NASA Conference Publication 2212

The Third International Cloud Condensation Nuclei Workshop

Reno Workshop Objectives, Accomplishments, Instrument Descriptions and Review Papers

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The Desert Research Institute
University of Nevada System
Reno, Nevada

Proceedings of a workshop sponsored by
The National Aeronautics and Space Administration
and The National Science Foundation
and held at
The Desert Research Institute
Reno, Nevada
October 6–17, 1980

National Aeronautics and
Space Administration

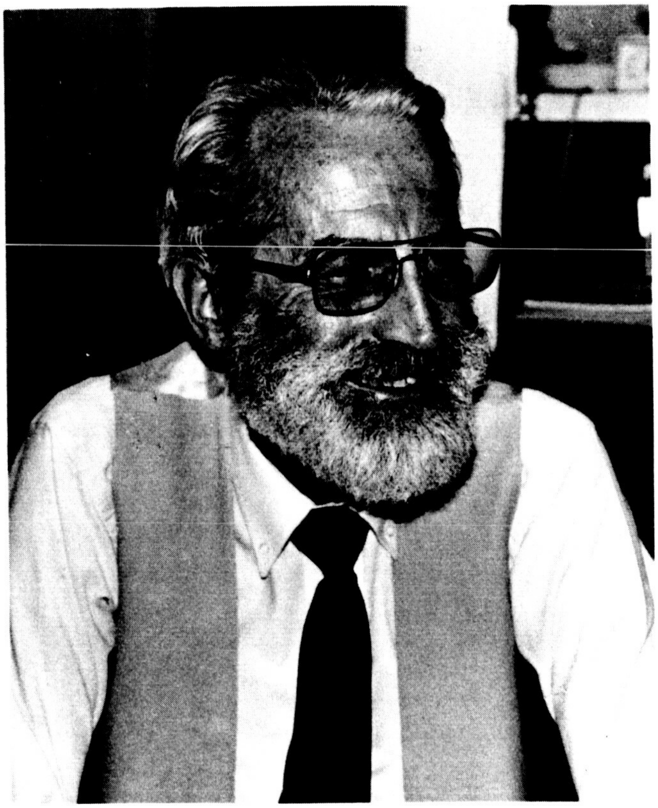
1981

DEDICATION

It is with great sorrow that we recall the untimely loss of our good friend and colleague, Professor Roger Lincoln Steele.

A man of great talent and undeniable style, Professor Steele contributed extensively to Workshops such as this one, from his scientific involvement in the First International Workshop at Lannemezan, France in 1967, to his responsibilities as Chairman of the Organizing/Steering Committee during the Second Workshop held in Ft. Collins, Colorado in 1970.

Professor Steele will remain in our minds as an individual of uncommon strength and unique character, and it is to his memory that we dedicate these Proceedings.



ROGER LINCOLN STEELE

February 12, 1924 - November 10, 1980

CCN WORKSHOP PARTICIPANTS

Standing, left to right:

A. Gagin, H. Nuzitsa, U. Katz, J. Dea, W. Hoppel, J. Hudson, J. Jiusto, H. Gerber, R. Borys, R. Serpolay, E. Hindman, V. Keller, M. Politovitch, T. Ohtake, W. Mach, R. Hucek, R. McKenzie, W. Kocmond, F. Rogers, T. Wojciechowski, M. Kitchen, J. Fitzgerald, G. Ayers, G. Lala

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ABSTRACT

The Third International Cloud Condensation Nuclei Workshop was held at the Desert Research Institute, Reno, Nevada, October 6-17, 1980. The goals of the Workshop were to intercompare CCN measurement technology and to perform a limited number of experiments of fundamental scientific interest. A total of 39 scientists representing 20 institutions were in attendance. Twenty-five instruments were tested, including size characterization devices and two Aitken counters. The test aerosols were supplied to the instruments by an on-line generation system, thereby eliminating the need for storage bags. Some of the main conclusions reached during the two-week Workshop were as follows:

(1) Test aerosols of pure soluble salts, both monodisperse and polydisperse, can be provided with stability in output concentration to about ±3% per hour;

(2) Of nine static diffusion chambers (SDC), the five best units (averaged) agreed to within 20% of the NRL mobility analyzer and to within 10% at 1% supersaturation;

(3) Four of the five continuous flow diffusion (CFD) chambers agreed with each other to within about 15% at 0.7% supersaturation and about 20% at 0.3% supersaturation;

(4) The best CFD's and SDC's agreed to within about 15%;

(5) Two of four isothermal haze chambers agreed with each other to within about 40%;

(6) Analysis of the results showed that most instruments' estimation of the CCN spectral slope, k, and the known dry aerosol size distribution slope, β, confirmed the theoretical relationship $k = 2/3\ \beta$.

THIRD INTERNATIONAL CLOUD CONDENSATION NUCLEI WORKSHOP

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SECTION I. INTRODUCTION

In 1967 the First International Workshop on Condensation and Ice Nuclei was convened under the guidance of Prof. Henri Dessens at his Centre de Recherches Atmospheriques in Lannemezan, France. The Workshop provided a unique opportunity for scientists from all parts of the world to exchange ideas on measurement techniques and to compare instruments for observing ice and condensation nuclei.

A number of important lessons were learned from the first Workshop; principal among them was the need for improved methods of particle generation and characterization, and also the requirement to provide a continuous and stable source of nuclei to the instruments. Solutions to these problems were provided by the combined efforts of several scientists, and at the Second International Workshop, held at Colorado State University in Ft. Collins, Colorado, in August 1970, substantial progress was made in generating, storing and delivering aerosols in the desired size ranges to the more than 25 CCN and Ice Nucleus measuring devices.

In retrospect, the Ft. Collins Workshop was an enormous success, providing researchers an opportunity to learn about the strengths and limitations of the then current instruments used for measuring atmospheric nuclei. At the conclusion of the Workshop, it was determined that, since the needs of CCN and IN counters are so vastly different in terms of aersol concentrations, separate workshops would be preferable in the future for comparing these two major types of instrumentation. Indeed, this has been the case and, in 1975, an independent Ice Nucleus Workshop was held at the University of Wyoming in Laramie, Wyoming. The objective of that Workshop was to measure and compare methods of ice nucleus measurement; additional useful experiences were gained in methods of generating and delivering ice-forming nuclei to the instrument.

Ten years were to pass before the present Workshop was convened at the Desert Research Institute (DRI) in Reno, Nevada. In the intervening period, progress has been made in instrument design technology, and several new measurement concepts have emerged. Notable among them have been the various types of continuous flow diffusion (CFD) chambers, the isothermal "haze" chambers which are able to operate at extremely low supersaturations, the highly efficient CFD spectrometers and the automated static diffusion chambers. Detailed discussions of each of these types of CCN instruments are provided within these proceedings.

The advances in CCN counter technology have been more than matched by the growth and improvements in aerosol size characterization technology. As just one example, electrical aerosol analyzers are now an off-the-shelf item in use in laboratories throughout the world, whereas at the time of the Ft. Collins Workshop, only a few groups possessed prototype devices.

In view of the many recent innovations in CCN counters, as well as the vast improvements that have been made in particle characterization technology, it was the unanimous decision of the Ad Hoc Commission of the Nucleation Committee, International Commission on Cloud Physics (ICCP), that a high quality instrument comparison workshop be conducted. With the support of the National Science Foundation and the National Aeronautics and Space Administration, such a Workshop was conducted at DRI, Reno, Nevada, October 6-17, 1980, with W. Kocmond and J. Jiusto serving as sponsor Principal Investigators. It is the purpose of these proceedings to document the results and activities of the two-week Reno Workshop.

SECTION II. OBJECTIVES

In the broadest sense, the Third International CCN Workshop had two principal objectives:

(1) To intercompare CCN measurement technology over a wide range of instrument operating conditions, and

(2) to perform one or perhaps two fundamental cloud physics experiments of interest to the scientific community.

Because of the strong desire to check each instrument's detection limits and response characteristics under varying operating conditions, most experiments were directed toward this goal. Deliberations by a Workshop Steering Committee (Gagin, Jiusto, Kassner, Kocmond, Megaw, Ruskin and Radke) in conjunction with DRI representatives produced several recommendations with regard to the scientific details of the experiments that were performed. The principal recommendations were:

(1) that the composition of the test aerosols should include NaCl, AgI and $(NH_4)_2SO_4$;

(2) aerosol concentrations should be in the range of a few hundred to a few thousand per cm^3 active at 0.1 to 1.0% supersaturation;

(3) ambient air monitoring should be a part of each day's runs;

(4) on-line continuous generation of aerosols with high stability ($\pm 2\%$) would be preferred over use of a storage bag to supply aerosols to the instruments;

(5) aerosol samples should be forced through a duct, rather than drawn by suction in order to avoid possible contamination from negative line pressures; and

(6) both polydisperse and monodisperse aerosols should be generated for the intended instrument checks.

In addition to these recommendations, the consensus held that a few steep sloped aerosol distributions should be produced for tests of instrument responsiveness and also one or two experiments of very high (> 2000 cc^{-1} active at 1.0%) and very low (< 200 cc^{-1} active at 1% supersaturation) aerosol concentrations should be performed to test each instrument's limits of detection.

With such a broad range of instrument calibration checks, there was less opportunity to conduct specific experiments of fundamental scientific interest. A number of suggestions were considered which included e.g. tests of Kohler theory for a range of particle sizes; comparisons of experiment and theory regarding condensation on particles of limited wettability; checks of temperature dependence of CCN activity in terms of S_c; and attempts to identify conditions under which particle multiplication may occur.

Partial answers to several of these questions were obtained from the results of experiments performed during the course of the Workshop. Details regarding the findings can be found in the individual summary papers.

SECTION III. WELCOMING REMARKS

Welcoming Address

by

H.W. Georgii
Institut fur Meteorologie und Geophysik
Frankfurt, Germany

Ladies and Gentlemen:

It is a privilege for me to welcome you to the Third International Workshop sponsored by the Committee on Nucleation of the International Commission on Cloud Physics and supported by the National Science Foundation and NASA. We are here as the guests of the Desert Research Institute of the University of Nevada, and my special thanks and gratitude go to the host, Professor Warren Kocmond and his associates who provided these beautiful facilities for us. To all of you, I want to express our gratitude. This workshop is mainly devoted to the measurement of cloud condensation nuclei. As a matter of fact, the Second International Workshop, held during August 1970 at Fort Collins had to deal, among other goals, with the following subjects:

(1) Survey of the state-of-the-art in the field of measurement of CCN, (2) compare the operating characteristics of various types of CCN counters, and (3) humidity activation characteristics in various types of CCN counters. While the main effort of the 1970 Workshop, and also of the 1975 Workshop held at the University of Wyoming in Laramie, was devoted to the measurement of ice nuclei, six CCN counters were also tested at Ft. Collins. In the meantime, during the last decade, the importance of CCN for cloud and precipitation physics became more evident. We therefore found it appropriate to devote this Workshop predominantly to the measurement of cloud condensation nuclei.

We became aware in the meantime that only aerosol particles activated at a supersaturation of about 0.5% are of interest to the cloud physicist. We have improved our knowledge on the distribution of CCN in the troposphere and its relation to the atmospheric aerosol in general. This is important, since concentration and composition of cloud nuclei influence directly the average size of cloud drops, the number concentration of cloud drops, the colloidal stability of clouds and the optical density of clouds. The importance of sulfate containing particles as potential cloud nuclei was emphasized during the last ten years by many investigators, and it was confirmed that over oceans the sea-salt particles are only a small fraction of the total maritime cloud condensation nuclei. It could be shown that also over the oceans a large fraction of cloud nuclei is composed of ammonium sulfate or sulfuric acid.

Not long ago, it was assumed that Aitken nuclei are of little importance as cloud nuclei. According to more recent observations, we have to assume that a certain fraction of Aitken nuclei is activated as cloud nuclei. However, the results are still somewhat controversial. A large concentration of Aitken particles does not always lead to a large number of CCN. While measurements in the plumes of large cities in the United States showed an increase of CCN downwind of pollution sources, this was not observed in Israel. In general, it can be said that the concentrations of cloud nuclei over the continent range from 100 to 1000/cc while over the oceans they range from some tens to a few hundred/cc. These values are in good agreement with the drop concentrations in continental or maritime clouds. From this point of view, it appears that the cloud nuclei counters used in these investigations detect the right fraction of the atmospheric aerosol activated in the process of cloud formation. One problem, still unsolved, is the possible long-term trend of the cloud nuclei concentration on a global scale. One major source of cloud nuclei is probably the emission of reactive gases and the subsequent formation of secondary nuclei by gas to particle conversion. A long-term increase of the cloud nuclei population will certainly influence the efficiency of the rain-forming process.

During the 1970 Workshop, five CCN counters of the thermal diffusion principle showed satisfactory results and good agreement with natural aerosols. The agreement among the instruments was less satisfactory for artificial aerosols. In the meantime, more sophisticated instruments have been developed and we are looking forward with interest to the experimental phase of this Workshop. Cloud nuclei have become a more and more important fraction of the atmospheric aerosols. I therefore believe that this Workshop is very timely and provides the necessary international platform to study and to discuss the progress which had been made during the last ten years and to give the necessary directives to researchers in this field.

Welcoming and Keynote Address

by

Sean A. Twomey*
University of Arizona
Tucson, Arizona

A. Historical Perspectives

Early workers (e.g., P. Squires) were aware that there were many more condensation nuclei than cloud droplets; the realization came that it was important to make measurements at low supersaturations rather than with Aitken counters. Discussions in the early 1950's turned to the problem of detecting and counting the small cloud droplets that would be produced at small, cloud-like supersaturations.

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*This summary of Dr. Twomey's Welcoming and Keynote remarks has been composed based upon notes provided by the author.

The creation of small supersaturations under isothermal conditions (rather than by adiabatic expansion) seemed highly desirable, leading to the conception of the chemical diffusion chamber. At that time (middle 1950's), Wieland in Switzerland had constructed a thermal gradient diffusion chamber and used it to nucleate and grow droplets at small supersaturations. Detection and counting in Wieland's chamber was accomplished by examination of a sticky layer on the chamber floor, into which droplets fell and were hopefully preserved. Twomey introduced photographic detection, and soon the thermal gradient diffusion chamber, with large diameter-to-height ratio, cooled at the base (for convective stability and to avoid transient supersaturations), became the standard device. Photography became the standard detection method, although problems such as nominally "fast" film being sometimes slower than nominally "slower," but less grainy films, remained to be sorted out. Enough devices were in operation that an early comparison workshop could be held at NRL's Chesapeake Bay Annex in 1965.

Whatever the detection method, it will have a threshold - a minimum detectable size of droplet, and it is evidently vital to determine or estimate that, since otherwise one may be counting inactivated (haze) droplets, or not counting all activated droplets. At very low supersaturations an inactivated droplet may be several microns radius and a clear distinction between "haze" and "cloud" (in terms of size) no longer exists. Under such conditions, a simple counting procedure is hardly sufficient and some method of sizing is required, essentially calling for a different technology.

At about the same time, NRL's airborne CCN studies began, and soon investigators were able to compare CCN counts to cloud droplet concentrations. The comparison results were, in general, satisfactory.

B. Points Concerning the Sizes and Composition of CCN

An aspect of typical cumulative CCN distributions fortunate for cloud physics is that there is found a convenient and simple proportionality between critical supersaturation and numbers of activated cloud droplets:

$$N = CS^k,$$

where k is typically less than unity and often around 0.5 or so. The parameter k could equally well have been much larger, or the simple power law could have been replaced by some less tractable functional relationship. At very low critical supersaturations, k does tend to increase to greater than unity, creating a more difficult situation where the number of droplets activated is critically dependent upon small variations in the ambient supersaturation, and hence on the detailed time evolution of temperature before and during the condensation processes.

The sizes of natural CCN have been shown by several experiments to be close to the minimum size that Köhler's theory (of the critical supersaturation of pure soluble electrolytes) would allow. Again, it is fortunate that most CCN of interest seem to be soluble compounds, not simply insoluble, wettable particles of various contact angles.

It has long seemed that the most likely candidates for these soluble compounds were sodium chloride, ammonium sulfate, and sulfuric acid. Ammonium sulfate continues to be regarded as a predominant constituent.

C. Gaps in the Understanding of CCN

The sources of CCN are not completely understood, although gas-to-particle processes must be a major contributor. The speaker described observations of CCN production occurring over several-hour periods in Arizona, as well as diurnal cycles in the CCN count at the Robertson site in Australia. Related observations by J. Hudson and J. Jiusto were mentioned. CCN are apparently rather transient in nature, with a lifetime of no more than a couple of days. Indeed they cannot exhibit a diurnal cycle if their life expectancy is much longer.

The region of the size spectrum between Aitken nuclei and CCN is another unknown; the ratio of Aitken particle concentrations to CCN concentrations is highly variable, and it seems unlikely that any simple extrapolation or interpolation to connect the two will be sufficient. And to completely understand the progenitors of CCN, it is important to obtain information on the size range from Aitken nuclei on down to molecular clusters, although this region may not be directly relevant to CCN.

The opposite end of the spectrum - from CCN up to "giant" nuclei - is sometimes of influence in cloud droplet growth calculations. It is certainly the critical range in slow condensation processes such as many fogs may be.

A critical instrumental shortcoming is the minimum detectable size of nuclei; some aerosol workers quote 0.01 μm as the minimum sensitive size for particular expansion counters, too large to be helpful in resolving the problems just mentioned.

Welcoming Address

by

Vincent J. Schaefer
State University of New York
Albany, NY

I am very pleased to have the opportunity to participate in this Workshop on instruments for measuring cloud condensation nuclei. I am particularly intrigued to see the number of young scientists now involved in this interesting and important aspect of cloud physics.

About 25 years ago, Ted Rich of the General Electric Company and I (then Director of Research of the Munitalp Foundation) gathered most of the persons interested in atmospheric nuclei and held a three-day conference on this fascinating subject. Only about 20 scientists and engineers could be found in the United States. During this conference, we identified most of the problems that are still with us, but our techniques then were somewhat primitive when compared with the sophisticated electronic equipment now being used in the laboratory, as well as in the field and on aircraft.

I was intrigued with the comments of Dr. Georgii, which in his absence were read by Dr. Dieter Stein. I am indeed sorry to learn that due to illness Dr. Georgii will not be attending this Workshop. I had looked forward to seeing him and hope he is well on the road to recovery. Several statements in his remarks were particularly interesting to me, since I have spent a great deal of time in many parts of the world in an attempt to establish the aerosol concentration patterns in a wide variety of environments. My findings agree completely with the patterns mentioned by Dr. Georgii.

Using the portable and highly reliable Gardner counter with which most of you are familiar, I have found consistent patterns in the concentration of both condensation and cloud condensation nuclei in very clean as well as in very polluted air.

It is well recognized that the Gardner counter provides a very good indication of the concentration of Aitken nuclei when used to provide supersaturations in excess of 300 percent. I have found that this instrument can also be used to provide consistent, as well as semi-quantitative measurements of the number of cloud condensation nuclei in an air sample. If instead of using 20 to 27 inches of mercury vacuum only one scale division is used, the Gardner provides a rather good measurement of the concentration of particles active as water condensing nuclei (CCN) at 1 percent supersaturation.

There are several reasons why this method of using this instrument is frowned upon! Ted Rich who, as you know, invented the so-called Gardner counter was the first to tell me that such a procedure was highly irregular and meaningless. He cited intricate relationships in the life cycle of the cloud droplets forming on nuclei at various supersaturations which he had measured during the development of his instrument.

Despite this disapproval, I have made many thousands of measurements using this instrument in its low vacuum mode as well as high and median settings. I have found that the results provide an extremely consistent measurement of the concentration of cloud condensation nuclei in a particular type of environment. Thus in particle-free air I read zero particles. In very clean air, such as the stratosphere, mid-ocean, the Fiji Islands, mountain summits, caverns, deep forests, and similar places far from man's influence, my measurements of cloud condensation nuclei (CCN) range from 0 to 150 CCN cm^{-3} when the Aitken particle concentration ranges from 200 to 1000 particles per cubic centimeter.

At the other extreme, in cities, the plumes of heavy industries, large airports, superhighways, vehicular tunnels, and the like, the values I find range from 800 to 3000 cloud condensation nuclei and 50,000 to 300,000 Aitken nuclei pe. cubic centimeter.

I have classified the natural and anthropogenic aerosol concentration measured mostly in the Northern Hemisphere and have summarized these findings in three volumes which have recently been published by our Research Center and which I'll be glad to send to participants of this Workshop while the supply lasts.

I hasten to add that what I have just said does not in any way suggest that the Workshop which is starting with this meeting is not extremely important. If progress is to be made in our cloud physics studies, it is extremely important that all measuring instruments used to establish scientific facts such as the concentration of atmospheric particles should agree with each other. Only then will we be able to communicate with each other in a meaningful way.

As most of you who have worked in the atmosphere know, the concentration of airborne particles varies over a considerable range, no matter where it is measured. It is necessary when establishing an aerosol "climatology" at a given geographic location to determine the range in concentration over a period of time, its diurnal pattern and the effects that appear with wind direction and atmospheric stability. It is also necessary to measure seasonal variations.

On the west coast of Ireland, for example, with a southerly or southeasterly flow the particle concentration pattern shows the characteristic of continental air (1000 CCN cm^{-3}/40,000 AN cm^{-3}) while with a northerly or northwesterly flow it is Polar Maritime (100 CCN cm^{-3}/800 AN cm^{-3}). Even in a region noted for high pollution levels such as the Los Angeles Basin, a strong persistent flow of oceanic air will drive the Basin pollution through the mountain passes and even over the crest of the Sierra to affect the air quality of Las Vegas, Phoenix, Flagstaff and more distant places. When this occurs, the particulate levels which could have been 3000 CCN cm^{-3}/300,000 AN cm^{-3} can drop to 500 CCN cm^{-3}/10,000 AN cm^{-3}. When this happens, the visibility is greatly improved and it is possible to see what a delightful place the Basin would be if its population was reduced by an order of magnitude!

I hope when this Workshop is ended and we collectively gain a higher appreciation of the performance of our instruments that extensive field measurements can be mounted so as to establish confidence in the meaning of our data as they relate to atmospheric visibility, the genesis and nature of storms, the stability of clouds and the formation of precipitation, as well as the basic causes of such specific occurrences as acid rain.

I look forward to participating in this Workshop and look forward to meeting you all and seeing your equipment in satisfactory operation.

Have fun!

SECTION IV. WORKSHOP PROGRAM, PROCEDURES AND FACILITIES

In developing a plan for the Third International CCN Workshop, initial efforts were carried out by an Ad Hoc Commission of the Nucleation Committee of the International Committee on Cloud Physics (ICCP); this Ad Hoc Commission, appointed by Professor Georgii, Chairman of the Nucleation Committee, included J. Kassner, J. Megaw, L. Radke, K. Whitby, and J. Jiusto, Chairman. The Ad Hoc Commission returned the recommendation that the Desert Research Institute's offer to host the meeting should be accepted and that a Steering Committee composed of A. Gagin, J. Jiusto, J. Kassner, W. Kocmond, J. Megaw, L. Radke, and R. Ruskin should proceed with the planning of the specific logistical and scientific details of the meeting.

The Steering Committee functioned until the end of the Workshop on October 17, 1980, as the principal scientific decision-making body. A group completely local to DRI, the "Local Arrangements Committee," handled logistical matters such as participant travel arrangements and lodging, the shipping of instruments to and from Reno, and the creation of suitable laboratory space. Individual members of the DRI staff took responsibility for technical matters such as design of an aerosol generation system which would meet the goals set by the Steering Committee, determinations of instrument power supply and heat rejection requirements, and tentative placement of instruments along the aerosol supply duct.

In the meantime, correspondence between the offices of the Principal Investigators and interested individuals, together with announcements in the Bulletin of the American Meteorological Society and the *Journal de Recherches Atmospheriques*, resulted in a tentative list of over 40 participants, later to be somewhat reduced to the actual attendees as shown in Table 1.

As the effort proceeded into the summer months of 1980, it was decided that some members of the Steering Committee could meet during the International Cloud Physics Conference, Clermont-Ferrand, France (July 1980). Three Steering Committee members who attended this meeting held discussions with a contingent of three DRI representatives; out of the talks came a number of important recommendations that were incorporated into the Workshop Objectives (see Section II).

At DRI, U. Katz took primary responsibility for the aerosol generation and distribution system (Figure 1); a more thorough description of the system can be found in Section V. Aerosol sizing, also described in Section V, was "officially" provided by the Naval Research Laboratory at the request of the Steering Committee.

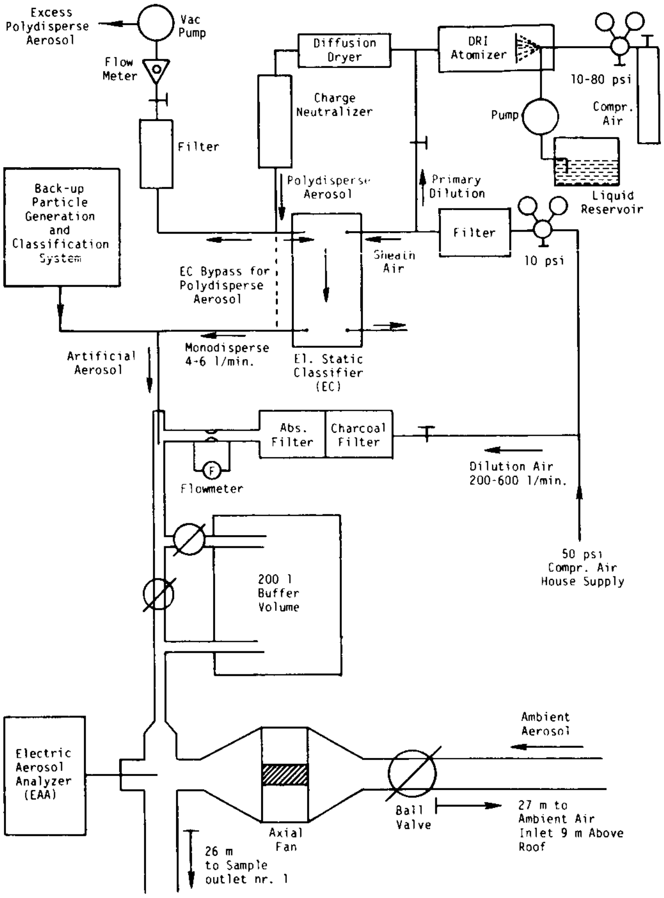

Figure 1. Schematic of Aerosol Generation System

The final physical and logistical arrangements were handled by the Local Arrangements Committee, mainly through Mrs. Jo Janowski and the staff of the DRI machine shop. Under their supervision, the large components of the aerosol delivery system were installed, provision was made for both 50 Hz and 60 Hz electricity totalling over 80 kw delivered to outlets spaced along the entire length of the aerosol duct, and 12 new laboratory benches were built. Travel and lodging arrangements were finalized for 22 participants from the USA and 7 from overseas. A total of 17 instruments of various types had to be transported to DRI; in the case of instruments from overseas, customs inspections and clearances were involved.

With most participants and instruments in Reno by October 6, the Workshop opened with welcoming remarks by Prof. W.C. Kocmond, Prof. H.-W. Georgii (represented by Mr. D. Stein) and Dr. V. Schaefer. A keynote address was given by Dr. S. Twomey. Two weeks of intense activity then began.

The Steering Committee met daily to plan the test aerosols to be used; generally their deliberations were conducted at the beginning of each day, while instrument operators readied their devices and monitored outside ambient aerosol. Table 2 summarizes the 30 experiments actually performed. The specifications for each test aerosol varied day-to-day, in response partly to earlier suggestions originating in the Steering Committee or coming from individual participants:

(a) High CCN concentrations (relevant to the atmosphere in areas of high pollution, volcanic plumes, etc.) to establish the practical upper limit of applicability of various instruments;
(b) Low CCN concentrations (e.g., less than 100 cm^{-3} at 1%), to check instrument performance in clean maritime or polar environments;
(c) A bimodal size distribution (two monodisperse, soluble aerosols of different nominal sizes), to check the ability of instruments to resolve a correspondingly bimodal CCN activity spectrum.

With "feedback" from participants, these suggestions were incorporated into the rather tight experiment schedule (suggestion "a" is reflected in experiments 9 and 24, "b" in 4 and 23, and "c" in 10). Additional suggestions during the Workshop led to experiment 21, a test of the ability of instruments to give a consistent and accurate reading over a prolonged period of time, CCN concentration being held constant; experiment 25, a test of the "zero" of instruments sampling particle-free air, and experiment 29, a test of the possible CCN activity of a hydrophobic aerosol, paraffin wax.

Daily activities included frequent discussions between members of the Steering Committee and the larger body of participants. Steering Committee members assisted with the presentation of collected data after each experiment; in addition, participants presented informal talks on their equipment on a daily basis.

At the end of the Workshop, the Steering Committee completed its function by requesting all participants to supply a description of their instruments together with comments on performance during these experiments; those reports are assembled in Section V. In addition, various individuals were asked to submit reports on special interest topics, such as reviews of the CCN counters by generic type; those reports are to be found in Section VI.

The final action of the assembled group was to provide verbal and written response to the Steering Committee's request for criticisms and suggestions for improvements. The following points resulted:

(a) Although previously debated, the question of whether or not to standardize data-taking such that all CCN counters would measure CCN concentrations at a few, given "set-point" supersaturations should be reviewed again. The practice at this Workshop was to avoid specific, standard settings (because of different instrument requirements) and to provide as complete a spectrum as possible. "Set-points" would simplify data comparisons but, of course, not all instruments are designed to operate at the same supersaturations.

(b) It was intended that the results of each experiment would be quickly entered onto computer file. In practice, this effort, which ideally could have provided data listings and computer graphics in short turn-around time, was hampered by difficulties in design and planning as well as equipment problems. Future Workshops would benefit from rapid turn-around of the data, but better control of the experimenter input is also needed.

(c) Power and aerosol supply were in reasonably good shape; ambient heat rejection (air conditioning) and physical space had less margin of comfort but were satisfactory. Noise level was high at times; one participant suggested that a vacuum manifold (replacing numerous individual pumps) would alleviate this problem.

In summary, most participants felt that the Workshop proceeded quite smoothly and that the objectives set forth by the Ad Hoc Commission of the Nucleation Committee were successfully achieved. In making this determination, special mention must be made of the close cooperation between participants, Steering Committee and DRI hosts. Several social events were held during the 12 day Workshop, including an open house hosted by Dr. Cliff Murino, President of DRI. The strong sense of friendship and good times that develop in a working environment such as this will always be remembered.

TABLE 1. CCN WORKSHOP PARTICIPANTS

Name/Affiliation	Instrument	Duct No.
Dr. Jeffrey B. Anderson Space Science Lab NASA-MSFC Alabama 35812		
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Dr. L.R. Eaton General Electric Company Box 8555 Philadelphia, PA 19101		
Dr. J. Fitzgerald Atmospheric Physics Branch Naval Research Laboratory Washington, DC 20375	IHC	11
Dr. Abe Gagin Cloud Physics Laboratory Department of Meteorology Hebrew University Jerusalem, Israel	STDGCC	9
Dr. Herman E. Gerber Naval Research Laboratory Washington, DC 20375		
Dr. Edward Hindman II Colorado State University Dept. of Atmospheric Sciences Ft. Collins, CO 80523	IHC	26
Dr. W.A. Hoppel, Code 4320 Atmospheric Physics Branch Naval Research Laboratory Washington, DC 20375	Aero. Sizing	12
Mr. Richard Hucek Florida State University Dept. of Meteorology Tallahassee, FL 32306	CFDCC Impactor	22, 23
Dr. James G. Hudson Desert Research Institute University of Nevada System P.O. Box 60220 Reno, NV 89506	CFDCC 3SS CFDCC IHC	14,16,18
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Dr. Vernon Keller Space Sciences Lab NASA-MSFC Alabama 35812		
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Name/Affiliation	Instrument	Duct No.
Dr. William H. Mach Florida State University Department of Meteorology Tallahassee, FL 32306	CFDCC Impactor	22,23
Mr. Thomas R. Mee Mee Industries, Inc. 1629 S. Del Mar Avenue San Gabriel, CA 91776	STGDCC	8
Dr. W.J. Megaw Department of Physics York University 4700 Keele Street Downsview, Toronto CANADA M3J1P3	Diffusion Tube	7
Dr. Sherm Neste General Electric Company Box 8555 Philadelphia, PA 19101		
Ms. Hana Nuzitsa Dept. of Meteorology Hebrew University Jerusalem, Israel	STGDCC	9
Dr. T. Ohtake Geophysical Institute University of Alaska Fairbanks, AK 99701	Impactor/ Photomicrography	27
Dr. Myron Plooster Denver Research Institute 7420 Spring Drive Boulder, CO 80303		
Ms. Marsha Politovitch University of Wyoming Dept. of Atmos. Science Box 3038, Univ. Station Laramie, WY 82071	STGDCC Aerosol Sizing	1,2
Dr. Lawrence F. Radke Dept. of Atmos. Sciences University of Washington Seattle, WA 98195	4SS CFDCC	20
Dr. C. Fred Rogers Desert Research Institute University of Nevada System P.O. Box 60220 Reno, NV 89506	DRI-NASA CFDCC	15
Dr. David Rogers University of Wyoming Dept. of Atmos. Science Box 3038, Univ. Station Laramie, WY 82071	STGDCC Aerosol Sizing	1,2
Dr. R. Ruskin Naval Research Laboratory Washington, DC 20375	STGDCC	17
Dr. V.J. Schaefer State University of New York Albany, NY 12222		
Dr. R. Serpolay Universite' de Clermont Institut et Observatoire de Physique du Globe du Puy de Dome 12, Avenue des Landais Clermont-Ferrand, France	STGDCC	24
Dr. Patrick Squires Convective Storms Division NCAR P.O. Box 3000 Boulder, CO 80307		
Dr. D. Stein Institut fur Met. und Geophy. D6000 Frankfurt a. Main-1 Feldbergstr. 47, Germany		
Mr. M. Trueblood Grad. Center for Cloud Physics Univ. of Missouri-Rolla 109 Norwood Hall Rolla, MO 65401	CFDCC	21
Dr. Sean Twomey Inst. of Atmospheric Science University of Arizona Tucson, AZ 95721		
Mr. C.H. Wilson NASA Langley Research Center MS 404B Hampton, VA 23665		
Dr. T. Wojciechowski Naval Research Laboratory Atmospheric Physics Branch Washington, DC 20375	STGDCC	17

Table 2. List of Experiments

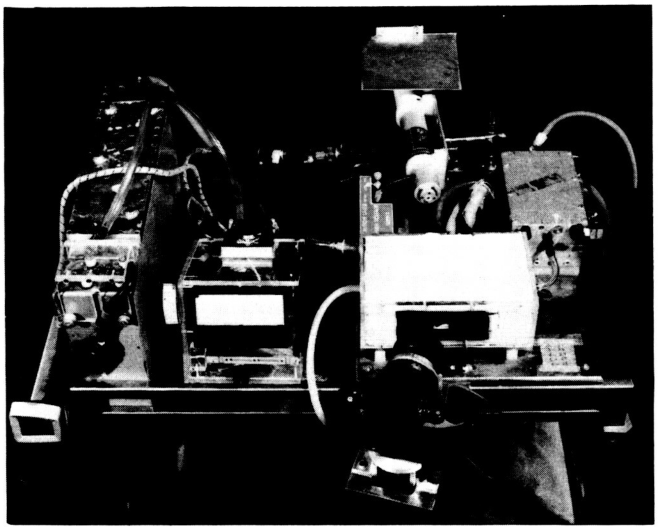
No.	Date	Aerosol A=Ambient; M=Monodisperse; P=Polydisperse
0	Tues 7 Oct AM	M - $(NH_4)_2SO_4$
1	Tues PM	P - NaCl - oscillating concentration
2	Tues PM	P - NaCl - higher concentration
3	Wed 8 Oct AM	A - quite fluctuating
4	Wed AM	M - NaCl - low concentration
5	Wed PM	M - NaCl - medium concentration
6	Wed PM	A
7	Thurs 9 Oct AM	A - aborted - duct blockage
8	Thurs AM	M - NaCl - slight drift down
9	Thurs AM	M - NaCl - higher concentration
10	Thurs PM	Bimodal - NaCl - "flat k"
11	Thurs PM	A
12	Fri 10 Oct AM	A
13	Fri AM	P - $(NH_4)_2SO_4$
14	Fri PM	P - $(NH_4)_2SO_4$
15	Fri PM	M - $(NH_4)_2SO_4$
16	Fri PM	A
17	Mon 13 Oct AM	A
18	Mon AM	M - $(NH_4)_2SO_4$
19	Mon AM	M - $(NH_4)_2SO_4$
20	Mon PM	M - $(NH_4)_2SO_4$
21	Mon PM	M - $(NH_4)_2SO_4$ - time variations
22	Tues 14 Oct AM	P - $(NH_4)_2SO_4$ - medium concentration
23	Tues PM	P - $(NH_4)_2SO_4$ - low concentration
24	Tues PM	P - $(NH_4)_2SO_4$ - high concentration
25	Wed 5 Oct AM	Filtered air - noise check
26	Wed AM	A
27	Wed PM	P - AgI, "insoluble"
28	Wed PM	M - AgI, "insoluble"
29	Wed PM	P - paraffin, hydrophobic

SECTION V. INSTRUMENT DESCRIPTIONS

CONTRIBUTION TO CCN WORKSHOP REPORT FROM UNIVERSITY OF WYOMING GROUP

David C. Rogers and Marcia K. Politovich

University of Wyoming
Laramie, Wyoming



1. APPARATUS

The University of Wyoming's CCN counter is a static, horizontal, parallel plate thermal gradient diffusion chamber of rather conventional design. Its intended use is primarily for field measurements, hence the small physical size and straightforward simplicity of operation. The plate separation is 0.9 cm, and the inside chamber dimensions are 8.5 cm x 10.0 cm; aspect ratio is 9.4:1. Activated CCN grow to visible size droplets which are photographed with a 35 mm camera (Nikon F, Micro-Nikkor-P lens f3.5,55 mm plus M2 extension tube, Tri-X film developed at ASA 1600). Illumination is provided by a Helium-Neon laser (0.6328 μm wavelength, multimode 5 mw) oriented at an angle of 23° from the forward direction of the camera's optical axis. The multimode character of the laser provides a flat-top intensity profile which serves to reduce uncertainties about the size of the illuminated volume. The angle of 23° in the forward direction was chosen to take advantage of the first broad peak in the Mie scattering function for water droplets which are in the size range 3 to 7 μm diameter. The circular laser beam is 0.18 cm in diameter and is centered in the chamber to illuminate the middle 20% of the vertical distance. A fixed width on the film is used to define the horizontal dimension of the sample volume; this volume is .034 cm^3, in the form of an elongated cylinder.

The temperature difference between the top and bottom plates is measured by precision thermistors which are flush-mounted between the aluminum plates and the surface wicking material (blotting paper).

This temperature measurement is displayed to ±0.1°C and is also used by an electronic circuit to control the temperature difference. The measurement is compared with a value selected by the operator, and the difference is used to control the current to thermoelectric modules which cool the bottom plate. The range of temperature differences normally used extends from 3 to 7°C; this results in a range of supersaturations of approximately 0.3 to 2%.

Sample air passes through a temperature preconditioning chamber just before entering the CCN chamber. The preconditioning chamber is maintained slightly warmer than the top plate of the CCN chamber. In this manner, transient supersaturations are minimized. Air samples are brought into the chamber under suction and, after thorough flushing, the chamber outlet is closed. A time delay of several seconds between this closing time and the photography allows droplets to grow large enough to be photographed but not so large that they fall out of the illuminated volume; this delay is controlled and decreases with larger supersaturations.

Earlier calibration experiments using monodisperse latex particles determined the photographic minimum detectable particle size is less than 0.7 μm diameter. Aerosol losses in the entrance region have been measured as negligible by comparing size distributions of various aerosols before and after passing through the chamber. Finally, earlier comparisons with theory and other CCN chambers have been performed for monodisperse and polydisperse salt aerosols as well as natural aerosols. Comparisons between the University of Wyoming's (UW) chamber and that of the Desert Research Institute (DRI) were made during March 1978. These comparisons are briefly summarized in Tables 1 and 2, and Figure 1.

TABLE 1. CFD-SDL COMPARISONS

Aerosol	Super-saturation(%)	Concentration (no. cm^{-3})		CFD/SDL
		SDL	CFD	
Room air	.28	95	168	1.77
	.36	207	288	1.39
	.50	164	219	1.34
	.65	243	352	1.43
	1.02	1310	3596	2.75
Outside air	.35	320	241	0.75
Polydisperse NaCl	1.00	327	497	1.52
Polydisperse AgI	1.00	371	613	1.65
		368	544	1.48
Monodisperse AgI (0.2 μm dia.)	0.2	485	750	1.55
	1.0	485	810	1.67

CFD/SDL avg. 1.57 ± .47

Omitting 2 extremes, avg. 1.53 ± .14

TABLE 2. CRITICAL SUPERSATURATION

Aerosol	Critical Supersaturation(%) SDL	CFD	Theory
NaCl .03 μm diameter	.36	.32	.35
NaCl .05 μm diameter	.75	.68	.75
$AgI\text{-}NH_4I$ complex (0.2 μm dia.)	<0.2	<.25	.07

SDL = Static Diffusion Liquid CCN Chamber (UW)
CFD = Continuous Flow Diffusion CCN Chamber (DRI)

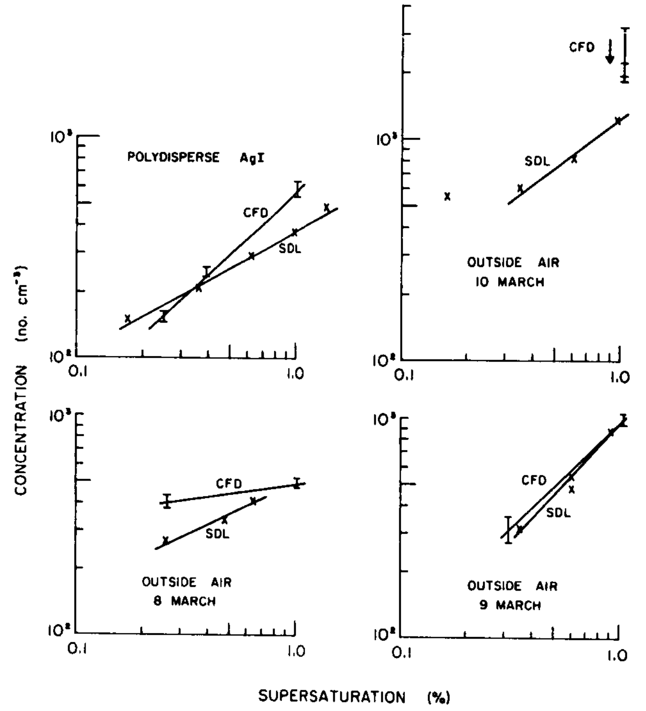


Figure 1. CCN spectra measured in Laramie, March 1978. SDL = Static Diffusion Liquid CCN Chamber (UW); CFD = Continuous Flow Diffusion CCN Chamber (DRI).

2. WORKSHOP PARTICIPATION

Our main interests in participating in the International CCN Workshop were to compare the University of Wyoming's CCN chamber with the others present and to discuss with and learn from the participants various aspects of CCN measurement techniques, their current thinking, and advances in the ten years since the last workshop.

Unfortunately, problems with the electronics in our device arose during the Workshop and prevented us from operating the chamber above about 0.3% supersaturation, so our comparison experiments were attenuated.

3. DATA USAGE

The emphasis of our work with the CCN counter has been in the application of CCN data obtained from it, rather than development of the instrument itself. We have kept the design simple and the size small to enable us to transport it to remote sites for in situ sampling. We include here several examples to illustrate the manner in which the data are used.

Figure 2 shows a C-K plot of measurements obtained at and near our cloud observation facility at Elk Mountain in southeastern Wyoming. These measurements were taken to characterize winter CCN populations in southeastern Wyoming, particularly near Elk Mountain. The data suggest a trend of increasing C-values later in the spring while retaining similar K-values. There was significant snow cover in and upwind of the sampling location during January and February. In later months, snow cover was sparse if present at all.

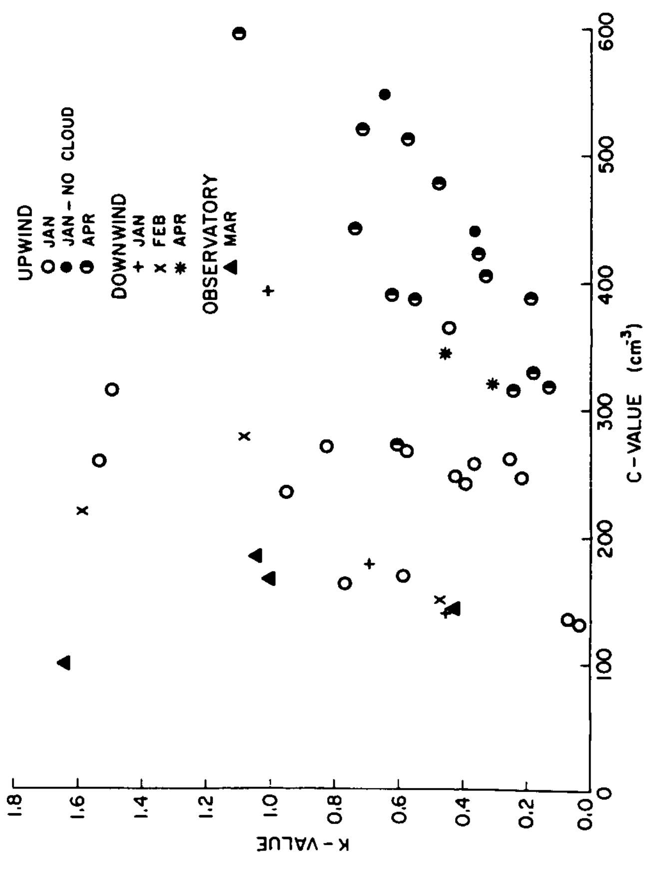


Figure 2. C-K plot of the CCN spectra measured during the winter of 1978-79 near Elk Mountain. Sample months and locations are indicated.

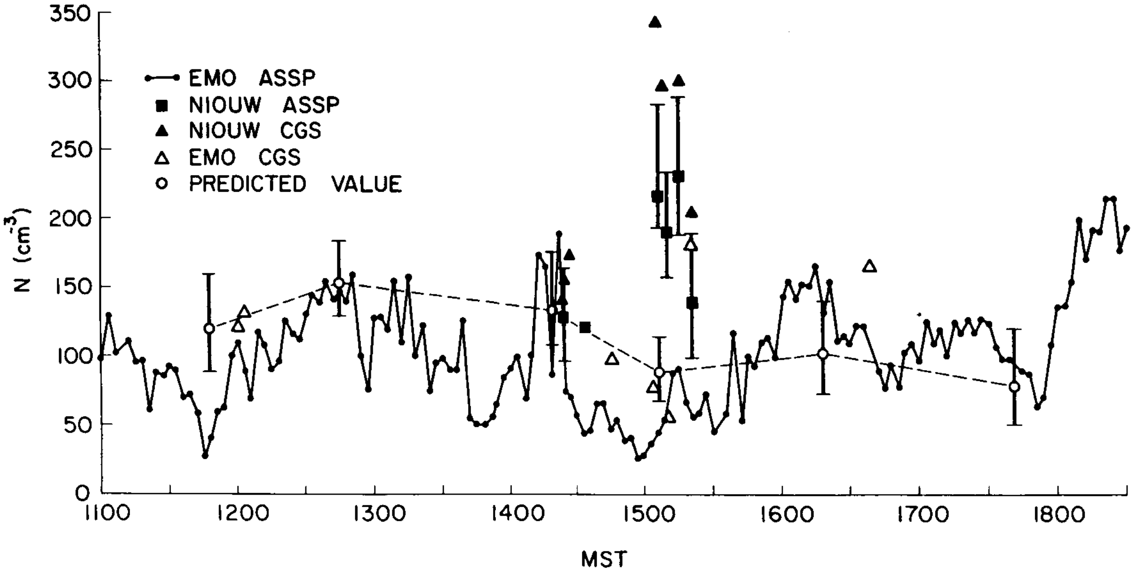


Figure 3. Droplet measurements obtained in an orographic cloud which formed over Elk Mountain on 16 January 1979. Data sources are indicated (ASSP is the Axially Scattering Spectrometer Probe, Particle Measuring Systems, Boulder, CO, and CGS is the University of Wyoming's soot-coated impactor slide droplet sampler). CCN predictions represent application of Twomey's (1959) relationship between CCN spectrum parameters and droplet concentrations to measurements taken upwind of Elk Mountain. (O) represents an updraft of 50 cm/s, (I) represents the range of updrafts 25-100 cm/s. A 20-minute time lag was added to CCN data to account for transport time from the CCN sampling site to the droplet measuring site.

An important use of our CCN data has been in comparisons of droplet concentrations derived from the upwind CCN spectra (using Twomey's, 1959, equation[1] and Young's, 1979, cloud model[2]) with in situ measurements from the observatory and instrumented aircraft in the Elk Mountain cap clouds. Figure 3 shows the results of such a comparison on 16 January 1979. The CCN predictions track the actual measurements from the observatory well. Droplet concentrations measured by the aircraft (N10UW) were higher than those from the observatory (EMO) on this day, which we attribute to variations in the vertical structure of aerosol concentrations in the boundary layer, which were measured by the aircraft, rather than substantial increases in updraft speeds at that level.

These figures are from a paper by M.K. Politovich which is being prepared for publication.

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[1] Twomey, S., 1959: The nuclei of natural cloud formation, Part II: The supersaturation in natural clouds and the variations in cloud droplet concentration. *Geophysics Pura. Appl.*, *43*, 243-249.

[2] Young, K.C., 1974: A numerical simulation of wintertime, orographic precipitation. Part I: Description of model microphysics and numerical techniques. *J. Atmos. Sci.*, *31*, 1735-1748.

DESCRIPTION AND DISCUSSION OF THE NRL TGDCC

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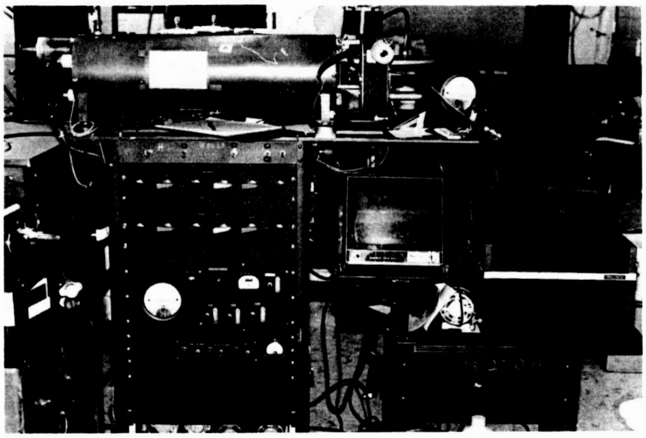

The NRL thermal gradient diffusion cloud chamber (TGDCC) is identical to that described in the Proceedings of the Second International Workshop on Condensation and Ice Nuclei (Grant, 1971). The chamber consists of two plates 7.5 cm in diameter separated by 1.25 cm and covered with saturated filter paper. The cylindrical wall separating the plates is glass. The top plate is at room temperature and the bottom plate is cooled with a thermoelectric cooler. The temperature difference is measured with several sets of thermocouples. A high intensity mercury arc lamp with appropriate lens and collimating slits which are imaged in the cloud chamber defines an illuminated volume 0.15 cm thick and 0.3 cm high by 1.5 cm long. This illuminated volume is viewed at 90° scattering angle by an 8 mm camera and a video camera system.

The video system permits immediate playback and stopframe counting of the cloud droplet concentration in the chamber. The 12-inch monitor screen is marked off to identify the viewing dimensions for ease in counting the droplet images.

At the Workshop, samples for a given experiment were admitted to the TGDCC directly from the sampling duct which was slightly pressurized. The count was recorded both on video tape and on a number of frames of an 8 mm movie film. The 8 mm Bolex camera is operated manually while viewing the chamber through the camera. The first frame is taken one to two seconds after closing the valve and about 10 to 15 frames are taken manually until it is clear that the maximum particle count has passed. The photographic results were not available at the Workshop. The video data were read immediately after each experiment. The method for obtaining the count supplied at the Workshop is as follows: two (or three) successive samples were recorded at each supersaturation. The recordings from these samples were played back and visually examined to obtain the succession of frames for each sample where the maximum count occurred. Several of these frames were counted and the maximum count obtained. The maximum counts from two (or three) samples were averaged to obtain the data submitted at the Workshop.

The photographic recordings have not yet been analyzed but it has always been our experience in the past with atmospheric aerosols that the two methods track very well but that the photographic count is always about 10 to 15% higher. We attribute this to the smaller detectable size obtained with the photographic method. The minimum detectable size for our photographic system is estimated to be about a half micron whereas the minimum detectable size for the video system is estimated to be just under one micron.

There are definite limits on the supersaturation range for which the results of the TGDCC are valid. The range of validity is usually given as 0.2 to 1%. However, even within this range there can be significant errors depending upon the nuclei spectrum (size distribution) being measured. The accuracy limitations of TGDCC's in general and our chamber in particular were investigated by Hoppel and Wojciechowski (1976).

The smaller particles which have critical supersaturations about the same as the maximum supersaturation in the TGDCC are not nucleated until the chamber has reached its steady state value and then grow more slowly than the larger particles which are nucleated before the chamber has reached equilibrium. The object is to find a period of time when the less active particles have grown to minimum detectable size and the larger (more active) particles have not yet started to fall out. A time which satisfies both criteria may not exist for all size distributions. If such a period of time does exist, then it should evidence itself by a plateau in the curve of number detected versus time. A well-defined plateau was not found to exist in the data on natural continental aerosols presented by Hoppel and Wojciechowski (1976). Alofs and Carstens (1976) did a numerical simulation of the TGDCC which predicted large errors depending upon the nuclei distribution and minimum detectable size.

Another source of uncertainty in the TGDCC is statistical in nature and has to do with the fact that the number of particles in a small volume will deviate from the true macroscopic mean with a standard deviation given by the square root of the mean. The typical number of particles in our viewing volume varies from about 20 for nuclei concentrations of 300 cm^{-3} to 200 for nuclei concentrations of 3000 cm^{-3}. At the lower end there is therefore a standard deviation (in a large number of measurements) due to real natural variations of over 20%. This uncertainty, of course, can be reduced by averaging more measurements from the same macroscopic sample of air.

For a monodisperse nuclei sample the plateau in number versus time should be much more pronounced than in the case of a steep size distribution as is usually the case for continental aerosols. At the Workshop, we had a unique opportunity to sample nearly monodisperse aerosols as well as polydisperse and natural aerosols. The Workshop data, therefore, offered a unique opportunity to look for a plateau in number as a function of time.

Figures 1 through 4 show the results of counting every tenth frame (every third of a second) on the videotape starting shortly after the motion in the chamber subsided. There has been no attempt to synchronize the starting points to the same time after the valve was closed. Therefore, there may be a maximum of a half second offset in the plotted times from one sample to the next. The supersaturation in all four figures was about 0.72%.

Figures 1 and 2 are for monodisperse NaCl and $(NH_4)_2SO_4$ with two and three runs, respectively. Both of these figures evidence more of a plateau type behavior than we have seen in those ambient samples which we have previously examined in detail. We assume that the variations from one frame to the next after the maximum is caused by the unequal rates at which particles fall into or out of the sensitive volume. Any difference in the level of the plateau from one sample to the next would be due to natural fluctuations discussed above and should have a standard deviation equal to the square root of the number of particles counted.

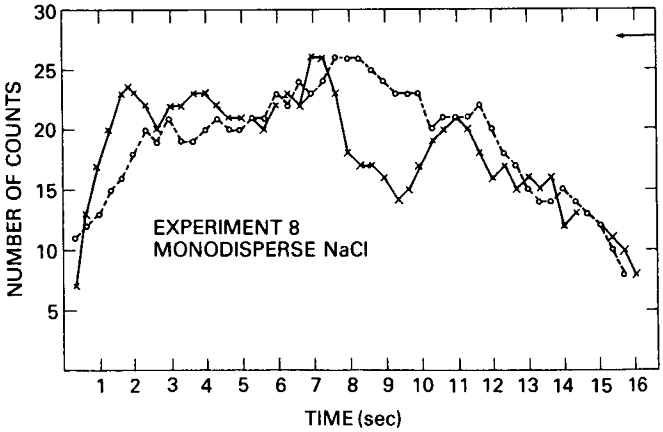

Figure 1

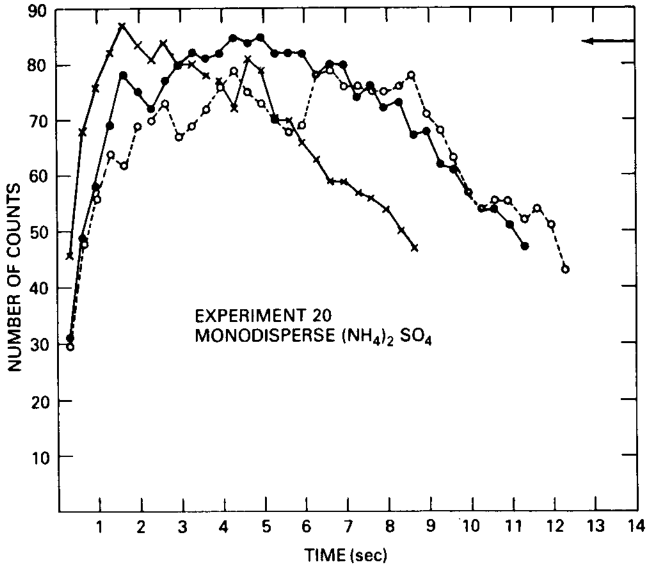

Figure 2

Figures 3 and 4 are for polydisperse $(NH_4)_2SO_4$ and ambient air, respectively. Here the curves are peaked more strongly as would be expected with little evidence of a plateau. The arrows along the right side of the figures indicate the values obtained at the Workshop by the method of analysis indicated earlier.

For many years, NRL has used the standard method cited earlier for determining the CCN concentration from the video recording. This procedure of averaging the maximum count obtained on several successive recordings at the same supersaturation results in concentrations which are somewhat higher than concentrations calculated from an average across the plateau. We have persisted in analyzing our data in this manner for several reasons: (1) the time required to count enough frames to define a plateau (or lack of one) is prohibitive on a routine basis; (2) comparison of results using our photographic system and video system gives values for the video system which are 10 to 15% lower than those obtained with the photographic system, which has a smaller minimum detectable size; (3) most importantly, if there is no plateau then the maximum value should be closest to the correct value; and (4) our results over many years are internally consistent since we have not changed this procedure.

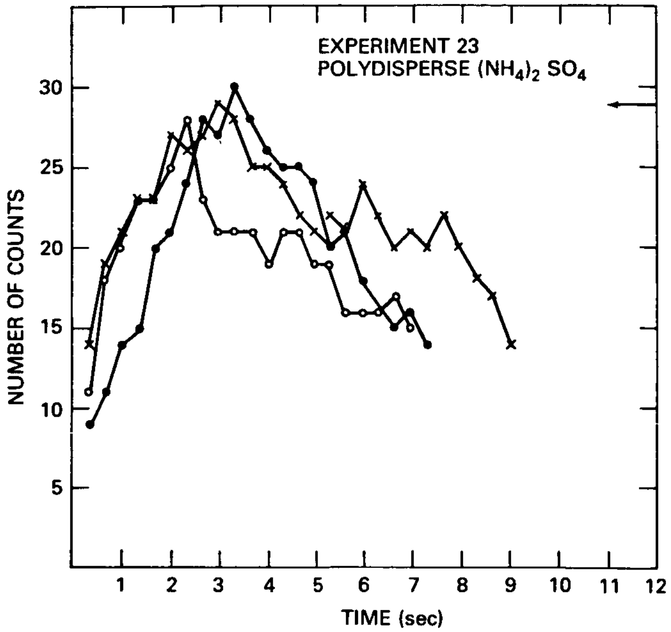

Figure 3

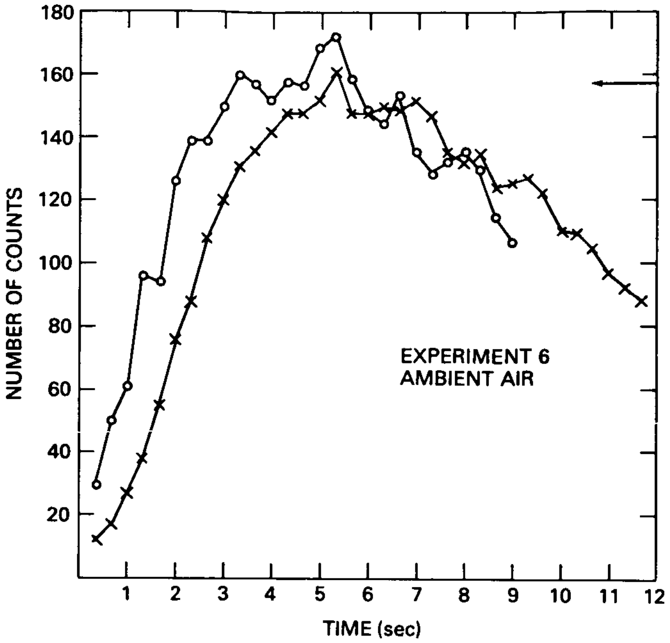

Figure 4

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ACKNOWLEDGEMENTS

This work was partly supported by the Naval Air Systems Command.

THE CCN COUNTER OF THE I.O.P.G. OF PUY DE DOME: MAIN CHARACTERISTICS AND RESULTS OF MEASUREMENTS

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1. DESCRIPTION OF THE INSTRUMENT

The experimental device used by the I.O.P.G. of Puy de Dome for counting CCN during the Workshop is a cylindrical static thermal diffusion chamber with horizontal plates, 7.0 cm in diameter and 2.1 in thickness (volume V ≃ 80 cc). The system includes a multimode laser beam (power > 5mW), illuminating a part of the median volume of the chamber in which the maximal supersaturation is developing. A video set (TV camera + monitor) displays a motion picture of the droplets generated by the CCN and observed in a volume $V = 7.5\ 10^{-3}$cc. For obtaining a better signal-to-noise ratio (a better contrast), the TV tube was selected so that its current-wavelength characteristic was in good agreement with the (He, Ne) laser radiation. The TV image is recorded on a video tape recorder, thus allowing analysis shortly after the time of measurement.

Instead of counting by sight, a device called "Image Processing Unit", originally provided for counting in real time, is used. The upper plate is electrically heated and the lower plate is at ambient temperature. Water vapor is supplied by a wet mineral paper filter. The desired temperature difference ΔT (limited at 5°C) between the horizontal plates is displayed and then regulated by an automatic control system, which includes a series of eight differential thermocouples imbedded in the plates. This mounting has the advantage of not only amplifying the voltage but also of taking into account an average temperature on each plate.

The air sample under analysis is introduced in the chamber at a flow rate of 1.0 ℓ/m, and a section of the air intake tube is heated, allowing air sample introduction into the chamber at a temperature of about 3°C above the lower plate temperature. The supersaturation range covered by this equipment is generally between 0.1 and 1.5% and the time required for obtaining a spectrum in this supersaturation range is approximately 30 to 40 minutes. But in conditions of ambient temperature above 25°C (as occurred during the Workshop), it is not possible to exceed a supersaturation of 0.8% because of the ΔT limitation (see above). Because the device cannot use another greater value of observed sample volume, the accuracy of the measurement is poor at the low extremity of supersaturation range (about 50%).

2. SELECTIVE DATA ANALYSIS

2.1 Global Survey

With such a device, 20 supersaturation spectra (plus one point for Experiment No. 13) corresponding to our complete participation in the Workshop have been outlined and classified according to their shape and position in regard to the series of others established for each experiment.

The following main characteristics of our spectra, appearing in Table 1 with the same capital letter, have been distinguished like that: (A) similar to and well placed among the others in the series; (B) same type of concavity as for the majority in the series; (C) close to the upper (or lower) extremes of the series; (D) smaller CCN concentrations at low supersaturation and/or greater CCN concentrations at higher supersaturation; (E) CCN concentrations abnormally high along the most part of the spectra, with some of them being higher than those obtained with Pollak or TSI counters; (F) lack of plateau; and (G) type of concavity differing from that of the majority.

For each supersaturation spectrum denoted by the number of the experiment, one, two or three, but no more, of these main characteristics have been summarized in Table 1 by a cross in the corresponding square. On Line C, we distinguish respectively by an "s" or "i" index, the fact that the spectrum is close to the upper or lower envelope of the series. In comparing the measurement sheet and the TSI recorded graph corresponding to Experiment No. 16, it can be observed that the abnormal concavity of the spectrum might correspond to a measurement carried out during a peak of aerosol discharge (cross in bracket, Line G).

Through this analysis, Table 1 appears to be divided into two parts: (A, B, C) - grouping the characteristics which reveals a behaviour not far from a "supposed mean" behaviour for a CCN counter; and (D, E, F, G) - grouping the characteristics which reveals an anomaly of behaviour. It is obvious that the percentage of crosses shown in the first group (A,B,C) is higher than that of the other group, i.e., 62% against 38%.

Character-ization	Experiment n°																				
	4	6	8	9	10	11	12	13	14	15	16	17	18	19	20	22	23	24	26	27	28
A	X			X	X	X						X	X	X		X					
B		X	X		X	X	X					X	X			X	X	X			X
C		X_s					X_s	X_s	X_i		X_s							X_i		X_s	
D													X		X		X		X	X	X
E			X												X						
F	X									X				X							
G				X					X	X	(X)								X		

Table 1

Another more realistic analysis consists of dividing the supersaturation spectra in three categories:

1. The crosses pertaining to a given spectrum are shown in the upper part of Table 1. This situation, corresponding to a good behaviour of the device, concerns 9 spectra, i.e., 43% of the whole.
2. The crosses pertaining to a given spectrum are shown in the lower part of Table 1. This situation, corresponding to a frankly bad behaviour of the device, concerns only 3 spectra, i.e., 14% of the whole spectra.
3. The crosses pertaining to a given spectrum are distributed on both parts of Table 1. This situation corresponds to an intermediate behaviour and concerns the remaining spectra, i.e., 43%.

Moreover, it is possible to point out that: (a) the number of spectra for which the crosses are found either on Line C or D is relatively high, i.e., 13 out of 21; and (b) on Line C, the number of crosses affected by the "s" index (i.e., 5) is higher than the number of crosses affected by the "i" index (i.e., 2). Both factors denote a trend in the device to overestimate the CCN concentration, especially in the range of high supersaturation.

2.2 Individual Comparison

Comparisons have been made between our results and spectra obtained using similar equipment (i.e., static diffusion chamber) on corresponding experiments. At times, the spectra were in close agreement, such as: NRL (n° 6-11-12-17); CSIRO (n° 9-10-14-17-28); SUNY (n° 9-14); Hebrew University (n° 9-14-17-18-24). However, the comparison also revealed differences in the spectra, with the concentration ratio reaching 2 to 3 with NRL (n° 9); CSIRO (n° 4-6-8-20); CSU (n° 4-23); SUNY (n° 6-8-9-10) and Hebrew University (n° 10-28). The discrepancy with the Wyoming equipment was still larger (n° 11-12-14-22-23). Surprisingly, for about 62% of the experiments, a number of our spectra were found in reasonable agreement with those resulting from measurements with the DRI continuous flow diffusion chamber (n° 9-12-14-17-18-19-22-27-28) or the Missouri-Rolla haze chamber (N° 6-10-11-12-13-18-19-22-27-28).

2.3 Stability of the Measurements

In Experiment No. 21, which tested the repeatability of the measurements, two runs were carried out continuously during approximately 16 minutes and 30 minutes at supersaturations 0.50% and 0.26%, respectively. At the same time, the aerosol to be analyzed was delivered at a stable concentration level of 860 cc^{-1} (measured with the TSI equipment) or 1000 cc^{-1} (measured with the CCN Pollak counter). After calculating the corresponding standard deviation, the average concentration values were 1210 ± 105 at 0.50% supersaturation for the 1st run and 190 ± 70 at 0.26% supersaturation for the 2nd run.

Two features are emerging from these results: (1) a sensible overestimate of the concentration; and (2) a standard deviation which reaches an acceptable percentage (9%) of the concentration values at mean or high supersaturation, while it is not acceptable (37%) at low supersaturation. This is mainly due to the fact that the examined volume cannot be adjusted to discrete supersaturation ranges.

3. CONCLUSIONS

In performing the data analysis of the measurements achieved during the Workshop with our device, a global approach was preferred rather than an individual analysis, in order to illustrate some main characteristics in the behaviour of the device with respect to a "mean behaviour" resulting from a general survey of all the equipments involved in each experiment. In this regard, our device seems to have a behaviour not unlike a "mean behaviour", although it tends generally to overestimate the CCN concentrations measured near the high supersaturations and sometimes underestimates the concentrations close to 0.1% or 0.2% of supersaturation. Despite the fact that it belongs to a type of static diffusion chamber, it shows, however, similar spectra to those obtained with other types of chambers (continuous flow diffusion chamber and haze chamber).

In the spring of 1980, at the site selected by WMO for a possible Precipitation Enhancement Project in the area of Valladolid, Spain, the CSIRO device and our static thermal diffusion chamber were placed side by side for the purpose of analyzing the same natural air sampling. Although at that time, the air intake of our chamber was not yet equipped with a heater, the main difference between the two devices was the way in which the ΔT between the plates was achieved. In fact, in the CSIRO device the lower horizontal plate is cooled. The comparison of the results displayed CCN concentrations from twice to three times higher with our device, so that our CCN measurements on the P.E.P. site in 1979 and 1980 were questioned.*

Such discrepancies between these devices were again found in some Workshop experiments; however, it was possible to observe that, in a number of other experiments at the least equivalent, the corresponding spectra were rather close to each other (see Section 2.2). Neither the difference in the methods used to obtain ΔT nor the differences in the geometry of the chambers suffice to explain such variable results. Nevertheless, it is obvious that the comparisons made during meetings of a workshop type are able to greatly improve our knowledge of the behaviour of the device involved. As

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*Personal communication of Dr. Warren King from CSIRO.

for our equipment, it seems that the best way to try to reduce its trend to overestimate the CCN concentrations should consist in cooling the lower plate instead of heating the upper one and in searching for a better diameter-to-depth ratio in order to improve the stability inside the chamber.

4. ACKNOWLEDGEMENTS

Our participation to the Reno Workshop was aided and funded by grants from NSF and GGIU French Committee.

We are grateful to F. Romeuf from C.R.A. of Lannemezan, for his help in the construction of our static diffusion chamber, and to G. Michel and M. Rahon for having built all the complementary accessories. The Image Processing Unit was designed and built and then calibrated respectively by Miss M. Martin and J.E. Ourtau. The contribution of R. Cordesses and V. Kromer to the maintenance of this unit was also appreciated. Much of the preparation of our journey and that of the present paper was in the capable hands of Mrs. P. Boudinhon.

UMR DUAL MODE CCN COUNTER
(MODES: CFD PLUS HAZE)

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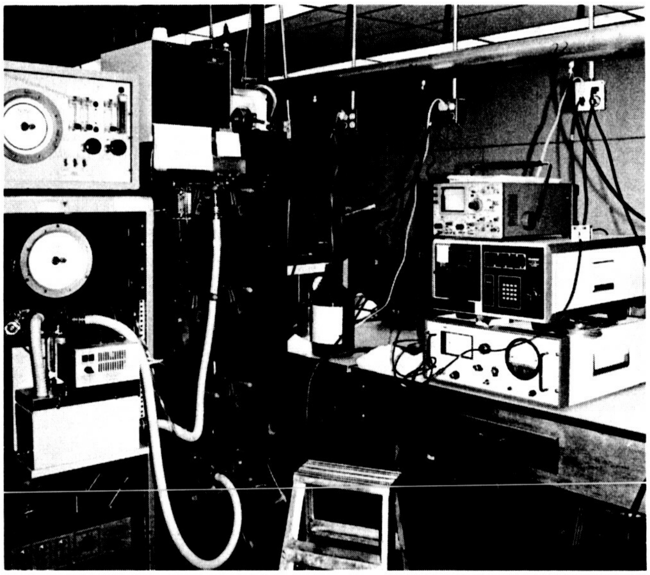

1. INSTRUMENT DESCRIPTION

This instrument and its performance characteristics have recently been described in detail (Alofs, 1978; Alofs, *et al.*, 1979). Therefore only a brief description of it is given here.

The chamber consists of two vertical plates 100 cm long in the vertical direction and 13 cm wide, with a 0.8 cm spacing between the plates. The sample flows downward between the plates in a small diameter stream surrounded by filtered air. The sample flow into the chamber is usually 0.008 liters/min, determined by the pressure drop through a capillary tubing 0.25 mm diameter. This flow branches off of a larger delivery flow of 5 liters/min, to avoid diffusional losses.

The droplets formed on the CCN are counted and sized using a Climet Model 201 optical particle counter (OPC) with an 8-channel pulse height analyzer (Climet Model 210). An advantage of the Climet over the Royco 225 is that the response curves increase monotonically with size (no dips to produce multivalue sizes for a given pulse height). The Cooke and Kerker (1978) calculations are used to correct for index of refraction. A sheath air inlet was constructed for the Climet OPC, similar in design to that used in the Royco 225. The rate of flow into the Climet OPC is 0.35 to 1.0 liters/min.

The haze mode is used for the nuclei active at supersaturations (S) from 0.0133 to 0.173%. In this mode the two plates are kept at the same temperature (25°C). The values of S are determined from the drop sizes, using the relation $S = .08/d$, with S in % and with the drop diameter d in μm. For nuclei with $.068 < S < .173$, the total chamber flow (sample plus filtered air) is 1 liter/min, giving a residence time of 39 sec. For lower S, the chamber flow is 0.35 liter/min and the time is 110 sec. In either case, all of the flow is drawn into the OPC.

In the CFD mode the supersaturation is determined by the temperature difference between the two plates. This temperature difference is controlled by water baths, and is measured with a mercury-glass thermometer immersed sequentially in each water bath. Separate experiments show that the temperature difference at the plate surfaces (measured with thermocouples on the air side of the filter paper) equals the bath temperature difference to within 5%.

About 40 minutes is required to obtain a spectrum (5 values of S in the CFD mode, plus 7 values of S in the haze mode). About half of this time is used to adjust the temperatures and flows; the rest is used in actual counting of the nuclei. Generally the measurement begins in the CFD mode, with the hot plate at 25°C and the cold plate at 20°C. The cold plate temperature is raised in steps (the baths heat very quickly, 1000 watts of heating versus about 50 watts of cooling). The chamber flow rate is usually reduced as S is decreased. The time for flushing the chamber is quite short in the CFD mode, but amounts to about 5 minutes in the haze mode at 0.35 liters/min.

2. PERFORMANCE AT THE WORKSHOP

The analysis that follows was performed based on the computer printouts of the data, as supplied to us in February, 1981.

Consider first the monodisperse sodium chloride and ammonium sulfate experiments. Let S_{CU} denote the critical supersaturation determined from the size given by U. Katz. On a plot of CCN count versus S, these aerosols show a plateau. At a count of 50% of the plateau value, let the corresponding S be defined as the measured critical supersaturation, S_C. Define the parameter X by $X = (S_C - S_{CU})/S_{CU}$. Table 1 shows the average ($\overline{X}$) and standard deviation (σ) of X for eight instruments that we judged to be giving above average performance. There are two groups of experiments, with $S_{CU} > 0.1$ shown on the top 6 rows, and $S_{CU} < 0.1$ shown on the bottom 4 rows. In each group the instruments are arranged according to σ, lowest σ on top.

In the top group of Table 1, it can be seen that our instrument gave $\overline{X} = +0.0296$ and $\sigma = 0.107$

INSTRUMENT	EXPERIMENTS	S_{CU} RANGE	$X = (S_C - S_{CU})/S_{CU}$	
			AVERAGE, $\bar{X}$	STD.DEV., σ
#18, DRI-CFD Hudson-Squires type	4,5,10,15, 18,20	>0.1	-0.0565	0.103
#21, UMR CFD mode	4,5,10,15, 18,20	>0.1	+0.0296	0.107
#17, NRL Twomey type	4,5,10,18	>0.1	-0.171	0.125
#12, NRL elect. class.	4,5,10,15, 18,20	>0.1	+0.0169	0.156
#15, DRI-CFD NASA	10,15,18, 20	>0.1	+0.0067	0.158
#10, SUNY static, scattering	5,10,18	>0.1	-0.0019	0.315
#21, UMR haze mode	8,9,10,19	<0.1	+0.109	0.0453
#12, NRL elect. class.	8,9,10,19	<0.1	+0.0932	0.0897
#14, DRI haze	8,9,10,19	<0.1	+0.221	0.190
#11, NRL haze	8,9,10,19	<0.1	+0.184	0.321

TABLE 1. Critical Supersaturation (S_C) of Monodisperse Aerosols. S_{CU} = Value from U. Katz Electrical Classifier.

which is about the same performance as we have reported in the literature (Alofs, *et al.*, 1979). Except for instruments #17 ($\bar{X} = -0.171$) and #10 ($\sigma = 0.315$), the other instruments (#18, #12, #15) gave performance of similar quality, with $|\bar{X}| < 0.06$ and $\sigma < 0.16$.

Now consider the bottom 4 rows of Table 1; that is, experiments with $S_C < 0.1$. A very good performance is indicated by our instrument in the haze mode ($\bar{X} = +0.109$, $\sigma = 0.0453$). The NRL electrical classifier showed somewhat higher σ (0.089) and the haze chambers of DRI and NRL showed considerably higher σ. These instruments (#14 and #11) both gave $X \approx 0.4$ for experiments #8 and #9, and $|X| < .05$ for experiments #10 and #19. These instruments also both use Royco Model 225 optical counters, which have a multiple value response function for water drops in the range 1 to 2 μm diameter (Cooke and Kerker, 1975). Experiments #8 and #9 give haze drops of about 2 μm diameter, which is within the ambiguous size range of the Royco and probably explains the decrease in sizing accuracy.

Table 2 shows another type of comparison. The concentration ratio (R = ours ÷ other) was computed for S = 0.03, 0.1, 0.3, and 1.0. The average ($\bar{R}$) and standard deviation (σ) of R were then computed over the available set of experiments for each instrument.

In Table 2, consider first the Hudson-Squires type CFD of DRI. At S = 0.3, $\bar{R}$ = 1.04 and at S = 1, $\bar{R}$ = 1.18. Thus our counts were 4-18% higher than theirs. This is pretty good agreement in our opinion. However, $\sigma/\bar{R}$ = 0.275 at S = 0.3, which is definitely higher than we expected in view of the 1% agreement that Hudson and Squires (1976) obtained with a pair of their CFD's. At S = 1, the value of $\sigma/\bar{R}$ is considerably lower (0.132), and is the lowest value of $\sigma/\bar{R}$ in Table 2.

In the haze mode, our instrument compares well with the NRL haze chamber ($\bar{R}$ = .974 at S = .03, $\bar{R}$ = 1.067 at S = .1) but gives considerably higher concentration than the DRI haze chamber ($\bar{R}$ = 2.2) and lower concentration than the NRL electrical classifier. The standard deviations at S = .03 and S = 0.1 are higher than in Table 1, but are still not too bad considering the problems involved in sizing water drops with optical counters.

OTHER INSTRUMENT	SUPERSATURATION (%) / EXPERIMENTS	Average Ratio, $\bar{R}$, Univ. of Mo. (#21) ÷ Other				Relative Std. Deviation $\sigma/\bar{R}$			
		.03	.1	.3	1.	.03	.1	.3	1.
#18, DRI-CFD Hudson-Squires type	5,8,9,10,11,12,13, 14,15,16,18,19,20, 22,23,26,27,28	--	--	1.04	1.18	--	--	0.275	0.132
#17, NRL Twomey type	1,2,3,4,5,8,9,10, 11,12,14,15,18,19, 20,22,23,26,27	--	--	0.943	0.937	--	--	0.258	0.215
#10, SUNY static,scattering	5,8,9,10,12,13,14, 15,18,19,20,22,23, 26,27,28	--	--	0.885	1.27	--	--	0.221	0.200
#12, NRL elect. class.	1,2,4,5,8,9,10,13, 14,15,18,19,20,22, 23,24	0.678	0.632	0.899	0.915	0.302	0.418	0.284	0.209
#11, NRL, haze	1,2,3,6,8,9,10,11, 12,14,15,19,20,22, 23,24,26	0.974	1.067	--	--	0.600	0.382	--	--
#14, DRI haze	8,9,10,11,12,14,15, 16,17,19,20,22,23, 24,26	2.17	2.18	--	--	0.722	0.333	--	--

TABLE 2. Ratio, University of Missouri ÷ Other Instrument

3. ACKNOWLEDGEMENTS

This material is based upon work supported by the Division of Atmospheric Sciences, National Science Foundation under Grant ATM 7924326.

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A CLOUD CONDENSATION NUCLEUS SPECTROMETER DESIGNED FOR AIRBORNE MEASUREMENTS

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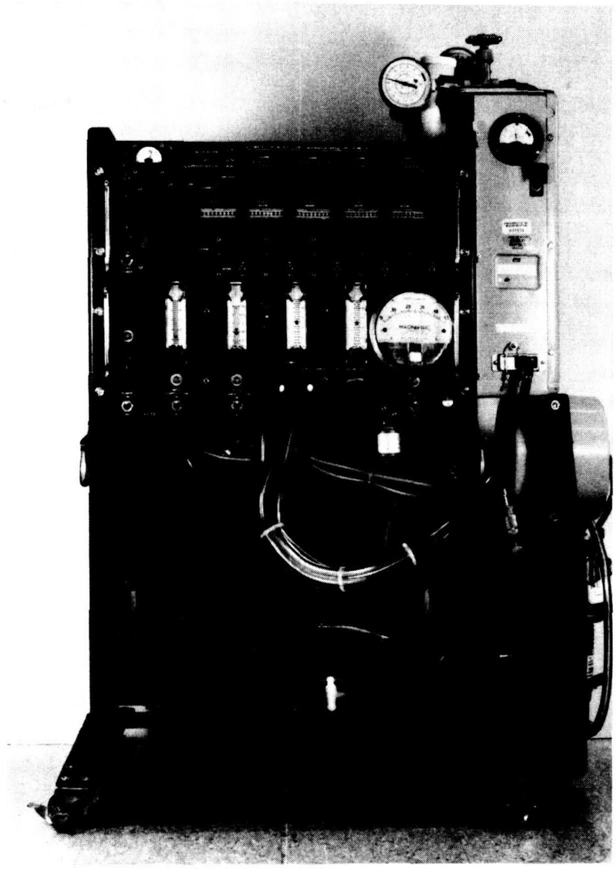

Abstract

A portable, vertical plate cloud condensation nucleus spectrometer, suitable for mounting aboard a small aircraft, is described. This instrument, which incorporates several unique design features, is automated and can provide rapid, simultaneous measurements of the concentrations of cloud condensation nuclei at four supersaturations.

1. INTRODUCTION

In 1970, at the Second International Workshop on Condensation and Ice Nuclei, all but one of the cloud condensation nucleus (CCN) counters were horizontal static-diffusion chambers operating in a manner little changed from those used in the 1950's [1,2]. Only one of the static chambers was fully automated [3]. All of the counters had significant limitations in time resolution and all required an operating time of several minutes or more to measure the supersaturation spectrum.

Recently, variations on the continuous flow CCN counters developed in the 1960's [4,5,6] have produced a number of automated and semi-automated CCN counters which use single particle optical counters as detectors. These new devices offer the potential for both significantly improved accuracy and time resolution in CCN measurements, although most have provided only limited improvements in quickly measuring the CCN activity spectrum.

The CCN spectrometer to be described in this paper is a simple extension of the continuous flow diffusion chamber (CFDC) operated in the vertical mode, much like the instruments described in [7], [8] and [9]. The principal new design features of our instrument are its rapid time response and ability to rapidly measure the CCN activity spectrum. Also, the instrument is small enough to be mounted and operated in a research aircraft of modest size.

2. PHYSICAL LAYOUT AND AIRFLOW

The activity spectrum of CCN in an air sample is measured rapidly by simultaneously operating the spectrometer at four supersaturations. The CCN spectrometer consists of four essentially independent CFDC's in a parallel array (Fig. 1). Each CFDC is 61 cm long, 10 cm wide, and consists of two vertical parallel plates 1 cm apart, maintained at different temperatures. Each CFDC has a single particle optical counter located at the center of its base.

The instrument operates in the following sequential manner:

i) An air sample is drawn through the duct at the top of the CFDC's.

ii) A fraction of the airflow exits the sample duct through a symmetrical, streamlined slit at the bottom of the duct. The rest of the sample flow is discarded.

iii) As the air enters the top of one of the CFDC's, it is sheathed with two temperature-conditioned, particle-free "curtains" of air (called the "sheath flows").

iv) The three airstreams travel in laminar flow, with negligible intermixing, down each of the CFDC's where, after 8 cm of travel, they encounter a saturated felt on the cold plate. At a further distance downstream, the warm plate is also covered with wet felt. This results in the airstream becoming supersaturated and CCN are activated to form droplets. The total length of felt on the

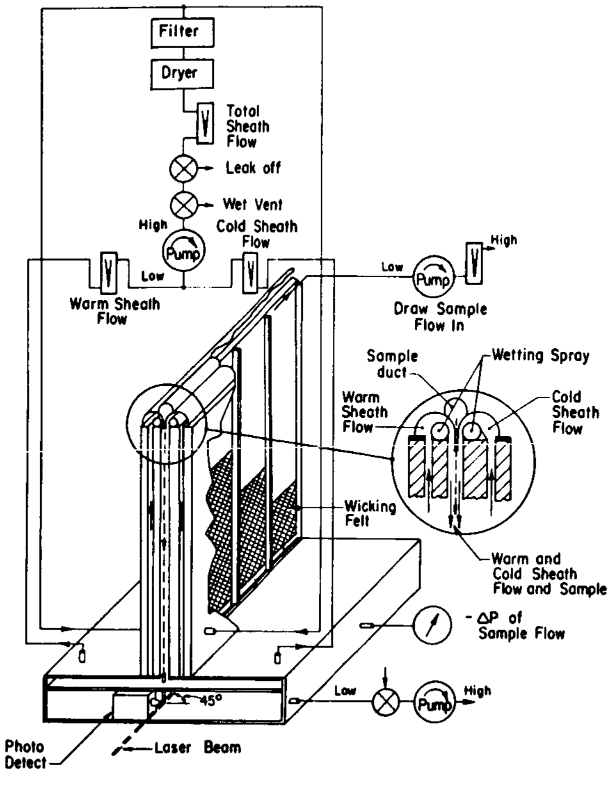

Figure 1. Schematic showing the airflow and optics of the University of Washington's CCN Spectrometer.

warm plate is roughly inversely proportional to the supersaturation in the chamber.

v) As the airstreams leave each of the CFDC's they are split along the vertical, central plane of the sample air, with half of the total flow being removed on each side at the base of the CFDC. A small fraction of the airflow is removed as the stream is divided by a small tube which extends up into the airflow. The droplets in this fraction of the airflow are subsequently counted by optical counters (see §4).

vi) The position of the airstream with respect to the inlet to the optical counters can be precisely adjusted by changing the flow rates in the sheath flows; this allows the airflow to be exactly centered on the inlet to the optical counters.

vii) The two halves of the total airflow are then filtered, dried and reinserted on the back sides of the warm and cold plates. These two airstreams travel up the plates and are in thermal equilibrium with the plates; when they arrive at the top of the CFDC they form the warm and cold sheath flows.

