the study to help install the equipment and train the operators.

At the start of each day when the Q107 was operated, the LAS-X calibration was checked with an aerosol of polystyrene latex (PSL) spheres using an air-jet nebulizer system supplied by Los Alamos. No LAS-X calibration adjustments could be made in the field, so the PSL measurements served only as a check on the operation of the instrument. Los Alamos provided PSL particles from the same source bottle to each FTF as dilute suspensions which had been prepared at the same time and in the same way. After checking the LAS-X calibration, an FTF operator measured the Q107 aerosol size distribution at the beginning of each day when the Q107 was used to test HEPA filters and at approximately 2-hour intervals thereafter. Size

18th DOE NUCLEAR AIRBORNE WASTE MANAGEMENT AND AIR CLEANING CONFERENCE

distributions were obtained only when the Q107 was being operated at a volume flow rate of 28.3 m³/min (1000 cfm) with the filter chuck closed and the Owl reading 29 ± 1°.

Prior to initiating the acquisition of data by the microcomputer, the operator was required to enter or verify the values of several parameters, including the date, aerosol material (di-2(ethylhexyl) phthalate [DEHP] or di-2(ethylhexyl) sebacate [DEHS]), LAS-X sample flow rate, two diluter meter readings (from which an approximate dilution ratio was calculated), and the Owl reading. Data acquisition required approximately 1 minute (11 seconds for each of 4 ranges with a potential initial "dead time" of 11 seconds) after which the filter chuck could be opened and normal operations continued. The microcomputer analyzed the data immediately after acquiring a complete set. The data analysis included index of refraction corrections for DEHP and DEHS. The output of the data analysis system was printed on a paper tape in the form of a graph of the raw data and the calculated lognormal distribution, a table of all entered and calculated parameter values, and a table of the raw data (Figure 1). In addition, the raw data were stored on a cassette tape along with all relevant parameter values.

The operator kept a logbook containing a summary of each calibration and size distribution measurement and a record of comments, costs, and time spent conducting the study. Approximately once a month, the cassette tape and a copy of the relevant logbook pages were sent to Los Alamos for analysis. No preliminary results of the data analyses were provided prior to the end of the 1-year study in order to avoid potential bias of the data.

Each data set recorded on a cassette tape was reanalyzed at Los Alamos to obtain another paper tape copy of the raw data and the results of the data analysis. Initially, the Los Alamos analysis was performed with the same software as had been provided to the FTFs to obtain the principal parameters of the size distribution, the geometric mean diameter (D_g) and the geometric standard deviation (σ_g). The data analysis technique incorporated into that software provided a fast and convenient means of describing the parameters of the measured size distribution by direct calculation of D_g and σ_g from the histogram data. However, one characteristic of that data analysis technique was that it provided an inaccurate description of the size distribution when it was truncated, i.e., a significant fraction of the particles were outside the measurement range of the LAS-X.

It was apparent that truncation was occurring with many of the data sets received from the FTFs, so the data were analyzed with another (much slower) data analysis technique which avoided errors due to truncation of the size distribution. This nonlinear least-squares data analysis technique used a modified simplex search procedure to find the three parameters of a lognormal distribution (number concentration, geometric mean diameter, and geometric standard deviation) which minimized the sum of the squared deviations between the histogram data and the corresponding quantities calculated from the lognormal distribution. All measurements of the Q107 aerosol were analyzed by the nonlinear least-squares technique and those results are presented in this paper. All of the best-fit lognormal distribution found by this technique appeared to fit the data well when checked visually. For data sets in which no significant truncation of the size distribution occurred, the results of the two data analysis techniques agreed well.