3. SUPERSATURATION CONTROL

A novel method is used for providing four distinct temperature differences between the warm and cold plates of the four CFDC's. As shown in Fig. 2, a large aluminum plate is cooled nearly uniformly by a small mechanical refrigerator. The warm plate, which is made of copper, is connected to the cold plate by a brass end plate and at the opposite end it is heated by the hot refrigerator gases. The copper plate is vertically segmented between each CFDC with a thin insulator. The four copper segments stabilize at four distinct, and nearly uniform, temperatures. From measurements of these temperatures, and the temperature of the cold plate, the supersaturation in each of the CFDC's is computed by a microprocessor. Note that the supersaturations in all four CFDC's are adjusted by a single control. The four supersaturations normally achieved are approximately 0.2%, 0.5%, 1.0% and 1.5%[*].

4. OPTICAL DETECTION AND DATA PROCESSING

The CCN activated in the CFDC's are detected as droplets in an optical box (Fig. 2). The optical box contains a three mW He-Ne laser and four identical photo-detectors placed beneath each of the sample outlet tubes from the four CFDC's. The streams of droplets pass through the laser beam and are viewed by the photo-detectors at a forward scattering angle of 45° ± 5°. The photometers readily detect all droplets greater than 0.5 μm in diameter. The available growth times in the CFDC's (5-20s) are more than adequate to grow the activated CCN into droplets that are much larger than any unactivated haze droplets. Thus, by appropriate sensitivity adjustments, activated droplets are detected but the unactivated haze droplets are not.

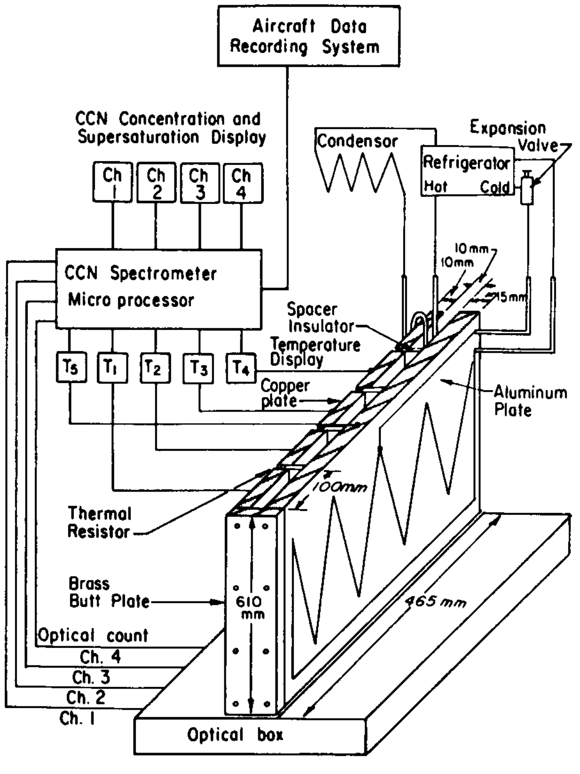

Figure 2. Schematic of thermal and electrical components of the CCN Spectrometer.

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[*] During the CCN Workshop the range of supersaturations achieved was limited by a malfunction of the refrigerator unit.

A microprocessor is programmed to process the data in several ways. It can display the supersaturation and CCN concentrations measured in each of the four CFDC's on command from the aircraft's central computer. Alternatively, the microprocessor can delay output and accumulate data until certain statistical counting criteria are met.

5. CONCLUSIONS

We have designed and built a compact and reasonably simple CCN spectrometer for airborne use. In its first full-scale testing, at the Third International Measurement Workshop on CCN, it compared well with both conventional CCN counters and large continuous flow CCN counters designed for use on the ground. This instrument is currently undergoing final laboratory testing and modification before flight testing.

6. ACKNOWLEDGEMENTS

This work was supported in part by Contract NAS8-33148 from the National Aeronautics and Space Administration (Marshall Space Flight Center).

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STATIC DIFFUSION CLOUD CHAMBER

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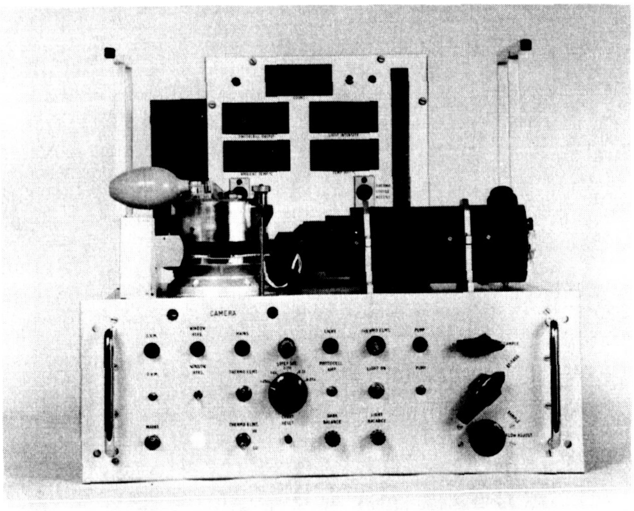

1. CHAMBER GEOMETRY

The thermal diffusion chamber is based upon an earlier design of Twomey and Davidson, the cylindrical glass walls of which have been replaced by an annular perspex (plexiglass) spacer 12.5 mm in height, which is fitted with a very thin stainless steel liner that contacts both top and bottom plates so as to linearize the edge temperature gradient. Gagin and Terliuc (1968) used a somewhat thicker liner for this purpose.

The optical arrangement is similar to that used by Lala and Jiusto (1977). In the present design heated windows have been installed at appropriate places to allow a waisting light beam from a projector - lamp/lens combination to pass through the chamber. A window is placed at 45° with respect to the beam to view the forward scattered light with a photocell and lens. A further window at 90° to the beam allows the number of drops in the illuminated cloud to be recorded photographically.

Summary of Chamber Geometry:

Inside diameter 75 mm
Height 12.5 mm
Scattered light at 45° recorded with a peak detector
Cloud droplets recorded photographically at 90°
Sample volume 10 mm x 3 mm x 3 mm

2. SAMPLING SYSTEM

Air is drawn continuously through the equipment at about 1 - 1.25 dm^3/min by means of a simple aerator (aquarium) pump. The flow bypasses the chamber until a measurement is required, at which point air is admitted by turning a four-way selector valve to the "sample" position. A two-way selector valve in the air circuit enables the sample air to be passed through an absolute filter so that periodic zero checks can be made.

Sampled air enters the chamber from six peripheral holes in the underside of the top plate after passing twice around the edge in a gallery to attain the same temperature as the top plate.

The chamber and associated air lines are sealed from the ambient atmosphere so that, if required, the equipment may be operated at pressures below ambient. A prototype of this design has been successfully operated in the Division's pressurized aircraft.

2.1 Supersaturation Range

Readings are taken at five fixed points: 0.25%, 0.5%, 0.75%, 1.0% and 1.25%.

2.2 Detection System

Light source: Sylvania EJV Projector Lamp

150W - 21V operated at approximately 19V, illuminating at a distance of 45 mm a 2.4 mm square of ground glass screen. Light from this screen is passed through infrared absorbing glass and focused by means of a Bell and Howell projector lens (F1.2; focal length 51 mm) to give a beam waisting down to a 3 mm square section over a 15 mm length at the center of the diffusion chamber. The central 10 mm is used for droplet detection.

Camera: Canon AE-1 fitted with a Vivitar

55 mm Macro F2.8 lens, power-winder and data back. Film used is Tri-x (400 A.S.A.) processed for 600 A.S.A. Photographs are taken at 1/4 sec. and F4, though the effective aperture is much smaller (higher F number) since the camera views the chamber through a small window set in a short tube. Photographs of a mm graticule placed at 45° to the incident light beam and camera window confirmed both the beam cross sectional area and that depth of field was sufficient to encompass the 3 mm width of the beam.

Photocell detector: An EG and G Electro-Optics Silicon Photovoltaic Detector type PV-215 coupled to a two-stage amplifier having an output gain of 100V per micro-amp of cell currrent. Amplifier output is fed to a peak detector having a digital panelmeter readout. A manual reset is used. The photocell views the scattered light from virtually the same sample volume as the camera, but at an angle of 45°, and through an 8 mm focal length lens. A mask in front of the lens serves to define the viewed sample volume.

3. TEMPERATURE CONTROL

Temperature of the top and bottom plates is measured using semi-conductor transducers (National Semiconductor type LM3911 or similar). The transducers are coupled to amplifiers to give outputs of 100mV per K and have been set to within 1 or 2 hundredths of a K at ice point and at 293·15K. Digital panelmeters read the top plate temperature to 0·1K and the top-bottom temperature difference to 0·01K, though the bottom plate temperature varies by ±·04K due to "hunting" of the controller. Thermocouples have been built into both plates to provide an independent check on the performance of the temperature measurement and control circuitry.

Bottom plate cooling is by means of a Komatsu thermoelectric cooling element, type KSF-2012. Simple circuitry uses the temperature transducer outputs to establish and maintain automatically the required ΔT, regardless of top plate temperature variations.

4. CALIBRATION

Calibration amounts to relating the peak value of scattered light intensity to the number of droplets in the sample volume at the time at which the peak occurred. In the present case, a chart recorder was used to register, simultaneously, variation in scattered light intensity and the time at which photographs of the scattering volume were taken (usually a series of 5-7 frames at 1 per second). It was then a simple matter to determine which frame corresponded most closely in time to the peak in the scattered light intensity. In this way, calibration curves were constructed for each supersaturation in the form of plots relating "film count (cm^{-3})" to "peak reading".

The simple analysis of a thermal gradient chamber discussed by Lala and Jiusto (1977) suggests the peak value in scattered light intensity is dependent on supersaturation and droplet concentration only and, in particular, that the number of droplets present in the sample volume at the time the peak is reached is only two-thirds of the initial nucleus concentration, independent of supersaturation. Thus our final estimate of CCN concentration is made by multiplying the "film count" by a factor of 1·5.

Calibration curves used at the workshop were derived from room air samples by blending varying amounts of filtered and unfiltered air to obtain a range of peak readings.

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AN AIRBORNE ISOTHERMAL HAZE CHAMBER

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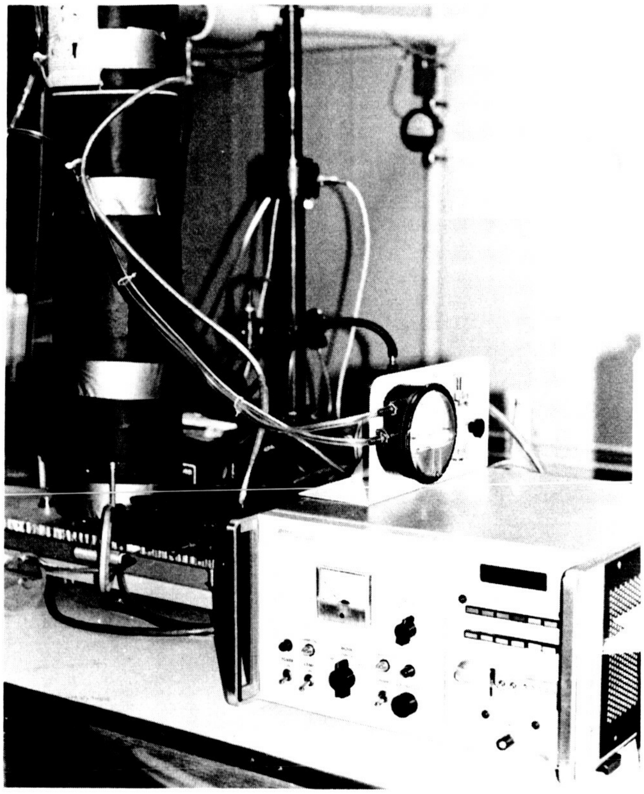

1. INTRODUCTION

Thermal gradient diffusion cloud chambers (TGDCC) are used to determine the concentrations of cloud condensation nuclei (CCN) with critical supersaturations (S_c) greater than or equal to about 0.2% (Hoppel and Wojciechowski, 1976). The concentrations of CCN active at $S_c \lesssim 0.2\%$ can be determined using an isothermal haze chamber (IHC) following the work of Alofs (1978), Hoppel (1979) and Hudson (1980). They have shown that CCN spectra over a supersaturation range $0.01 \leq S_c \leq 1.0\%$ can be obtained from simultaneous measurements with a TGDCC and an IHC. Their instruments are designed to operate either in the laboratory or in the field.

The IHC discussed in this paper and operated at the CCN Workshop was designed for use in a light aircraft. It is based on the IHC design of Hudson (1980). The objectives of our participation in the Workshop were to (1) compare the response of the airborne IHC to the theoretical response (based on accurate sizes, numbers and compositions of aerosol particles), (2) compare the response of the IHC to the response of the larger laboratory IHC's, and (3) compare the response of the IHC to the response of the CSU-Mee TGDCC (Borys, 1980) in the region of overlapping supersaturations. The Mee instrument resembles that constructed by Lala and Jiusto (1977).

2. DESCRIPTION OF THE CHAMBER

Hudson (1980) provides a schematic of the IHC and the operating principles. Here we will provide details of the airborne version of Hudson's chamber which we have constructed. The line drawings for the chamber are given in Figure 1. The air flow and water flow through the chamber are given in Figure 2.

The supersaturation range of the instrument is determined by the size range of the solution droplets (in equilibrium at 100.0% RH) which the ROYCO sensor can detect. The equilibrium droplet size is related to its critical supersaturation as follows:

$$r_{100} = 4.1 \times 10^{-6}/S_c \qquad (1)$$

where r is in centimeters and S_c is in percent, after Laktionov (1972), Hoppel and Fitzgerald (1977), Alofs (1978) and Hudson (1980). The ROYCO sensor latex-sphere calibration was revised for water droplets by Fitzgerald (1980, private communication) following Cooke and Kerker (1975); see Figure 3. The sensor was adjusted such that the critical supersaturation thresholds corresponding to the droplet sizes from (1) were 0.15%, 0.11%, 0.041%, 0.027% and 0.016%, respectively.

The ROYCO Model 225 optical particle counter which is described by Liu, *et al.* (1974) was used to size and count the solution drops produced in the IHC. The instrument was operated at a 60 s sampling interval. Consequently, it took 1 minute for a CCN spectra to be obtained.

The maximum flow F to permit droplet equilibrium in the chamber was estimated following a procedure outlined by Hudson (1980). The results of the variations in particle concentrations as a function of F were similar to the results reported by Hudson. We found the maximum value of F should be ~ 35 cm^{3}s^{-1}. Values of F greater than this value would provide insufficient time for droplets to reach equilibrium size before passing through the ROYCO sensor.

The volume sampled for a CCN spectra corresponds to the flow rate f through the sensor multiplied by the sample period: ~ 1 cm^{3}s^{-1} x 60 s = 60 cm^3. This result is valid because the main flow F is essentially particle free.

There is no cooling or heating requirements for the chamber; the chamber is isothermal.

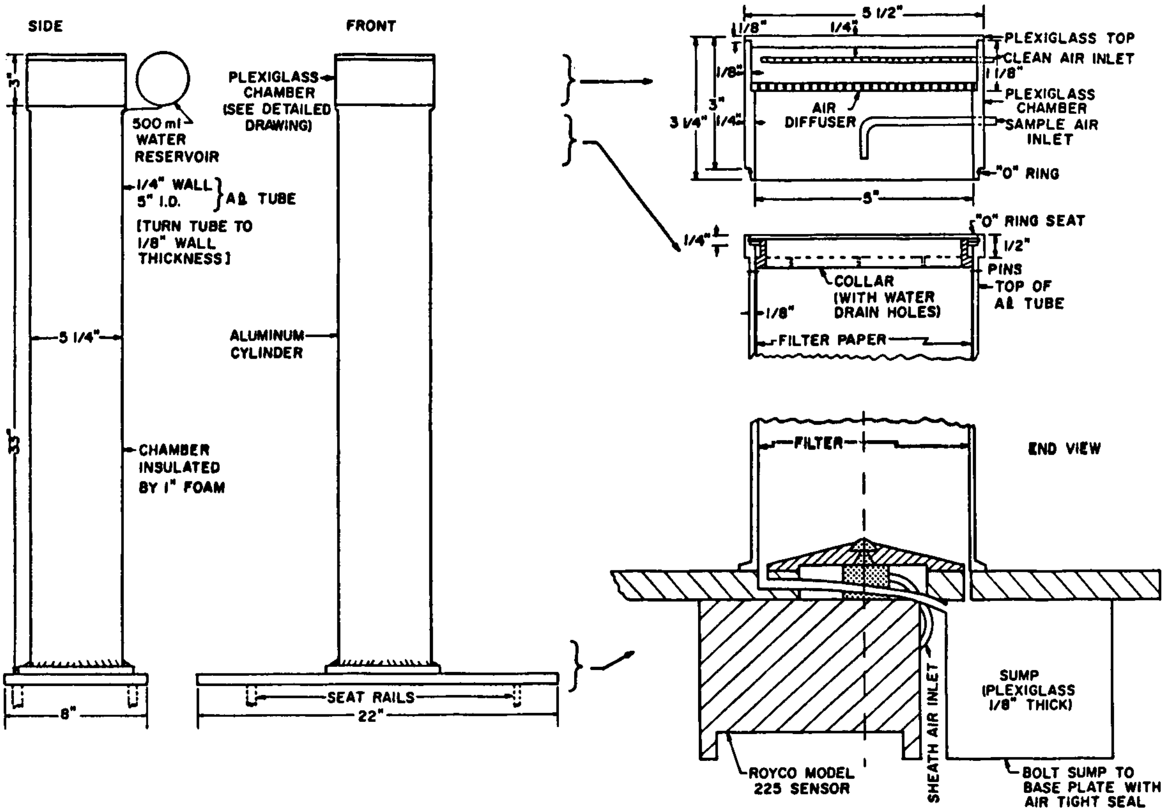

Figure 1. Isothermal haze chamber and main components: Aluminum cylinder with inside walls covered with Whatman 41 cellulose high-volume filter paper; plexiglass top into which flows particle-free air, sample air and water by gravity feed from the 500 ml reservoir; the ROYCO Model 225 sensor which sizes and counts the solution droplets which form in the chamber; the sump for receiving the water which drains from the filter paper.

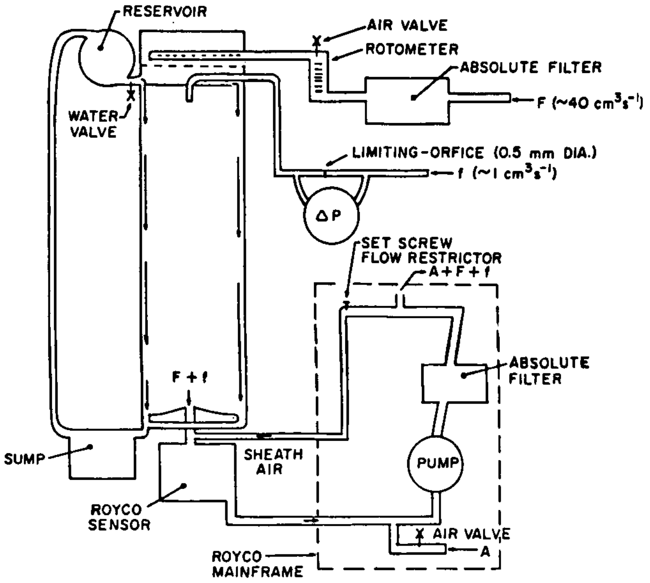

Figure 2. Airflow and water flow schematic.

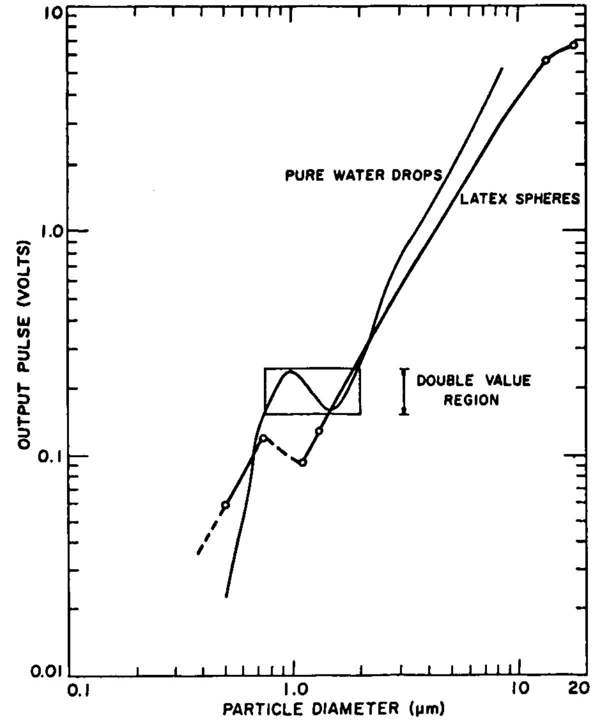

Figure 3. Calibration of ROYCO sensor for latex spheres. The calibration for pure water drops was from Fitzgerald (1980, private communication).

The minimum detectable drop size is 0.62 μm diameter (see Figure 3). This is the minimum size setting before electronic noise interferes.

3. RESULTS

During Experiments 1 through 13, the IHC was operated in the same fashion ($f = 1.3\ cm^3s^{-1}$, $F = 35\ cm^3s^{-1}$). It was clear from these early experiments that the concentrations of CCN detected by the airborne IHC were significantly below the concentrations detected by the laboratory IHC's (see the Table). For example, in the Table, the airborne IHC detected an average of 94 times fewer CCN active at $S_c \leq 0.05\%$ than did the laboratory IHC's.

One reason for the CCN concentration differences between the laboratory and airborne IHC's was thought to be a malfunctioning CSU ROYCO 225 sensor. The sensor was checked with the York University ROYCO 225 sensor and no significant difference was found between the dry particle size distributions measured by the two instruments. Further, during Experiments 14 and 15, the spare NRL ROYCO 225 sensor was connected to the CSU IHC and the CCN concentrations continued to be too low. Consequently, the CSU ROYCO 225 sensor appeared to be operating normally.

Another reason for the CCN concentration differences was thought to be a subsaturated chamber. Consequently, a humidifier (courtesy of Dr. Fred Rogers) was placed in the main-flow air line downstream of the filters during Experiment 17. The humidifier remained in the line from Experiment 18 to the end of the Workshop. The results in the Table show that the humidification reduced the differences in concentrations between the lab IHC's and the airborne IHC. For example, the factor of 94 difference mentioned earlier reduced to a factor of 7.5 following humidification. The Table presents a comparison of the results from theory and from the airborne IHC. Following humidification, the airborne IHC measured 9.0 times fewer CCN active at 0.05% and 7.9 times fewer CCN active at 0.14% than predicted to occur by theory.

Figure 4 illustrates the results obtained from the simultaneously operating CSU IHC and CSU TGDCC. Also plotted are the results obtained using measured particle sizes and the theoretical relationship between the dry $(NH_4)_2SO_4$ particle size and its critical supersaturation from Fitzgerald (1973):

$$r_d = 1.53 \times 10^{-6}\ S_c^{-2/3} \tag{2}$$

where r_d is in centimeters and S_c is in percent. It can be seen from Figure 4 that the results from the two instruments tracked the theoretical response but with concentrations significantly less than the theoretical response. Further, the supersaturation ranges of the two instruments did not overlap because the lowest value of the TGDCC range was 0.2% as established by Borys (1980) and the smallest droplet detected by the ROYCO was 0.62 μm diameter which is equivalent to a S_c of 0.13%. Nevertheless, it can be seen the slopes of the curves in this region approximate the theoretical slope.

TABLE

Selected CCN Concentration Measurements for $S_c \leq 0.05$ and $\leq 0.14\%$

	Humidity?	Experiment	Theory*	NRL	UMR	DRI	CSU	Theory/CSU		Lab IHC's**/CSU	
$N(S_c \leq 0.05\%)cm^{-3}$	No Humidity	8	300	120	100	80	1.5	200	351	67	94
		9	600	270	250	200	5.0	120		48	
		10	66	30	17	8	0.09	733		203	
		11	-	90	26	-	1.0	-		58	
	Humidity	19	110	-	65	25	4.0	28	9.0	11	7.5
		20	0.4	2	2	2	0.1	4		20	
		22	5	1	1	1	1.4	3.6		0.7	
		23	1	0.5	1	0.5	0.15	6.7		4.4	
		24	10	5	7	4	4	2.5		1.3	
$N(S_c \leq 0.14\%)cm^{-3}$	No Humidity	8	420	290	300	240	120	3.5	4.1	2.3	4.1
		9	800	600	850	350	300	2.7		2.0	
		10	270	240	210	100	30	9.0		6.1	
		11	-	350	460	-	70	-		5.8	
	No Humidity	19	1000	-	1000	350	250	4.0	7.9	2.7	3.9
		20	140	190	140	58	30	4.7		4.3	
		22	150	100	100	30	17	8.8		4.5	
		23	28	17	13	5	2	14		5.1	
		24	400	170	230	70	50	8.0		3.1	

* The dry-particle sizes and numbers were known and their S_c could be calculated using theoretical relationships developed by Fitzgerald (1973).

** The Lab IHC value is the average of the NRL, UMR and DRI measurements.

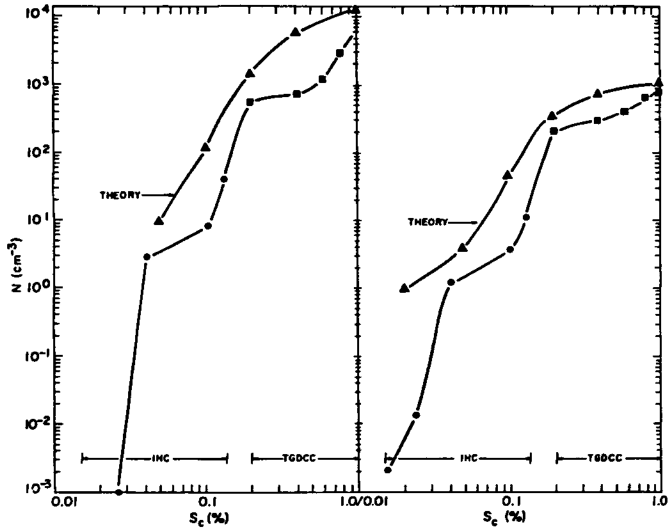

Figure 4. Results from the CSU IHC and the CSU TGDCC for Experiment No. 24 (left) and Experiment No. 22 (right). The particles in both cases were polydisperse $(NH_4)_2SO_4$.

4. DISCUSSION

How subsaturated must the airborne IHC have been to account for the differences between the theoretical results and the measurements? From Figure 4 it can be seen that if the S_c values were shifted from 0.1% to about 0.05% then the theoretical results and measurements would be identical. The r_{100} corresponding to these two S_c values are 0.41 μm and 0.82 μm, respectively, using (1). Consequently, we may have been measuring the concentrations of droplets with radii $\geq$ 0.41 μm at an unknown RH. The unknown RH can be estimated from a graphical representation (Figure 5) of the relationship between S_c, $r_{equilibrium}$ and RH ($\leq$ 100.0%) provided by Hoppel (1980, private communication). As can be seen from Figure 5, droplets $\geq$ 0.82 μm at 100.0% RH become droplets $\geq$ 0.41 μm at 99.1% RH. So, if the chamber achieved only 99.1% RH, this subsaturation would explain all of the differences between theory and measurements.

How long a growth time is required for the largest solution drop measured (r_{100} = 2.5 μm) to closely approximate its equilibrium size? Hoppel (1980, private communication) has calculated the growth times to reach the critical radius (r_c); r_c is greater than r_{100}. The times are shown in Figure 6. Interpolating between his worst case values (condensation coef. = 0.036) the growth time to reach 2.5 μm is about 280 s. The growth time available in the chamber is about 307 s (35 cm^{3}s^{-1}/126 cm^2 x 83 cm). Consequently, sufficient time exists for the largest solution drops to reach equilibrium. Insufficient growth times cannot explain the differences between theory and the measurements.

Could the water droplet calibration for the ROYCO sensor account for the differences between the theoretical results and the measurements? To do this, the droplets with diameters indicated to be 0.62, 0.82 and 2.0 μm, according to the calibration in Figure 3, would have had to indicate 1.13, 1.64 and 3.56 μm, respectively. These latter values are a dramatic departure from the calibration. The calibration works adequately with the NRL ROYCO 225 which is connected to their IHC. Consequently, it is believed the sensor calibration cannot account for all of the differences between theory and measurements.

The only particle losses in the system occur across the limiting-orifice (Figure 2). The losses were measured to be at most a factor of 1.3. This loss cannot account for much of the factors of 3.9 and 7.5 reported in the Table.

What is the possibility that droplets entering the ROYCO sensor at equilibrium size (RH = 100%) shrink in size by the time they pass through the optics? It can be seen from Figure 1 that the sensor inlet protrudes into the IHC. Therefore, the time for a particle to travel from the inlet to the optics is approximately 1.1 ms (7.9 x 10^{-3} x 5.1 cm/37 cm^{3}s^{-1}). Since the sheath air entering the sensor was slightly warmer and dryer than air entering the sensor from the IHC, conditions

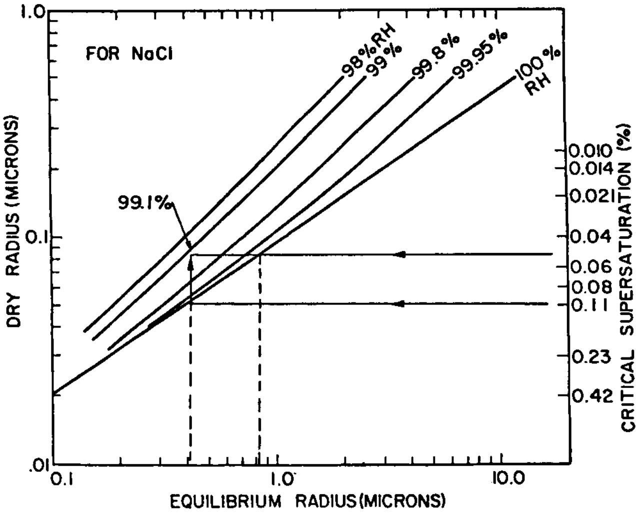

Figure 5. Relationship between r_{dry}, $r_{equilibrium}$, RH ($\leq$ 100.0%) and S_c for NaCl particles (close approximation to $(NH_4)_2SO_4$ particles). From Hoppel (1980, private communication).

for droplet evaporation were present. Alofs (1978) calculated effects of droplet shrinkage on S_c for different droplet residence times. Applying our 1.1 ms time to his worst case situation (95% RH in the optics) it was found that the effect would be confined to $S_c \geq 0.1\%$ and at most would change the inferred S_c of 0.16% to about 0.15%. Consequently, droplets will not shrink significantly due to the extremely short residence time.

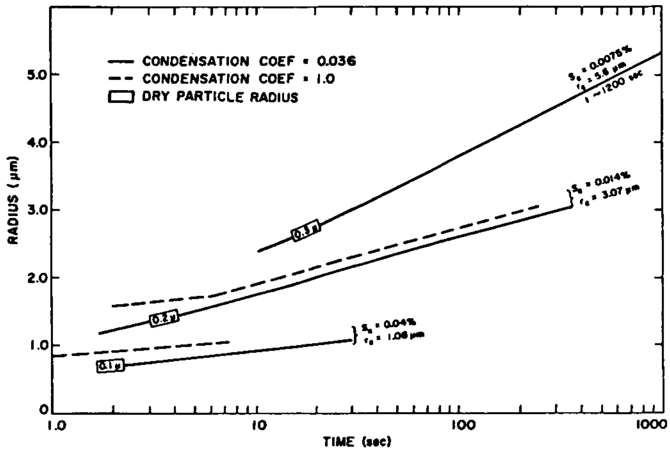

Figure 6. Growth times for dry-particles to reach their critical sizes (r_c). From Hoppel (1980, private communication).

Finally, errors in the theoretically derived CCN response should be negligible. Gerber, *et al.* (1977) demonstrated experimentally the soundness of the theoretical relationship between r_d and S_c given by (2). The same particle sizing and counting equipment used by Gerber, *et al.*, was used by Hoppel during the CCN Workshop to provide the measurements for deriving the CCN concentrations.

5. CONCLUSIONS

The following conclusions can be made based on the results obtained from the CCN Workshop. The CCN concentrations measured with the airborne IHC were lower than theoretically predicted by factors ranging between 7.9 and 9.0. The CCN concentrations measured with the airborne IHC were lower than the concentrations measured with the larger laboratory IHC's by factors ranging between 3.9 and 7.5. The bounds of the supersaturation ranges of the airborne IHC ($S_c \leq 0.16\%$) and the CSU-Mee TGDCC ($S_c \geq 0.2\%$) do not overlap. Nevertheless, the slopes of the interpolated data between the bounds agree favorably with the theoretical slopes. Slight subsaturations in the IHC plus uncertainties with the sensor calibration are the most probable causes for the discrepancies between the measured and predicted CCN concentrations.

6. ACKNOWLEDGEMENTS

The Desert Research Institute is gratefully acknowledged for organizing and executing such an excellent and productive Workshop. The author's participation was sponsored by ONR Contract N00014-79-C-0793.

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A DESCRIPTION OF THE UK METEOROLOGICAL OFFICE CCN COUNTER

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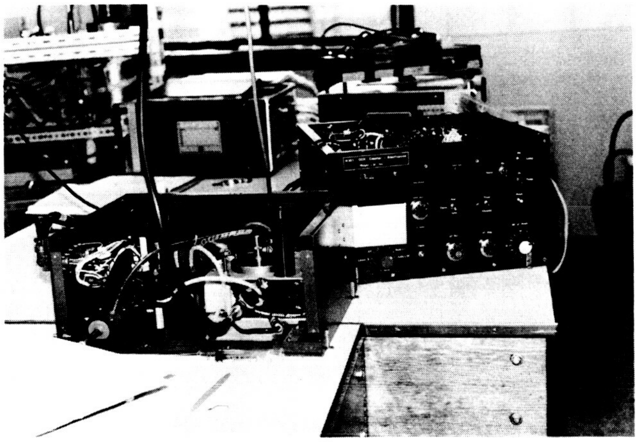

The Meteorological Office CCN Counter is a modified Mee Industries* Model 130 CCN Counter which was purchased in 1977.

1. THE CHAMBER

The chamber is a thermal gradient diffusion type with the upper plate at room temperature and the lower plate thermoelectrically cooled. The light from a 25W projector bulb is focused in a beam of approximate dimensions 1x3 mm in the central part of the chamber. The light scattered by drops is viewed in the forward direction (40°) by a microscope and a sensitive photodetector.

Experiments have been performed to relate the peak output from the photocell with the maximum number of drops in the beam recorded photographically. The microscope is used to check the calibration at low concentrations of CCN.

2. ANCILLARIES

Modifications to the original Mee design are as follows:

(a) In order to reduce the time necessary to obtain an activation spectrum, the thermal capacity of the cooling system has been reduced by mounting the thermoelectric cooler adjacent to the bottom plate. In order to reduce the temperature difference between the plates (ΔT) and hence the supersaturation, the current is reversed through the cooler, instead of a separate heater being employed.

(b) The temperature of the top and bottom plates is monitored using precision surface mounting thermistors (YSI 400) bonded directly to the back of the sintered bronze plate. Horizontal temperature gradients across the lower plate are minimized by placing a brass disk, into which water drainage channels have been machined, directly below the plate and on top of the Peltier cooler.

(c) The new control circuits enable a sampling sequence in which an activation spectrum consisting of CCN measurements at a predetermined number of supersaturations and over any desired range to be made. ΔT is stepped up and back down through this range automatically. There is also a circuit which monitors ΔT and prevents new air samples being taken until the desired level of temperature stability in the chamber has been reached. At present, this is set to $d(\Delta T)/dt \leq 0.01°Cs^{-1}$. A typical portion of this sequence is shown in Figure 2 below.

(d) The chief use of the instrument is onboard the Meteorological Research Flight C-130 aircraft. To make the instrument suitable for this use, it has been repackaged and is powered by a 115V, 400 Hz aircraft supply. For use in ground-based field projects, data logging is performed by an HP9830 calculator.

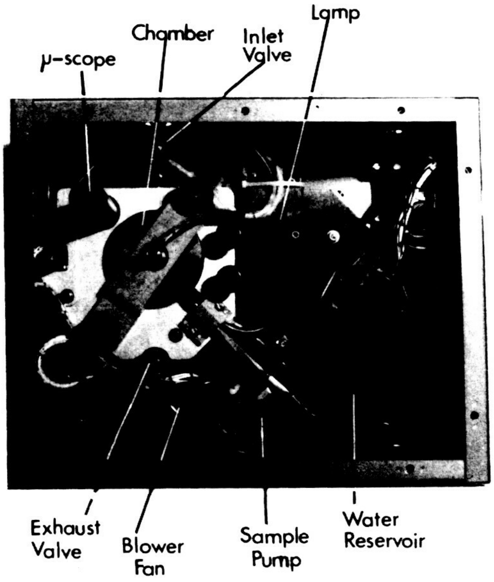

Figure 1. A view of the chamber; the control electronics, power supplies, etc. are in a separate box, not shown).

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*Mee Industries Inc., Rosemead, CA 91770

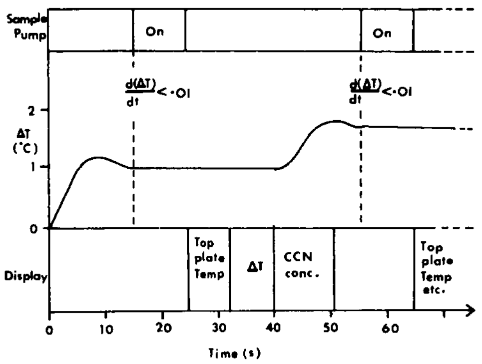

Figure 2. A typical sampling sequence. The "display" is a digital display on the front panel and the "CCN concentration" is the peak photocell output after amplification. A four-point activation spectrum in the range of supersaturation 0-1.5% requires approximately 10 minutes to complete.

3. PERFORMANCE

From experience in the operation of the modified Mee counter at the CCN Workshop and during field projects, it has become clear that there are a number of deficiencies in the design which have yet to be corrected.

(a) The low intensity light source results in a poor signal-to-noise ratio in the photodetector output.

(b) Calibration is difficult because photography of the drops growing in the chamber is hindered by the low illumination.

(c) The high fall speed of the drops viewed through the microscope is evidence of flow inside the chamber air sample. This raises doubts about whether a quasi-thermodynamic equilibrium is achieved.

(d) The sintered bronze plates are difficult to clean and may be subject to contaminants.

(e) Condensation occasionally occurs on the chamber windows, reducing the amount of scattered light focused onto the photodetector.

4. CONCLUSION

The modifications made to the Mee CCN counter have improved the temperature control and stability and also reduced the time taken to produce an activation spectrum. However, measurements of CCN concentration using this instrument have shown that its performance is still affected by design deficiencies.

5. ACKNOWLEDGEMENT

Financial assistance from the National Science Foundation and the National Aeronautics and Space Administration enabled the UK Meteorological Office to take part in this Workshop.

CLOUD CONDENSATION NUCLEUS COUNTER BY IMPACTOR SAMPLING TECHNIQUE

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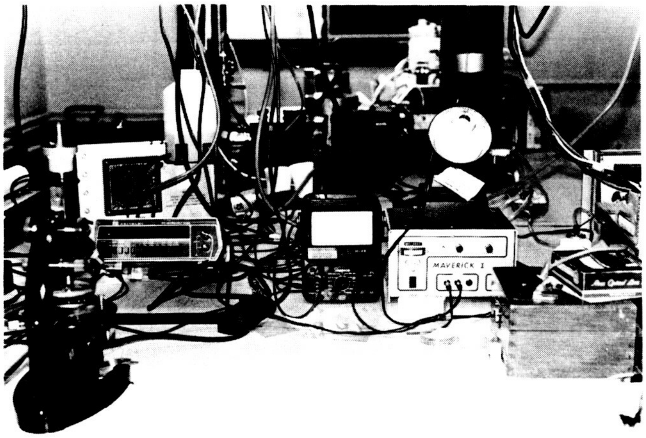

Unlike typical CCN counters, this device counts the numbers of water droplets condensed on aerosol particles sampled on a microcover glass at various different relative humidities. The relative humidities ranged from 75% to a calculated value of 110%. A schematic of the apparatus is shown in Figure 1. The individual CCN can be identified in an optical micrograph and scanning electron micrograph and may be inspected for their chemical composition later.

Sampling is made by means of an impactor and a vacuum pump of about 3 liters or less air volume onto an area of 3.35 mm by 0.25 mm of a microcover glass (0.2 mm thick). Then the cover glass is transferred to a small humidifying chamber where temperature is controlled by a thermoelectric cooler at the bottom of the chamber. The chamber has a closed glass top, and the circular side wall of the chamber has a blotting paper soaked with a saturated aqueous solution of sodium chloride, giving an equilibrium relative humidity of 75% in the temperature range between 20° and 70°C.

As the cover glass is cooled down by applying a direct current to the thermoelectric cooler, it is chilled to a lower temperature producing a relative humidity of 100%. Additional current produces relative humidities beyond water saturation. The exact saturation point is identified by the observation of dew on the cover glass which was previously coated with aluminum, using a vacuum evaporation to form a mirror. Simultaneously, the temperature difference between the cover glass and the air is observed by means of a thermojunction and a microvolt meter from the starting point of cooling, giving the "0" reading.

Humidity values are determined from interpolation and extrapolation of the microvolt reading at the point dew forms. A usual microvolt reading at the dew point is about 150 microvolts for a 25% humidity difference. In this case, every 6 microvolt change indicates a 1% relative humidity change. Consequently, a 12 microvolt reading higher than that necessary to obtain the dew point gives a nominal 2% supersaturation. Due to various cooling water temperatures, the reading at the dew point has been found to change slightly.

The water drops condensed are photographed for counting by a Polaroid micrograph camera or a normal microscope camera. Since the sizes of the water drops on a cover glass are larger than 5 microns, the resolution of an optical microscope is adequate.

The greatest advantage of this technique is to allow the inspection of sizes and chemical composition of the individual nuclei by an electron microscope combined with an X-ray energy spectrometer with a specimen cooling device to prevent possible heating on volatile nuclei. Such analysis is in progress for the aerosols sampled over the Arctic Ocean. The second advantage is that the aerosols sampled can be stored for a long time and their condensation ability can be examined later.

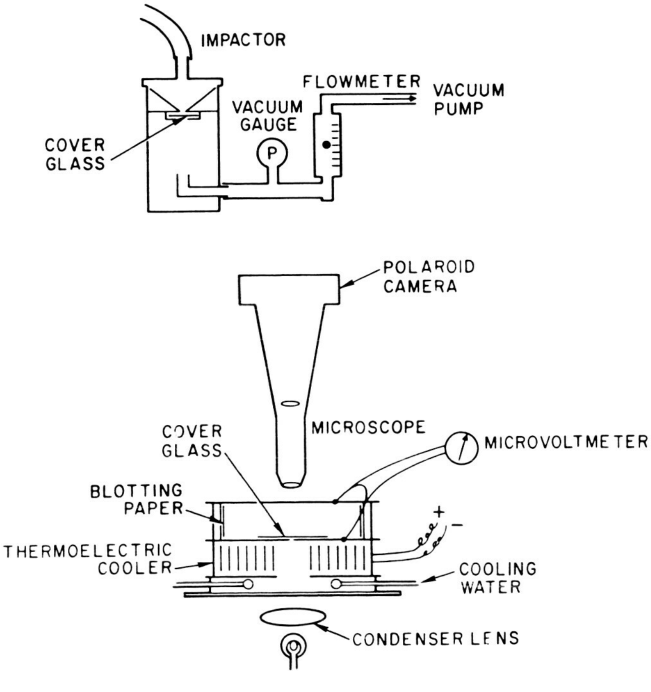

Figure 1

However, as it has probably been seen, this technique may not give an accurate absolute concentration of cloud nuclei. The poor collection efficiency on the sampler may limit the collection of aerosol particles smaller than 0.1 microns diameter, although this may be improved by use of a better sampling technique (possibly by a micro-orifice impactor). If the vacuum or air speed at the nozzle is reduced, small particles will be missing from the cover glass. Thermal precipitator will result in the particles being evaporated. Cooling thermal precipitator using liquid nitrogen will result in frosting on the substrate.

Another problem is the humidity value on a substrate where the aerosols were sampled. Water vapor molecules tend to diffuse to the particles and some condensed water drops will restrict many adjacent aerosols from condensing to water drops as pointed out by Lala and Jiusto (1972) for the case of ice nucleation. Effective relative humidity on substrate may therefore never reach water saturation. For CCN counts at room temperatures, humidity reaches saturation values confirming by observations of visible dew on a very clean mirror. However, the actual degree of supersaturation may not exceed by more than 0.1%, even though the calculated value of supersaturation may be 2%. The real supersaturation degrees for calculated humidity values remain unknown. In order to break the microscale boundary layer over hygroscopic particles, circulation of humidity-controlled air should be adequate. Preliminary experiments have confirmed this procedure to be successful.

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DIFFUSION TUBE

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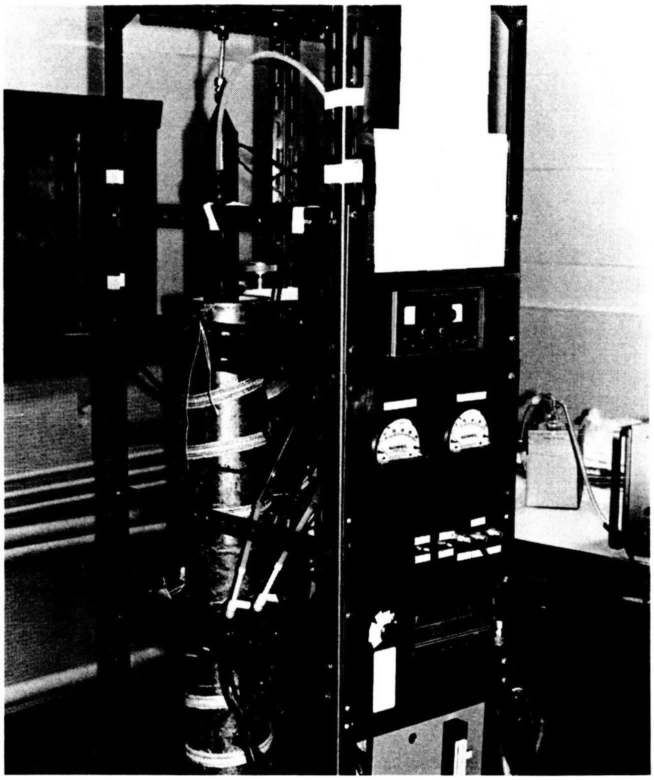

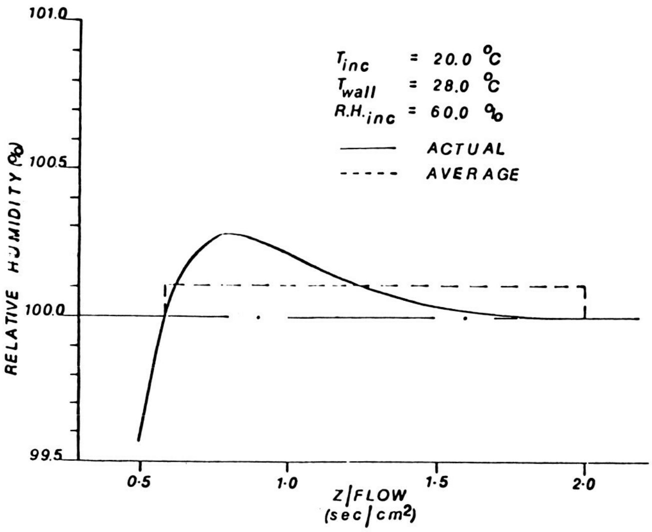

Figure 1. Relative humidity profile, average supersaturation = 0.11%. Z ≡ tube length = 87 cm.

1. EQUIPMENT DESCRIPTION

The diffusion tube is designed to operate below about 0.25% of water supersaturation. It is simply a long tube lined on the inside with a damp chamois cloth, and heated isothermally to a few degrees centigrade above the incoming air.

The diffusion coefficient for water vapour is slightly larger than that for heat, making it possible to supersaturate the airflow. This is the same principle by which transient supersaturations may occur in parallel plate cloud chambers. Our elementary analysis considers only the diffusion of vapour and heat from the walls into the moving air.

The droplet sampling tube which inserts into the main diffusion tube draws the central 4 or 5% of the total volume from the tube. It is only necessary then to compute the supersaturation for the air stream in the centre of the tube. A typical supersaturation profile is shown in Figure 1 (solid line). It is dependent upon the relative humidity and temperature of the incoming air and the temperature of the tube walls. The abscissa represents the tube length divided by the total flow rate. The cutoff is chosen at 2.0 to permit reasonably isokinetic droplet sampling and because the relative humidity is reduced to nearly 100%.

Figure 2. Numerical growth study for profile shown in Fig. 1. Dry distribution is nearly monodisperse.

TABLE 1

Royco Channel No.	Channel Threshold Dia. (μm)	NaCl D100 Value Cr.S.S.(%)	$(NH_4)_2SO_4$ D100 Value Cr.S.S.(%)	Channel Used Down to S.S.(%)
1	1.25	0.066	0.088	0.08
2	1.5	0.055	0.073	0.07
3	2.0	0.038	0.056	0.05
4	2.5	0.025	0.037	0.035
5	3.0	0.016	0.024	0.02

In order to define a single supersaturation from this transient, we average the water in excess of 100% relative humidity over the period from the point of reaching 100% to Z/flow equal to 2.0. This we define as the operating supersaturation. The dashed line in Figure 1 indicates this average for this curve. The validity of this approach has been investigated numerically. A dry salt distribution was grown along both paths in Figure 1. The resulting distributions are given in Figure 2. Studies have indicated agreement between droplet distributions is good below 0.1% supersaturation and adequate up to 0.2% at least.

The most serious difficulty occurs with the interpretation of the CCN. Since the available growth time (about 10-12 seconds) is short, for small S.S.'s, the droplets are small (1-4 μm dia.) and confusion may result with inactivated haze droplets, whose D100 values are greater than our threshold. During the Workshop, only one channel on our Royco O.P.C. was used to count the droplets. The threshold level was set at 1.5 μm dia.; as a result some haze particles were counted at supersaturations below about 0.06%. This was noted in Experiment 22 and particularly during our second run in Experiment 26. We have tried to overcome this by evaluating the CCN according to Table 1. The CCN are determined from the counts in Channel 1 down to an operating supersaturation of about 0.08%. Channel 2 is then used to 0.07%, etc.

Experiments with monodisperse aerosols generated with our own classifier have suggested the following:

1. Very good resolution is possible at low supersaturations, down to at least 0.05%.
2. Our estimation of the operating supersaturation is high by about 30% of our value.
3. Results for similar conditions are very reproducible.

The combination of 1 and 3 are encouraging, but work must be continued to assess the proper supersaturations. The high values are thought to be attributable to free convective activity and a slight temperature gradient between the wall temperature sensor and the actual wet surface. Both are being investigated. We expect that at higher supersaturations the free convection will be a greater problem because of larger temperature gradients involved. This is in agreement with a general decrease in accuracy with increasing supersaturation noted during our classifier experiments. The problem may be somewhat alleviated by beginning with higher initial humidity levels.

The computed operating supersaturations for different wall temperatures and humidity conditions, with an incoming air temperature of 20.0°C, are plotted in Figure 3. It is quite obvious the supersaturation is dependent equally upon the initial relative humidity as well as temperature differences between the wall and air. The dependence, on both parameters, lessens towards the lower supersaturations thus indicating better accuracy, in terms of temperature and humidity measurements, for the small values.

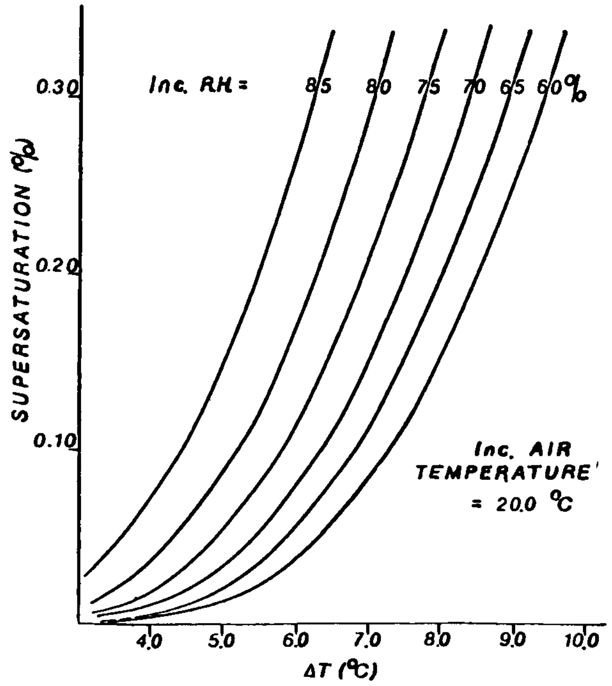

Figure 3. Operating supersaturations as a function of the temperature difference between the wall and ambient, for different incoming relative humidities.

2. OPERATION

The total flow rate is 2.55 L/m; there are two input flows. Humidified filtered air is mixed 3 or 4 to 1 with the air to be measured. A Royco 225 samples about 250 cc/m from the centre of the air stream (0.2 of the radius). The sampling tube extends 12 cm into the tube bottom (see Figure 4), with the remaining flow (about 2.3 L/m) being drawn out by two tubes at the very bottom. The residence time in the sampling tube is no more than 0.1 seconds.

The relative humidity of the incoming air is kept between 65 and 80%. The water bath is heated to about 8 or 9°C above the ambient. Measurements are taken in between adding cool water to lower the wall temperature. Initially it was hoped to vary the incoming humidity while keeping the temperature gradients constant but we encountered some difficulty with the response time of the humidity sensor to large changes.

The temperatures are recorded with YSI precision thermistors (±0.1°C). There are six located in the tube walls. The measured temperature appears stable and quite isothermal. The humidity is measured with dry and wet bulb thermistors. The wet bulb thermistor is encased in a cotton wick and thoroughly wetted.

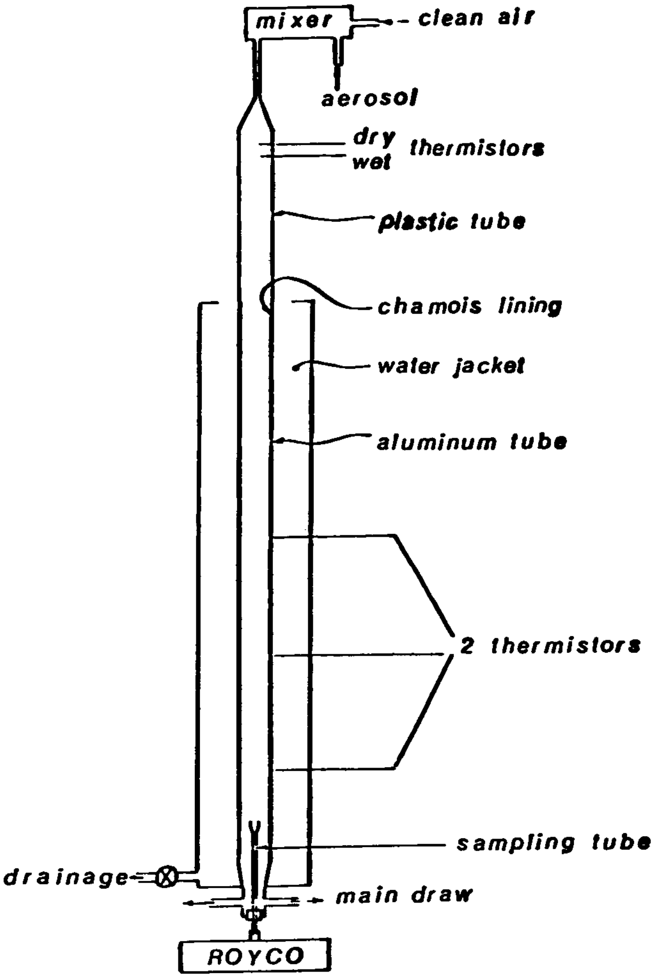

Figure 4. Schematic, in section, of diffusion tube. Aluminum tube is about 100 cm in length, plastic entrance tube is 30 cm long, and sampling tube is 16.5 cm.

AN AUTOMATIC LIGHT SCATTERING CCN COUNTER

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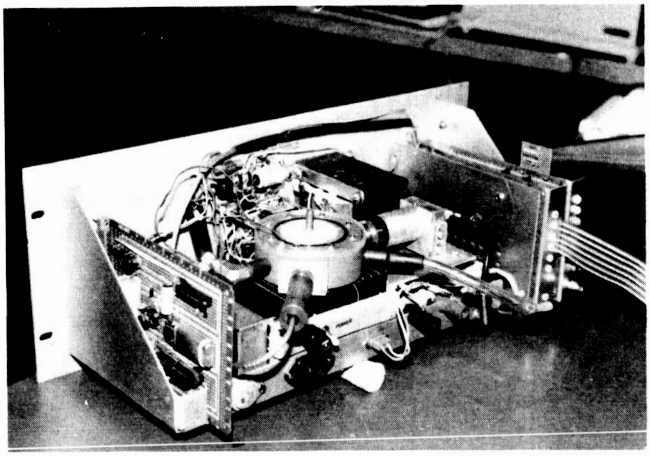

1. PRINCIPLE OF OPERATION

The ASRC cloud condensation nucleus counter is a static thermal diffusion chamber which has been modified to include an optical system for the determination of droplet concentration by the measurement of scattered light. The principle of operation is the same as that described by Lala and Jiusto (1977). The determination of concentration is made by measurement of the peak scattered light signal from the cloud of growing droplets which is a function of both the droplet concentration and chamber supersaturation. Because the formation of the peak is related to the rate of growth of the droplets and sedimentation, both of which are determined by supersaturation, the system calibration can be uniquely determined by comparison with an absolute counter such as a static diffusion chamber with a photographic recording system. This approach to the measurement of droplet concentration in the cloud chamber has made possible the design of a compact system with low power requirements which can be operated automatically under electronic control to provide real time measurement of cloud nucleus concentration.

2. CCN SYSTEM COMPONENTS

2.1 Diffusion Chamber

The cloud chamber is a cylindrical volume bounded by temperature controlled wet plates at the top and bottom of a cylindrical plastic wall. The chamber diameter is 7.6 cm with a plate separation of 1.0 cm with a volume of 45.6 cm^3.

The temperature of the top and bottom surface of the chamber is measured by means of integrated circuit transistor thermometers (Analog Devices, Inc. AD590) which have a high sensitivity with excellent linearity and long term stability. The sensors are embedded in the center of the aluminum plates approximately 0.1 cm below the surface. The difference in the plate temperature, as sensed by the transistor thermometer, is used as the feedback signal for a closed loop temperature regulator which maintains the temperature difference at a fixed reference level by controlling the current to a thermoelectric cooler attached to the lower plate. This system has been designed to have a long term stability of ±0.02°C, while having the capability of rapidly changing the plate temperature by heating or cooling (8 sec to stabilize to within ±0.05°C for a 1°C change in plate temperature).

The moisture supply for both the top and bottom surface is provided by water saturated blotter paper. Complete saturation of the upper surface is insured by a connection to an external reservoir through holes in the plate with capillary forces providing the flow of water required. A water supply is not provided for the lower surface because once wet, the normal operation of the chamber maintains saturation of the blotter by the vertical diffusion of water vapor from the upper surface.

2.2 Illumination System

The original design of the system described by Lala and Jiusto (1977) used polychromatic illumination from a tungsten halogen lamp. At that time, it was thought that broadband illumination was necessary to insure the smoothing of the Mie scattering peaks required to produce a scattered light signal which was monotonically increasing with droplet size. Subsequent calculations of the scattering of monochromatic light has shown that the angular integration over the scattering volume and collection aperture provides sufficient smoothing of the scattering peaks. The present design, taking advantage of this, uses monochromatic illumination from an infrared-emitting diode (General Electric F5D1) with a nominal emission wavelength of 880 mm. In order to provide sufficient illumination, the diode is operated in the pulsed mode at 6.25 kHz. The diverging illumination from the diode is collimated by a simple lens to form a cylindrical beam with a diameter of 0.4 cm. The principal advantages of using the infrared diode are that its emission wavelength matches the peak sensitivity of the scattered light detector, the power requirements are small in comparison to the tungsten lamp, and the long lifetime of the diode.

2.3 Scattered Light Detection System

The scattered light detection system is identical to that used in the previous design. A lens located at a 45 degree scattering angle forms an image of the cloud on a slit which serves to eliminate stray light to define the length of the scattering volume (1.5 cm). Directly behind the slit is a hybrid photodetector-amplifier (Bell and Howell 529) which converts the scattered light to a voltage signal. The low level light signal is amplified and converted to a D.C. voltage signal by means of a synchronous detector. The overall system gain produces a sensitivity of 500 μv/droplet at a supersaturation of 0.5%.

2.4 Measurement and Control System

All data handling and timing requirements of the system are handled by a single board microcomputer (Rockwell International AIM65). Communication between the computer system and the temperature control and light scattering system is performed by analog to digital and digital to analog converters. By means of this interface, the computer is able to control all of the system functions, as well as the processing and display of the data. All user control of the system is handled through computer software, making it possible to alter the system operating parameters without having to configure new control circuits for special applications. The use of computer control allows for the optimization of the overall system performance, as well as complete flexibility in the application of the system for CCN measurements.

3. SYSTEM OPERATION

A measurement cycle can be initiated either by the computer or by an input from the operator. After receiving the start command, the computer determines the chamber top plate temperature and calculates the necessary temperature difference required to produce the desired supersaturation. By means of the digital to analog converter, the computer establishes the temperature reference and waits for the actual temperature difference to settle to within ±0.05°C for two seconds before proceeding. After temperature stabilization, the computer opens the sample valves and purges the chamber by means of a small pump. During the last second of the six second sample cycle, an average value of the background signal is determined. The sample cycle is terminated by stopping the pump and closing the valve after a one-half second delay. During the period which follows, the computer continuously samples the scattered light signal and waits for the occurrence of a peak defined by the signal falling below 80% of the highest previous reading. At this time, the peak value minus the background signal is converted to a concentration and displayed along with the chamber operating condition. The complete cycle is completed in 20 to 45 seconds, depending on the supersaturation used.

4. SYSTEM CALIBRATION

The calibration of the system is obtained by direct comparison with a second thermal gradient diffusion chamber equipped for photographic recording. The chamber and temperature control system for the photographic unit are identical to the automatic system. The illumination for the photographic system is provided by a 100 watt mercury arc lamp and a large aperture lens system which forms a rectangular beam with an 0.2 cm by 0.4 cm cross section. Droplets in the illuminated volume are photographed at right angles to the beam with a modified oscilloscope camera.

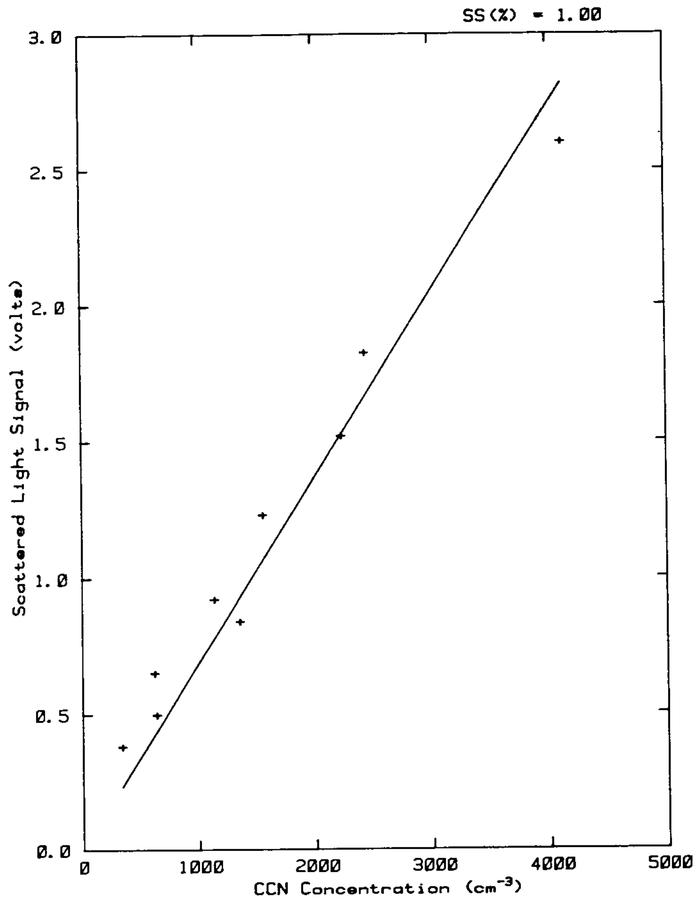

Fig. 1

The calibration procedure consists of taking a 200 liter sample of ambient aerosol which is used as a source for both systems during simultaneous measurements. Concentrations are adjusted by diluting the sample with clean air and repeating the measurement after stabilization. Figure 1 shows a plot of the scattered light signal against the concentration determined by the photographic system at a supersaturation of 1%. This procedure is repeated at five supersaturations between 0.25% and 1% which is used to determine the system calibration in terms of concentration and supersaturation.

5. ACKNOWLEDGEMENTS

The assistance of Dr. J.E. Jiusto in the design of the instrument and Mr. L.E. Weed in the construction of the instrument is gratefully acknowledged.

6. REFERENCES

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DESCRIPTION OF THE NRL ISOTHERMAL HAZE CHAMBER

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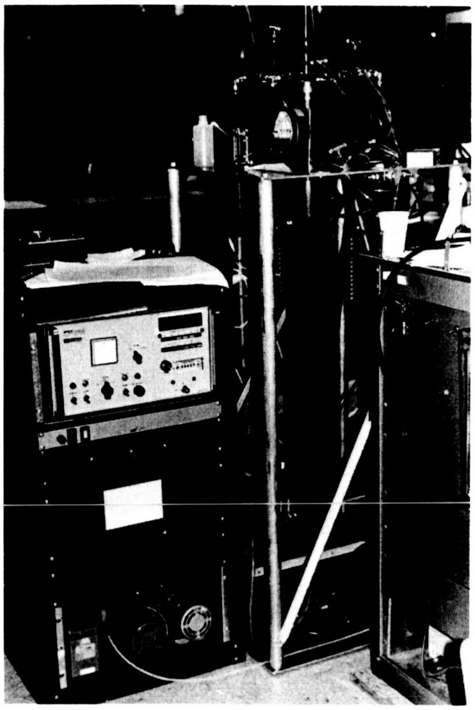

The background and rationale for using the isothermal haze chamber (IHC) concept to extend the range of CCN measurements to lower supersaturations than is possible with the thermal gradient diffusion chamber is given in the overview section. In the IHC the critical supersaturation is inferred from the measurement of the size of particles which have grown to their equilibrium size at exactly 100% RH. Here the Naval Research Laboratory (NRL) isothermal haze chamber will be described, and the reason for its unique design will be explained.

There are three major design constraints which had to be met:

1. Calculations of the equilibrium size as a function of relative humidity show that the humidity in the IHC must be within about 0.01% of saturation if the inferred critical supersaturation is not to be significantly in error.

2. The smaller the critical supersaturation of the particle, the larger is its equilibrium size. The larger its equilibrium size, the longer it takes to reach that size. Over 100 sec of growth time is needed for a particle with a critical supersaturation of about 0.015% to reach 95% of its equilibrium size at saturation. Much longer times are necessary for particles with smaller critical supersaturation. The second design criteria was that the chamber must provide over 100 sec of residence time at high humidity. It is this limitation which places the lower limit of about 0.015% on the critical supersaturation of our IHC.

3. The commercial optical counter (Royco) which was available has a sample flow rate of 47 cc per sec. Our decision to stick with the manufacturer's flow rate determined the third major design constraint.

The NRL IHC has cylindrical symmetry as is shown schematically in Figure 1. The design is a two-tube design. The sample first enters a small tube lined with ceramic saturated with water. The pressure drop across the small inlet orifice is less than a quarter of an inch of water and this pressure drop is used to monitor the sample flow rate. The sample flow rate which is about 3 cc per sec was recalibrated at the altitude of the Workshop prior to its start. Filtered air enters through four ports on the outer circumference of a humidifier which consists of passages between concentric cylinders lined with saturated, sponge-like material (see Figure 1). The filtered air, after leaving the humidifier, flows downward through the annular ceramic-lined passage between two tubes and forms a sheath flow around the sample flow beyond the point where the sample emerges from the small tube. At the bottom of the IHC the sample, together with sheath flow (47 cc per sec), enters the optical particle counter where the humidified particles are sized into five size channels between about 0.25 and 3 μm radius.

The distance required for air passing through a wet-walled tube to reach saturation depends only on the volume flow rate and length of tube and not on the radius of the tube. The reason for using the small tube for initial humidification of the sample is to bring the sample to high humidity in the shortest distance possible. This can best be accomplished by keeping the sample flow, which is very small, isolated from the larger sheath flow until both are fully humidified. The small tube in our IHC is 45 cm long, has a diameter of 1.27 cm and a volume flow rate of 3 cc per sec. Solutions to the diffusion equation show that a sample entering at 50% RH is within 0.004% of saturation by the time it has passed 10 cm down the tube. The residence time in the small tube is about 20 sec.

When the sample joins the sheath air, there is an increase in the cross-sectional area of about 36 and an increase in flow of about 15, resulting in a net increase in residence time per unit length of 2.3. The total residence time in the large tube is about 90 sec, giving a total residence time for growth at high relative humidity of about 110 sec.

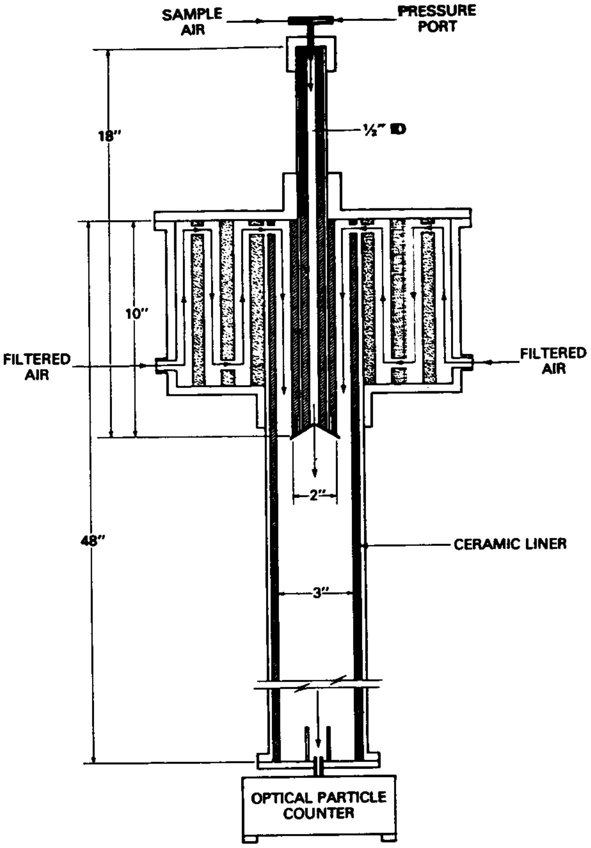

Figure 1. NRL Isothermal Haze Chamber

The value of the filtered sheath flow is multiple: (a) the filtered sheath flow helps prevent gravitational fallout by confining the sample to the central region of the chamber; (b) sheath air is necessary for dilution. The large number of small particles which swell to optically detectable sizes at high humidities will swamp the optical detection system and cause coincidence counting problems if the sample is not diluted with sheath air; and (c) the total air flow required by the optical particle counter is supplied with the minimum overall length by introducing the humidified sheath air after the sample has already reached high humidity.

During a measurement period, the optical counter was on a one-minute counting cycle controlled by its internal timer. However, resetting, starting and reading the BCD output was accomplished with the same HP 9825 computer used to control the NRL mobility analyzer described elsewhere. During each size distribution taken with the mobility analyzer, 12 individual one-minute readings of the NRL IHC were taken and printed out and, at the end of the size distribution, the average of the 12 readings for each size channel was printed out. For most experiments, it was the average of the 12 one-minute samples that was supplied to the Workshop.

The factory calibration of the optical counter was done with latex spheres which have a much different index of refraction than does the water droplets. A size calibration for water droplets was estimated from the factory calibration and the work of Cook and Kerker (1975).

It is our opinion that the NRL IHC functioned well throughout the Workshop with only a minor problem created by the failure of one of the metering pumps which wet the ceramic. This failure required periodic, partial disassembly and manual wetting on a schedule less frequent than would have been done if the pump had been functioning.

The absolute accuracy of the measurement is difficult to assess. The biggest source of possible error in our system is thought to be the stability and accuracy of the calibration of the optical particle size spectrometer.

The largest size channel corresponds to a critical supersaturation of 0.014%. The growth time required for particles of this size to reach their equilibrium size exceeds the 110 second residence time in our IHC. Since the supersaturation spectrum is always very steep in this region, the contribution of these larger particles which have not yet attained their equilibrium size to smaller size channels is negligible. However, failure of these particles to reach their equilibrium size could result in a significant lowering of the count in the size channel corresponding to the smallest critical supersaturation.

Acknowledgements

This work was partly supported by the Naval Air Systems Command.

Reference

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MODIFIED MEE INDUSTRIES STATIC THERMAL GRADIENT DIFFUSION CLOUD CHAMBER

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1. EQUIPMENT DESCRIPTION

The purpose of attending the CCN Workshop was to calibrate and determine the usable operating range of the cloud chamber. The instrument consisted of a Mee Model 130 Cloud Condensation Nucleus Counter (Serial #3). The original optical bench, light source, and detection components were removed and replaced with a simple laser illumination-photographic counting system. The purpose of the modification was to permit discrete droplet counting rather than the original method of scattered light detection and to extend the minimum concentration detection limit to approximately 10/cm^3 for use in remote areas where aerosol concentrations were expected to be low. The system consisted of a 5 mw HeNe laser with an operating wavelength of 0.65 microns. The laser beam was incident to the camera field of view at a 40° angle, the same angle used in the original instrument configuration utilizing a photo diode as a scattered light detector. In both arrangements, the detector, in this case the camera, sensed the forward scattered light at the given angle from the center of the parallel plate thermal gradient diffusion chamber. The film used was Kodak 2475 recording film developed at 3000 ASA. Photographs were made at 1/2 second exposure through a microscope attachment to the chamber producing a magnification of 3.47 x on the film negative. The observed volume was 0.011 cm^3. Temperature and ΔT were controlled by thermoelectric cooling of the bottom plate with the upper plate at ambient temperature.

The operation procedure consists of flushing the chamber for 10 seconds at a sample flow rate of 4 liters per minute. An observation is then made through the eyepiece to determine the time required for maximum droplet number concentration to occur. This time is then used for subsequent measurements at the same selected chamber conditions. One to 30 exposures are made on each frame to obtain 50-100 droplet images per frame, depending upon the CCN concentration. This produces uncertainties of 10-15% in the CCN concentration determination. At the upper limit of 30 exposures used, concentrations of 10 cm^{-3} can be determined with uncertainties of 50%. The time to determine a four-point CCN spectrum of low concentrations (<500 cm^{-3} at 0.5% SS) is 90 minutes. At high concentrations the time reduces to about 30 minutes. Since the droplet counting is from images of droplets on film, the minimum detectable concentration and uncertainty can be selected by the operator with the subsequent loss or gain of time resolution. The instrument in its present form can only be operated manually.

2. RESULTS OF THE WORKSHOP

The experiments performed at the Workshop were undertaken to confirm the calculated sample volume, determine the usable range of supersaturation, and minimum detectable size.

Problems with chamber leaks were discovered for the experiments 0-10. Hence the data from these experiments cannot be used for comparison. Comparison of absolute CCN concentrations with other state-of-the-art continuous flow diffusion chambers at supersaturations near 1% indicated that the volume used produced CCN concentrations well within the range of CCN concentrations determined at the Workshop. This agreement is interpreted to mean the sample volume was correct. Direct measurements of the beam geometry done in the laboratory indicated a factor of 4-5 error. This error is apparently due to the larger apparent visible beam diameter versus the actual usable beam diameter given the droplet illumination, chamber optical geometry, microscope optics and film characteristics. It is therefore suggested that the only way in which the sample volume should be determined is by experimentation with known droplet sizes and numbers via known aerosol generation and sampling.

By comparison of the results from experiments 19 and 15, it was determined that the minimum usable supersaturation for this chamber was between 0.09% and 0.22%, respectively. By using the dry aerosol data from experiments 15, 18, 19 and 20, and the number of droplets detected at indicated supersaturation of 0.1%, the minimum supersaturation the instrument was able to achieve was 0.11%, 0.17%, 0.09%, and 0.19%, respectively. Therefore, 0.20% was determined as the lowest usable supersaturation.

A minimum detectable size of about one micron radius was determined, based upon the smallest observed image on the film, the known magnification of the image by the microscope attachment, and the artificial enlarging of the image by diffraction of the relatively long wavelength monochromatic light through the small diameter lenses of the microscope. This agrees roughly with a droplet size of 0.7 microns radius at which the maximum in light scattering efficiency occurs for the wavelength light used.

The chamber response to known aerosol at different supersaturations compared favorably to theory, both in the predicted slope for polydisperse aerosol and the determination of the critical supersaturation for monodisperse aerosol. However, there appears to be some tendency to undercount at mid-range supersaturations giving an anomalous concave upward appearance to the curve for some experiments, but not all. The cause of this effect is unknown. Further testing will be required to look more closely at this effect.

TABLE 1. INSTRUMENT PARAMETERS

Detection System:	
Laser light source	5 milliwatt 0.65 micron wavelength
Photographic counting	2475 recording film ASA 3000
Minimum detection size	~1 μm radius
Sampling:	
Flow rate	4 lpm for 10 sec
Sample volume	0.011 cm^3
Time for spectra (4 pts)	30-90 min
Chamber Specifications:	
Aspect ratio	4.6:1
Temperature control	Thermoelectric cooling of lower plate
Usable supersaturation range	0.2 - 2.0%

SIMULTANEOUS OPERATION OF THREE CCN COUNTERS AND AN ISOTHERMAL HAZE CHAMBER AT THE 1980 INTERNATIONAL CCN WORKSHOP

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1. INTRODUCTION

The Desert Research Institute (DRI) operated four devices for the detection and characterization of cloud condensation nuclei (CCN) and fog condensation nuclei (FCN) during the International CCN Workshop, Reno, Nevada, October 6-17, 1980. In chronological order of development, the CCN devices are the conventional continuous-flow diffusion chamber (CFD), the rapid-cycle CCN spectrometer, and the instantaneous CCN spectrometer. The FCN detection device is an isothermal haze chamber (IHC). These four instruments will be discussed in sequence, and general comments on their performance at the Workshop will be given.

2. CONVENTIONAL CONTINUOUS-FLOW DIFFUSION CHAMBER

2.1 Instrument Description

One of the DRI Continuous Flow Diffusion (CFD) Chambers (Hudson and Squires, 1973, 1976) was used in this Workshop. Since this instrument is largely unchanged since 1976, only the more important features will be described here, along with the values of some of the operating parameters used during the Workshop.

The CFD was operated in the vertical mode; that is, the parallel plates were vertical although the sample traveled in a horizontal direction. The plate separation was 1.3 cm while the width of the plates (this is actually a vertical distance when the chamber is operated in the vertical mode) is 30 cm. The sample enters the working volume of the chamber through a slit in a transverse tube which is at one end of the chamber midway between the plates. It is confined to a 1 mm thick zone about the central plane by the two particle-free air flows which go around each plate. The sample slit is about one-third of the chamber width so that in the other dimension, the sample comes no closer than 10 cm from the "side" walls of the chamber. This allows a minimum aspect ratio of 8. The length of the plates is 40 cm which is the total distance the sample travels through the instrument while the length of the wet paper on the cold plate is 38 cm which allows a 2 cm dry space for the sample after its introduction. The wet paper on the warm plate does not begin for another 10 cm as it is 28 cm long.

2.2 Operation

The main flow of particle-free air enters the chamber at two ports on the backsides of the diffusion plates. These flows then pass over the plates and then turn 180° at their ends where these two flows merge with each other and with the sample flow. By this time, the air should have attained a reasonably complete temperature equilibrium with each plate. The total flow of air then moves between the plates to the end of the chamber where all of the air is pulled through an optical particle counter (OPC). It is actually the pump in the OPC which produces the air flow through the chamber and the slight underpressure (∿8" of H_2O) within the chamber. A valve on the flowmeter which measures the main flow, F, can be adjusted to change F which, during the Workshop, varied from 20 to 58 cm^3/sec. Thus the velocity in the central plane of the chamber was $v = 3/2\ F/A$, where $A = 39\ cm^2$ is the cross-sectional area. Thus, v ranged from 0.77 to 2.23 cm^3/sec so that the time which the sample spent in the supersaturated volume of the chamber varied between approximately 12 and 36 seconds. The lower flow rates (longer times) were generally used for the lower supersaturations where longer growth times are necessary while faster flows or shorter times were used for the higher supersaturations where fallout could be a problem.

The sample flow rate is controlled by a glass capillary tube which restricts the flow to specific values depending on the pressure difference across the tube. The rate of flow through a given capillary was calibrated for the pressure differences to be used while it is in operation. For most of the Workshop experiments, the sample flow rate was about 0.6 cm^3sec^{-1} although it varied from 0.1 cm^3sec^{-1} to 1 cm^3sec^{-1} during the course of the Workshop.

Supersaturations in this chamber during the Workshop ranged from 0.02% to 1.5%. Although supersaturations below 0.1% are normally beyond the useful range of the instrument, certain monodisperse aerosols may yield useful results at such low supersaturations. The time required to complete a spectrum depends on how many supersaturations are used. Although a smaller number of steps generally requires less time, if more steps are used, the time required to change plate temperatures is reduced since the steps are smaller. Typically, it takes at least five minutes to change plate temperatures and at least three minutes to acquire useful data at a given supersaturation.

The drops exit the chamber along with the total air flow. All of this passes through the active volume of the Royco 225 optical particle counter (OPC). In this instrument, the drops (or particles) are counted individually as they scatter light when they pass through an incandescent light beam. The scattered light is gathered by a PM tube which produces a signal which is roughly proportional to the amount of light scattered which is somewhat proportional to the particle size. Since the light beam is larger than the cross-sectional area of the particle stream, all particles which enter

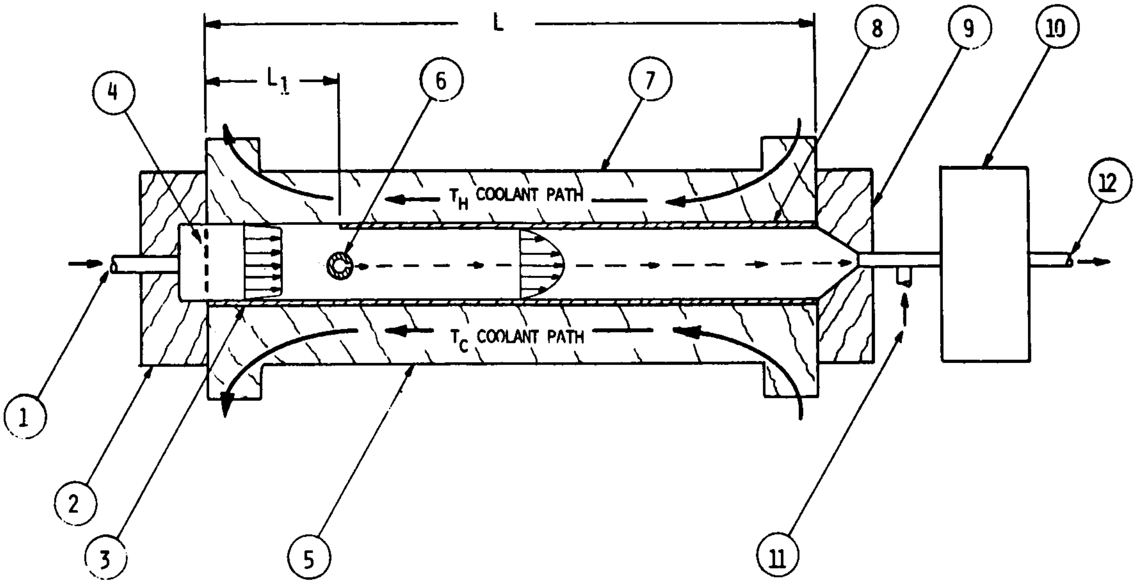

Figure 1. Physical Schematic of the Rapid Cycle CCN Spectrometer.

Legend

1. *Carrier flow entrance*
2. *Entrance manifold*
3. *Cold plate wicking surface*
4. *Diffuser screen*
5. *Cold thermal plate*
6. *Sample injection tube*
7. *Warm thermal plate*
8. *Warm plate wicking surface*
9. *Exhaust manifold*
10. *Optical particle counter*
11. *Sheath flow entrance*
12. *OPC exhaust*

Dimensions: *L = 44.45 cm*
L1 = 10 cm
Width = 29 cm
Plate spacing = 1.6 cm

the OPC scatter light. The chances of more than one particle being within the beam simultaneously are insignificant unless the OPC count is more than 100,000/min so the drops are usually counted and sized individually. When count rates were higher than this, lower sample flows were used.

The plate temperatures are controlled by circulating fluid from constant temperature baths. Plate temperatures are monitored by stainless steel thermisters which are imbedded in the plates just below the wet filter paper on its surface.

This instrument participated in and yielded valid data for all of the Workshop experiments.

3. RAPID CYCLE CCN SPECTROMETER

This instrument was built as a prototype for the NASA low gravity Atmospheric Cloud Physics Laboratory (ACPL). Rapid changes in supersaturation are accomplished by injecting a surge of fluid into the temperature-controlled plates. This displacing fluid is at a temperature different from the original plate temperatures. Thus the change in temperature of the plates is accomplished by proper mixing of an appropriate amount of fluid from a reservoir at an extreme temperature. A hot and a cold reservoir are on hand for this purpose. Microprocessor control is used to inject the fluid into the plates so that a smooth cycle of supersaturations can be obtained. Thus four or five supersaturations can be examined within a period of 5 to 10 minutes, depending upon the desired accuracy and the particle concentration. This same period of time is required just to make one change in supersaturation with the conventional CFD's.

Figure 1 is a schematic diagram of the rapid cycle CCN spectrometer. It is quite similar even in dimensions to the earlier versions of the CFD's. A notable exception to this is the elimination of the flow around the back sides of each plate. In this version, the carrier flow enters the chamber at the opposite end of the chamber from the optical bench (Royco 225) unlike the previous CFD's, where the carrier flow entered at the optical bench end of the chamber behind both plates only to flow toward the other end of the chamber around the plates and back between the plates. The laminar flow so accomplished is obtained in the spectrometer by the use of a diffuser screen. A stainless steel wicking surface is used instead of filter paper as the wet surface on the inside of the plates.

A hypothetical experiment is shown in Figure 2. Each supersaturation can be maintained as long as desired; each subsequent supersaturation can be established and stable within about 30 seconds.

Each thermal plate is accurately controlled in temperature such that the temperature difference between the two plates is stable and known to

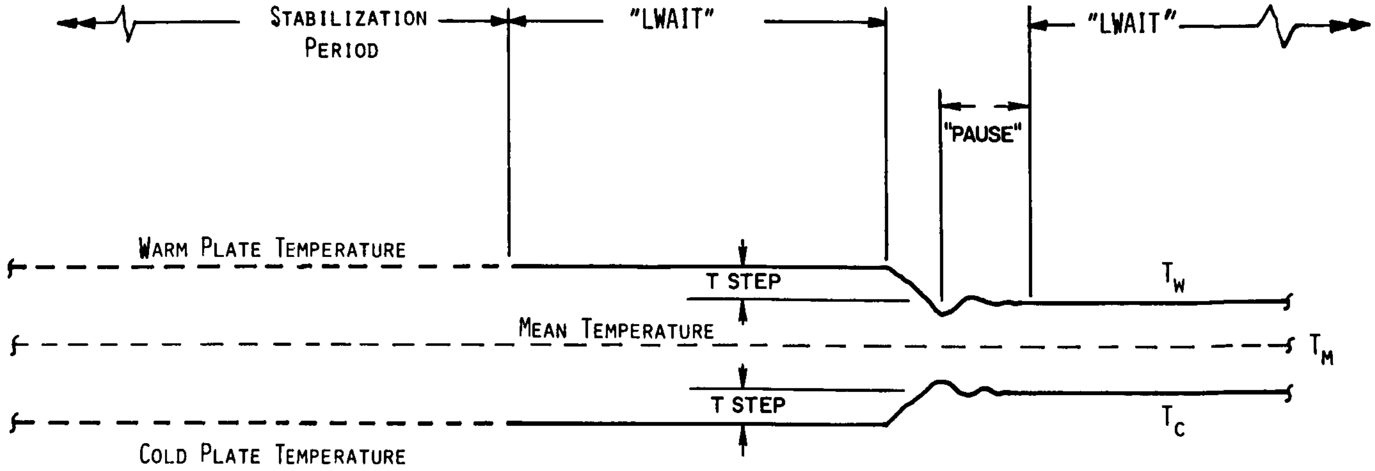

Figure 2. Temperature control of the thermal plates of the rapid cycle CCN spectrometer is programmed to follow the sequence shown below.

Event Sequence:

1. *Stabilization: ∿15-20 min is required to allow the CFD to become equilibrated at the initial temperature settings.*
2. *"LWAIT" Period: The experiment is initiated by a manual command at the start of "LWAIT". This period is long enough to allow sufficient time for counting particles in the OPC.*
3. *"TSTEP": Counting stops at the end of the "LWAIT" period. TSTEP is a temp. parameter required for reaching the next supersaturation level in the experiment protocol. The computer control servos around the value Tw defined by this variable. Time required for this step is ∿2-5 sec.*
4. *"PAUSE": Allows time for system to stabilize at new temp. settings. This has been a period of ∿30 sec in preliminary experiment. The end of "PAUSE" initiates another "LWAIT" period at a new supersaturation. The instrument continues to sequence until ΔT reaches a predetermined minimum.*

within about ±0.01°C for each supersaturation. Figure 3 is a schematic of the hydraulic circuit for the warm thermal plate. A centrifugal pump circulates water through the thermal plate and a housing containing four electrically resistive immersion heaters in a coolant flow of about 60 cm^3/sec The coolant is also circulated over a small glass bead thermistor just downstream of the pump; this method of temperature measurement provides an accurate estimate of the average temperature because of the thorough mixing present at the pump exit. The thermal plate consists of a covered channeled metal surface with large distribution manifolds at both ends. The large manifolds assure that flow through each of the 18 water channels is uniform. Placing the exit and entrance ports on the same side of the thermal plate assures kinematic mixing of the water in the primary circuit. The time required for a parcel of water to flow completely around the primary circuit is one to two seconds.

Temperature control is provided by a secondary hydraulic circuit consisting of a thermoelectric module (TEM) powered "cold source" heat exchanger and a small gear pump. Since this is a closed hydraulic system, operation of the gear pump (trickle pump) displaces cold water into the primary circuit and returns warmer water to the cold source heat exchanger. By correctly metering the proper water flow, any equilibrium temperature of the thermal plate above the cold source temperature can be maintained. Very fine temperature control can be achieved by metering slightly more cold water than is required (slightly overcooling the primary circuit) and adding electrical energy with the use of the immersion heater. Both immersion heater output and flow of water through the trickle pump are under servo control of the control computer.

A second pump is included in the secondary hydraulic circuit in order to provide rapid changes of thermal plate temperature during the "TSTEP" period shown in Figure 2. The surge pump is operated full on for a period ranging from about 1 to 7 seconds, depending upon the magnitude of the desired temperature decrease in the warm plate. A relatively large parcel of cold water is displaced into the primary circuit during this period, causing a rapid drop in temperature. A period of about 10-30 seconds is required for temperature equilibrium. The surge pump is not used again until another change in plate temperature is desired. The hydraulic circuit for the cold plate is similar to that described above except that the surge pump for the cold plate is attached to a separate TEM-powered heat exchanger (Hot Source), controlling the temperature of the water above the mean temperature of the experiment. Operation of the surge pump for the cold circuit raises the temperature of the cold plate, such that the temperature difference between the plates is reduced in steps as the experiment progresses.

The ΔT measurement is accomplished with the use of a ten-element thermopile mounted on the back surface of each thermal plate. The thermocouple junctions are chromel-constantan and are potted in good thermal contact with an aluminum-base with thermally conductive epoxy. The thermopile is assembled in the form of a yoke; the thin thermo-

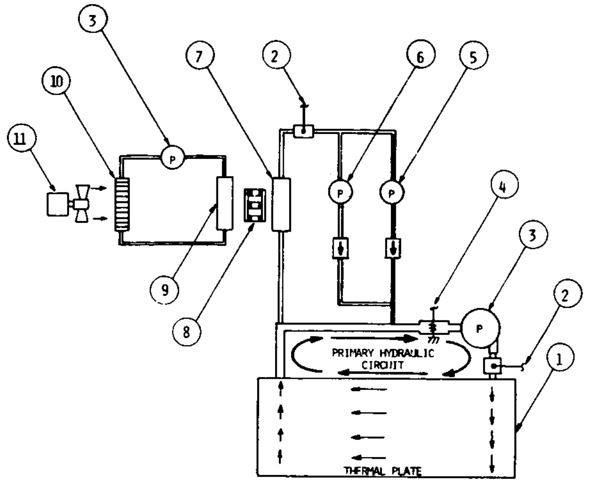

Figure 3. Schematic representation of hydraulic circuit of the rapid cycle CCN spectrometer.

Legend

1. *Thermal plate*
2. *Thermistor*
3. *Centrifugal pump*
4. *Servo heater*
5. *Trickle pump*
6. *Surge pump*
7. *Cold source heat exchanger*
8. *Thermoelectric module*
9. *Water jacket*
10. *Waste heat radiator*
11. *Fan*

couple leads are sandwiched between two layers of grounded copper foil tape for support and electrical shielding. The entire bundle is mounted on a thin (0.04 cm x 2.5 cm) strip of fiberglass that forms a yoke around the two thermal plates. The base of the yoke mounts on the thermopile amplifier, located at the bottom edge of the CFD chamber, reducing the lead length of the thermocouples to a minimum. The resolution of measurement is 0.0024°C.

Carrier flow and sample flow rates are similar to those used in the earlier model CFD's. The high degree of precision and accuracy achieved with the earlier models is preserved in the spectrometer. In fact, the increased temperature uniformity and measurement sensitivity allows for increased accuracy. Moreover, this accuracy holds true during the supersaturation cycles of the spectrometer. Thus, the entire spectrum can be monitored with precision and accuracy limited primarily by statistics.

Figure 4 displays an example of an F-plateau in the rapid cycle CCN spectrometer. This shows that the nucleus concentration is independent of the time the sample is exposed to the supersaturation. Thus all particles are allowed to activate but not fall out. This is more fully explained in Hudson and Squires (1976). Figure 4 also displays a comparison in particle concentration between the rapid cycle spectrometer and the earlier model CFD's. Agreement was within 3% which is about the same as the experimental uncertainty.

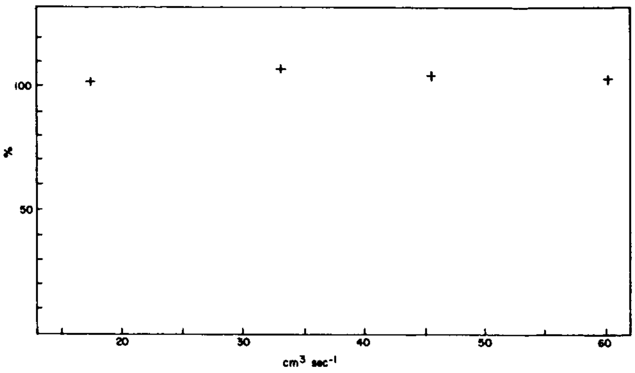

Figure 4. Relative concentration of CCN detected by the rapid cycle spectrometer vs. carrier (main) flow through the chamber. Here the count is normalized to the deduced concentration in a conventional CFD operating side-by-side. The supersaturation in both instruments was fixed at 0.80%.

The rapid cycle CCN spectrometer operated very well during the International Workshop; during many of the experiments, it was actually operating under computer control with no operator present. There were three problems, two of which were instrument-related, and a third which may be classified as operator error. First, the chamber had been newly cleaned and reassembled at the time of the Workshop, and was operating with a background count of order 10-20 cm^{-3} (at 1% supersaturation). This count is about an order of magnitude higher than the normal background for this device; after the Workshop it was found to be entirely due to a slightly loose fitting on the carrier flow inlet. Second, the losses of CCN in the sample inlet system were higher than designed for, due in large part to the presence of charged aerosols in many of the experiments. This problem is discussed in greater detail by Hudson and Alofs in a companion paper discussing CFD design and performance. Finally, due both to occasional, necessary operator absences and operator unfamiliarity with CFD operation at low supersaturations, the main, carrier air flow was not always adjusted properly as the microprocessor stepped the chamber through its range of supersaturations. The result generally manifested itself in a tendency to undercount.

4. INSTANTANEOUS SPECTROMETER

4.1 Equipment Description

This instrument was built along the same lines as the DRI continuous flow diffusion (CFD) chamber (Hudson and Squires, 1976). The most important feature of this instrument is that it uses the sizes of the drops detected by the optical counter to deduce the critical supersaturations of the nuclei. Since several size thresholds can be used, this allows the possibility of simultanously determining the number, N, vs. critical supersaturation S_c, for several S_c's. This is difficult in a conventional CFD where the drops usually achieve a nearly monodisperse size distribution regardless of the range of S_c's in the sample aerosol (Hudson, 1976).

4.2 Theory of Operation

The instantaneous spectrometer, however, contains three supersaturation steps which disperse the drop spectrum over a wider size range. This range is further widened since the sample is exposed to these supersaturations in ascending order. The device, which is shown in Figure 5, is a series of three CFD's inside one chamber. It contains a sequence of three pairs of temperature controlled plates so that a sample aerosol can be exposed to three separate supersaturations (S_1, S_2, S_3). This means that in the first zone only the largest nuclei become activated drops. That is, only those nuclei with S_c's below S_1 grow into droplets while the remaining nuclei remain as unactivated haze drops. After being exposed to this constant supersaturation, these drops approach a monodisperse distribution.

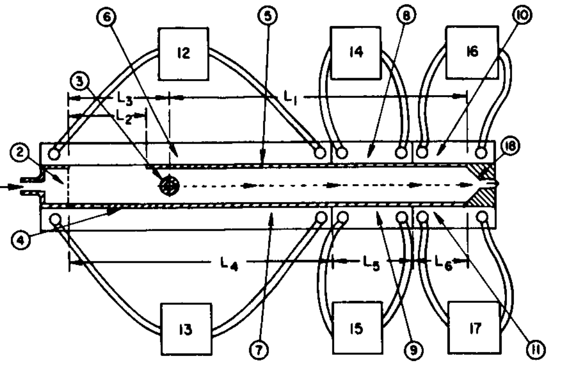

Figure 5. Schematic of the instantaneous CCN spectrometer.

Legend: $L_1 = 48$ cm; $L_2 = 8.4$ cm; $L_3 = 10.4$ cm; $L_4 = 38.4$ cm (1st supersaturation zone - S_1, T_3, T_4); $L_5 = 12$ cm (2nd supersaturation zone - S_2, T_2, T_5); $L_6 = 8$ cm (3rd supersaturation zone - S_3, T_1, T_6).

Supersaturation: $S_1<S_2<S_3$

Plate Temp: $T_1<T_2<T_3<T_4<T_5<T_6$

(1) Carrier flow entrance; (2) Diffuser screen; (3) Sample injection tube; (4) Cold plate wicking surface; (5) Warm plate wicking surface; (6) First warm section, T_4; (7) First cold section, T_3; (8) Second warm section, T_5; (9) Second cold section, T_2; (10) Third warm section, T_6; (11) Third cold section, T_1; (12) Temperature bath at T_4; (13) Temperature bath at T_3; (14) Temperature bath at T_5; (15) Temperature bath at T_2; (16) Temperature bath at T_6; (17) Temperature bath at T_1; (18) Exhaust to OPC.

In the next zone nuclei with $S_1<S_c<S_2$ become activated and grow into cloud droplets with similar sizes. In the meantime the drops which were already activated in the first zone grow even larger in the second zone. In fact, their growth rate is speeded up due to the higher driving supersaturation in zone two. Thus, the nuclei with $S_c<S_1$ grow even larger and somewhat more monodisperse and at the end of the second zone a bimodal drop distribution should result. Finally, the third zone activates the smallest nuclei (largest S_c) with $S_2<S_c<S_3$ and a trimodal distribution should result.

The most significant result is not the trimodal distribution but the fact that the drop size spectrum has a wider spread than it has in a CFD. In the spectrometer the drop concentration is less sensitive to drop size and it is easier to discriminate nucleus S_c's based on drop sizes. Therefore, a small change in the drop size thresholds results in a smaller change in apparent concentration than would be the case with the monodisperse distribution in a CFD. Thus it is much more feasible to relate drop sizes to S_c and to establish size thresholds which correspond to certain S_c's. If there were no other factors than S_c affecting drop size, then a trimodal drop distribution with clear separations between modes would always result. In that case, size discrimination could be made between the modes and a definite N vs. S_c spectrum could be made which would correspond to the three supersaturations used in the chamber. In such a case, a cumulative distribution would have three plateaus where the number concentration would be constant over a range of sizes. In the CFD there is one drop size plateau which ensures that all nuclei are activated but that none fall to the floor so that a direct determination of N vs. S_c can be made with S_c being the applied supersaturation in the chamber. There are some situations when the instantaneous spectrometer has three drop size plateaus which then allow direct determinations of N vs. S_c for the three S_c's. However, in most situations the modes are not completely separated (Fig. 6) and instead of plateaus in the cumulative distribution, we find decreases in the slope of N vs. r (Fig. 7). Although this is a much better situation than in the CFD, the lack of a plateau limits the accuracy of direct measurements of N vs. S_c. Accuracy can be increased by setting the voltage thresholds so that the number concentration in the spectrometer matches that in a CFD monitoring the same sample at a specific supersaturation.

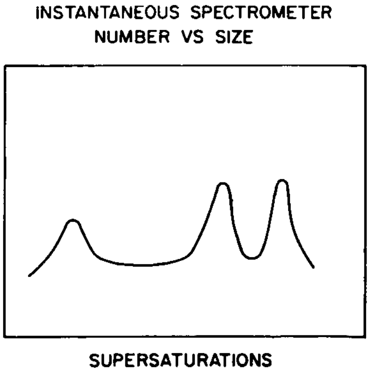

Figure 6. Relative number of drops vs. relative sizes (voltages) for the instantaneous spectrometer. Note that this is a differential and not a cumulative plot.

Although this can also be done with two CFD's (Hudson, 1976) (where one of the CFD's takes the role of the spectrometer and the other one is used to calibrate the first CFD), the process works much

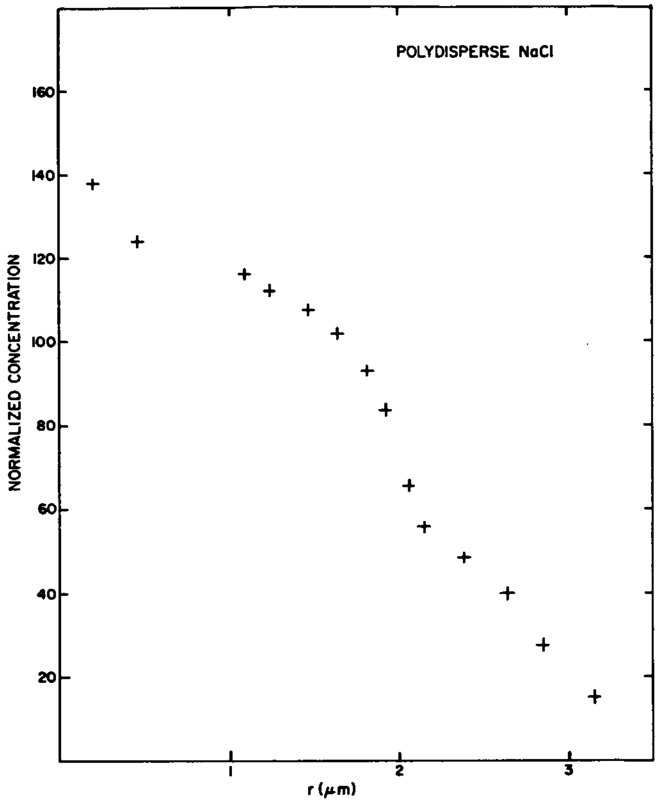

Figure 7. Relative cumulative number of drops vs. size in the instantaneous spectrometer. Applied supersaturations were 1%, 0.4% and 0.15%.

better with the instantaneous spectrometer where there is nearly a constant concentration over some parts of the size range. This considerably reduces the requirement for stability of the various operating parameters. With the instantaneous spectrometer it has been possible to keep the operating parameters constant enough that voltage settings can be used for many days or weeks with continued good accuracy.

4.3 Description

Figure 5 shows most of the dimensions of the instantaneous spectrometer. The plates are separated by 1.6 cm while the plate width is 29 cm. This chamber was also operated with the plates vertical and sample moving horizontally. The main flow through the chamber was 50 cm^3 sec^{-1} throughout the Workshop. This resulted in a particle velocity of v = 1.62 cm sec^{-1} so that the sample spent about 31 sec in the chamber; 18.6 sec at S_1, 7.4 sec at S_2, and 5 sec at S_3.

As with the DRI CFD, a Royco 225 optical particle counter is used as the detecting device for the instantaneous spectrometer. In addition a 512 channel analyzer (MCA) (Northern Scientific, Inc.) is also interfaced to the Royco to increase particle size resolution so that greater detail in the concentration vs. size spectrum can be displayed.

The plate temperatures were roughly the same for the entire Workshop so that the supersaturations were nearly constant at S_1 = 0.30%, S_2 = 0.55% and S_3 = 0.90%. The droplet size thresholds were set by matching the number concentrations in the instantaneous spectrometer with the concentrations measured with the CFD set at the three different plate temperatures in the instantaneous device. The largest drops corresponded with the lowest supersaturations, etc. All of the drops which could be detected down to the smallest sizes (~0.2 μm radius water drops) corresponded to the number of CCN active at the highest supersaturation in the spectrometer.

Channel 2 was set for about 1.42 μm radius water drops while Channel 3 was set for 1.75 μm radius water drops. A slight number vs. drop size plateau was observed here and the concentration of CCN in the CFD at 0.55% supersaturation (which was S_2 in the spectrometer) was found to be always less than the number of drops in Channel 2 but more than that found in Channel 3 of the instantaneous spectrometer. This meant that nuclei with S_c of 0.55% produced drops within the size range of 1.42 μm and 1.75 μm radius in that particular configuration of the instantaneous spectrometer. Thus, the average of Channels 2 and 3 were used to deduce the number of CCN active at 0.55% in the spectrometer. Channel 4 was set at 2.77 μm radius water drops and Channel 5 was set for 3.0 μm water drops. In a similar fashion, these corresponded to 0.30% S_c. It was found necessary to make a small adjustment in the size thresholds only once during the Workshop.

The sample flow rate was usually the same as the CFD, 0.60 cm^3sec^{-1}, although it was at times as low as 0.1 cm^3sec^1. The plates were also controlled by the same regulator baths and the same types of thermisters were embedded in the plates. This chamber differed from the CFD in three other respects: (1) There were no flows of particle-free air around the backside of the plates. Instead, a diffuser screen was used to eliminate any turbulence; (2) A metal mesh screen was used instead of filter paper for the moist plate surfaces; and (3) Instead of dripping water onto the plates as in the CFD's, water was fed to the metal screens by capillary action from a reservoir of distilled water.

4.4 Operation

Several tests can be performed to check the performance of the instantaneous spectrometer. When the upstream lowest supersaturation, S_1, is increased, the larger sized droplet peak increases and becomes larger as it should. When the higher downstream supersaturation, S_3, is increased, the magnitude of the smaller sized peak is increased and there is an increase in its size. Under these conditions, the larger sized peak is only shifted to a slightly larger size. These observations are all in keeping with the operating principles. Thus, sizes which allow separations between the peaks can be chosen. Moreover, the Royco voltage thresholds can be set so that certain size channels can be used to monitor the concentration at specific supersaturations. The size channels can be adjusted so that an individual drop size plateau can be obtained for each supersaturation (see Hudson and Squires, 1976). This assures that all drops which should have been activated at a certain supersaturation were activated and counted. Changes in the downstream supersaturation, S_3, do not affect the detected concentration active for instance at S_1 or S_2.

The spectrum of three supersaturations was available simultaneously as soon as the OPC counted and printed out the numbers. Agreement with the DRI CFD was very good and consistent throughout the Workshop as shown by the results.

5. ISOTHERMAL HAZE CHAMBER

The measurement of CCN can be extended to lower values of supersaturation by using the isothermal haze chamber (IHC) first described by Laktionov (1972). The basic operating principle of the IHC relates to the fact that the equilibrium size of a haze droplet, r_{100}, at 100% RH (supersaturation = 0) is uniquely related to the critical supersaturation S_c of the nucleus. Following Laktionov (1972) and Alofs (1978), at T = 20°C the relationship is

$$r_{100} = \frac{4.1 \times 10^{-6}}{S_c} \qquad (1)$$

where r is in centimeters and S_c is in percent. According to Hoppel and Fitzgerald (1977), this relationship is unique if the particle is at least 1% soluble. Eq. (1) can be applied if drops are grown to their equilibrium sizes in a saturated environment and then counted as a function of size.

The Desert Research Institute IHC is a device which subjects sample aerosol to 100% relative humidity for 100-200 s. In most cases, this is enough time to allow the drops to attain their equilibrium sizes at which time they are counted and sized by an optical particle counter (OPC Royco 225). The size is then related to the critical supersaturation S_c so that an N vs. S_c curve can be drawn.

This instrument was built along the same lines as the continuous flow diffusion (CFD) chamber (Hudson and Squires, 1976), in that the sample occupies only a small volume of the cloud chamber which is made up mostly of particle-free air. Figure 8 is a schematic diagram of the DRI IHC. The geometry, of course, is different from the CFD in that the IHC is a right circular cylinder, while the CFD is a rectangular parallelepiped. In the IHC, the sample travels vertically downward (the sample always travels horizontally in the DRI CFD) so that fallout of the large drops still carries them into the optical counter instead of onto the walls where they would be lost.

As with the CFD the total flow F of air can be changed without altering the sample flow f. This allows the capability of changing the time which the sample spends in the saturated volume of the chamber. Therefore, like the CFD, it is possible to give the sample nuclei various growth times before counting and sizing by the OPC which is attached at the outflow end of the cylinder which is the bottom of the chamber.

Using this device, it is possible to experimentally determine whether the drops have had sufficient time to reach their equilibrium sizes. If a plateau exists in the relationship between F and the number of drops larger than specific threshold sizes (Fig. 9), then it is reasonable to assume that these drops have reached their equilibrium sizes r_{100}. According to calculations made by Laktionov (1972), 100 s are required to grow nuclei with S_c = 0.02% to within 95% of their r_{100} which is 2 µm. The available time in the DRI IHC usually approaches 200 s. The existence of an F plateau ensures that drops have enough time to grow to their equilibrium size and that they do not evaporate in the OPC.

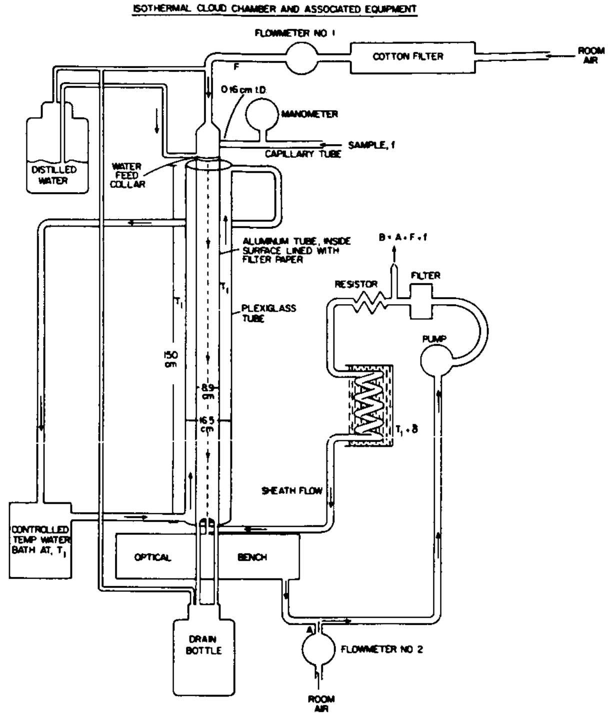

Figure 8. Schematic diagram of the DRI isothermal haze chamber (IHC) and associated apparatus.

Various flows of air through the IHC imply various velocities through the optical counter. In theory, this should not affect the size calibration of the instrument which should only depend on pulse height and not pulse width. Although Alofs (1978) has found that this dependence is not always true at extremely low flows, the flows used in the DRI IHC were never that low. In fact, the size calibration was found to be the same within experimental error for the various flows which were used.

The response of the Royco OPC depends on the index of refraction of the particles. The instrument is calibrated with latex spheres which have an index of refraction of 1.59. Calculations for various OPC's including a Royco have been made by Cooke and Kerker (1975). Although this is probably the best treatment of the subject, it has many shortcomings in this application. The limits of the scattering angles are slightly different for the Royco 225's used in this study and the values for the Royco 245 referred to by Cooke and Kerker. The largest discrepancy is the angle β (the upper limit of the scattering cone) which Cooke and Kerker refer to as 25° for the Model 245; the manufacturer quotes a value of 28° for the Model 225 while the author measured 27.4° on one of the 225 instruments. This discrepancy may or may not be enough to change the results of the Mie scattering calculations. Moreover, Cooke and Kerker did not perform a calculation for index of refraction 1.59 which is the index of refraction of the latex spheres used

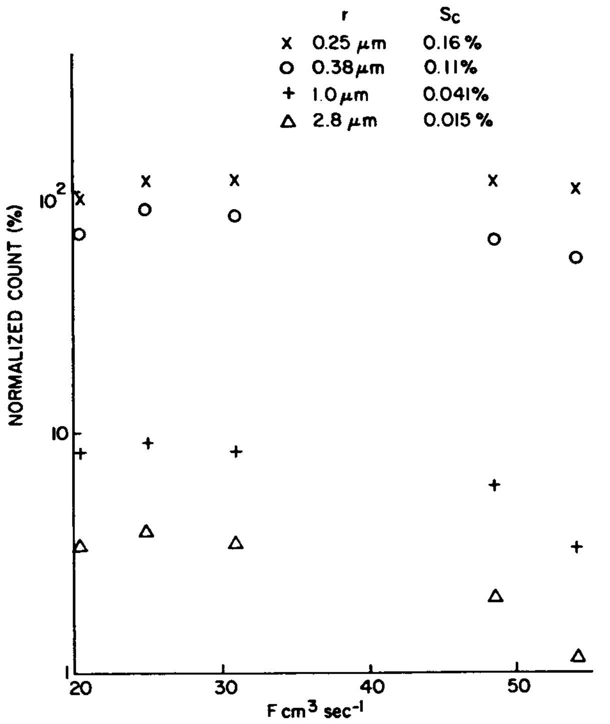

Figure 9. Number of drops exceeding various size thresholds as a function of the total flow in the IHC. The numbers were normalized to the concentration in a simultaneously operating CFD at 0.15% supersaturation. This figure illustrates a plateau in number concentration for various growth times for various critical supersaturations.

to calibrate the device. The best one can do is to interpolate between the 1.54 and 1.70 curves and compare this with the response curve for index 1.33. A correction curve can then be developed so that the instrument calibration performed with latex spheres can be applied to water drops. This index of refraction correction was then applied to the IHC.

This device operated fairly well during the Workshop, but there are indications that the smallest droplets, those grown on FCN of highest critical supersaturation, may have suffered evaporation in the Royco OPC. The consequence of evaporation of this sort is that the IHC tends to undercount in the region of operation overlapping CFD chamber operation, or about 0.1% to 0.2% supersaturation.

6. ACKNOWLEDGEMENTS

This work was supported by the National Aeronautics and Space Administration under Grant No. NAS8-33820, and the National Science Foundation under Grant No. ATM79-21558.

Development of the rapid cycle CCN spectrometer was supported by the NASA Marshall Space flight Center, under Contract NAS8-31470. Principal Investigators for this contract were Patrick Squires and Warren Kocmond. The contributions of Sam Keck, Peter Wagner, and Darrel Reid to this project are gratefully acknowledged.

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STEADY GENERATION OF AEROSOLS WITH AN IMPROVED CONSTANT OUTPUT ATOMIZER

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1. INTRODUCTION

It is common practice to generate laboratory aerosols of soluble materials with pneumatic atomizers. In a typical device, a solution of the substance to be aerosolized is injected into a jet of air and the liquid is broken up into very small droplets. After forced evaporation, a dry aerosol of the solute is produced. In most atomizers, a solid surface is placed into the droplet-laden jet such that the larger droplets are impacted and a narrower size distribution is produced.

In preparation for the Workshop, a number of commercially available devices were tested that operated on the above principle. Devices included the DeVilbiss No. 644*, the Nano-Mist** and other inhalation nebulizers, and the TSI*** Model 3076 Constant Output Atomizer (COA), specifically intended for laboratory use. The schematic example (Figure 1) shows a vertical cross-section of the TSI-COA which amounts to a slightly modified version of the Collison Atomizer (May, 1973). Its distinctive feature is the ducted portion of the jet within which the liquid is injected, in contrast to the open jet mostly used in various other inhalation nebulizers (as shown schematically in Figure 3).

Despite differences in design, all the atomizers tested suffered from short- and/or long-term fluctuations of their output particle number concentrations. Some of the devices displayed a constant unsteady behavior while others, such as the TSI-COA, occasionally performed well but then flipped into a very unstable mode for prolonged periods. For many types of laboratory investigations, especially where several instruments are involved as in the case of the CCN Workshop, it is essential that temporal stability of test aerosols be maintained within a few percent. The aim of the present study was to elucidate the mechanisms responsible for atomizer instabilities and to find methods for alleviating these problems.

2. STUDY OF OUTPUT INSTABILITIES

In most atomizers, it is not possible to observe the critical nozzle area during operation nor can the nozzle geometry be modified to effect changes in the performance. In order to overcome these difficulties a variable geometry atomizer (VGA) with a transparent housing was designed. Using this device, the relative position and the size of the air jet, liquid feed tube and impaction surface could be varied. Atomizer performance was assessed by analyzing its output in an electrostatic classifier (EC, TSI Model 3071) and an electrical aerosol detector (EAD, TSI Model 3068) the signal of which was recorded on a stripchart.

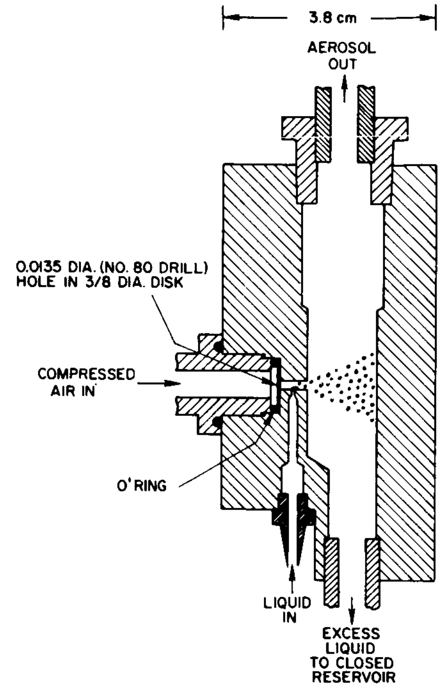

Figure 1. Cross-section of TSI constant output atomizer (from TSI Manual).

Initially, it was thought that build-up of electric charges on non-conductive components of the aerosol flow system were responsible for the sometimes very abrupt changes in aerosol output. However, this interpretation had to be ruled out on the basis of experiments with systems that were made totally conductive.

A series of tests in conjunction with other aerosol measuring devices and with various atomizers confirmed that the observed output fluctuations were not artifacts of the aerosol instruments but, indeed, originated in the atomizer system. The same tests also indicated that the output variations occurred over the entire particle size range, though not necessarily to exactly the same extent. In the case of the TSI-COA, the average output in the unstable operating mode contains a considerably higher proportion of larger particles than in the steady mode as Figure 2 attests.

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* DeVilbiss Company, Somerset, PA.

** Eastfield Corporation, Noroton, CN.

*** TSI Incorporated, St. Paul, MN.

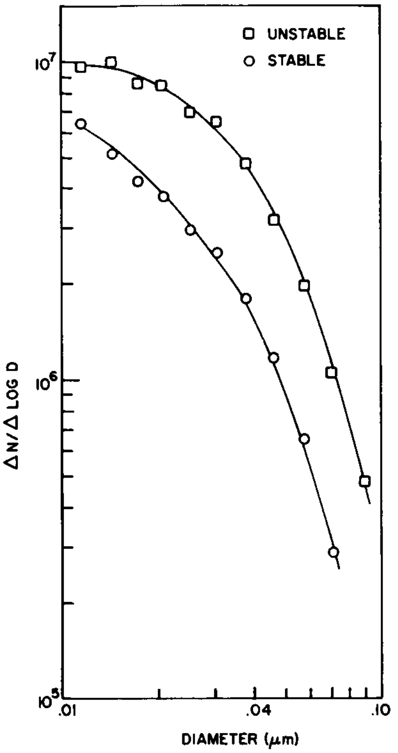

Figure 2. Size distributions of NaCl aerosol generated by TSI-COA at 30 psi with a 0.01% solution in stable and unstable operating modes.

Visual observation of the VGA in operation uncovered several phenomena causing unsteady aerosol outputs. By monitoring the impact area of the jet on a transparent plate, it was found that the size and position of that area was fluctuating in correlation with the particle output fluctuations. Measurements, on the other hand, showed a strong dependence of the output from the mutual position of jet and liquid feed tube. Closer scrutiny (by stereo microscope) indicated:

(a) that in case of wide (∿1 mm diameter) liquid feed tubes, the jet and associated turbulence caused the liquid surface to oscillate and, as a consequence, to release liquid at irregular intervals into different portions of the jet, thus generating output irregularities as observed, e.g., in the DeVilbiss nebulizer. This is schematically depicted in Figure 3a, while a narrow tube as in Figure 3b alleviates the problem;

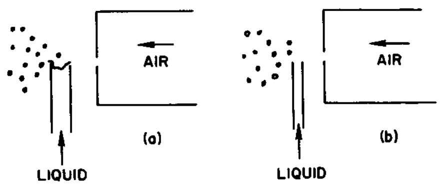

Figure 3. Schematic of open-jet atomizer, (a) with wide liquid feed tube causing irregular output; and (b) with narrow liquid feed providing improved output stability.

(b) that salt deposits at the rim of liquid feed tubes were forming after a period of operation - sooner when working with concentrated solutions, later for dilute solutions. Both the liquid discharge into the jet as well as the jet itself are influenced by the presence of the salt accumulation resulting in erratic output behavior. Removal of the minute salt obstacle immediately restored a steady output; and

(c) that gradually accumulated solution from spray droplets being whirled around between nozzle and impaction surface or solution directly from the liquid feed tube is periodically entrained, or drips into, the jet resulting in temporary output maxima. Concentrated solutions aggravate the problem due to their tendency for foaming, as frequently observed in the TSI-COA where the narrow vertical cavity promotes this undesirable effect.

3. DESIGN AND PERFORMANCE OF THE IMPROVED CONSTANT OUTPUT ATOMIZER (ICOA)

With temporal stability being the main criterion, a new atomizer design was considered essential in order to eliminate or minimize the above mentioned causes of fluctuations found in other units. Thus in a succession of test models, a geometrical arrangement of air jet, liquid feed tube and impaction surface evolved that showed none of the previously described problems.

The top of Figure 4 depicts a cross-section and face-view of the air nozzle and liquid feed combination that evolved. By allowing the liquid to travel in a short, open channel from the tube end to the air nozzle (aided by capillarity and Venturi effect), the formation of salt deposits as well as entrainment of spilled-over liquid was eliminated. A sufficiently large housing (typically ∿1 ℓ volume) and the impaction surface positioned

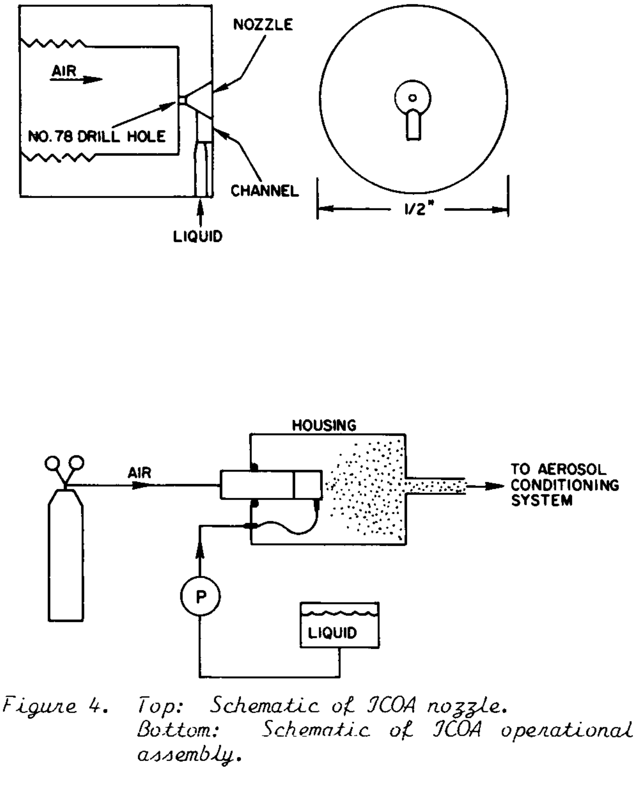

Figure 4. Top: Schematic of ICOA nozzle. Bottom: Schematic of ICOA operational assembly.

several (~4) centimeters from the nozzle provided enough space for the spray to dissipate without forming deposits that would drip into the jet. The exit cone of the 0.41 mm nozzle allowed the liquid to enter the jet from all sides and thus further prevented accumulation of liquid near the nozzle.

By operating the unit with a liquid metering pump (such as FMI-RHOCKC*) as shown in Figure 4, bottom, at a rate of 0.05 to 2.0 ml min^{-1}, size spectra as shown in Figure 5 could be obtained at less than ±1% deviation from the average particle number concentration for periods of one hour or more. An illustration of this can be seen in Figure 6 which shows concentration data for the beginning and end of a six hour run. Occasional minor long term drifts of the output (typically under 2%) have tentatively been traced to the liquid metering pump. The atomizer has been operated successfully at air pressures between 10 and 100 psi; below 10 psi, the output is slightly less stable.

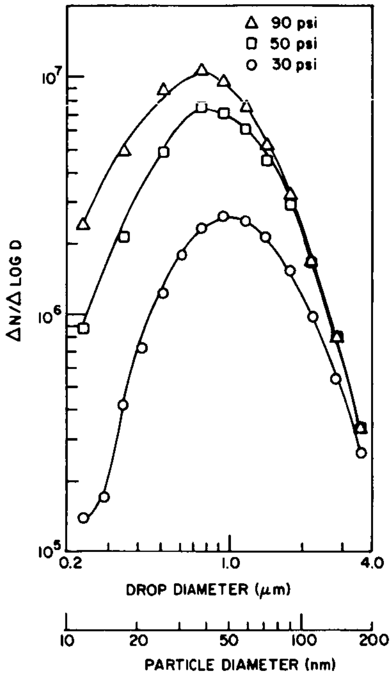

Figure 5. Aerosol size distributions obtained with the DRI-ICOA at the three indicated air pressures with 0.025% NaCl solution. Upper scale refers to original droplet diameters as inferred from particle sizes and solution concentration.

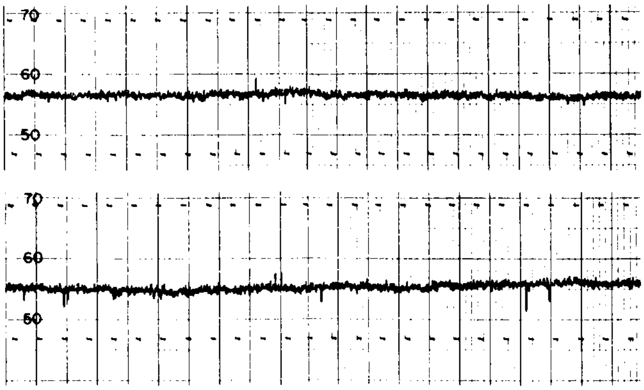

Figure 6. Strip chart record of ICOA output as measured by EC-EAD for a six hour run; shown are first and last 20 minutes, demonstrating good constancy over long periods.

4. ACKNOWLEDGEMENTS

We gratefully acknowledge the support by the National Aeronautics and Space Administration under Grant No. NAS8-33820, and the National Science Foundation under Grant No. ATM79-21558.

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[*] Fluid Metering, Inc., Oyster Bay, NY.

SECTION VI. SUMMARY - REVIEW PAPERS

CCN COMPARISONS OF STATIC DIFFUSION CHAMBERS

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ABSTRACT

Nine CCN counters of the static diffusion (SDC) type were compared with one another and with continuous flow diffusion (CFD) chambers. The nine SDCs showed a considerable amount of variation, largely attributable to newness and/or lack of prior calibration of some units. The five more consistent instruments agreed quite well, to within at least 20% of the NRL mobility anlayzer and to within 10% at 1% supersaturation. There was satisfactory agreement between the more reliable SDC and CFD chambers.

1. INTRODUCTION

At the first International Workshop on Cloud Nuclei in Lannemezan, France (1967), it was not necessary to distinguish between types of instruments for measuring CCN concentrations. Only a few were in existence and present, and all were of the Twomey-type (1963), based on a method of Wieland (1956). In these thermal gradient diffusion chambers, nucleated droplets were detected individually on photographic film. Even at the second Workshop in Fort Collins, Colorado (1970), five of the six units present again were of the thermal diffusion (static) chamber type.

As is evident from the instrument descriptions, a whole host of CCN counters were represented at this Workshop in Reno. They may be classified by type as static diffusion chambers (SDC), continuous flow diffusion chambers (CFD), and low supersaturation "haze" chambers. In this preliminary analysis, we will concentrate on the performance of the static diffusion chambers, although some brief reference to the other instrument types may be appropriate.

At the 1970 Fort Collins Workshop, the five thermal diffusion chambers (excluding one commercial unit) agreed quite well, to within ±30% of the mean (Ruskin and Kocmond, 1971). Chamber operation and expansions were essentially at three supersaturations S: 0.3, 0.75 and 1.0%. By contrast we operated at Reno over a broader supersaturation range, included more S points, and did not prescribe standard S values. In retrospect, the latter was unfortunate and made the data analyses from computer printout data quite laborious and time consuming. The inclusion of many S levels did enhance the data base and allow for, among other things, consideration of CCN supersaturation spectra shapes (e.g., Jiusto and Lala article).

Some of the basic questions that such an analysis can address are as follows:

a. How well did the SDC units intercompare?
b. Where discrepancies occurred, were there logical explanations?
c. Was there general agreement between SDCs and the more sophisticated CFD units?
d. Has the science of CCN concentration measurements advanced during the past decade?

Clearly in light of the wealth of data produced and time limitations involved, we will only touch on some of these complex questions. Hopefully, more definitive answers will emerge after further analyses of the data and future experiments stimulated by this International Workshop.

2. CCN INSTRUMENTS

The static diffusion chambers operated at the Workshop are listed in Table 1. Of the nine instruments, only one - the NRL counter - was essentially the same as that used at Fort Collins. This instrument has been used extensively over the years in field programs and in comparisons with other counters. Thus it is considered a useful reference for intercomparisons. The Hebrew University counter was present at all three workshops, though at Reno it employed a different detection method.

As is evident, there has been a trend in recent years away from individual droplet counting in static diffusion chambers to measuring the total scattered light from a sample volume of droplets and transformation to CCN concentrations. Some of the advantages and disadvantages of each approach are discussed in Section 3.4.

Five of the nine SDCs employed a scattered light principle. A related approach apparently was first used by Radke and Hobbs (1969) but with "side" scatter detection over a broad angle, necessary recording of the Mie peak, and a sizable chamber geometry. The commercial unit of Mee, Inc. introduced near-forward light scattering which allows for considerable counter size reduction and portability. Lala and Jiusto (1977) established the theoretical relationship for forward scatter chambers linking supersaturation (drop growth), light scatter intensity and drop concentration; full automation and data reduction via microprocessor control were achieved.

TABLE 1

CCN Counters - SDC Type

Instrument No.	Figure Symbol	Organization	Operator	Droplet (Nuclei) Detection	Light Source
2	0	U. of Wyoming	Rogers/Politovitch	Photographic	He-Ne Laser (5 mW)
5	B	British Met. Office	Kitchen	Light Scatter	25 W Tungsten
8	E	Mee, Inc.	Mee	Light Scatter	25 W Tungsten
9	H	Hebrew U.	Gagin/Nuzitsa	Light Scatter	100 W Halogen
10	S	SUNY	Lala/Jiusto	Light Scatter	I.R. Emit. Diode (25 mW)
13	I	CSIRO	Ayers	Light Scatter	150 W Tungsten
17	N	NRL	Wojciechowski	Video Camera	200 W Mercury Arc
24	F	France	Serpolay	Video Camera	He-Ne Laser (5 mW)
25	C	CSU	Borys	Photographic	He-Ne Laser (5 mW)

In essence the CCN instruments of SUNY, Hebrew University and CSIRO are reasonably similar in principle and all incorporate a back-up standard photographic method for calibration. The British Met Office and CSU units are modified Mee, Inc. commercial counters. The instrument from France employs a laser light beam and a video camera detector, while the Wyoming counter utilizes laser illumination and records droplet images with a 35 mm camera.

Several of the SDCs had undergone recent redesign or modification, partly in preparation for the Workshop. Others were newly assembled and admittedly brought to the Workshop to test their performance and obtain first-time cross calibrations. This was counter to the original plan of comparing "proven" instruments, but the more open approach undoubtedly added to the overall learning process. Under such circumstances, one might expect a fair spread in the data obtained, and indeed it occurred.

The NRL mobility analyzer (electrical classifier) provided accurate aerosol size information from which supersaturation spectra could be computed with aerosols of known chemical composition (see Hoppel article). These derived spectra also served as a useful reference for instrument comparison.

3. RESULTS

3.1 Overall SDC Performance

One method of evaluating the data was to examine the CCN concentration measurements made with all SDC instruments on all experiments at designated supersaturations. The supersaturations considered were 0.2%, 0.5% and 1.0%. As noted previously, not all counters operated at these specific S values, so a good deal of judicious extrapolation was necessary. The 0.2% supersaturation is at the lower bound of reliability for static diffusion chambers because of problems associated with haze discrimination, non-uniform drop sizes (light scatter method), and temperature control. As one approaches 0.5 to 1.0%, higher reliability should be expected.

Table 2 lists by experiment the coefficient of variation, and the average CCN concentration $\bar{N}$ of all SDCs (5 to 9) participating in a given experiment compared with the NRL SDC, the NRL mobility analyzer (MA), and the UMR continuous flow chamber. The coefficient of variation V is a dimensionless function of the standard deviation and the arithmetic mean, i.e.,

$$V = \sigma/\bar{N} \text{ or } V(\%) = 100\ \sigma/\bar{N}.$$

V is a relative measure of the dispersion of the data and, in a very loose sense for these data, can be thought of as the percentage to each side of the mean that will encompass most of the CCN concentration values.

Table 2 reveals a number of noteworthy items:

1. The three classes of experiments - involving polydisperse salts, monodisperse salts, and ambient air - were not too dissimilar in terms of the presented variables. Thus for simplicity one can concentrate on the overall averages of the bottom row.

2. $\sigma/\bar{N}$ values of about 0.5 at 0.2% and 0.5% S were comparable and not overly satisfying. At 1% S the degree of dispersion had reduced to 0.32.

3. The concentration ratios ($\bar{N}$ divided by the count of each of the three indicated instruments) show that, on average, the SDCs were under-estimating CCN concentrations. This was graphically evident at the Workshop where certain instruments were obviously registering low counts. Inadequate light intensity or an inefficient optics system are usually the sources of such difficulties. Possible calibration error, depending on the standard used, can also introduce discrepancies.

TABLE 2

Average Performance of All SDC Instruments
(Coefficient of Variation and Concentration Ratios vs. S)

	0.2% S				0.5% S				1.0% S			
a. Polydisperse Salts	$\sigma/\bar{N}$	$\bar{N}$/NRL	$\bar{N}$/MA	$\bar{N}$/UMR	$\sigma/\bar{N}$	$\bar{N}$/NRL	$\bar{N}$/MA	$\bar{N}$/UMR	$\sigma/\bar{N}$	$\bar{N}$/NRL	$\bar{N}$/MA	$\bar{N}$/UMR
Exps. 1, 2, 10, 13, 14, 22, 23, 24*	0.51	0.80	0.84	1.01	0.50	0.70	0.58	0.72	0.33	0.86	0.73	0.79
b. Monodisperse Salts												
Exps. 4, 5, 8, 9, 15, 18, 19, 20*	0.46	0.75	0.89	0.87	0.54	0.70	0.80	1.02	0.31	0.87	0.91	0.95
c. Ambient Air												
Exps. 3, 6, 11, 12 16, 17, 26	0.54	0.67	-	0.91	0.57	0.76	-	0.71	0.33	0.85	-	0.84
Overall Average	0.50	0.74	0.87	0.93	0.54	0.72	0.69	0.82	0.32	0.86	0.82	0.86

*0.25% S rather than 0.20% S

TABLE 3

Average Performance of Five SDC Instruments:
NRL, CSIRO, SUNY, Hebrew University, and France
(Coefficient of Variation and Concentration Ratios vs. S)

	0.2% S				0.5% S				1.0% S			
a. Polydisperse Salts	$\sigma/\bar{N}$	$\bar{N}$/NRL	$\bar{N}$/MA	$\bar{N}$/UMR	$\sigma/\bar{N}$	$\bar{N}$/NRL	$\bar{N}$/MA	$\bar{N}$/UMR	$\sigma/\bar{N}$	$\bar{N}$/NRL	$\bar{N}$/MA	$\bar{N}$/UMR
Exps. 10, 13, 14, 22, 23, 24*	0.42	0.79	0.95	1.09	0.29	0.77	0.68	0.84	0.19	0.85	0.83	0.89
b. Monodisperse Salts												
Exps. 5, 8, 9, 15, 18, 19, 20*	0.36	0.84	0.98	0.97	0.30	0.84	0.90	1.08	0.31	0.93	0.99	0.97
c. Ambient Air	0.48	0.74	-	1.03	0.35	0.91	-	0.89	0.22	0.94	-	0.99
Exps. 6, 11, 12, 17, 26												
Overall Average	0.42	0.79	0.97	1.03	0.31	0.84	0.79	0.94	0.24	0.91	0.91	0.95

*0.25% S rather than 0.2% S

Because of problems with some instruments, a degree of smoothing was in order. Table 3 presents identical information for just five of the SDC counters whose performance was considered more reliable at the Workshop; these were the units from NRL, CSIRO, SUNY, Hebrew University and France. Even these units on certain experiments registered values that were out of the mainstream. For inclusion of an experiment in this analysis, at least four of the five instruments had to be participating.

The coefficient of variation (Table 3) improved considerably, decreasing to 0.42, 0.31 and 0.24 as supersaturation increased from 0.2 to 0.5 to 1.0%. $\sigma/\bar{N}$ was somewhat better (smaller) for the laboratory aerosol tests than for ambient air, due largely to greater ambient aerosol fluctuations. Such temporal fluctuations (even with lab aerosols at times) can introduce misleading scatter in the data because the CCN counters possessed different sample processing times and also could not readily be synchronized in time to common S levels.

The overall concentration ratios of Table 3 present a similar but more consistent picture than Table 2 data. At 0.2% the SDC's appeared to underestimate (0.79) with respect to the NRL counter but were within 3% of both the NRL mobility analyzer (0.97) and UMR CFD (1.03). At 0.5% the SDC's apparently underestimated concentrations by about 6 to 20%. At the higher 1% supersaturation, the concentration ratios were all quite respectable, reaching 0.91 to 0.95 values. In general, the SDC's were in somewhat better agreement with the UMR counter than with the other two references. Note that similar agreement would have been obtained with the DRI CFD (instrument #15) which tracked very closely with the UMR counter.

3.2 Individual Experiments and Comparisons

Figures 1-5 depict some representative SDC experiments (not necessarily the best nor the worst cases, but ones that were reasonably well controlled with many participants). The CCN concentrations vs. S data were taken from the printout sheets provided each participant after the Workshop; then averaged where appropriate if several runs were made; and plotted by computer in the fashion shown. The solid lines represent CCN-S spectra computed by NRL from particle size data obtained with the NRL mobility analyzer. Refer to Table 1 for instrument symbol designation.

In the monodisperse aerosol experiments shown in Figures 1 and 2, the critical supersaturations were $\leq$0.2% so that CCN concentrations should be uniform over the indicated S range. Indeed, most data points were within 20% of the plateau. In three other monodisperse aerosol experiments, S_c fell within the SDC operating range of 0.2-1% S. A glance at the Workshop data indicates that most instruments were capable of detecting S_c to within ±0.1% S.

It should be noted that in Figure 1 the British Met Office instrument data were not plotted and in Figure 2 the CSU data were ignored. Both instruments were experiencing difficulties and undercounting. While the Mee, Inc. instrument is represented in Fig 1 (E symbols), it was periodically malfunctioning during the limited days it was

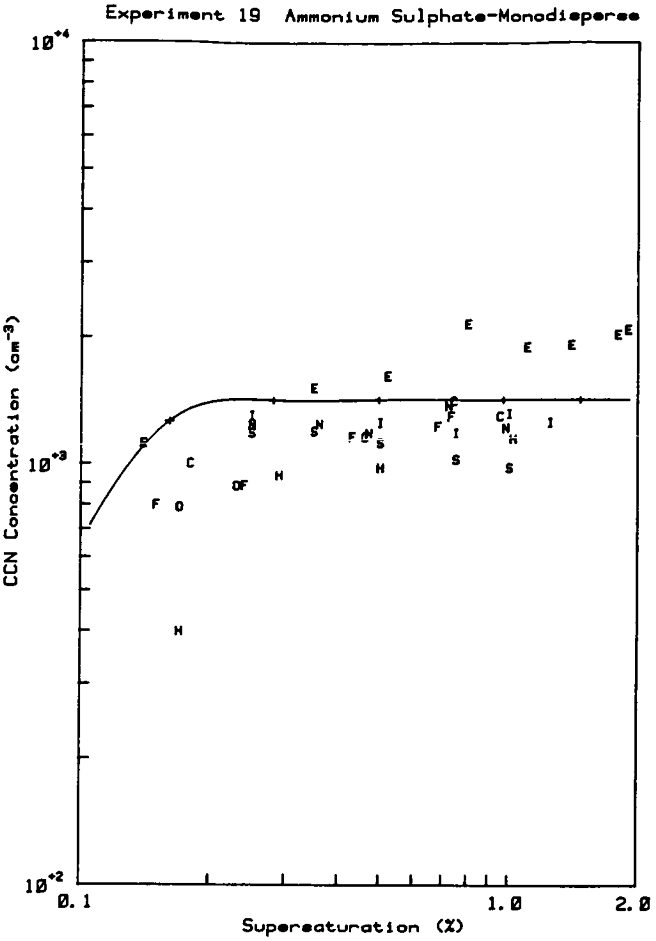

Figure 1. Static Diffusion Chamber Values and Mobility Analyzer Curve (see Table 1 for instrument symbol legend).

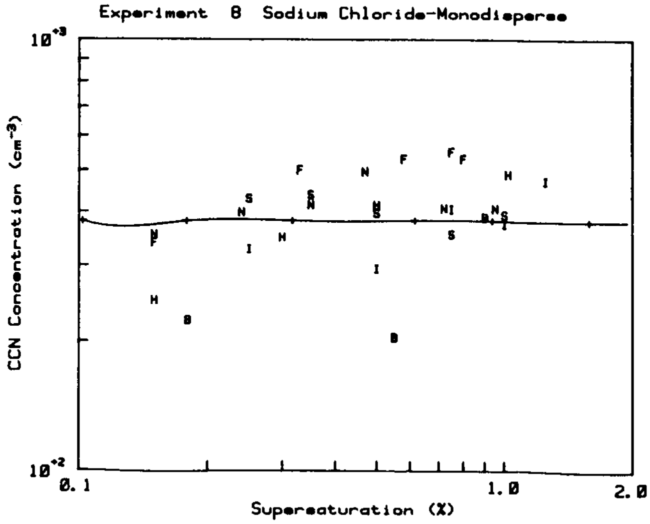

Figure 2. Static Diffusion Chamber Values and Mobility Analyzer Curve.

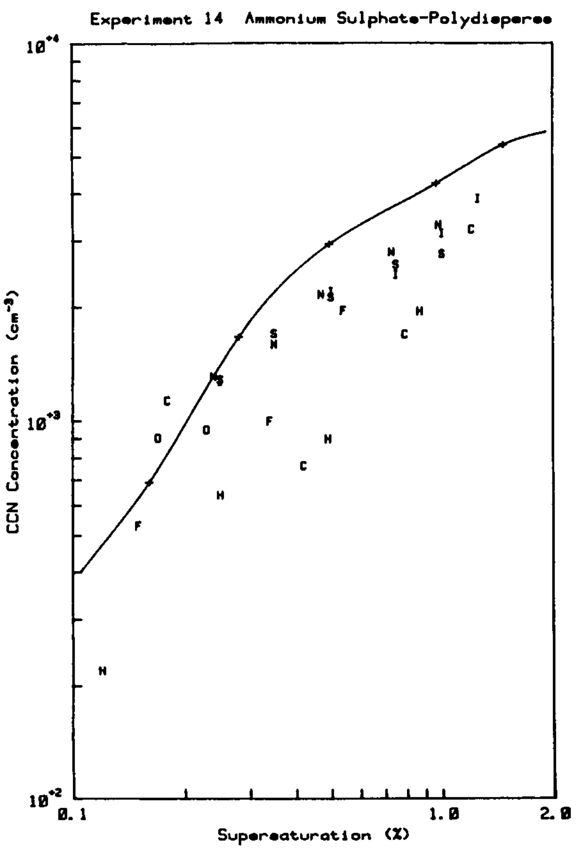

Figure 3. Static Diffusion Chamber Values and Mobility Analyzer Curve.

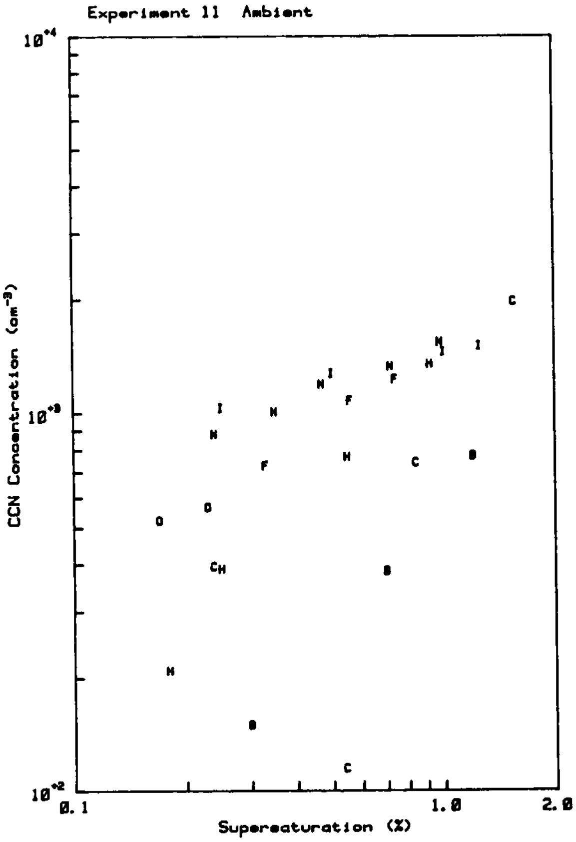

Figure 5. Static Diffusion Chamber Values in Ambient Air.

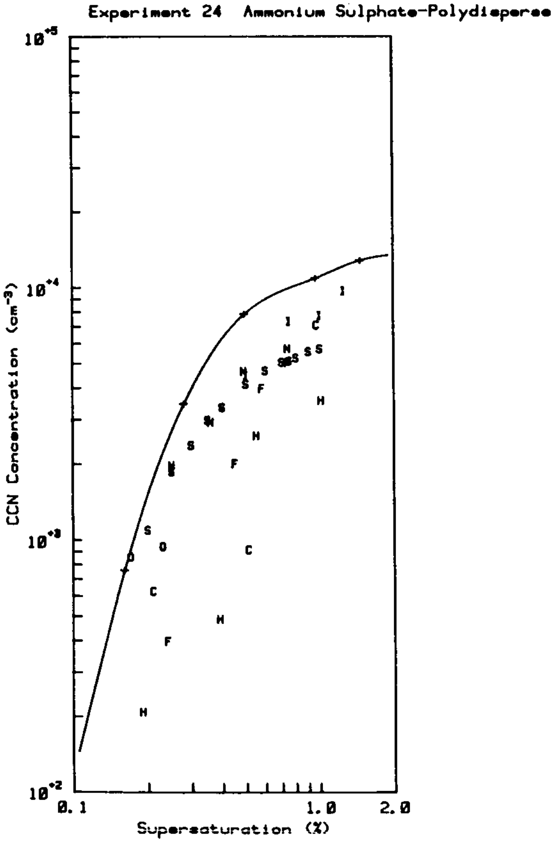

Figure 4. Static Diffusion Chamber Values and Mobility Analyzer Curve.

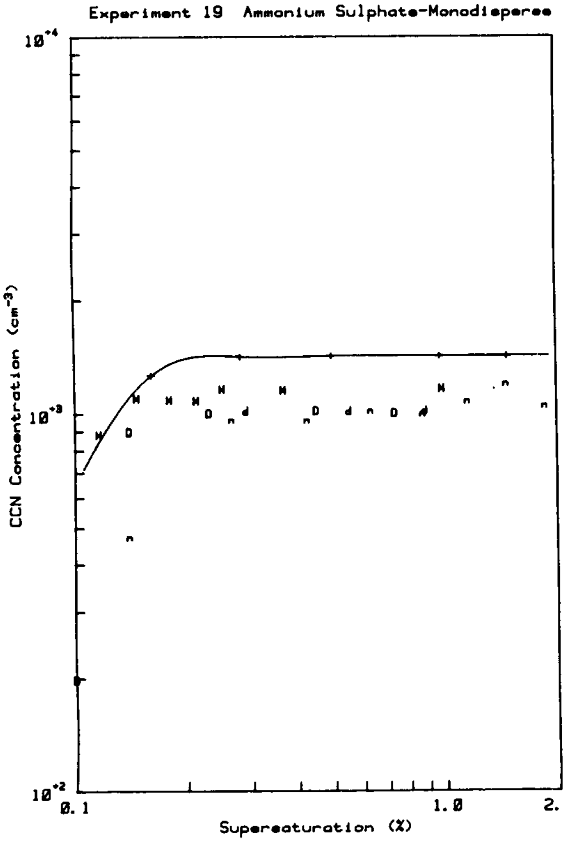

Figure 6. CFD Instrument Values and Mobility Analyzer Curve (see instrument symbols in Sec. 3.3 of text).

at the Workshop. It was a new factory unit and reportedly rushed to the Workshop without the customary time for checkout.

Figures 3 and 4 illustrate polydisperse aerosol experiments. Most points in these two experiments lie below the mobility analyzer curve, with considerably more data spread in Experiment 24 (Figure 4). In these and several other cases, the NRL, CSIRO and SUNY instruments tracked reasonably close to one another, with the Hebrew University unit also close at the higher supersaturations. Overall the consistent NRL chamber data matched most closely the NRL mobility analyzer data.

An ambient air case is shown in Figure 5 with considerable data spread. Both the "B" and "C" point instrument are presumably in an early stage of development. The remaining data points cluster reasonably well.

3.3 SDC and CFD Chambers

Figures 6-8 represent CFD chamber data for three of the same experiments just described. Instrument symbols are as follows:

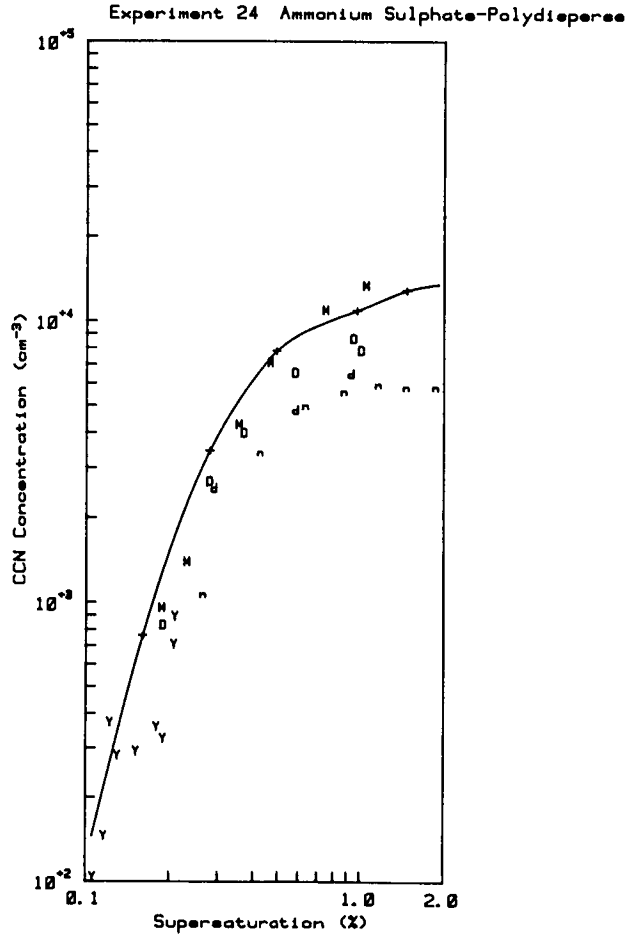

Figure 7. CFD Instrument Values and Mobility Analyzer Curve.

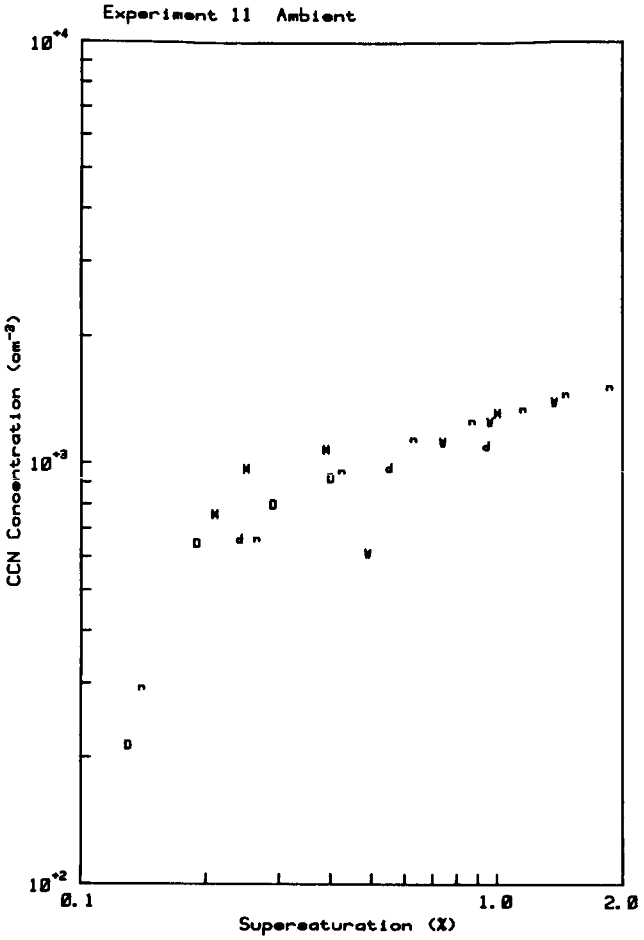

Figure 8. CFD Instrument Values in Ambient Air.

Symbol	Instrument No.	Group
n	15	DRI (NASA unit)
d	16	DRI (Spectrometer)
D	18	DRI
M	21	UMR
W	20	Univ. of Washington
Y	7	York University (different concept/see Leaitch and Megaw)

One cannot help but be impressed by the relatively small degree of data spread, particularly in the ambient air case (Figure 8). The fact that only five CFD instruments are involved, that three of these were developed at one institution, and that all have benefitted from extensive engineering and intercomparisons certainly are constructive factors. The results perhaps contain an instructive message for those wishing to develop CCN units.

Comparing Figures 6 and 7 with Figures 1 and 4, it is seen that most CFD points were also just below the NRL classifier curve. By carefully examining these figures (and the ambient case), it is evident that the CFD data and more reliable cluster of higher SDC data points overlapped quite well. In short, we sugest that a well-designed SDC and a well-designed CFD will both perform well. That is evident from the concentration ratios of Table 3 (five SDC's vs. UMR CFD) and from Alofs' determination (described elsewhere in this report) that the UMR CFD and NRL SDC systems agreed on average to 6% at 0.3 and 1.0% S.

3.4 SDC Types

As mentioned previously, SDC instruments now take two principal forms: individual droplet imaging and counting via TV monitors and regular cameras or total light scattering from an ensemble of droplets. The results from this Workshop are not definitive in terms of whether either class is inherently superior. At least one or two of each type appeared to give above average performance while others did not.

An objection to the light scattering method is that at the lower supersaturations, drop sizes are - less uniform and less apt to yield accurate concentration data. Similarly with individual droplet detection methods at low S, it is very difficult to discriminate haze from activated droplets. Also with low nucleus concentrations, some subjective judgement can enter as to what frame or portion of a sample volume to count. With either type system, very small sample volumes (light beams) can produce erratic results in low concentration aerosols.

Allowing that Twomey-type chambers with an experienced operator may possess higher inherent accuracy, there is much to be said for the light scattering technique. The latter approach lends itself to more miniaturization, portability, and automatic operation and recording of data. This facilitates field studies of CCN concentrations (and spectral slopes k) on fine time and spatial scales that otherwise would be formidable. A flexible compromise configuration, in evidence at the Workshop, is an SDC that incorporates both the optical and light scattering concepts with the camera operation used at least for periodic calibration.

4. CONCLUDING REMARKS

In summary, the International CCN Workshop provided a wealth of data and information on different classes of instruments and their performance. In view of the massive quantity of data available, much of which could not be thoroughly covered, this report contribution should be considered preliminary.

In general, the more reliable SDCs performed acceptably most of the time. Some are clearly in need of modification and further development. Even those with above-average performance were occasionally out of the mainstream and improvements were undoubtedly suggested to their instrument developers.

The combined average CCN concentrations from five SDC's agreed to within at least 20% with the NRL mobility analyzer, and to within 10% at 1% supersaturation. Agreement between the NRL SDC and the mobility analyzer was even closer. The coefficient of variation ($\sigma/\bar{N}$) of the five instruments was 0.42 at 0.2% S, 0.31 at 0.5% S and 0.24 at 1.0% S.

The spread of SDC data was considerable and in excess of that at the prior Fort Collins Workshop. We largely attribute this to the greater number of instruments present, many of which were relatively new and untested previously. By contrast, four of five CFD units present showed closer agreement with one another, in part for just the opposite reasons cited above as well as for indispensible long-term engineering. The above-average SDC's agreed most satisfactorily (within about 10-15%) with the UMR and DRI CFD's over their common S range.

We began by posing the general question as to whether the science of CCN concentration measurements has advanced over the past decade. We believe it has! Certainly the capability of measuring at supersaturations lower by about an order of magnitude with haze chambers and certain CFD's is an all-important achievement; now virtually all cloud and fog condensation nuclei can be discriminated. CFD instruments have ushered in a high degree of engineering sophistication and accuracy for many applications. The Twomey-type counter, as represented by the NRL SDC, continues to maintain an enviable level of performance. It will undoubtedly remain a useful standard for SDC units. The introduction of light scattering techniques for SDC performance, while not necessarily adding to accuracy, provides for much simpler operation and data processing. The net result may be CCN information with a time and spatial resolution heretofore unavailable.

5. ACKNOWLEDGEMENTS

We acknowledge with deep thanks the DRI Workshop hosts, NASA and NSF sponsors, and all participants and their spirit of cooperation. We also appreciate the efforts of Dr. G. Lala in preparing the figures.

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CCN-SUPERSATURATION SPECTRA SLOPES (k)

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ABSTRACT

Theoretically the slope k of a CCN-supersaturation spectrum ($N = cS^k$) should equal two-thirds of the slope of the total (soluble) aerosol size-distribution. Workshop results tended to verify this relation. As has been noted before, the k values are markedly different depending on whether one is measuring ambient CCN concentrations at supersaturations S above or below ∿0.1-0.2%. The larger k values for $S \lesssim 0.1\%$ is consistent with the greater decrease in large particle concentration with increasing size. Over the S range of 0.02% to 2%, two power fits (and k values) may sometimes suffice for a reasonable approximation of the CCN distribution. At other times, and with laboratory generated aerosols, such an approach is inadequate and requires refinement.

1. INTRODUCTION

Since the inception of cloud condensation nucleus measurements, it has been observed experimentally that nucleus concentration N versus supersaturation S can be expressed reasonably well by the power function

$$N = cS^k \text{ (Twomey, 1959).} \qquad (1)$$

With thermal gradient diffusion chambers operating above ∿0.2%, slope values k typically range from about 0.4 to 1.0. Early indications were that lower values are associated with maritime aerosols and the higher values with continental aerosols (Twomey, 1959; Kocmond, 1965; Jiusto, 1967). Twomey and Wojciechowski (1969) in an extensive aircraft measurement program over various parts of the world reported average k values aloft of 0.5 and 0.7 (0.2 to several % S) for continental and maritime air, respectively.

From Köhler theory for droplet growth, it is evident that the critical supersaturation and size of soluble nuclei are related by $S_c \propto r^{-3/2}$. Similarly a Junge power-function relation exists between particle size and cumulative particle concentration: $N_{cum} \propto r^{-\beta}$. Combining these relations with expression (1) above lead to:

$$k = 2/3\ \beta \qquad (2)$$

where β is the slope of the total soluble aerosol size distribution. Junge and McLaren (1971) demonstrated that the shape or slope k of a CCN supersaturation spectrum is more dependent on aerosol size distribution than on aerosol composition, provided the particles are at least 10% soluble. Added confirmation was provided by an analysis of data from the 1970 Fort Collins Nucleus Workshop (Fitzgerald, 1973).

Because Junge total aerosol size distributions often have slopes $\beta \gtrsim 3$ for particle radii >0.1 μm, CCN k slopes of 2 are sometimes mentioned. This misconception is occasionally encountered in the literature. At chamber supersaturations of 0.2-1%, nuclei much smaller than 0.1 μm radius are activated as well. Because of their much greater abundance, the resultant k values should be weighted to the flatter portion of the Junge curve and hence yield values less than 2 and generally less than 1.

Conversely, at low supersaturations <0.1-0.2%, where larger condensation nuclei are activated, one should expect higher k values. Such evidence was first reported via direct measurements by Laktionov (1973). Subsequently, the development of "haze" chambers operating at low supersaturations confirmed the trend (e.g., Hoppel, 1978; Hudson, 1980).

Clearly, the topic of CCN spectra shape over a broad range of supersaturation deserves further resolution. This International CCN Workshop, with its variety of chambers, offered an opportunity to explore such questions as:

a. Is the relation $k = 2/3\ \beta$ generally valid?

b. Over what S range can one safely apply the empirical function $N = cS^k$ with a single k value?

c. For ambient air, will two k values suffice for the respective supersaturation ranges less than or greater than about 0.2%?

2. APPROACH

Detailed particle size distributions were obtained at the Workshop by NRL with their highly advanced mobility analyzer. (See section by Hoppel and 23 size spectra so produced). From the NRL cumulative size distributions, one can readily calculate slopes (β_i) between two size increments and also average β over any desired size range. Figure 1 illustrates the equivalent k (2/3 β) values versus size for the polydisperse NaCl aerosol generated during Experiment 2. The critical supersaturation S_c scale corresponding to NaCl dry particle size is also shown. For the two salts employed at the Workshop, the approximate function relations between critical supersaturation and dry particle size are:

$$\begin{aligned} S_c &= 1.31 \times 10^{-11}\ r_d^{-3/2} \text{ (NaCl)} \\ S_c &= 2.01 \times 10^{-11}\ r_d^{-3/2}\ (NH_4)_2SO_4 \end{aligned} \qquad (3)$$

For experiments with ambient air, it was tentatively assumed that aerosol composition could be approximated by ammonium sulfate particles.

CCN spectra values of k were calculated for selected instruments and experiments, based on final Workshop data printouts provided each participant. Slopes k were determined for rather narrow supersaturation increments (three successive S values) as dictated by each instrument's operating levels. Also k was caluclated for broad S ranges over which each instrument normally functions, i.e., ∿0.2-1.5% for static diffusion chambers (SDC) and continuous flow diffusion chambers (CFD) and ∿0.01-0.2% for haze chambers.

Listed in Table 1 are the CCN instruments considered in this preliminary analysis.

TABLE 1

CCN Instrument Numbers, Types, and Organizations

Instrument No.	Group	Operator	Chamber Type
10	SUNY	Lala	SDC
11	NRL	Hoppel	Haze
13	CSIRO	Ayers	SDC
14	DRI	Hudson	Haze
15	DRI	Rogers	CFD
17	NRL	Wojciechowski	SDC
21	UMR	Alofs	Dual CFD and Haze

3. RESULTS

3.1 CCN Slopes Above and Below 0.2% S

Table 2 presents the k values for broad S ranges above and below ∿0.2%. Theoretical values computed from NRL particle size data (k = 2/3 β) are indicated followed by actual measured values ($N = cS^k$) for given CCN chambers.

Overall, the comparisons between CCN instruments and between calculated and measured k values are quite respectable. This is particularly true when one considers that the instruments were not operated over identical S ranges or time intervals. The former diluting effect can be appreciated from Figure 1, where it is evident that a modest shift in the S range covered would lead to differing k averages, particularly at the large particle (low S) end of the spectrum. Also, time variations in ambient aerosol concentrations were considerable and would influence the comparative results from different instruments requiring anywhere from 10 minutes to 30 minutes, respectively, to complete a CCN spectrum. The NRL mobility aerosol (size) analyzer data represent the smoothed average of typically 2 to 4 size spectra (∿25 min each) over the duration of an experiment.

While the number of cases is limited, one may note that for ambient aerosols, the slope values for $S > 0.2\%$ were typically less than 1, and for $S < 0.2\%$ were much steeper ($k \gtrsim 2$ to 3). This is consistent with prior field measurements and with Junge type aerosol distributions. Laboratory-generated aerosols also showed a steeper slope k at low S, reflecting an analogous greater decrease in large particle concentration with increasing size.

If k values for ambient aerosol monotonically increased with size over, say, the 0.1-1.0% S range as shown for a lab aerosol (Figure 1 and others to follow), then a single k value would hardly suffice.

3.2 CCN Slopes over Narrow Size (S) Increments

Finer increments of the size and supersaturation spectra were examined in terms of their associated k values. The results are shown in Figures 2-6 for laboratory and ambient aerosols. Again the solid line represents k values constructed from the NRL MA particle size distributions. Superimposed are measured k values as obtained with the four indicated CCN chambers. Some observations are as follows:

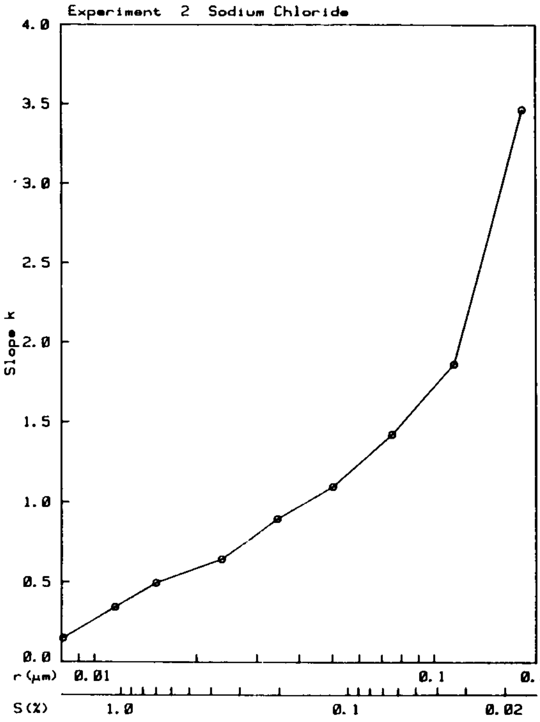

Figure 1. Slope k derived from mobility analyzer data as a function of dry particle radius (critical supersaturation computed). In this and subsequent figures, each plotted point typically represents the average over the interval bounded by immediately adjacent points.

With the possible exception of Experiment 17 (Figure 6), the agreement between theoretical and measured k values is considered good for $S > 0.2\%$ for both ambient and laboratory aerosols. Agreement is also reasonably good for $S < 0.2\%$ for laboratory aerosols (Figures 2 and 3), but not for ambient air (Figures 4 and 5). In ambient air, the typically higher measured k values for $S < 0.2\%$ may be due to sample time and concentration variations or to inherent accuracy limitations of sparse data. However, it may be that particles larger than ∿0.1 μm with suitable fractions of soluble material to serve as effective CCN have steeper aerosol distribution slopes than the total (Junge-type) aerosol distribution. Evidence is accumulating (e.g., Meszaros, 1968; Winkler, 1970) to the effect that large particles > 0.1 μ have considerably lower solubility ratios than smaller particles.

In the 0.2-1.0% S range, the ambient aerosols tested do seem to possess a reasonably flat k plateau. This generally was not the case in the .02 to 0.2% S range.

Experiment 17 (Figure 6) was a case in which the ambient aerosol concentration fluctuated greatly with time. A good deal of the scatter in the

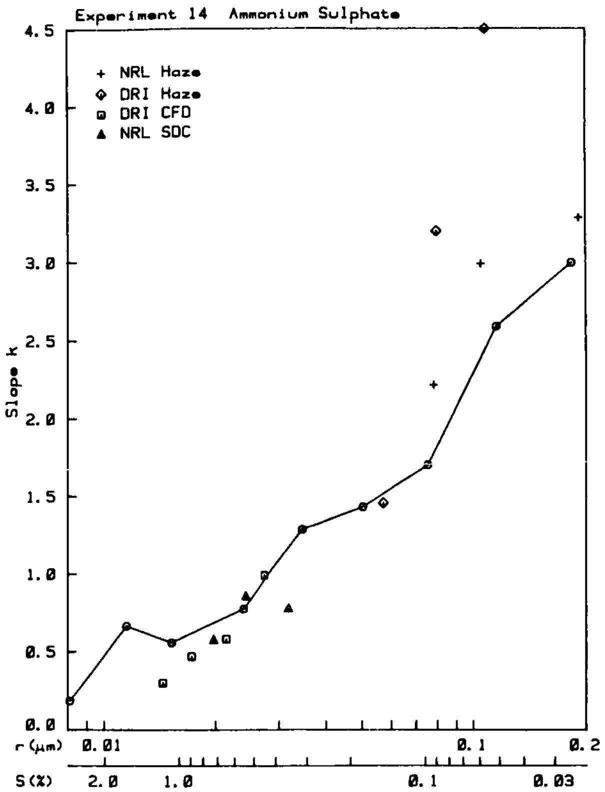

Figure 2. Comparison of k values from CCN spectra (four instruments) and from mobility analyzer derived slopes (solid line) -- laboratory aerosol.

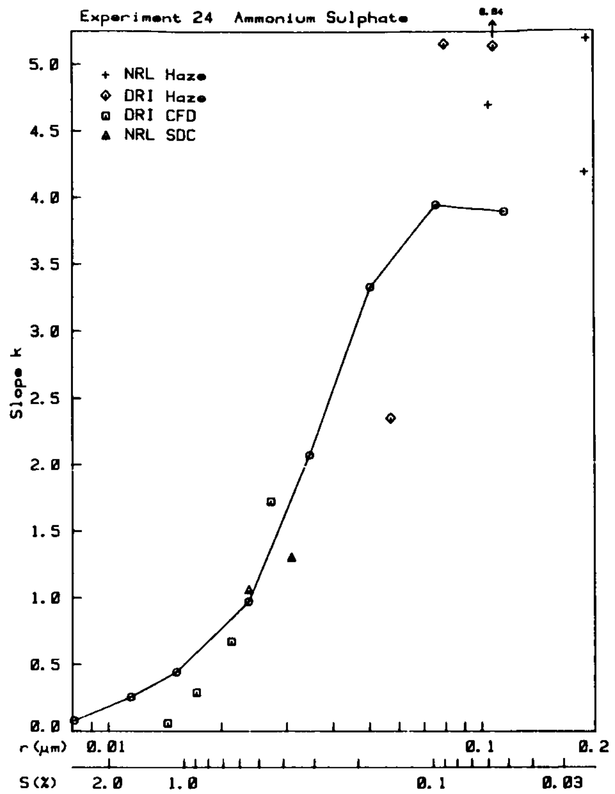

Figure 3. Comparison of k values from CCN spectra (four instruments) and from mobility analyzer derived slopes (solid line) -- laboratory aerosol.

TABLE 2

CCN Supersaturation Slopes k*
Instrument Number and Type

				SDC		CFD				Haze	
Experiment No.	Aerosol	NRL MA†	10	13	17	15	21	NRL MA†	11	14	21
2	NaCl	0.69	--	0.50	0.49	--	0.79	2.48	1.78	2.57	1.63
14	$(NH_4)_2SO_4$	0.89	0.63	0.71	0.67	0.67	1.0	2.47	2.81	3.31	2.66
23	$(NH_4)_2SO_4$	0.96	0.66	1.49	1.07	0.93	1.33	2.62	4.80	4.61	4.16
23	$(NH_4)_2SO_4$	1.21	0.90	1.01	1.01	0.93	1.60	3.91	4.82	5.22	3.85
6	Ambient	0.83	0.75	0.74	0.85	0.91	--	2.28	3.08	3.76	1.83
11	Ambient	0.62	--	0.37	0.39	0.44	0.51	2.02	2.60	2.29	3.80
17	Ambient	0.93	1.08	0.83	0.63	1.27	2.32	1.95	2.98	2.14	2.71

*For SDC and CFD Chambers - S range from ∿0.2 to 1.5%
For Haze Chambers - S range from ∿.01 to 0.2%

†NRL Mobility Analyzer (MA), sometimes referred to in other Workshop data as the NRL Electrical Classifier (EC).

data can undoubtedly be attributed to this factor. Under such circumstances, CCN instruments with short time constants are distinctly advantageous. Otherwise a storage vessel for "grab samples" should be employed. If the NRL mobility analyzer curve is truly representative (and not also influenced by temporal aerosol variations), it is evident that a single k value in the 0.1-1% S range would be questionable.