18th DOE NUCLEAR AIRBORNE WAST2 MANAGEMENT AND AIR CLEANING CONFERENCE

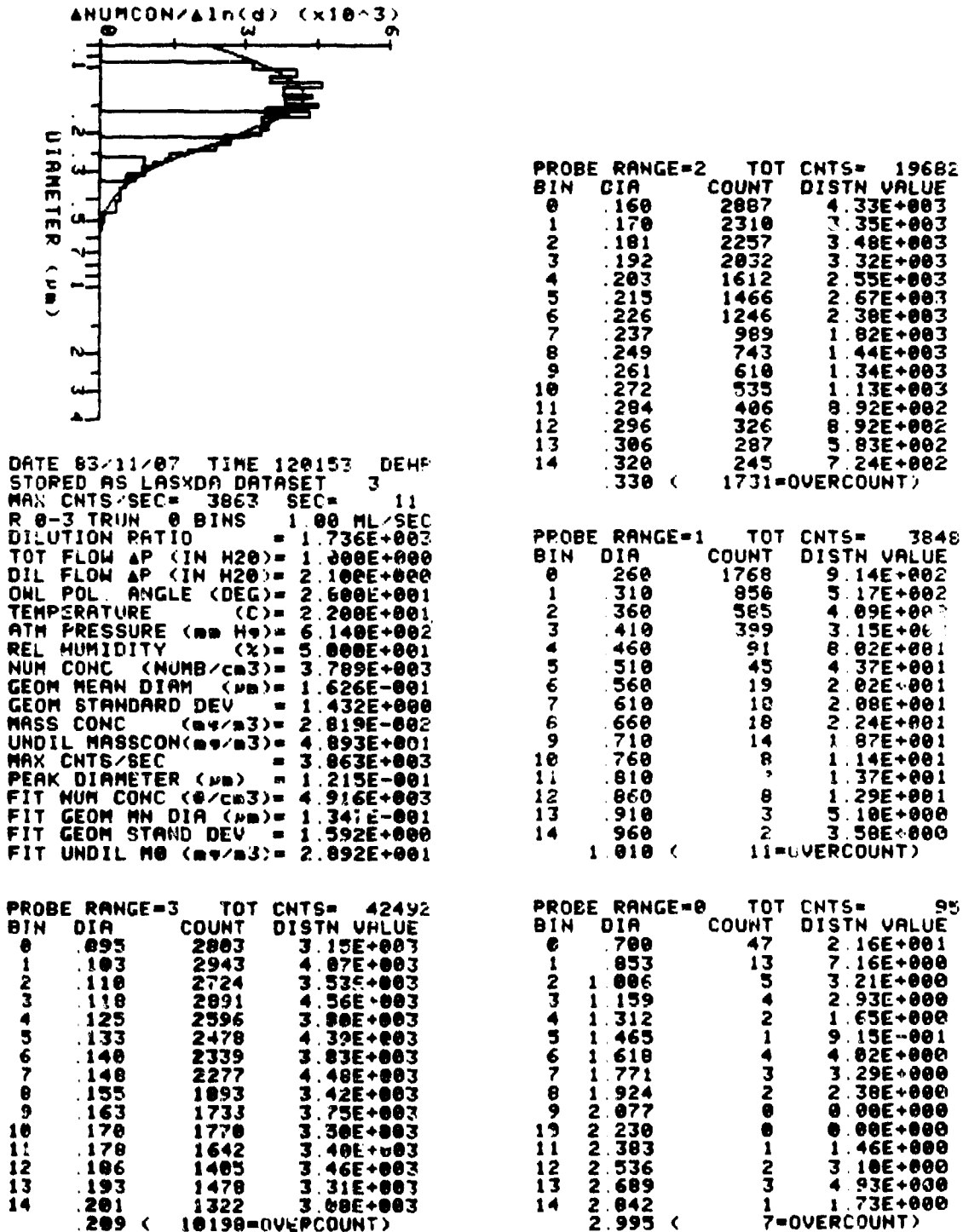


Figure 1. Example paper tape generated by the HP-85 data analysis system, including graph of histogram data and fitted lognormal distribution, table of all entered and calculated parameters, and table of raw counts and derived histogram values.

18th DOE NUCLEAR AIRBORNE WASTE MANAGEMENT AND AIR CLEANING CONFERENCE

The acceptability of each data set for inclusion in the final summaries was judged on three criteria: 1) all data was properly entered (date, aerosol type, Owl reading, and dilution ratio), 2) the count rate was less than 5000 s^{-1} , and 3) there was good overlap in the distribution, i.e., there was good agreement between the two size distribution values obtained at those sizes where adjacent LAS-X ranges overlap. As reported elsewhere in this meeting, the LAS-X count rate must be below 3000 s^{-1} in order to assure accurate counting of particles.⁽¹⁾ However, the less stringent limit on count rate of 5000 s^{-1} was adopted as an upper limit in this study for obtaining valid size measurements. Those data for which the count rate was below 3000 s^{-1} were analyzed separately to determine if the two count rate limits had any significant effect on the results.

IV. Results

Detailed analyses of the costs, manpower requirements, and operational acceptability of the LAS-X will be presented in the final report after all the data are available. The results presented in this interim report are drawn from the calibration data and the measured size distributions of the Q107 aerosols. Table 1 shows the number of days on which data were collected for the study and the number of calibration and Q107 aerosol data sets accepted and rejected for each of the FTFs.

Table 1. Data set census.

| | <u>Number of Data Collection Days</u> | <u>Number of Calibration Data Sets</u> | | <u>Number of Q107 Aerosol Data Sets</u> | |
|----------|---|--|-----------------|---|-----------------|
| | | <u>Accepted</u> | <u>Rejected</u> | <u>Accepted</u> | <u>Rejected</u> |
| RF-FTF | 109 | 97 | 25 | 128 | 212 |
| HEHF-FTF | 46 | 55 | 14 | 23 | 60 |
| OR-FTF | 45 | 55 | 15 | 58 | 39 |

The detailed results of each acceptable data set are graphed in Figure 2 for the Rocky Flats (RF) FTF, in Figure 3 for the Hanford Environmental Health Foundation (HEHF) FTF, and in Figure 4 for the Oak Ridge (OR) FTF as a function of time. The calibration results are presented in the top graph in each of the three figures. The narrow size distribution of each PSL measurement was examined to determine the LAS-X size channel with the maximum height. The central diameter corresponding to that size channel was then plotted on the ordinate as a measure of the size of the PSL spheres as determined by the LAS-X.

The second graph in each of the three figures shows the count rate. All data sets corresponding to count rates greater than 5000 s^{-1} were considered unacceptable for inclusion in the analysis. The count rate was calculated in the data analysis program from the sample duration and the largest of the particle counts recorded in the four LAS-X ranges.

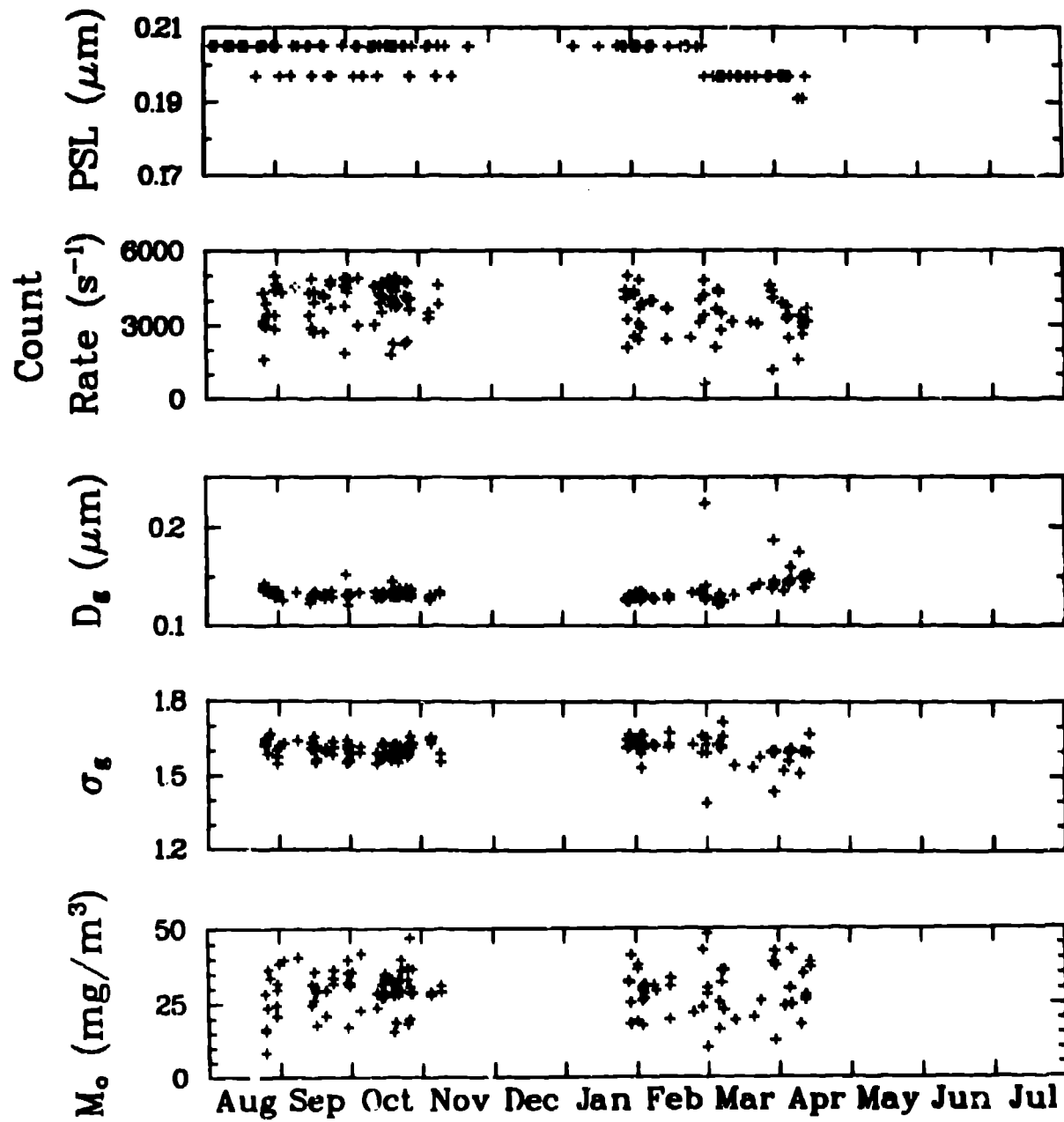


Figure 2. Summary of first 9 months of data from all acceptable Rocky Flats FTF data sets (having count rate $< 5000 \text{ s}^{-1}$), including the central diameter of the LAS-X channel containing the highest peak for PSL, count rate, geometric mean diameter, geometric standard deviation, and estimated mass concentration.