4. CONCLUSIONS

Much more is known about CCN concentration variations than about the shape (k) of the CCN supersaturation spectrum. While experiments at the Workshop were not specifically designed to focus on k values, some relevant information was obtained as a byproduct. Some preliminary insights gained were as follows:

a. From Köhler theory and ambient aerosol distributions, it is predicted that $k = 2\beta/3$, where β is the slope of the (soluble) total aerosol size distribution. Workshop results tended to verify this relation.

b. Over the typical S range (0.2 to 1%) of many CCN counters (SDC's and CFD's), the CCN spectrum slope in the ambient air cases was generally uniform; such is necessary for applicability of a single-valued power function of the form $N = cS^k$. A uniform k does not hold for the laboratory generated aerosols, and is not always an accurate approximation in ambient air.

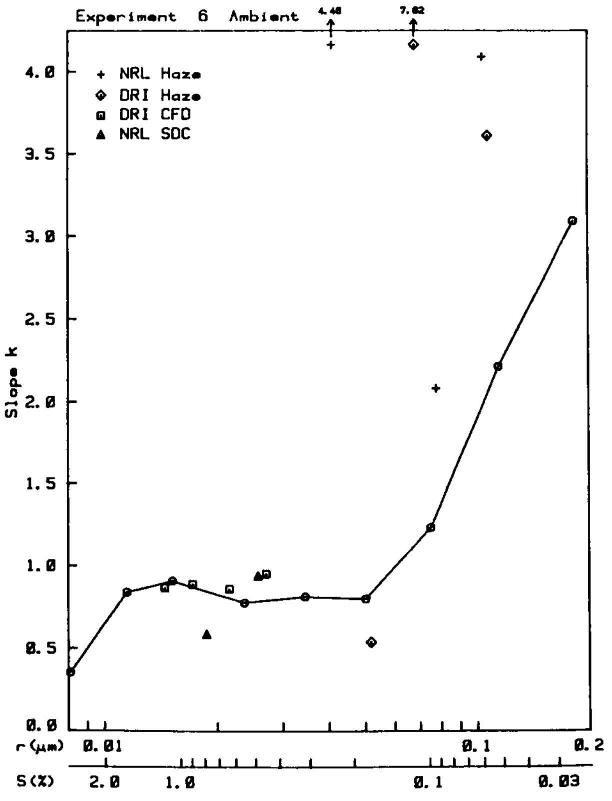

Figure 4. Comparison of k values from CCN spectra (four instruments) and from mobility analyzer derived slopes (solid line) -- ambient aerosol.

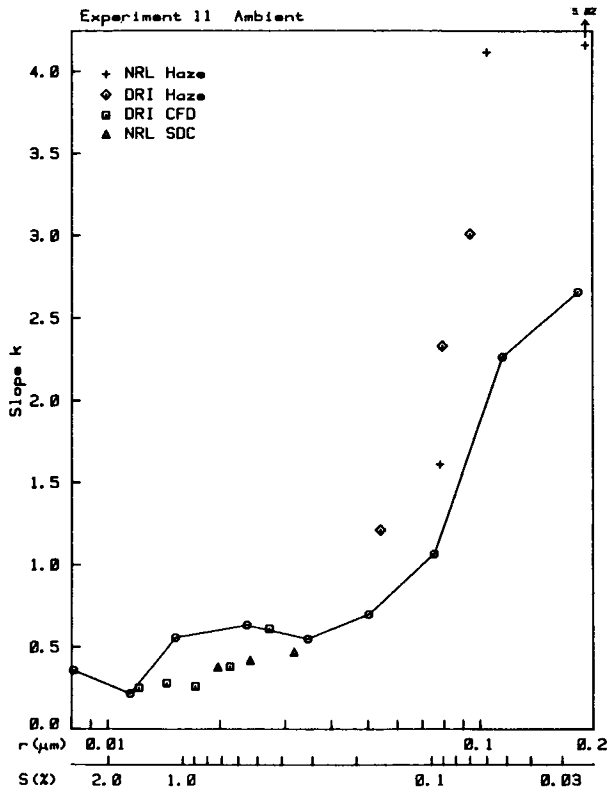

Figure 5. Comparison of k values from CCN spectra (four instruments) and from mobility analyzer derived slopes (solid line) -- ambient aerosol.

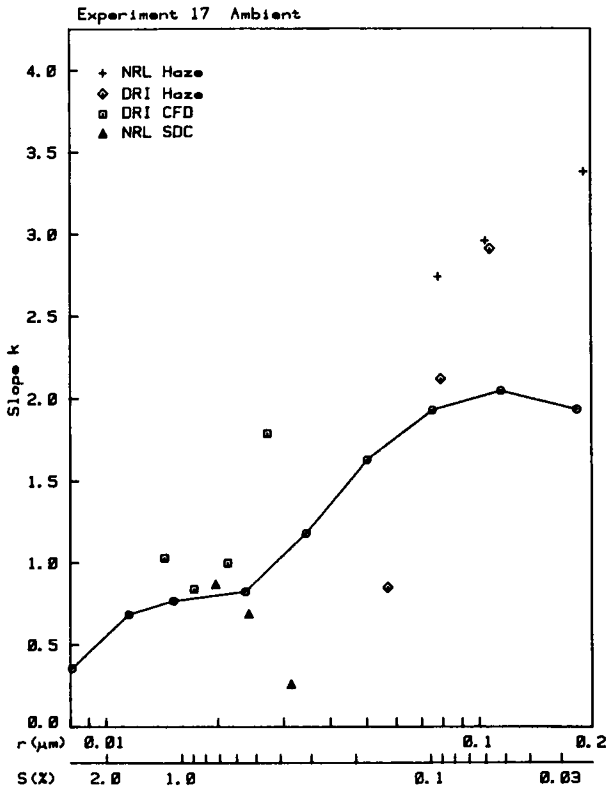

Figure 6. Comparison of k values from CCN spectra (four instruments) and from mobility analyzer derived slopes (solid line) -- ambient aerosol.

d. At supersaturations from ~0.01-0.2%, k values were much larger and seemingly less constant over the S range of interest. Future measurements will help determine whether a single power fit is adequate in this range.

e. The measured k values for ambient air in this low S range were typically larger than those calculated from an assumed soluble aerosol size distribution. This may merely reflect insufficient data and lack of suitable experimental control. However, another hypothesis to examine is whether these larger CCN particles, with suitable effective solubility ratios, decrease in number more rapidly with size than the total aerosol distibution.

f. CCN concentrations can change quite rapidly with time in ambient air. Unless fast-response CCN counters are used or large point-sample containers employed, erroneous k values and power functions can result.

5. ACKNOWLEDGEMENTS

We acknowledge with deep thanks the DRI Workshop hosts, NASA and NSF sponsors, and all participants and their spirit of cooperation. The NRL Mobility Analyzer data generously provided by Dr. William Hoppel was indispensable in the evaluation.

This analysis was partially supported by the National Science Foundation (Grant ATM7624048-02, Atmospheric Research Section) and by the Army Research Office (Contract No. DAAG29-81-K-0019, Geosciences Division).

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MEASUREMENT OF THE AEROSOL SIZE DISTRIBUTION WITH NRL'S MOBILITY ANALYZER

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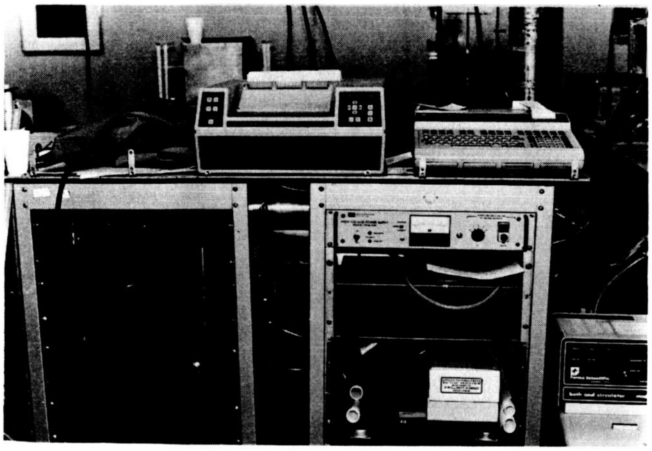
ABSTRACT

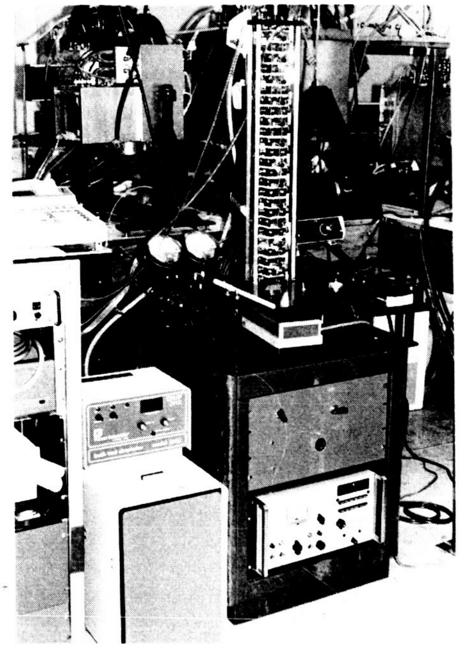
The size distribution of the aerosol sample generated at the International CCN Workshop was measured with the NRL mobility analyzer/size spectrometer in the size range between 0.0057 and 0.57 µm radius. A description of the instrumentation and data analysis is given, together with the measured size distributions calculated for each of 23 experiments carried out at the Workshop.



The size distribution of aersol particles between 0.0057 µm and 0.57 µm radius was measured with NRL's mobility analyzer. The basic instrument is shown in Figure 1. The aerosol sample is first brought to charge equilibrium by passing the sample through a region of bipolar ionization. The sample air enters the mobility analyzer through a slit in the outer cylindrical wall where it is confined to a thin laminar layer along the wall by filtered sheath air. A small amount of filtered air is extracted through a slit in the inner electrode. When a voltage is applied to the inner electrode, those particles which are charged and lie in a narrow mobility range will be withdrawn with the extracted air. By measuring the particle concentration in the extracted air as a function of voltage, the mobility distribution of the charged fraction can be obtained. From the mobility distribution of the charged fraction (of one polarity) and the equilibrium (Boltzmann) charge distribution, the size distribution can be calculated. The theory of the analyzer and the analytical procedure for obtaining the size distribution has been given by Hoppel (1978).

The concentration of particles in the extracted air is much lower than in the sample air. The first data obtained with the mobility analyzer was taken by measuring the concentration in the extracted air with a Pollak counter. Although the long-tube Pollak counter is probably the most sensitive of the light scattering CN counters, its use imposed rather severe limitations on the sensitivity of the system. Useful size distributions could be obtained in atmospheres which had high concentrations of particles but when the total count dropped below about 1000 particles per cm^3 the system could not be used. Even at higher concentrations the sensitivity was not adequate to detect particles in all size channels over the specified range.

In an attempt to increase the sensitivity of the system, a single particle condensation nucleus counter was developed at NRL, which now allows much greater sensitivity and has made it possible to automate the system. While this new continuous particle counter is currently used as part of the mobility analyzer system, it is novel and will possibly have other applications in regard to CCN and CN. Figure 2 shows the design of the segmented thermal gradient CN counter for single particle counting. The sample air enters along the axis of the chamber and is surrounded by filtered, humidified sheath air. The walls are water saturated with alternating segments maintained at alternating temperatures. The basic principle is similar to that employed in the TGDCC where a supersaturation exists between horizontally oriented hot and cold plates with saturated walls. The TGDCC is limited to measuring particles activated in a narrow range of supersaturations between about 0.2% and 1.0% due to well-documented reasons related to fall-out during the time required to establish the equilibrium supersaturation in the TGDCC. The advantage of the



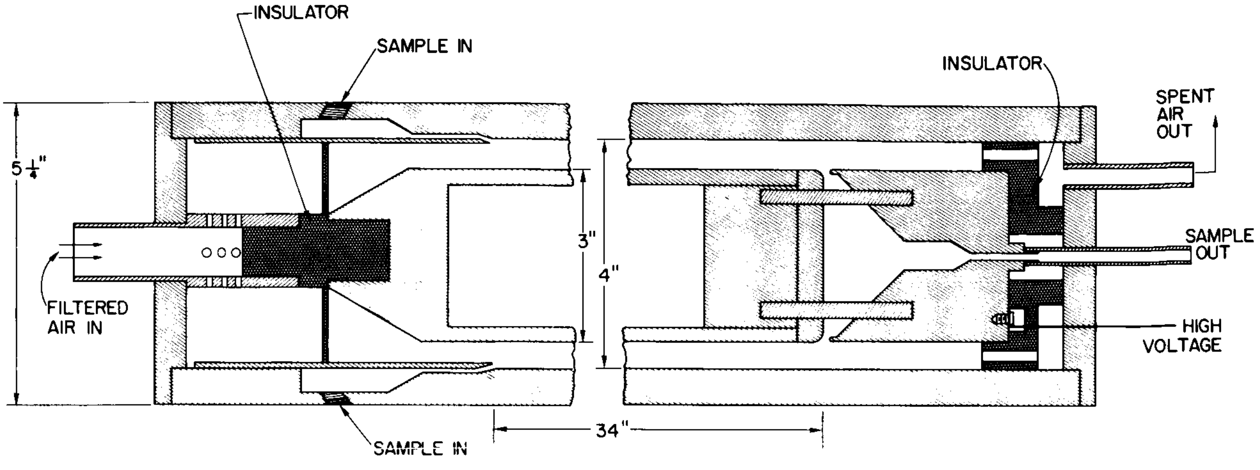


Figure 1. Diagram of NRL Mobility Analyzer.

segmented chamber is that particles falling vertically are not lost and the segmented geometry suppresses large scale convective motions which would occur between vertically oriented hot and cold walls. The criteria in designing the segmented chamber is that the air flow rate must be such that the residence time in a single segment is short compared to the time required for moisture or heat to diffuse in from the walls to the center; whereas the residence time of the sample in the entire chamber must be longer than the diffusion time. When this criterion is met, the air along the axis will reach a temperature and vapor pressure which is approximately midway between the temperature and vapor pressure of each segment. Along the axis the asymtotic supersaturation will be the same as exists in the center of a TGDCC working at the same temperature difference. Figure 3 shows the development of the supersaturation within the chamber. Details of the design and analysis of the chamber are given by Hoppel, Twomey, and Wojciechowski (1979, 1980). The particles are nucleated and grown to optically detectable sizes in the segmented chamber and then transmitted directly into an optical counter for single particle counting. When the segmented chamber is used with the mobility analyzer, a small portion of the output sample from the mobility analyzer is passed from the analyzer to the segmented chamber for counting. At the Workshop, the chamber was operated at a temperature difference of about 20°C which results in a supersaturation of about 20 percent.

The system (mobility analyzer and segmented chamber) has been operated using either 21 or 11 size channels to cover the specified range. After considerable experience with atmospheric measurements, it was decided to standardize to 11 channels when the system was automated. The reason for using fewer channels is that it takes about 18 minutes to cover 11 channels and about twice that long for 21 channels. In the atmosphere the increased resolution offered by 21 channels is less important than making the measurement as quickly as possible because of temporal changes in concentrations. On those occasions at the CCN Workshop when very stable nearly monodisperse particles were generated, it would have been helpful to have had the added resolution of 21 channels.

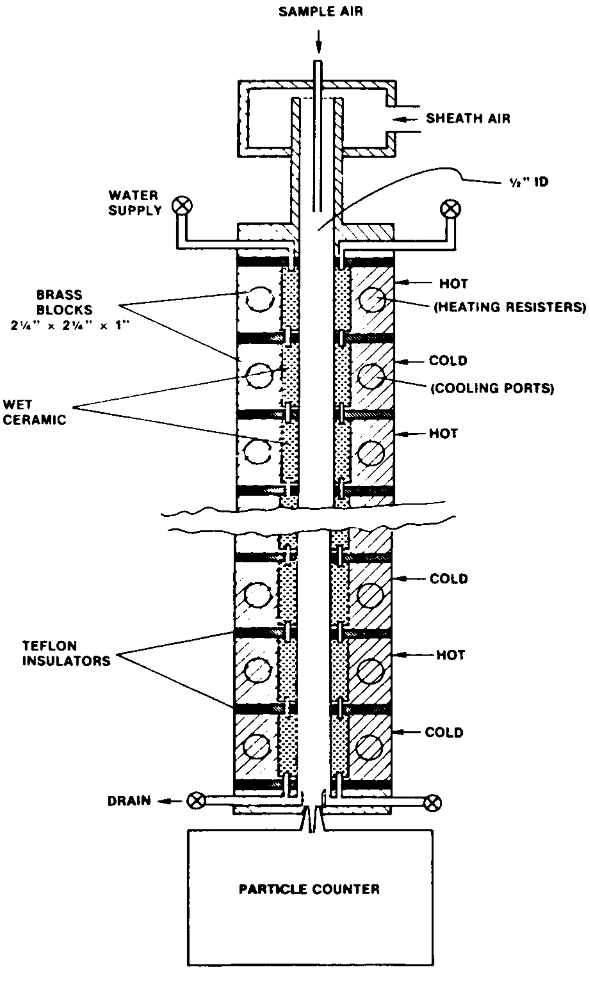


Figure 2. Design of NRL segmented CN counter for single particle counting.

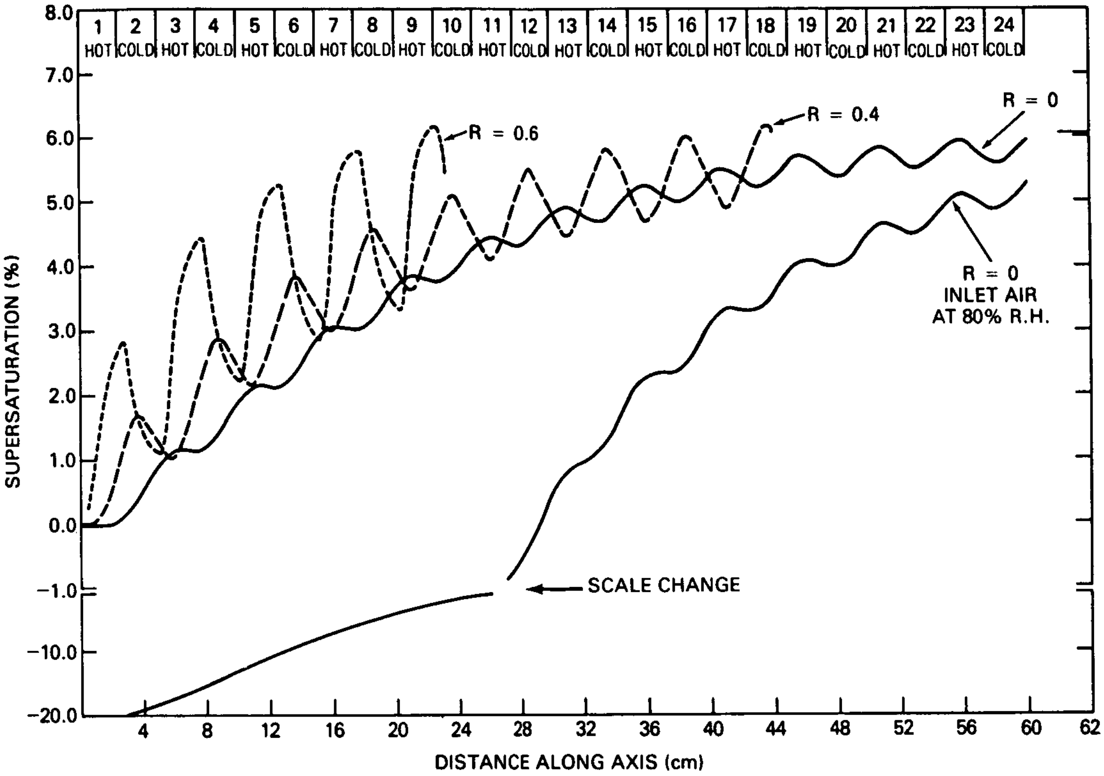


Figure 3. Supersaturation within segmented CN counter.

The system is automated with the aid of Hewlett Packard 9825 desktop computer with a real time clock. The voltage is changed every 84 seconds by a 16 bit word written to a 16 bit parallel port which controls the output of the high voltage power supply. Sixty seconds are allowed for flushing and stabilization at which time the single particle counter (Royco) is reset and two 12 second counts are recorded, averaged, and stored. The Royco is controlled through a binary port and read with a BCD interface. At the end of the cycle (12 voltage steps including zero volt background count) the computer calculates the mobility distribution and size distribution by an iterative procedure (given by Hoppel, 1978) which corrects for the effect of multiply charged particles according to the Boltzmann charge distribution. A computer controlled plotter then produces real time plots of the differential and cumulative size distribution. These size distributions were available immediately after each experiment. Usually several (two to four) individual size distributions were taken during each experiment.

After the Workshop, the raw data from the individual runs were examined and averaged. An average size distribution was then calculated for each experiment for which data was available. It is believed that the averaged size distribution is preferred to the individual distribution in all experiments for the following reasons: (1) temporal variations in the concentration may occur between voltage steps and this will distort the size distribution. The more data there is to be averaged, the less will be the distortion due to temporal variations; (2) even if the temporal variations are small, variations due to counting statistics of the samples are reduced by averaging; (3) there are occasions when the high supersaturation in the segmented chamber results in the formation of a droplet at the mouth of the Royco. When this droplet is drawn through the Royco a large spurious count is encountered. This spurious count is easily recognized by examining the count in the different Royco channels recorded as raw data. The spurious reading caused by the droplet results in a large disparity between channels which is easily detected. When the system is working correctly, the count is nearly the same in all Royco channels. In the averaged data, the spurious points are removed before averaging.

The size distributions calculated from the averaged data for each experiment are shown in the 23 figures given at the end of this contribution.

Experiments 27 and 28 were for silver iodide aerosol. The accuracy of the size distribution for these experiments cannot be trusted but the distributions are included for sake of completeness. Sivler iodide is quite insoluble and therefore many of the particles may not have been nucleated at the 20% supersaturation in the segmented chamber. Some compensation was made by increasing the supersaturation during these runs by an unrecorded amount. The raw data from the optical counter did not behave normally in that the number of particles was not the same in all channels, i.e., the particles did not appear to grow in the manner expected for nucleated droplets.

It should be pointed out that the largest channel is uncorrected for multiple charging. In order to correct a channel for the presence of larger particles with multiple charges, some knowledge of the concentration of larger particles must be available. It is therefore impossible to make this correction in the largest channel on the basis of analyzer data. However, if the size distribution is decreasing very rapidly at the largest size (as is nearly always the case), this correction will be small. Since the largest channel is uncorrected it must be viewed with suspicion.

Also, when the cumulative count drops below a few particles per cc, the count cannot be trusted because this corresponds to a raw count which is close to background levels. (This is not an inherent lower limit since this lower limit can be easily decreased further by increasing the dilution ratio in the segmented chamber. The dilution ratio is presently about 1 to 15.)

The accuracy with which the boundaries of the size channels are determined is more easily evaluated than the accuracy with which the total number of particles in that channel can be evaluated. The sizing accuracy is related to the accuracy with which the mobilities are determined. The midpoint mobility of an interval is given by

$$k_1 = \frac{\phi_1}{4\pi CV}\ (\text{esu}) = \frac{\epsilon\phi_1}{CV}\ (\text{mks})$$

Where ϕ is the volume flow rate of the sheath air, C the electrical capacity, and V the voltage. The accuracy of C and V are not in question. The airflows were remeasured by the "bubble" method at the altitude of the Workshop and are calibrated to within 3%. The accuracy to which the airflows are set and maintained throughout a given run is about 5%. A 5% error in flow results in a 5% error in mobility. A 5% error in mobility translates into approximately a 5% error in radius at the larger sizes and a 10% error in radius at the smaller sizes. The Stokes-Cunningham-Millikin relationship is used to calculate the radius from mobility. If this relationship introduces no further errors, then the maximum error in the size boundary is certainly less than 15%. It should be pointed out that the radius in the size measurement is the equivalent drag radius which may be slightly different than the "mass" radius required in the Kohler theory.

The accuracy with which the number concentration of particles in a given size channel is known depends on several factors: (1) the detection system, (2) the shape of the size distribution and, (3) the validity of the Boltzmann charge distribution. The nucleated droplets are detected by the Royco particle counter which, in this application, is used as a single particle counter and not as a sizing device. It is generally acknowledged that the absolute counting accuracy of optical counters is much better than their sizing ability. The errors due to counting are believed to be small compared to factors (2) and (3). The method of extracting the mobility distribution assumes that the distribution is nearly linear across any given channel. This assumption is not justified in the case when the distribution is strongly peaked in a single channel as was the case for many of the monodisperse experiments at the Workshop. Since the transmission function is the greatest at the center of the interval and drops to zero at each extreme, it would appear that if the peak in the monodisperse size distribution occurs at the center of one of the (preset) channels, then the total number of particles would be overestimated, whereas if the peak occurs near the boundary of the channel, the total number would be underestimated. Below a radius of about 0.02 μm the validity of the Boltzmann distribution is in doubt. There are experimental results which indicate that the Boltzmann law hold down to 0.01 μm (Lui and Pui, 1974 and Servaas and Krider, 1977), but on the other hand, there is theoretical justification to indicate that the real distribution departs from Boltzmann below about 0.03 μm and that the ratio of charged to uncharged particles is larger than predicted by the Boltzmann law.

As a result of these three factors, it is difficult to quantify the accuracy of the total numbers of particles measured with the mobility analyzer. However, we believe that the second order mobility analyzer is the most accurate method of measuring the size distribution presently available.

Acknowledgements

This work was partly supported by the Naval Air Systems Command.

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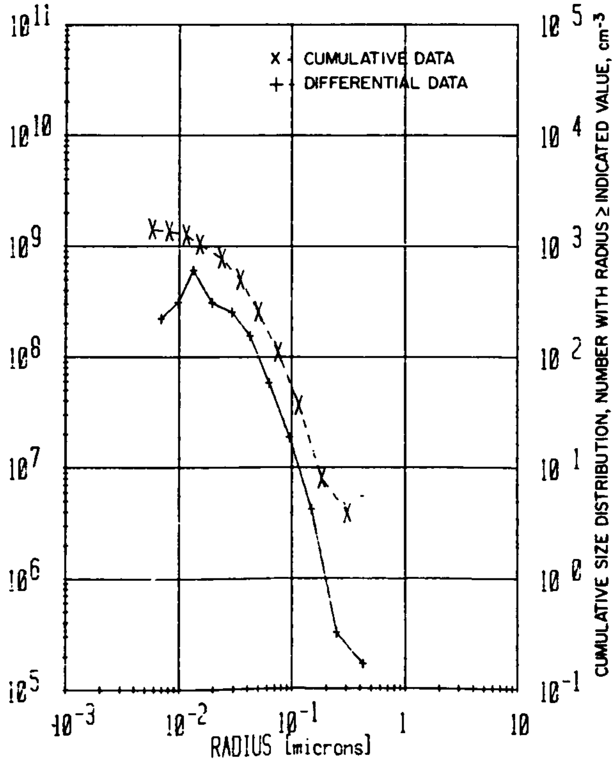
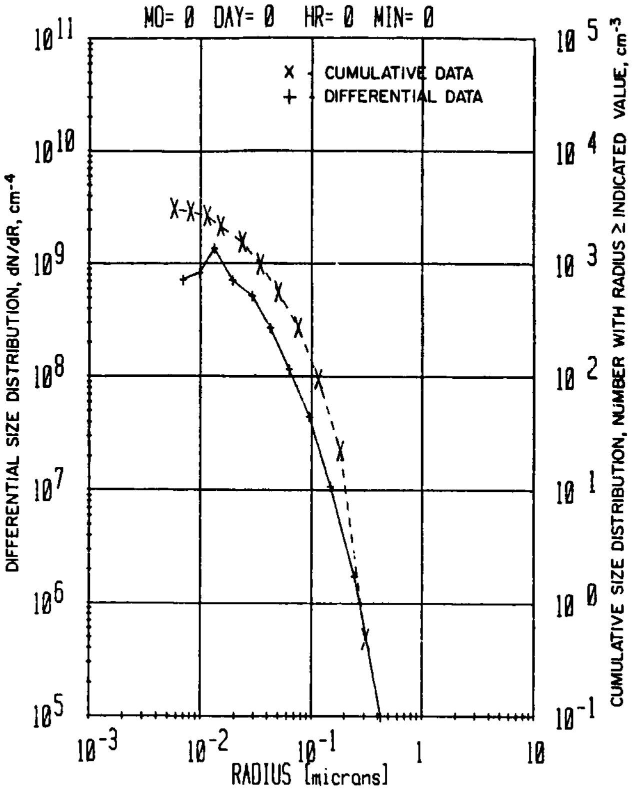


Experiment #1 - Average of 3 Runs



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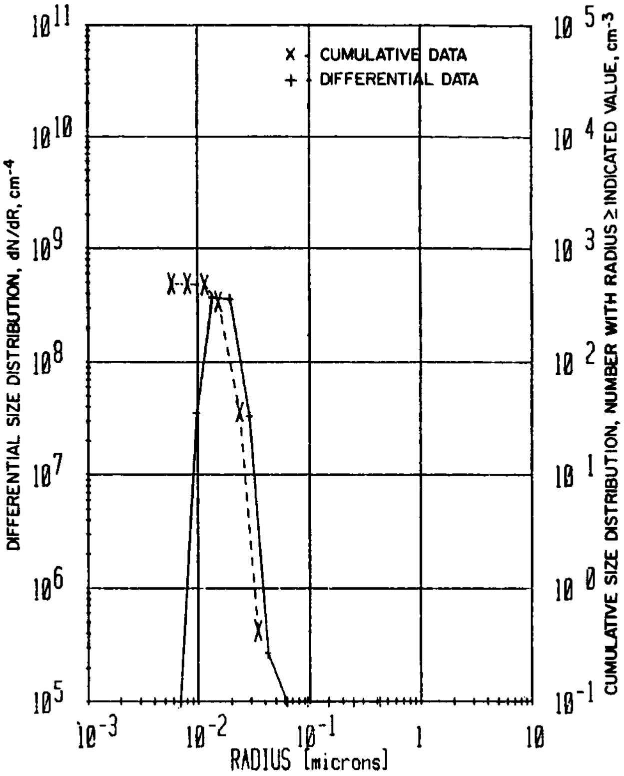

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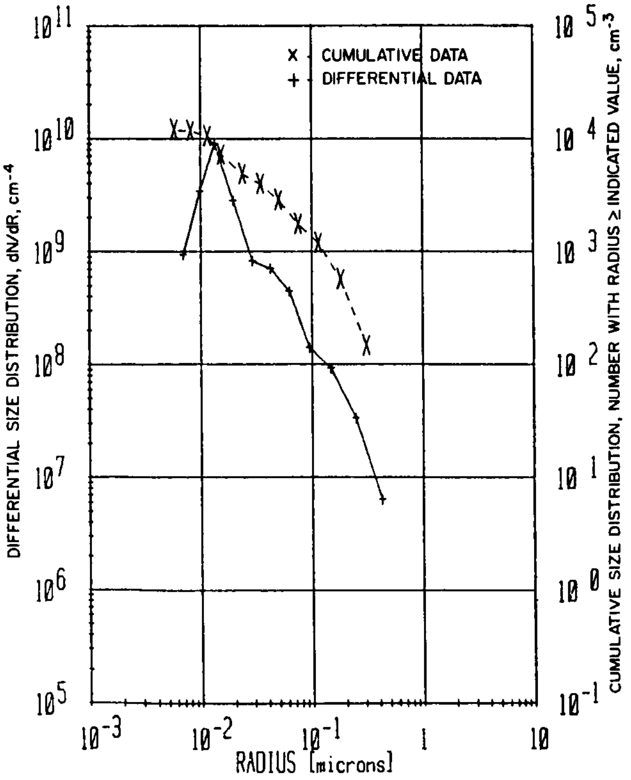
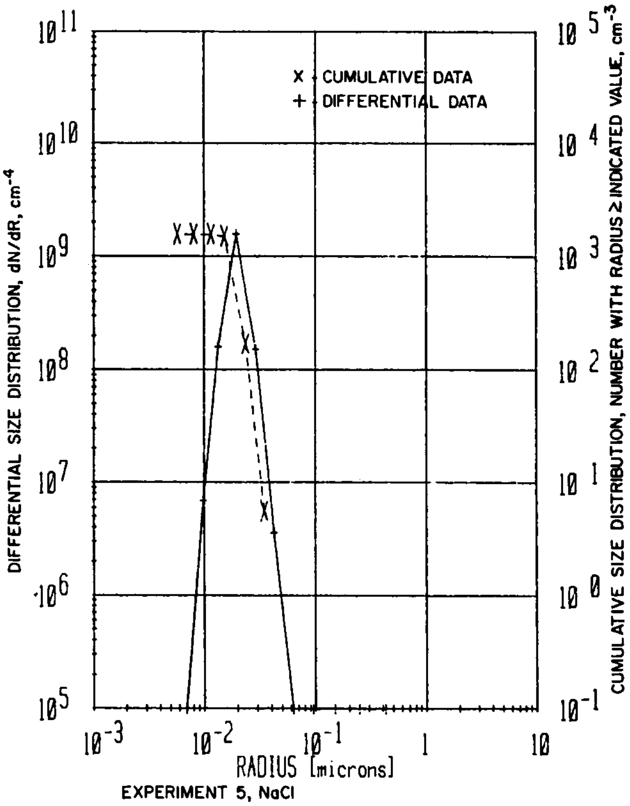
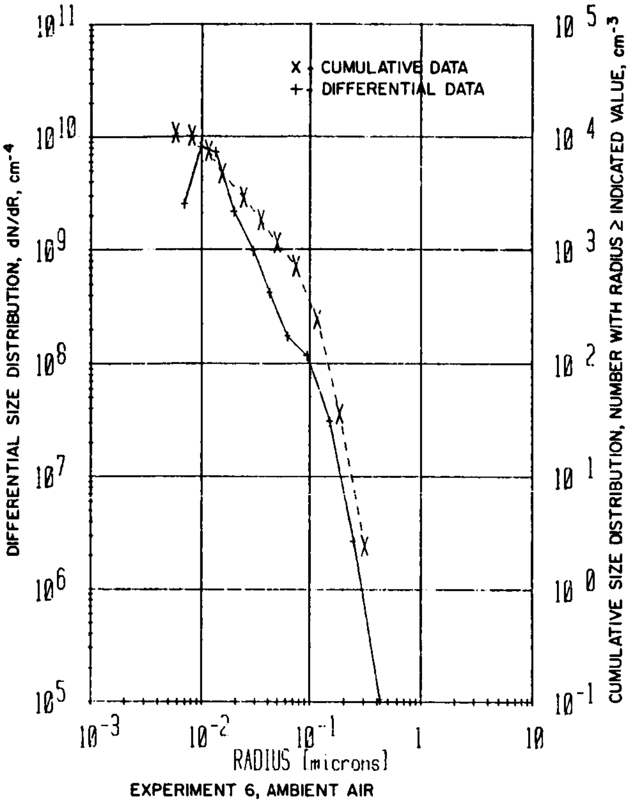


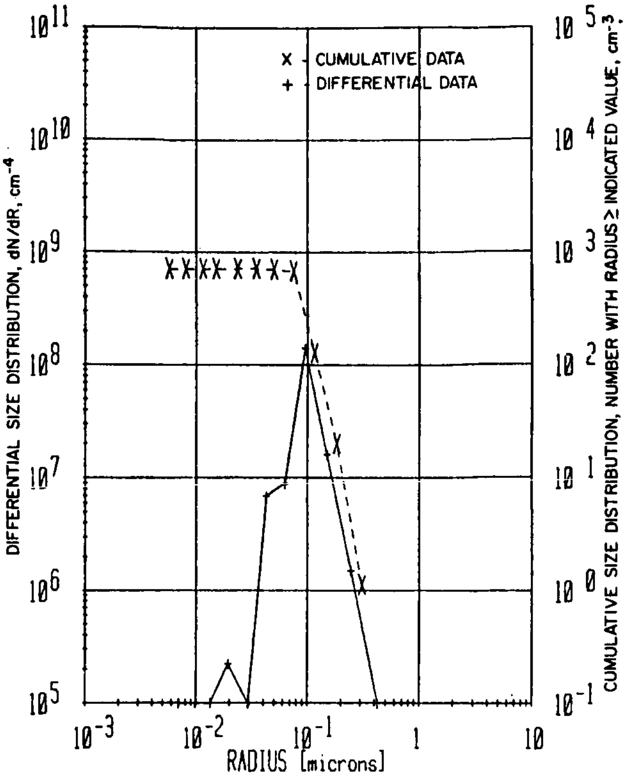
Experiment #3 - One Run Only



Experiment #5 - Average of 3 Runs



Experiment #6 - Average of 3 Runs



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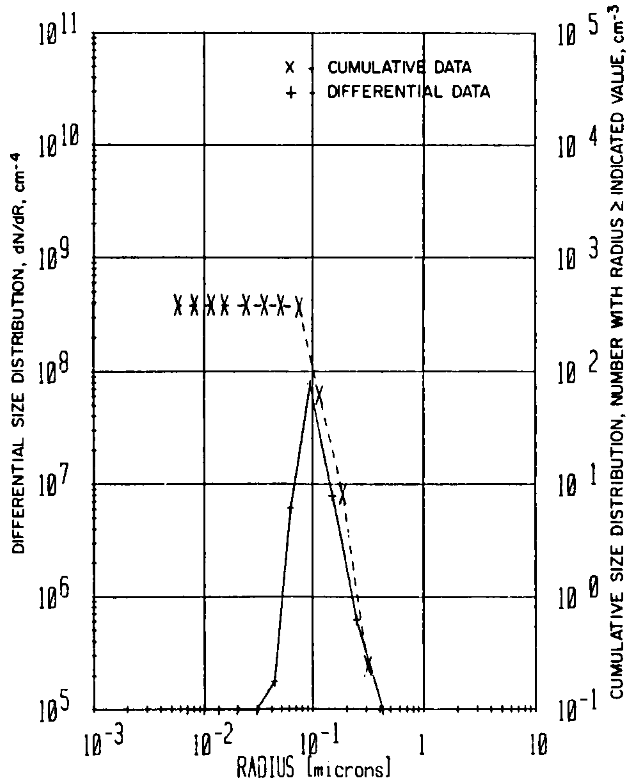
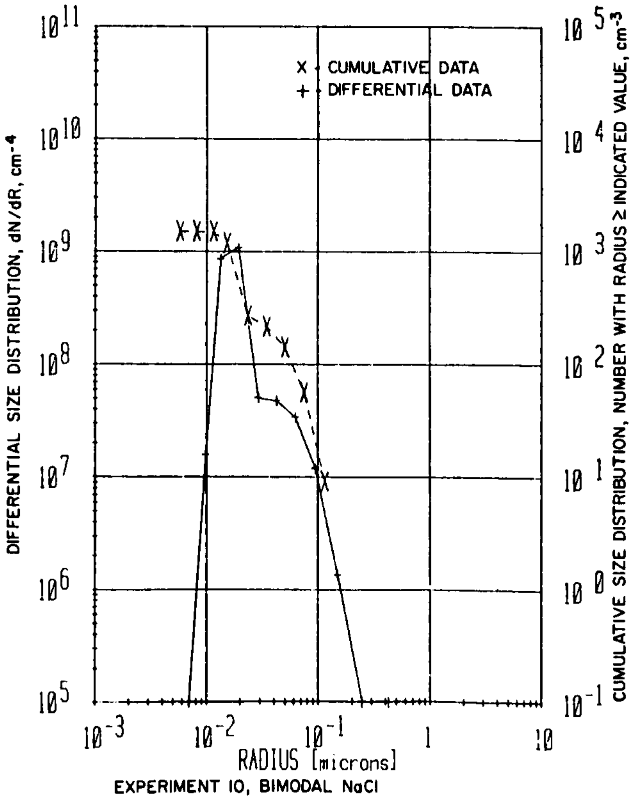
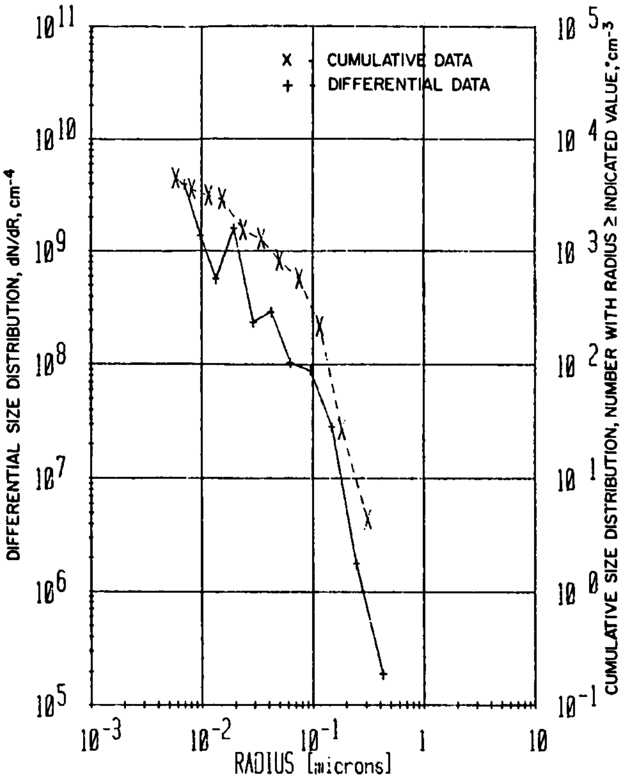


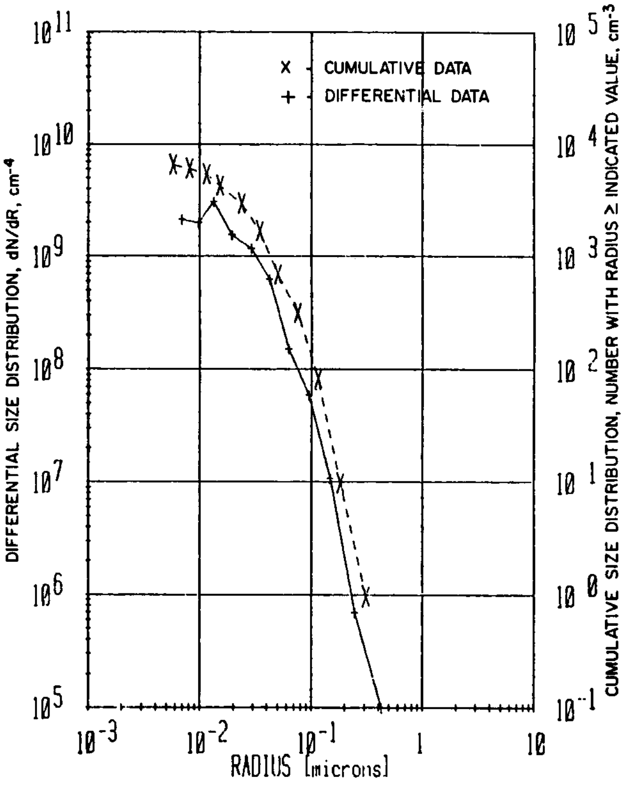
Experiment #8 - Average of 2 Runs



Experiment #10 - Average of 2 Runs



Experiment #11 - Average of 3 Runs



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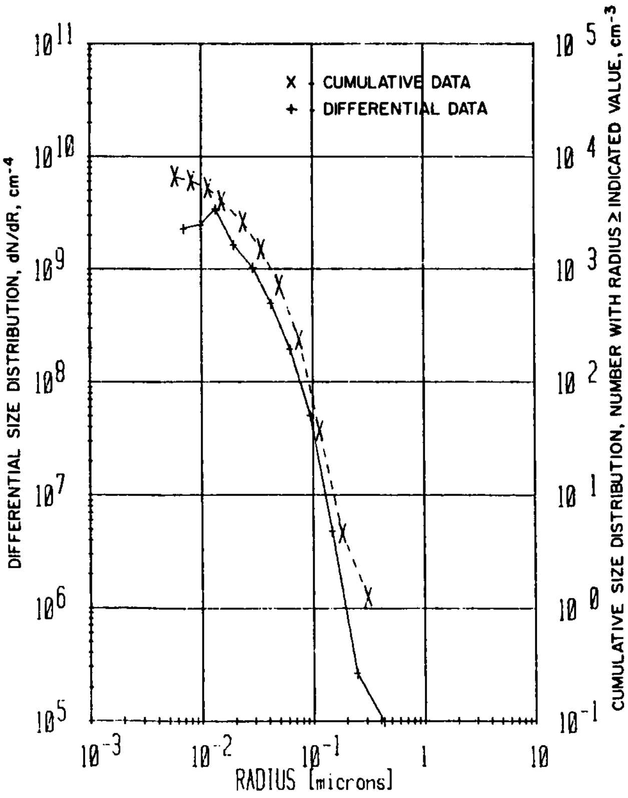
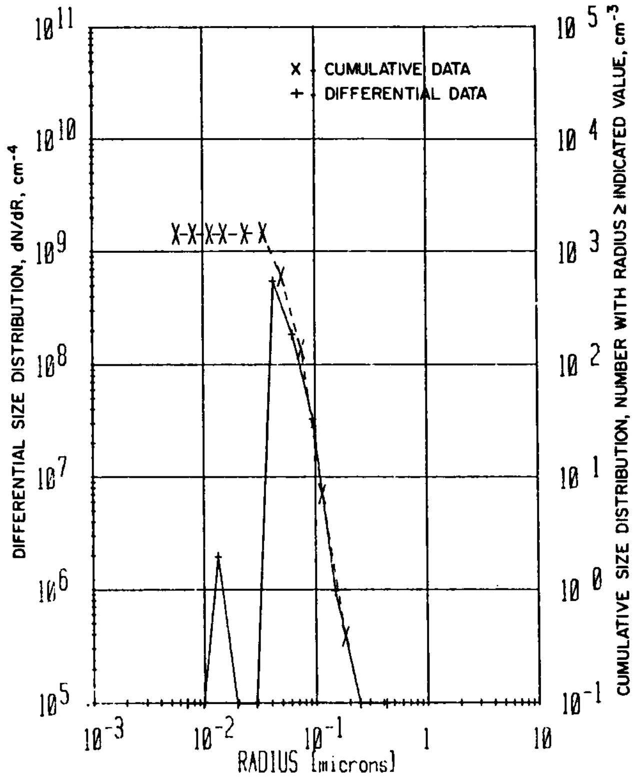


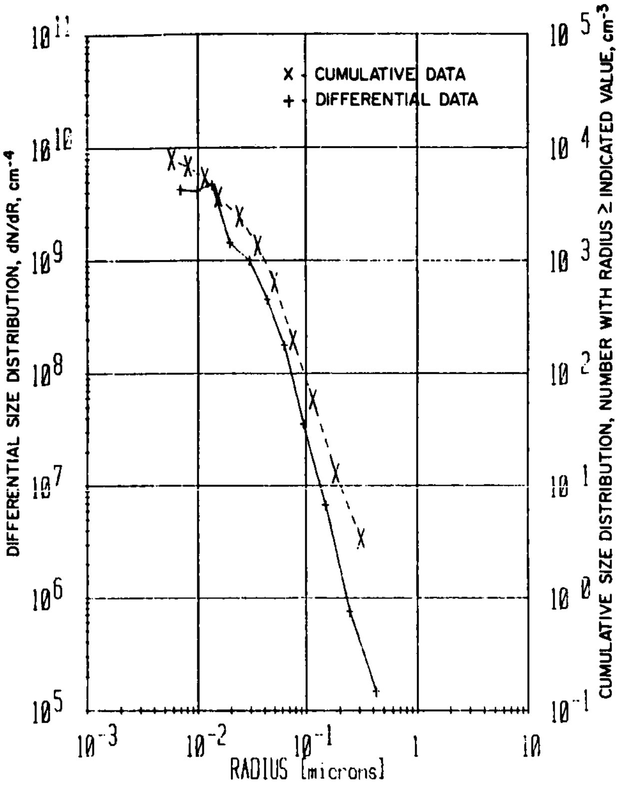
EXPERIMENT 13, POLYDISPERSE $(NH_4)_2$ SO_4

Experiment #13 - Average of 3 Runs

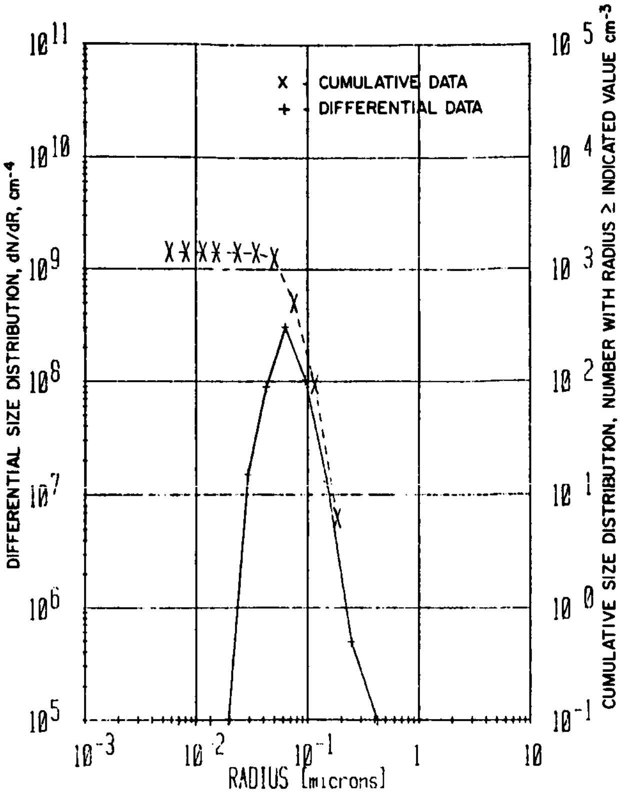


EXPERIMENT 15, $(NH_4)_2$ SO_4

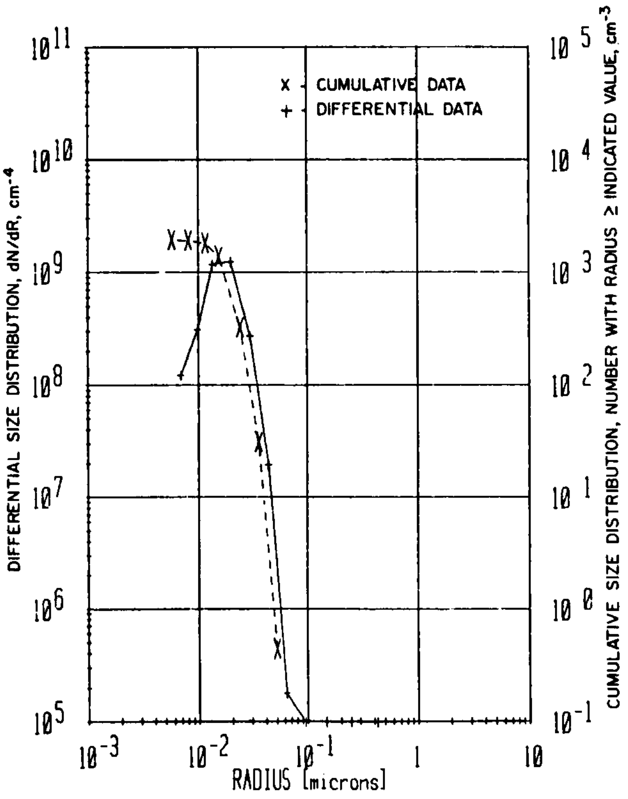
Experiment #15 - Average of 2 Runs



Experiment #17 - Average of 2 Runs



Experiment #19 - Average of 4 Runs



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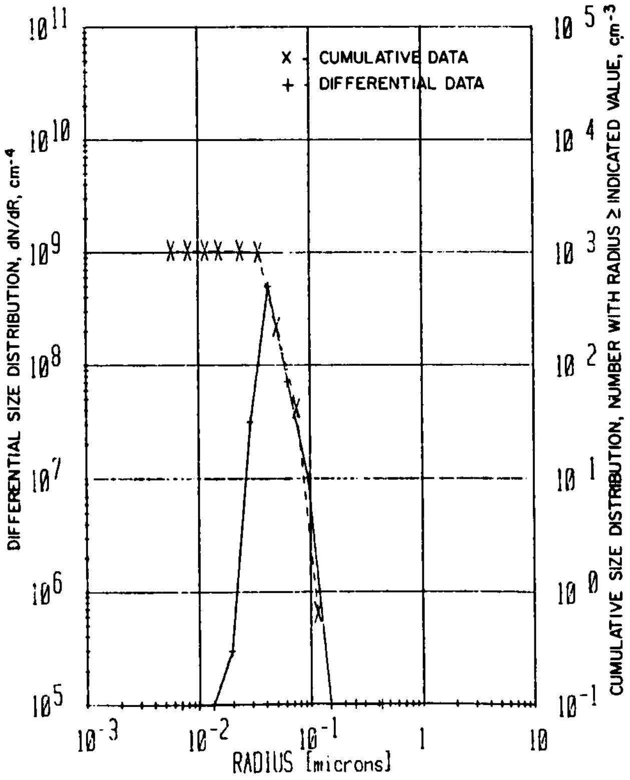
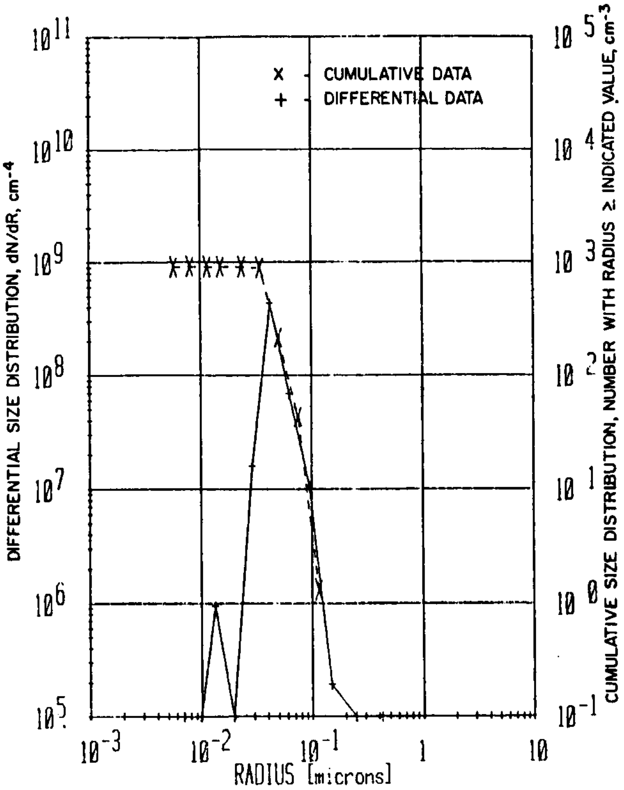
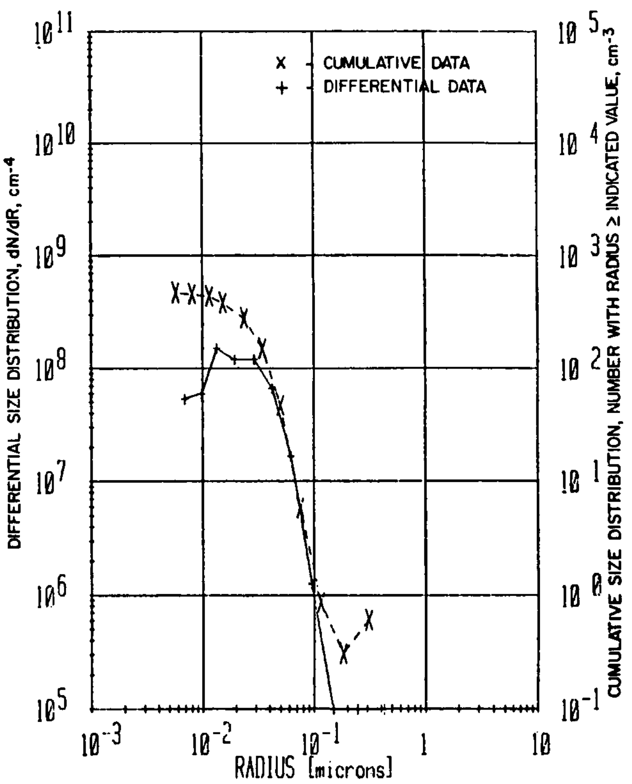


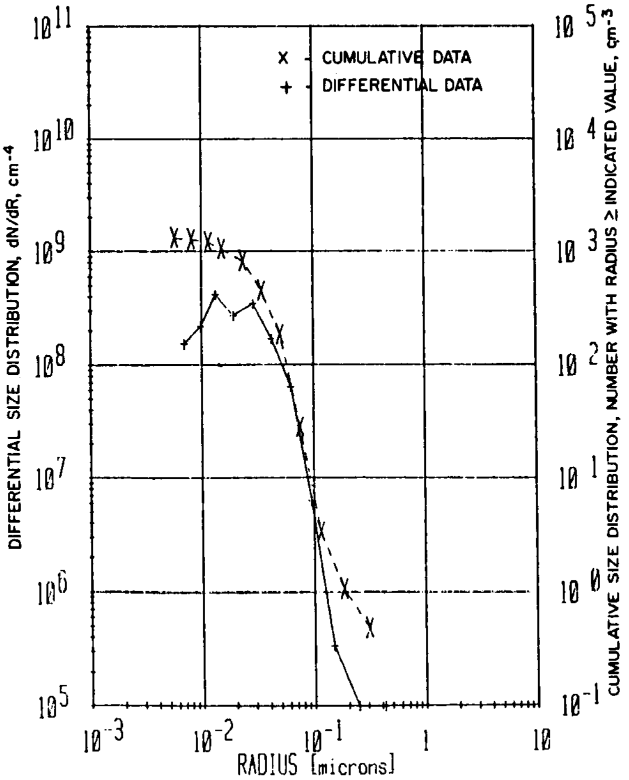
Experiment #20 - Average of 4 Runs



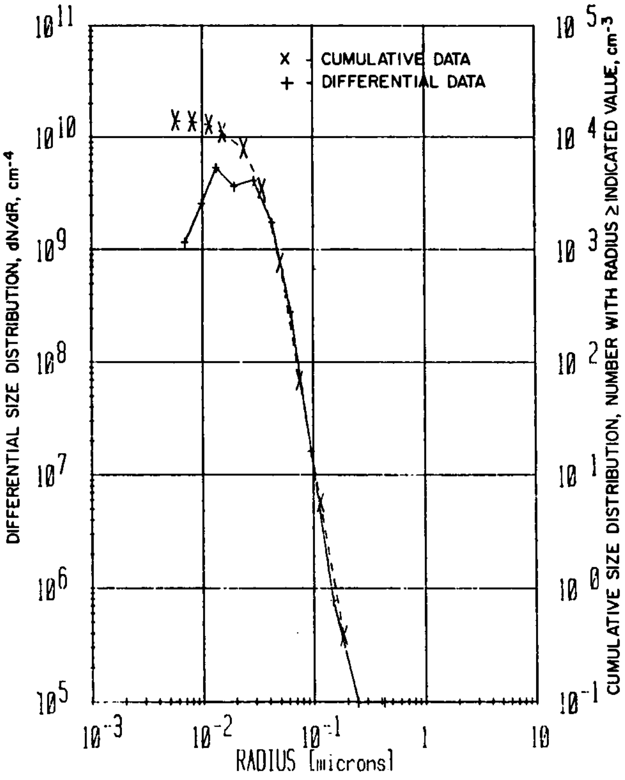
Experiment #21 - Average of 4 Runs



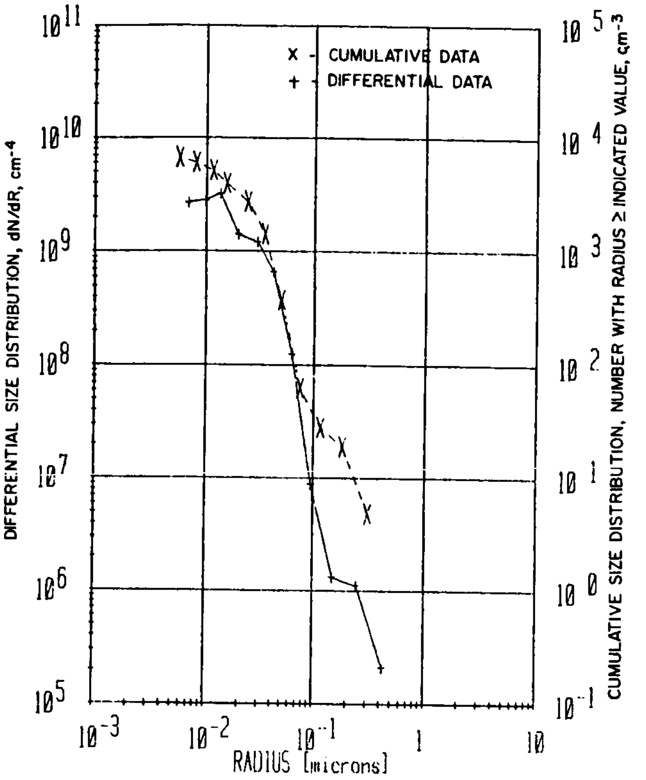
Experiment #23 - Average of 4 Runs



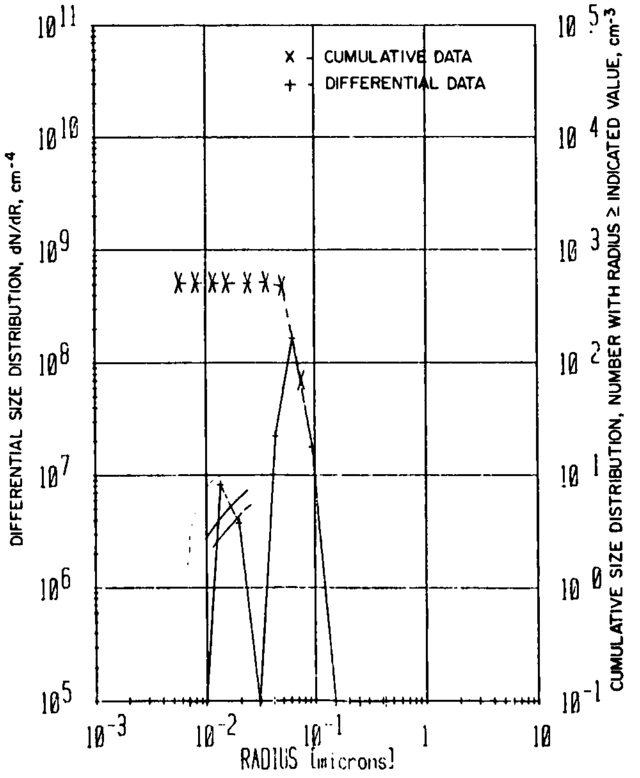
Experiment #22 - Average of 3 Runs (2,3 and 4)
[taken between 1100 and 1220; early run (#1)
was taken when the count was higher
and remains as distributed at Workshop].



Experiment #24 - Average of 4 Runs



Experiment #27 - Average of 4 Runs



Experiment #28 - Average of 2 Runs

PERFORMANCE OF THE CONTINUOUS FLOW DIFFUSION CHAMBERS

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ABSTRACT

A brief comparative description is made of the five continuous flow chambers which participated in the Workshop. Overall, comparisons for the various types of experiments - monodisperse, polydisperse and ambient aerosol - showed agreement among these chambers to within 15% in most cases. A careful analysis of the results indicated that a proper accounting of certain parameters would bring about much closer agreement among four of these instruments.

1. COMPARATIVE DESCRIPTION OF INSTRUMENTS

There were five continuous flow diffusion chambers in the Workshop. Three of these were from the Desert Research Institute (DRI), one was from the University of Missouri-Rolla (UMR), and the other was from the University of Washington. One of the DRI chambers was the conventional continuous flow diffusion (CFD) chamber, designated C. The second DRI chamber was the rapid cycle spectrometer built for NASA, designated N. The third DRI chamber was the instantaneous spectrometer, designated I. The UMR instrument acted in a dual capacity since it also was used as an isothermal haze chamber. This article will be restricted to analysis of its operation in the CFD mode. The designations M and W will, respectively, denote the UMR and University of Washington instruments.

All of these chambers moved samples of aerosol through parallel plate diffusion chambers after which the drops which formed were detected by optical particle counters. The parallel plates in all five chambers were vertically oriented although the original design of CFD chambers called for the plates to be horizontal to suppress convection. However, the widespread acceptance of vertical plates seems to indicate that this convection is not a serious problem. The direction of the sample flow was not the same in all chambers since the sample moves horizontally in the three DRI chambers (C, N and I) and vertically downward in the M and W chambers. In all five chambers, the sample was confined to a plane midway between the plates by particle-free air. The sample was spread out into a lamina in the plane midway between the plates for all chambers except UMR where the sample was an axial stream. The sample was thus confined in these chambers to keep it in the zone of maximum supersaturation which is approximately midway between the plates. In the DRI and UMR chambers, all of the sample which entered the chambers was detected by the optical particle counters (OPC's), whereas the Washington chamber detected only a small fraction of the sample which was carried through a central tube to an optical box. In all of the chambers, the time of exposure to each supersaturation was adjusted for maximum performance by using suitable lengths of the wet zones and by adjusting the total flows. The times used in each of the chambers seemed to be consistent when similar supersaturations were considered. The wet surfaces were filter paper for the C and M chambers, metal for the N and I chambers, and felt for the W CFD.

Plate temperatures in the C and I chambers were controlled by water baths whereas the W chamber had refrigeration coils in direct contact with the cold plate. The warm plate of the W chamber was heated by the exhaust gases from the refrigerator along one edge of the warm plate. The N chamber also used circulating fluid but the regulation of that fluid was done with computer-controlled thermoelectric modules.

The M plate temperatures were monitored by checking the reservoir temperatures with mercury thermometers. The C and I CFD's used thermistors imbedded in the plates whereas the N CFD used a thermopile to measure ΔT. The W chamber also used thermisters to monitor the plate temperatures.

The M, C and N chambers obtained spectra by changing plate temperatures. The former two were changed manually while the N CFD changed temperatures according to a prearranged computer program. The I and W chambers did not normally change plate temperatures. The I chamber simultaneously maintained three supersaturations by using three chambers in series and using the droplet distributions from one OPC to deduce the concentrations for three supersaturations. The W instrument had four chambers in parallel and four detectors to monitor the concentrations at four supersaturations.

The DRI chambers (C, I and N) all used Royco 225 optical particle counters while the M chamber used a Climet 201 OPC. The W chamber used four non-commercial OPC's using a single laser for illumination and four photodiodes for detectors. This system does not give as much size discrimination as the commercial OPC's, but accurate sizing is not usually necessary at the higher supersaturations where the W instrument was normally operated.

2. PARTICIPATION AND EXPERIMENT TYPES

Of the 29 experiments, five did not yield data suitable for comparison purposes. Experiments 3, 7 and 17 were ambient aerosols which were not constant enough in time to permit useful comparisons. Experiment 25 was a noise test which all of the participating CFD's passed. Experiment 29 was a truly insoluble aerosol (paraffin) which did not show activated droplets in any of the continuous chambers.

Of the 24 useful experiments, the M instrument participated in all except Experiment 21 where its haze chamber mode was used exclusively. The C chamber was involved in all 24 experiments. The DRI spectrometers (N and I) participated in 20 of the 24 experiments as they missed the first 4 (No. 1,2,4 and 5). The W instrument participated in 10 experiments.

The most important division of the experiments is between the monodisperse aerosols on the one hand and the polydisperse and ambient aerosol experiments on the other hand. These two distinct types of aerosols require separate analysis. One conventional way of describing the CCN spectra of aerosols is by noting the concentration, C, at one reference supersaturation (e.g. 1%) and the slope, K, of the distribution. Such a characterization is not applicable to some of the Workshop aerosols, because the slope of the distribution sometimes varied greatly over the range of supersaturations.

3. MONODISPERSE AEROSOL EXPERIMENTS

A monodisperse aerosol is an extreme CCN spectrum because there is a very steep slope over a narrow range of S and a flat distribution over other parts of the spectrum. Hence, this type of spectrum would not be characterized very well by C and K. Instead, a monodisperse aerosol should be characterized by the total number of drops active on the plateau and by the supersaturation (S_C) in the very steep region.

Experiments with a monodisperse aerosol allow a determination of the counting ability of the instruments because, as long as the chamber can attain a supersaturation greater than S_C, the concentration should be constant. Thus this concentration is insensitive to supersaturation levels in the chambers. In fact there should be agreement between the CFD's and Aitken particle counters for monodisperse aerosols. On the other hand, S_C, the second parameter which characterizes the monodisperse aerosols should be a very sensitive test of the supersaturations in the chambers.

3.1 Total Concentration

There were 10 monodisperse experiments, Nos. 4,5,8,9,15,18,19,20,21, and 28. An examination of the experimental plots shows that the M, C, I and N chambers always exhibit a constant concentration for supersaturations above the critical supersaturation, S_C of the aerosol when the chambers operated at high enough supersaturations. The W chamber observed a flat distribution for only one (No. 9) of the four monodisperse experiments in which it participated.

Table 1 shows the total CCN concentrations for each instrument; that is, the concentrations at and above the flat portion of the distribution beyond which no more nuclei are detected. Also listed is the percentage count compared to the M chamber. At the bottom is the average and standard deviation of the comparison with M. The data in Table 1 is averaged over the entire duration of the experiment. Although the aerosol generator was usually quite constant, this data is subject to error due to the fact that the instruments may have been operating at the high supersaturations during different time periods over which the concentration may have changed.

Table 2 was devised in an attempt to cover the above shortcoming. It was derived by choosing time periods during the monodisperse experiments when there was simultaneous data from at least two chambers. Simultaneous Pollak and TSI Aitken (CN) nucleus data is also presented. These should be in agreement with the CCN counters since these are monodisperse aerosols. Also listed in the table is the percentage difference of each CCN counter from the Pollak counter (or TSI when the Pollak data was not available). The last row shows the average and standard deviation of the comparison with the CN counters. These tables are quite consistent showing that Table 2 is fairly representative of the discrepancies between the chambers. This is in spite of the fact that the data in Table 2 is incomplete and rather unequally distributed. Simultaneous times could not be found for some instruments for some experiments while more than one case could be found for some experiments and instruments. Hence Table 2 is more precise, while the data from Table 1 is more representative.

Table 1 shows that the three DRI instruments were in excellent agreement with each other but that they were about 15% lower than the UMR chamber. Since the DRI instruments are so similar, this would seem to represent a systematic error between the UMR and DRI instruments, especially since the standard deviations for the DRI instruments are about equal. As pointed out above, this discrepancy in concentration for monodisperse aerosol reflects actual differences in counting rather than a problem with supersaturation. Either the sample volume or the counting efficiencies are different or the same sample is not being seen by each chamber.

TABLE 1. MONODISPERSE TOTAL COUNT

Exp. No.	M	C		N		I		W	
		N cm^{-3}							
4	260	220	85%						
5	1300	950	73%						
8	310	295	95%	260	84%	295	95%	400	129%
9	~610	490	79%	540	89%	535	88%	440	72%
15	1630	1290	79%	1290	79%	1290	79%		
18	1080	900	83%	920	85%	900	83%	1080	100%
19	1030	990	96%	990	96%	990	96%		
20	1030	900	87%	910	88%	970	89%	1020	99%
21	no data	880				880			
28	430	370	80%	330	77%	380	88%		
Averages		85% ± 7%		85% ± 6%		88% ± 6%		100% ± 23%	

TABLE 2. MONODISPERSE TOTAL COUNT, SIMULTANEOUS CASES

Exp. No.	Time	Pollak	TSI	M		C		N		I	
4	1010-1026	262 ± 2	275-280	269	103%						
	1141-1156	282 ± 6	300			230	82%				
5	1428-1440	[~1304]	2800	1405	108%						
	1537-1553	1241	2750			968	78%				
8	1005-1037	273	300-270	308 ± 22	113%	284 ± 17	104%	304ψ	111%	297	109%
9	1207-1221	572	570-550	649	113%			642	112%	~616	108%
	1245-1247		510	544	*						
	1247-1302		510-470			504				530	
15	1510-1529	1683	3200-3300	1810	108%	1509	90%	1564	93%	1563	93%
18	1014-1021	1112	2400	1168	105%			965	87%		
	1044-1053	1190	2500			971	82%			968	81%
19	1145-1206	1057	910-890	1125	106%	1009	95%	1047	99%	1020	96%
20	1400-1425	1068	900-910	1137	106%			1040	97%	990	93%
	1427-1429	"	910	1117	105%	961	90%	966	90%	976	91%
	1513-1516	[1081]	900			900	84%			926	86%
28	1532-1548	392	210	438	112%	400	102%	392	100%	408	104%
	Averages			108 ± 3.6		89 ± 9.2		98 ± 9		96 ± 9	

* = Haze Mode
ψ = Abbreviated Experiment

Figures 1-4 were plotted to see if the discrepancies were dependent on particle size. Data from Table 2 was used because of its superior precision. The data from the three DRI chambers (Figs. 2-4) is quite similar and shows a definite size dependence whereas the UMR chamber (Fig. 1) shows only weak size dependence. Loss of particles due to diffusion is a size dependent process which could be responsible for some of the discrepancies between these continuous flow chambers and the TSI. Diffusion loss also depends on the sample flow rate and the distance which the sample has to travel. Since these quantities were nearly identical for the DRI chambers, and the DRI chambers yielded similar data, loss by diffusion seems to be a good possibility. Furthermore, diffusional losses for the UMR chamber are expected to be smaller, because the smaller sample flow branched off of a larger delivery flow. Thus the UMR data reflects this fact (Fig. 1).

Figures 5 and 6 show the theoretical diffusion loss rate for the UMR and DRI chambers, respectively. The agreement between the experimental and theoretical curves indicates that diffusion losses can account for the size dependent relationship between the CFD's and the TSI and thus the differences between the UMR and DRI chambers. However, the data seems to show a linear relationship whereas the theory shows a parabolic relationship. Another possible cause of size dependent particle loss is by electrostatic effects. Since the monodisperse particles were produced from an Electrostatic Classifier, they are all charged particles. It has been found that just touching the plastic tubing or even the conducting tubing through which the sample aerosol passed caused reductions in the apparent concentration. This is especially true for the smaller particles which have higher mobilities.

These results indicate that, if theoretical diffusional losses were accounted for, the agreement between the UMR and DRI continuous flow chambers would be much better than Table 1 would indicate. With such a correction, it would appear that the UMR and DRI chambers agree to about 5 percent on the plateau concentration for monodisperse aerosols.

3.2 Critical Supersaturation, S_c

The other parameter used for the monodisperse aerosols is S_c, the critical supersaturation, corresponding to the peak in the differential aerosol size distribution. The measured value of S_c was defined as the supersaturation which yielded one half of the concentration found at the high supersaturations where the concentrations were constant (and presumably all particles were being counted). These one-half values for each chamber and for each monodisperse experiment are listed in Table 3. Also listed are the theoretical values, based on the size from the TSI electrostatic classifier used to generate the aerosols. As to the theoretical

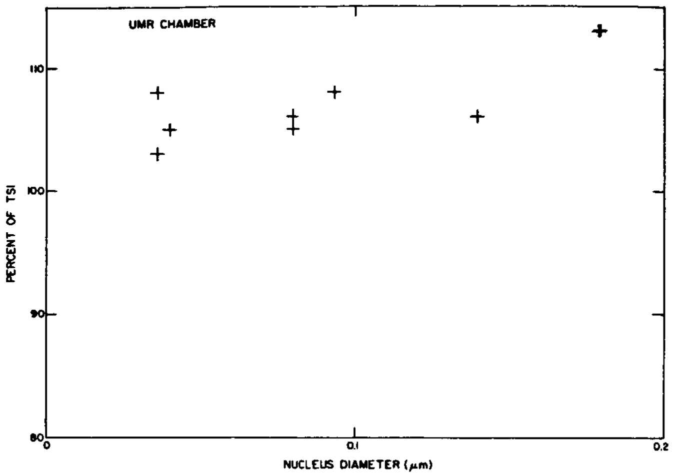

Figure 1. Ratio of concentrations in UMR chamber to those in the TSI CN counter for monodisperse particles of various sizes. Data taken from Table 2.

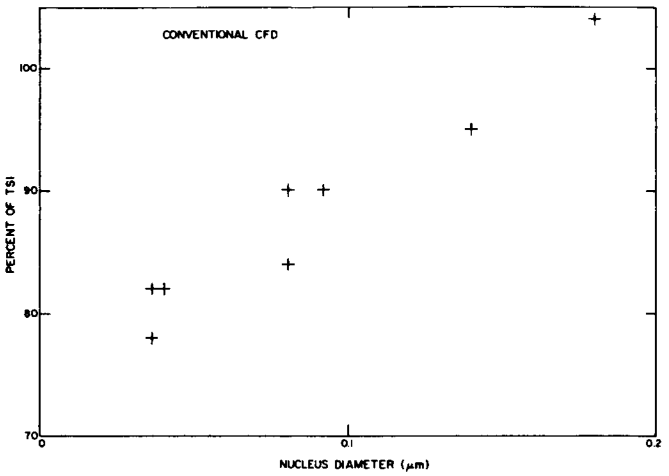

Figure 2. Same as Fig. 1, for DRI conventional CFD.

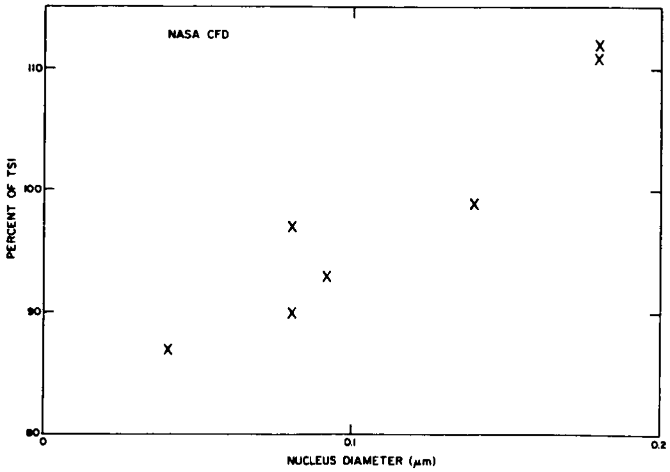

Figure 3. Same as Fig. 1, for DRI NASA chamber.

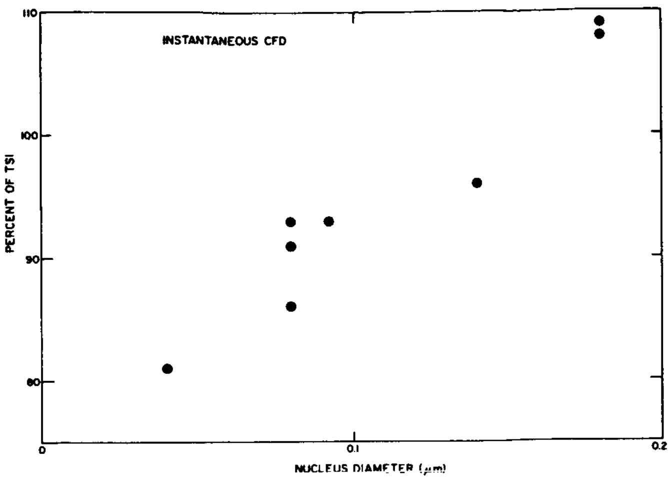

Figure 4. Same as Fig. 1, for DRI instantaneous chamber.

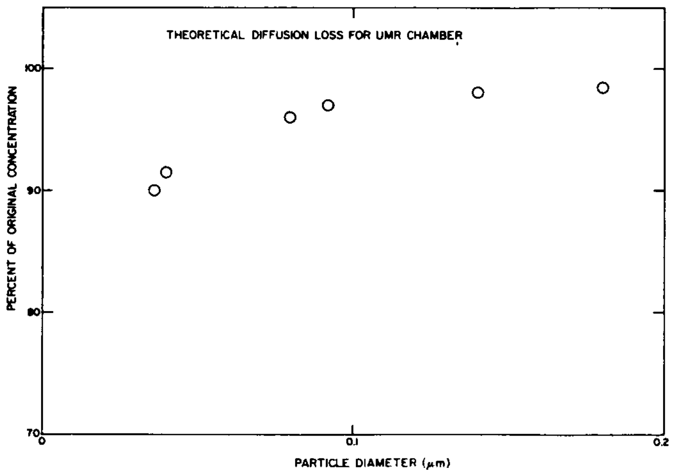

Figure 5. Calculated diffusion losses for the UMR chamber for various particle sizes.

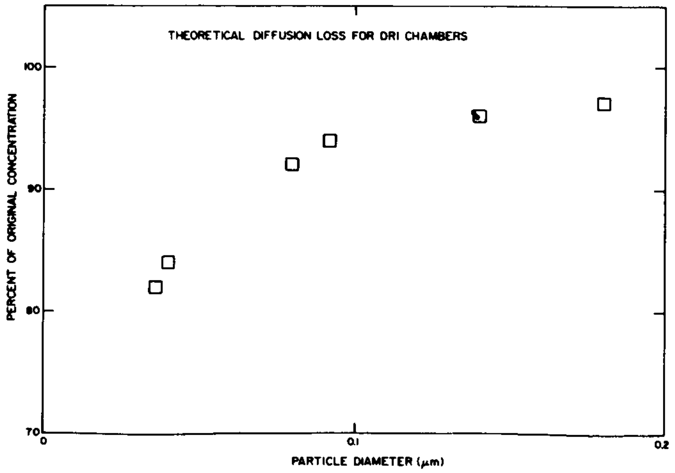

Figure 6. Same as Fig. 5, for DRI chambers. All three DRI chambers would have the same diffusion loss characteristics.

TABLE 3. MONODISPERSE S CUTOFF

Exp. No.	Size/Composition	Theoretical S_c	M		C		N		I		W	
4	0.036 NaCl	0.50	0.52	104%	0.52	104%						
5	0.036 Nacl	0.50	0.54	108%	0.52	104%						
8	0.18 NaCl	0.045	0.052	116%	0.084	187%						
9	0.18 NaCl	0.045	0.05	111%	0.065	144%						
15	0.092 Amon	0.18	0.21	86%	0.17	81%	0.2	95%				
18	0.04 Amon	0.64	0.62	85%	0.61	84%	0.54	74%	0.70	96%	0.33	45%
19	0.14 Amon	0.091	0.11	100%	0.12	109%	0.13	118%				
20	0.08 Amon	0.22	0.20	69%	0.18	69%	0.22	85%			0.30	115%
28	AgI		0.33		0.40		0.38		0.40			
Averages			97% ± 16%		110% ± 38%		93% ± 18%					
[Excluding Exp. 8,9]			92% ± 15%		92% ± 16%		93% ± 18%					

relation between dry size and S_c, we note that various sources disagree somewhat. For example, for ammonium sulfate at 20°C, Hanel (1976) lists S_c values of 1.91% and 0.0532% at dry diameters of 0.02 μm and 0.2 μm respectively. Jiusto and Lala (their equation 3, this proceedings volume) give approximate relation which, for the corresponding conditions give higher values of S_c (2.01% and 0.0635%, respectively). For sodium chloride, the two sources agree much more closely. In Table 3, we have used the values from Hanel.

It can be seen in Table 3 that the M, C and N chambers showed excellent agreement with theory and each other. The I chamber was really not participating in this aspect of the experiment since it was always operating at three fixed supersaturations throughout the Workshop. Experiments 8 and 9 were actually below the range of the DRI chambers and within the haze mode of the UMR chamber. Exclusion of these two experiments reveals a more realistic test of the diffusion chambers.

The agreement of the UMR and DRI chambers on S_c, indicates that these chambers were sensing the same supersaturations. The agreement with theory shows that the deduced supersaturations were probably accurate.

4. POLYDISPERSE AND AMBIENT EXPERIMENTS

These CCN distributions were more conventional so they could usually be characterized by more typical parameters such as C and K from $N = CS^K$, where C is the concentration at 1% supersaturation and K is the slope of the log-log distribution. However, the calculation of K rests on the assumption of a constant slope and even when this condition is fulfilled, the calcuation of K is one step removed from the data. For these reasons, we decided that a better method of analysis of this data would consist of direct comparisons of all of the chambers at the two most extreme supersaturations which can be used. This would test C and K in a more direct manner without the necessity of a straight line distribution. The two supersaturations chosen were 0.70% and 0.30%.

Tables 4 and 5 show the results of this analysis. There is not a standard instrument to relate the measurements to but, since there are so many similarities between the three DRI instruments, we have again chosen to relate all measurements to the UMR chamber. The fact that the DRI chambers show better agreement with UMR at 0.30% is consistent with the results of the monodisperse experiments. Thus the smallest CCN seemed to be undercounted in the DRI chambers, suggesting that once again diffusion losses or electrostatic charging is a problem. The magnitude of the discrepancy is also quite similar to that found in the monodisperse experiments.

Figure 7 shows that there was probably some undercounting by the DRI instruments at very high concentrations. This data is rather inconclusive except for the concentration of 10,000 cm^{-3} (Exp.24). Such a graph tests the possibility of effects such as vapor depletion in the cloud chamber or coincidence losses in the OPC. It appears that one of these is a problem in the DRI chambers at very high concentrations.

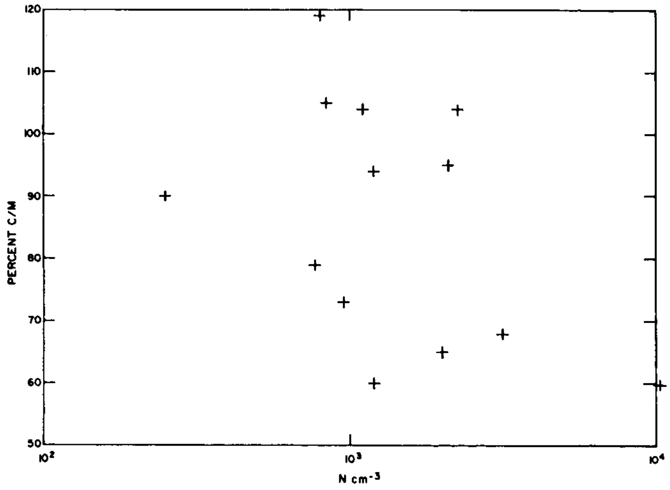

Figure 7. Ratio of concentration in DRI conventional chamber to the UMR chamber vs. concentration in the DRI chamber. Data taken from Table 4.

TABLE 4. POLYDISPERSE AND AMBIENT, 0.7%

Exp. No.	Composition	M	C		N		I		W	
1	NaCl	960	700	73%					410	43%
2	NaCl	2000	1300	65%					820	41%
6	Ambient	1200	1125	94%	1300	108%	1175	98%		
10	Bimodal/NaCl	800	950	119%	800	100%	700	88%	1150	144%
11	Ambient	1250			1100	88%	1030	82%	1040	83%
12	Ambient	2100	2000	95%	2000	95%	2000	95%	1000	48%
13	Ammon. Sul.	2250	2350	104%	2150	96%	2000	89%	1200	53%
14	Ammon. Sul.	3150	2150	68%	2300	73%	2100	67%		
16	Ambient	840	880	105%	800	95%	820	98%		
22	Ammon. Sul.	1200	720	60%	720	60%	700	58%		
23	Ammon.Sul.	250	225	90%	235	94%	225	90%		
24	Ammon. Sul.	10800	6500	60%	5000	46%	5200	48%		
26	Ambient	1100	1140	104%	1150	105%	1140	104%		
26	Run 2/Amb.	1250			1280	102%	1150	92%		
27	AgI	775	615	79%	400	52%	650	84%		
27	Run 2	510			320	63%	500	98%		
	Averages		86% ± 20%		84% ± 21%		85% ± 16%		69% ± 40%	

TABLE 5. POLYDISPERSE AND AMBIENT, 0.3%

Exp. No.	Composition	M	C		N		I	
1	NaCl	500	435	87%				
2	NaCl	1010	890					
6	Ambient	940	800	85%	700	74%	940	100%
10	Bimodal/NaCl	315	260	83%	280	89%	300	95%
11	Ambient	960	820	85%	700	73%	700	73%
12	Ambient	1000	1200	120%	1200	170%	1200	170%
13	Ammon. Sul.	1300	1010	78%	1010	78%	990	76%
14	Ammon. Sul.	1500	1100	73%	1130	75%	1000	67%
16	Ambient	600	670	112%	540	90%	420	70%
22	Ammon. Sul.	525	450	86%	310	59%	415	79%
23	Ammon. Sul	110	115	105%	100	91%	120	109%
24	Ammon. Sul.	3050	2800	92%	1300	43%	2500	87%
26	Ambient	600	600	100%	460	77%	660	110%
26	Run 2/Amb.	620			620	100%	620	100%
27	AgI	42	21	50%	65	155%	70	167%
27	Run 2	13			25	192%	42	323%
28	AgI		0.7		101			
	Averages		89% ± 18%		94% ± 39%		112% ± 66%	

5. CONCLUSIONS

The five continuous flow diffusion chambers showed good agreement with each other in spite of differences such as three types of optical particle counters and three different wicking materials. With the various aerosol distributions and types of particles, the chambers nearly always agreed to within 15% in number concentrations and supersaturation determinations. Error analysis showed that diffusion losses could account for most of these differences.

6. REFERENCES

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REVIEW OF ISOTHERMAL HAZE CHAMBER PERFORMANCE

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ABSTRACT

Isothermal haze chambers (IHC) were present at the 1980 International CCN Workshop (Reno, Nevada); the theory of this method of characterizing cloud condensation nuclei (CCN) over the critical supersaturation range of about 0.01% to 0.2% is reviewed, and guidelines for the design and operation of IHC's are given. IHC data from the International Workshop are presented and critically analyzed. Two of the four IHC's agreed to about 40% over the entire range of S_c's. A third chamber showed similar agreement with the first two over the lower part of the S_c range but only a factor of two agreement at higher S_c's. Some reasons for the discrepancies are given.

1. INTRODUCTION

Since the Second International Workshop on Condensation and Ice Nuclei in 1970, the measurement of cloud condensation nuclei (CCN) has been extended to the range of 0.015%-0.15% supersaturation through the use of the isothermal haze chamber (IHC), a new type of CCN counter first described by Laktionov (1972). The principle of operation of the IHC derives from the almost unique relationship which exists between the critical supersaturation, S_c, of a particle and its equilibrium size, r_{100}, at 100% RH. In the IHC, nuclei are grown to their equilibrium sizes in an environment of 100% RH and are then counted as a function of size. From these data and the relationship between S_c and r_{100}, one obtains the CCN supersaturation spectrum. Alofs and Podzimek (1974) are credited with bringing Laktionov's work to the attention of the Western cloud physics community.

Four groups operated IHC's at the International CCN Workshop, Reno, NV, 6-17 October 1980: the Desert Research Institute (DRI), the University of Missouri at Rolla (UMR), the Naval Research Laboratory (NRL), and Colorado State University (CSU). All of these instruments are described in companion papers. In addition, descriptions of the DRI and UMR instruments have been published by Hudson (1980) and Alofs (1978), respectively.

The purpose of this review is threefold: (1) to describe the S_c - r_{100} relationship; (2) to discuss some of the critical design aspects of the IHC; and (3) to present some results of the IHC intercomparisons conducted at the Workshop.

2. THE S_c - r_{100} RELATIONSHIP

From the relationship between S_c and dry particle radius (r_0) and that between r_{100} and r_0 one obtains the following relationship between S_c and r_{100}.

$$S_c(\%) = 38.5\left(\frac{2\sigma_c'}{\rho_w R_v T}\right)\left(\frac{\sigma_c' i_{100}}{\sigma'_{100} i_c}\right)^{\frac{1}{2}} r_{100}^{-1} \qquad (1)$$

In this equation σ_c' and i_c are the surface tension and van't Hoff factor of the solution droplet when it has attained its critical radius; σ'_{100} and i_{100} are the surface tension and van't Hoff factor of the droplet in equilibrium at 100% RH; ρ_w is the density of water; T is the temperature; and R_v is the gas constant of water vapor.

The relationship between S_c and r_{100} depends on particle composition only to the extent that the value of $\sigma_c'(\sigma_c' i_{100}/\sigma'_{100} i_c)^{\frac{1}{2}}$ depends on composition. If we assume that $i_{100} = i_c$ and that $\sigma'_{100} = \sigma'_c = \sigma_w$, σ_w being the surface tension of pure water, then Eq. (1) reduces to

$$S_c(\%) = 38.5\left(\frac{2\sigma_w}{\rho_w R_v T}\right) r_{100}^{-1}, \qquad (2)$$

which is the relationship used by Laktionov (1972). At T = 20°C, and with r_{100} expressed in microns, Eq. (2) may be written

$$S_c(\%) = \frac{0.041}{r_{100}}. \qquad (3)$$

Taking into account the temperature dependence of σ_w, we find that S_c varies approximately as $T^{-3/2}$ for a fixed value of r_{100}.

Corrandini and Tonna (1979) analyzed the S_c vs. r_{100} relationship for the main electrolytes composing continental and marine aerosol particles. They found that the uncertainty in the actual electrolytic composition of CCN results in a maximum deviation from Eq. (2) of approximately 6%.

Hoppel and Fitzgerald (1977) examined the effect of insoluble material in aerosol particles on the relationship between S_c and r_{100}. Their calculations showed that insoluble material will not cause a significant departure from Eq. (2) as long as soluble material accounts for at least 5% of the dry particle mass.

The largest departure from the Laktionov relationship [Eq. (2)] is likely to be caused by the presence of surface-active organic materials in the particles which will lower the droplet surface tension below the value for pure water. In the presence of organic material Eq. (2) overestimates S_c by (σ_w/σ_c'), where σ_c' is the actual surface tension of the droplet at its critical radius. The surface tension of the droplets formed upon atmospheric aerosol particles is not well known. Hanel (1976) made a few measurements of the surface tension of dilute aqueous solutions of atmospheric aerosol samples collected in central Europe and found values 10% to 30% below the value of pure water.

3. CRITICAL DESIGN ASPECTS OF THE IHC

In addition to the errors in IHC data arising from the lack of specific knowledge about the chemical composition of the aerosol particles, the accuracy of CCN spectra obtained with the IHC also depends on the accuracy with which the equilibrium particle size distribution at 100% RH can be determined. In order to achieve an accurate measurement of this size distribution, the humidifying section of the IHC must be truly isothermal, the relative humidity of the air sample must be brought acceptably close to 100%, the aerosol particles must be allowed enough growth time to reach r_{100} and the droplets must be accurately counted and sized. We shall now discuss each of these requirements in turn.

3.1 Isothermal Operation

The diffusivities of heat and water vapor in air are not equal (at standard conditions, the latter exceeds the former by about 15%). Therefore, if an air sample containing CCN flows through a tube having wet walls, the temperature of which increases in the direction of flow, a small supersaturation will be experienced by the CCN. Conversely, if the temperature of the tube decreases along the direction of flow, undersaturation may result. Under either of these conditions, the size of the CCN can depart significantly from r_{100}. It is important, therefore, that the humidifying section of the IHC be accurately isothermal and that its temperature be known to sufficient accuracy.

It is, of course, also important to take into account the inherent dependence of r_{100} upon temperature. From Eq. (2) we find that knowledge of T to an accuracy of 1°C easily suffices for 1% accuracy in S_c.

3.2 Humidification of the Air Sample

It is not possible to humidify the air entering the IHC to exactly 100% RH since this would require an infinitely long chamber. In practice, then, the sample is brought close enough to saturation that the error in S_c resulting from the departure of the actual equilibrium particle size from r_{100} is acceptably small. Figure 1 shows the relative error in S_c as a function of the deviation in relative humidity from saturation. The quantity 1-S plotted along the abscissa is one minus the saturation ratio. The error has been computed for different values of dry particle radius (r_0) having the indicated values of S_c. For the purpose of these calculations it was assumed that particles are composed of pure ammonium sulfate. We see from Fig. 1, for instance, that in order to operate an IHC as low as S_c = 0.015% with an error (in S_c) of no more than 10%, the sample must be humidified to 99.99% RH. If we require an error of less than 5% then we must humidify the sample to 99.996% RH. It is also seen that, should the maximum humidity achieved be only 99.95%, then errors in S_c of as much as 40% can be expected. If the CCN spectrum can be described by the relationship $N = CS_c^k$, then the error ΔN in particle concentrations due to an error ΔS_c in critical supersaturation is given by $\Delta N/N = -k\Delta S_c/S_c$.

We now turn to the question of how long the humidifying section must be to attain the desired relative humidity. Since most IHC's are of cylindrical geometry, we shall consider the case of air flow through a tube. For flow through a wetted tube, the increase in relative humidity depends only on the length of the tube and the volume flow rate and not on the radius (R) of the tube. The reason for this is that both the time constant for diffusion of water vapor from the walls and the residence time of the sample in the tube are proportional to R^2. Figure 2 shows the relative humidity at the center of a wetted tube as a function of distance from the inlet and volume flow rate, ϕ, for the case of an air sample having an initial relative humidity of 50%. Figure 2 is based on analytical solutions to the diffusion equations for laminar flow through tubes (Goldstein, 1965). These solutions assume Poiseuille flow and neglect the axial diffusion term. For initial relative humidities of 30% and 70%, the tube length required to raise the relative humidity of the sample above 99.9% is about 5% greater and 10% less, respectively, than the length needed for air entering at 50% RH.

The volume flow rate through the humidifying section is usually determined by the flow requirements of the optical particle counter (OPC) used to count and size the droplets. The Royco 225 optical counter, for instance, uses a flow of 47 cm^3s^{-1} (or 2.8 liters/min). For this flow rate, a tube length of 140 cm is required to humidify the sample from 50% RH to 99.99% RH.

3.3 Residence Time Needed to Achieve Droplet Equilibrium

When an aerosol particle is exposed to an environment of increasing relative humidity its actual size will lag behind its equilibrium size. The smaller the critical supersaturation of a particle, the larger is its equilibrium size, r_{100}, and the longer it takes to grow to that size. Therefore, the humidifying section of the IHC must provide enough residence time at ~100% RH so that the CCN can grow acceptably close to r_{100}.

Laktionov (1972) presented, without documentation, calculated values of the time required for droplets to grow to within 5% of r_{100} in an environment of 100% RH. These values have been used in determining the length of, or time required in, the humidifying section of the IHC. Recently, Robinson and Scott (1980) computed growth times of water solution droplets in an IHC, using a new droplet growth equation derived from first-principles kinetic theory. This equation was shown to agree with a conventional growth equation to within 5% for droplets smaller than 1 μm and to within 0.1% for large radii. Table 1 is taken directly from their paper and shows the time needed for nuclei of varying S_c to grow from their dry size to 95% and 99% of r_{100} in a saturated environment. The computations of Robinson and Scott assumed that nuclei are composed entirely of sodium chloride and that the condensation coefficient of water is 0.036. Table 1 also lists Laktionov's values of the time needed

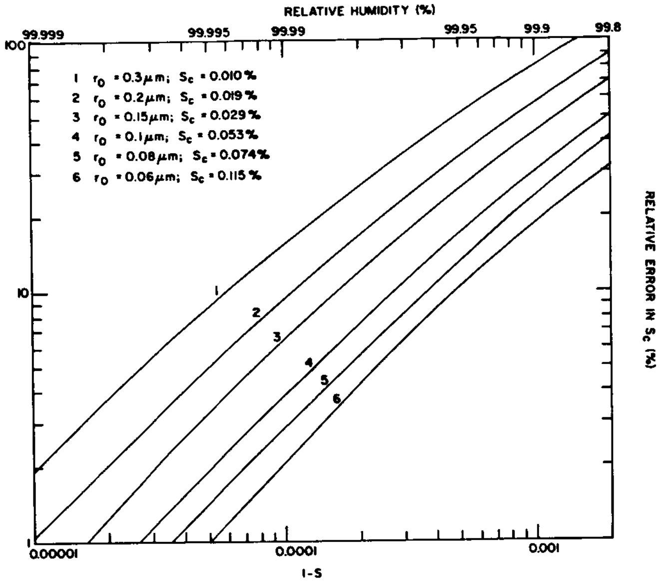

Figure 1. Relative error in S_c, in percent, as a function of the deviation in relative humidity in the THC from saturation. The error is shown for six values of dry particle radius, r_0, having the indicated values of S_c.

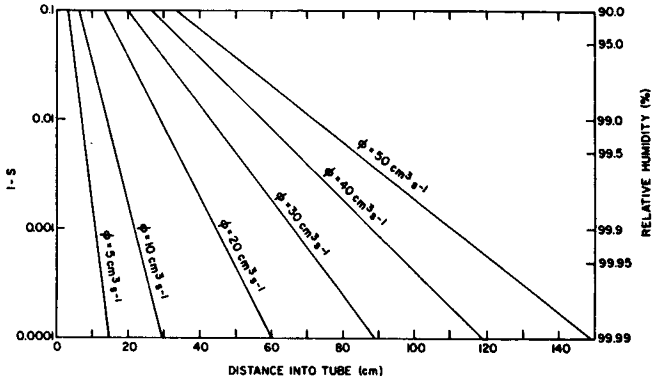

Figure 2. Relative humidity of the air at the center of a wet-walled tube as a function of distance down the tube and volume flow rate, ϕ. The initial relative humidity of the air is 50%.

TABLE 1. TIME REQUIRED FOR DROPLET GROWTH FROM DRY SIZE TO 95 AND 99 PERCENT OF r_{100} AT S = 1.0, T = 20°C

S_c(%)	0.103	0.063	0.051	0.041	0.033	0.026	0.021	0.016
r_{100}(μm)	0.40	0.65	0.80	1.0	1.25	1.6	2.0	2.5
t(S) to .95 r_{100}	1.6	4.6	7.4	12.5	21.3	38.9	68.1	121
t(S) to .99 r_{100}	3.3	9.8	16.7	26.6	45.5	84.1	148	262
t(S) [Laktionov] to .95 r_{100}	4	10	15	25	40	65	100	180

to grow to 95% of r_{100}. It is seen that Laktionov's growth times are significantly greater than those computed by Robinson and Scott.

Since Laktionov did not give the details of his calculations, we do not know the reason for the discrepancy in growth times. If we accept the values of Robinson and Scott, then we see that an IHC must provide over 120 s of growth time at a relative humidity of ~100% if it is to give accurate results at supersaturations as low as 0.015%.

A conservative estimate of the total length needed for the humidifying section may be obtained by adding together the length needed to humidify the air to an acceptable closeness to 100% RH (see previous section) and the additional length necessary to provide 120 s of residence time at ~100% RH.

3.4 Droplet Sizing and Counting

The accuracy of CCN spectra obtained with the IHC also depends on the accuracy with which the droplets emerging from the isothermal (humidifying) chamber are counted and sized. In order to obtain an accurate measurement of the droplet size distribution, the droplets must enter the OPC without serious modification of their numbers or sizes, and the response curve of the OPC must be well known, both in terms of absolute accuracy and resolution.

(a) Entry of Droplets into the OPC

The IHC droplet size distribution can be modified as a result of impaction of droplets on the walls of the inlet tube of the OPC and by evaporation shrinkage of the droplets before they enter the light beam. Alofs (1978) made a thorough investigation of both of these problems as part of an analysis of the performance of his dual-range cloud nucleus counter. In Alofs' device, these two problems may be amplified, compared to other IHC's, because the droplets must pass through a tube 1.3 mm diameter by 12 cm long to reach the OPC.

Alofs (loc. cit.) checked the problem of impaction by varying the flow into his OPC (a Royco at that time) while keeping the main flow through the humidifying chamber constant. The tests were made for 2.5 μm and 5.0 μm radius droplets. For each of these sizes, it was found that a plateau of count vs. Royco flow existed (where presumably impaction is not a problem) and that at higher flow rates the count dropped off due to impaction. Losses due to impaction set in at a flow rate of ~1.0 liters/min in the case of the 2.5 μm droplets and at a flow of ~0.5 liters/min for the 5.0 μm droplets. Alofs attributed the loss in counts to the fact that the aerosol stream was not exactly lined up with the 1.3 mm inlet tube. It seems reasonable to expect that in an IHC in which the droplets do not pass through a narrow tube to reach the OPC, higher flow rates can be used before impaction becomes a problem.

The inlet tube of the OPC will normally be warmer than the isothermal chamber temperature due to electrically-generated internal heat in the OPC. This will result in some evaporation of the droplets before they are sized. Alofs (loc. cit.) calculated the change in droplet size due to evaporation in the OPC inlet tube of his device. One may conclude from these calculations that, for nuclei with $0.01\% \leq S_c \leq 0.1\%$, evaporation will be relatively insignificant in an IHC which uses the full manufacturer's flow rate through the OPC (2.8 liters/min in the case of the Royco 225), even if the inlet tube is as much as 0.5°C warmer than the isothermal chamber. However, if the droplet residence time in the OPC inlet is significantly increased due to the use of a reduced flow rate, then it is necessary to avoid evaporation. Alofs showed that the problem of evaporation (of nuclei with $S_c \leq 0.1\%$) could be effectively eliminated by thermostatting the OPC so that the inlet tube is not more than 0.1°C warmer than the humidifying section.

The problems of impaction and evaporation are both very difficult to avoid completely by a priori design provisions. It seems best to allow enough adjustability in the IHC design, that these phenomena can be avoided by experimental adjustments.

(b) Sizing Accuracy of the OPC

In contrast with OPC use with continuous-flow, parallel-plate counters, the OPC on an IHC must not only count, but must also size accurately in order to give the concentration of nuclei as a function of S_c. This means that the response curve (i.e., signal strength as a function of particle radius) of the particular OPC used must be accurately known for the case of water spheres. OPC's are calibrated by the manufacturer with polystyrene latex spheres which have an index of refraction, m, of 1.59. Therefore, use of the OPC with the IHC to size water droplets (m = 1.33) means that the manufacturer's calibration curve must be corrected for index of refraction.

Cooke and Kerker (1975) used a Mie scattering computer program to predict the theoretical response curves of several widely used commercial OPC's, including Royco and Climet devices, for a range of values of refractive index. These curves, for all but the Climet and Royco 220 devices, show an initial monotonic increase in signal with increasing particle size, followed by a region of multivalued response. For particle sizes larger than about 1 μm radius, the response of OPC's again becomes single valued. The Royco 225, a popular device used by Hudson (1980) and others, is not treated by Cooke and Kerker, but its response should be close to that of the Royco 245, which is treated.

The calculated response curves of Cooke and Kerker are presently the best available basis for extrapolating the manufacturer's polystyrene latex calibration to work with water droplets. In using these curves to correct for index of refraction, a problem arises in that the response curves are calculated for refractive indices 1.33, 1.45, 1.54, and 1.70, but not for index 1.59, that of polystyrene. The operators of IHC's, then, have been forced to interpolate between the curves presented by Cooke and Kerker, a procedure which is made difficult by the oscillatory, mathematically complicated nature of these curves. As pointed out by Hodkinson and Greenfield (1965), the initial monotonically increasing portions of the response curves represent the large-radius end of the Rayleigh scattering region, the upper limit of which occurs at a particle radius of about 0.05 μm. As long as the monotonic character of the response curves persists above the Rayleigh scattering region, the response can be expected to vary as $(m^2-1)^{\frac{1}{2}} (m^2+2)^{-\frac{1}{2}}$, and the interpolation between curves to provide response values for other indices of refraction may be carried out on that basis. However, the oscillatory (multivalued) region of many OPC response curves sets in at values of radius well below 0.5 μm, marking the end of any resemblance to the behavior in the Rayleigh region. Outside the Rayleigh region, the complicated nature of the scattering functions (wherein m appears both as the coefficient and argument of Bessel and Legendre functions) precludes easy interpolation. One then has the choice of either repeating the work of Cooke and Kerker for $m = 1.59$ or simply doing a visual interpolation based on the Cooke and Kerker curves. There may, of course, be considerable error involved in determining the response curve by the latter method.

OPC size resolution on the order of 0.1 μm is required to be able to distinguish between nuclei differing by as much as 0.02% in S_c. Whitby and Willeke (1979) have estimated that most OPC's in good adjustment will artificially broaden a monodisperse spectrum to the extent that the resulting geometric standard deviation is of order 1.1. This would imply, for example, that slightly over 68% of the count of an ideal 1.0 micron aerosol would be interpreted by the OPC as belonging to aerosol sizes between 0.91 and 1.1 μm.

The actual calibration of any OPC should be checked by the user but, in general, sizing errors are a serious concern, especially if the OPC has a multivalued response function in the radius range of interest.

4. HAZE CHAMBER DATA FROM THE INTERNATIONAL WORKSHOP

4.1 Preliminary Comments

While IHC's were operational during all 29 experiments of the International Workshop, useable data resulted from only a subset of the total number of experiments when the aerosol was large enough to register and when other problems such as fluctuations were not present. In addition, the four instruments (#11, Naval Research Laboratory; #14, Desert Research Institute; #21, University of Missouri; #26, Colorado State University) were not always simultaneously operational. Therefore, the data to be discussed is a subset of the total data file, which will generally cover those experiments where the aerosol was suitable for IHC and all four IHC's were operational.

A few remarks about the instruments themselves are worthwhile. IHC #21 is unlike the others in that it uses a Climet OPC for detection and sizing of the haze droplets. IHC #11 is actually a second-generation device, built by the Naval Research Laboratory after considerable experience had been gained with an earlier model. In particular, a very efficient sheath air pre-humidifier is found on this version. IHC #14 and #26 are related in terms of design; #26 was constructed following, to some extent, the mechanical details of #14 but was only newly-completed at the time of this Workshop. Some difficulties in the operation of #26 were experienced, but allowance should be made for the fact that it was a newly-constructed device. Finally, one should generally note that IHC's are required to respond to concentrations that span many (eg, 3-5) orders of magnitude, a considerable dynamic range which is taxing under the best of circumstances.

In the process of analyzing the data, it was discovered that somewhat different procedures were used to deal with the index of refraction problem cited in Section 3.4(b) of this report. Although DRI and NRL both used Royco OPC's it was determined that subtle differences in the procedure used to correct for the index of refraction resulted in some significant differences in the data. Specifically, this meant that different S_c's were deduced from voltage threshold responses which would have shown identical sizes for the polystyrene latex spheres used for size calibrations. After this was discovered, the DRI data were redone using the method similar to that used by NRL. Since the CSU data were treated identically to NRL data, this modification then allowed all Royco-equipped IHC's to be compared on an equivalent basis. It is difficult to determine which procedure is best, although the NRL procedure does yield higher concentrations, at a given S_c, in better agreement with the UMR chamber and with the mobility analyzer.

The operators of the UMR chamber accounted for the index of refraction in an entirely different manner. While the procedures used for the Royco-equipped chambers were based solely on theory, the UMR IHC relied most heavily on an empirical technique. Size thresholds were determined by passing known sized NaCl nuclei through the UMR IHC; the nuclei would form drops which were assumed to be the equilibrium size of solution droplets at 100% R.H. This procedure was followed for one or two sizes and the rest of the curve was completed by using the functional shape of the Cooke and Kerker results. This circumvents the index of refraction problems which have been described in Section 3.4(b) and in the last paragraph for the Roycos.

4.2 Best and Typical Agreement Cases

In Figure 3, the IHC results of Experiment 20 (monodisperse ammonium sulfate aerosol) are shown; the data provide the best agreement between IHC's found during the Workshop. The curve labeled #14' is the original DRI data; #14 has been redone with the index of refraction correction treated similarly to the data of #11 and #26. This yielded much better agreement with #11 and #21. Note that the theoretical CCN spectra derived from the NRL mobility analyzer data (#12) are also plotted; these were obtained by using the theoretical (Kohler) relationship between S_c and dry particle size for ammonium sulfate aerosols to transform the NRL size distribution data into a CCN spectrum. (IHC #26 did not report data for this experiment.)

Figure 4 shows a count-versus-S_c plot of Experiment 9, monodisperse sodium chloride, and represents the more "typical" case from the Workshop. Once again, it is apparent that #14' shows much closer agreement with #11, #12, and #21. The difference between #14 and #14' shows the sensitivity to the method used to correct for the index of refraction. In contrast to Figure 3, it was more frequently the case that the count magnitudes were in the order shown in Figure 4 at the higher S_c's: IHC #11 and #21 highest, #14' next, then #14, and #26 lowest. At the lowest supersaturations, however, curves 14', 11, and 21 were in no consistent

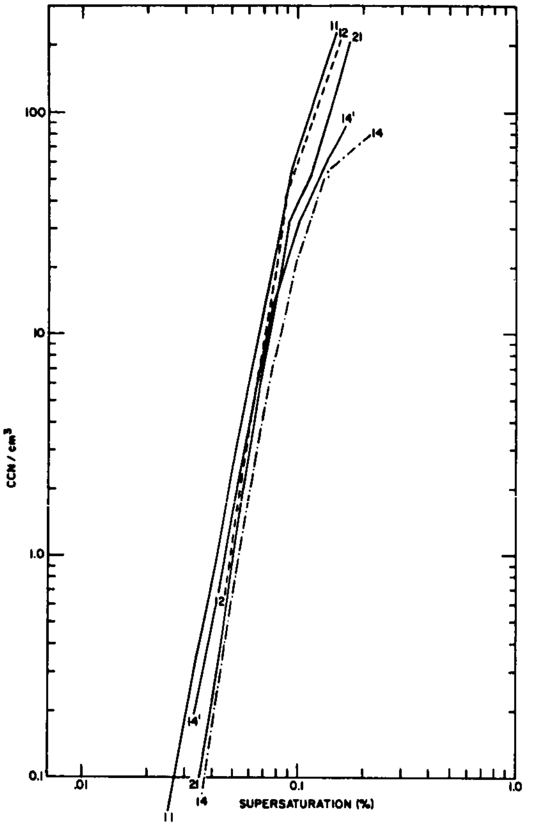

Figure 3. Concentrations registered by isothermal haze chambers and NRL mobility analyzer as a function of supersaturation setting, for Experiment 20. Aerosol was monodisperse ammonium sulfate. Mobility analyzer data are labelled by instrument Number 12. Haze chamber data are similarly labelled; see text for instrument numbers.

order and agreement between the three IHC's was much better.

Not shown in Figure 4 are the counts of the continuous-flow CCN counters. In Figure 3 this data shows a "plateau" in count; the mean S_c of this nominally monodisperse aerosol was 0.045%, with the smallest CCN in the distribution exhibiting S_c as high as 0.06% to 0.1% supersaturation. For this experiment the counts from those devices generally fell in the range 500-600, or at about the same magnitude as indicated at 0.15% by IHC #11, #21, and #14. IHC's #21 and #14 (#14' also) detected a plateau in number vs. S_c which allowed them to estimate the S_c of the aerosol. These were all overestimates of the theoretical value 0.045%; #21 saw 0.055%, #14' estimated 0.073%, #14 0.086%. Although IHC #11 did not detect a plateau this may have just been due to the OPC channel threshold selections. If 0.15% were assumed to be a plateau reading, #11 would estimate 0.073%. Experiment #8 was the only other experiment which used an S_c in the IHC range, 0.045% as Experiment 9. Although the concentration was lower in Experiment 8, the results were nearly identical to Experiment 9. IHC #26 often exhibited a kink in the region around and immediately below 0.1%; this kink may correspond to the double-valued region of the particular Royco in use on IHC #26.

The relative order (by magnitude of count at a given S_c) of the four instruments was preserved throughout most of the experiments. Considering that three of the devices utilized a Royco OPC, the double-valued response region of which falls in the approximate S_c interval of 0.04% to 0.08% (r_{100} of 0.5×10^{-4}cm to 1.0×10^{-4}cm), it may be inferred that at least a given Royco OPC seems to consistently place signals of the same magnitude in the same electronic channel, even though the signals may fall within the double-valued region. Otherwise, interpretation of data from the IHC's using the Royco (IHC #11, #14, #26) would be next to impossible in the 0.04% to 0.08% S_c range. (Even granting this consistency, it is not too surprising to see discrepancies in this troublesome region of the spectrum.)

4.3 Relative IHC Results as a Function of Experiment

Figures 5 and 6 simply display the relative counts of each IHC as a function of experiment number, where the relative count is shown as a percentage of the NRL mobility analyzer count at the same S_c (S_c = 0.09% for Fig. 5 and 0.15% for Fig. 6). The curves on Figs. 5 and 6 show discontinuities where data are inappropriate or missing. These S_c values were chosen somewhat arbitrarily; our intention is simply to display relative performance at representative points along the S_c spectrum.

In Figure 5 once again #14' is plotted. As in the last two figures, this represents DRI data which has been corrected for the index of refraction in a manner similar to that used by the other

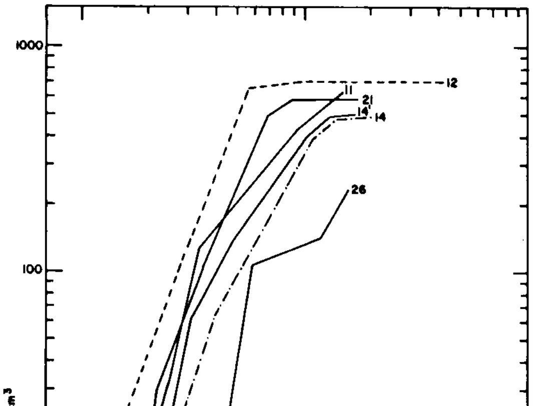

Figure 4. Same as Figure 3, but for Experiment 9. Aerosol was monoidisperse sodium chloride.

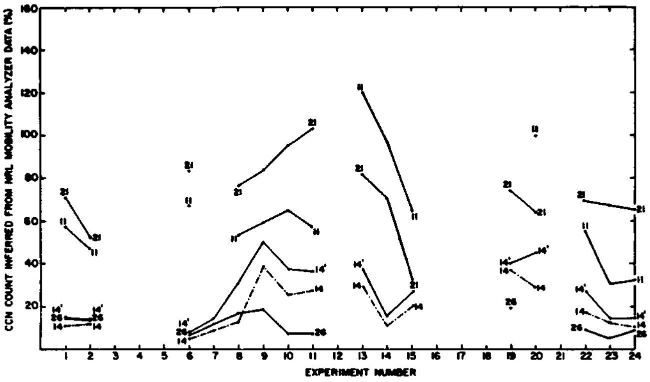

Figure 5. Isothermal haze chamber data compared to NRL mobility analyzer data, plotted as a function of experiment number, for a supersaturation setting of 0.09%.

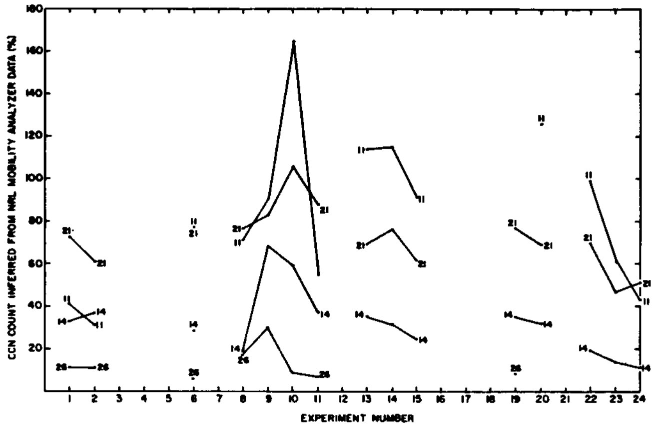

Figure 6. Same as Figure 5, but for a supersaturation setting of 0.15%.

two Royco equipped IHC's. No. 14' is not plotted in Figure 6 because at 0.15% the ratio of #14' to #14 is only about 1.15 except in Experiments #22, 23 and 24 where it is about 1.5, causing only a small change in the relative positions of the data from the various instruments.

In examining these figures, it is apparent that the relative order of the instruments is generally preserved although #11 and #21 seem to alternate as the highest reading IHC. A similar figure for S_c = 0.04% was constructed, but had very large gaps in data, and considerably more scatter than seen in Figs. 5 and 6. Nevertheless, the order was like that of Figure 5, except that #14' alternated with #11 and #21 for highest readings. These data cover ambient aerosols (Experiments 6 and 11), monodisperse sodium chloride (8 and 9), polydisperse sodium chloride (1,2,10), monodisperse ammonium sulfate (15, 19,20) and polydisperse ammonium sulfate (13, 14,22,23,24). The maxima and minima of the curves of the four instruments sometimes seem to occur in unison, but are not clearly related to any particular type of aerosol. Rather, it appears that a significant variable might be the response of the NRL mobility analyzer, more than the type of aerosol under study. From experiment to experiment, small changes were occasionally made in the sample flow rate (time of exposure of the sample to saturation) of instrument #14. Although these should have been within the region where counts have plateau values as a function of carrier flow, this may not have always been the case for all of the OPC droplet size thresholds used.

Figure 6 takes on additional significance if we regard 0.15% as representative of the supersaturation range where haze chamber data overlaps that of the static and continuous-flow CCN counters. Inspection of the Workshop data shows that the NRL mobility analyzer usually read somewhat higher than the approximate average of the static and continuous counters, by a factor between one and two. Therefore, if those CCN counters were also shown on Figure 6, their results would fall in about the same range as given by the curve for IHC #21, a result that is not too surprising because this IHC always gave data which was continuous with the higher supersaturation data given by the dual-mode operation of chamber #21. Thus, both IHC #21 and IHC #11 tended to agree well with other chambers around 0.15% supersaturation. The other two IHC's were less often in agreement in this region, although often #14 seemed to give data which joined well with the data of a continuous CCN counter from the same institution, #15.

Although Figures 5 and 6 indicate that there is a considerable counting discrepancy between the various IHC's, it should be kept in mind that when the slope of the CCN spectrum is very steep (as was often the case in the range of S_c of the IHC's), a small absolute error in S_c can result in a large error in particle count. Thus small discrepancies in the sizes assigned to given water droplets by various OPC's could lead to large differences in count; ignoring for the moment all other sources of the discrepancies, the primary calibrations (even of OPC's from one manufacturer) of OPC's differ from instrument to instrument. In regard to the present data, clearly the most desirable approach would have been to compare the OPC's (at least the three Roycos) on a non-water aerosol such as polystyrene latex before or during the Workshop.

4.4 Conclusions

The general tradition in comparisons of CCN counters has been to regard the instruments which register the highest counts as the most correct. That tradition should never be accepted without scrutiny, for instruments may overcount as well as undercount, although generally there are more reasons for the latter. In the case of these comparisons, there are additional measurements which drive one to the conclusion that the higher-counting instruments are indeed to be favored; those measurements are the continuous-flow and static CCN counts, in the case of monodisperse aerosols where a plateau in the count-versus-S_c is to be found, and the results of the NRL mobility analyzer. It would appear, then, that instruments #11 and #21 offer some advantages over the other devices.

The differences between #14 and #14' point out the problems involved in correcting for the index of refraction. Although these differences at first appeared to be very minor, they resulted in significant differences in the region of supersaturation between 0.04% and 0.08%, corresponding to the double valued region of the Royco. The steepness of the aerosol distribution in this region results in a very high sensitivity to this variability. Fortunately all of the IHC's usually avoided using voltage thresholds in this region of the spectrum. Hence the differences involved in correcting for index of refraction were usually not as serious as they could have been. Although the differences which resulted from variations in the procedure are significant they are not overwhelming. Nevertheless, it would have been much better to use a uniform method of correcting for index of refraction at the time of the Workshop as corrections made later are not certain to be identical. In the future, it would be desirable to look into the whole question more thoroughly.

IHC #21 is different in that it uses a Climet OPC. However, it is difficult to compare the treatment applied by its operator to the index of refraction problem, which unlike the Royco-equipped chambers, does not strictly rely on theoretical considerations. Hence it is difficult to determine if the Climet OPC offers advantages in sizing water droplets based upon calibration with polystyrene latex spheres of a different index of refraction. Nonetheless, the UMR IHC does show good number concentration agreement with the NRL mobility analyzer as well as better agreement with the theoretical S_c's in the monodisperse experiments (8 and 9). This is understandable since the UMR chamber was essentially calibrated with a mobility classifier, which may be a better method for applied CCN counting. Nevertheless even though the Royco equipped IHC's have considerable calibration problems they do at least use an independent method of calibration. There are more occasions when IHC #11 counts higher than the NRL mobility analyzer, than is the case with IHC #21, but such occasions are rare enough that no conclusion can be drawn.

All IHC's in this study were basically stable, rugged devices which at least showed an output data signal which was proportional to the input aerosol concentration, despite the taxing dynamic range and requirement that OPC accuracy and resolution be pushed to the limit. These devices clearly have a promising future in certain measurements of hygroscopic aerosols, such as the counting of fog condensation nuclei, or even in new applications such as studies of aerosol retention in the human lungs.

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6. ACKNOWLEDGEMENTS

This work was supported by NASA Grant No. NAS8-33820, and NSF Grant No. ATM79-21558.

AEROSOL GENERATION AND DISTRIBUTION SYSTEM FOR THE THIRD INTERNATIONAL CLOUD CONDENSATION NUCLEI WORKSHOP

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ABSTRACT

In order to obtain identical samples participating CCN instruments and aerosol characterizing equipment were located along and connected to a 8.2 cm diameter aluminum tube through which the test aerosols were pumped directly from the source at a rate of 200 to 600 ℓ min^{-1} and at very slight overpressure.

Of the total of 29 experiments, 18 were carried out with artificial NaCl or $(NH_4)_2SO_4$ aerosols. These were generated from salt solutions by pneumatic atomizers of special design (by DRI) to ensure high constancy of the aerosol output concentration. In three experiments with insoluble CCN (AgI, paraffin wax) the aerosols were generated thermally. In some of the tests, an electrostatic classifier was used for narrowing the particle size distributions.

1. INTRODUCTION

Comparisons or cross-calibrations of small particle instrumentation are often performed, for convenience's sake, with the aid of most easily obtainable aerosols, such as the ones present in room or atmospheric air, the particles of which are usually not well characterized and are mostly of a rather complex nature. However, since different aerosol instruments generally differ in their response spectra, these differences can only be assessed and ultimately understood if aerosols of distinct characteristics are utilized. Thus, in order to achieve the objectives of the Workshop, it was imperative to provide test aerosols of high monodispersity and chemical purity, and to take the utmost care in conveying the sample to the instruments.

2. AEROSOL DISTRIBUTION SYSTEM

Based on the favorable experience in previous Workshops (WS), the primary requirement of supplying all instruments simultaneously with as nearly identical samples as possible was met by locating the instruments along a sample duct (or manifold) in which a flow rate was maintained that was high compared to the sample flow extracted from the duct by the instruments.

A further requirement was to provide a steady flow of aerosol in which variations of particle concentration with time were less than a few percent ($\leq$ ±3%, according to recommendations from the Steering Committee). In order to achieve this criterion, the choice was to either use a large storage bag (as had been the case at the Ft. Collins WS) or to operate a very constant aerosol source.

Several considerations led to the decision to deliver aerosols directly into the sampling duct instead of using a large bag. With regard to artificial aerosols, generation techniques at the DRI had improved over the years to the point where runs of one to two hours could be achieved with about 90% probability of keeping the particle concentration within ±5% of a mean value whereby the short term fluctuations (which are generally more detrimental for instrument comparisons) usually were even smaller; superimposed on this was a slow drift in the particle concentration. Furthermore, examination of the Ft. Collins WS data (Grant, 1971) indicated that samples stored in the 54 m^3 bag were decaying at a considerable rate; total NaCl particle concentration, -10% hr^{-1}; large submicron particles, ∿ -50% hr^{-1}; and -20 to -30% hr^{-1} for the CCN of atmospheric samples active at 1% supersaturation. These values did not point to an advantage of a bag system, not even for the case of ambient aerosol when compared with the low level of fluctuations in the prevailing situations of westerly winds usually experienced at the DRI during routine direct measurements of the atmospheric aerosol.* Another disadvantage of a bag system is its finite volume dictating the duration of an experiment (which may be too short for certain investigations; some participants had indicated the desirability of prolonging some experiments well beyond an hour).

Since the DRI aerosol laboratory was already equipped with a duct system to aspirate outside air through an inlet 9 m above the roof (i.e., ∿ 25 m above ground level) for distribution to instruments, it was relatively easy to extend that system to the WS room. Figure 1 shows the floor plan of the 150 m^2 WS area and the layout of the sample duct. The numbers 1 to 28 refer to the sampling outlets spaced about 0.6 m apart along the 8.2 cm ID aluminum duct. The sampling outlets were of 5 mm stainless steel tubing having a 90° bend inside the duct, pointing into the air flow; this resulted in isokinetic sampling conditions for instrument sampling rates of 0.0037 times the flow rate in the duct (which was varied between 200 and 700 ℓ min^{-1} from one experiment to another). Also shown are the sampling locations of all the instruments (identified by type and participating organization). In order to minimize the risk of losing particles

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*Unfortunately, unusually calm weather persisting during the period of the WS, combined with local industrial sources, was causing considerable fluctuations in aerosol concentration.

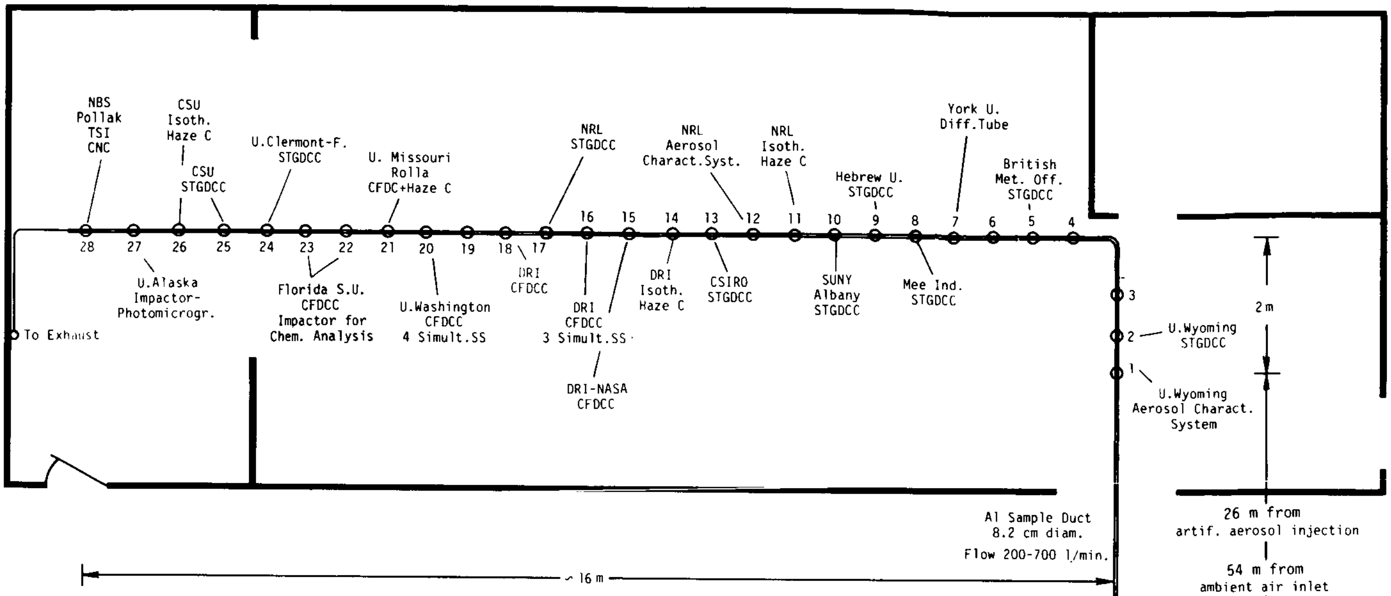

Figure 1. Layout of sampling duct and instruments in Workshop area.

through charge accumulation on surfaces, all instruments were connected to the sample duct by electrically conductive latex rubber tubing which had been tested previously and found to have no adverse effects on aerosol sampling.

Although the distance between the first and last sample outlet was 18 meters, the sample time delay between first and last instrument was only 8 to 25 seconds depending on the sample flow velocity of 0.6 to 2 m s^{-1}. Since significant changes in aerosol characteristics (mainly concentration) generally were associated with considerably longer time constants, simultaneous sampling by all instruments can be assumed for all but a few circumstances. By measuring the total particle concentration at sample outlets 3 and 28 with the same instrument (alternating between the two outlets) it was determined that no significant decay of the aerosol along the duct was taking place.

In order to prevent contaminants from entering the sampling duct, the latter was kept at slightly higher than room pressure, i.e., 0.05 to 0.5 mb, depending on sample flow rate. When using artificial aerosols, the compressed air generation system provided the needed overpressure while, in the case of ambient air sampling, an axial fan (Rotron Model TN3A2) built into the sampling duct upstream of the WS area produced the pressure difference. It was determined experimentally that the fan caused a reduction in total particle concentration in the ambient aerosol by about 5% but, more importantly, that its motor did not generate any particles.

3. AEROSOL GENERATION SYSTEM

For reasons mentioned previously, more emphasis was placed on work with artificial, well defined CCN which were used in 21 of the experiments while the ambient aerosol served in only eight comparison tests.

In order to cover the basic types of soluble, insoluble and hydrophobic aerosols, NaCl and $(NH_4)_2SO_4$ were selected for the first category due to their relevance to the real atmospheric aerosol. The choice for the water insoluble CCN material fell on pure AgI, mainly due to the relative ease with which this highly insoluble substance can be dispersed; it has to be pointed out that these AgI particles most likely do not resemble the ones generated for cloud seeding purposes which usually possess a water soluble component. Originally, the candidate material for hydrophobic CCN was Teflon (briefly used at the Ft. Collins WS), but the lack of a satisfactory dispersal method led to the use of paraffin wax instead.

Parameters to be varied other than the chemical make-up were the total particle number concentration (a few hundred to several thousand per cm^3), and the particle size distribution ("monodisperse", polydisperse and mode at several different sizes).

The experimental set-up for producing these aerosols is shown schematically in Figure 2. The aerosol generator, in this case a pneumatic atomizer for the production of water soluble CCN from salt solutions, is depicted at the top right of the figure. While many types of atomizers, especially inhalation therapy nebulizers, could, in principle, have been used for the present purpose, the requirements of constant output and prolonged operation demanded the design of a specialized and more versatile device as described in detail by Dea and Katz (1981) in a subsequent article.

In order to minimize contamination while providing a wide range of pressures needed for control of output parameters, the atomizer was operated with high grade compressed air from commercial tanks. The salt solutions were prepared from J.T. Baker and Fisher Scientific reagent grade salts and HPLC water (J.T. Baker Chemical Co.). The concentration of the salt solutions was varied according to the particle size requirements of individual experiments. After emerging from the atomizer, the fine mist of solution droplets was diluted about

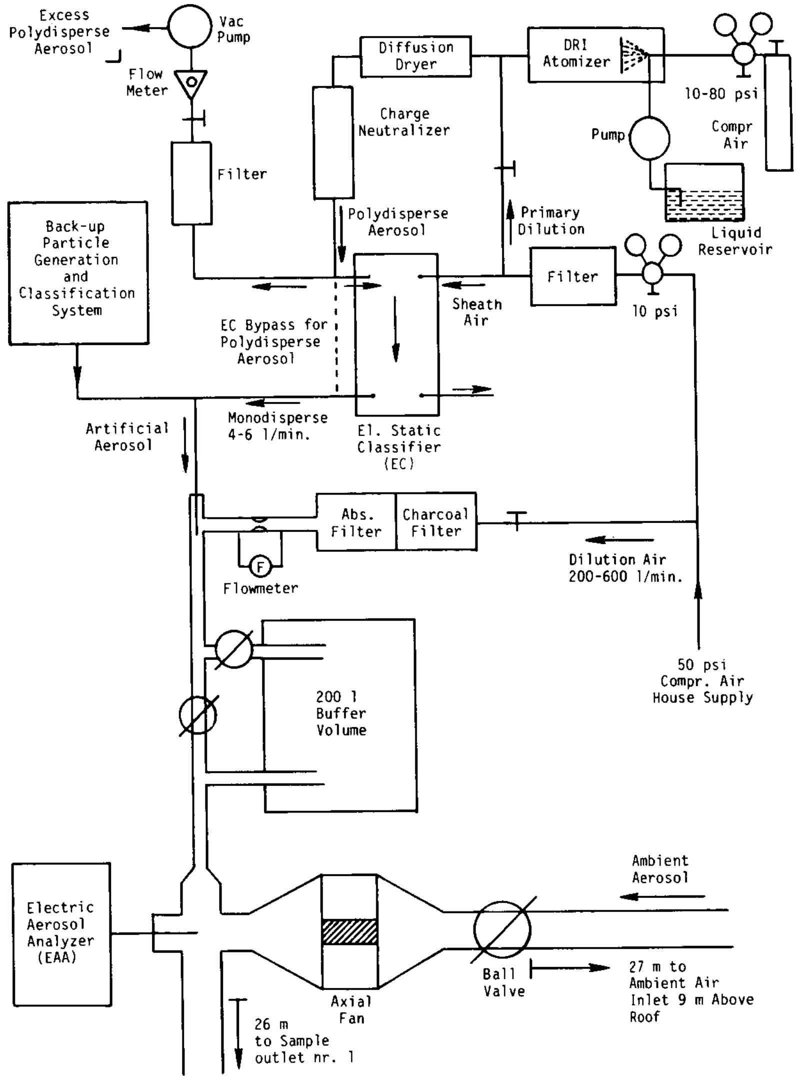

Figure 2. Schematic of Aerosol Generation System.

1:1 with dry filtered air, mainly to promote rapid evaporation of the droplets, but also to help reduce coagulation which is considerable at typical number densities of the order of $10^8 cm^{-3}$.

After complete removal of liquid water from the particles in the diffusion dryer (TSI Model 3062), the aerosol was brought to charge equilibrium by passing it through a charge neutralizer equipped with a 10 mCi Kr^{85} source. While this procedure helped reduce particle losses caused by charge effects, it was mainly preparatory to extracting a quasi-monodisperse fraction from the total atomizer output by means of an electrostatic classifier (EC, TSI Model 3071). Since theory and operation of this device are discussed extensively in a variety of papers (Knutson, 1975, 1976; Hoppel, 1978), only the following points most relevant to the WS application will be mentioned: The fact that the particles are classified by electrical mobility means that, in addition to particles of the desired size, a small but not negligible percentage of larger, multiply-charged particles were included in the nominally monodisperse aerosol leaving the EC. Also, the population of particles having essentially the selected size is not truly monodisperse but has a size distribution of finite width which depends on the flow conditions through the EC - a typical geometric standard deviation being about 1.2. Since laminar flow inside the EC is essential, the aerosol flow in and out of the EC is limited, in the present case, to about $100 cm^3s^{-1}$. Due to this condition, it was necessary to discard excess aerosol prior to entering the EC (the filter shown in that line on Figure 2 serves to protect the flow control valve and flow meter from salt deposits). Furthermore, this flow limitation in the EC, combined with a maximum particle number concentration imposed by coagulation rates, resulted in a maximum rate on the order of $10^7 s^{-1}$ at which "monodisperse" particles could be introduced into the sampling duct.

In order to achieve the necessary flow in the sampling duct (cf. previous section), the aerosol was injected axially into a turbulent stream of 200 to 600 ℓ min^{-1} clean dilution air. The 3 cm diameter dilution and mixing section shown in the center of Figure 2 incorporated an optional 200 ℓ buffer volume to smoothen high frequency fluctuations in aerosol concentration. Due to the large volume required, the dilution air had to be drawn from the house compressed air system which, in turn, necessitated particularly careful purification with oversized absolute and charcoal filters, especially in view of the fact that the dilution air constituted 97 to 99% of the air in the final aerosol delivered to the sampling duct. For flows under 600 ℓ min^{-1}, it was possible to keep the rate constant within two percent.

As the bottom part of Figure 2 indicates, the artificial aerosol was fed into the sampling duct 26 m from the first sampling outlet, just downstream of the axial fan. A 6 cm ball valve was used to seal off the ambient aerosol branch of the duct during artificial aerosol experiments.

The upper left-hand side of Figure 2 displays the location of an auxiliary aerosol generation system which was essentially a duplicate of the one described above. The auxiliary system was equipped with commercial inhalation type nebulizers and operated with filtered compressed air from the house supply. This system was used during some preliminary WS experiments and also during Experiment No. 10 where two "monodisperse" aerosols with different particle size were mixed.

In those experiments where no monodisperse aerosol was desired, the EC was by-passed as indicated by the dashed line in Figure 2. In contrast to the monodisperse case, the problem facing us here was to produce a sufficiently low particle concentration to be meaningful and acceptable for CCN instruments. Reduction of the air pressure on the atomizer to only a few psi drastically lowered the number output but, at the same time, reduced the output stability markedly. Similarly, when nearly all the aerosol originating from the atomizer was removed by aspiration into the excess aerosol line, the small differential flow into the sampling system underwent amplification of the small irregularities in the atomizer or excess flows. However, by applying both methods in moderation it was possible to provide a final particle concentration in the sampling duct as low as 400 cm^{-3}.

For the few experiments carried out with other than soluble CCN, the atomizer in Fig. 2 was replaced with the devices shown in Figs. 3 and 4.

AgI (purified, Fisher Scientific) was aerosolized thermally by bringing a small amount of the substance ($\sim$ 1 g) slightly above its melting point (550°C) by means of the arrangement shown in Fig. 3. The AgI was placed in a tantalum boat which was mounted on two copper electrodes inside a Pyrex flask. The temperature of the Ta-boat was controlled by manually regulating the low voltage heating current. A stream of dry N_2 (several $\ell\ min^{-1}$) directed at the hot AgI served to quench the vapors thus inducing recondensation of AgI particles. The resulting aerosol left the generator through the side tubulation and subsequently underwent the same handling as the soluble aerosols. In order to provide assurance that no parts of the generator other than the AgI were participating in aerosol formation, the device was tested without AgI; not until reaching temperatures well above 600° C did particle generation from the hot Ta set in. While temporal stability of the polydisperse AgI aerosol was quite within the required tolerances, the monodisperse case suffered from deviations in concentration of up to 10% from the mean.

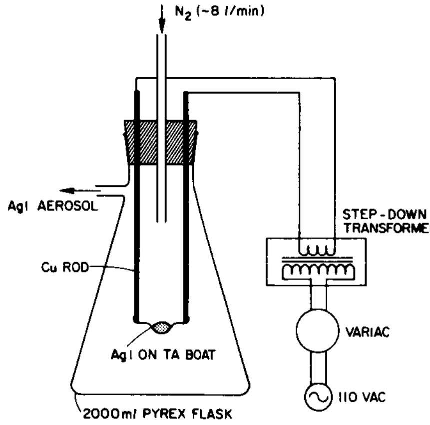

Figure 3. AgI Aerosol Generator

Preparation of the paraffin wax aerosol followed similar procedures. About 50 ml of paraffin were kept molten in a Pyrex flask at constant temperature by immersion in a bath of boiling water. A jet of dry N_2 from a capillary tube was blown vertically onto the liquid paraffin surface, again triggering particle formation through a quenching action. The polydisperse aerosol fluctuated in concentration by about 5%. Since the particle concentration was only in the vicinity of 400 cm^{-3} and most CCN instruments were able to detect only a small percentage of the hydrophobic particles, no experiment with monodisperse paraffin aerosol was carried out.

In order to facilitate interpretation of the CCN instruments' response to the test aerosols, a few WS participants measured size distributions (Hoppel, 1981; Rogers, 1981) and total number concentrations (Rogers and McKenzie, 1981), while Mach and Hucek (1981) performed some chemical analyses; the reader is referred to the respective papers for additional details.

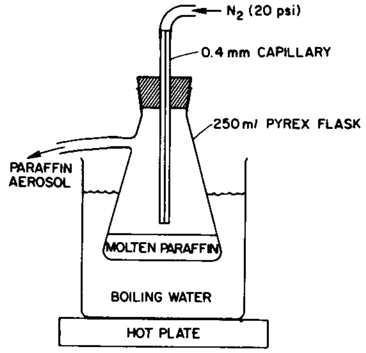

Figure 4. Paraffin Aerosol Generator

4. ACKNOWLEDGEMENTS

We gratefully acknowledge the support by the National Aeronautics and Space Administration under Grant No. NAS8-33820, and the National Science Foundation under Grant No. ATM79-21558.

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ELEMENTAL COMPOSITION OF AEROSOLS IN FOURTEEN EXPERIMENTS OF THE CLOUD CONDENSATION NUCLEI WORKSHOP

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ABSTRACT

International Cloud Condensation Nuclei (CCN) Workshop aerosols were collected with two Ci Impactors and analyzed with proton induced X-ray emission (PIXE) for chemical composition and to detect if contamination was present. One of the impactors sampled the generated aerosols; the other impactor sampled droplets from a diffusion cloud chamber. The purpose of the experiments was to test the feasibility of a study of the transfer of chemical elements from the fine particle sizes to the coarse particle sizes, after CCN are activated and cloud droplets are formed. The data indicated that sulfur-containing aerosols did exhibit the expected transfer.

1. INTRODUCTION

The aerosols generated during fourteen experiments of the International Cloud Condensation Nuclei Workshop were collected with seven stage, single orifice, Battelle-type cascade impactors (Mitchell and Pilcher, 1959) and analyzed with proton induced X-ray emission (PIXE) (Johansson et al, 1975) for chemical composition. Seven experiments were associated with the generation of aerosols of ammonium sulfate, three with sodium chloride, two with silver iodide, and two with ambient aerosols. A sample of AgI powder used to generate the aerosols was also analyzed with PIXE. Katz and Dea (1980) described the source of this AgI powder. The aerosols were analyzed for the mass in nanograms of Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, Cr, V, Mn, Fe, Ni, Cu, Zn, Br, Pb, Ag. The aerosols generated during the workshop did not always contain these elements; however, the aerosols were analyzed to detect any contamination. Several experiments were combined into one sampling period with the impactors. The aerosols were sampled in the experiments: 8-9, 10, 13-14, 15, 18-19, 20, 22, 24, 26, 27, 28.

2. DESCRIPTION OF INSTRUMENT AND ANALYSIS

Two cascade impactors were used to collect the aerosols. One impactor was connected to the tube that supplied aerosols to each experimenter, and a second impactor was placed behind a continuous flow diffusion (CFD) chamber that is similar to the CFD described by Hudson and Squires (1973, 1976). Both impactors have six stages with a Mylar film for collecting the aerosols and one stage with a 0.4 μm Nuclepore filter. The six stages separate the sampled aerosol into six size ranges with > 8, 8-4, 4-2, 2-1, 1-0.5, 0.5-0.25 μm aerodynamic diameter. Aerosols with aerodynamic diameters less than 0.25 μm were collected on the seventh stage with the Nuclepore filter. This Nuclepore filter limited the flow through the impactor to approximately 1 l/min. The first five Mylar films were coated with Vaseline and the sixth Mylar film was coated with paraffin. Each set of six coated Mylar films and one Nuclepore filter were matched with Mylar films and Nuclepore filter that were not exposed to the aerosol but were analyzed with PIXE to establish the background chemical composition of the filters.

The continuous flow diffusion chamber has two aluminum plates that are 50 cm long, 33 cm wide, and separated by 1.5 cm. The temperature of each plate is maintained with a circulating water bath, and the inner surface of each plate is covered with a black cotton cloth. Each cloth is wetted with water from the appropriate water bath. The chamber was normally operated with a temperature difference across the plates that produced a supersaturation of approximately 1%. The aerosol is sampled at the entrance of the chamber through a capillary tube that restricted the flow to about 0.25 l/min. A sheath flow of air maintained the aerosol in the middle of the chamber and provided air to supply the 1 l/min required for the cascade impactor at the exit port of the chamber.

In the analysis of the aerosols with PIXE, the aerosol sample is exposed to 5 MeV protons. The resulting X-ray spectrum is decomposed with a modified version of a computer program described by Kaufmann et al, 1977. Constants in this program are specified after the analysis of the spectra from a set of standards, which are samples of compounds or elements whose mass is known to within ±5%. The analysis by PIXE can provide a mass measurement to within ±5 nanograms.

3. DISCUSSION OF EXPERIMENTS

The purpose of these experiments with the two cascade impactors was to test the feasibility of a study of the transfer of chemical elements from the fine particle sizes, where $d < 0.5$ μm, to the coarse particle sizes, where $d > 4$ μm, after condensation of water vapor produces droplets. The chemical elements in those aerosol particles that are cloud condensation nuclei (CCN) will be transferred to the larger sizes; those elements in the aerosol particles that are not CCN, however, will remain at the smaller sizes. Several experiments with the two cascade impactors did indicate a possible transfer of sulfur. For example, a comparison of the sulfur collected on each stage of the impactor during experiments 13 and 14 is shown in Figure 1. These two experiments were sampled with the same filters to obtain more mass on each stage of the

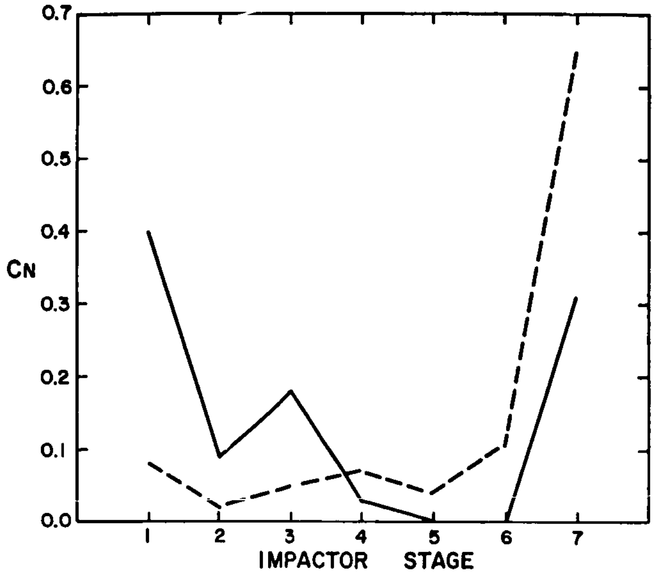

Figure 1. Comparison of mass of sulfur on seven stages of two Cascade Impactors. Stage 1 collects aerosol particles with an aerodynamic diameter d < 0.25 μm, and stage 7 collects particles with d > 8 μm. The mass collected by the impactor behind the CFD is shown with the dashed line, and the mass supplied to the CFD is shown with the solid line. The mass collected by each impactor has been normalized with the total mass collected on the impactor.

impactors. Stage 1 is the Nuclepore filter that collects aerosol particles with d < 0.25 μm, and stage seven collects particles with d > 8 μm. There is a smaller amount of sulfur, where the amount is expressed as a percent of the total mass of sulfur collected on all stages, on the Nuclepore filter and a larger amount on the seventh stage of the impactor behind the CFD.

Two problems made these experiments with the cascade impactors difficult. There was usually insufficient mass of a chemical element on a filter to permit a good determination of the total mass of each element on the filter. And some sulfur, as well as other elements, was usually found on stage seven of the impactor connected to the tube that supplied the aerosol from the aerosol generator. The CFD will be redesigned to provide more aerosol for the impactor. Furthermore, a filter can be placed in front of the CFD to prevent aerosol with d > 8 μm from entering the chamber.

The analysis of experiment 26, which was conducted with ambient aerosols that were in the room normally used to generate the aerosols, indicated 296 nanograms of bromine on the Nuclepore of the impactor connected to the tube. The Nuclepore on the CFD had 264 nanograms. The bromine was not found on the filters that were analyzed to provide an analysis of the chemical elements in the filters. The bromine, therefore, was on aerosols with d < 0.25 μm; and these aerosols were neither deliquescent nor sufficiently hygroscopic to be CCN at the imposed supersaturation of approximately 1%.

The sample of AgI powder used to generate the AgI aerosols was analyzed with PIXE to search for contamination with trace elements. No contamination was found in the analysis of this AgI powder.

4. ACKNOWLEDGEMENT

This work was supported by the National Aeronautics and Space Administration under Grant No. NAS8-33820, and the National Science Foundation under Grant No. ATM79-21558.

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COMPARISON BETWEEN TWO AITKEN COUNTERS
AND WITH CLOUD CONDENSATION NUCLEI COUNTERS
AT THE 1980 INTERNATIONAL CCN WORKSHOP

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ABSTRACT

Activities at the 1980 International CCN Workshop (Reno, Nevada) included using a Pollak counter and a TSI Model 3020 Condensation Nucleus Counter to monitor the test aerosol concentration. The performance of these two counters has been intercompared and, when monodisperse CCN were used as the test aerosol, these two counters have also been compared to one of the CCN counters which gave consistently good performance and is representative of the CCN counters involved in the Workshop. The Pollak and the TSI 3020 counters agreed to within about 10% at concentrations below 1000 cm^{-3}, whereas above that concentration, substantial systematic differences were observed. When the test aerosol was monodisperse and the CCN counters were operated at supersaturations that should nucleate all the aerosol, the Pollak counter read about 6% to 20% lower than the CCN counter in the concentration range from 250 cm^{-3} to 1800 cm^{-3}. This discrepancy is similar to that reported by Emmanuel and Squires (1969). The TSI 3020 read about 20% lower than the CCN counter at concentrations less than 1000 cm^{-3}, and a factor of about two higher at concentrations above 1000 cm^{-3}. Post-workshop calibration of the Pollak counter indicates that its performance was essentially in agreement with expectations for the instrument. Post-workshop evaluation of the TSI 3020 performance suggests the cause of the poor performance above 1000 cm^{-3} and indicates the care one must use to be sure the instrument is operated in such a way as to fulfill all the theoretical assumptions its proper performance is based upon.

1. INTRODUCTION

The main purpose of the October 6-17, 1980 International Cloud Condensation Nuclei Workshop, held at Reno, Nevada, was the intercomparison and performance evaluation of instruments which utilize applied supersaturations of the order of 1%. Such supersaturations should activate most cloud condensation nuclei (CCN), i.e., those nuclei capable of initiating cloud droplet growth in atmospherically-realistic conditions. Two inherently different instruments - Aitken counters - were also operated during the Workshop; these devices detect particles which nucleate at supersaturations of the order of 200% (which includes the special class of CCN). The Aitken counter data were used to monitor the stability of the output of the Workshop's test aerosol generation facility. The main purpose of this paper, however, is to discuss the intercomparison of the two Aitken counters - a Pollak counter and a TSI Model 3020 Condensation Nucleus Counter - and to compare them with the CCN counters when the test aerosol was a monodisperse aerosol under experimental conditions where it should be activated and detected by all the various devices.

The Nolan-Pollak Aitken counter has, in its present configuration, been in use about 20 years (Pollak and Metnieks, 1960). Detailed descriptions of this device and of its immediate predecessors are readily available (e.g., Metnieks and Pollak, 1959; Pollak and Metnieks, 1960; Pollak and Metnieks, 1957). [We shall follow the custom of referring to this device in an abbreviated manner as the "Pollak" counter, although the name of P.J. Nolan was also associated with the critical, early years of development of the instrument; see for example Nolan and Pollak (1946) - a work establishing the technical relationship and comparison of the Pollak counter to the classical Aitken counter.]

Subsequent workers examined various aspects of the operation and calibration of the Pollak counter. Kassner, et al. (1968) responded to earlier work criticizing the adiabaticity of the device, but concluded the reported discrepancies were a function of inappropriate diagnostic techniques rather than the Pollak counter itself. Emmanuel and Squires (1969) used a laboratory version Aitken counter in which activated droplets were recorded photographically to calibrate a Pollak counter over the approximate concentration range from zero to 1000 cm^{-3}. The resulting calibration curve gave concentrations about 30% higher than the curve of Pollak and Metnieks (1960). Liu, et al. (1975), responding to reports that the Pollak counter did not agree well with aerosol concentration measurements by the electrical mobility analyzer, reported careful comparison studies which indicated agreement to better than 10% between these two vastly different measurement techniques for concentrations less than $10^4 cm^{-3}$. In general, then, the Pollak counter has found widespread acceptance and use, particularly at concentrations below about $10^4 cm^{-3}$ where vapor depletion by growing droplets does not significantly depress the applied supersaturation. The Pollak counter used in this study is No. 7 of the series manufactured by R. Gussman.*

The newer Aitken counter at the Workshop was a TSI Model 3020 Condensation Nucleus Counter**

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(Serial No. 12). This counter samples a continuous, uninterrupted flow of aerosol through a saturation chamber (using butyl alcohol as the working fluid) and a chilling section, 25°C colder than the saturator, where the supersaturation is achieved. The commercial instrument was developed directly from the laboratory design described by Bricard, et al. (1976). The principle of operation and performance were discussed at the Ninth International Nucleation Conference (Argawal, et al., 1977). To the best of our knowledge, this report is the first published critical evaluation of the TSI Model 3020.

2. EXPERIMENTAL ARRANGEMENT

The layout of the Workshop laboratory is shown in Figure 1, indicating the arrangement of the various participants along the sample supply duct. The two Aitken counters received their sample from the same sample port, which was the last port on the supply line. Other papers in this volume discuss the details and results of the other instruments, and the nature of the aerosol generation and supply system. Twenty-nine separate experiments were carried out during the course of the Workshop (one of which had to be terminated due to an accidental duct blockage). A chronological listing and description of the type of aerosol used in each experiment is indicated in Table 1.

Excluding Experiment "0", for which no Aitken data were taken, there were ten experiments involving artificial monodisperse aerosols, ten involving artificial polydisperse aerosols, and eight involving natural (ambient) polydisperse aerosols. This comparison is mainly concerned with the monodisperse aerosol experiments, in which the aerosols were obtained by passing the polydisperse output from an atomizer through an "electrostatic classifier" which selects a monodisperse fraction of aerosol based upon electrical mobility. Aerosols thus prepared are not strictly monodisperse; however, examination of the results of these experiments in the form of cumulative CCN counts plotted as a function of individual CCN counter supersaturation setting usually shows a "plateau" or region where counts do not increase above a certain supersaturation, indicating that the size distribution is in fact very narrow. The results of these kinds of measurements are discussed in more depth in the papers describing the performance and intercomparison of the continuous-flow and static diffusion chambers. For our purposes, it is sufficient to note that when such a "plateau" exists, the nuclei concentration measured with an Aitken counter should be equal to the concentration measured on the "plateau" by a CCN counter, i.e., the existence of the "plateau" demonstrates that all the nuclei in the sample have been activated at the supersaturation setting of the CCN counter at which the "plateau" occurs and all nuclei will, of course, have been activated in the Aitken counters which operate at much higher supersaturations.

The operation of the Aitken counters was generally according to standard practice. The Pollak counter was operated according to the recommended procedure of Metnieks and Pollak (1959, op. cit.) with two exceptions: the light beam was slightly convergent (as recommended by Pollak and Metnieks (1960, op. cit.)), and 152 mm Hg over-pressure was used instead of the sea level value of 160 mm Hg in order to compensate for the effect of laboratory altitude above sea level upon the amount of liquid water released during the expansion (cf. Emmanuel and Squires, 1969, op. cit.).

The TSI 3020 CNC was operated according to manufacturer's instructions, with extra care given to maintain the sample flow rate through the instrument at the prescribed value of 5 cm^3/sec. Because the instrument uses a mass flow meter to measure and control flow, it is necessary to adjust the instrument flow control in response to altitude

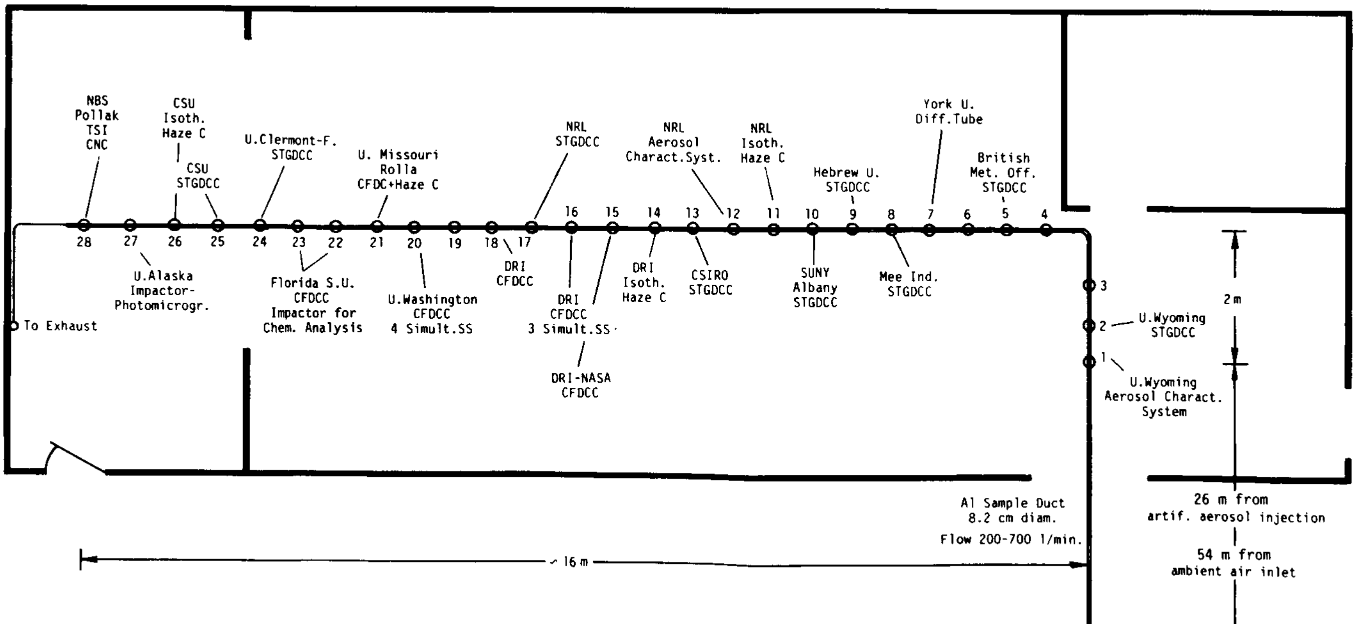

Figure 1. Layout of Sampling Duct and Instruments in Workshop Area.

TABLE 1. LIST OF EXPERIMENTS

No.	Date			Aerosol A=Ambient; M=Monodisperse; P=Polydisperse
0	Tues	7 Oct	AM	M - $(NH_4)_2SO_4$
1	Tues		PM	P - NaCl - oscillating concentration
2	Tues		PM	P - NaCl - higher concentration
3	Wed	8 Oct	AM	A - quite fluctuating
4	Wed		AM	M - NaCl - low concentration
5	Wed		PM	M - NaCl - medium concentration
6	Wed		PM	A
7	Thurs	9 Oct	AM	A - aborted - duct blockage
8	Thurs		AM	M - NaCl - slight drift down
9	Thurs		AM	M - NaCl - higher concentration
10	Thurs		PM	Bimodal - NaCl - "flat k"
11	Thurs		PM	A
12	Fri	10 Oct	AM	A
13	Fri		AM	P - $(NH_4)_2SO_4$
14	Fri		PM	P - $(NH_4)_2SO_4$
15	Fri		PM	M - $(NH_4)_2SO_4$
16	Fri		PM	A
17	Mon	13 Oct	AM	A
18	Mon		AM	M - $(NH_4)_2SO_4$
19	Mon		AM	M - $(NH_4)_2SO_4$
20	Mon		PM	M - $(NH_4)_2SO_4$
21	Mon		PM	M - $(NH_4)_2SO_4$ - time variations
22	Tues	14 Oct	AM	P - $(NH_4)_2SO_4$ - medium concentration
23	Tues		PM	P - $(NH_4)_2SO_4$ - low concentration
24	Tues		PM	P - $(NH_4)_2SO_4$ - high concentration
25	Wed	5 Oct	AM	Filtered air - noise check
26	Wed		AM	A
27	Wed		PM	P - AgI, "insoluble"
28	Wed		PM	M - AgI, "insoluble"
29	Wed		PM	P - paraffin, hydrophobic

effects on the density of air if one wants to maintain the volumetric flow rate at 5 cm^3/sec. When checked with a volumetric flowmeter (a bubble meter), the volumetric flow rate through the instrument was 4.92 cm^3/sec. The TSI 3020 CNC continuous real-time output, displayed on a chart recorder, provided a valuable monitor of the Workshop aerosol generation and delivery system stability.

3. EXPERIMENTAL RESULTS

A. Intercomparison of the Pollak and TSI CNC

The results of simultaneous measurements of the concentration of both polydisperse and monodisperse aerosols by the two instruments are shown in Figure 2. The results obtained with the TSI CNC are dependent upon the operating mode of the instrument, i.e., whether it was in the single-count mode or the photometric mode. The agreement between the two instruments is quite good when the TSI was operating in the single-count mode (lower curve in Figure 2), with the Pollak reading consistently about 10% lower. When the TSI operated in the photometric mode (upper curve) a nonlinear response occurred in the concentration range from 1000 cm^{-3} to 2000 cm^{-3}, and above that concentration the TSI gave values twice those of the Pollak. The discontinuity in the results of the TSI between the two operating modes and the nonlinear portion of the response curve will be discussed below in the section on TSI Performance Evaluation. We have post-Workshop evidence to suggest that the Pollak performed according to expectations and we conclude that the upper curve in Figure 2 indicates that the TSI performance suffered from a systematic calibration error in the photometric mode. This error did not seriously detract from the value of the instrument as a continuous monitor of the relative aerosol concentration during the course of the various experiments performed during the Workshop.

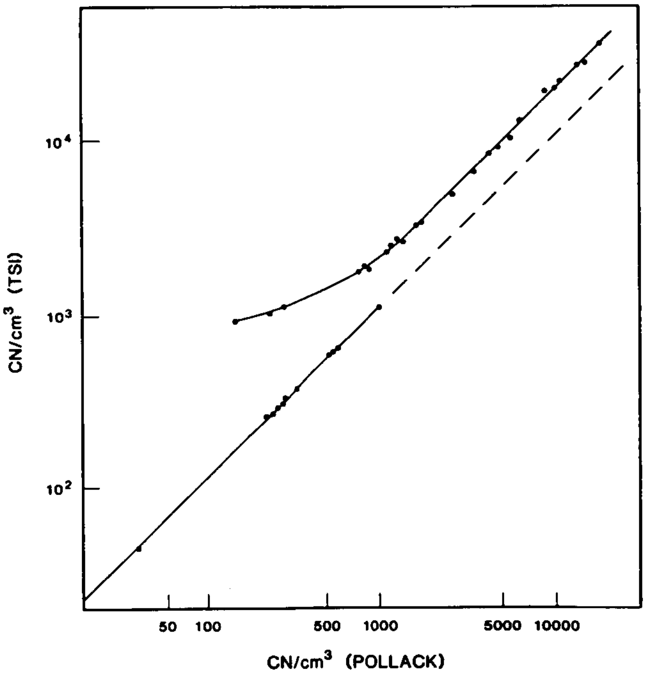

Figure 2. Comparison of the Pollak and TSI 3020 CN Counters.

We can also compare the Aitken counters with a representative CCN counter when all three instruments were sampling monodisperse aerosols. Monodisperse sodium chloride of nominal diameter 0.036 μm (Experiments 4 and 5) and 0.18 μm (Experiments 8 and 9) and monodisperse ammonium sulfate of nominal diameters 0.092, 0.04, 0.14 and 0.08 μm (Experiments 15, 18, 19, and 20, respectively) were the test aerosols. Monodisperse silver iodide of nominal diameter 0.12 μm was the test aerosol in Experiment 28. (The tenth monodisperse aerosol experiment was Experiment 21, a repeat of No. 20 for the purpose of evaluating the measurement reproducibility of the various instruments; it is not included here because the CCN counter selected for comparison to the Aitken counters was operated as an isothermal haze chamber during that experiment.)

B. Intercomparison of the Pollak and TSI with a CCN Counter

It has not been a trivial task to select a "representative" CCN counter for use in this comparison. Many devices, both static diffusion and continuous-flow diffusion types, appeared to operate well during the course of the Workshop. We have selected the continuous-flow diffusion (CFD) chamber from the University of Missouri at Rolla for the comparison, as it consistently provided concentration values that were higher in comparison to the average of all CCN counters, but not so high as to indicate a malfunction. Results from this chamber on monodisperse aerosols usually exhibited a well-defined "plateau" in the plot of cumulative CCN concentration as a function of supersaturation value. The higher-than-overall-average count values for this chamber may suggest it had fewer sampling and detection losses. In another paper in this volume, comparing this chamber (hereinafter referred to as the UMR CFD) with the other CFD chambers in the Workshop, it was identified as showing good comparative performance (Hudson and Alofs, 1981).

Figure 3 shows a comparison of the Pollak counter and the UMR CFD using count values taken from the "plateau" regions. Error bars on the data simply indicate the magnitude of the statistical counting error. Only the lowest value shows perfect agreement (Exp. 24). The UMR CFD gives higher values by 20% at the lower concentration experiments to 6% at the higher concentration experiments. It is interesting to recall that Emmanuel and Squires (1969, op. cit.) reported that the Pollak using the 1960 calibration values, undercounted in comparison to their photographic device, by about 30% over the concentration range from about 200 cm^{-3} to 1000 cm^{-3}. In a post-Workshop comparison of the DRI Pollak with another Pollak counter maintained as a standard by Dr. Austin Hogan, the DRI Pollak read high by some 10% to 20% (to be discussed below). Taking this discrepancy into consideration, the UMR CFD would be in agreement with the photographic device results reported by Emmanuel and Squires. These data, then, support the suggestion that a good CFD chamber will typically indicate on the order of 10% to 30% higher values than a Pollak counter when sampling monodisperse aerosol under conditions where the CFD is operating in the "plateau" for aerosols of varied chemical composition and of moderate concentration. (The activity of silver iodide as CCN is still a matter of some debate; here we present the one available data point (Experiment 28) and note that it is unremarkable in position on the plot.))

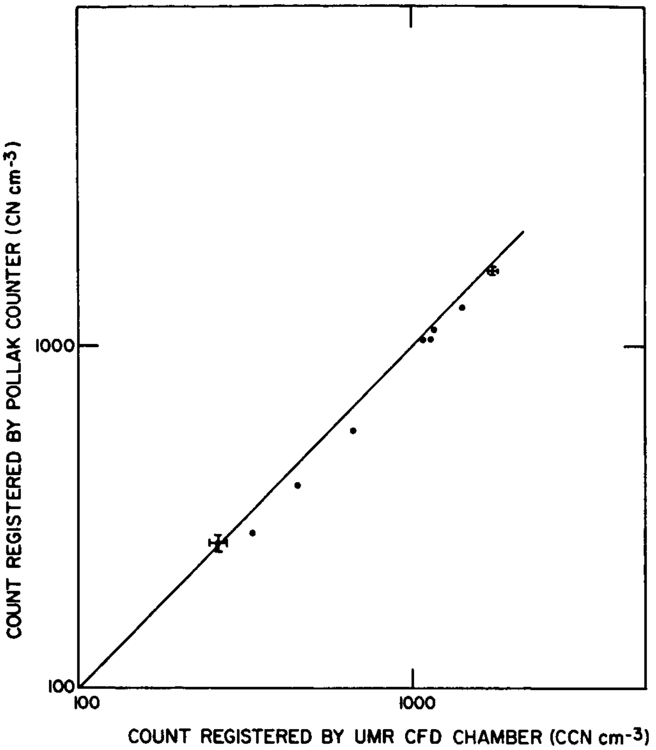

Figure 3. Comparison of the Pollak Counter and the UMR CFD CCN Counter.

A comparison of the results of the TSI CNC and the UMR CFD is shown in Figure 4 where, again, the values for the UMR CFD are the cumulative concentration values determined from the "plateau". The UMR CFD results correlate very well with the TSI (with the possible exception of silver iodide), being consistently 20% higher over the range up to 1000 cm^{-3}, where the TSI is operating in the single-count mode. As one would anticipate from the data presented in Figure 2, the TSI reads higher by a factor of about 2 when operating in the photometric mode.

4. POST-WORKSHOP CALIBRATION OF THE POLLAK COUNTER

The DRI Pollak counter (No. 7) was built and calibrated according to the published procedures of its inventors, but had not been compared against another Pollak counter in recent years before the Workshop. At the kind invitation of Drs. Jim Jiusto and Austin Hogan of the Atmospheric Sciences Research Center, State University of New York at Albany, a post-Workshop calibration was performed in February, 1981 in their laboratory. Pollak counter No. 7 was first compared to No. 12 "as is", and then was dismantled and the internal alignment of the light beam was checked. The "as is" calibration gave the result that the DRI Pollak No. 7 consistently read 10% to 20% higher than No. 12 over the concentration range for 400 cm^{-3} to 70,000 cm^{-3}. Upon dismantling and inspecting No. 7, it was found that although the light beam was of the proper diameter at the photocell end of the fog tube, it was off-axis by about 0.4 cm. Correction of this misalignment did not, however, change the systematic discrepancy that existed between the two instruments.

Several possible sources of such a systematic difference were explored, for example, by interchanging the photocells and the microammeters which provide the output signals and readings of the Pollak counters, and by interchanging operators. None of these changes removed the discrepancy. A potentially important parameter suggested in the paper of Pollak and Metnieks (1960, op.cit.) led us to investigate the rapidity with which the clean-air overpressure was established in the two instruments. Due to minor differences in the plumbing of these instruments, No. 12 achieved overpressure at a slower rate than No. 7. Standardizing both devices to the overpressure rate of No. 12 led to excellent agreement, with differences now less than would be anticipated due to statistical counting errors. It appears that the time to achieve overpressure in No. 7 (the Pollak used in the Workshop) was less than that recommended by Pollak and Metnieks (1960, op.cit.), whereas the time required for No. 12 was longer than the recommended time. We can only estimate that Pollak No. 7 was reading higher during the Workshop than an "ideal" Pollak would have, by an amount less than 10 to 20% of the number concentration.

5. TSI PERFORMANCE EVALUATION

A brief description of the operational modes and the associated underlying assumptions of the TSI CNC is necessary in order to evaluate its performance during the Workshop. The sample stream is first saturated with alcohol and then passed through a chilled condenser tube where supersaturation occurs; the nuclei are activated and the resulting droplets grow to 5 μm to 10 μm diameter. The sample of droplets then passes into a viewing/ detection volume. There are two modes of operation

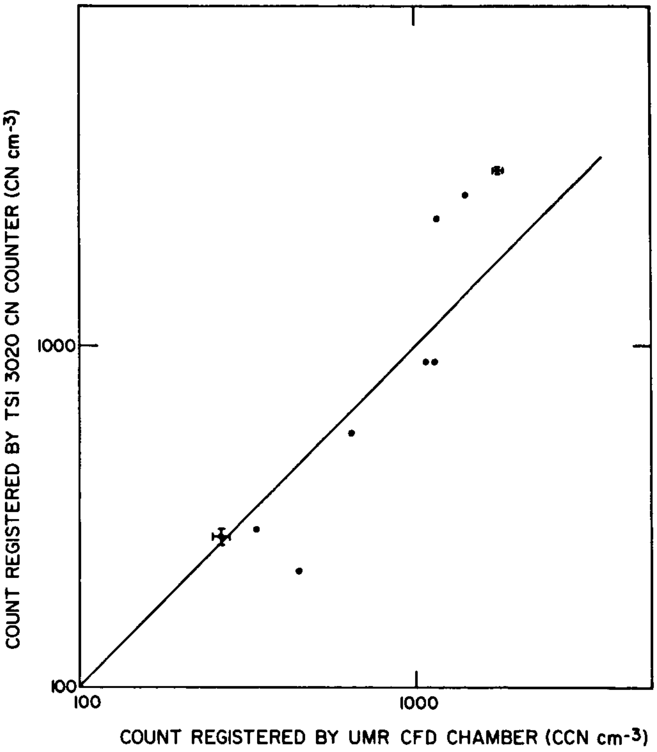

Figure 4. Comparison of the TSI 3020 CN Counter and the UMR CFD CCN Counter.

for detecting the droplets. At concentrations below 1000 cm^{-3}, electrical pulses generated by light scattered from individual droplets are counted and this count rate is converted to particle concentration and displayed on the front panel and is also available as an analog output. At particle concentrations above $10^3 cm^{-3}$, the photodetector circuit measures the light scattered from all the droplets present in the viewing volume at any given time. The photodetector output is calibrated as a function of concentration, and the results of the calibration are incorporated into the electronics of the instrument so that it displays the correct concentration.