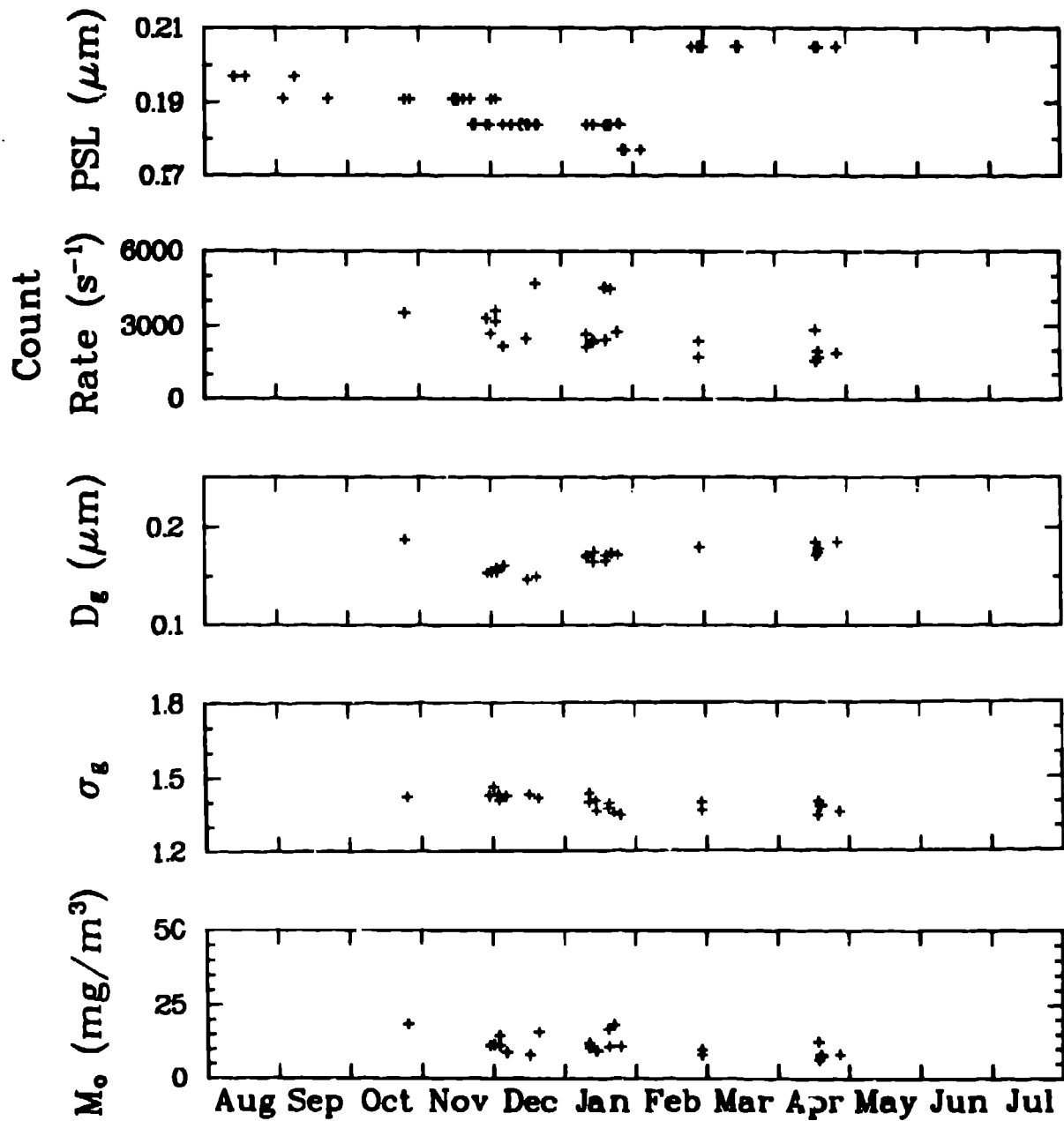


Figure 3. Summary of first 9 months of data from all acceptable Hanford Environmental Health Foundation FTF data sets (having count rate $< 5000 \text{ s}^{-1}$), including the central diameter of the LAS-X channel containing the highest peak for PSL, count rate, geometric mean diameter, geometric standard deviation, and estimated mass concentration.