In the single count mode the instrument operates in an absolute counting mode and the accuracy of the concentration is determined only by the accuracy of the flow rate of the sample and correction for coincidence losses occurring due to two or more droplets passing through the viewing volume simultaneously. (Statistical errors of counting for low count values can be reduced to desired levels by increasing counting times.) Because the flow monitor and control system is based upon a mass flow meter, the volumetric flow rate through the instrument will be sensitive to altitude and must be corrected if the instrument is operated at altitudes other than that at which it was set up. One can either reset the flow to give 5 cc^3/sec or calculate the actual volumetric flow and apply an appropriate correction factor to the indicated concentration (i.e., multiply by [5 cm^3sec^{-1}/(actual volumetric flow in cm^3sec^{-1})]). The instrument we used in the Workshop was adjusted to correct the flow to 4.92 cm^3sec^{-1}.

In the photometric mode additional conditions must be met to assure that the instrument performs in calibration. Because the final droplet size determines the amount of light scattered per original activated nuclei, any parameter that affects droplet size must be controlled to maintain the conditions for which the photometric mode was calibrated. Changes in altitude in this case will affect not only the flow rate (and therefore the growth time in the condenser) but may also affect vapor diffusivity and thermal diffusivity. These effects have not yet been well studied for this instrument. A second precaution one must be aware of is the effect of dirty optics in the photodetector. In the single count mode, this will have no affect because one is just counting pulses, not scattered intensity. However, in the photometric mode all scattered light contributes to the count rate, whether it is scattered from dirty optics or from droplets in the viewing volume. The error will be most pronounced at low values in the photometric mode and will become increasingly less important as the concentration increases. We believe that this is the cause of the non-linear portion of the TSI response when compared to the Pollak in the log-log plot in Figure 2. Dirty optics will produce a constant, small D.C. offset that will be integrated into the signal in the photometric mode signal. As the total signal increases, it becomes a negligible contribution to the signal and the response then appears linearly related to the Pollak response. (Unfortunately there has not been opportunity since the Workshop to inspect the optics as they were during the Workshop in order to confirm this explanation of that portion of the curve.) The linear portion of the photometric mode response is parallel to the single count mode response when extrapolated to the photometric mode concentration range. This suggests that the discrepancy is due to an error in the calibration factor for the instrument under the operating conditions encountered at the Workshop. One instrumental parameter that is useful in helping determine if the calibration may be in error is the photodetector pulse height. For the instrument we used, the value when the CNC was calibrated was 0.30 Volts peak-to-peak. A post-Workshop reading indicated it was 0.55 to 0.6 Volts, indicating that the instrument would not be expected to be in proper calibration. It is tempting to note that the ratio of the actual pulse height to the correct pulse height is the same as the difference between the photometric mode results and the extrapolated single count mode values, i..e, a factor of about 2. This cannot, however, be applied in such a straightforward manner because calibration will also depend on other parameters. It is sufficient here to note that there is reasonable evidence to indicate that the photometric mode results are high because the calibration is not applicable under the conditions in which we used the instrument, but that the linear response with concentration indicates that the TSI CNC will still give reliable relative concentration values under these conditions. These results again demonstrate the importance of understanding the underlying principles of the detection/measurement process of the instrument.

6. CONCLUSIONS

The performance of a Pollak counter (No. 7) of nearly standard specifications was compared with that of a set of CCN counters as represented by the UMR CFD under conditions where both were sampling the same monodisperse aerosol. Nine experiments are represented in the comparison data which indicates that the Pollak underestimates the concentration by 10% to 30% over the concentration range from about 260 cm^{-3} to 1800 cm^{-3} in comparison to the UMR CFD. This discrepancy is of the same sign, but of slightly smaller magnitude than that reported earlier by Emmanuel and Squires (1969, op.cit.) for a comparison of the Pollak counter with an "absolute" Aitken counter which recorded the droplet concentration photographically for subsequent counting.

A TSI 3020 CNC was also compared with the Pollak and the UMR CFD counters. It gave concentration values 20% lower than the UMR CFD in the concentration range from 260 cm^{-3} to 1000 cm^{-3} (i.e., when the TSI was in the single-count mode). It gave values 10% higher than the Pollak over the same concentration range. Above 1000 cm^{-1}, when the TSI operated in the photometric mode, it gave values about 2 times higher than the Pollak or the UMR CFD.

This work, then, has demonstrated very good agreement between three instruments of vastly different design and detection/measurement principles - the Pollak counter, a continuous-flow CCN counter, and a continuous-flow CNC. The present results essentially confirm the earlier work of Emmanuel and Squires (1969, op.cit.) which indicated a small positive correction to the calibration of the Pollak at aerosol concentrations below 1000 cm^{-3}. The apparent discrepancy between the Pollak and the UMR CFD is somewhat accentuated by the fact that the UMR CFD consistently read higher than the average of the other CCN counting devices in the Workshop.

The comparison study by Hudson and Alofs (1981, op.cit.) indicates that the UMR CFD was operating properly and providing accurate data. The excellent agreement with the TSI, which is a self-calibrating or absolute detector when in the single-count mode, is particularly gratifying and provides additional confidence in the validity of the large store of Aitken concentration values that have been obtained through the use of the Pollak counter over the past 20 some years.

The TSI 3020 CNC exhibited very good performance in the single-count mode and, despite loss of absolute accuracy in the photometric mode (as discussed in the text), it still provided valuable real-time relative concentration measurements which were of great utility in assessing the stability of the test aerosol generation system.

7. ACKNOWLEDGEMENTS

The authors wish to thank Dr. Austin Hogan, Mr. Stephen Barnard, and Mr. Mike Meyer for their very careful efforts in the post-Workshop calibration of the Pollak counter. This work was supported by the National Aeronautics and Space Administration under Grant No. NAS8-33820, and the National Science Foundation under Grant No. ATM79-21558.

Certain commercial equipment, instruments or materials are identified in this paper in order to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Bureau of Standards nor does it imply that the materials or equipment are necessarily the best available for the purpose.

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COMPARING DRY AEROSOL SIZE MEASUREMENTS

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Two instruments were used to size dry aerosols for the CCN experiments. The Naval Research Laboratory (NRL) instrument uses an electrical mobility analyzer (Hoppel, 1978) to separate the aerosol size fractions and a diffusion chamber (Hoppel, et al., 1979) to grow and count the particles. The University of Wyoming (WYO) Aerosol Monitoring System (Rogers and Vali, 1981) consists of three devices which are monitored and controlled by a minicomputer. The devices are: a Thermo-systems Electrical Aerosol Size Analyzer (Model 3030) which covers the size range 0.005 to 0.18 µm radius, an Environment One (E1) Condensation Nucleus Monitor (Model Rich 100) for Aitken particles, and an optical particle counter (Climet Model 6064A optics and in-house electronics) to cover the size range 0.15 to 8 µm radius.

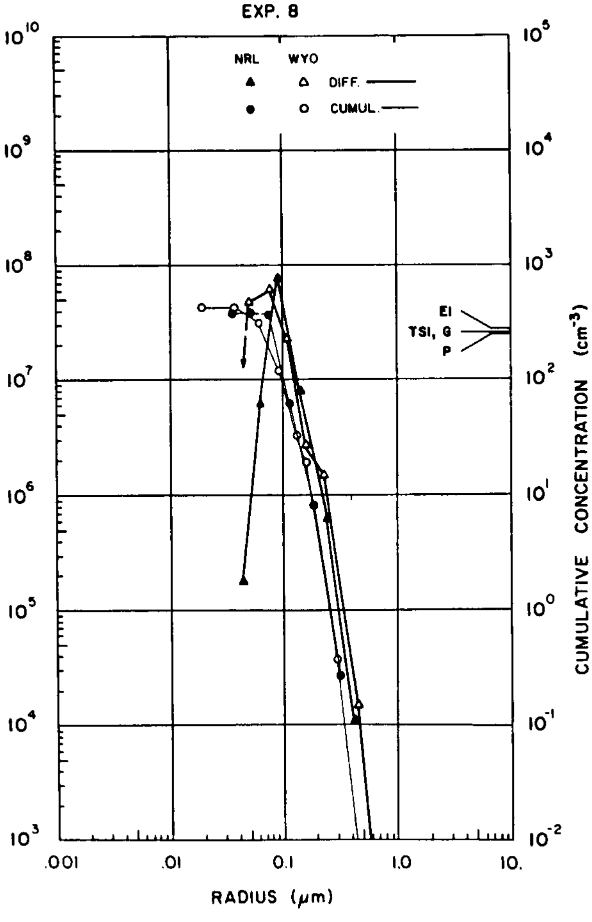


Figure 1. Aerosol size distributions of Experiment 8: average of two Naval Research Laboratory (NRL) measurements and of three University of Wyoming (WYO) measurements. Also shown are Aitken counter values (El = Environment One, Model Rich 100, TSI = Thermo-systems Model 3020, P = Pollak Counter and G = Gardner Counter).

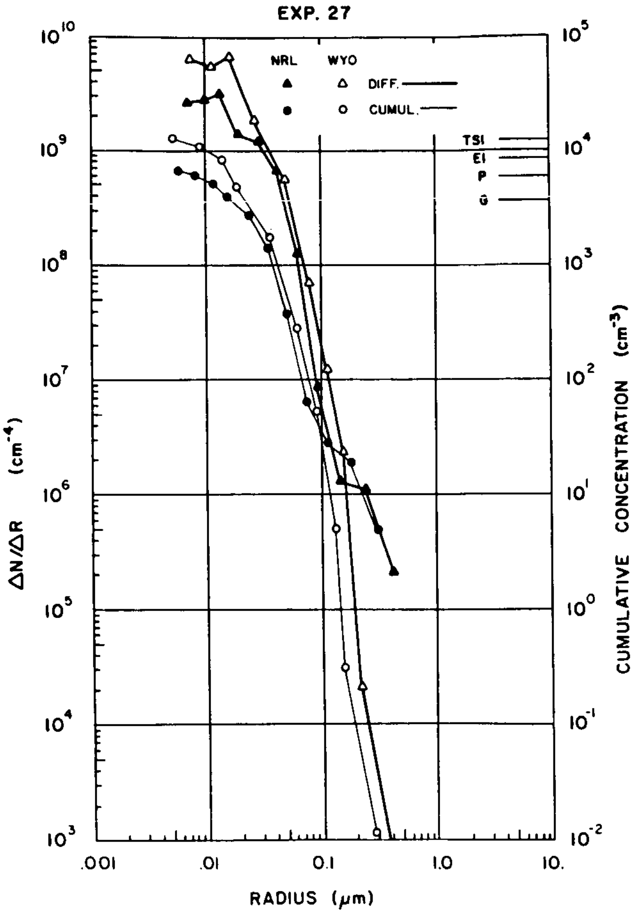


Figure 2. As for Figure 1, but aerosol from Experiment 27: average of four NRL measurements and of two WYO measurements.

Measurements from these two systems were usually found to be in agreement during the CCN Workshop. Two examples are presented here to compare aerosol size distribution measurements of the two instruments: Experiment 8 (monodisperse NaCl) and Experiment 27 (polydisperse AgI). Differential (dN/dR) and cumulative plots are shown for both instruments for Experiment 8 in Figure 1 and for Experiment 27 in Figure 2; also shown are Aitken particle measurements for comparison. The monodisperse peak of Experiment 8 was well defined by both instruments, although information below 0.05 µm was not discernible for the WYO system; this is likely due to the low concentration, lower than the mobility analyzer is expected to detect reliably. Both instruments indicated peak concentrations in the range 0.08 to 0.1 µm radius and total particle concentrations of 400 to 500 cm^{-3}. The total concentrations from the mobility analyzers are approximately twice the values obtained from the Aitken counters.

Measurements of the shape of the aerosol size distribution of Experiment 27 were in substantial agreement below 0.1 μm, even to detecting a slight peak at 0.2 μm radius. At larger sizes, the NRL instrument measured a higher concentration than the WYO optical counter, and at smaller sizes, the WYO mobility analyzer measured higher concentrations than NRL. Both instruments indicated that the greatest concentrations occurred at the small sizes, but the Aitken particle counters offer little help in resolving the discrepancy in integrated total concentration, since their values range over a factor of 3. Perhaps the chemical composition and shape of the aerosol was partly responsible, as thermally generated AgI is expected to be wettable but unsoluble and may have a linear rather than globular shape.

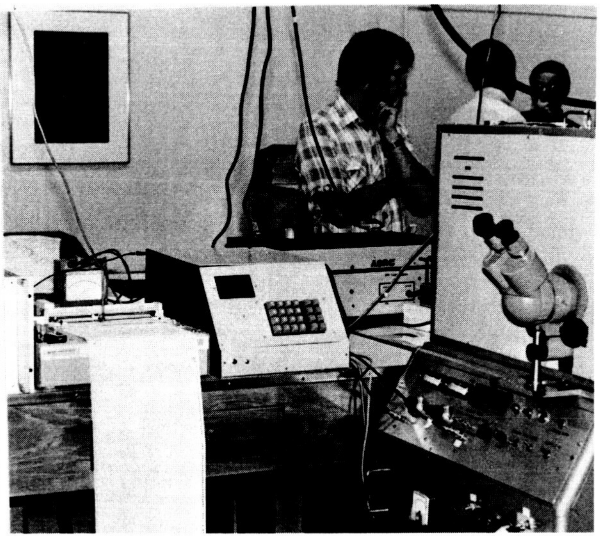
References

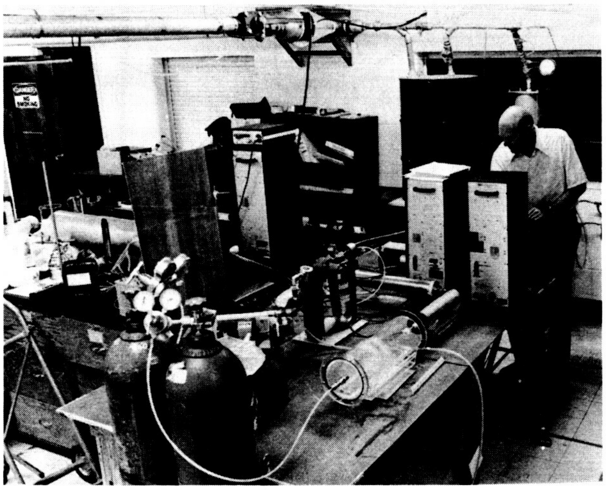
Hoppel, W.A., 1978: Determination of the aerosol size distribution from the mobility distribution of the charged fraction of aerosols. *J. Aerosol Sci.*, *9*, 41-54.

Hoppel, W.A., S. Twomey and T.A. Wojciechowski, 1979: A segmented thermal diffusion chamber for continuous measurements of CN. *J. Aerosol Sci.*, *10*, 369-373.

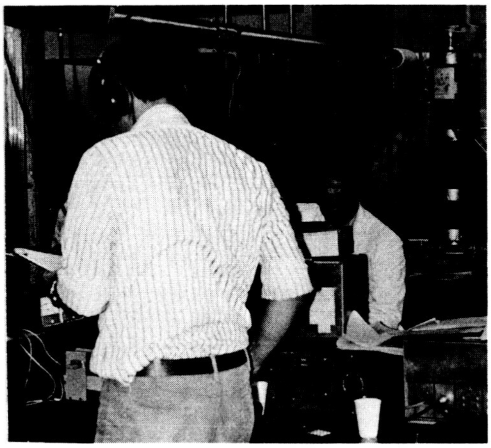
Rogers, D.C. and G. Vali, 1981: Aerosols, cloud nuclei and ice nuclei. Chapter 3 of 1976 National Hail Research Experiment Final Report (in press), NCAR, Boulder, Colorado.

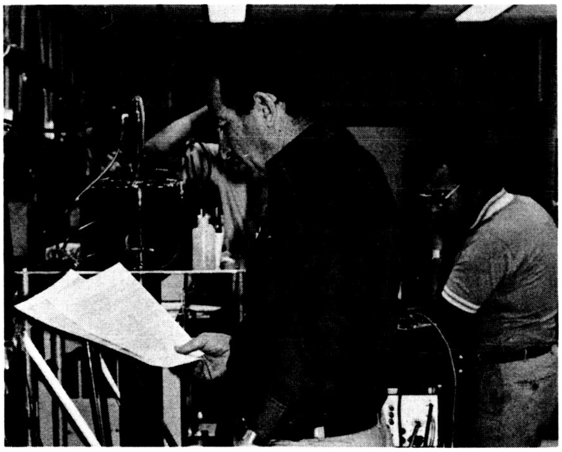

CONDENSATION NUCLEUS
tsi

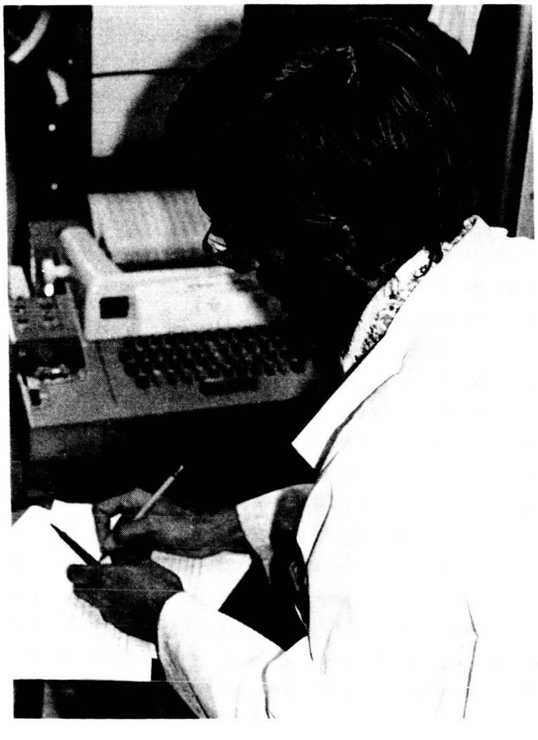


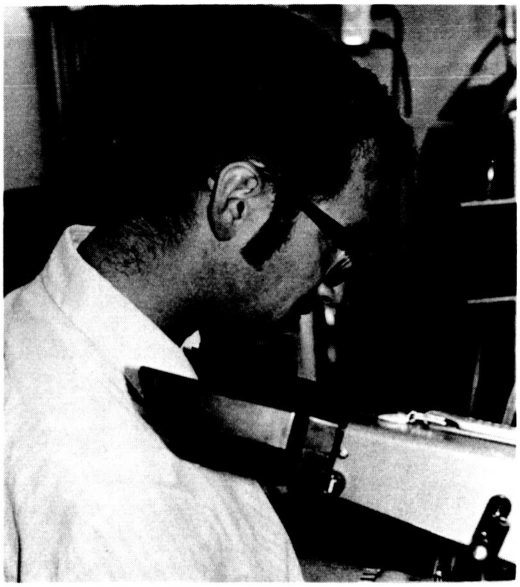


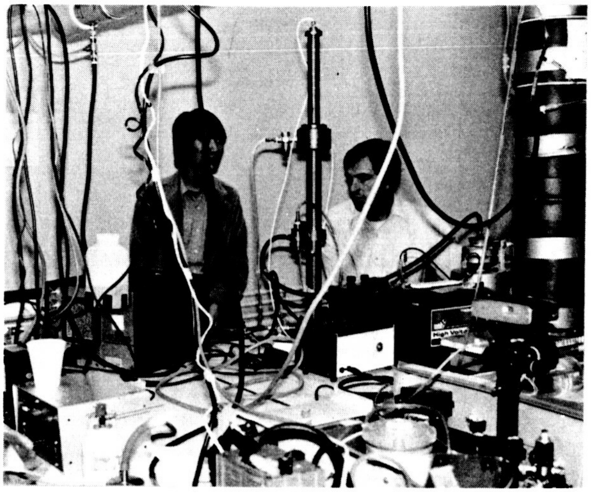
DANGER
NO SMOKING

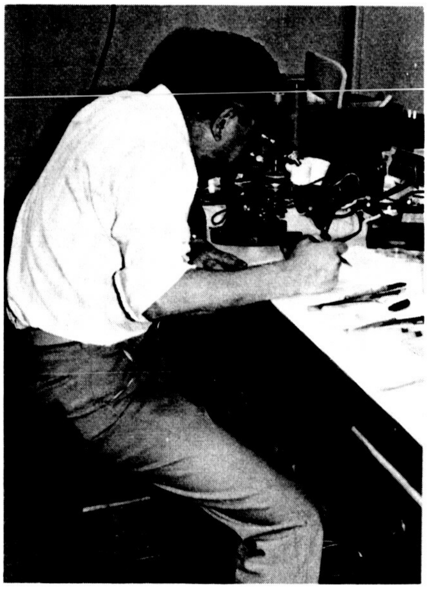


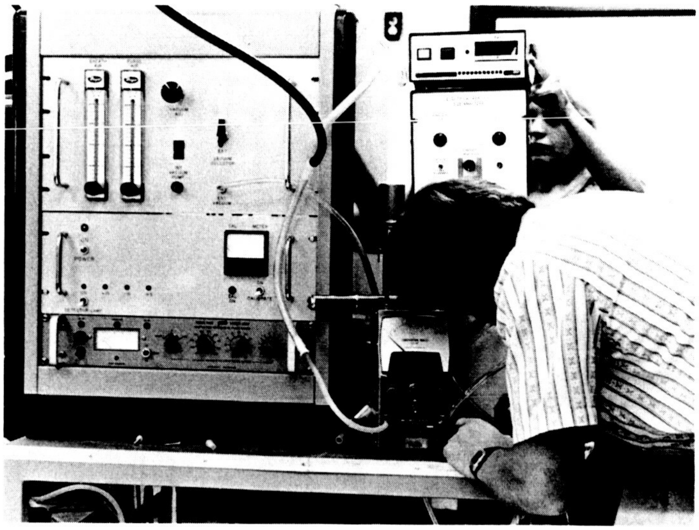












APPENDIX A

TABULATED DIFFERENTIAL SIZE SPECTRA RESULTS FROM NRL MOBILITY ANALYZER

FOR FURTHER DETAILS, REFER TO WILLIAM A. HOPPEL PAPER,
"MEASUREMENT OF THE AEROSOL SIZE DISTRIBUTION WITH NRL'S MOBILITY ANALYZER"
CONTAINED IN SECTION VI.

NOTE THAT ABSENCE OF AN ENTRY IN DN/DR COLUMN INDICATES CONCENTRATION WAS VERY LOW OR ZERO.

Experiment #1 - Average of 3 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	1.69×10^{5}
2	1.83×10^{-5}cm	3.24×10^{5}
3	1.15×10^{-5}cm	4.19×10^{6}
4	7.53×10^{-6}cm	1.87×10^{7}
5	5.03×10^{-6}cm	5.80×10^{7}
6	3.46×10^{-6}cm	1.55×10^{8}
7	2.37×10^{-6}cm	2.53×10^{8}
8	1.52×10^{-6}cm	3.09×10^{8}
9	1.15×10^{-6}cm	6.05×10^{8}
10	8.10×10^{-7}cm	3.12×10^{8}
11	5.75×10^{-7}cm	2.23×10^{8}

Experiment #2 - Average of 2 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	2.11×10^{4}
2	1.83×10^{-5}cm	1.72×10^{6}
3	1.15×10^{-5}cm	1.07×10^{7}
4	7.53×10^{-6}cm	4.41×10^{7}
5	5.03×10^{-6}cm	1.15×10^{8}
6	3.46×10^{-6}cm	2.67×10^{8}
7	2.37×10^{-6}cm	5.14×10^{8}
8	1.52×10^{-6}cm	7.05×10^{8}
9	1.15×10^{-6}cm	1.35×10^{9}
10	8.10×10^{-7}cm	8.22×10^{8}
11	5.75×10^{-7}cm	7.14×10^{8}

Experiment #3 - One Run Only

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	6.40×10^{6}
2	1.83×10^{-5}cm	3.33×10^{7}
3	1.15×10^{-5}cm	9.17×10^{7}
4	7.53×10^{-6}cm	1.40×10^{8}
5	5.03×10^{-6}cm	4.44×10^{8}
6	3.46×10^{-6}cm	7.06×10^{8}
7	2.37×10^{-6}cm	8.23×10^{8}
8	1.52×10^{-6}cm	2.81×10^{9}
9	1.15×10^{-6}cm	8.97×10^{9}
10	8.10×10^{-7}cm	3.41×10^{9}
11	5.75×10^{-7}cm	9.41×10^{8}

Experiment #4 - Average of 4 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	
2	1.83×10^{-5}cm	
3	1.15×10^{-5}cm	
4	7.53×10^{-6}cm	
5	5.03×10^{-6}cm	
6	3.46×10^{-6}cm	2.70×10^{5}
7	2.37×10^{-6}cm	3.26×10^{7}
8	1.52×10^{-6}cm	3.57×10^{8}
9	1.15×10^{-6}cm	3.68×10^{8}
10	8.10×10^{-7}cm	3.54×10^{7}
11	5.75×10^{-7}cm	

Experiment #5 - Average of 3 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	
2	1.83×10^{-5}cm	
3	1.15×10^{-5}cm	
4	7.53×10^{-6}cm	
5	5.03×10^{-6}cm	
6	3.46×10^{-6}cm	3.54×10^{6}
7	2.37×10^{-6}cm	1.51×10^{8}
8	1.52×10^{-6}cm	1.55×10^{9}
9	1.15×10^{-6}cm	1.60×10^{8}
10	8.10×10^{-7}cm	6.88×10^{6}
11	5.75×10^{-7}cm	

Experiment #6 - Average of 3 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	1.06×10^{5}
2	1.83×10^{-5}cm	2.66×10^{6}
3	1.15×10^{-5}cm	3.06×10^{7}
4	7.53×10^{-6}cm	1.17×10^{8}
5	5.03×10^{-6}cm	1.74×10^{8}
6	3.46×10^{-6}cm	4.19×10^{8}
7	2.37×10^{-6}cm	9.75×10^{8}
8	1.52×10^{-6}cm	2.15×10^{9}
9	1.15×10^{-6}cm	7.26×10^{9}
10	8.10×10^{-7}cm	8.03×10^{9}
11	5.75×10^{-7}cm	2.54×10^{9}

Experiment #8 - Average of 2 Runs

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	$1.08x10^{4}$
2	$1.83x10^{-5}$cm	$6.22x10^{5}$
3	$1.15x10^{-5}$cm	$7.83x10^{6}$
4	$7.53x10^{-6}$cm	$7.67x10^{7}$
5	$5.03x10^{-6}$cm	$6.13x10^{6}$
6	$3.46x10^{-6}$cm	$1.77x10^{5}$
7	$2.37x10^{-6}$cm	
8	$1.52x10^{-6}$cm	$8.27x10^{4}$
9	$1.15x10^{-6}$cm	$2.54x10^{4}$
10	$8.10x10^{-7}$cm	$1.76x10^{2}$
11	$5.75x10^{-7}$cm	

Experiment #11 - Average of 3 Runs

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	$1.90x10^{5}$
2	$1.83x10^{-5}$cm	$1.77x10^{6}$
3	$1.15x10^{-5}$cm	$2.81x10^{7}$
4	$7.53x10^{-6}$cm	$8.86x10^{7}$
5	$5.03x10^{-6}$cm	$1.03x10^{8}$
6	$3.46x10^{-6}$cm	$2.89x10^{8}$
7	$2.37x10^{-6}$cm	$2.35x10^{8}$
8	$1.52x10^{-6}$cm	$1.59x10^{9}$
9	$1.15x10^{-6}$cm	$5.69x10^{8}$
10	$8.10x10^{-7}$cm	$1.36x10^{9}$
11	$5.75x10^{-7}$cm	$3.95x10^{9}$

Experiment #9 - Average of 3 Runs

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	$4.86x10^{4}$
2	$1.83x10^{-5}$cm	$1.49x10^{6}$
3	$1.15x10^{-5}$cm	$1.58x10^{7}$
4	$7.53x10^{-6}$cm	$1.39x10^{8}$
5	$5.03x10^{-6}$cm	$8.82x10^{6}$
6	$3.46x10^{-6}$cm	$6.89x10^{6}$
7	$2.37x10^{-6}$cm	
8	$1.52x10^{-6}$cm	$2.21x10^{5}$
9	$1.15x10^{-6}$cm	$4.72x10^{4}$
10	$8.10x10^{-7}$cm	$3.19x10^{2}$
11	$5.75x10^{-7}$cm	

Experiment #13 - Average of 3 Runs

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	$5.49x10^{4}$
2	$1.83x10^{-5}$cm	$2.65x10^{5}$
3	$1.15x10^{-5}$cm	$4.76x10^{6}$
4	$7.53x10^{-6}$cm	$4.98x10^{7}$
5	$5.03x10^{-6}$cm	$1.93x10^{8}$
6	$3.46x10^{-6}$cm	$4.93x10^{8}$
7	$2.37x10^{-6}$cm	$1.02x10^{9}$
8	$1.52x10^{-6}$cm	$1.63x10^{9}$
9	$1.15x10^{-6}$cm	$3.39x10^{9}$
10	$8.10x10^{-7}$cm	$2.44x10^{9}$
11	$5.75x10^{-7}$cm	$2.26x10^{9}$

Experiment #10 - Average of 2 Runs

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	
2	$1.83x10^{-5}$cm	
3	$1.15x10^{-5}$cm	$1.33x10^{6}$
4	$7.53x10^{-6}$cm	$1.19x10^{7}$
5	$5.03x10^{-6}$cm	$3.38x10^{7}$
6	$3.46x10^{-6}$cm	$4.75x10^{7}$
7	$2.37x10^{-6}$cm	$5.06x10^{7}$
8	$1.52x10^{-6}$cm	$1.07x10^{9}$
9	$1.15x10^{-6}$cm	$8.61x10^{8}$
10	$8.10x10^{-7}$cm	$1.58x10^{7}$
11	$5.75x10^{-7}$cm	

Experiment #14 - Average of 3 Runs

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	$4.22x10^{4}$
2	$1.83x10^{-5}$cm	$6.92x10^{5}$
3	$1.15x10^{-5}$cm	$1.07x10^{7}$
4	$7.53x10^{-6}$cm	$5.86x10^{7}$
5	$5.03x10^{-6}$cm	$1.50x10^{8}$
6	$3.46x10^{-6}$cm	$6.23x10^{8}$
7	$2.37x10^{-6}$cm	$1.16x10^{9}$
8	$1.52x10^{-6}$cm	$1.54x10^{9}$
9	$1.15x10^{-6}$cm	$3.04x10^{9}$
10	$8.10x10^{-7}$cm	$1.98x10^{9}$
11	$5.75x10^{-7}$cm	$2.13x10^{9}$

Experiment #15 - Average of 2 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	
2	1.83×10^{-5}cm	3.09×10^{4}
3	1.15×10^{-5}cm	9.70×10^{5}
4	7.53×10^{-6}cm	3.26×10^{7}
5	5.03×10^{-6}cm	1.84×10^{8}
6	3.46×10^{-6}cm	5.43×10^{8}
7	2.37×10^{-6}cm	
8	1.52×10^{-6}cm	
9	1.15×10^{-6}cm	1.93×10^{6}
10	8.10×10^{-7}cm	
11	5.75×10^{-7}cm	5.20×10

Experiment #17 - Average of 2 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	1.48×10^{5}
2	1.83×10^{-5}cm	7.51×10^{5}
3	1.15×10^{-5}cm	6.71×10^{6}
4	7.53×10^{-6}cm	3.53×10^{7}
5	5.03×10^{-6}cm	1.77×10^{8}
6	3.46×10^{-6}cm	4.49×10^{8}
7	2.37×10^{-6}cm	9.97×10^{8}
8	1.52×10^{-6}cm	1.43×10^{9}
9	1.15×10^{-6}cm	4.67×10^{9}
10	8.10×10^{-7}cm	4.12×10^{9}
11	5.75×10^{-7}cm	4.23×10^{9}

Experiment #18 - Average of 3 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	
2	1.83×10^{-5}cm	
3	1.15×10^{-5}cm	
4	7.53×10^{-6}cm	
5	5.03×10^{-6}cm	1.77×10^{5}
6	3.46×10^{-6}cm	1.93×10^{7}
7	2.37×10^{-6}cm	2.71×10^{8}
8	1.52×10^{-6}cm	1.23×10^{9}
9	1.15×10^{-6}cm	1.17×10^{9}
10	8.10×10^{-7}cm	3.10×10^{8}
11	5.75×10^{-7}cm	1.21×10^{8}

Experiment #19 - Average of 4 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	
2	1.83×10^{-5}cm	4.95×10^{5}
3	1.15×10^{-5}cm	1.29×10^{7}
4	7.53×10^{-6}cm	1.03×10^{8}
5	5.03×10^{-6}cm	3.04×10^{8}
6	3.46×10^{-6}cm	8.90×10^{7}
7	2.37×10^{-6}cm	1.49×10^{7}
8	1.52×10^{-6}cm	
9	1.15×10^{-6}cm	4.04×10^{4}
10	8.10×10^{-7}cm	6.39×10^{2}
11	5.75×10^{-7}cm	

Experiment #20 - Average of 4 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	
2	1.83×10^{-5}cm	
3	1.15×10^{-5}cm	9.62×10^{4}
4	7.53×10^{-6}cm	1.03×10^{7}
5	5.03×10^{-6}cm	7.06×10^{7}
6	3.46×10^{-6}cm	4.96×10^{8}
7	2.37×10^{-6}cm	3.14×10^{7}
8	1.52×10^{-6}cm	3.00×10^{5}
9	1.15×10^{-6}cm	
10	8.10×10^{-7}cm	
11	5.75×10^{-7}cm	

Experiment #21 - Average of 4 Runs

Channel	Cumulative Radius	DN/DR
1	3.09×10^{-5}cm	
2	1.83×10^{-5}cm	
3	1.15×10^{-5}cm	1.92×10^{5}
4	7.53×10^{-6}cm	1.05×10^{7}
5	5.03×10^{-6}cm	6.84×10^{7}
6	3.46×10^{-6}cm	4.29×10^{8}
7	2.37×10^{-6}cm	1.59×10^{7}
8	1.52×10^{-6}cm	
9	1.15×10^{-6}cm	9.44×10^{5}
10	8.10×10^{-7}cm	
11	5.75×10^{-7}cm	

Experiment #22 - Average of 3 Runs (2,3 and 4)
[taken between 1100 and 1220; early run (#1)
was taken when the count was higher
and remains as distributed at Workshop].

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	$2.11x10^{4}$
2	$1.83x10^{-5}$cm	$4.59x10^{4}$
3	$1.15x10^{-5}$cm	$3.37x10^{5}$
4	$7.53x10^{-6}$cm	$6.21x10^{6}$
5	$5.03x10^{-6}$cm	$6.29x10^{7}$
6	$3.46x10^{-6}$cm	$1.67x10^{8}$
7	$2.37x10^{-6}$cm	$3.43x10^{8}$
8	$1.52x10^{-6}$cm	$8.69x10^{8}$
9	$1.15x10^{-6}$cm	$4.13x10^{8}$
10	$8.10x10^{-7}$cm	$2.15x10^{8}$
11	$5.75x10^{-7}$cm	$1.52x10^{8}$

Experiment #23 - Average of 4 Runs

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	$2.64x10^{4}$
2	$1.83x10^{-5}$cm	
3	$1.15x10^{-5}$cm	$8.20x10^{4}$
4	$7.53x10^{-6}$cm	$1.25x10^{6}$
5	$5.03x10^{-6}$cm	$1.64x10^{7}$
6	$3.46x10^{-6}$cm	$6.55x10^{7}$
7	$2.37x10^{-6}$cm	$1.19x10^{8}$
8	$1.52x10^{-6}$cm	$1.19x10^{8}$
9	$1.15x10^{-6}$cm	$1.50x10^{8}$
10	$8.10x10^{-7}$cm	$5.93x10^{7}$
11	$5.75x10^{-7}$cm	$5.32x10^{7}$

Experiment #24 - Average of 4 Runs

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	
2	$1.83x10^{-5}$cm	$3.09x10^{4}$
3	$1.15x10^{-5}$cm	$7.78x10^{5}$
4	$7.53x10^{-6}$cm	$1.59x10^{7}$
5	$5.03x10^{-6}$cm	$2.78x10^{8}$
6	$3.46x10^{-6}$cm	$1.72x10^{9}$
7	$2.37x10^{-6}$cm	$4.04x10^{9}$
8	$1.52x10^{-6}$cm	$3.60x10^{9}$
9	$1.15x10^{-6}$cm	$5.28x10^{9}$
10	$8.10x10^{-7}$cm	$2.52x10^{8}$
11	$5.75x10^{-7}$cm	$1.15x10^{9}$

Experiment #27 - Average of 4 Runs

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	$2.11x10^{5}$
2	$1.83x10^{-5}$cm	$1.11x10^{6}$
3	$1.15x10^{-5}$cm	$1.32x10^{6}$
4	$7.53x10^{-6}$cm	$8.76x10^{6}$
5	$5.03x10^{-6}$cm	$1.24x10^{8}$
6	$3.46x10^{-6}$cm	$6.60x10^{8}$
7	$2.37x10^{-6}$cm	$1.20x10^{9}$
8	$1.52x10^{-6}$cm	$1.41x10^{9}$
9	$1.15x10^{-6}$cm	$3.16x10^{8}$
10	$8.10x10^{-7}$cm	$2.76x10^{9}$
11	$5.75x10^{-7}$cm	$2.66x10^{9}$

Experiment #28 - Average of 2 Runs

Channel	Cumulative Radius	DN/DR
1	$3.09x10^{-5}$cm	
2	$1.83x10^{-5}$cm	
3	$1.15x10^{-5}$cm	
4	$7.53x10^{-6}$cm	$1.78x10^{7}$
5	$5.03x10^{-6}$cm	$1.65x10^{8}$
6	$3.46x10^{-6}$cm	$2.23x10^{7}$
7	$2.37x10^{-6}$cm	
8	$1.52x10^{-6}$cm	$3.72x10^{6}$
9	$1.15x10^{-6}$cm	$8.17x10^{6}$
10	$8.10x10^{-7}$cm	
11	$5.75x10^{-7}$cm	

APPENDIX B

In this section, the complete 1980 International CCN Workshop data file is presented, in the form of both tables and graphs of CCN counted as a function of supersaturation setting, for all experiments. The reader is urged to consult the companion review papers (covering the static diffusion chambers, continuous-flow chambers, and isothermal haze chambers by generic type) for important commentaries and points necessary to interpret these data. For example, as discussed in "Review of Isothermal Haze Chamber Performance", the interpretation of haze chamber results is dependent upon understanding the method used to calibrate the chamber optical counters for the sizing of water droplets. Useful summaries of the data will also be found in the review papers; discussions of the methods of obtaining data from the various instruments will generally be found in the relevent instrument description papers in Section V.

The data file is presented exactly as the data were received during the Workshop, with the exception of three post-Workshop revisions, all of which were cases of straightforward errors in the reporting of data. These revisions occurred in the cases of data from instruments #13 (CSIRO, G. Ayers), #14 (DRI, J. Hudson), and #25 (CSU, R. Borys); below we summarize, in the words of each instrument operator, the change in data together with reasons.

Instrument #13 - Ayers

I learned upon my return to CSIRO that the newly-generated calibration curves relate "film count" to "peak reading", and that to get to an estimate of the "true" CCN concentration, the "film count" must be increased by 50%. Thus all the concentration values I fed into your data system should be multiplied by a factor of 1.5. This factor is explained at more length in the notes. I regret that I was unaware of it and hope that it does not cause too much inconvenience.

Instrument #14 - Hudson

In the process of writing the review paper on the IHC's, I looked back into my original Workshop notebook. I discovered that, from experiment #12 to the end of the Workshop, the threshold supersaturations for channel 3 were mislabeled in the data file. According to the original notebook, this should have been 0.11%. However, it was written into the Workshop data sheets as 0.085% which it had actually been set at for a couple of earlier experiments.

Instrument #25 - Borys

CCN concentrations were revised for the CSU static diffusion chambers for experiments 17-20. The changes were made because of errors in reading the original photographic film (i.e., counting the droplet images visually) by being out of sequence one frame for a 36 exposure roll of film. The results were spectra shifted to the left on plots done at DRI, thus artificially increasing the concentrations over all supersaturations. This was easily done since there were plateaus in the curves and the error wasn't noticed until the data were reviewed in detail after returning to CSU. The net effect is to simply correct a "human error". There was no physical instrumental correction made.

CCN WORKSHOP
NUCLEI MEASUREMENTS DATA SHEET

Experiment No:

Date: / / (yr) (mo) (day)

Purpose:

Run No:[1] Instrument No: Duct No: Observer:

NUCLEI MEASUREMENTS

Sample Time		Plate Temp °C		Volume Sampled (ℓ)	S_c(%)	Nuclei Count	$\overline{N}$	Est K	Remarks[2]	
Start	End	Cold	Hot							
										1
										2
										3
										4
										5
										6
										7
										8
										9
										10

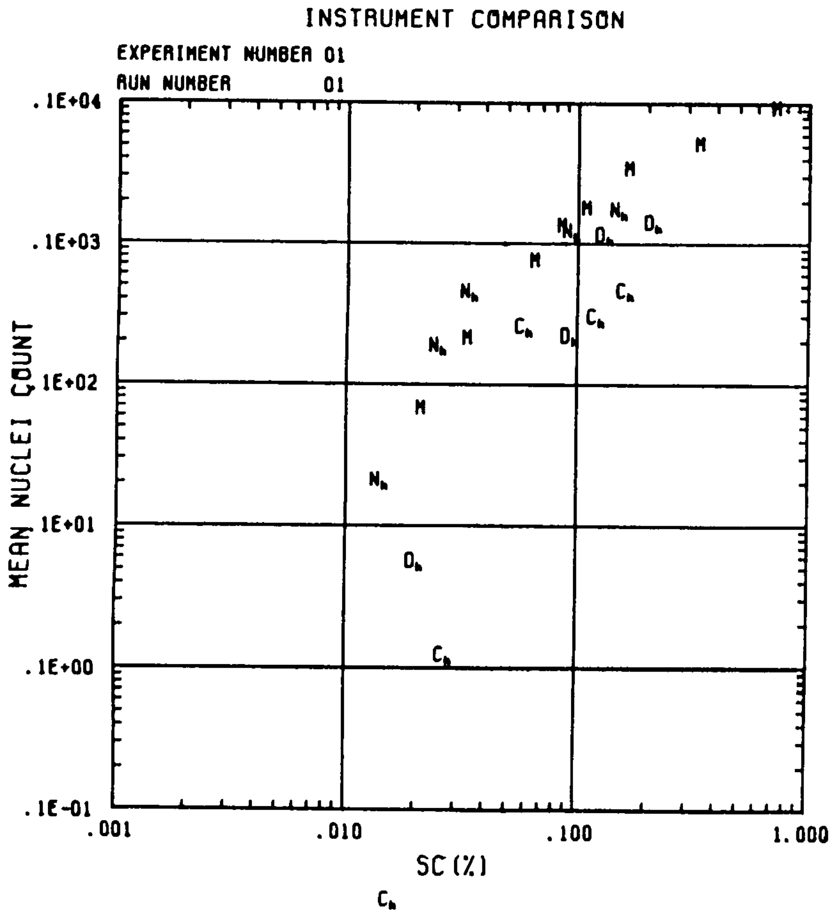
---

[1] If more than one spectrum is run, please record the data on another sheet with a new run number.

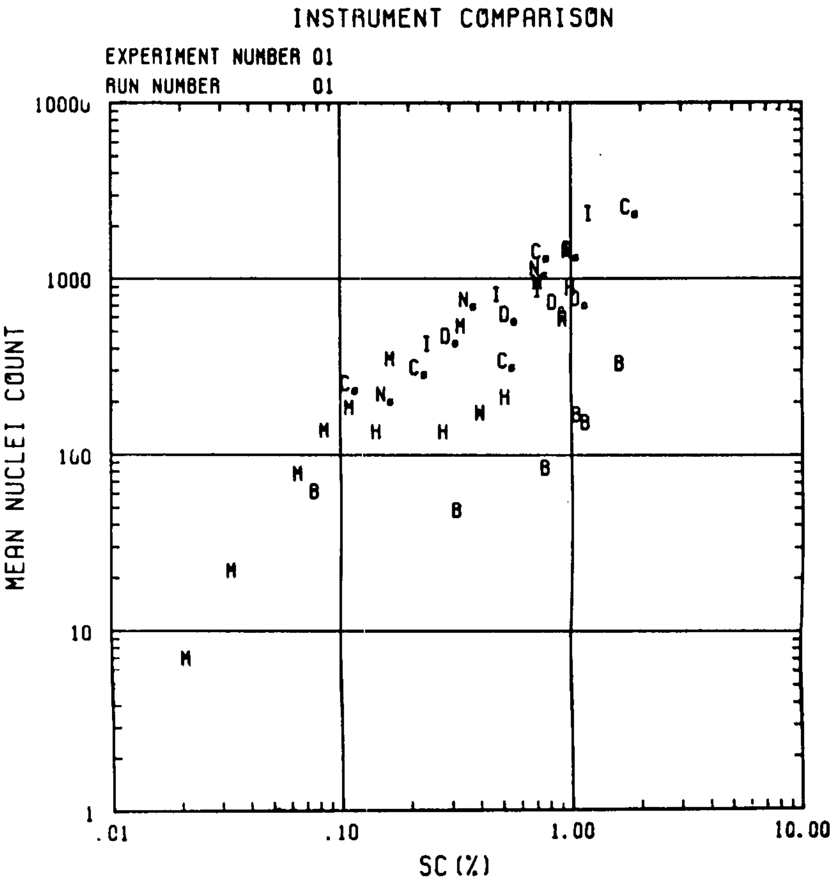
[2] Only the first 25 characters of the remarks column will be recorded and displayed via computer processing.

CCN WORKSHOP DATA CODE

Inst. No.	Group	Graphics Code
2	Wyoming	O
5	British Met Office	B
7	York Univ.	Y
9	Hebrew Univ.	H
10	SUNY	S
11	NRL	Nh (Haze)
13	CSIRO	I
14	DRI	Dh (Haze)
15	DRI	Dn (Spec. NASA)
16	DRI	Di (Spec. Instant)
17	NRL	Ns (SDC)
18	DRI	Dc (CFD)
20	Washington	W
21	Missouri	M
22	Florida	
23	Florida	
24	France	F
25	CSU	Cs (SDC)
26	CSU	Ch (Haze)
27	Alaska	A
28	NBS	Gt
29	NBS	Gp



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

```
                                      EXPERIMENT # 01
                                                                               80/10/07
PURPOSE
-------
 INSTRUMENT COMPARISON WITH POLYDISPERSE ARTIFICIAL CCN

DESCRIPTION OF EXPERIMENT
-------------------------
                  TIME
  DATE            START    END
  ------------    -----------
  07 OCT,1980     1458    1615

  NUCLEI TYPE
  -----------
   NACL, POLYDISPERSE

  GENERATION METHOD
  -----------------
   DRI ATOMIZER, 18 PSI

  SIZE DISTRIBUTION SHAPING
  -------------------------
   NONE

REMARKS
-------
 OUTPUT FLUCTUATES +- 8%
 SAMPLE WET BULB 55 (F), DRY BULB 81 (F), DIL. AIRFLOW 670 L/MIN.

WEATHER SYNOPSIS
----------------
 NA

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
         ROOM CONDITIONS                          OUTSIDE CONDITIONS

 --------------------------------     ------------------------------------------------
 AVG TEMP     AVG RH    AVG PRESS     AVG TEMP    AVG RH    AVG PRESS   AVG WS   AVG WD
   (C)         (%)        (MB)          (C)        (%)        (MB)      (M/S)    (DEG)
 --------     ------    ---------     --------    ------    ---------   ------   ------

   NA           NA         NA            NA         NA         NA         NA       NA
```

```
                                                                    NUCLEI MEASUREMENTS
EXPERIMENT #: 01                                                                                                       PROCESSING DATE:  81/07/29
                 OBSERVER                                         PLATE TEMP
MACH  DUCT  ------------------  SAMPLE  TIME                                         VOLUME    SUPER   NUCLEI    OBS      EST
NO.   NO.   NAME           NO.  START   END       COLD     HOT      DELTA    SAMPLED   SAT     COUNT      -       K      REMARKS
                                                           (C)                (L)      (%)               N
----  ----  -------------- ---  -----   ----     ------   ------   ------   -------   ------  ------    -----    -----   -------------------
RUN:  1

  5     5   KITCHEN         12  1529             25.80    27.50     1.70               .08      62
  5     5   KITCHEN         12  1530             24.70    27.80     3.10               .33      64
  5     5   KITCHEN         12  1531             23.80    28.00     4.20               .8       90
  5     5   KITCHEN         12  1532             22.60    28.20     5.60              1.2      160
  5     5   KITCHEN         12  1533             21.50    28.30     6.80              1.7      340
  5     5   KITCHEN         12  1534             22.90    28.40     5.50              1.1      177
  5     5   KITCHEN         12  1535             24.20    28.50     4.30               .8       84
  5     5   KITCHEN         12  1536             25.60    28.60     3.00               .33      37
  5     5   KITCHEN         12  1537             26.00    28.70     2.70               .08      67               1.10
RUN:  2

  5     5   KITCHEN         12  1538             26.00    29.00     3.00               .33      51
  5     5   KITCHEN         12  1540             24.70    29.00     4.30               .8      114
  5     5   KITCHEN         12  1541             23.30    28.90     5.60              1.2      250
  5     5   KITCHEN         12  1542             22.30    29.00     6.70              1.7      463
  5     5   KITCHEN         12  1543             23.60    29.10     5.50              1.1      259
  5     5   KITCHEN         12  1544             24.70    28.90     4.20               .7      132
  5     5   KITCHEN         12  1545             25.70    28.70     3.00               .33      77
  5     5   KITCHEN         12  1546             26.80    28.50     1.70               .08      70               1.10

RUN:  1

  9     9   GAGIN            5  1521             20.30    25.40     5.10      1.2     1.04     920                       VOLUME SAMPLE ALWAYS
  9     9   GAGIN            5  1524             21.90    25.50     3.60      1.2      .54     220                       THE SAME - CONSTANT
  9     9   GAGIN            5  1526             22.90    25.50     2.60      1.2      .29     140
  9     9   GAGIN            5  1530             23.70    25.50     1.80      1.2      .15     140
RUN:  2

  9     9   GAGIN            5  1534             20.40    25.40     5.00      1.2      .1      890
  9     9   GAGIN            5  1537             21.90    25.40     3.50      1.2      .51     170
  9     9   GAGIN            5  1539             22.60    25.30     2.70      1.2      .5      130
  9     9   GAGIN            5  1542             23.80    25.60     1.80      1.2      .16     180
RUN:  3

  9     9   GAGIN            5  1550             20.50    25.30     4.80      1.2      .93     620
  9     9   GAGIN            5  1555             22.80    25.50     2.70      1.2      .33     150
RUN:  4

  9     9   GAGIN            5  1602             20.70    25.40     4.70      1.2      .88     730
  9     9   GAGIN            5  1605             22.10    25.50     3.40      1.2      .47     170
  9     9   GAGIN            5  1607             22.50    25.70     3.20      1.2      .43     140
  9     9   GAGIN            5  1610             24.00    25.60     1.60      1.2      .18     150

RUN:  1

 11    11   HOPPEL           7  1516    1533                                           .15    186.5    186.5             ISOTHERMAL HAZE CHAM
 11    11   HOPPEL           7  1516    1533                                          .094    131.2    131.2
 11    11   HOPPEL           7  1516    1533                                          .034     48.1     48.1
 11    11   HOPPEL           7  1516    1533                                          .025     19.9     19.9
 11    11   HOPPEL           7  1516    1533                                          .014      2.2      2.2
RUN:  2

 11    11   HOPPEL           7  1540    1556                                           .15    168.1    168.1             ISOTHERMAL HAZE CHAM
 11    11   HOPPEL           7  1540    1556                                          .094    122      122
 11    11   HOPPEL           7  1540    1556                                          .034     45.3     45.3
 11    11   HOPPEL           7  1540    1556                                          .025     17.6     17.6
 11    11   HOPPEL           7  1540    1556                                          .014      1.9      1.9

RUN:  1

 13    13   AYERS            2  1521    1522     25.64    28.10     2.46               .25     480                       NOISE ON COUNT RESET
```

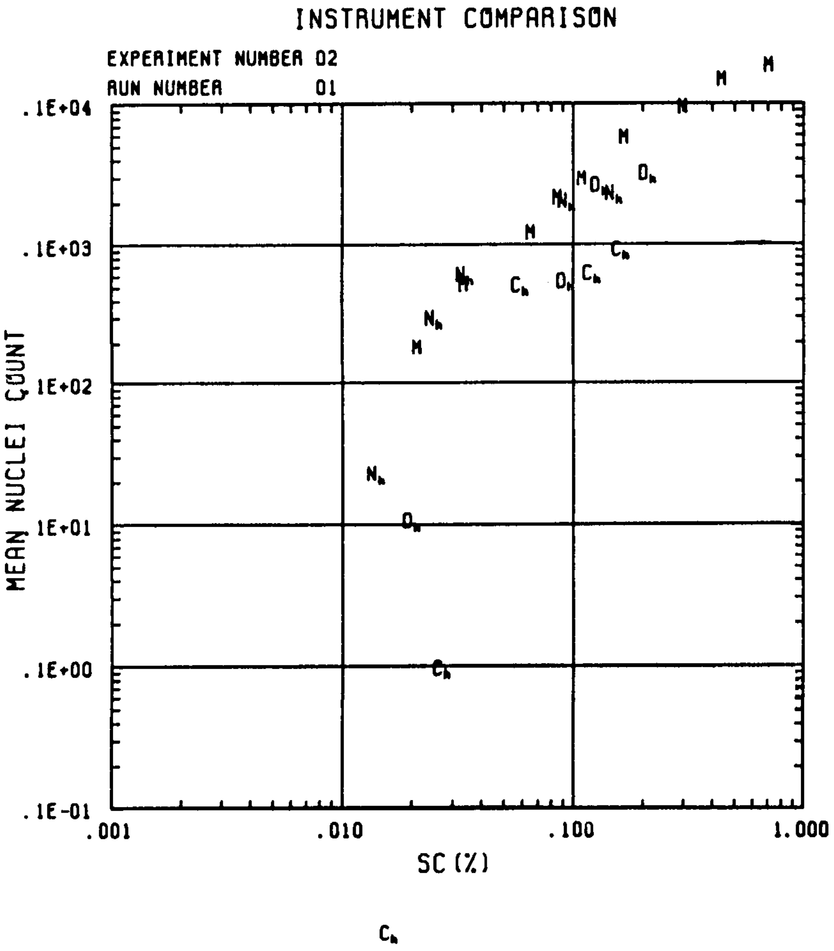
EXPERIMENT #: 01

NUCLEI MEASUREMENTS

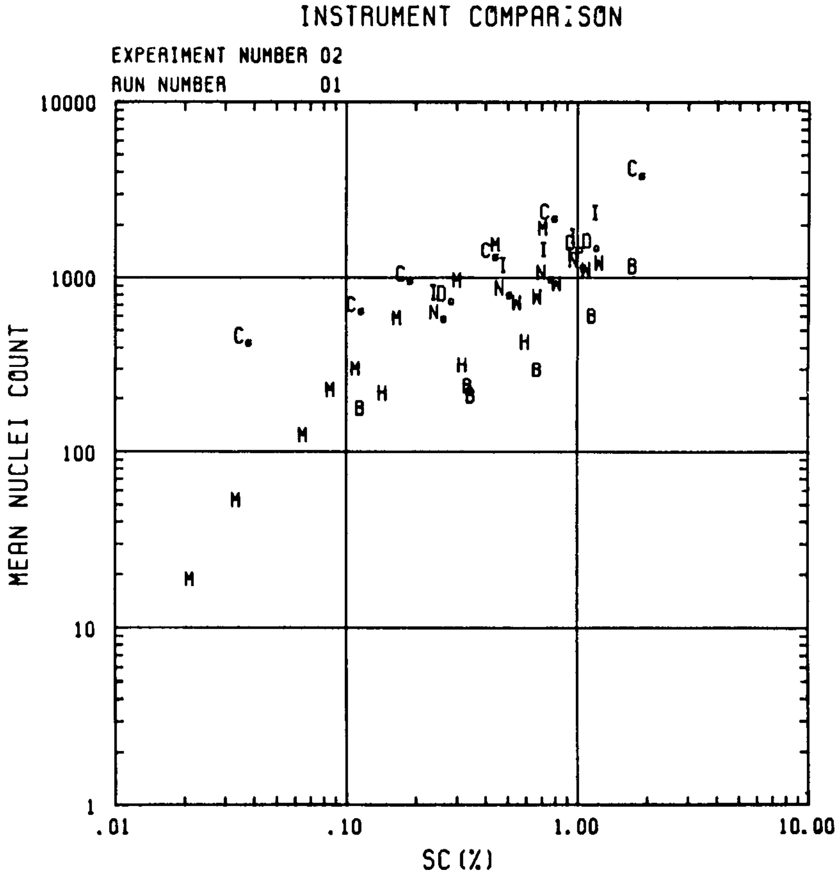
PROCESSING DATE: 81/07/29

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	PLATE TEMP DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
13	13	AYERS	2	1523	1524	24.60	28.10	3.50		.5	825			LINE OCCASIONALLY
13	13	AYERS	2	1527	1528	23.21	28.20	4.99		1	825			GIVES HIGH READING
13	13	AYERS	2	1529	1530	22.63	28.20	5.57		1.25	2700			ERROR INCREASES WITH
13	13	AYERS	2	1530	1531	22.63	28.20	5.57		1.25	2775			DECREASING SC.
13	13	AYERS	2	1532	1533	23.17	28.20	5.03		1	930			
13	13	AYERS	2	1533	1534	23.22	28.20	4.98		1	2580			SC VALUES LISTED ARE
13	13	AYERS	2	1534	1535	23.23	28.20	4.97		1	1575			PRESET ON INSTR.
13	13	AYERS	2	1536	1537	23.17	28.20	5.03		1	1575			AND ARE APPROXIMATE
13	13	AYERS	2	1537	1538	23.23	28.20	4.97		1	1800			ONLY
13	13	AYERS	2	1600	1601	23.00	28.60	5.60		1.25	1575			
13	13	AYERS	2	1550	1551	26.03	28.50	2.47		.25	405			
13	13	AYERS	2	1554	1555	26.08	28.60	2.52		.5	870			
13	13	AYERS	2	1556	1557	25.05	28.60	3.55		.5	825			
13	13	AYERS	2	1557	1558	23.00	28.60	5.60		1.25	2775			
13	13	AYERS	2	1602	1603	24.30	28.60	4.30		.75	780			
13	13	AYERS	2	1603	1604	24.29	28.60	4.31		.75	1005			
RUN: 1														
14	14	HUDSON	9	1532	1612				.02	.21		150		
14	14	HUDSON	9	1532	1612				.02	.13		123		
14	14	HUDSON	9	1532	1612				.02	.093		23.5		
14	14	HUDSON	9	1532	1612				.02	.02		.6		
RUN: 1														
17	17	WOJCIECHOWSKI	27	1542	1544					.157	229.4	229.4		TGDCC
17	17	WOJCIECHOWSKI	27	1542	1544					.36	791.8	791.8		
17	17	WOJCIECHOWSKI	27	1542	1544					.73	1191.4	1191.4		
17	17	WOJCIECHOWSKI	27	1542	1544					1	1502.2	1502.2		
RUN: 1														
18	18	HUDSON	9	1523	1527	22.00	25.70	3.70	.0024	.54		652		
18	18	HUDSON	9	1535	1539	22.50	25.25	2.75	.0024	.3		490		
18	18	HUDSON	9	1557	1600	21.55	26.25	4.70	.0024	.87		760		
18	18	HUDSON	9	1603	1607	21.20	26.45	5.25	.003	1.09		798		
RUN: 1														
20	20	RADKE	21	1540						.42	180			HIGH SS CHANNEL
20	20	RADKE	21	1540						.96	610			FAILED RESULTS APPRX
RUN: 1														
21	21	TRUEBLOOD	26	1524	1525	20.70	25.00	4.30		.75	1000			
21	21	TRUEBLOOD	26	1528	1529	22.10	25.00	2.90		.35	555			
21	21	TRUEBLOOD	26	1547	1548	25.00	25.00	0.00		.173	365			
21	21	TRUEBLOOD	26	1547	1548	25.00	25.00	0.00		.114	193			
21	21	TRUEBLOOD	26	1547	1548	25.00	25.00	0.00		.089	144			
21	21	TRUEBLOOD	26	1547	1548	25.00	25.00	0.00		.068	80.8			
21	21	TRUEBLOOD	26	1554	1556	25.00	25.00	0.00		.035	22.8			
21	21	TRUEBLOOD	26	1554	1556	25.00	25.00	0.00		.022	7.28			
RUN: 1														
25	25	BORYS	3	1518	1518	17.90	24.40	6.50	1.06	1.8	2688	2688		VOL SAMP X 10**5
25	25	BORYS	3	1522	1522	20.70	24.90	4.20	2.12	.74	1485	1485		PROBLEMS WITH LEAKS
25	25	BORYS	3	1531	1532	21.90	25.50	3.60	5.3	.53	354	354		
25	25	BORYS	3	1544	1546	23.80	26.20	2.40	10.6	.22	325	325		
25	25	BORYS	3	1600	1605	25.10	26.90	1.80	15.9	.11	264	264		
RUN: 1														
26	26	HINDMAN	6	1525	1605	25.00	25.00	0.00	.83	.16	49	49		E=1.0, 0.5 UM

```
                                                         NUCLEI MEASUREMENTS
EXPERIMENT #: 01                                                                                   PROCESSING DATE:  81/07/29
                   OBSERVER                                       PLATE TEMP
MACH  DUCT  -------------------  SAMPLE  TIME                                   VOLUME   SUPER   NUCLEI    DBS    EST
NO.   NO.   NAME            NO.  START   END    COLD    HOT     DELTA  SAMPLED   SAT     COUNT      -      K     REMARKS
                                                         (C)                (L)     (%)                 N
----  ----  --------------  ---  -----  ----  ------  ------  ------  -------  ------  ------   -----  -----  --------------------
 26    26   HINDMAN           6  1525   1605   25.00   25.00    0.00      .83     .12      32      32          E=0.70, 0.7 UM
 26    26   HINDMAN           6  1525   1605   25.00   25.00    0.00      .83    .059      27      27          E=0.64, 1.4 UM
 26    26   HINDMAN           6  1525   1605   25.00   25.00    0.00      .83    .027     .13     .13          E=0.023, 3.0 UM
 26    26   HINDMAN           6  1525   1605   25.00   25.00    0.00      .83    .016   .0024   .0024          E=0.0016, 5.0 UM

RUN:  1

 27    27   OHTAKE           19  1059   1100                              8.5            .473                  90% R.H.
 27    27   OHTAKE           19  1059   1100                              8.5            .508                  100% R.H.
```



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

```
                                          EXPERIMENT # 02
                                                                                    80/10/07
PURPOSE
-------
 INSTRUMENT COMPARISON WITH POLYDISPERSE ARTIFICIAL CCN

DESCRIPTION OF EXPERIMENT
-------------------------
                TIME
  DATE         START   END
  ----------   ----------
  07 OCT,1980  1640   1740

  NUCLEI TYPE
  -----------
   NACL POLYDISPERSE

  GENERATION METHOD
  -----------------
   DRI ATOMIZER, 30 PSI

  SIZE DISTRIBUTION SHAPING
  -------------------------
   NONE

REMARKS
-------
 STABLE OUTPUT ONLY AFTER 1700. BETTER STABILITY THAN #1; DIL. AIRFLOW 570 L/MIN.

WEATHER SYNOPSIS
----------------
 NA

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
        ROOM CONDITIONS                          OUTSIDE CONDITIONS

 --------------------------------     ---------------------------------------------------
 AVG TEMP    AVG RH    AVG PRESS      AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)        (%)        (MB)           (C)        (%)        (MB)       (M/S)     (DEG)
 --------    ------    ---------      --------    ------    ---------    ------    ------
   NA          NA         NA             NA         NA          NA         NA        NA
```

EXPERIMENT #: 02

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/07/29

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
RUN: 1														
5	5	KITCHEN	12	1656		27.60	29.40	1.80		.12	191			
5	5	KITCHEN	12	1657		26.40	29.50	3.10		.36	214			
5	5	KITCHEN	12	1659		23.90	29.50	5.60		1.2	719			
5	5	KITCHEN	12	1701		22.80	29.60	6.80		1.8	1202			
5	5	KITCHEN	12	1702		24.10	29.60	5.50		1.2	534			
5	5	KITCHEN	12	1703		25.30	29.60	4.30		.7	308			
5	5	KITCHEN	12	1704		26.70	29.70	3.00		.35	243			
5	5	KITCHEN	12	1705		27.90	29.70	1.80		.12	175		.90	
RUN: 2														
5	5	KITCHEN	12	1717		23.10	29.90	6.80		1.8	1432			
5	5	KITCHEN	12	1718		24.40	29.90	5.50		1.2	930			
5	5	KITCHEN	12	1719		27.00	30.00	3.00		.35	313			
5	5	KITCHEN	12	1721		28.20	30.00	1.80		.12	22			
5	5	KITCHEN	12	1722		26.90	30.00	3.10		.35	331			
5	5	KITCHEN	12	1723		25.70	30.00	4.30		.7	568			
5	5	KITCHEN	12	1724		24.50	30.00	5.50		1.2	951			
5	5	KITCHEN	12	1725		23.20	30.00	6.80		1.8	1431			
5	5	KITCHEN	12	1726		25.70	30.00	4.30		.7	538		.90	
RUN: 1														
9	9	GAGIN	5	1705		20.40	25.40	5.00	1.2	1	1410			VOLUME SAMPLE ALWAYS THE SAME - CONSTANT
9	9	GAGIN	5	1708		21.50	25.40	3.90	1.2	.62	450			
9	9	GAGIN	5	1710		22.70	25.50	2.80	1.2	.33	330			
9	9	GAGIN	5	1713		23.60	25.60	2.00	1.2	.15	220			
RUN: 2														
9	9	GAGIN	5	1717		20.00	25.00	5.00	1.2	1.02	1360			
9	9	GAGIN	5	1719		21.60	25.60	4.00	1.2	.65	390			
9	9	GAGIN	5	1721		22.20	25.40	3.20	1.2	.4	310			
RUN: 3														
9	9	GAGIN	5	1726		20.30	25.30	5.00	1.2	1	1690			
9	9	GAGIN	5	1729		21.60	25.40	3.80	1.2	.59	320			
9	9	GAGIN	5	1731		22.60	25.30	2.70	1.2	.3	270			
9	9	GAGIN	5	1735		23.80	25.50	1.70	1.2	.16	260			
RUN: 1														
11	11	HOPPEL	7	1704	1721					.15	246.8	246.8		ISOTHERMAL HAZE CHAM
11	11	HOPPEL	7	1704	1721					.094	215	215		
11	11	HOPPEL	7	1704	1721					.034	64.2	64.2		
11	11	HOPPEL	7	1704	1721					.025	31.1	31.1		
11	11	HOPPEL	7	1704	1721					.014	2.4	2.4		
RUN: 2														
11	11	HOPPEL	7	1728	1733					.15	257.4	257.4		ISOTHERMAL HAZE CHAM
11	11	HOPPEL	7	1728	1733					.094	225	225		
11	11	HOPPEL	7	1728	1733					.034	67	67		
11	11	HOPPEL	7	1728	1733					.025	33.3	33.3		
11	11	HOPPEL	7	1728	1733					.014	2.6	2.6		
RUN: 1														
13	13	AYERS	2	1704	1705	25.70	28.20	2.50		.25	870			SC VALUES LISTED ARE PRESET ON INSTR. AND ARE APPROXIMATE ONLY.
13	13	AYERS	2	1706	1707	25.74	28.20	2.46		.25	975			
13	13	AYERS	2	1707	1708	24.60	28.10	3.50		.5	1275			
13	13	AYERS	2	1708	1709	24.57	28.10	3.53		.5	1290			
13	13	AYERS	2	1712	1713	23.66	28.00	4.34		.75	1500			DROPLET POPULATIONS
13	13	AYERS	2	1714	1715	23.70	28.00	4.30		.75	1425			

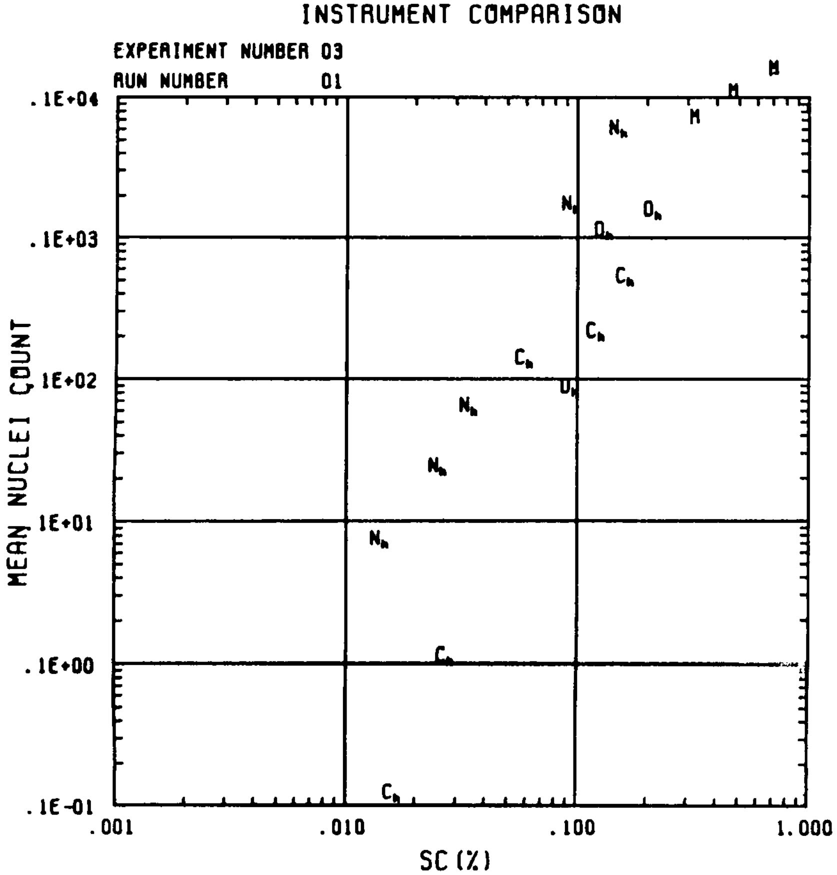
EXPERIMENT #: 02

NUCLEI MEASUREMENTS

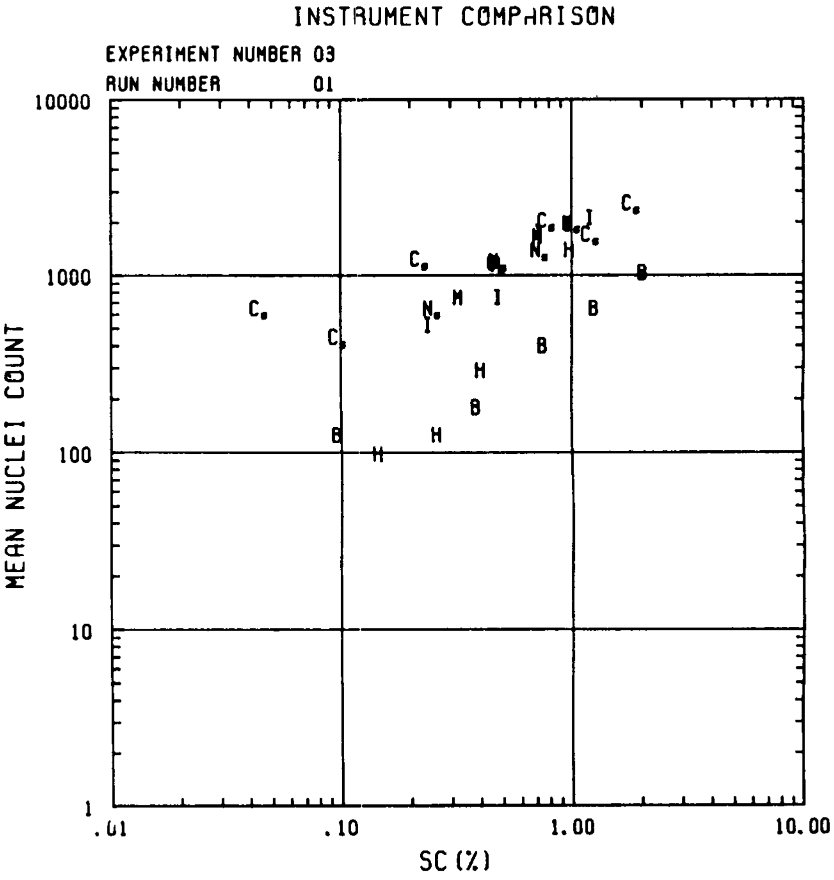
PROCESSING DATE: 81/07/29

MACH NO.	DUCT NO.	OBSERVER		SAMPLE START	TIME END	PLATE TEMP			VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	ORS - N	EST K	REMARKS
		NAME	NO.			COLD	HOT (C)	DELTA						
13	13	AYERS	2	1716	1717	22.91	27.90	4.99		1	1830			RECORDED PHOTOGRAPH-
13	13	AYERS	2	1719	1720	22.93	27.90	4.97		1	2010			CALLY (35 MM CAMERA)
13	13	AYERS	2	1720	1721	22.26	27.80	5.54		1.25	2445			BETWEEN 1704 1724
13	13	AYERS	2	1722	1723	22.17	27.70	5.53		1.25	2453			INCLUSIVE
13	13	AYERS	2	1723	1724	22.07	27.60	5.53		1.25	2445			
13	13	AYERS	2	1725	1726	22.62	27.60	4.98		1	1575			
13	13	AYERS	2	1729	1730	23.30	27.60	4.30		.75	1575			
13	13	AYERS	2	1731	1732	24.09	27.60	3.51		.5	1125			
13	13	AYERS	2	1733	1734	24.12	27.60	3.48		.5	1200			
13	13	AYERS	2	1735	1736	25.20	27.70	2.50		.25	750			
13	13	AYERS	2	1736	1737	25.20	27.70	2.50		.25	825			
RUN:	1													
14	14	HUDSON	9	1706	1735				.015	.21		336		
14	14	HUDSON	9	1706	1735				.015	.13		277		
14	14	HUDSON	9	1706	1735				.015	.093		57.8		
14	14	HUDSON	9	1706	1735				.015	.02		1.11		
RUN:	1													
17	17	WOJCIECHOWSKI	27	1702	1703					.25	660	660		TGDCC
17	17	WOJCIECHOWSKI	27	1702	1703					.48	910.2	910.2		
17	17	WOJCIECHOWSKI	27	1702	1703					.73	1117.4	1117.4		
17	17	WOJCIECHOWSKI	27	1702	1703					1	1310	1310		
RUN:	1													
18	18	HUDSON	9	1700	1706	21.10	26.50	5.40	.0036	1.15		1691		
18	18	HUDSON	9	1711	1714	21.30	26.25	4.95	.0024	.97		1645		
18	18	HUDSON	9	1730	1735	22.60	25.20	2.60	.003	.27		840		
RUN:	1													
20	20	RADKE	21	1715	1730					.57	750			LARGE SUPPLY VARIATN
20	20	RADKE	21	1715	1730					.7	810			EARLY IN RUN
20	20	RADKE	21	1715	1730					.85	950			HIGH SS CHANNEL
20	20	RADKE	21	1715	1730					1.14	1150			FAILED
20	20	RADKE	21	1715	1730					1.3	1250			
RUN:	1													
21	21	ALOFS	1	1701	1702	20.70	25.00	4.30		.74	1987			
21	21	ALOFS	1	1707	1708	21.60	25.00	3.40		.462	1591			
21	21	ALOFS	1	1711	1713	22.20	25.00	2.80		.314	1003			
21	21	ALOFS	1	1722	1724	25.00	25.00	0.00		.173	613			
21	21	ALOFS	1	1722	1724	25.00	25.00	0.00		.114	312			
21	21	ALOFS	1	1722	1724	25.00	25.00	0.00		.089	231			
21	21	ALOFS	1	1722	1724	25.00	25.00	0.00		.068	178			
21	21	ALOFS	1	1727	1728	25.00	25.00	0.00		.035	54.9			
21	21	ALOFS	1	1727	1728	25.00	25.00	0.00		.022	19.5			
RUN:	1													
25	25	BORYS	3	1704	1704	19.30	26.00	6.70	1.06	1.8	4385	4385	.62	VOL SAMP * 10**5
25	25	BORYS	3	1710	1710	21.30	25.70	4.40	2.12	.76	2476	2476		
25	25	BORYS	3	1715	1716	22.30	25.60	3.30	4.24	.42	1485	1485		
25	25	BORYS	3	1722	1724	23.30	25.50	2.20	6.36	.18	1085	1085		
25	25	BORYS	3	1732	1735	23.70	25.40	1.70	8.48	.11	725	725		
25	25	BORYS	3	1738	1744		25.30		15.9	.036	481	481		
RUN:	1													
26	26	HINDMAN	6	1708	1737	25.00	25.00	0.00	1.6	.16	97	97		E=0.31, 0.5 UM

```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 02                                                                                              PROCESSING DATE:  81/07/29

                      OBSERVER                                   PLATE TEMP
MACH  DUCT  -------------------  SAMPLE TIME                                VOLUME  SUPER  NUCLEI    OBS    EST
NO.   NO.   NAME            NO.  START   END    COLD    HOT     DELTA   SAMPLED  SAT   COUNT      -      K    REMARKS
                                                        (C)               (L)    (%)              N
----  ----  --------------- ---  -----  ----   ------  ------  ------  -------  ------  ------   -----  -----  --------------------
 26    26   HINDMAN           6  1708   1737   25.00   25.00    0.00      1.6     .12      66      66         E=1.2, 0.7 UM
 26    26   HINDMAN           6  1708   1737   25.00   25.00    0.00      1.6    .059      54      54         E=1.1, 1.4 UM
 26    26   HINDMAN           6  1708   1737   25.00   25.00    0.00      1.6    .027      .1      .1         E=0,020, 3.0 UM
 26    26   HINDMAN           6  1708   1737   25.00   25.00    0.00      1.6    .016   .0013   .0013         E=0.0088, 5.0 UM

RUN:  1

 27    27   OHTAKE           19  1500   1500                              8.5            .542                 90% R.H.
 27    27   OHTAKE           19  1500   1500                              8.5            .926                 100% R.H.
 27    27   OHTAKE           19  1703                                    4.75            .202                 80% R.H.
 27    27   OHTAKE           19  1703                                    4.75            .192                 90% R.H.
 27    27   OHTAKE           19  1703                                    4.75            .253                 100% R.H.
 27    27   OHTAKE           19  1703                                    4.75            .293                 101% R.H. NOMINAL
```



HAZE CHAMBER RESULTS



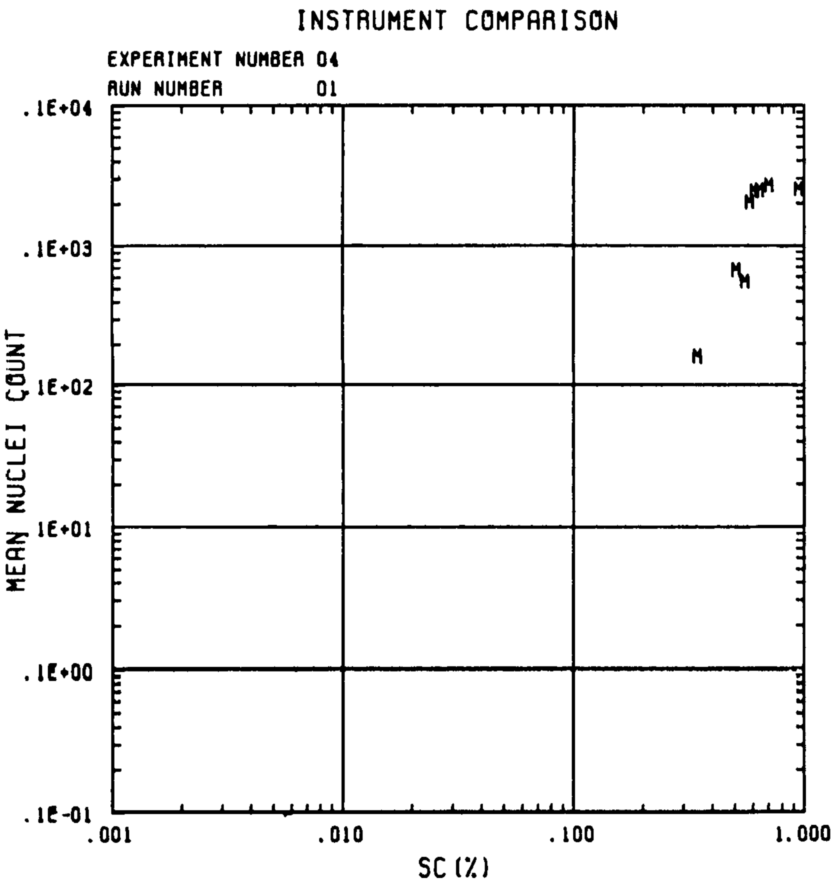
SDC/CFD RESULTS

```
                                          EXPERIMENT # 03                                   80/10/08

PURPOSE
-------
 INSTRUMENT COMPARISON WITH AMBIENT AEROSOL

DESCRIPTION OF EXPERIMENT
-------------------------
                    TIME
  DATE              START   END
  ------------      -----------
  08 OCT,1980       0805    0930

  NUCLEI TYPE
  -----------
   AMBIENT

  GENERATION METHOD
  -----------------
   NA

  SIZE DISTRIBUTION SHAPING
  -------------------------
   NA

REMARKS
-------
 HIGHLY FLUCTUATING

WEATHER SYNOPSIS
----------------
 NA

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
         ROOM CONDITIONS                              OUTSIDE CONDITIONS

 --------------------------------      --------------------------------------------------
 AVG TEMP     AVG RH    AVG PRESS      AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)         (%)        (MB)           (C)        (%)        (MB)        (M/S)     (DEG)
 --------     ------    ---------      --------    ------    ---------    ------    ------
   21.0        20.0       NA             NA          NA         NA          NA        NA
```

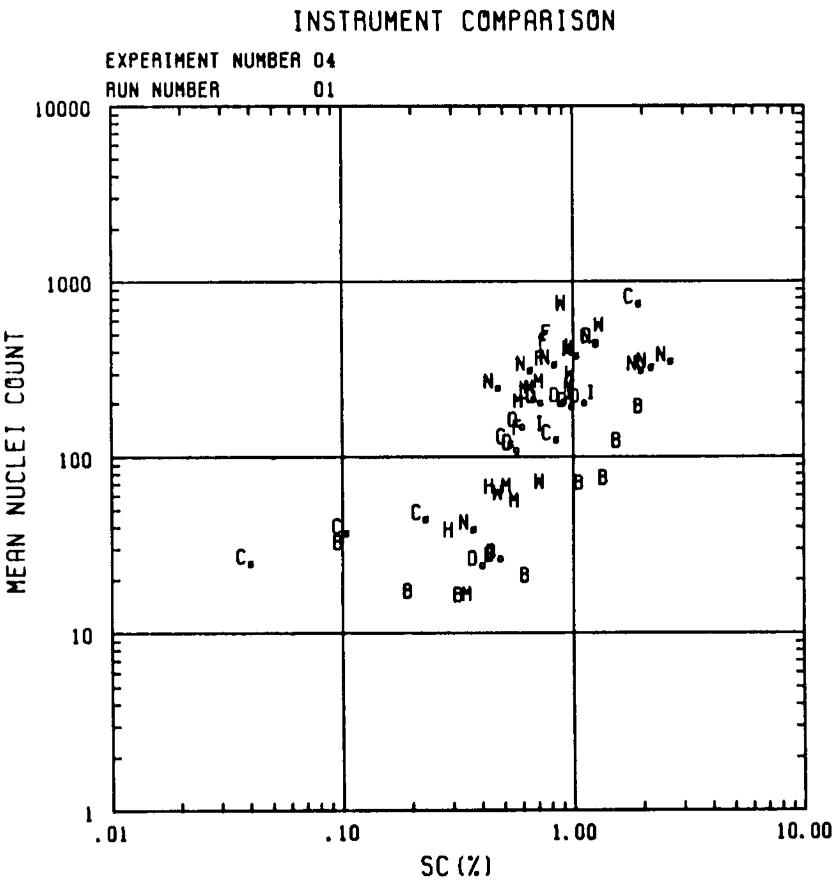
```
                                                        NUCLEI MEASUREMENTS
EXPERIMENT #: 03                                                                                                     PROCESSING DATE:  81/07/29
                 OBSERVER                                             PLATE TEMP
MACH  DUCT  -------------------   SAMPLE  TIME                                 VOLUME    SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME             NO.  START    END    COLD     HOT     DELTA   SAMPLED    SAT     COUNT      -       K     REMARKS
                                    .                      (C)               (L)      (%)               N
----  ----  --------------- ---   -----   ----   ------   ------   ------  -------   ------   ------   -----   -----   -------------------

RUN:  1

  5     5   KITCHEN          12   0817           15.40    22.20     6.80               2.1     1022
  5     5   KITCHEN          12   0818           16.80    22.30     5.50               1.3      650
  5     5   KITCHEN          12   0819           18.10    22.30     4.20               .78      372
  5     5   KITCHEN          12   0820           19.40    22.40     3.00                .4      186
  5     5   KITCHEN          12   0821           20.70    22.50     1.80                .1      131
  5     5   KITCHEN          12   0823           19.60    22.60     3.00                .4      186
  5     5   KITCHEN          12   0824           17.10    22.60     5.50               1.3      760
  5     5   KITCHEN          12   0825           15.90    22.60     6.70               2.1     1119
  5     5   KITCHEN          12   0826           17.10    22.60     5.50               1.3      610
  5     5   KITCHEN          12   0827           19.70    22.70     3.00               .78      454

RUN:  2

  5     5   KITCHEN          12   0854           22.20    23.90     1.70                .1       93
  5     5   KITCHEN          12   0856           21.00    24.00     3.00                .4      111
  5     5   KITCHEN          12   0857           19.70    24.00     4.30               .78      154
  5     5   KITCHEN          12   0858           18.60    24.10     5.50               1.3      418
  5     5   KITCHEN          12   0859           17.40    24.20     6.80                 2     1154
  5     5   KITCHEN          12   0900           18.80    24.30     5.50               1.3      421
  5     5   KITCHEN          12   0901           20.30    24.50     4.20               .78      238
  5     5   KITCHEN          12   0902           21.60    24.60     3.00                .4      113
  5     5   KITCHEN          12   0903           23.00    24.70     1.70                         71


RUN:  1

  9     9   GAGIN             5   0831           20.10    25.10     5.00      1.2     1.02     1450
  9     9   GAGIN             5   0834           21.60    24.80     3.20      1.2      .42      300
  9     9   GAGIN             5   0837           22.40    25.10     2.70      1.2      .27      130
  9     9   GAGIN             5   0839           23.30    25.30     2.00      1.2      .15      100

RUN:  2

  9     9   GAGIN             5   0842           20.10    25.10     5.00      1.2     1.02     1340
  9     9   GAGIN             5   0845           21.60    25.00     3.40      1.2      .49      290
  9     9   GAGIN             5   0848           22.40    24.90     2.50      1.2      .23      220
  9     9   GAGIN             5   0851           23.40    25.20     1.80      1.2      .15      180

RUN:  3

  9     9   GAGIN             5   0915           20.20    25.20     5.00      1.2     1.01     1650
  9     9   GAGIN             5   0918           21.60    25.20     3.60      1.2      .55      360
  9     9   GAGIN             5   0921           22.30    25.30     3.00      1.2      .33      180
  9     9   GAGIN             5   0924           23.40    25.40     2.00      1.2      .15      220

RUN:  4

  9     9   GAGIN             5   0927           20.20    25.30     5.10      1.2     1.01     1320
  9     9   GAGIN             5   0930           21.70    25.20     3.50      1.2      .52      370
  9     9   GAGIN             5   0932           22.10    25.20     3.10      1.2      .41       30
  9     9   GAGIN             5   0935           23.30    25.30     2.00      1.2      .15       40


RUN:  1

 11    11   HOPPEL            7   0859    0913                                         .15      650      650
 11    11   HOPPEL            7   0859    0913                                        .094      187      187
 11    11   HOPPEL            7   0859    0913                                        .034      6.9      6.9
 11    11   HOPPEL            7   0859    0913                                        .025      2.6      2.6
 11    11   HOPPEL            7   0859    0913                                        .014       .8       .8

RUN:  1

 13    13   AYERS             2   0842    0843   21.84    24.30     2.46               .25      540                      ALL SC VALUES ARE
 13    13   AYERS             2   0843    0844   20.87    24.30     3.43                .5      780                      PRESET ON INSTR.
 13    13   AYERS             2   0844    0845   19.97    24.20     4.23               .75     1830                      AND ARE APPROXIMATE
 13    13   AYERS             2   0846    0847   19.35    24.20     4.85                 1     2100                      ONLY
```

```
                                                    NUCLEI MEASUREMENTS
EXPERIMENT #: 03                                                                                            PROCESSING DATE:  81/07/29

                 OBSERVER                                   PLATE TEMP
MACH  DUCT  ---------------------   SAMPLE TIME                           VOLUME   SUPER   NUCLEI  - ORS     EST
NO.   NO.   NAME              NO.   START   END    COLD     HOT    DELTA  SAMPLED   SAT    COUNT     -       K     REMARKS
                                                            (C)             (L)     (%)              N
----  ----  ---------------- ---    -----  ----   ------  ------  ------  -------  ------  ------  -----   -----  --------------------
 13    13   AYERS               2   0852   0853   18.58   24.00    5.42             1.25    2475
 13    13   AYERS               2   0853   0854   18.59   24.00    5.41             1.25    1950
 13    13   AYERS               2   0855   0856   19.13   24.00    4.87                1    1950

RUN:  2

 13    13   AYERS               2   0906   0907   21.56   24.00    2.44              .25     630
 13    13   AYERS               2   0909   0910   19.12   24.00    4.88                1    1875
 13    13   AYERS               2   0910   0911   19.13   24.00    4.87                1    1710
 13    13   AYERS               2   0911   0912   18.69   24.10    5.41             1.25    1950
 13    13   AYERS               2   0915   0916   18.70   24.10    5.40             1.25    1995
 13    13   AYERS               2   0918   0919   19.89   24.10    4.21              .75    1275
 13    13   AYERS               2   0920   0921   20.02   24.20    4.18              .75    1140
 13    13   AYERS               2   0922   0923   20.79   24.20    3.41               .5     930
 13    13   AYERS               2   0923   0924   20.77   24.20    3.43               .5     780

RUN:  1

 14    14   HUDSON              9   0922   0932                              .05      .21             170
 14    14   HUDSON              9   0922   0932                              .05      .13             120
 14    14   HUDSON              9   0922   0932                              .05     .093             9.3

RUN:  1

 17    17   WOJCIECHOWSKI      27   0844   0846                                       .25     673     673
 17    17   WOJCIECHOWSKI      27   0844   0846                                       .48    1258    1258
 17    17   WOJCIECHOWSKI      27   0844   0846                                       .73    1443    1443
 17    17   WOJCIECHOWSKI      27   0844   0846                                         1    2065    2065

RUN:  1

 20    20   RADKE              21   0925   0927                                               .47     161
 20    20   RADKE              21   0925   0927                                               .72     453
 20    20   RADKE              21   0925   0927                                               .87     774
 20    20   RADKE              21   0925   0927                                              1.14    1474
 20    20   RADKE              21   0925   0927                                               1.3    1241
 20    20   RADKE              21   0925   0927                                               1.3    1725
 20    20   RADKE              21   0925   0927                                               .52     157
 20    20   RADKE              21   0925   0927                                               .91    1076

RUN:  1

 21    21   ALOFS               1   0827   0829   20.70   25.00    4.30              .74    1735
 21    21   ALOFS               1   0834   0835   21.50   25.00    3.50              .49    1196
 21    21   ALOFS               1   0838   0839   22.10   25.00    2.90             .336     775
RUN:  2

 21    21   ALOFS               1   0846   0847   25.00   25.00    0.00             .173  1412.8
 21    21   ALOFS               1   0846   0847   25.00   25.00    0.00             .114   393.8
 21    21   ALOFS               1   0846   0847   25.00   25.00    0.00             .089   225.8
 21    21   ALOFS               1   0846   0847   25.00   25.00    0.00             .068   100.8
 21    21   ALOFS               1   0850   0851   25.00   25.00    0.00             .035    12.6
 21    21   ALOFS               1   0850   0851   25.00   25.00    0.00             .022     4.4

RUN:  1

 25    25   BORYS               3   0826   0830   22.80   23.90    1.10     10.6    .044     679     679      .48   VOL SAMP X 10**5
 25    25   BORYS               3   0833   0840   22.10   23.70    1.60     10.6    .097     467     467
 25    25   BORYS               3   0848   0853   20.80   23.20    2.40     8.48     .22    1291    1291
 25    25   BORYS               3   0858   0905   19.40   22.80    3.40      5.3     .47    1217    1217
 25    25   BORYS               3   0912   0918   18.30   22.60    4.30     4.24     .78    2122    2122
 25    25   BORYS               3   0923   0924   17.10   22.30    5.20     3.18     1.2    1764    1764
 25    25   BORYS               3   0930   0930   15.60   22.10    6.50     2.12    1.81    2688    2688

RUN:  1

 26    26   HINDMAN             6   0843   0931   22.60   22.60    0.00      1.5     .16      57      57            E=2.1, 0.5 UM
```

```
                                                   NUCLEI MEASUREMENTS
EXPERIMENT #: 03                                                                                        PROCESSING DATE:  81/07/29
                  OBSERVER                                      PLATE TEMP
MACH  DUCT  -------------------  SAMPLE TIME                                  VOLUME  SUPER   NUCLEI    ORS    EST
NO.   NO.   NAME            NO.  START   END    COLD    HOT    DELTA  SAMPLED  SAT    COUNT      -      K     REMARKS
                                                        (C)                (L)    (%)               N
----  ----  --------------- ---  -----  ----  ------  ------  ------  -------  ------  ------  -----  -----  ------------------
 26    26   HINDMAN           6  0843   0931   22.60   22.60    0.00      1.5     .12      23     23          E=0.80, 0.7 UM
 26    26   HINDMAN           6  0843   0931   22.60   22.60    0.00      1.5    .059      15     15          E=0.56, 1.4 UM
 26    26   HINDMAN           6  0843   0931   22.60   22.60    0.00      1.5    .027     .12    .12          E=0.010, 3.0 UM
 26    26   HINDMAN           6  0843   0931   22.60   22.60    0.00      1.5    .016    .013   .013          E=0.0030, 5.0 UM

RUN:  1

 27    27   OHTAKE           19  0840   0840                              3.2                                PICTURE IS NOT AVAIL
```



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

```
                                        EXPEPIMENT # 04
                                                                                 80/10/08
PURPOSE
-------

 DETERMINE SC AGREEMENT THROUGH USE OF VERY LARGE K (SHARPLY MONODISPERSE
 AEROSOL).

DESCRIPTION OF EXPERIMENT
-------------------------

  DATE          TIME
                START   END
  ------------  -----------

  08 OCT,1980   0945   1338

  NUCLEI TYPE
  -----------

   NACL, MONODISPERSE

  GENERATION METHOD
  -----------------

   DRI ATOMIZER, NO PREDILUTION

  SIZE DISTRIBUTION SHAPING
  -------------------------

   EC, 486V, NOM. 0.036 UM DIA.
   3.3 L/MIN. SAMPLE FLOW

REMARKS
-------

 T 73 (F), TD 50 (F), DIL. FLOW 300 L/MIN.
 NOTE DISTURBANCE BETWEEN 1035 AND 1040

WEATHER SYNOPSIS
----------------

 NA

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

         ROOM CONDITIONS                          OUTSIDE CONDITIONS

 --------------------------------    ----------------------------------------------------

 AVG TEMP     AVG RH    AVG PRESS     AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)         (%)        (MB)          (C)        (%)        (MB)        (M/S)     (DEG)
 --------     ------    ---------     --------    ------    ---------    ------    ------

   22.0        20.0       852            NA         NA         NA          NA        NA
```

```
                                                         NUCLEI MEASUREMENTS
EXPERIMENT #: 04                                                                                                 PROCESSING DATE:  81/07/29

                      OBSERVER                                      PLATE TEMP
MACH  DUCT  -----------------------  SAMPLE  TIME                                   VOLUME   SUPER   NUCLEI    OBS    EST
NO.   NO.   NAME                NO.  START   END     COLD      HOT      DELTA     SAMPLED   SAT     COUNT      -      K     REMARKS
                                                                (C)                 (L)     (%)               N
----  ----  ---------------    ---   -----   ----   ------    ------   ------    -------  ------  ------   -----  -----  --------------------

RUN:  1
  5     5   KITCHEN             12   1127            19.40     26.60     7.20                  2     199
  5     5   KITCHEN             12   1128            20.10     26.60     6.50                1.6     127
  5     5   KITCHEN             12   1129            20.80     26.70     5.90                1.4      79
  5     5   KITCHEN             12   1130            21.40     26.70     5.30                1.1      74
  5     5   KITCHEN             12   1131            22.60     26.70     4.10                .64      22
  5     5   KITCHEN             12   1132            23.20     26.70     3.50                .45      29
  5     5   KITCHEN             12   1133            23.80     26.70     2.90                .33      17
  5     5   KITCHEN             12   1134            24.60     26.90     2.30                 .2      18
  5     5   KITCHEN             12   1135            25.20     26.90     1.70                 .1      34

RUN:  2
  5     5   KITCHEN             12   1144            19.90     27.00     7.10                  2     219
  5     5   KITCHEN             12   1145            20.40     27.00     6.60                1.6      97
  5     5   KITCHEN             12   1146            21.10     27.00     5.90                1.4      88
  5     5   KITCHEN             12   1147            21.70     27.00     5.30                1.1      66
  5     5   KITCHEN             12   1148            22.40     27.10     4.70                .62      57
  5     5   KITCHEN             12   1149            23.00     27.10     4.10                .45      44
  5     5   KITCHEN             12   1150            24.20     27.10     2.90                .33      40


RUN:  1
  9     9   GAGIN                5   1014            20.20     25.30     5.10       1.2     1.01     440
  9     9   GAGIN                5   1017            21.80     25.00     3.20       1.2      .45      70
  9     9   GAGIN                5   1021            22.40     25.30     2.90       1.2       .3      40
  9     9   GAGIN                5   1023            23.50     25.40     1.90       1.2      .15       0

RUN:  2
  9     9   GAGIN                5   1027            20.10     25.30     5.20       1.2     1.08     410
  9     9   GAGIN                5   1029            21.60     25.10     3.50       1.2      .49      70
  9     9   GAGIN                5   1032            22.30     25.30     3.00       1.2      .33      40

RUN:  3
  9     9   GAGIN                5   1037            20.10     25.10     5.00       1.2     1.02     480
  9     9   GAGIN                5   1040            21.70     25.30     3.60       1.2      .51      70
  9     9   GAGIN                5   1046            23.40     24.90     1.50       1.2      .15      40

RUN:  4
  9     9   GAGIN                5   1052            19.80     25.30     5.50       1.2     1.24     530
  9     9   GAGIN                5   1055            21.60     25.10     3.50       1.2      .49      40
  9     9   GAGIN                5   1057            22.50     25.10     2.60       1.2      .27      50

RUN:  5
  9     9   GAGIN                5   1100            20.20     25.20     5.00       1.2     1.01     410
  9     9   GAGIN                5   1103            21.70     25.20     3.50       1.2      .52      40
  9     9   GAGIN                5   1106            22.60     25.40     2.80       1.2      .33      50
  9     9   GAGIN                5   1108            23.50     25.30     1.80       1.2      .17      20

RUN:  6
  9     9   GAGIN                5   1138            20.30     25.40     5.10       1.2     1.01     420
  9     9   GAGIN                5   1141            21.50     25.40     3.90       1.2      .62      50
  9     9   GAGIN                5   1143            22.30     25.30     3.00       1.2       .3      30
  9     9   GAGIN                5   1145            23.40     25.40     2.00       1.2      .15      30


RUN:  1
 13    13   AYERS                2   1013    1014    23.54     26.00     2.46                .25       0                   SC VALUES ARE PRESET
 13    13   AYERS                2   1015    1016    22.62     26.10     3.48                 .5       0                   ON INSTR. AND ARE
 13    13   AYERS                2   1018    1019    21.86     26.10     4.24                .75     158                   APPROXIMATE ONLY
 13    13   AYERS                2   1022    1023    21.18     26.10     4.92                  1     240
 13    13   AYERS                2   1025    1026    20.61     26.10     5.49               1.25     240
```

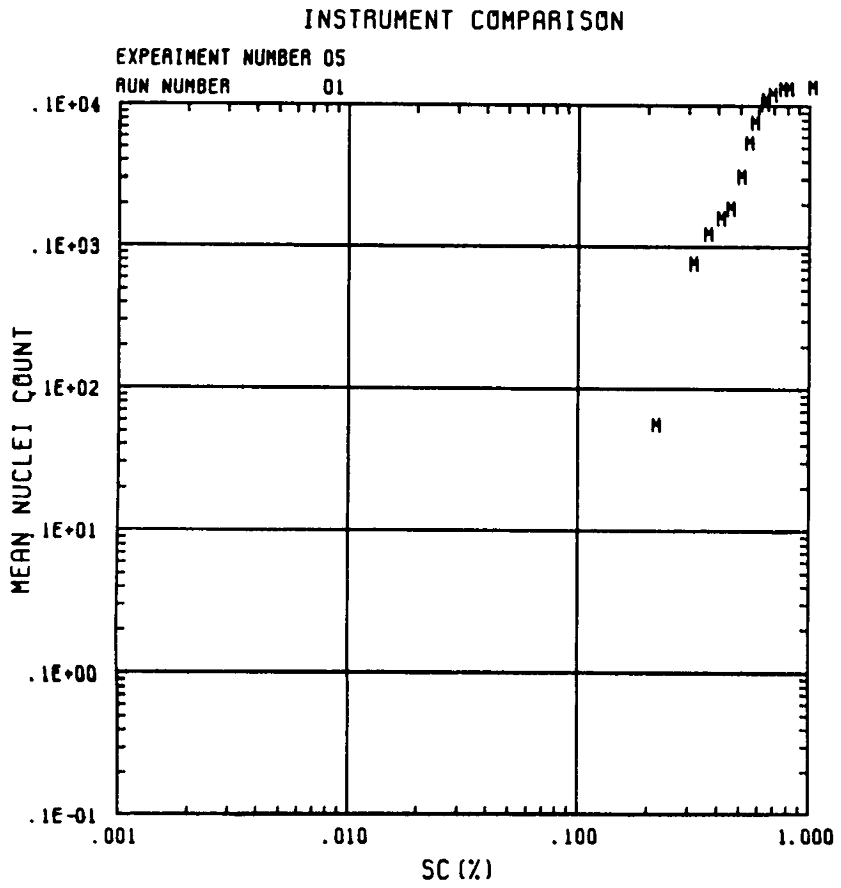
EXPERIMENT #: 04

NUCLEI MEASUREMENTS

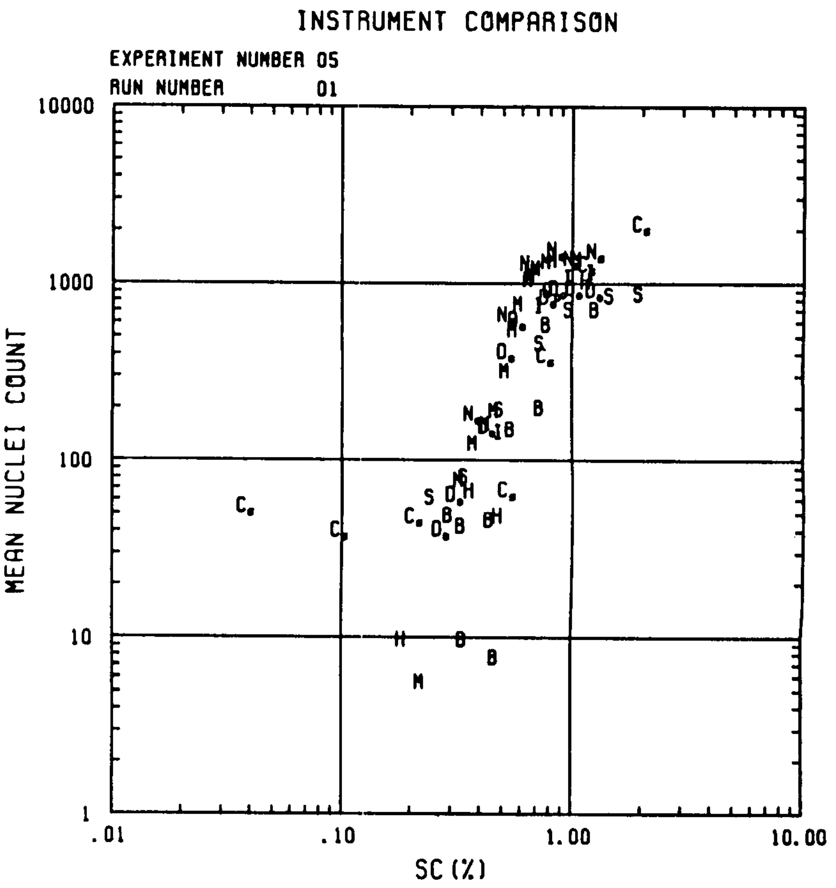
PROCESSING DATE: 81/07/29

MACH NO.	DUCT NO.	OBSERVER		SAMPLE START	TIME END	PLATE TEMP			VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
		NAME	NO.			COLD	HOT (C)	DELTA						
RUN:	2													
13	13	AYERS	2	1028	1029	20.61	26.10	5.49		1.25	233			
13	13	AYERS	2	1030	1031	21.20	26.10	4.90		1	225			
13	13	AYERS	2	1032	1033	21.80	26.10	4.30		.75	210			
13	13	AYERS	2	1034	1035	22.59	26.10	3.51		.5	0			
13	13	AYERS	2	1036	1037	23.74	26.20	2.46		.25	0			
RUN:	3													
13	13	AYERS	2	1056	1057	24.32	26.80	2.48		.25	0			
13	13	AYERS	2	1058	1059	23.29	26.80	3.51		.5	0			
13	13	AYERS	2	1059	1100	22.52	26.80	4.28		.75	158			
13	13	AYERS	2	1101	1102	21.88	26.80	4.92		1	195	145		
13	13	AYERS	2	1102	1103	21.86	26.80	4.94		1	240			
13	13	AYERS	2	1105	1106	21.30	26.80	5.50		1.25	233			
RUN:	1													
14	14	HUDSON	9	1040	1150				.033	.21		0		
14	14	HUDSON	9	1040	1150				.033	.13		0		
14	14	HUDSON	9	1040	1150				.033	.093		0		
14	14	HUDSON	9	1040	1150				.033	.02		0		
RUN:	1													
17	17	WOJCIECHOWSKI	27	1132	1138					.25	0	0		
17	17	WOJCIECHOWSKI	27	1132	1138					.35	44.4	44.4		
17	17	WOJCIECHOWSKI	27	1132	1138					.45	281.2	281.2		
17	17	WOJCIECHOWSKI	27	1132	1138					.62	355.2	355.2		
17	17	WOJCIECHOWSKI	27	1132	1138					.79	384.8	384.8		
17	17	WOJCIECHOWSKI	27	1132	1138					.98	429.2	429.2		
17	17	WOJCIECHOWSKI	27	1132	1138					1.19	503.2	503.2		
17	17	WOJCIECHOWSKI	27	1132	1138					1.87	355	355		
17	17	WOJCIECHOWSKI	27	1132	1138					2.07	370	370		
17	17	WOJCIECHOWSKI	27	1132	1138					2.5	399.6	399.6		
RUN:	1													
18	18	HUDSON	9	1027	1031	21.55	26.35	4.80	.0024	.94		218		
18	18	HUDSON	9	1037	1040	22.00	26.00	4.00	.0024	.64		241		
18	18	HUDSON	9	1044	1047	22.45	25.55	3.10	.0024	.38		27.6		
18	18	HUDSON	9	1058	1101	22.35	25.75	3.40	.0018	.46		30.1		
18	18	HUDSON	9	1105	1108	22.75	25.95	3.20	.0024	.54		123		
18	18	HUDSON	9	1124	1126	22.20	26.00	3.80	.0018	.57		166		
18	18	HUDSON	9	1141	1143	22.10	26.30	4.20	.0018	.69		230		
18	18	HUDSON	9	1148	1150	21.80	26.50	4.70	.0018	.87		231		
18	18	HUDSON	9	1154	1156	21.60	26.80	5.20	.0018	1.06		228		
RUN:	1													
20	20	RADKE	21	1108						.49	59			
20	20	RADKE	21	1108						.74	67			
20	20	RADKE	21	1108						.93	777			
20	20	RADKE	21	1121						.49	70			
20	20	RADKE	21	1121						.74	82			
20	20	RADKE	21	1121						1.01	307			
20	20	RADKE	21	1121						1.35	590			
RUN:	2													
20	20	RADKE	21	1200	1205					.36	62			
20	20	RADKE	21	1200						.54	50			
20	20	RADKE	21	1200						.78	620			
20	20	RADKE	21	1200						1.04	704			
20	20	RADKE	21	1205						.4	48			

```
                                                    NUCLEI MEASUREMENTS
EXPERIMENT #: 04                                                                                      PROCESSING DATE:  81/07/29
                 OBSERVER                             PLATE TEMP
MACH  DUCT  ------------------  SAMPLE  TIME                           VOLUME   SUPER  NUCLEI   OBS    EST
NO.   NO.   NAME           NO.  START    END    COLD     HOT    DELTA  SAMPLED   SAT    COUNT      -      K    REMARKS
                                                          (C)            (L)     (%)              N
----  ----  -------------- ---  ------  ----  ------  ------  ------  -------  ------  ------  -----  -----  ------------------
 20    20   RADKE           21    1205                                            .65      20
 20    20   RADKE           21    1205                                            .85     593
 20    20   RADKE           21    1205                                           1.04     601

RUN:  3

 20    20   DOMONKOS         4    1304  1310                                      .39      41
 20    20   DOMONKOS         4    1304                                            .57      28
 20    20   DOMONKOS         4    1304                                            .76     638
 20    20   DOMONKOS         4    1304                                           1.06     774

RUN:  1

 21    21   ALOFS            1    1010  1014   20.00   25.00    5.00                1   265.9
 21    21   ALOFS            1    1019  1020   20.70   25.00    4.30              .74   281.7
 21    21   ALOFS            1    1024  1026   20.90   25.00    4.10             .672   260.4
 21    21   ALOFS            1    1028  1030   21.20   25.00    3.80             .578    58.7
 21    21   ALOFS            1    1033  1036   21.00   25.00    4.00              .64   257.4
 21    21   ALOFS            1    1036  1036   21.10   25.00    3.90             .608   214.6
 21    21   ALOFS            1    1036  1037   21.35   25.00    3.65             .533      71
 21    21   ALOFS            1    1041  1042   22.00   25.00    3.00              .36    17.2

RUN:  1

 24    24   SERPOLAY        25    1045  1055   23.70   27.60    3.90      .77      .6     150
 24    24   SERPOLAY        25    1105  1115   24.50   28.90    4.40      .77     .75     380
 24    24   SERPOLAY        25    1120  1125   25.00   29.60    4.60      .77      .8     530
 24    24   SERPOLAY        25    1130  1135   25.40   30.00    4.60      .77     .78     470

RUN:  1

 25    25   BORYS            3    1012  1020   21.60   22.60    1.00    26.51    .038      28     28    .91  VOL SAMP X 10**5
 25    25   BORYS            3    1025  1032   21.10   22.70    1.60    21.21    .099      42     42         LEAK PROBLEMS
 25    25   BORYS            3    1042  1049   20.50   22.80    2.30    21.21    .218      50     50
 25    25   BORYS            3    1056  1103   19.40   22.90    3.50    21.21     .51     134    134
 25    25   BORYS            3    1109  1114   18.50   22.80    4.30    15.91      .8     141    141
 25    25   BORYS            3    1120  1124   17.50   22.70    5.20     10.6    1.18     509    509
 25    25   BORYS            3    1135  1138   16.10   22.60    6.50      5.3    1.82     849    849

RUN:  1

 26    26   HINDMAN          6    1018  1145   22.60   22.60    0.00      1.1     .16       0      0         0.5 UM
 26    26   HINDMAN          6    1018  1145   22.60   22.60    0.00      1.1     .12       0      0         0.7 UM
 26    26   HINDMAN          6    1018  1145   22.60   22.60    0.00      1.1    .059       0      0         01.4 UM
 26    26   HINDMAN          6    1018  1145   22.60   22.60    0.00      1.1    .027       0      0         3.0 UM
 26    26   HINDMAN          6    1018  1145   22.60   22.60    0.00      1.1    .016       0      0         5.0 UM

RUN:  1

 27    27   OHTAKE          19    1016  1016                            3.2             .405                94% R.H.
 27    27   OHTAKE          19    1016  1016                            3.2             .405                100% R.H.
 27    27   OHTAKE          19    1016  1016                            3.2             .555                101% R.H. NONINAL
 27    27   OHTAKE          19    1016  1016                            3.2             .495                102% R.H. NOMINAL
```



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

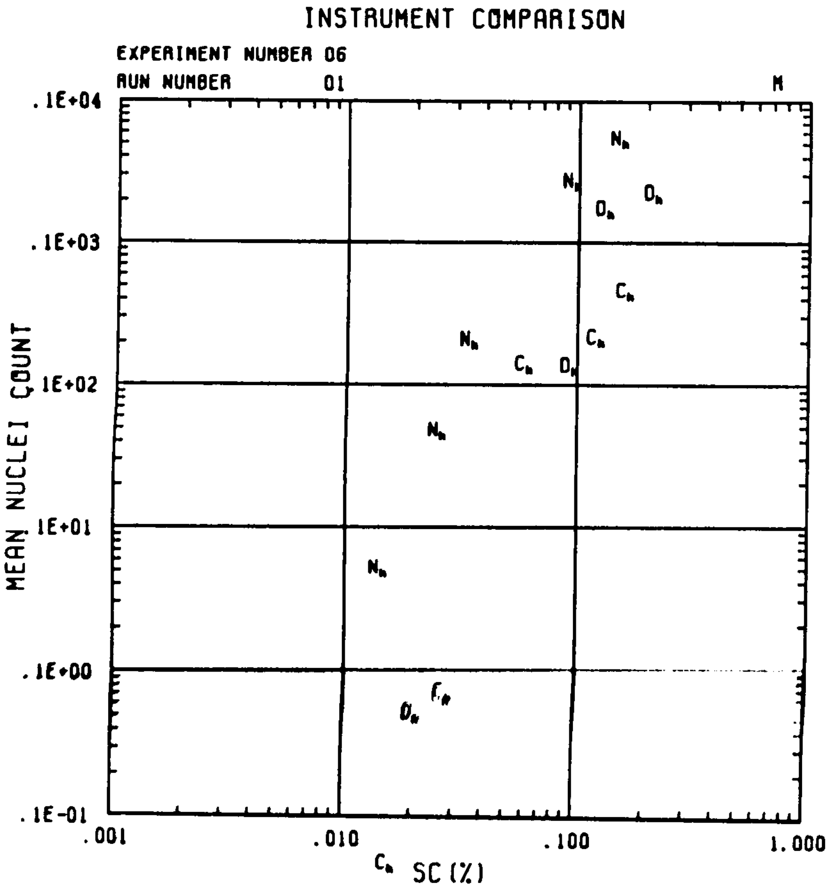
```
                                   EXPEPIMENT # 05
                                                                           80/10/08
PURPOSE
-------
 AS # 4, BUT HIGHER AEROSOL CONCENTRATION

DESCRIPTION OF EXPERIMENT
-------------------------
                  TIME
  DATE            START   END
  ------------    ----------
  08 OCT,1980     1410    1606

  NUCLEI TYPE
  -----------
   NACL, MONODISPERSE

  GENERATION METHOD
  -----------------
   DRI ATOMIZER, NO PREDILUTION, 70 PSI.

  SIZE DISTRIBUTION SHAPING
  -------------------------
   EC, 486V (NOM. 0.036 UM DIA.)
   6.7 L/MIN. SAMPLE FLOW, 250 L/MIN DIL. FLOW.

REMARKS
-------
 T 74(F),  TD 50(F)

WEATHER SYNOPSIS
----------------
 NA

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
         ROOM CONDITIONS                          OUTSIDF CONDITIONS

 --------------------------------     ----------------------------------------------------
 AVG TEMP    AVG RH    AVG PRESS      AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)         (%)       (MB)           (C)         (%)       (MB)       (M/S)     (DEG)
 --------    ------    ---------      --------    ------    ---------    ------    ------
   23.0       21.0       852             NA          NA         NA          NA        NA
```

```
                                                                 NUCLEI MEASUREMENTS
EXPERIMENT #: 05                                                                                                          PROCESSING DATE:  81/07/29
                     OBSERVER                                     PLATE TEMP
MACH  DUCT  -------------------------  SAMPLE  TIME                                   VOLUME    SUPER   NUCLEI   OBS    EST
NO.   NO.   NAME                  NO.   START   END     COLD    HOT     DELTA   SAMPLED   SAT     COUNT     -      *      REMARKS
                                                                (C)               (L)      (%)                N
----  ----  ----------------     ---   -----   ----   ------  ------  ------  -------   ------  ------   -----  -----  ------------------
RUN:  1

  5     5   KITCHEN               12    1434           21.40   24.90    3.50              .45      48
  5     5   KITCHEN               12    1435           22.00   24.90    2.90              .3       51
  5     5   KITCHEN               12    1436           21.90   25.00    3.10              .35      10
  5     5   KITCHEN               12    1437           21.40   25.00    3.60              .48       8
  5     5   KITCHEN               12    1441           19.40   25.10    5.70             1.3      743
  5     5   KITCHEN               12    1442           20.40   25.10    4.70              .8      609
  5     5   KITCHEN               12    1443           20.70   25.10    4.40              .75     208
  5     5   KITCHEN               12    1444           21.20   25.10    3.90              .56     155
  5     5   KITCHEN               12    1445           22.20   25.10    2.90              .34      44
RUN:  2

  5     5   KITCHEN               12    1451           21.30   25.60    4.30              .68     146
  5     5   KITCHEN               12    1452           21.90   25.60    3.70              .8      294
  5     5   KITCHEN               12    1453           20.20   25.60    5.40             1.1      236
  5     5   KITCHEN               12    1454           19.10   25.60    6.50             1.8      540
  5     5   KITCHEN               12    1455           17.10   26.20    9.10             3       1446
  5     5   KITCHEN               12    1505           21.60   26.20    4.60              .8      101
  5     5   KITCHEN               12    1510           22.10   26.90    4.80              .88     143
  5     5   KITCHEN               12    1511           21.70   26.90    5.20             1.1      255
  5     5   KITCHEN               12    1512           21.00   26.90    5.90             1.4      603

RUN:  1

  9     9   GAGIN                  5    1427           19.60   25.00    5.40     1.2     1.19    1070
  9     9   GAGIN                  5    1430           21.60   25.10    3.50     1.2      .49      50
  9     9   GAGIN                  5    1432           22.20   25.20    3.00     1.2      .37      70
  9     9   GAGIN                  5    1435           23.30   25.00    1.70     1.2      .19      10
RUN:  2

  9     9   GAGIN                  5    1440           19.40   24.70    5.30     1.2     1.17     880
  9     9   GAGIN                  5    1442           21.50   24.90    3.40     1.2      .45      50
  9     9   GAGIN                  5    1445           22.60   24.70    2.10     1.2      .2       40
RUN:  3

  9     9   GAGIN                  5    1451           20.20   25.20    5.00     1.2     1.01     680
  9     9   GAGIN                  5    1454           21.70   25.00    3.30     1.2      .45      80
  9     9   GAGIN                  5    1457           22.10   25.00    2.90     1.2      .41      20
  9     9   GAGIN                  5    1459           23.30   25.30    2.00     1.2      .15       0
RUN:  4

  9     9   GAGIN                  5    1504           19.70   24.80    5.10     1.2     1.04     640
  9     9   GAGIN                  5    1507           21.40   25.00    3.60     1.2      .52      20
  9     9   GAGIN                  5    1509           22.40   25.20    2.80     1.2      .3       40
  9     9   GAGIN                  5    1512           23.50   25.40    1.90     1.2      .15      50
RUN:  5

  9     9   GAGIN                  5    1525           20.00   25.30    5.30     1.2     1.12     500
  9     9   GAGIN                  5    1527           21.60   25.40    3.80     1.2      .59      60
  9     9   GAGIN                  5    1530           22.00   25.30    3.30     1.2      .3       50
RUN:  6

  9     9   GAGIN                  5    1553           20.20   25.00    4.80     1.2      .94     540
  9     9   GAGIN                  5    1555           21.30   24.80    3.50     1.2      .46      50
  9     9   GAGIN                  5    1600           22.50   25.20    2.70     1.2      .3       20

RUN:  1

 10    10   LALA                  13    1430           22.93   25.46    2.53      .4      .25      55
 10    10   LALA                  13    1430           22.97   25.50    2.53      .4      .25      73      64
 10    10   LALA                  13    1430           22.64   25.63    2.99      .4      .35      87
```

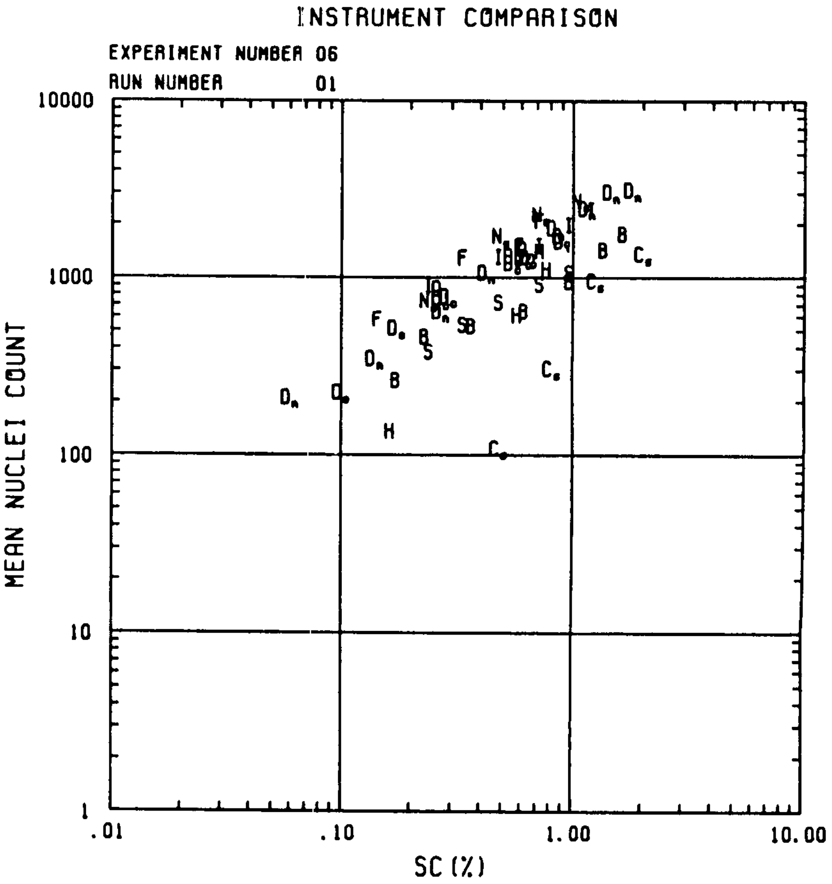
```
                                                              NUCLEI MEASUREMENTS
EXPERIMENT #: 05                                                                                                          PROCESSING DATE:  81/07/29

                       OBSERVER                                        PLATE TEMP
MACH  DUCT  -------------------        SAMPLE TIME                                      VOLUME   SUPER   NUCLEI      OBS     EST
NO.   NO.   NAME                NO.    START   END     COLD       HOT      DELTA   SAMPLED   SAT     COUNT       -        K      REMARKS
                                                                   (C)                (L)      (%)                N
----  ----  --------------- ---        -----  ----    ------    ------   ------   -------   -----   ------     -----    -----  ------------------
 10    10   LALA                13     1430            22.61    25.60     2.99       .4       .35     80.8      83.9
 10    10   LALA                13     1430            22.01    25.57     3.56       .4       .5      203
 10    10   LALA                13     1430            21.97    25.53     3.56       .4       .5      198       200.5
 10    10   LALA                13     1430            21.15    25.49     4.34       .4       .75     454
 10    10   LALA                13     1430            21.10    25.45     4.35       .4       .75     501       477.5
 10    10   LALA                13     1430            20.35    25.35     5.00       .4      1        728
 10    10   LALA                13     1430            20.30    25.30     5.00       .4      1        742         735
 10    10   LALA                13     1430            19.23    25.32     6.09       .4      1.5      882
 10    10   LALA                13     1430            19.17    25.25     6.08       .4      1.5      887       884.5
 10    10   LALA                13     1430            18.19    25.19     7.00       .4      2        907
 10    10   LALA                13     1430   1443     18.08    25.07     6.99       .4      2        898       902.5

RUN:   2

 10    10   LALA                13     1453            23.82    26.36     2.54       .4       .25      54
 10    10   LALA                13     1453            23.80    26.34     2.54       .4       .25     68.3       61.1
 10    10   LALA                13     1453            23.32    26.32     3.00       .4       .35     84.8
 10    10   LALA                13     1453            23.26    26.26     3.00       .4       .35     76.6       80.7
 10    10   LALA                13     1453            22.64    26.22     3.58       .4       .5     186.2
 10    10   LALA                13     1453            22.59    26.17     3.58       .4       .5     186.2      186.2
 10    10   LALA                13     1453            21.65    26.01     4.36       .4       .75     532
 10    10   LALA                13     1453            21.58    25.94     4.36       .4       .75     534         533
 10    10   LALA                13     1453            20.83    25.85     5.02       .4      1       676.9
 10    10   LALA                13     1453            20.75    25.76     5.01       .4      1        700         688
 10    10   LALA                13     1453            19.53    25.64     6.11       .4      1.5      836
 10    10   LALA                13     1453            19.60    25.71     6.11       .4      1.5     830.9        833
 10    10   LALA                13     1453            18.47    25.49     7.02       .4      2        886
 10    10   LALA                13     1453            18.39    25.40     7.01       .4      2        843       864.5

RUN:   3

 10    10   LALA                13     1535            24.07    26.62     2.55                .25     78.8
 10    10   LALA                13     1535            24.03    26.58     2.55                .25     54.5      66.65
 10    10   LALA                13     1535            23.50    26.56     3.06                .35     97.8
 10    10   LALA                13     1535            23.49    26.50     3.01                .35    103.1     100.45
 10    10   LALA                13     1535            22.86    26.45     3.59                .5     182.8
 10    10   LALA                13     1535            22.80    26.39     3.59                .5     204.2      193.5
 10    10   LALA                13     1535            21.90    26.28     4.38                .75    465.5
 10    10   LALA                13     1535            21.17    26.20     5.03                .75    528.9      497.2
 10    10   LALA                13     1549            21.17    26.20     5.03               1       727.9
 10    10   LALA                13     1549            21.10    26.13     5.03               1       762.9      745.4
 10    10   LALA                13     1549            19.92    26.05     6.13               1.5     881.2
 10    10   LALA                13     1549            19.84    25.97     6.13               1.5     872.8        877
 10    10   LALA                13     1549            18.77    25.80     7.03               2       824.9
 10    10   LALA                13     1549   1558     18.74    25.77     7.03               2       829.5      827.2


RUN:   1

 13    13   AYERS                2     1427   1428     25.52    28.00     2.48                .25       0                       35 MM FILM RECORD
 13    13   AYERS                2     1429   1430     24.39    27.90     3.51                .5      150                       ALSO TAKEN
 13    13   AYERS                2     1431   1432     23.49    27.80     4.31                .75     780
 13    13   AYERS                2     1433   1434     22.73    27.70     4.97               1       1125
 13    13   AYERS                2     1435   1436     22.05    27.60     5.55               1.25     1200

RUN:   2

 13    13   AYERS                2     1440   1441     25.03    27.50     2.47                .25      15                       35 MM FILM RECORD
 13    13   AYERS                2     1442   1443     23.85    27.40     3.55                .5      293                       ALSO TAKEN
 13    13   AYERS                2     1443   1444     23.87    27.40     3.53                .5      270
 13    13   AYERS                2     1445   1446     22.96    27.30     4.34                .75     900
 13    13   AYERS                2     1447   1448     22.33    27.30     4.97               1       1095
 13    13   AYERS                2     1450   1451     21.67    27.20     5.53               1.25     1200


RUN:   1

 14    14   HUDSON               9     1530   1610                                .019      .21                   0
 14    14   HUDSON               9     1530   1610                                .019      .13                   0
 14    14   HUDSON               9     1530   1610                                .019      .093                  0
 14    14   HUDSON               9     1530   1610                                .019      .02                   0
```

```
                                                              NUCLEI MEASUREMENTS
EXPERIMENT #: 05                                                                                                   PROCESSING DATE:  81/07/29
                          OBSERVER                                        PLATE TEMP
MACH   DUCT   -------------------------   SAMPLE  TIME                                        VOLUME    SUPER    NUCLEI     OPS      EST
NO.    NO.    NAME                   NO.   START   END       COLD     HOT      DELTA    SAMPLED    SAT      COUNT      -        K      REMARKS
                                                                      (C)                  (L)      (%)                  N
----   ----   ---------------       ---   -----   ----     ------   ------   ------   -------   ------   ------    -----    -----   ------------------

RUN:   1

 17     17    WOJCIECHOWSKI          27    1423    1433                                           .173        0          0
 17     17    WOJCIECHOWSKI          27    1423    1433                                           .235        0          0
 17     17    WOJCIECHOWSKI          27    1423    1433                                            .37    192.4      192.4
 17     17    WOJCIECHOWSKI          27    1423    1433                                            .52    695.6      695.6
 17     17    WOJCIECHOWSKI          27    1423    1433                                            .65     1346       1346
 17     17    WOJCIECHOWSKI          27    1423    1433                                            .85     1628       1628
 17     17    WOJCIECHOWSKI          27    1423    1433                                              1   1450.4     1450.4
 17     17    WOJCIECHOWSKI          27    1423    1433                                           1.26   1583.6     1583.6

RUN:   2

 17     17    WOJCIECHOWSKI          27    1504    1506                                            .35    251.6      251.6
 17     17    WOJCIECHOWSKI          27    1504    1506                                            .45    843.6      843.6
 17     17    WOJCIECHOWSKI          27    1504    1506                                            .73     1583       1583
 17     17    WOJCIECHOWSKI          27    1504    1506                                            .98     1702       1702
 17     17    WOJCIECHOWSKI          27    1504    1506                                           1.24   1938.8     1938.8

RUN:   1

 18     18    HUDSON                  9    1422    1426     21.70    26.80     5.10     .0024     1.02                 975
 18     18    HUDSON                  9    1444    1447     22.50    26.15     3.65     .0018      .52                 428
 18     18    HUDSON                  9    1454    1457     23.00    25.65     2.65     .0024      .27                42.6
 18     18    HUDSON                  9    1502    1504     22.95    25.75     2.80     .0018      .31                66.8
 18     18    HUDSON                  9    1511    1514     22.70    26.00     3.30     .0018      .43                 161
 18     18    HUDSON                  9    1523    1525     22.50    26.35     3.85     .0018      .58                 648
 18     18    HUDSON                  9    1537    1539     22.05    26.75     4.70     .0018      .87                 982
 18     18    HUDSON                  9    1542    1545     21.60    27.25     5.65     .0018     1.25                 962
 18     18    HUDSON                  9    1551    1553     22.20    26.70     4.50     .0018      .82                 960
 18     18    HUDSON                  9    1559    1601     22.40    26.50     4.10     .0018      .79                 870

RUN:   1

 21     21    TRUEBLOOD              26    1428    1429     19.78    25.00     5.22               1.09     1431
 21     21    TRUEBLOOD              26    1435    1436     20.39    25.00     4.61                .85     1398
 21     21    TRUEBLOOD              26    1439    1440     20.52    25.00     4.48               .803     1386
 21     21    TRUEBLOOD              26    1442    1443     20.75    25.00     4.25               .722     1269
 21     21    TRUEBLOOD              26    1445    1446     20.88    25.00     4.12               .679     1167
 21     21    TRUEBLOOD              26    1449    1449     20.91    25.00     4.09               .669     1098
 21     21    TRUEBLOOD              26    1452    1452     21.10    25.00     3.90               .608      800
 21     21    TRUEBLOOD              26    1455    1455     21.22    25.00     3.78               .572      570
 21     21    TRUEBLOOD              26    1458    1458     21.36    25.00     3.64                .53    333.9
 21     21    TRUEBLOOD              26    1501    1502     21.55    25.00     3.45               .476      199
 21     21    TRUEBLOOD              26    1503    1504     21.70    25.00     3.30               .436    168.4
 21     21    TRUEBLOOD              26    1507    1508     21.90    25.00     3.10               .384    129.8
 21     21    TRUEBLOOD              26    1514    1515     22.12    25.00     2.88               .332     80.4
 21     21    TRUEBLOOD              26    1521    1522     22.60    25.00     2.40                .23      5.9

RUN:   1

 25     25    BORYS                   3    1427    1433     22.90    23.90     1.00      21.2     .038       57         57             VOL SAMP. # 10**5
 25     25    BORYS                   3    1439    1446     22.10    23.70     1.60      21.2     .098       42         42             PROBLEM WITH LEAK
 25     25    BORYS                   3    1453    1500     21.20    23.50     2.30      21.2     .205       50         50
 25     25    BORYS                   3    1510    1515     19.80    23.30     3.50      21.2      .52       71         71
 25     25    BORYS                   3    1527    1530     18.80    23.10     4.30      10.6      .77      410        410
 25     25    BORYS                   3    1539    1541     17.70    22.90     5.20       5.3     1.16     1330       1330
 25     25    BORYS                   3    1548    1549     16.10    22.80     6.70      2.12     1.98     2263       2263

RUN:   1

 26     26    HINDMAN                 6    1429    1536     23.00    23.00     0.00       1.1      .16        0          0             D>= 0.5 UM
 26     26    HINDMAN                 6    1429    1536     23.00    23.00     0.00       1.1      .12        0          0             D>= 0.7 UM
 26     26    HINDMAN                 6    1429    1536     23.00    23.00     0.00       1.1     .059        0          0             D>= 1.4 UM
 26     26    HINDMAN                 6    1429    1536     23.00    23.00     0.00       1.1     .027        0          0             D>= 3.0 UM
 26     26    HINDMAN                 6    1429    1536     23.00    23.00     0.00       1.1     .016        0          0             D>= 5.0 UM
```

```
EXPERIMENT #: 05                                      NUCLEI MEASUREMENTS                                        PROCESSING DATE:  81/07/29

                  OBSERVER                                    PLATE TEMP
MACH  DUCT  ---------------------   SAMPLE TIME                                VOLUME   SUPER  NUCLEI    OBS     EST
NO.   NO.   NAME              NO.   START   END    COLD     HOT     DELTA   SAMPLED   SAT   COUNT      -       K    REMARKS
                                                            (C)               (L)      (%)               N
----  ----  ---------------- ---   -----  ----   ------   ------  ------  -------  ------  ------    -----  -----  -------------------

RUN:  1
 27    27   OHTAKE             19   1430   1430                                3.5             .677                  118% R.H. NOMINAL
```



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

```
                                   EXPERIMENT # 06                                    80/10/08

PURPOSE
-------
 INSTRUMENT COMPARISON WITH AMBIENT AEROSOL

DESCRIPTION OF EXPERIMENT
-------------------------
                    TIME
  DATE              START   END
  ------------      -----------
  08 OCT,1980       1618    1800

  NUCLEI TYPE
  -----------
   AMBIENT

  GENERATION METHOD
  -----------------
   NA

  SIZE DISTRIBUTION SHAPING
  -------------------------
   NA

REMARKS
-------
 T=75(F), TD=54(F)
 WIND CALM, W.D. VARIABLE

WEATHER SYNOPSIS
----------------
 NA

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
        ROOM CONDITIONS                            OUTSIDE CONDITIONS

 ---------------------------------      -----------------------------------------------------
 AVG TEMP     AVG RH     AVG PRESS      AVG TEMP     AVG RH     AVG PRESS     AVG WS    AVG WD
   (C)         (%)         (MB)           (C)         (%)         (MB)        (M/S)     (DEG)
 --------     ------     ---------      --------     ------     ---------     ------    ------
   25.0        21.0        852             NA          NA          NA           0.0       90
```

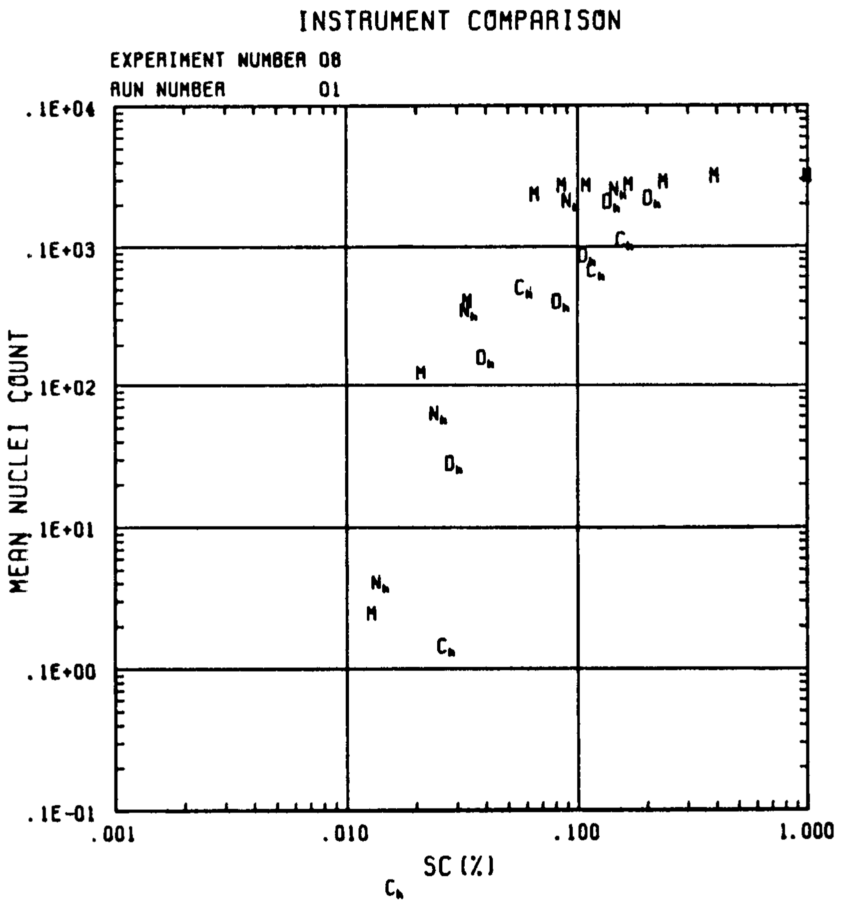
```
                                                                      NUCLEI MEASUREMENTS
EXPERIMENT #: 06                                                                                                                         PROCESSING DATE:  81/07/29

                     OBSERVER                                    PLATE TEMP
MACH  DUCT  ------------------------  SAMPLE  TIME                                     VOLUME    SUPER   NUCLEI     OBS     EST
NO.   NO.   NAME                NO.   START   END     COLD     HOT      DELTA   SAMPLED   SAT     COUNT       -       K     REMARKS
                                                                (C)               (L)     (%)                N
----  ----  ---------------   ---   -----   ----   ------   ------   ------   -------   ------   ------    -----   -----  ------------------
RUN:   1

 5     5    KITCHEN            12    1620           24.10    26.60    2.50               .24      475
 5     5    KITCHEN            12    1621           24.30    26.50    2.20               .18      272
 5     5    KITCHEN            12    1622           23.30    26.40    3.10               .38      552
 5     5    KITCHEN            12    1623           22.50    26.40    3.90               .64      716
 5     5    KITCHEN            12    1624           21.50    26.30    4.80              1        1063
 5     5    KITCHEN            12    1625           20.60    26.20    5.60              1.4      1516
 5     5    KITCHEN            12    1626           19.60    26.10    6.50              1.7      1810
 5     5    KITCHEN            12    1627           20.50    26.10    5.60              1.4      1434
 5     5    KITCHEN            12    1628           21.30    26.10    4.80              1         907
 5     5    KITCHEN            12    1629           22.20    26.10    3.90               .64      625              1.00
RUN:   2

 5     5    KITCHEN            12    1631           23.90    26.10    2.20               .18      238
 5     5    KITCHEN            12    1632           24.80    26.10    1.30               .06      119
 5     5    KITCHEN            12    1638           22.10    26.00    3.90               .64      477
 5     5    KITCHEN            12    1639           21.10    25.90    4.80              1         691
 5     5    KITCHEN            12    1640           20.20    25.90    5.70              1.4      1051
 5     5    KITCHEN            12    1641           19.30    25.80    6.50              1.7      1463
 5     5    KITCHEN            12    1642           20.30    25.90    5.60              1.4      1096
 5     5    KITCHEN            12    1643           21.10    25.90    4.80              1         631
 5     5    KITCHEN            12    1644           22.00    25.90    3.90               .64      451
 5     5    KITCHEN            12    1645           22.80    25.90    3.10               .38      178              1.00

RUN:   1

 9     9    GAGIN               5    1634           20.50    25.20    4.70      1.2      .8      1150
 9     9    GAGIN               5    1636           21.10    25.00    3.90      1.2      .6       630
 9     9    GAGIN               5    1638           22.50
 9     9    GAGIN               5    1640           23.60    25.40    1.80      1.2      .17      140
RUN:   2

 9     9    GAGIN               5    1655           20.10    25.20    5.10      1.2     1.05     1250
 9     9    GAGIN               5    1657           21.70    25.40    3.70      1.2      .55      380
 9     9    GAGIN               5    1700           22.50    25.20    2.70      1.2      .3       200
 9     9    GAGIN               5    1703           23.40    25.60    2.20      1.2      .19      200
RUN:   3

 9     9    GAGIN               5    1712           20.20    25.20    5.00      1.2     1.01     1340
 9     9    GAGIN               5    1714           21.10    25.00    3.90      1.2      .6       330
 9     9    GAGIN               5    1718           23.10    25.20    2.10      1.2      .19      200

RUN:   1

10    10    LALA               13    1621           24.42    26.98    2.56               .25      372.2
10    10    LALA               13    1621           24.37    26.93    2.56               .25      413.5    393      .73
10    10    LALA               13    1621           23.87    26.89    3.02               .35      565               .73
10    10    LALA               13    1621           23.80    26.82    3.02               .35      544      554.5    .73
10    10    LALA               13    1621           23.16    26.76    3.60               .5       697               .73
10    10    LALA               13    1621           23.09    26.68    3.59               .5       801.3    749      .73
10    10    LALA               13    1621           22.23    26.61    4.38               .75      903               .73
10    10    LALA               13    1621           22.16    26.54    4.38               .75      975.5    939.3    .73
10    10    LALA               13    1621           21.41    26.46    5.05              1        1090               .73
10    10    LALA               13    1621    1630   21.34    26.38    5.04              1        1109     1099     .73   N=1154 S 0.73
RUN:   2

10    10    LALA               13    1645           24.47    27.03    2.56               .25      324
10    10    LALA               13    1645           24.41    26.97    2.56               .25      425      374
10    10    LALA               13    1645           23.88    26.90    3.02               .35      548
10    10    LALA               13    1645           23.82    26.84    3.02               .35      579      563.5
10    10    LALA               13    1645           23.18    26.78    3.60               .5       796
10    10    LALA               13    1645           23.11    26.71    3.60               .5       784.5    790.2
10    10    LALA               13    1645           22.26    26.64    4.38               .75      972.3
```

```
                                                     NUCLEI MEASUREMENTS
EXPERIMENT #: 06                                                                                      PROCESSING DATE:  81/07/29
                 OBSERVER                                  PLATE TEMP
MACH  DUCT  -------------------  SAMPLE TIME                          VOLUME  SUPER  NUCLEI  OBS    EST
NO.   NO.   NAME            NO.  START  END    COLD    HOT    DELTA  SAMPLED  SAT   COUNT    -      K     REMARKS
                                                        (C)             (L)    (%)            N
----  ----  ---------------- ---  -----  ----   ------  ------  ------ ------- ------ ------  ----- -----  -------------------
  10    10  LALA             13   1645          22.18   26.57    4.39            .75 1022.9  997.6
  10    10  LALA             13   1645          21.44   26.49    5.05              1 1095.3
  10    10  LALA             13   1645  1651    21.37   26.41    5.04              1 1082.7 1088.5         N=1202 S 0.77

RUN:  1
  11    11  HOPPEL            7   1632  1644                                     .15  583.5  583.5         ISOTHERMAL HAZE CHAM
  11    11  HOPPEL            7   1632  1644                                    .094    290    290
  11    11  HOPPEL            7   1632  1644                                    .034   22.3   22.3
  11    11  HOPPEL            7   1632  1644                                    .025   5.07   5.07
  11    11  HOPPEL            7   1632  1644                                    .014    .55    .55
RUN:  2
  11    11  HOPPEL            7   1650  1707                                     .15  542.7  542.7         ISOTHERMAL HAZE CHAM
  11    11  HOPPEL            7   1650  1707                                    .094    220    220
  11    11  HOPPEL            7   1650  1707                                    .034   19.7   19.7
  11    11  HOPPEL            7   1650  1707                                    .025   2.55   2.55
  11    11  HOPPEL            7   1650  1707                                    .014    .37    .37

RUN:  1
  13    13  AYERS             2   1630  1631    25.31   27.80    2.49            .25    930                ALL SC VALUES
  13    13  AYERS             2   1632  1633    24.14   27.70    3.56             .5   1350                ARE APPROXIMATE ONLY
  13    13  AYERS             2   1634  1635    23.30   27.60    4.30            .75   1560
  13    13  AYERS             2   1636  1637    22.59   27.60    5.01              1   2055                35 MM PHOTO RECORDS
  13    13  AYERS             2   1639  1640    21.85   27.40    5.55           1.25   2505                TAKEN
RUN:  2
  13    13  AYERS             2   1640  1641    21.86   27.40    5.54           1.25   2513                35 MM PHOTO
  13    13  AYERS             2   1644  1645    22.42   27.40    4.98              1   1905                RECORDS TAKEN
  13    13  AYERS             2   1646  1647    22.86   27.20    4.34            .75   1350
  13    13  AYERS             2   1649  1650    23.69   27.20    3.51             .5   1110
  13    13  AYERS             2   1652  1653    24.70   27.20    2.50            .25    930
RUN:  3
  13    13  AYERS             2   1653  1654    24.70   27.20    2.50            .25    930                WARM PLATE
  13    13  AYERS             2   1656  1657    23.65   27.20    3.55             .5   1245                DRIED OUT TOWARDS
  13    13  AYERS             2   1658  1659    22.91   27.20    4.29            .75   1350                END OF RUN - LAST
  13    13  AYERS             2   1700  1701    22.13   27.10    4.97              1   2250                3 POINTS QUESTIONARL
  13    13  AYERS             2   1703  1704    21.58   27.10    5.52           1.25   2130
  13    13  AYERS             2   1705  1706    21.56   27.10    5.54           1.25   2100                35 MM PHOTO TAKEN
RUN:  4
  13    13  AYERS             2   1717  1718    24.37   26.80    2.43            .25    720
  13    13  AYERS             2   1718  1719    24.37   26.80    2.43            .25    735
  13    13  AYERS             2   1719  1720    23.54   27.00    3.46             .5   1215
  13    13  AYERS             2   1720  1721    22.62   26.90    4.28            .75   1650
  13    13  AYERS             2   1722  1723    21.98   26.90    4.92              1   2625
  13    13  AYERS             2   1724  1725    21.40   26.90    5.50           1.25   2775
  13    13  AYERS             2   1725  1726    21.35   26.90    5.55           1.25   2400

RUN:  1
  14    14  HUDSON            9   1630  1730                             .029    .21           240
  14    14  HUDSON            9   1630  1730                             .029    .13           185
  14    14  HUDSON            9   1630  1730                             .029   .093          14.4
  14    14  HUDSON            9   1630  1730                             .029    .02          .056

RUN:  1
  15    15  KEYSER           11   1640  1641    18.30   25.00    6.70            1.8   3261                PLATE TEMP APPROX IN
  15    15  KEYSER           11   1644  1645    19.00   25.00    6.00           1.46   3175                ABS VALUE OK IN DELT
  15    15  KEYSER           11   1648  1649    19.70   25.00    5.30           1.15   2547
```

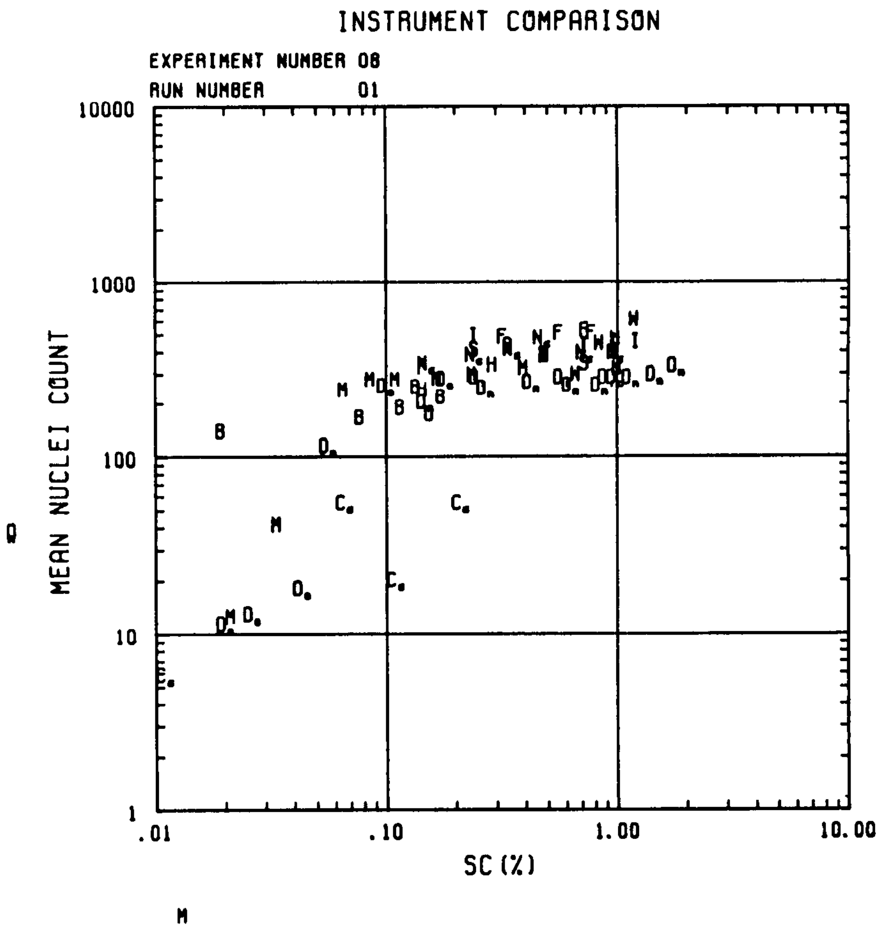
```
                                                             NUCLEI MEASUREMENTS
EXPERIMENT #: 06                                                                                              PROCESSING DATE:  81/07/29
                       OBSERVER                                   PLATE TEMP
MACH  DUCT   -----------------------   SAMPLE TIME                                 VOLUME   SUPER  NUCLEI    OBS     EST
NO.   NO.    NAME                 NO.   START  END     COLD     HOT    DELTA    SAMPLED   SAT    COUNT      -       K      REMARKS
                                                                (C)              (L)     (%)               N
----  ----   ---------------- ---   -----  ----   ------   ------   ------   -------   ------  ------   -----   -----   --------------------
 15    15    KEYSER            11   1652   1653   20.40    25.00     4.60                .84    1966                    DIV RAW COUNT BY
 15    15    KEYSER            11   1656   1657   21.40    25.00     3.60                .63    1495                    12.4 TO GET CONC.
 15    15    KEYSER            11   1700   1701   21.75    25.00     3.25               .425    1102
 15    15    KEYSER            11   1704   1705   22.40    25.00     2.60                .27     663                    TIMES GOOD TO PLUS
 15    15    KEYSER            11   1708   1709   23.10    25.00     1.90                .14     360                    OR MINUS 3 MIN
 15    15    KEYSER            11   1712   1713   23.80    25.00     1.20                .06     219

RUN:  1

 16    16    HUDSON             9   1621   1626   21.40    26.10     4.70     .003       .9              1663
 16    16    HUDSON             9   1621   1626   21.70    25.40     3.70     .003       .55             1379
 16    16    HUDSON             9   1621   1626   22.25    24.85     2.60     .003       .27              897

RUN:  2

 16    16    HUDSON             9   1637   1641   21.40    26.10     4.70     .0024      .9              1853
 16    16    HUDSON             9   1637   1641   21.70    25.40     3.70     .0024      .55             1366
 16    16    HUDSON             9   1637   1641   22.25    24.85     2.60     .0024      .27              882

RUN:  3

 16    16    HUDSON             9   1649   1651   21.40    26.10     4.70     .0018      .9              1875
 16    16    HUDSON             9   1649   1651   21.70    25.40     3.70     .0018      .55             1394
 16    16    HUDSON             9   1649   1651   22.25    24.85     2.60     .0018      .27              889

RUN:  4

 16    16    HUDSON             9   1659   1702   21.40    26.10     4.70     .0018      .9              1851
 16    16    HUDSON             9   1659   1702   21.70    25.40     3.70     .0018      .55             1356
 16    16    HUDSON             9   1659   1702   22.25    24.85     2.60     .0018      .77              880

RUN:  5

 16    16    HUDSON             9   1708   1710   21.40    26.10     4.70     .0018      .9              1837
 16    16    HUDSON             9   1708   1710   21.70    25.40     3.70     .0018      .55             1364
 16    16    HUDSON             9   1708   1710   22.25    24.85     2.60     .0018      .27              776

RUN:  6

 16    16    HUDSON             9   1713   1716   21.40    26.10     4.70     .0018      .9              1851
 16    16    HUDSON             9   1713   1716   21.70    25.40     3.70     .0018      .55             1376
 16    16    HUDSON             9   1713   1716   22.25    24.85     2.60     .0018      .27              792

RUN:  7

 16    16    HUDSON             9   1720   1723   21.40    26.10     4.70     .0018      .9              1809
 16    16    HUDSON             9   1720   1723   21.70    25.40     3.70     .0018      .55             1363
 16    16    HUDSON             9   1720   1723   22.25    24.85     2.60     .0018      .27              772

RUN:  8

 16    16    HUDSON             9   1730   1732   21.40    26.10     4.70     .0018      .9              1754
 16    16    HUDSON             9   1730   1732   21.70    25.40     3.70     .0018      .55             1316
 16    16    HUDSON             9   1730   1732   22.25    24.85     2.60     .0018      .27              746

RUN:  1

 17    17    WOJCIECHOWSKI     27   1629   1630                                          .24   769.6    796.6
 17    17    WOJCIECHOWSKI     27   1631   1632                                          .49  1768.6   1768.6
 17    17    WOJCIECHOWSKI     27   1632   1633                                          .73  2338.4   2338.4
 17    17    WOJCIECHOWSKI     27   1633   1634                                         1.08  2804.6   2804.6

RUN:  1

 18    18    HUDSON             9   1621   1626   22.45    26.45     4.00      .03       .64    1357
 18    18    HUDSON             9   1637   1641   22.20    26.90     4.70     .024       .89    1767
 18    18    HUDSON             9   1649   1651   22.60    26.50     3.90     .018       .61    1333
 18    18    HUDSON             9   1659   1702   22.60    26.30     3.70     .024       .55    1246
```

```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 06                                                                                                        PROCESSING DATE:  81/07/29
                  OBSERVER                                     PLATE TEMP
MACH  DUCT   -------------------    SAMPLE TIME                                 VOLUME   SUPER   NUCLFI    ORS     EST
NO.   NO.    NAME               NO.  START  END    COLD     HOT    DELTA   SAMPLED   SAT    COUNT      -       K      REMARKS
                                                           (C)              (L)     (%)                N
----  ----   --------------- ---    -----  ----   ------  ------  ------  -------  ------  ------   -----   -----   -------------------
 18    18    HUDSON            9    1708   1710   23.10   25.80    2.70    .018      .29     812
 18    18    HUDSON            9    1713   1716   23.10   25.70    2.60    .024      .27     788
 18    18    HUDSON            9    1720   1723   23.35   25.45    2.10    .018     .175     533
 18    18    HUDSON            9    1730   1732   23.60   25.20    1.60    .018      .1      233

RUN:   1
 21    21    ALOFS             1    1622   1623   20.70   25.00    4.30              .75    1684
 21    21    ALOFS             1    1625   1629   20.70   25.00    4.30              .75    1397
 21    21    ALOFS             1    1630   1633   20.70   25.00    4.30              .75    1353
 21    21    ALOFS             1    1635   1637   20.70   25.00    4.30              .75    1391
 21    21    ALOFS             1    1639   1642   20.70   25.00    4.30              .75    1238
 21    21    ALOFS             1    1643   1646   20.70   25.00    4.30              .75    1547
 21    21    ALOFS             1    1647   1649   20.70   25.00    4.30              .75    1683
RUN:   2
 21    21    ALOFS             1    1701   1702   25.00   25.00    0.00             .068     118
 21    21    ALOFS             1    1701   1702   25.00   25.00    0.00             .089     246
 21    21    ALOFS             1    1701   1702   25.00   25.00    0.00             .114     349
 21    21    ALOFS             1    1701   1702   25.00   25.00    0.00             .173     695
RUN:   3
 21    21    ALOFS             1    1704   1707   25.00   25.00    0.00             .068     114
 21    21    ALOFS             1    1704   1707   25.00   25.00    0.00             .089     239
 21    21    ALOFS             1    1704   1707   25.00   25.00    0.00             .114     324
 21    21    ALOFS             1    1704   1707   25.00   25.00    0.00             .173     655
RUN:   4
 21    21    ALOFS             1    1708   1712   25.00   25.00    0.00             .068     119
 21    21    ALOFS             1    1708   1712   25.00   25.00    0.00             .089     254
 21    21    ALOFS             1    1708   1712   25.00   25.00    0.00             .114     358
 21    21    ALOFS             1    1708   1712   25.00   25.00    0.00             .173     720
RUN:   5
 21    21    ALOFS             1    1713   1714   25.00   25.00    0.00             .068     117
 21    21    ALOFS             1    1713   1714   25.00   25.00    0.00             .089     244
 21    21    ALOFS             1    1713   1714   25.00   25.00    0.00             .114     335
 21    21    ALOFS             1    1713   1714   25.00   25.00    0.00             .173     676
RUN:   6
 21    21    ALOFS             1    1716   1717   25.00   25.00    0.00             .068     119
 21    21    ALOFS             1    1716   1717   25.00   25.00    0.00             .089     243
 21    21    ALOFS             1    1716   1717   25.00   25.00    0.00             .114     341
 21    21    ALOFS             1    1716   1717   25.00   25.00    0.00             .173     693

RUN:   1
 24    24    SERPOLAY         25    1625   1635   23.20   25.20    2.00     .77      .15     600
 24    24    SERPOLAY         25    1635   1645   23.70   26.70    3.00     .77      .35    1330
 24    24    SERPOLAY         25    1655   1700   24.60   28.60    4.00     .77      .61    1550
 24    24    SERPOLAY         25    1710   1715   25.20   29.60    4.40     .77      .75    2150

RUN:   1
 25    25    BORYS             3    1633   1635   15.10   21.90    6.80    2.12       2     1415    1415     .91   VOL. SAMP * 10**5
 25    25    BORYS             3    1642   1645   16.50   21.90    5.40    3.18     1.25     990     990
 25    25    BORYS             3    1652   1655   17.60   22.00    4.40    4.24      .82     318     318
 25    25    BORYS             3    1713   1720   19.70   22.00    2.30    8.48      .48     113     113

RUN:   1
 26    26    HINDMAN           6    1628   1717   23.00   23.00    0.00     1.2      .16      49      49           E=1.5, D>= 0.5 UM
```

```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 06                                                                                            PROCESSING DATE:  81/07/29

                 OBSERVER                                        PLATE TEMP
MACH  DUCT  -------------------    SAMPLE  TIME                                    VOLUME    SUPER    NUCLFI     OBS      EST
NO.   NO.   NAME               NO.  START   END      COLD      HOT      DELTA     SAMPLED    SAT      COUNT       -        K      REMARKS
                                                               (C)                  (L)      (%)                  N
----  ----  --------------- ---    -----   ----    ------   -------   ------    -------    ------   ------    ------   -----   ---------------------
 26    26   HINDMAN            6    1628    1717    23.00    23.00      0.00       1.2       .12       23        23             E=0.80, D>= 0.7 UM
 26    26   HINDMAN            6    1628    1717    23.00    23.00      0.00       1.2      .059       15        15             E= 0.57, D>=1.4 UM
 26    26   HINDMAN            6    1628    1717    23.00    23.00      0.00       1.2      .027      .075      .075            E= 0.012, D>= 3.0 UM
 26    26   HINDMAN            6    1628    1717    23.00    23.00      0.00       1.2      .016     .0049     .0049            E= 0.0020. D>= 5.0UM

RUN:  1

 27    27   OHTAKE            19    1620    1620                                   .35               2.89                      102%
 27    27   OHTAKE            19    1620    1620                                   .35               5.35                      103%
 27    27   OHTAKE            19    1620    1620                                   .35               5.35                      115%
```



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

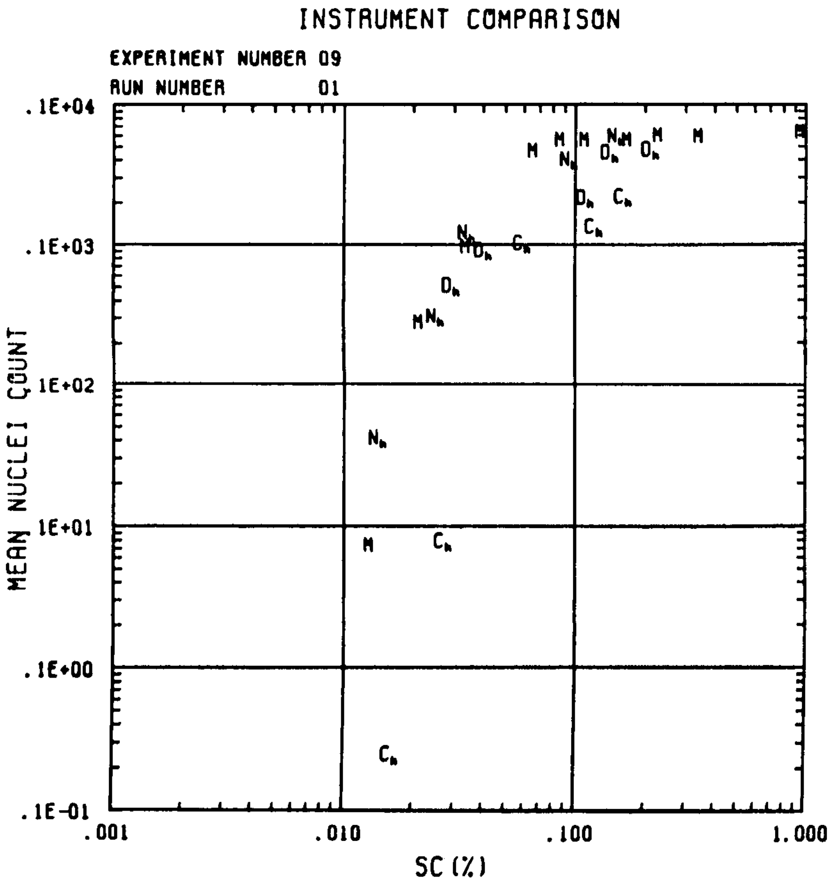
```
                                              EXPERIMENT # 08
                                                                                       80/10/09
PURPOSE
-------

 HAZE CHAMBER TEST WITH LARGE PARTICLES

DESCRIPTION OF EXPERIMENT
-------------------------

  DATE           TIME
                 START   END
  ------------   ----------
  09 OCT,1980    0955    1152

  NUCLEI TYPE
  -----------

   NACL, MONODISPERSE, D=0.18 UM

  GENERATION METHOD
  -----------------

   DRI ATOMIZER, 40 PSI, 0.025 % SOLUTION.

  SIZE DISTRIBUTION SHAPING
  -------------------------

   EC, 8550V, MONODISPERSE FLOW 6 L/MIN.
   DILUTION FLOW 210 L/MIN.

REMARKS
-------

 SLIGHT DRIFT OF PARTICLE CONC. TO LOWER VALUES.

WEATHER SYNOPSIS
----------------

 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

         ROOM CONDITIONS                           OUTSIDE CONDITIONS

 --------------------------------      ----------------------------------------------------

 AVG TEMP     AVG RH     AVG PRESS      AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)         (%)         (MB)           (C)        (%)        (MB)       (M/S)     (DEG)
 --------     ------     ---------      --------    ------    ---------    ------    ------

   26.0        22.0        854             NA         NA         NA          NA        NA
```

```
                                                                  NUCLEI MEASUREMENTS
EXPERIMENT #: 08                                                                                                                     PROCESSING DATE:  81/07/29
                     OBSERVER                                      PLATE TEMP
MACH  DUCT  -----------------------  SAMPLE  TIME                                       VOLUME   SUPER   NUCLEI    OBS    EST
NO.   NO.   NAME                NO.  START    END    COLD     HOT     DELTA   SAMPLED    SAT    COUNT      -      K     REMARKS
                                                              (C)               (L)      (%)               N
----  ----  ---------------     ---  -----   ----   ------   ------  ------   -------  ------   ------   -----  -----  --------------------

RUN:  1
  2    2    ROGERS, DAVE        22   1050    1051   22.40    24.40    2.00               .16              179

RUN:  1
  5    5    KITCHEN             12   0959    0959   26.90    27.60     .70               .02     144                  NORMAL OPERATION
  5    5    KITCHEN             12   1004    1004   25.80    27.60    1.80               .12     208                  ONLY ABOVE 0.15%
  5    5    KITCHEN             12   1005    1005   25.60    27.70    2.10               .14     284
  5    5    KITCHEN             12   1006    1006   25.40    27.70    2.30               .18     225
  5    5    KITCHEN             12   1007    1007   25.70    27.70    2.00               .14     240
  5    5    KITCHEN             12   1008    1008   25.90    27.70    1.80               .12     186
  5    5    KITCHEN             12   1009    1009   26.30    27.90    1.60               .08     172
RUN:  2
  5    5    KITCHEN             12   1038    1038   23.50    28.20    4.70               .9      369
  5    5    KITCHEN             12   1039    1039   24.40    28.30    3.90               .6      387
  5    5    KITCHEN             12   1040    1040   24.40    28.30    3.90               .6      358
  5    5    KITCHEN             12   1041    1041   25.10    28.30    3.20               .36     281
  5    5    KITCHEN             12   1042    1042   25.10    28.30    3.20               .36     261
  5    5    KITCHEN             12   1043    1043   25.10    28.30    3.20               .36     177
  5    5    KITCHEN             12   1044    1044   23.50    28.30    4.80               .9      407
  5    5    KITCHEN             12   1045    1045   24.60    28.30    3.70               .55     204
  5    5    KITCHEN             12   1046    1046   24.00    28.30    4.30               .65     458
  5    5    KITCHEN             12   1047    1047   24.00    28.30    4.30               .65     331

RUN:  1
  9    9    GAGIN                5   1012           21.80    26.90    5.10      1.2     1.02     490
  9    9    GAGIN                5   1015           23.10    27.00    3.90      1.2      .5      400
  9    9    GAGIN                5   1017           24.10    26.70    2.60      1.2      .3      350
  9    9    GAGIN                5   1020           25.20    26.60    1.40      1.2      .15     250
RUN:  2
  9    9    GAGIN                5   1024           21.70    26.70    5.00      1.2     1.02     460
  9    9    GAGIN                5   1026           23.30    26.80    3.50      1.2      .47     450
  9    9    GAGIN                5   1029           24.00    27.00    3.00      1.2      .36     360
  9    9    GAGIN                5   1032           25.10    27.30    2.20      1.2      .17     310
RUN:  3
  9    9    GAGIN                5   1036           21.60    26.70    5.10      1.2     1.06     410
  9    9    GAGIN                5   1038           23.20    26.60    3.40      1.2      .46     400
  9    9    GAGIN                5   1040           24.20    27.00    2.80      1.2      .33     250
  9    9    GAGIN                5   1043           25.10    27.20    2.10      1.2      .17     240
RUN:  4
  9    9    GAGIN                5   1052           21.90    26.60    4.70      1.2      .89     330
  9    9    GAGIN                5   1054           25.10    26.80    1.70      1.2      .53     370
  9    9    GAGIN                5   1056           24.00    27.00    3.00      1.2      .36     300
  9    9    GAGIN                5   1058           25.10    26.90    1.80      1.2      .13     240

RUN:  1
 10   10    LALA                13   1006           22.56    25.08    2.52               .25     418.6
 10   10    LALA                13   1007           22.56    25.08    2.52               .25     428.5   423.5
 10   10    LALA                13   1008           22.10    25.08    2.98               .35     466
 10   10    LALA                13   1009           22.10    25.10    3.00               .35     425     445.5
 10   10    LALA                13   1010           21.51    25.06    3.55               .5      393
 10   10    LALA                13   1011           21.46    25.00    3.54               .5      408     400.5
 10   10    LALA                13   1012           20.64    24.97    4.33               .75     376
 10   10    LALA                13   1013           20.61    24.94    4.33               .75     334       355
 10   10    LALA                13   1014           19.89    24.88    4.99              1        419
 10   10    LALA                13   1015           19.84    24.83    4.99              1        409       414
```

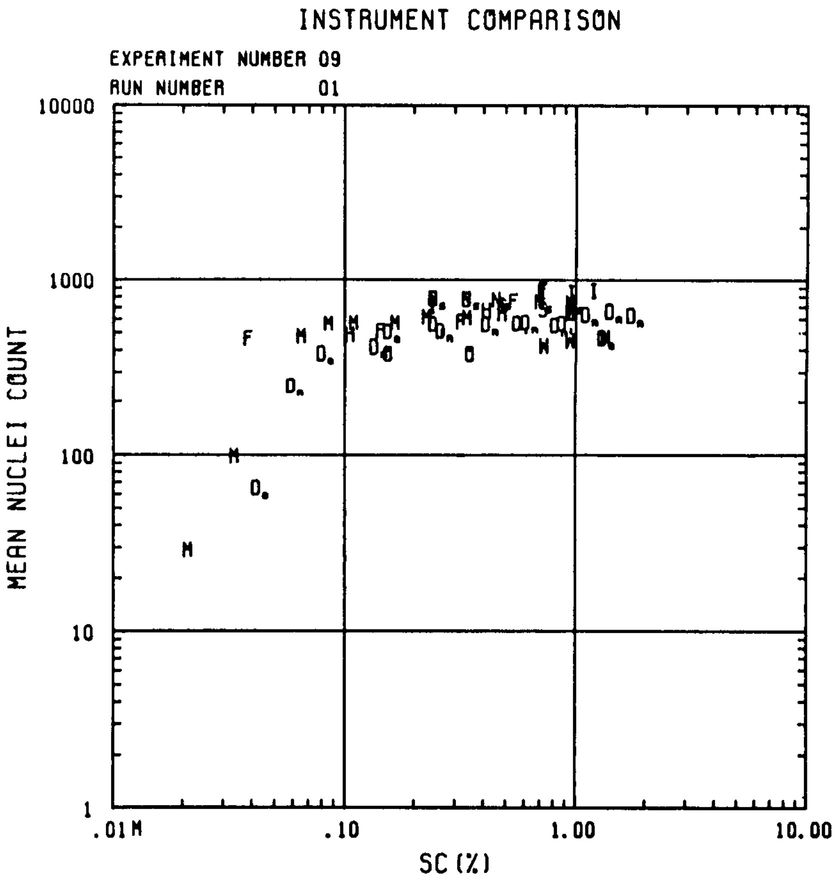
```
EXPERIMENT #: 08                               NUCLEI MEASUREMENTS                          PROCESSING DATE:  81/07/29

                 OBSERVER                       PLATE TEMP
MACH  DUCT  ------------------ SAMPLE  TIME                          VOLUME   SUPER   NUCLEI   OBS    EST
NO.   NO.   NAME           NO.  START   END   COLD    HOT    DELTA   SAMPLED   SAT     COUNT    -      K     REMARKS
                                                      (C)              (L)     (%)              N
----  ----  -------------- ---  -----  ----  ------  ------  ------  -------  ------  ------  -----  -----  ------------------

RUN:  2

  10    10  LALA            13   1022         22.70   25.23    2.53              .25     418
  10    10  LALA            13   1022         22.68   25.21    2.53              .25     450    434
  10    10  LALA            13   1023         22.21   25.19    2.98              .35   421.7
  10    10  LALA            13   1023         22.19   25.17    2.98              .35   437.5  429.6
  10    10  LALA            13   1024         21.59   25.15    3.56               .5   391.5
  10    10  LALA            13   1025         21.60   25.13    3.53               .5     394  392.8
  10    10  LALA            13   1026         20.76   25.10    4.34              .75     360
  10    10  LALA            13   1027         20.73   25.10    4.37              .75   346.5  353.3
  10    10  LALA            13   1028         20.03   25.02    4.99                1   337.3
  10    10  LALA            13   1028  1028   19.99   24.98    4.99                1   410.1  373.7

RUN:  3

  10    10  LALA            13   1045         22.88   25.65    2.77       .4      .3   394.5
  10    10  LALA            13   1046         22.43   25.62    3.19       .4      .4   373.3
  10    10  LALA            13   1047         22.02   25.59    3.57       .4      .5   342.9
  10    10  LALA            13   1048         21.65   25.54    3.89       .4      .6     371
  10    10  LALA            13   1049         21.30   25.50    4.20       .4      .7     393
  10    10  LALA            13   1050         20.96   25.45    4.49       .4      .8   319.1
  10    10  LALA            13   1051         20.65   25.40    4.75       .4      .9   346.4
  10    10  LALA            13   1052         20.35   25.35    5.00       .4       1   362.6

RUN:  1

  11    11  HOPPEL           7   1103  1110                                      .15     270    270
  11    11  HOPPEL           7   1103  1110                                     .094     222    222
  11    11  HOPPEL           7   1103  1110                                     .034    36.5   36.5
  11    11  HOPPEL           7   1103  1110                                     .025     6.6    6.6
  11    11  HOPPEL           7   1103  1110                                     .014     .43    .43

RUN:  2

  11    11  FITZGERALD      28   1004  1019                                      .15     308    308
  11    11  FITZGERALD      28   1004  1019                                     .094     250    250
  11    11  FITZGERALD      28   1004  1019                                     .034    31.3   31.3
  11    11  FITZGERALD      28   1004  1019                                     .025     8.3    8.3
  11    11  FITZGERALD      28   1004  1019                                     .014      .7     .7

RUN:  1

  13    13  AYERS            2   1018  1019   24.61   27.10    2.49              .25     510
  13    13  AYERS            2   1020  1021   23.55   27.10    3.55               .5     398
  13    13  AYERS            2   1022  1023   22.72   27.00    4.28              .75     450
  13    13  AYERS            2   1024  1025   22.01   27.00    4.99                1     473
  13    13  AYERS            2   1027  1028   21.45   27.00    5.55             1.25     473

RUN:  2

  13    13  AYERS            2   1034  1035   24.35   26.80    2.45              .25     233                PHOTO RECORDS TAKEN
  13    13  AYERS            2   1036  1037   24.32   26.80    2.48              .25     285  267.5
  13    13  AYERS            2   1037  1038   24.31   26.80    2.49              .25     285
  13    13  AYERS            2   1039  1040   23.29   26.80    3.51               .5     225    260
  13    13  AYERS            2   1041  1042   23.26   26.80    3.52               .5     315
  13    13  AYERS            2   1043  1044   23.28   26.80    3.52               .5     240
  13    13  AYERS            2   1045  1046   22.46   26.80    4.32              .75     390  382.5
  13    13  AYERS            2   1047  1048   22.44   26.70    4.26              .75     375
  13    13  AYERS            2   1050  1051   21.78   26.70    4.92                1     375  337.5
  13    13  AYERS            2   1052  1053   21.73   26.70    4.97                1     300

RUN:  1

  14    14  HUDSON           9   1123  1133                            .0065     .21     239                F=48.5, D=0.38
  14    14  HUDSON           9   1123  1133                            .0065     .14     223                F=48.5, D=0.67
  14    14  HUDSON           9   1123  1133                            .0065    .085    42.6                F=48.5, D=2.2
  14    14  HUDSON           9   1123  1133                            .0065     .04    17.8                F=48.5, D=2.7
```

```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 08                                                                                                       PROCESSING DATE:  81/07/29
                     OBSERVER                           PLATE TEMP
MACH  DUCT  ------------------     SAMPLE TIME                              VOLUME   SUPER   NUCLEI     OBS     EST
NO.   NO.   NAME              NO.  START  END     COLD    HOT     DELTA   SAMPLED   SAT     COUNT       -       K      REMARKS
                                                          (C)              (L)      (%)                N
----  ----  ---------------  ---  -----  ----   ------  ------  ------   -------  ------   ------    -----   -----   --------------------
 14    14   HUDSON             9  1123   1133                              .0065    .029      3.2                     F=48.5, D=4.0
 14    14   HUDSON             9  1142   1145                              .0026    .21       230                     F=48.5, D=0.38
 14    14   HUDSON             9  1142   1145                              .0026    .14       214                     F=48.5, D=0.67
 14    14   HUDSON             9  1142   1145                              .0026    .11        91                     F=48.5, D=1.3
 14    14   HUDSON             9  1142   1145                              .0026    .04      15.9                     F=48.5, D=2.7
 14    14   HUDSON             9  1142   1145                              .0026    .029     2.66                     F=48.5, D=4.0

RUN:  2

 14    14   HUDSON             9  1152   1155                              .0026    .21       180                     F=28, D=0.38
 14    14   HUDSON             9  1152   1155                              .0026    .14       174                     F=28, D=0.67
 14    14   HUDSON             9  1152   1155                              .0026    .11       156                     F=28, D=1.3
 14    14   HUDSON             9  1152   1155                              .0026    .04      50.6                     F=28, D=2.7
 14    14   HUDSON             9  1152   1155                              .0026    .029     30.9                     F=28, D=4.0

RUN:  1

 15    15   ROGERS, FRED      23  1026   1027   18.30   25.00    6.70              1.8       347                     BACKGROUND CNT
 15    15   ROGERS, FRED      23  1030   1031   18.74   24.75    6.01              1.46      307                     ABOUT 10 PER CC
 15    15   ROGERS, FRED      23  1033   1034   19.12   24.44    5.32              1.15      296
 15    15   ROGERS, FRED      23  1037   1038   19.49   24.13    4.64               .84      268                     PLATE TEMPS APPROX
 15    15   ROGERS, FRED      23  1042   1043   19.87   23.81    3.94               .63      268                     IN ABSOLUTE. OK IN
 15    15   ROGERS, FRED      23  1045   1046   20.23   23.50    3.27               .425     277                     DELTA
 15    15   ROGERS, FRED      23  1049   1050   20.63   23.19    2.56               .27      256
 15    15   ROGERS, FRED      23  1053   1054   21.00   22.89    1.89               .148     213                     READING ROYCO CH. 2
 15    15   ROGERS, FRED      23  1057   1058   21.45   22.61    1.16               .056     119                     LESS BACKGROUND
 15    15   ROGERS, FRED      23  1130   1131   22.10   22.25     .15               .002      40                     LAST PT. NEAR ISOTH

RUN:  1

 16    16   HUDSON             9  1005   1008   21.40   26.10    4.70      .0018    .9        312
 16    16   HUDSON             9  1005   1008   21.70   25.50    3.80      .0018    .58       311
 16    16   HUDSON             9  1005   1008   22.30   24.80    2.50      .0018    .25       311
 16    16   HUDSON             9  1019   1022   21.40   26.10    4.70      .0018    .9        299
 16    16   HUDSON             9  1019   1022   21.70   25.50    3.80      .0018    .58       298
 16    16   HUDSON             9  1019   1022   22.30   24.80    2.50      .0018    .25       298
 16    16   HUDSON             9  1035   1037   21.40   26.10    4.70      .0018    .9        280
 16    16   HUDSON             9  1035   1037   21.70   25.50    3.80      .0018    .58       280
 16    16   HUDSON             9  1035   1037   22.30   24.80    2.50      .0018    .25       280

RUN:  2

 16    16   HUDSON             9  1057   1101   21.40   26.10    4.70      .0024    .9        266
 16    16   HUDSON             9  1057   1101   21.70   25.50    3.80      .0024    .58       266
 16    16   HUDSON             9  1057   1101   22.30   24.80    2.50      .0024    .25       266
 16    16   HUDSON             9  1114   1116   21.40   26.10    4.70      .0018    .9        262
 16    16   HUDSON             9  1114   1116   21.70   25.50    3.80      .0018    .58       262
 16    16   HUDSON             9  1114   1116   22.30   24.80    2.50      .0018    .25       262
 16    16   HUDSON             9  1152   1154   21.40   26.10    4.70      .0018    .9        253
 16    16   HUDSON             9  1152   1154   21.70   25.50    3.80      .0018    .58       253
 16    16   HUDSON             9  1152   1154   22.30   24.80    2.50      .0018    .25       252

RUN:  1

 17    17   WOJCIECHOWSKI     27  1015   1016   25.00   27.00    2.00               .15                355.2
 17    17   WOJCIECHOWSKI     27  1018   1019   24.50   27.00    2.50               .24                399.6
 17    17   WOJCIECHOWSKI     27  1021   1022   24.00   27.00    3.00               .35                429.2
 17    17   WOJCIECHOWSKI     27  1024   1025   23.50   27.00    3.50               .47                495.8
 17    17   WOJCIECHOWSKI     27  1027   1028   22.70   27.00    4.30               .72                  407
 17    17   WOJCIECHOWSKI     27  1030   1031   22.00   27.00    5.00               .98                  407

RUN:  1

 18    18   HUDSON             9  1005   1008   22.00   26.90    4.90      .0018    .98       298
 18    18   HUDSON             9  1019   1022   23.40   25.50    2.10      .0018    .18       290
 18    18   HUDSON             9  1035   1037   23.65   25.25    1.60      .0018    .1        265
 18    18   HUDSON             9  1057   1101   24.10   24.80     .70      .0024    .02      11.8
```

```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 08                                                                                                PROCESSING DATE:  81/07/29
                   OBSERVER                                      PLATE TEMP
MACH  DUCT  -------------------    SAMPLE  TIME                                  VOLUME    SUPER   NUCLFI    OBS    EST
NO.   NO.   NAME             NO.   START   END    COLD     HOT     DELTA    SAMPLED   SAT     COUNT      -      K      REMARKS
                                                           (C)               (L)      (%)               N
----  ----  ---------------  ---   -----   ----   ------   ------  ------   -------   ------  ------   -----  -----  -------------------
 18    18   HUDSON             9   1114    1116   24.10    24.90     .80     .0018     .026    13.3
 18    18   HUDSON             9   1152    1154   24.00    25.05    1.05     .0018     .043    18.6

RUN:   1

 20    20   DOMONKOS           4   1120    1130                                         .69     310
 20    20   DOMONKOS           4   1120    1130                                         .87     460
 20    20   DOMONKOS           4   1120    1130                                        1.23     630

RUN:   1

 21    21   TRUEBLOOD         26   1007    1009   19.89    25.00    5.11               1.04     333
 21    21   TRUEBLOOD         26   1014    1015   21.80    25.00    3.20                .41     337.9
 21    21   TRUEBLOOD         26   1026    1027   22.52    25.00    2.48                .246    309.1
 21    21   TRUEBLOOD         26   1035    1037   25.00    25.00    0.00                .173    291.3
 21    21   TRUEBLOOD         26   1035    1037   25.00    25.00    0.00                .114    289.8
 21    21   TRUEBLOOD         26   1035    1037   25.00    25.00    0.00                .089    289.8
 21    21   TRUEBLOOD         26   1035    1037   25.00    25.00    0.00                .068    249.5
 21    21   TRUEBLOOD         26   1042    1044   25.00    25.00    0.00                .035     43.2
 21    21   TRUEBLOOD         26   1042    1044   25.00    25.00    0.00                .022     13.1
 21    21   TRUEBLOOD         26   1042    1044   25.00    25.00    0.00                .0133      .26

RUN:   1

 24    24   SERPOLAY          25   1000    1005   26.40    28.40    2.00      .77       .15     340
 24    24   SERPOLAY          25   1015    1030   26.40    29.40    3.00      .77       .33     500
 24    24   SERPOLAY          25   1030    1035   26.70    30.70    4.00      .77       .58     530
 24    24   SERPOLAY          25   1040    1045   26.90    31.50    4.60      .77       .75     550
 24    24   SERPOLAY          25   1045    1050   27.00    31.70    4.70      .77       .8      530

RUN:   1

 25    25   BORYS              3   1010    1020   23.90    24.30     .40     26.5      .011       6       6          VOL. SAMP. X10**5
 25    25   BORYS              3   1024    1033   23.70    24.40     .70     21.2      .021       0       0          CHAMBER PROBLEM.
 25    25   BORYS              3   1036    1046   24.50    24.50    0.00     21.2      .042       0       0
 25    25   BORYS              3   1050    1100   23.40    24.80    1.40     21.2      .066      57      57
 25    25   BORYS              3   1103    1108   23.10    24.80    1.70     21.2      .11       21      21
 25    25   BORYS              3   1120    1125   22.50    24.90    2.40     21.2      .21       57      27

RUN:   1

 26    26   HINDMAN            6   1007    1125   24.00    24.00    0.00      2.1      .16      117     117          E=3.0, D>=0.5 UM
 26    26   HINDMAN            6   1007    1125   24.00    24.00    0.00      2.1      .12       71      71          E=3.0,D>=0.7 UM
 26    26   HINDMAN            6   1007    1125   24.00    24.00    0.00      2.1      .059      53      53          E=2.0,D>=1.4 UM
 26    26   HINDMAN            6   1007    1125   24.00    24.00    0.00      2.1      .027      .15     .15         E=0.016,D>=3.0 UM
 26    26   HINDMAN            6   1007    1125   24.00    24.00    0.00      2.1      .016    .0029   .0029         E=0.0011,D>=5.0 UM

RUN:   1

 27    27   OHTAKE            19   1024    1024                               7               1.426                109% R.H. NOMINAL
```



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

PURPOSE

HAZE CHAMBER TESTS (LARGE PARTICLES)

DESCRIPTION OF EXPERIMENT

DATE	TIME START	END
09 OCT,1960	1152	1319

NUCLEI TYPE

NACL, MONODISPERSE, D=0.18 UM

GENERATION METHOD

DRI ATOMOZER, 40 PSI, 0.5% SOLUTION.