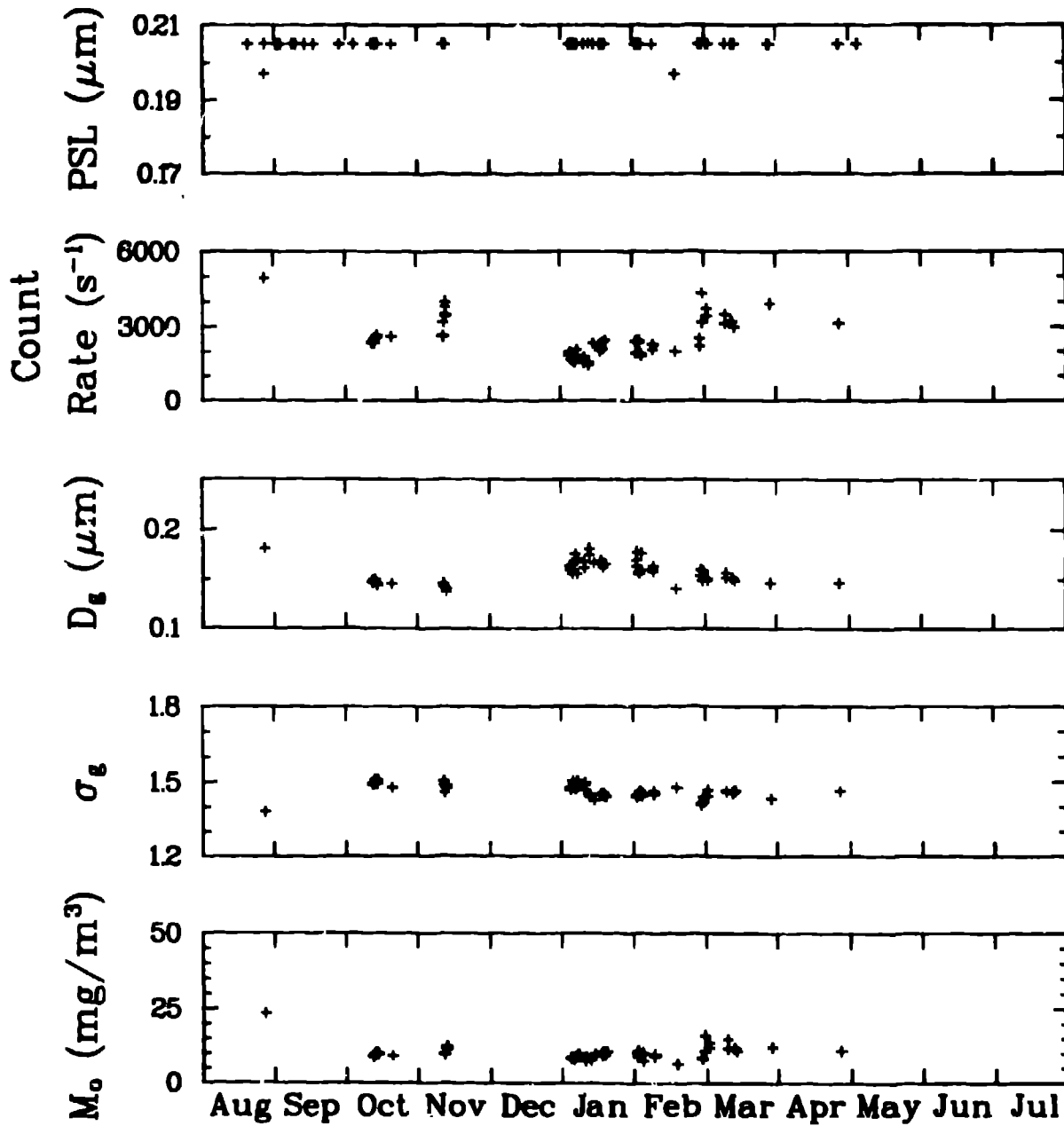


Figure 4. Summary of first 9 months of data from all acceptable Oak Ridge FTF data sets (having count rate $< 5000 \text{ s}^{-1}$), including the central diameter of the LAS-X channel containing the highest peak for PSL, count rate, geometric mean diameter, geometric standard deviation, and estimated mass concentration.

The bottom three graphs in the three figures show D_g , σ_g , and the calculated mass concentration (M_0) for the best-fit lognormal distribution determined by the nonlinear least-squares analysis of the data. These values provide an accurate description of the raw data, even when the size distribution is truncated.

The means and standard deviations of each of the five quantities graphed in Figures 2-4 are listed in Table 2 for each of the FTFs. The mean values of the geometric mean diameter and geometric standard deviation are essentially unchanged when only the data sets corresponding to a count rate below 3000 s^{-1} are included in the calculations.

Table 2. Summary of numerical results for Count Rate $< 5000 \text{ s}^{-1}$ (top line) and $< 3000 \text{ s}^{-1}$ (bottom line).

| | <u>RF-FTF</u> | <u>HEHF-FTF</u> | <u>OR-FTF</u> |
|---|---|--|--|
| PSL Peak (μm) | $.202 \pm .004$ [97] ^a | $.189 \pm .003$ [55] | $.205 \pm .002$ [55] |
| Count Rate (s^{-1}) | 3713 ± 898 [128] 2307 ± 590 [25] | 2769 ± 909 [23] 2266 ± 398 [16] | 2559 ± 767 [58] 2159 ± 364 [42] |
| Geometric Mean Diameter (μm) | $.14 \pm .01$ [128] $.14 \pm .02$ [25] | $.17 \pm .01$ [23] $.17 \pm .01$ [16] | $.16 \pm .01$ [58] $.16 \pm .01$ [42] |
| Geometric Standard Deviation | $1.61 \pm .04$ [128] $1.60 \pm .06$ [25] | $1.40 \pm .03$ [23] $1.39 \pm .03$ [16] | $1.46 \pm .03$ [58] $1.47 \pm .03$ [42] |
| Mass Concentration (mg/m^3) | 29 ± 7 [128] 20 ± 5 [25] | 11 ± 3 [23] 10 ± 2 [16] | 10 ± 2 [58] 9 ± 1 [42] |

^aMean \pm Standard Deviation [Number of Data Sets]

V. Discussion

As described by Scripsick, precise aerosol size, mass concentration, and penetration measurements using a laser spectrometer require a carefully operated and characterized diluter.⁽¹⁾ One important characteristic of a diluter in this application is the amount of variation of dilution ratio with particle size. Such variations might be seen if significant size dependent particle losses occur within the diluter.

The 5 cfm capillary diluters utilized in this study were not originally designed for use with the LAS-X, although they were among the few types available when they were provided to the FTFs during Salzman's early evaluations of the instrument.^(2,5) They have not yet been fully characterized with respect to the variation of dilution ratio as a function of particle size. However, the FTFs used identical diluters, so comparisons of size distributions at the FTFs should be valid. Also, the expected particle losses in the capillary due to diffusional losses to the wall are negligible due to the relatively high volume flow rate through it (0.14 L/min at a dilution ratio of 1000). Impaction and sedimentation losses should also be

18th DOE NUCLEAR AIRBORNE WASTE MANAGEMENT AND AIR CLEANING CONFERENCE

negligible for the small particle sizes encountered in this study. Thus, it is not expected that the preliminary size distribution measurements summarized in this interim report will differ significantly from those calculated once the diluters are more fully characterized.

The dilution ratios were calculated from the ratio of the volume flow rate through the capillary (calculated from the measured pressure drop across the capillary) and the volume flow rate through the bypass containing HEPA filters (calculated from the measured pressure drop across a metering orifice in the line). Limited validation of dilution ratios calculated by this technique was performed using a submicron oil aerosol and a photometer. The calculated dilution ratios should be considered to be approximate as should the mass concentrations derived using them. Since it was not an objective of this 1-year study to validate the ability of the LAS-X/diluter/HP-85 system to measure mass concentrations precisely, no further effort will be placed on refining the estimated dilution ratios and mass concentrations.

The data set census in Table 1 indicates that 1) the Rocky Flats FTF collected data on a larger number of days during the 9-month study period than did the other two FTFs, 2) approximately one-fifth of the calibration data sets were rejected as unacceptable, and 3) a large fraction of the Q107 aerosol data sets were rejected as unacceptable. Included in the number of data collection days in the first column of Table 1 were all days on which any calibration or Q107 aerosol data sets were recorded.

A "calibration data set" was defined as a data set for which the operator had chosen "PSL" as the value of the aerosol material parameter in the microcomputer program. In almost every case, at least one acceptable calibration data set was obtained by the FTF operators for each day that data was collected. In some cases, more than one calibration data set was obtained on a given day, especially near the beginning of the study when the operators were becoming familiar with the instrumentation and procedures. Common reasons for rejection of a calibration data set were 1) an incorrect date (often entered in an unacceptable format), 2) an incorrect choice of "PSL" for the value of the aerosol material parameter when sampling the Q107 aerosol, and 3) an error in not connecting the LAS-X to the PSL nebulizer output. These errors were relatively infrequent as shown by the 20 per cent rejection rate for the calibration data sets.

A large fraction of the Q107 data sets were rejected as unacceptable. Many of these data sets were rejected because the count rate was larger than 5000 s^{-1} . This was the case for approximately one-half of the rejected Q107 data sets at the RF-FTF, one-third of those at the HEHF-FTF, and three-fourths of those at the OR-FTF. These rejections are mostly due to the inability of the 5 cfm diluter supplied by Los Alamos to provide adequate dilution. During the first month of the study, the attainable dilution ratios were much too low making essentially every Q107 data set unacceptable. By the end of the first month of the study, Los Alamos had supplied a smaller diameter dilution tube to each FTF providing adequate dilution for many measurements, but not for all. Besides high count rates, other common reasons for rejection of Q107 aerosol data sets were 1) incorrect date, 2) incorrect identification of the aerosol material, e. g., DEHS at Rocky Flats where DEHP is used, 3) no dilution ratio entry, 4) no Owl reading entry, and 5) poor agreement in the overlap region of two LAS-X size ranges. Poor overlap is often a symptom of a count rate which is too high but could also be due to a fluctuating aerosol concentration.

18th DOE NUCLEAR AIRBORNE WASTE MANAGEMENT AND AIR CLEANING CONFERENCE

Figures 2-4 and Table 2 contain a large amount of information which will be discussed in some detail. Referring to the top plot in each of the three figures, it can be seen that the PSL calibrations were quite consistent over the 9-month period at the RF-FTF (Figure 2), changed systematically with time at the HEHF-FTF (Figure 3), and were very consistent at the OR-FTF (Figure 4). On the highly magnified particle diameter scale of the plots, apparent changes in the size of the PSL spheres are recorded as noticeable jumps in the recorded PSL diameter. Each jump corresponds to the peak of the narrow PSL size distribution changing by one LAS-X size channel. The LAS-X unit at the HEHF-FTF was the only one of the three which may not have adequately corrected for the gradual dirtying of the optics during the many hours of operation. As seen in Figure 3, the apparent PSL size gradually decreased, dropping by three LAS-X bins throughout the first several months of the study. It increased to one bin above the original level after the unit was sent to the factory for maintenance and repair, which included cleaning of the optics. With the exception of the HEHF-FTF unit, the model LAS-X has been found capable of maintaining a consistent calibration in this study and in the laboratory work performed by Los Alamos.

The second plot (labeled Count Rate (s^{-1})) in each of the Figures 2-4 shows that the count rate was quite variable, even among Q107 data sets taken on the same day. The diluter settings were not changed at each of the FTFs after the first several weeks of operation, having been set to give the highest attainable dilution. The variable count rates and nominally constant dilution ratio explain the high variability of the estimated mass concentrations shown in the bottom plot (labeled M_0 (mg/m^3)) of each of the Figures 2-4. Highly variable count rates could have arisen either from a highly variable concentration of Q107 aerosol or from a highly variable dilution ratio. If the concentration of the Q107 aerosol concentration varies significantly over 2 hours, the time between LAS-X measurements of the size distribution, it should be detectable as changes in the "100%" setting on the Q107 photometer. If the dilution ratio provided by the Los Alamos 5 cfm diluter varies significantly over 2 hours, it should be detectable as changes in the readings of the two gauges monitoring the two internal volume flow rates in the instrument. Further investigation may reveal the probable source of the high variability of the count rate and the estimated mass concentration. However, no definitive statement of the source of the variability can be made at this time with the available information.

The third plot [(labeled D_g (μm))] and the fourth plot (labeled σ_g) on each of the Figures 2-4 contain information relating to variations of the Q107 aerosol size distribution over time. With few exceptions, the two size distribution parameters are relatively constant at each FTF as shown in Table 2. There are no clear patterns of seasonal or daily variations which can be seen upon visual inspection of the data.

On February 29, the RF-FTF operators measured an unusually large geometric mean diameter (.22 μm) and an unusually small geometric standard deviation (1.40) for the first measurement of the Q107 aerosol of the day even though the Owl reading was constant at 29°. Two hours later the same two aerosol parameters had values of .13 μm and 1.66, which are much closer to the average values for the RF-FTF. A similar occurrence was noted about 4 weeks later when the two aerosol parameters values were $D_g = .19 \mu m$ and $\sigma_g = 1.44$ for the first Q107 aerosol size measurement of the day, when the Owl reading was 28°.

It is a characteristic of the Owl that it cannot distinguish among the many polydisperse size distributions which will give an Owl reading of 29°.(6,7) This is illustrated in a Mie calculation of the Owl reading (polarization ratio) for a variety of lognormal distributions having geometric mean diameters between .1 and .4 μm and geometric standard deviations between 1.0 and 1.5 (Figure 5). In these calculations, the Owl is approximated by a light source which emits a single wavelength at .534 μm and a detector which subtends an negligibly small solid angle at a scattering angle of 90°. The results of the calculations which include these approximations provide a good indication of the trends in Owl response to polydisperse aerosols. As seen in Figure 5, lognormally distributed aerosols having increasingly smaller geometric mean diameters will give the same Owl reading as a .3 μm monodisperse ($\sigma_g = 1.0$) aerosol providing the polydisperse aerosol has a sufficiently large geometric standard deviation. This is the same trend seen in the two unusual Q107 aerosol size distribution results obtained at the RF-FTF. It is this ambiguity in measuring the size of a polydisperse aerosol which led to the consideration of the LAS-X as an alternative to the Owl to monitor the size distribution of the test aerosol at each FTF.

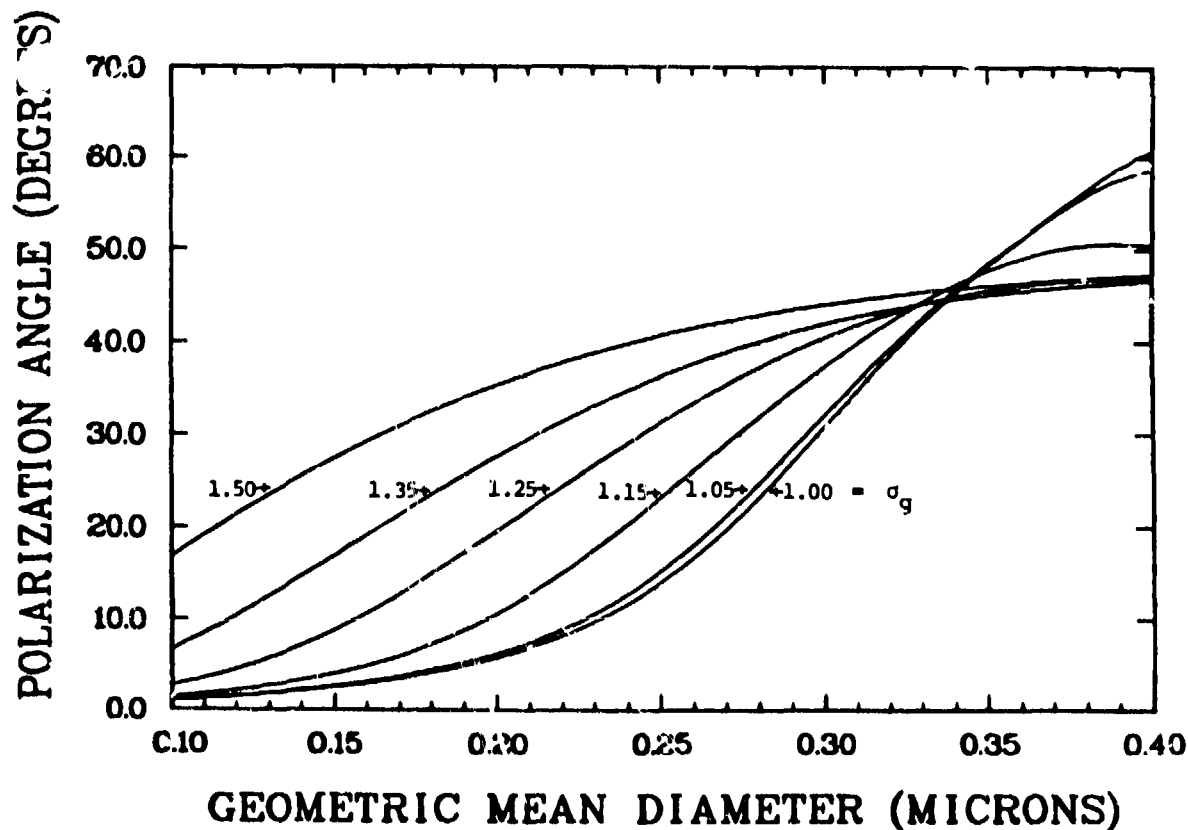


Figure 5. Results of Mie scattered light calculations providing approximate predictions of the response of the Owl as a function of the geometric mean diameter and geometric standard deviation of lognormally distributed DFHP aerosols. The illuminating wavelength was taken to be .524 μm and the polarization ratio was calculated for 90° scattering.

LEAR AIRBORNE WASTE MANAGEMENT AND AIR CLEANING CONFERENCE

ary in Table 2 of the mean geometric mean diameter and geometric standard deviation for each FTF makes it clear that the Q107 aerosol is different from the 0.3 μm monodisperse aerosol which is often the Dwl reading of 29° required by MIL-STD-282.(3) This is in agreement with previous reports.(2,6) The proposed DOE Nuclear Standard requires that any new penetrometer system which might be proposed to test Q107 should test HEPA filters with an aerosol having a geometric mean diameter between .16 and .24 μm and a geometric standard deviation of 1.5.(4) Table 2 indicates that two of the FTFs were testing HEPA filters during the first 9 months of the study with an aerosol which fell outside the specifications. The RF-FTF typically had a smaller geometric mean diameter and larger geometric standard deviation.

There is no requirement presently for the FTFs to test HEPA filters with an aerosol meeting the specifications in NE-F-3-43 and no attempt was made to adjust the Q107's to match those specifications. It is conceivable that adjustments to the Q107 aerosol size distribution could be made based on data obtainable from sampling with the LAS-X/diluter/HP-85 system to meet the aerosol specifications of NE-F-3-43 and the requirement of an aerosol of 29° in MIL-STD-282.

The RF-FTF proceeded with a planned replacement of the Q107 on which data were obtained during mid-1984. Approximately 1 month's data should be available at the end of the full study to indicate the typical aerosol size distribution generated by the new Q107 at the RF-FTF.

The mass concentration estimates summarized in Table 2 based on the LAS-X data should be considered approximate due to the incomplete calibration of the diluter provided to the FTFs for this study. Accurate mass concentration measurements with a laser spectrometer require accurate particle counting, and dilution ratios. It was not an objective of this study to make accurate mass concentration measurements with the LAS-X particle size measurement system.

The detailed evaluation of the operation of the LAS-X at each FTF during the study will be given in the final report. Some operational points of interest are: 1) FTF operators typically took only a few minutes to perform a daily check of the LAS-X and a few minutes to make each measurement of the Q107 aerosol, 2) a major repair of the RF-FTF LAS-X required due to a failure of a circuit involved in data transfer to the microcomputer, 3) a major repair of the GR-FTF LAS-X involved the replacement of a power supply, and 4) the HEHF-FTF LAS-X was sent to the manufacturer for cleaning and calibration due to the increasing error in measuring the PSL calibration aerosol. Loss of the LAS-X due to these incidents resulted in the major data gaps seen in Figures 2-4. Over the period of the study at Los Alamos, it has been found that each LAS-X typically requires the replacement of the laser tube approximately once each year. The manufacturer has recently stated that a new laser tube assembly technique may increase the laser tube lifetime to approximately 5 years. It is clear that if the LAS-X could be incorporated into the HEPA filter testing system, a back-up LAS-X should be available at each FTF in order to avoid delays in filter testing. Each LAS-X typically has to be removed from service at least once a year for factory calibration and/or repair. Such back-up capability is a normal requirement at any facility requiring continuous filter operation.

VI. Summary of Major Conclusions

Several major conclusions have been reached based on the analyses of the first 9 month's data from the 1-year study. Additional detailed conclusions and, perhaps, modifications of the following conclusions will be available in the final report detailing the results of the full study.

1. The LAS-X can be successfully operated in the FTF environment to measure the size distribution of the Q107 test aerosol.
2. Incorporation of the LAS-X into the quality assurance test procedures would require a back-up LAS-X at each FTF and a more convenient and better characterized diluter than the one provided to the FTFs for this study.
3. Either the concentration of the Q107 test aerosol or the dilution ratio of the diluter provided to the FTFs for this study is quite variable over time.
4. The measured Q107 aerosol size distributions are not monodisperse as assumed in the existing MIL-STD-282 and they do not all meet the size distribution specifications which a replacement aerosol would be required to meet by DOE Nuclear Standard NE-F-3-43.
5. The test aerosol at each FTF has a quite consistent size distribution over time.
6. The test aerosols at the three FTFs differ consistently.

The 1-year study is succeeding in providing information to DOE which will be important in deciding whether the LAS-X particle size measurement system should replace the Owl to monitor the aerosol size distributions at the FTFs.

Acknowledgements

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