SIZE DISTRIBUTION SHAPING

EC, 8550V, MONODISPERSE FLOW 6 L/MIN.
DILUTION FLOW 210 L/MIN.

REMARKS

SLIGHT DRIFT IN CONC TO LOWER VALUES DUE TO CHANGE IN MONODISPERSE FLOW

WEATHER SYNOPSIS

NA

MEAN WEATHER CONDITIONS DURING EXPERIMENT

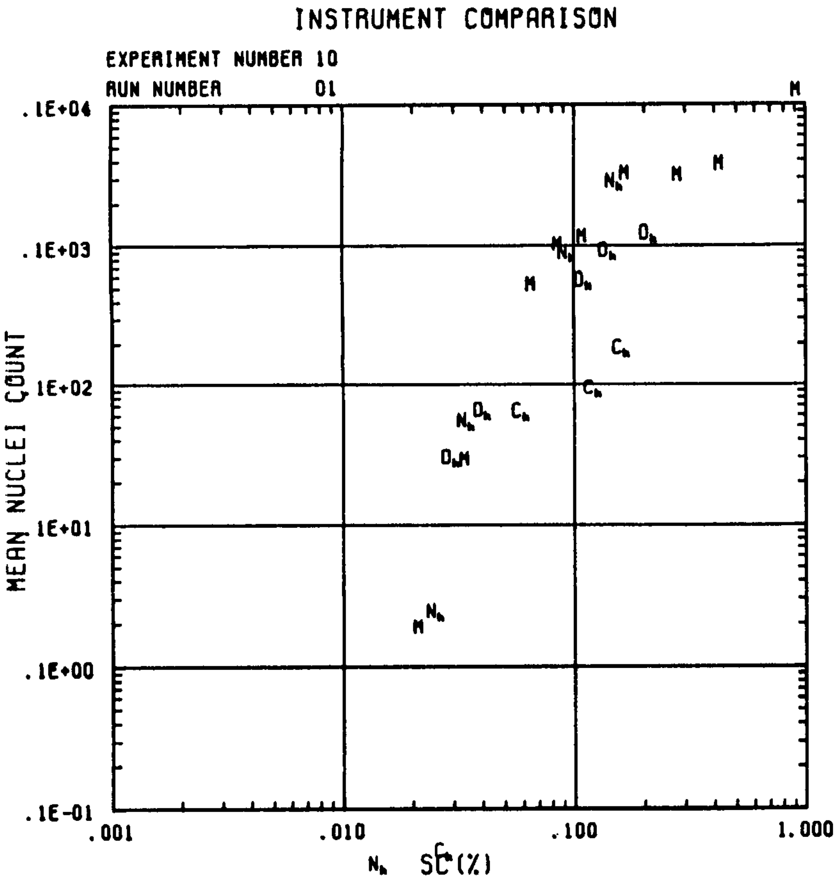
ROOM CONDITIONS			OUTSIDE CONDITIONS				
AVG TEMP (C)	AVG RH (%)	AVG PRESS (MB)	AVG TEMP (C)	AVG RH (%)	AVG PRESS (MB)	AVG WS (M/S)	AVG WD (DEG)
26.0	22.0	854	NA	NA	NA	NA	NA

```
                                                              NUCLEI MEASUREMENTS
EXPERIMENT #: 09                                                                                                       PROCESSING DATE:  81/07/29
                        OBSERVER                                        PLATE TEMP
MACH  DUCT  --------------------   SAMPLE TIME                                    VOLUME   SUPER   NUCLEI      OBS     EST
NO.   NO.   NAME                NO.  START   END    COLD     HOT    DELTA   SAMPLED   SAT     COUNT        -       K      REMARKS
                                                             (C)              (L)      (%)                 N
----  ----  ---------------  ---  -----  ----   ------  ------  ------  -------  ------  ------     -----   -----   ------------------

RUN:  1
  2     2   ROGERS, DAVE      22  1229   1230    23.30   25.30    2.00              .16                 392    0.00
  2     2   ROGERS, DAVE      22  1231   1232    22.30   25.30    3.00              .36                 392

RUN:  1
  9     9   GAGIN              5  1206           21.80   26.90    5.10     1.2     1.01     720
  9     9   GAGIN              5  1208           23.30   26.90    3.60     1.2      .5      670
  9     9   GAGIN              5  1210           23.70   27.00    3.30     1.2      .43     690
  9     9   GAGIN              5  1213           25.20   27.10    1.90     1.2      .11     500
RUN:  2
  9     9   GAGIN              5  1218           22.00   26.80    4.80     1.2      .91     760
  9     9   GAGIN              5  1220           23.20   26.90    3.70     1.2      .53     660
  9     9   GAGIN              5  1223           24.10   26.70    2.60     1.2      .3      610
  9     9   GAGIN              5  1226           25.20   27.10    1.90     1.2      .11     620
RUN:  3
  9     9   GAGIN              5  1230           21.80   27.00    5.20     1.2     1.08     600
  9     9   GAGIN              5  1232           23.20   26.90    3.70     1.2      .53     660
  9     9   GAGIN              5  1235           23.50   27.20    3.70     1.2      .42     530
  9     9   GAGIN              5  1257           25.00   27.00    2.00     1.2      .17     510

RUN:  1
 10    10   LALA              13  1205           22.08   24.59    2.51              .25     798.1
 10    10   LALA              13  1206           22.13   24.65    2.52              .25     814.8     806.5
 10    10   LALA              13  1207           21.70   24.67    2.97              .35     801.7
 10    10   LALA              13  1208           21.72   24.69    2.97              .35     800.5     800.9
 10    10   LALA              13  1209           21.16   24.70    3.54              .5      731.8
 10    10   LALA              13  1210           21.17   24.72    3.55              .5      753.7     742.7
 10    10   LALA              13  1211           20.39   24.71    4.32              .75     701.3
 10    10   LALA              13  1212           20.39   24.71    4.32              .75     695.9     698.6
 10    10   LALA              13  1213           19.73   24.70    4.97             1        655.4
 10    10   LALA              13  1214           19.71   24.69    4.98             1        689.9     672.7
RUN:  2
 10    10   LALA              13  1214           22.41   24.66    2.25              .2      812.5
 10    10   LALA              13  1215           21.96   24.71    2.75              .3      725.2
 10    10   LALA              13  1216           21.56   24.75    3.19              .4        759
 10    10   LALA              13  1217           21.22   24.76    3.54              .5        760
 10    10   LALA              13  1218           20.89   24.77    3.88              .6      669.6
 10    10   LALA              13  1219           20.60   24.77    4.17              .7      758.9
 10    10   LALA              13  1220           20.31   24.77    4.46              .8      710.3
 10    10   LALA              13  1221           20.04   24.77    4.73              .9      626.6
 10    10   LALA              13  1222           19.77   24.75    4.98             1          637
RUN:  3
 10    10   LALA              13  1221           22.31   24.82    2.51              .25     822.6
 10    10   LALA              13  1221           22.36   24.87    2.51              .25     882.6     857.6
 10    10   LALA              13  1221           21.93   24.90    2.97              .35     738.2
 10    10   LALA              13  1221           21.99   24.95    2.96              .35     762.8     750.2
*** INCORRECT EXPER. NO.
 10    10   LALA              13  1221           21.42   24.97    3.55              .5      670.1
 10    10   LALA              13  1221           21.43   24.97    3.54              .5      721.5     695.8
 10    10   LALA              13  1221           20.64   24.97    4.33              .75       685
 10    10   LALA              13  1221           20.63   24.96    4.33              .75     711.4     698.2
 10    10   LALA              13  1221           19.93   24.91    4.98             1        663.1
 10    10   LALA              13  1231           19.90   24.88    4.98             1        632.1     647.6

RUN:  1
 11    11   HOPPEL             7  1251   1307                                       .15       636       636            ISOTHERMAL HAZE CHAM
```

```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 09                                                                                                  PROCESSING DATE:  81/07/29

                      OBSERVER                                    PLATE TEMP
MACH  DUCT   -------------------  SAMPLE TIME                                  VOLUME   SUPER   NUCLEI     OBS     EST
NO.   NO.    NAME            NO.  START   END    COLD     HOT     DELTA   SAMPLED    SAT    COUNT       -       K     REMARKS
                                                           (C)              (L)      (%)                N
----  ----   --------------- ---  -----  ----   ------   ------  ------   -------   ------  ------    -----   -----  -------------------
 11    11    HOPPEL            7  1251   1307                                        .094     430      430
 11    11    HOPPEL            7  1251   1307                                        .034     128      128
 11    11    HOPPEL            7  1251   1307                                        .025      33       33
 11    11    HOPPEL            7  1251   1307                                        .014     4.4      4.4

RUN:   1

 13    13    AYERS             2  1208   1209   26.50    29.00    2.50                .25     585                     POSS. ZERO RESET ERR
 13    13    AYERS             2  1210   1211   26.50    29.00    2.50                .25     743
 13    13    AYERS             2  1212   1213   25.31    28.90    3.59                 .5     660
 13    13    AYERS             2  1214   1215   24.43    28.80    4.37                .75     930
 13    13    AYERS             2  1215   1216   24.42    28.80    4.38                .75     840
 13    13    AYERS             2  1217   1218   23.70    28.70    5.00                  1     840
 13    13    AYERS             2  1218   1219   20.71    28.70    7.99                  1     900
 13    13    AYERS             2  1219   1220   22.98    28.60    5.62               1.25     780
 13    13    AYERS             2  1220   1221   22.88    28.50    5.62               1.25     960
 13    13    AYERS             2  1223   1224   24.95    28.50    3.55                 .5     840
 13    13    AYERS             2  1224   1225   24.95    28.50    3.55                 .5     720
 13    13    AYERS             2  1226   1227   26.04    28.50    2.46                .25     675
 13    13    AYERS             2  1227   1228   26.04    28.50    2.46                .25     825
 13    13    AYERS             2  1228   1229   26.04    28.50    2.46                .25     825
 13    13    AYERS             2  1229   1230   26.02    28.50    2.48                .25     773
 13    13    AYERS             2  1232   1233   22.90    28.50    5.60               1.25     960

RUN:   1

 14    14    HUDSON            9  1211   1232                              .012      .21     509                     F=28, D=0.38
 14    14    HUDSON            9  1211   1232                              .012      .14     490                     F=28, D=0.67
 14    14    HUDSON            9  1211   1232                              .012      .11     429                     F=28, D=1.3
 14    14    HUDSON            9  1211   1232                              .012      .04   128.6                     F=28, D=2.7
 14    14    HUDSON            9  1211   1232                              .012     .029    83.4                     F=28, D=4.0
 14    14    HUDSON            9  1246   1254                             .0052      .21     498                     F=42.5, D=0.38
 14    14    HUDSON            9  1246   1254                             .0052      .14     476                     F=42.5, D=0.67
 14    14    HUDSON            9  1246   1254                             .0052      .11    30.9                     F=42.5, D=1.3
 14    14    HUDSON            9  1246   1254                             .0052      .04      64                     F=42.5, D=2.7
 14    14    HUDSON            9  1246   1254                             .0052     .029    24.4                     F=42.5, D=4.0
RUN:   2

 14    14    HUDSON            9  1306   1339                               .02      .21     396                     F=25, D=0.38
 14    14    HUDSON            9  1306   1339                               .02      .14     383                     F=25, D=0.67
 14    14    HUDSON            9  1306   1339                               .02      .11     351                     F=25, D=1.3
 14    14    HUDSON            9  1306   1339                               .02      .04   124.1                     F=25, D=2.7
 14    14    HUDSON            9  1306   1339                               .02     .029    81.1                     F=25, D=4.0

RUN:   1

 15    15    ROGERS, FRED     23  1208   1209   18.31    25.00    6.69                1.8     653                     BACKGROUND ABOUT
 15    15    ROGERS, FRED     23  1211   1212   18.74    24.75    6.01               1.46     686                     10 PER CC.
 15    15    ROGERS, FRED     23  1214   1215   19.12    24.44    5.32               1.15     659
 15    15    ROGERS, FRED     23  1220   1221   19.49    24.13    4.64                .84     573                     TEMPS APPROX IN      .
 15    15    ROGERS, FRED     23  1224   1225   19.87    23.81    3.94                .63     594                     ABSOLUTE, OK IN DELT
 15    15    ROGERS, FRED     23  1228   1229   20.23    23.50    3.27               .425     581
 15    15    ROGERS, FRED     23  1231   1232   20.63    23.19    2.56                .27     530                     READING ROYCO CH. 2
 15    15    ROGERS, FRED     23  1236   1237   21.00    22.89    1.89                .14     431                     LESS BACKGROUND
 15    15    ROGERS, FRED     23  1240   1241   21.36    22.56    1.20               .061     259                     NEAR ISOTHERMAL ON
 15    15    ROGERS, FRED     23  1248   1249   22.09    22.25     .16               .002      88                     LAST POINT

RUN:   1

 16    16    HUDSON            9  1203   1208   21.40    26.10    4.70     .003        .9     616
 16    16    HUDSON            9  1203   1208   21.70    25.50    3.80     .003       .58     616
 16    16    HUDSON            9  1203   1208   22.30    24.80    2.50     .003       .25     616
 16    16    HUDSON            9  1228   1230   21.40    26.10    4.70    .0018        .9     581
 16    16    HUDSON            9  1228   1230   21.70    25.50    3.80    .0018       .58     580
 16    16    HUDSON            9  1228   1230   22.30    24.60    2.50    .0018       .25     580
 16    16    HUDSON            9  1247   1250   21.40    26.10    4.70    .0018        .9     552
```

```
                                                        NUCLEI MEASUREMENTS
EXPERIMENT #: 09                                                                                                  PROCESSING DATE:  81/07/29
                    OBSERVER                                       PLATE TEMP
MACH  DUCT  -------------------------  SAMPLE TIME                                 VOLUME   SUPER  NUCLEI    OBS     EST
NO.   NO.   NAME                  NO.  START  END     COLD    HOT    DELTA   SAMPLED   SAT    COUNT      -       K     REMARKS
                                                              (C)              (L)     (%)               N
----  ----  ---------------  ---  -----  ----  ------  ------  ------  -------  ------  ------  -----  -----  -------------------
 16    16   HUDSON             9   1247  1250   21.70   25.50    3.80    .0018    .58     552
*** INCORRECT EXPER. NO.
 16    16   HUDSON             9   1247  1250   22.30   24.80    2.50    .0018    .25     551
*** INCORRECT EXPER. NO.

RUN:  2

 16    16   HUDSON             9   1259  1302   21.40   26.10    4.70    .0024    .9      508
*** INCORRECT EXPER. NO.
 16    16   HUDSON             9   1259  1302   21.70   25.50    3.80    .0024    .58     507
 16    16   HUDSON             9   1259  1302   22.30   24.80    2.50    .0024    .25     507

RUN:  1

 17    17   WOJCIECHOWSKI     27   1206  1207                                     .25     809     809
 17    17   WOJCIECHOWSKI     27   1207  1208                                     .35     809     809
 17    17   WOJCIECHOWSKI     27   1209  1210                                     .47   799.2   799.2
 17    17   WOJCIECHOWSKI     27   1210  1211                                     .72   779.4   779.4
 17    17   WOJCIECHOWSKI     27   1211  1212                                     .98   769.6   769.6

RUN:  1

 18    18   HUDSON             9   1203  1208   24.00   25.05    1.05    .003     .043     67
*** INCORRECT EXPER. NO.
 18    18   HUDSON             9   1228  1230   23.75   25.20    1.45    .0018    .082    396
 18    18   HUDSON             9   1247  1250   23.50   25.50    2.00    .0018    .16     525
 18    18   HUDSON             9   1259  1302   21.65   27.40    5.75    .0024   1.35     483

RUN:  1

 20    20   DOMONKOS           4   1245  1250                                     .76     436
 20    20   DOMONKOS           4   1245  1250                                     .98     463
 20    20   DOMONKOS           4   1245  1250                                    1.4      490

RUN:  2

 20    20   DOMONKOS           4   1305  1310                                     .64     405
 20    20   DOMONKOS           4   1305  1310                                     .74     480
 20    20   DOMONKOS           4   1305  1310                                    1.04     554

RUN:  1

 21    21   TRUEBLOOD         26   1207  1209   20.04   25.00    4.96             .984   672.1
 21    21   TRUEBLOOD         26   1214  1216   22.02   25.00    2.98             .355     633
 21    21   TRUEBLOOD         26   1220  1221   22.57   25.00    2.43             .236   642.4
 21    21   TRUEBLOOD         26   1228  1230   25.00   25.00    0.00             .173     593
 21    21   TRUEBLOOD         26   1228  1230   25.00   25.00    0.00             .114   590.2
 21    21   TRUEBLOOD         26   1228  1230   25.00   25.00    0.00             .089   590.1
 21    21   TRUEBLOOD         26   1228  1230   25.00   25.00    0.00             .068   495.4
 21    21   TRUEBLOOD         26   1237  1240   25.00   25.00    0.00             .035   102.6
 21    21   TRUEBLOOD         26   1237  1240   25.00   25.00    0.00             .022   29.87
 21    21   TRUEBLOOD         26   1237  1240   25.00   25.00    0.00            .0133     .78

RUN:  2

 21    21   TRUEBLOOD         26   1245  1247   25.00   25.00    0.00             .173   545.4
 21    21   TRUEBLOOD         26   1245  1247   25.00   25.00    0.00             .114   542.8
 21    21   TRUEBLOOD         26   1245  1247   25.00   25.00    0.00             .089   542.8
 21    21   TRUEBLOOD         26   1245  1247   25.00   25.00    0.00             .068   459.6

RUN:  1

 24    24   SERPOLAY          25   1205  1210   26.70   27.70    1.00     .77     .04     480
 24    24   SERPOLAY          25   1220  1225   26.70   28.70    2.00     .77     .15     530
 24    24   SERPOLAY          25   1233  1240   26.80   29.80    3.00     .77     .33     600
 24    24   SERPOLAY          25   1247  1255   27.00   30.90    3.90     .77     .56     780
 24    24   SERPOLAY          25   1305  1310   27.30   31.90    4.60     .77     .75     910

RUN:  1

 26    26   HINDMAN            6   1213  1315   25.00   25.00    0.00     1.1      .16     233     233          E=6.6, D>=0.5 UM
```

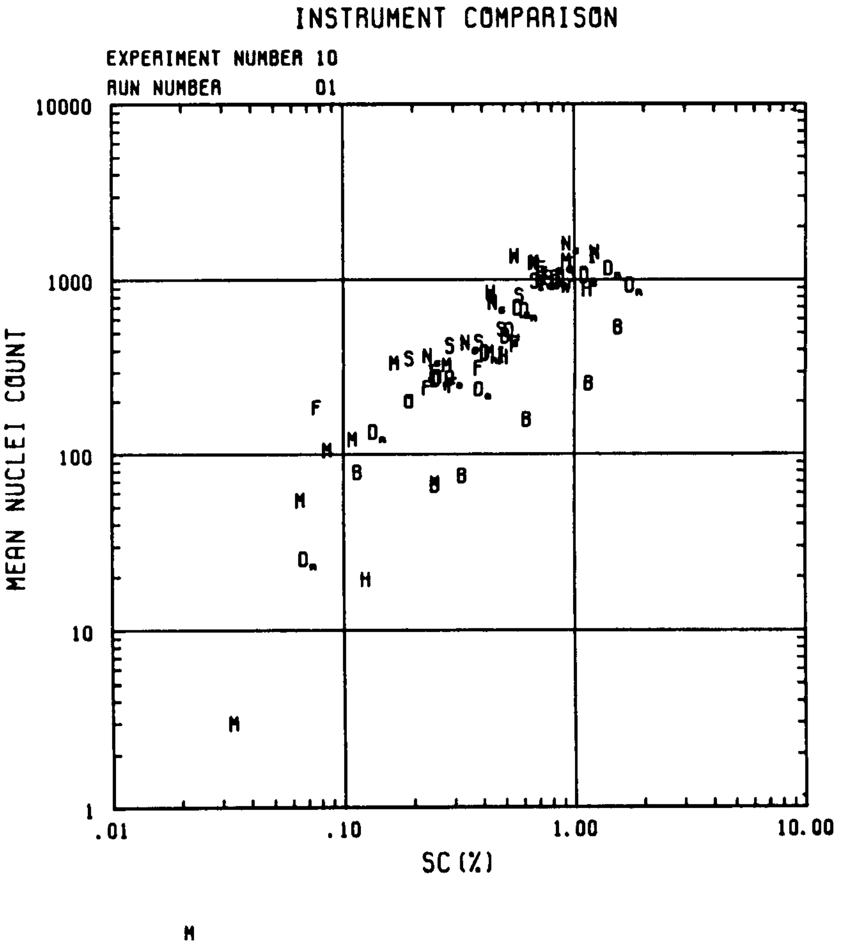
```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 09                                                                                                PROCESSING DATE:  81/07/29
                    OBSERVER                                        PLATE TEMP
MACH  DUCT  -------------------        SAMPLE  TIME                                   VOLUME   SUPER    NUCLFI     ORS      EST
NO.   NO.   NAME                NO.    START   END     COLD     HOT      DELTA    SAMPLED    SAT     COUNT      -         K      REMARKS
                                                                (C)                (L)      (%)                 N
----  ----  ---------------    ---    -----   ----   ------   ------   ------   --------   ------   ------    -----    -----   --------------------
 26    26   HINDMAN              6    1213    1315    25.00    25.00     0.00        1.1      .12      141      141              E=4.8, D>=0.7 UM
 26    26   HINDMAN              6    1213    1315    25.00    25.00     0.00        1.1     .059      108      108              E=3.8, D>=1.4 UM
 26    26   HINDMAN              6    1213    1315    25.00    25.00     0.00        1.1     .027      .83      .83              E=0.058, D>=3.0 UM
 26    26   HINDMAN              6    1213    1315    25.00    25.00     0.00        1.1     .016     .026     .026              E=0.0068, D>=5.0 UM

RUN:  1

 27    27   OHTAKE              19    1205    1205                                  .1225            42.318                     99% R.H.
 27    27   OHTAKE              19    1205    1205                                  .1225            70.531                     108% R.H. NOMINAL
```



INSTRUMENT COMPARISON

EXPERIMENT NUMBER 10
RUN NUMBER 01

HAZE CHAMBER RESULTS



INSTRUMENT COMPARISON

EXPERIMENT NUMBER 10
RUN NUMBER 01

SDC/CFD RESULTS

```
                                    EXPERIMENT # 10
                                                                            80/10/09
PURPOSE
-------
 BIMODAL NACL TO GET K-PLATEAU

DESCRIPTION OF EXPERIMENT
-------------------------
              TIME
 DATE         START   END
 ------------ -----------
 09 OCT,1980   1417   1620

 NUCLEI TYPE
 -----------
  NACL, 0.1% SOLUTION FOR SMALL, 0.5% FOR LARGE SIZE.

 GENERATION METHOD
 -----------------
  ATOMIZERS: DRI, 40 PSI, NANOMIST 19PSI.

 SIZE DISTRIBUTION SHAPING
 -------------------------
  EC1, 0.1UM DIA., EC2 0.03 UM DIA.
  EACH EC APPROX. 5.5 L/MIN, DIL AIR FLOW 410 L/MIN.

REMARKS
-------
 TOTAL N STEADY, BUT SMALL SIZE DRIFT UP, LARGE ONE DOWN.

WEATHER SYNOPSIS
----------------
 NA

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
        ROOM CONDITIONS                          OUTSIDE CONDITIONS

 ------------------------------   ----------------------------------------------------
 AVG TEMP    AVG RH   AVG PRESS    AVG TEMP    AVG RH   AVG PRESS   AVG WS   AVG WD
   (C)        (%)       (MB)         (C)        (%)       (MB)      (M/S)    (DEG)
 --------    ------   ---------    --------    ------   ---------   ------   ------
   26.0       22.0      851          NA          NA        NA         NA       NA
```

```
                                                                   NUCLEI MEASUREMENTS
EXPERIMENT #: 10                                                                                                                          PROCESSING DATE:  81/07/29
                     OBSERVER                                         PLATE TEMP
MACH  DUCT  ---------------------  SAMPLE  TIME                                     VOLUME   SUPER   NUCLEI   OBS      EST
NO.   NO.   NAME              NO.  START    END    COLD     HOT     DELTA   SAMPLED   SAT     COUNT     -        K     REMARKS
                                                             (C)                (L)      (%)              N
----  ----  ---------------  ---  -----   ----   ------   ------  ------  -------  ------  ------   -----   -----   -------------------

RUN:  1

 2     2    POLITOVICH        20   1506    1507   23.10    25.40    2.30               .2               206

RUN:  1

 5     5    KITCHEN           12   1503    1503   23.90    26.50    2.60              .26       68
 5     5    KITCHEN           12   1504    1504   21.00    26.50    5.50              1.2      325
 5     5    KITCHEN           12   1505    1505   19.90    26.50    6.60              1.6      554
 5     5    KITCHEN           12   1506    1506   25.30    26.50    1.20              1.2      250
 5     5    KITCHEN           12   1507    1507   22.40    26.60    4.20              .65      176
 5     5    KITCHEN           12   1508    1508   23.60    26.60    3.00              .34       77
 5     5    KITCHEN           12   1509    1509   25.00    26.70    1.70              .12       81
 5     5    KITCHEN           12   1510    1510   23.70    26.70    3.00              .34       79
 5     5    KITCHEN           12   1511    1511   22.60    26.80    4.20              .65      150
 5     5    KITCHEN           12   1512    1512   21.40    26.80    5.40              1.2      226

RUN:  2

 5     5    KITCHEN           12   1513    1513   21.40    26.80    5.40              1.2      226
 5     5    KITCHEN           12   1514    1514   20.20    26.80    6.60              1.6      473
 5     5    KITCHEN           12   1515    1515   21.50    26.90    5.40              1.2      266
 5     5    KITCHEN           12   1516    1516   22.70    26.90    4.20              .65       90
 5     5    KITCHEN           12   1517    1517   23.90    26.90    3.00              .34       82
 5     5    KITCHEN           12   1518    1518   25.30    27.00    1.70              .12       47

RUN:  1

 9     9    GAGIN              5   1506           21.60    27.00    5.40     1.2     1.18      920
 9     9    GAGIN              5   1508           23.80    27.40    3.60     1.2      .51      380
 9     9    GAGIN              5   1510           24.70    27.20    2.50     1.2      .26       70
 9     9    GAGIN              5   1513           25.60    27.30    1.70     1.2      .13       20

RUN:  2

 9     9    GAGIN              5   1517           22.30    27.30    5.00     1.2      .95      640
 9     9    GAGIN              5   1520           23.60    27.20    3.60     1.2      .52      180
 9     9    GAGIN              5   1522           24.50    27.20    2.70     1.2       .3      140
 9     9    GAGIN              5   1525           25.50    27.30    1.80     1.2       .1       40

RUN:  3

 9     9    GAGIN              5   1529           22.40    27.30    4.90     1.2      .92      670
 9     9    GAGIN              5   1532           23.60    27.30    3.70     1.2      .52      170
 9     9    GAGIN              5   1534           23.70    27.10    3.40     1.2      .46      150
 9     9    GAGIN              5   1536           25.60    27.60    2.00     1.2       .1       20

RUN:  4

 9     9    GAGIN              5   1540           22.30    27.10    4.80     1.2       .9      670
 9     9    GAGIN              5   1542           23.70    27.40    3.70     1.2      .51      150
 9     9    GAGIN              5   1545           24.30    27.00    2.70     1.2       .3       50
 9     9    GAGIN              5   1548           25.50    27.20    1.70     1.2       .1       10

RUN:  5

 9     9    GAGIN              5   1556           22.60    27.80    5.20     1.2     1.06      670
 9     9    GAGIN              5   1558           23.50    27.90    4.40     1.2      .62      320
 9     9    GAGIN              5   1605           25.80    28.00    2.20     1.2      .19       80

RUN:  1

10    10    LALA              13   1453           23.16    25.42    2.26               .2      370
10    10    LALA              13   1454           22.69    25.46    2.77               .3    434.7
10    10    LALA              13   1455           22.26    25.47    3.19               .4    450.7
10    10    LALA              13   1456           21.91    25.47    3.56               .5      542
10    10    LALA              13   1457           21.57    25.46    3.89               .6    844.6
```

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EXPERIMENT #: 10                                    NUCLEI MEASUREMENTS                                      PROCESSING DATE:  81/07/29

                  OBSERVER                                   PLATE TEMP
MACH  DUCT  ------------------     SAMPLE TIME                                    VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME             NO.   START  END      COLD     HOT     DELTA   SAMPLED   SAT     COUNT      -       K     REMARKS
                                                            (C)               (L)      (%)                N
----  ----  ---------------- ---   -----  ----    ------  ------   ------  -------   ------  ------   -----   -----   --------------------
 10    10   LALA              13   1458            21.25   25.45    4.20                .7     1024
 10    10   LALA              13   1459            20.96   25.44    4.48                .8     1061
 10    10   LALA              13   1500            20.67   25.42    4.75                .9     1102
 10    10   LALA              13   1501            20.40   25.40    5.00                1      1114
RUN:   2
 10    10   LALA              13   1503            23.32   25.59    2.27                .2    397.2
 10    10   LALA              13   1504            22.86   25.63    2.77                .3    396.3
 10    10   LALA              13   1505            22.46   25.66    3.20                .4    432.3
 10    10   LALA              13   1506            22.13   25.69    3.56                .5    614.3
 10    10   LALA              13   1507            21.80   25.70    3.90                .6    925.8
 10    10   LALA              13   1508            21.48   25.69    4.21                .7   1024.8
 10    10   LALA              13   1509            21.18   25.67    4.49                .8   1162.4
 10    10   LALA              13   1510            20.89   25.65    4.76                .9   1099.6
 10    10   LALA              13   1511            20.63   25.64    5.01                1    1028.7
RUN:   3
 10    10   LALA              13   1512            20.60   25.61    5.01                1      1128
 10    10   LALA              13   1513            20.83   25.58    4.75                .9   1132.1
 10    10   LALA              13   1514            20.06   25.55    5.49                .8   1137.3
 10    10   LALA              13   1515            21.34   25.54    4.20                .7   1032.9
 10    10   LALA              13   1516            21.64   25.54    3.90                .6    958.6
 10    10   LALA              13   1517            21.98   25.54    3.56                .5    607.6
 10    10   LALA              13   1518            22.39   25.58    3.19                .4    408.9
 10    10   LALA              13   1519            22.83   25.60    2.77                .3    344.6
 10    10   LALA              13   1520            23.37   25.64    2.27                .2    306.3

RUN:   1
 11    11   HOPPEL             7   1507   1524                                        .014   .0042   .0042            ISOTHERMAL HAGE CHAM
 11    11   HOPPEL             7   1507   1524                                        .15      308     308
 11    11   HOPPEL             7   1507   1524                                        .094      95      95
 11    11   HOPPEL             7   1507   1524                                        .034     5.8     5.8
 11    11   HOPPEL             7   1507   1524                                        .025     .26     .26

RUN:   1
 13    13   AYERS              2   1457   1458     26.91   29.40    2.49                .25     308
 13    13   AYERS              2   1459   1500     25.76   29.40    3.64                .5      390
 13    13   AYERS              2   1500   1501     21.40   29.30    7.90                .75     990
 13    13   AYERS              2   1502   1503     24.17   29.20    5.03                1      1275
 13    13   AYERS              2   1504   1505     23.49   29.10    5.61              1.25     1425
RUN:   2
 13    13   AYERS              2   1508   1509     23.19   28.80    5.61              1.25     1440
 13    13   AYERS              2   1510   1511     23.75   28.80    5.05                1      1350
 13    13   AYERS              2   1512   1513     24.35   28.70    4.35                .75     795
 13    13   AYERS              2   1514   1515     25.12   28.70    3.58                .5      480
 13    13   AYERS              2   1517   1519     25.60   28.60    3.00                .35     278
 13    13   AYERS              2   1519   1520     26.12   28.60    2.48                .25     233
RUN:   3
 13    13   AYERS              2   1526   1527     26.20   28.70    2.50                .25     255
 13    13   AYERS              2   1527   1528     25.18   28.70    3.52                .5      398
 13    13   AYERS              2   1529   1530     24.33   28.70    4.37                .75     930
 13    13   AYERS              2   1531   1532     23.60   28.60    5.00                1      1155
 13    13   AYERS              2   1555   1556     23.04   28.60    5.56              1.25     1425

RUN:   1
 14    14   HUDSON             9   1449   1455                               .0039    .21    118.3                    F=25, D=0.38
 14    14   HUDSON             9   1449   1455                               .0039    .14     92.8                    F=25, D=0.67
 14    14   HUDSON             9   1449   1455                               .0039    .11     69.3                    F=25, D=1.3
 14    14   HUDSON             9   1449   1455                               .0039    .04     10.4                    F=25, D=2.7
```

EXPERIMENT #: 10

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/07/29

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	PLATE TEMP DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
14	14	HUDSON	9	1449	1455				.0039	.029	5.53			F=25, D=4.0
14	14	HUDSON	9	1505	1519				.0085	.21	143.2			F=39,
14	14	HUDSON	9	1505	1519				.0085	.14	104.6			F=39,
14	14	HUDSON	9	1505	1519				.0085	.11	51.2			F=39,
14	14	HUDSON	9	1505	1519				.0085	.04	3.46			F=39,
14	14	HUDSON	9	1505	1519				.0085	.029	.82			F=39,
RUN: 2														
14	14	HUDSON	9	1520	1549				.017	.21	129			F=39
14	14	HUDSON	9	1520	1549				.017	.14	98.2			F=39
14	14	HUDSON	9	1520	1549				.017	.11	48.8			F=39
14	14	HUDSON	9	1520	1549				.017	.04	3.75			F=39
14	14	HUDSON	9	1520	1549				.017	.029	.85			F=39
14	14	HUDSON	9	1550	1619				.017	.21	115.4			F=39
14	14	HUDSON	9	1550	1619				.017	.14	84.2			F=39
14	14	HUDSON	9	1550	1619				.017	.11	40.2			F=39
14	14	HUDSON	9	1550	1619				.017	.04	2.87			F=39
14	14	HUDSON	9	1550	1619				.017	.029	.67			F=39
RUN: 1														
15	15	ROGERS, FRED	23	1444	1445	18.30	25.00	6.70		1.8	972			BACKGROUND NOW 10
15	15	ROGERS, FRED	23	1448	1449	18.74	24.75	6.01		1.46	1201			TO 16 PER CC.
15	15	ROGERS, FRED	23	1453	1454	19.12	24.44	5.32		1.15	1114			READING ROYCO CH.
15	15	ROGERS, FRED	23	1457	1458	19.49	24.13	4.64		.87	1007			2 LESS 16 PER CC.
15	15	ROGERS, FRED	23	1501	1502	19.87	23.81	3.94		.63	694			TEMPS ARE APPROX
15	15	ROGERS, FRED	23	1505	1506	20.25	23.50	3.25		.425	401			IN ABSOLUTE, OK IN
15	15	ROGERS, FRED	23	1509	1510	20.62	23.19	2.57		.265	290			DELTA
15	15	ROGERS, FRED	23	1513	1514	20.99	22.88	1.89		.14	137			
15	15	ROGERS, FRED	23	1517	1518	21.33	22.55	1.22		.07	26			LAST PT. IS CH 3 CNT
RUN: 1														
16	16	HUDSON	9	1511	1514	21.40	26.10	4.70	.0018	.9	1043			
16	16	HUDSON	9	1511	1514	21.80	25.45	3.65	.0018	.54	546			
16	16	HUDSON	9	1511	1514	22.30	24.90	2.60	.0018	.26	295			
16	16	HUDSON	9	1522	1524	21.40	26.10	4.70	.0018	.9	1046			
16	16	HUDSON	9	1522	1524	21.80	25.45	3.65	.0018	.54	512			
16	16	HUDSON	9	1522	1524	22.30	24.90	2.60	.0018	.26	272			
16	16	HUDSON	9	1539	1542	21.40	26.10	4.70	.0012	.9	1074			
16	16	HUDSON	9	1539	1542	21.80	25.45	3.65	.0012	.54	555			
16	16	HUDSON	9	1539	1542	22.30	24.90	2.60	.0012	.26	264			
RUN: 2														
16	16	HUDSON	9	1545	1548	21.40	26.10	4.70	.0018	.9	1112			
16	16	HUDSON	9	1545	1548	21.80	25.45	3.65	.0018	.54	541			
16	16	HUDSON	9	1545	1548	22.30	24.90	2.60	.0018	.26	289			
16	16	HUDSON	9	1600	1602	21.40	26.10	4.70	.0012	.9	1095			
16	16	HUDSON	9	1600	1602	21.80	25.45	3.65	.0012	.54	492			
16	16	HUDSON	9	1600	1602	22.30	24.90	2.60	.0012	.26	247			
16	16	HUDSON	9	1607	1610	21.40	26.10	4.70	.0018	.9	1080			
16	16	HUDSON	9	1607	1610	21.80	25.45	3.65	.0018	.54	482			
16	16	HUDSON	9	1607	1610	22.30	24.90	2.60	.0018	.26	228			
RUN: 3														
16	16	HUDSON	9	1618	1619	21.40	26.10	4.70	.0012	.9	1106			
16	16	HUDSON	9	1618	1619	21.80	25.45	3.65	.0012	.54	468			
16	16	HUDSON	9	1618	1619	22.30	24.90	2.60	.0012	.26	223			
RUN: 1														
17	17	WOJCIECHOWSKI	27	1446	1447					.24	385	385		
17	17	WOJCIECHOWSKI	27	1449	1451					.35	454	454		
17	17	WOJCIECHOWSKI	27	1453	1455					.46	770	770		
17	17	WOJCIECHOWSKI	27	1453	1455					.7	1307	1307		

```
EXPERIMENT #: 10                                NUCLEI MEASUREMENTS
                                                                                              PROCESSING DATE:  81/07/29
                     OBSERVER                              PLATE TEMP
MACH  DUCT  -----------------------  SAMPLE TIME                          VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME              NO.    START  END    COLD     HOT    DELTA  SAMPLED   SAT    COUNT      -       K      REMARKS
                                                            (C)              (L)    (%)               N
----  ----  ---------------   ---    -----  ----  ------  ------  ------  -------  ------  ------   -----   -----   -------------------
 17    17   WOJCIECHOWSKI      27    1453   1455                                    .96    1657     1657

RUN:   1

 18    18   HUDSON              9    1511   1514   23.10   25.85   2.75    .0018    .3      287
 18    18   HUDSON              9    1522   1524   22.65   26.25   3.60    .0018    .52     494
 18    18   HUDSON              9    1539   1542   22.15   26.75   4.60    .0012    .86    1055
 18    18   HUDSON              9    1545   1548   21.80   27.10   5.30    .0018   1.15    1082
 18    18   HUDSON              9    1600   1602   22.30   26.60   4.30    .0012    .74    1047
 18    18   HUDSON              9    1607   1610   22.50   26.40   3.90    .0018    .59     717
 18    18   HUDSON              9    1618   1619   22.85   26.00   3.15    .0012    .4      245

RUN:   1

 20    20   DOMONKOS            4    1530   1540                                    .45     870
 20    20   DOMONKOS            4    1530   1540                                    .69    1290
 20    20   DOMONKOS            4    1530   1540                                    .57    1410
 20    20   DOMONKOS            4    1530   1540                                   1.27    1480

RUN:   1

 21    21   TRUEBLOOD          26    1443   1445   20.10   25.00   4.90              .96    1334
 21    21   TRUEBLOOD          26    1451   1452   21.67   25.00   3.33              .444   404.4
 21    21   TRUEBLOOD          26    1456   1458   22.30   25.00   2.70              .292   340.2
 21    21   TRUEBLOOD          26    1506   1508   25.00   25.00   0.00              .173   350.3
 21    21   TRUEBLOOD          26    1506   1508   25.00   25.00   0.00              .114   124.6
 21    21   TRUEBLOOD          26    1506   1508   25.00   25.00   0.00              .089   109.4
 21    21   TRUEBLOOD          26    1506   1508   25.00   25.00   0.00              .068    56.6
 21    21   TRUEBLOOD          26    1512   1518   25.00   25.00   0.00              .035     3.1
 21    21   TRUEBLOOD          26    1512   1518   25.00   25.00   0.00              .022      .2
 21    21   TRUEBLOOD          26    1512   1518   25.00   25.00   0.00             .0133      0
RUN:   2

 21    21   TRUEBLOOD          26    1534   1536   20.95   25.00   4.05              .656   888.6
 21    21   TRUEBLOOD          26    1541   1542   21.13   25.00   3.87              .599   601.9
 21    21   TRUEBLOOD          26    1545   1546   21.37   25.00   3.63              .527   400.7
 21    21   TRUEBLOOD          26    1549   1550   21.62   25.00   3.38              .457   354.8
RUN:   3

 21    21   TRUEBLOOD          26    1600   1601   19.95   25.00   5.05             1.02    1429
 21    21   TRUEBLOOD          26    1602   1603   20.15   25.00   4.85              .941   1426
 21    21   TRUEBLOOD          26    1605   1605   20.37   25.00   4.63              .857   1468
 21    21   TRUEBLOOD          26    1608   1608   20.68   25.00   4.32              .746   1191
 21    21   TRUEBLOOD          26    1610   1611   20.95   25.00   4.05              .656   917.5
 21    21   TRUEBLOOD          26    1613   1614   21.10   25.00   3.90              .608   621.5
 21    21   TRUEBLOOD          26    1616   1617   21.40   25.00   3.60              .518   342.9
 21    21   TRUEBLOOD          26    1619   1620   21.60   25.00   3.40              .462   284.6

RUN:   1

 24    24   SERPOLAY           25    1445   1500   25.60   26.90   1.30     .77      .08     190
 24    24   SERPOLAY           25    1510   1520   26.00   28.40   2.40     .77      .24     250
 24    24   SERPOLAY           25    1525   1532   26.30   29.60   3.30     .77      .4      330
 24    24   SERPOLAY           25    1540   1550   26.70   31.30   4.60     .77      .75    1200
 24    24   SERPOLAY           25    1600   1605   27.20   31.20   4.00     .77      .57     450
 24    24   SERPOLAY           25    1617   1622   27.60   30.50   2.90     .77      .31     260

RUN:   1

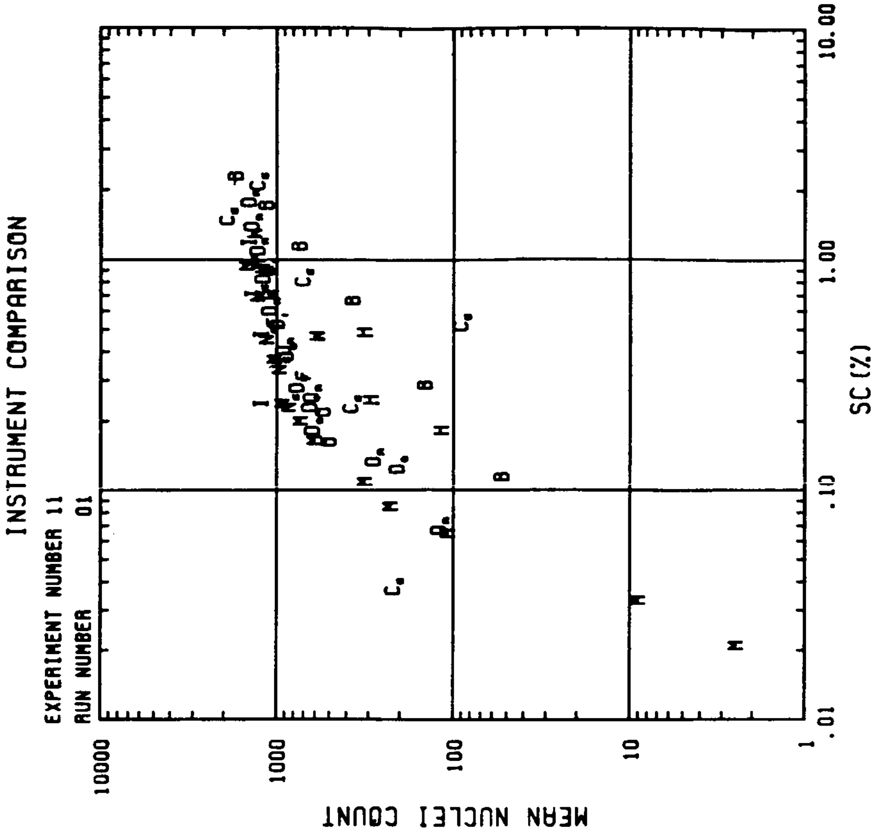
 26    26   HINDMAN             6    1453   1609   27.00   27.00   0.00     1.4      .16      20       20             E=0.78, D>=0.5 UM
 26    26   HINDMAN             6    1453   1609   27.00   27.00   0.00     1.4      .12      10       10             E=0.45, D>=0.7 UM
 26    26   HINDMAN             6    1453   1609   27.00   27.00   0.00     1.4      .059     6.8      6.8           E=0.45, D>=1.4 UM
 26    26   HINDMAN             6    1453   1609   27.00   27.00   0.00     1.4      .027   .0052    .0052          E=0.0022, D>=3 UM
 26    26   HINDMAN             6    1453   1609   27.00   27.00   0.00     1.4      .016      0        0            0, D>=5 UM
```

NUCLEI MEASUREMENTS

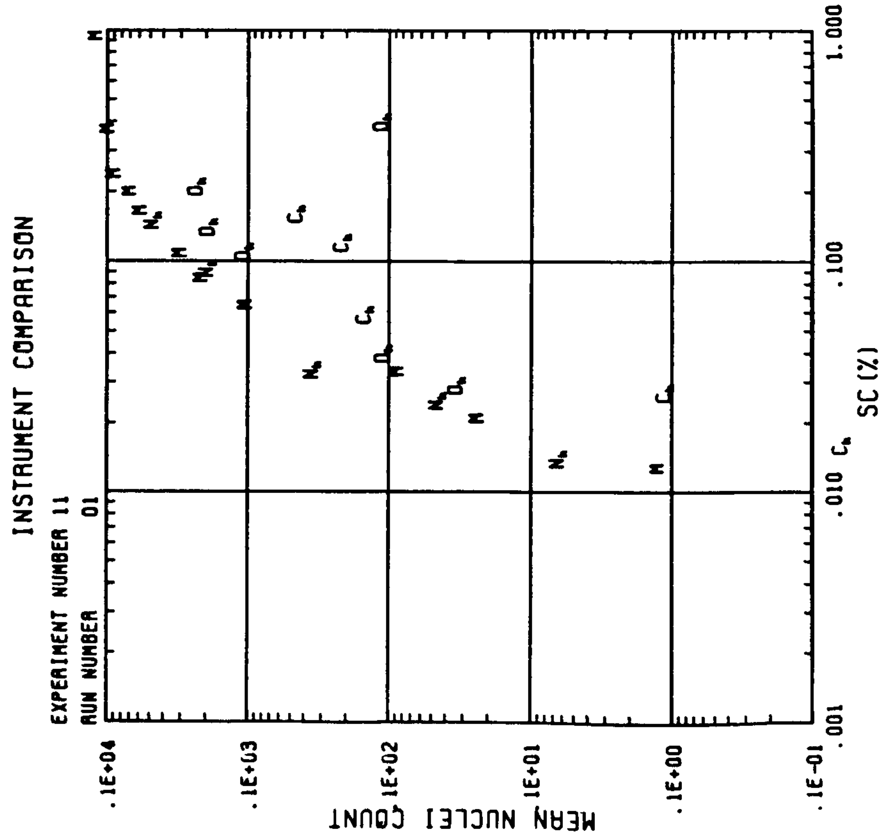
EXPERIMENT #: 10

PROCESSING DATE: 81/07/29

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	PLATE TEMP DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
RUN: 1														
27	27	OHTAKE	19	1444	1444				3.5		1.481			107% R.H. NOMINAL
27	27	OHTAKE	19	1601	1601				3.5		1.975			123% R.H. NOMINAL



SDC/CFD RESULTS



HAZE CHAMBER RESULTS

```
                                          EXPERIMENT # 11                                    80/10/09
PURPOSE
-------
 INSTRUMENT COMPARISON WITH AMBIENT AIR.

DESCRIPTION OF EXPERIMENT
-------------------------
                   TIME
  DATE             START   END
  ------------     -----------

  09 OCT,1980      1636    1725

  NUCLEI TYPE
  -----------
   AMBIENT

  GENERATION METHOD
  -----------------
   NA

  SIZE DISTRIBUTION SHAPING
  -------------------------
   NA

REMARKS
-------
 FLOW RATE 700 L/MIN.

WEATHER SYNOPSIS
----------------
 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
        ROOM CONDITIONS                             OUTSIDE CONDITIONS

 --------------------------------     ---------------------------------------------------
 AVG TEMP     AVG RH    AVG PRESS     AVG TEMP    AVG RH     AVG PRESS    AVG WS    AVG WD
   (C)         (%)        (MB)          (C)        (%)         (MB)       (M/S)     (DEG)
 --------     ------    ---------     --------    ------     ---------    ------    ------

   29.0        21.0       851           NA          NA          851         1.0       120
```

```
EXPERIMENT #: 11                                      NUCLEI MEASUREMENTS                                    PROCESSING DATE:  81/07/29
                        OBSERVER                                         PLATE TEMP
MACH  DUCT  -------------------------   SAMPLE  TIME                                       VOLUME   SUPER   NUCLEI    ORS     EST
NO.   NO.   NAME                  NO.   START   END     COLD      HOT      DELTA    SAMPLED  SAT     COUNT      -       K      REMARKS
                                                                   (C)                (L)      (%)                N
----  ----  ---------------  ---   -----   ----   ------   ------   ------   -------  ------   ------   -----   -----   -------------------

RUN:  1

  2     2   POLITOVICH        20    1702    1703    23.30    25.40     2.10               .17              523
  2     2   POLITOVICH        20    1712    1713    23.00    25.40     2.40               .23              567

RUN:  1

  5     5   KITCHEN           12    1640    1640    22.00    27.40     5.40              1.2      935
  5     5   KITCHEN           12    1641    1641    23.20    27.40     4.20               .7      512
  5     5   KITCHEN           12    1642    1642    24.50    27.40     2.90               .3       94
  5     5   KITCHEN           12    1643    1643    25.70    27.40     1.70               .12      55
  5     5   KITCHEN           12    1644    1644    24.40    27.40     3.00               .3      207
  5     5   KITCHEN           12    1645    1645    23.20    27.40     4.20               .7      257
  5     5   KITCHEN           12    1646    1646    22.00    27.40     5.40              1.2      745
  5     5   KITCHEN           12    1647    1647    19.50    27.40     7.90              2.4     1781
  5     5   KITCHEN           12    1648    1648    20.70    27.30     6.60              1.8     1186
  5     5   KITCHEN           12    1649    1649    21.90    27.30     5.40              1.2      638

RUN:  1

  9     9   GAGIN              5    1639            22.90    28.20     5.30      1.2     1.07     1330
  9     9   GAGIN              5    1642            24.00    27.60     3.60      1.2      .51      330
  9     9   GAGIN              5    1644            25.10    27.70     2.60      1.2      .26      300
  9     9   GAGIN              5    1646            25.80    28.10     2.30      1.2      .19      120
RUN:  2

  9     9   GAGIN              5    1649            22.90    27.80     4.90      1.2      .92     1350
  9     9   GAGIN              5    1652            24.40    28.20     3.80      1.2      .55      770
  9     9   GAGIN              5    1655            25.30    28.00     2.70      1.2      .25      390
  9     9   GAGIN              5    1658            26.20    28.10     1.90      1.2      .18      210

RUN:  1

 11    11   FITZGERALD        28    1644    1700                                          .15    525.2    525.2           ISOTHERMAL HOZE CHAM
 11    11   FITZGERALD        28    1644    1700                                          .094     212      212
 11    11   FITZGERALD        28    1644    1700                                          .034    38.2     38.2
 11    11   FITZGERALD        28    1644    1700                                          .025    4.95     4.95
 11    11   FITZGERALD        28    1644    1700                                          .014     .69      .69
RUN:  2

 11    11   FITZGERALD        28    1719    1725                                          .15      309      309            ISOTHERMAL HOZE CHAM
 11    11   FITZGERALD        28    1719    1725                                          .094     160      160
 11    11   FITZGERALD        28    1719    1725                                          .034    38.8     38.8
 11    11   FITZGERALD        28    1719    1725                                          .025    4.85     4.85
 11    11   FITZGERALD        28    1719    1725                                          .014     .72      .72

RUN:  1

 13    13   AYERS              2    1647    1648    28.33    30.90     2.57               .25     1275                    PHOTO. RECORDS TAKEN
 13    13   AYERS              2    1650    1651    27.20    30.80     3.60               .5      1275
 13    13   AYERS              2    1651    1652    26.39    30.80     4.41               .75     1425
 13    13   AYERS              2    1653    1654    25.53    30.60     5.07              1        1455
 13    13   AYERS              2    1655    1656    24.79    30.50     5.71              1.25     1500
 13    13   AYERS              2    1657    1658    24.69    30.40     5.71              1.25     1515
RUN:  2

 13    13   AYERS              2    1704    1705    27.84    30.40     2.56               .25      795                    PHOTO.RECORDS TAKEN
 13    13   AYERS              2    1706    1707    26.77    30.40     3.63               .5      1200
 13    13   AYERS              2    1708    1709    22.98    30.40     7.42               .75     1650
 13    13   AYERS              2    1710    1711    25.32    30.40     5.08              1        2100
 13    13   AYERS              2    1712    1713    25.37    30.40     5.03              1        2430
 13    13   AYERS              2    1713    1714    24.72    30.40     5.68              1.25     1500                    CHANGING AMBIENT
 13    13   AYERS              2    1714    1715    24.72    30.40     5.68              1.25     1425                    AEROSOL?
```

EXPERIMENT #: 11

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/07/29

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	PLATE TEMP DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
RUN: 1														
14	14	HUDSON	9	1651	1711				.012	.21	262			F=39
14	14	HUDSON	9	1651	1711				.012	.14	213.7			F=39
14	14	HUDSON	9	1651	1711				.012	.11	118.4			F=39
14	14	HUDSON	9	1651	1711				.012	.04	11.7			F=39
14	14	HUDSON	9	1651	1711				.012	.029	3.49			F=39
14	14	HUDSON	9	1712	1733				.013	.21	243			F=39
14	14	HUDSON	9	1712	1733				.013	.14	201			F=39
14	14	HUDSON	9	1712	1733				.013	.11	112.7			F=39
14	14	HUDSON	9	1712	1733				.013	.4	12.2			F=39
14	14	HUDSON	9	1712	1733				.013	.029	3.61			F=39
RUN: 1														
15	15	ROGERS, FRED	23	1651	1652	18.37	25.06	6.69		1.86	1506			BACKGROUND 10 PER CC
15	15	ROGERS, FRED	23	1654	1655	18.74	24.75	6.01		1.46	1448			
15	15	ROGERS, FRED	23	1659	1660	19.12	24.44	5.32		1.15	1334			AVERAGING LAST 4 COUNTS CH. 2
15	15	ROGERS, FRED	23	1704	1705	19.49	24.13	4.64		.87	1255			
15	15	ROGERS, FRED	23	1707	1708	19.86	23.81	3.95		.63	1138			
15	15	ROGERS, FRED	23	1711	1712	20.25	23.50	3.25		.425	954			
15	15	ROGERS, FRED	23	1715	1716	20.62	23.19	2.57		.265	660			
15	15	ROGERS, FRED	23	1720	1721	20.99	22.88	1.89		.14	293			
15	15	ROGERS, FRED	23	1724	1725	21.35	22.56	1.21		.07	125			LAST PT IS CH 3 CNT
RUN: 1														
16	16	HUDSON	9	1639	1641	21.40	26.20	4.80	.0018	.94	1136			
16	16	HUDSON	9	1639	1641	21.80	25.50	3.70	.0018	.55	1007			
16	16	HUDSON	9	1639	1641	22.50	24.95	2.45	.0018	.24	652			
16	16	HUDSON	9	1645	1649	21.40	26.20	4.80	.0024	.94	1164			
16	16	HUDSON	9	1645	1649	21.80	25.50	3.70	.0024	.55	1038			
16	16	HUDSON	9	1645	1649	22.50	24.95	2.45	.0024	.24	701			
16	16	HUDSON	9	1703	1704	21.40	26.20	4.80	.0012	.94	1208			
16	16	HUDSON	9	1703	1704	21.80	25.50	3.70	.0012	.55	1057			
16	16	HUDSON	9	1703	1704	22.50	24.95	2.45	.0012	.24	666			
RUN: 2														
16	16	HUDSON	9	1713	1714	21.40	26.20	4.80	.0012	.94	1012			
16	16	HUDSON	9	1713	1714	21.80	25.50	3.70	.0012	.55	900			
16	16	HUDSON	9	1713	1714	22.50	24.95	2.45	.0012	.24	584			
16	16	HUDSON	9	1733	1737	21.40	26.20	4.80	.0024	.94	980			
16	16	HUDSON	9	1733	1737	21.80	25.50	3.70	.0024	.55	882			
16	16	HUDSON	9	1733	1737	22.50	24.95	2.45	.0024	.24	705			
RUN: 1														
17	17	WOJCIECHOWSKI	27	1641	1642					.24	883	883		
17	17	WOJCIECHOWSKI	27	1643	1644					.35	1011	1011		
17	17	WOJCIECHOWSKI	27	1646	1647					.47	1194	1194		
17	17	WOJCIECHOWSKI	27	1649	1650					.72	1332	1332		
17	17	WOJCIECHOWSKI	27	1652	1653					.98	1544.1	1544.1		
RUN: 1														
18	18	HUDSON	9	1639	1641	22.85	26.00	3.15	.0018	.4	921			
18	18	HUDSON	9	1645	1649	23.10	25.80	2.70	.0024	.29	875			
18	18	HUDSON	9	1703	1704	23.40	25.60	2.20	.0012	.19	646			
18	18	HUDSON	9	1713	1714	23.60	25.40	1.80	.0012	.13	214			
18	18	HUDSON	9	1733	1737	23.20	25.90	2.70	.0024	.29	721			
RUN: 1														
20	20	DOMONKOS	4	1640	1650					.49	610			

```
                                                                NUCLEI MEASUREMENTS
EXPERIMENT #: 11                                                                                                             PROCESSING DATE:  81/07/29
                        OBSERVER                                          PLATE TEMP
MACH  DUCT   -------------------------   SAMPLE  TIME                                       VOLUME   SUPER   NUCLEI     ORS      EST
NO.   NO.    NAME                  NO.   START    END     COLD      HOT      DELTA   SAMPLED    SAT    COUNT       -        K     REMARKS
                                                                     (C)                (L)       (%)                N
----  ----   ---------------       ---   -----   ----   ------    ------    ------   -------   ------  ------    -----    -----  -------------------
 20    20    DOMONKOS                4   1640    1650                                               .74    1120
 20    20    DOMONKOS                4   1640    1650                                               .96    1250
 20    20    DOMONKOS                4   1640    1650                                              1.37    1390

RUN:   1

 21    21    TRUEBLOOD              26   1641    1642    19.95     25.00      5.05                     1    1312
 21    21    TRUEBLOOD              26   1647    1648    21.87     25.00      3.13                   .39    1079
 21    21    TRUEBLOOD              26   1650    1651    22.50     25.00      2.50                   .25     970
 21    21    TRUEBLOOD              26   1657    1658    22.70     25.00      2.30                   .21     757
 21    21    TRUEBLOOD              26   1710    1711    25.00     25.00      0.00                  .173     634
 21    21    TRUEBLOOD              26   1710    1711    25.00     25.00      0.00                  .114     327
 21    21    TRUEBLOOD              26   1710    1711    25.00     25.00      0.00                  .089     234
 21    21    TRUEBLOOD              26   1710    1711    25.00     25.00      0.00                  .068     112
 21    21    TRUEBLOOD              26   1717    1718    25.00     25.00      0.00                  .035    9.31
 21    21    TRUEBLOOD              26   1717    1718    25.00     25.00      0.00                  .022    2.56
 21    21    TRUEBLOOD              26   1717    1718    25.00     25.00      0.00                 .0133    .135

RUN:   1

 24    24    SERPOLAY               25   1645    1650    28.10     31.10      3.00       .77       .33     730
 24    24    SERPOLAY               25   1700    1705    28.50     32.50      4.00       .77       .56    1080
 24    24    SERPOLAY               25   1720    1725    29.00     33.60      4.60       .77       .74    1230

RUN:   1

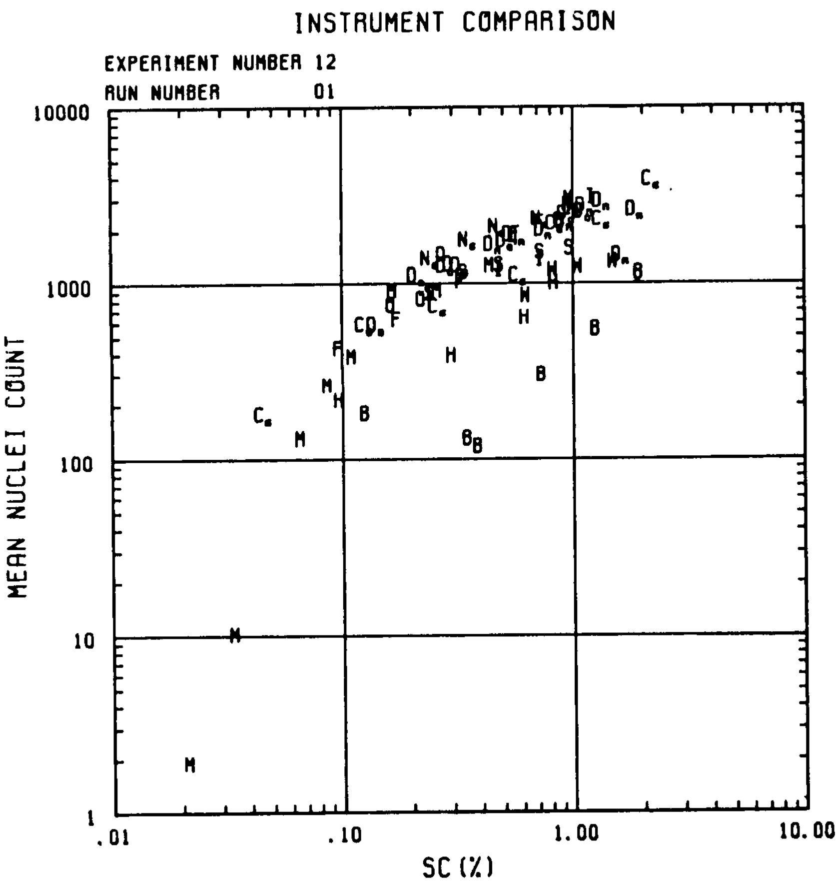
 25    25    BORYS                   3   1638    1642    17.60     24.80      7.20      2.12      2.18    1344      1344      .62  VOL SAMP X10**5
 25    25    BORYS                   3   1646    1652    19.60     25.40      5.80      3.18      1.55    1980      1980
 25    25    BORYS                   3   1653    1658    21.20     25.70      4.50      4.24       .84     743       743
 25    25    BORYS                   3   1706    1710    22.50     26.20      3.70      6.36       .54      94        94
 25    25    BORYS                   3   1714    1720    24.20     26.60      2.40      10.6      .238     396       396
 25    25    BORYS                   3   1722    1729    25.90     26.90      1.00      10.6      .038     226       226

RUN:   1

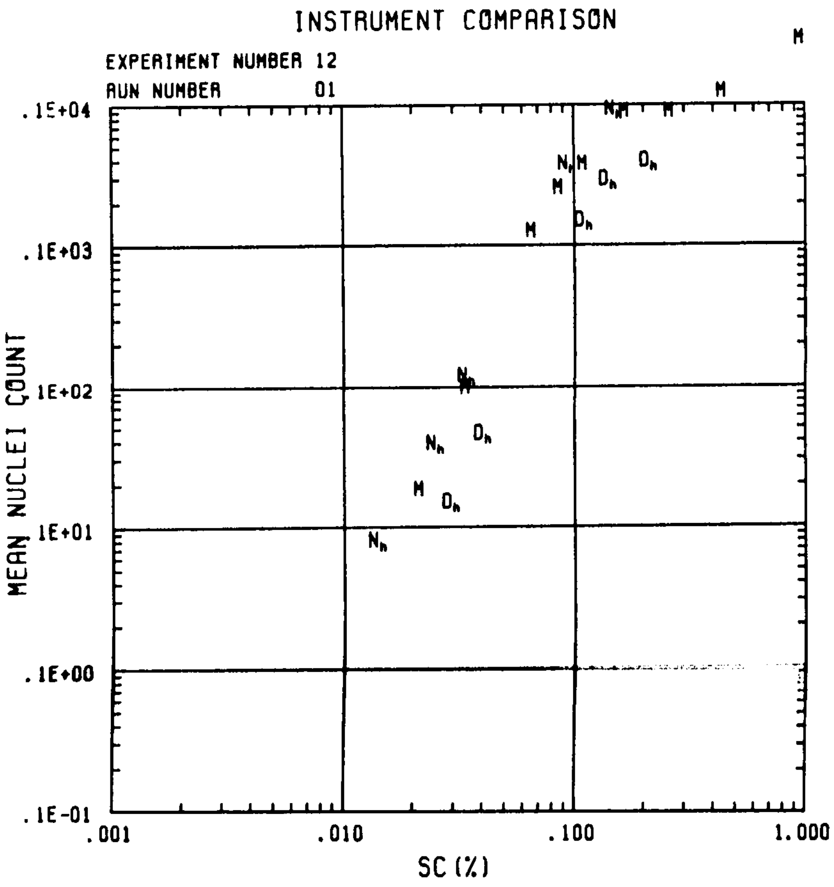
 26    26    HINDMAN                 6   1643    1719    27.00     27.00      0.00       1.2       .16      49        49           E=1.4, D>=0.5 UM
 26    26    HINDMAN                 6   1643    1719    27.00     27.00      0.00       1.2       .12      23        23           E=0.76, D>=0.7 UM
 26    26    HINDMAN                 6   1643    1719    27.00     27.00      0.00       1.2      .059      16        16           E=0.78, D>=1.4 UM
 26    26    HINDMAN                 6   1643    1719    27.00     27.00      0.00       1.2      .027     .12       .12           E=0.02, D>=3 UM
 26    26    HINDMAN                 6   1643    1719    27.00     27.00      0.00       1.2      .016   .0065     .0065           E=0.0029, D>= .5 UM

RUN:   1

 27    27    OHTAKE                 19   1645    1645                                  3.5               .311                  101% R.H. NOMINAL
 27    27    OHTAKE                 19   1645    1645                                  3.5               .494                  114% R.H. NOMINAL
```



SDC/CFD RESULTS



HAZE CHAMBER RESULTS

EXPERIMENT # 12

80/10/10

PURPOSE

INSTRUMENT COMPARISON WITH AMBIENT AEROSOL.

DESCRIPTION OF EXPERIMENT

	TIME	
DATE	START	END
10 OCT.1980	0830	1002

NUCLEI TYPE

AMBIENT

GENERATION METHOD

NA

SIZE DISTRIBUTION SHAPING

NA

REMARKS

T 23.5 (C), TD 12 (C)

WEATHER SYNOPSIS

NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT

ROOM CONDITIONS			OUTSIDE CONDITIONS				
AVG TEMP (C)	AVG RH (%)	AVG PRESS (MB)	AVG TEMP (C)	AVG RH (%)	AVG PRESS (MB)	AVG WS (M/S)	AVG WD (DEG)
25.0	21.0	852	NA	NA	NA	<1.0	360

```
                                                                 NUCLEI MEASUREMENTS
EXPERIMENT #: 12                                                                                                      PROCESSING DATE:  81/09/26
                       OBSERVER                                          PLATE TEMP
MACH  DUCT  ------------------------    SAMPLE TIME                                 VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME                NO.     START   END     COLD     HOT    DELTA   SAMPLED   SAT    COUNT      -       K     REMARKS
                                                                 (C)              (L)     (%)               N
----  ----  --------------- ---         -----  ----    ------  ------  ------  -------  ------  ------    -----   -----  -------------------

RUN:  1
 2     2    POLITOVICH           20      0926   0928    21.90   24.00    2.10              .17              785
 2     2    POLITOVICH           20      0930   0931    21.80   24.20    2.40              .23              853

RUN:  1
 5     5    KITCHEN              12      0830   0830    21.20   22.90    1.70              .13     187
 5     5    KITCHEN              12      0831   0831    19.90   22.90    3.00              .4      122
 5     5    KITCHEN              12      0832   0832    18.80   23.00    4.20              .76     331
 5     5    KITCHEN              12      0833   0833    17.60   23.00    5.40             1.3      528
 5     5    KITCHEN              12      0834   0834    16.40   23.00    6.60             2       1184
 5     5    KITCHEN              12      0835   0835    17.60   23.00    5.40             1.3      608
 5     5    KITCHEN              12      0836   0836    18.90   23.10    4.20              .76     300
 5     5    KITCHEN              12      0837   0837    20.30   23.10    2.80              .36     136              1.20
RUN:  2
 5     5    KITCHEN              12      0950   0950    22.50   24.70    2.20              .2      229
 5     5    KITCHEN              12      0951   0951    21.70   24.70    3.00              .36     445
 5     5    KITCHEN              12      0952   0952    21.00   24.70    3.70              .55     712
 5     5    KITCHEN              12      0953   0953    20.10   24.70    4.60              .85    1080
 5     5    KITCHEN              12      0954   0954    19.10   24.70    5.60             1.4     1650

RUN:  1
 9     9    GAGIN                 5      0838           23.00   27.70    4.70     1.2      .86    1050
 9     9    GAGIN                 5      0840           23.50   27.60    4.10     1.2      .64     670
 9     9    GAGIN                 5      0843           25.00   27.80    2.80     1.2      .31     410
 9     9    GAGIN                 5      0846           25.90   27.70    1.80     1.2      .1      220
RUN:  2
 9     9    GAGIN                 5      0912           23.10   28.10    5.00     1.2      .97    1670
 9     9    GAGIN                 5      0914           24.30   28.00    3.70     1.2      .53    1020
 9     9    GAGIN                 5      0916           25.10   27.80    2.70     1.2      .26     700
 9     9    GAGIN                 5      0918           26.30   28.00    1.70     1.2      .12     270
RUN:  3
 9     9    GAGIN                 5      0922           22.90   28.00    5.10     1.2     1.01    2010
 9     9    GAGIN                 5      0925           24.20   27.90    3.70     1.2      .53    1100
 9     9    GAGIN                 5      0927           25.10   28.00    2.90     1.2      .31     650
 9     9    GAGIN                 5      0930           26.30   28.50    2.20     1.2      .19     320
RUN:  4
 9     9    GAGIN                 5      0935           22.70   27.80    5.10     1.2      .99    2210
 9     9    GAGIN                 5      0937           24.40   28.10    3.70     1.2      .52     500
 9     9    GAGIN                 5      0840           25.30   28.08    2.70     1.2      .25     320
 9     9    GAGIN                 5      0842           26.20   28.20    2.00     1.2      .16     310

RUN:  1
10    10    LALA                 13      0836           21.71   24.22    2.51      .4      .25    950.5
10    10    LALA                 13      0837           21.73   24.23    2.50      .4      .25    880.8
10    10    LALA                 13      0838           21.27   24.23    2.96      .4      .35   1202.7
10    10    LALA                 13      0839           21.26   24.22    2.96      .4      .35   1210.7
10    10    LALA                 13      0840           20.69   24.21    3.52      .4      .5    1292.3
10    10    LALA                 13      0841           20.68   24.21    3.53      .4      .5      1336
10    10    LALA                 13      0842           19.90   24.21    4.31      .4      .75   1595.9
10    10    LALA                 13      0843           19.89   24.20    4.31      .4      .75   1536.2
10    10    LALA                 13      0844           19.19   24.15    4.96      .4     1      1631.9
10    10    LALA                 13      0845           19.17   24.12    4.95             1      1667.7                  N=1720.9 S**0.41
RUN:  2
10    10    LALA                 13      0850           22.07   24.58    2.51      .4      .25    957.6
```

```
EXPERIMENT #: 12                                    NUCLEI MEASUREMENTS                                 PROCESSING DATE:  81/09/26
                   OBSERVER                                  PLATE TEMP
MACH  DUCT  -----------------------  SAMPLE  TIME                              VOLUME   SUPER   NUCLEI      OBS   EST
NO.   NO.   NAME               NO.  START    END     COLD     HOT    DELTA    SAMPLED   SAT    COUNT          -      K      REMARKS
                                                              (C)              (L)      (%)                 N
----  ----  ----------------   ---  -----   ----    ------   ------  ------   -------  ------  ------   ------   -----   -------------------
 10    10   LALA               13   0851             22.03   24.54    2.51         .4    .25   1023.4
 10    10   LALA               13   0852             21.49   24.46    2.96         .4    .35   1680.4
 10    10   LALA               13   0853             21.47   24.43    2.96         .4    .35   1598.9
 10    10   LALA               13   0854             20.89   24.42    3.53         .4     .5   1813.7
 10    10   LALA               13   0855             20.87   24.40    3.53         .4     .5   1910.6
 10    10   LALA               13   0856             20.06   24.37    4.31         .4    .75   2200.2
 10    10   LALA               13   0857             20.03   24.34    4.31         .4    .75   2185.9
 10    10   LALA               13   0858             19.27   24.22    4.95         .4      1     2464
 10    10   LALA               13   0859             19.23   24.18    4.95                 1   2556.1
RUN:  3
 10    10   LALA               13   0917             22.28   24.80    2.52         .4    .25   1127.5
 10    10   LALA               13   0918             22.26   24.78    2.52         .4    .25   1285.8   1206.7
 10    10   LALA               13   0919             21.79   24.76    2.97         .4    .35   1492.5
 10    10   LALA               13   0920             21.77   24.74    2.97         .4    .35   1506.9   1499.7
 10    10   LALA               13   0921             21.21   24.75    3.54         .4     .5     1627
 10    10   LALA               13   0922             21.18   24.72    3.54         .4     .5   1734.4   1680.7
 10    10   LALA               13   0923             20.38   24.70    4.32         .4    .75   1843.4
 10    10   LALA               13   0924             20.34   24.66    4.32         .4    .75   2006.7   1925.1
 10    10   LALA               13   0925             19.59   24.56    4.97         .4      1   2947.5
 10    10   LALA               13   0926             19.55   24.51    4.96         .4      1     1992   2469.8

RUN:  1
 11    11   FITZGERALD         28   0924    0942                                         .15      995      995
 11    11   FITZGERALD         28   0924    0942                                        .094      400      400
 11    11   FITZGERALD         28   0924    0942                                        .034       13       13
 11    11   FITZGERALD         28   0924    0942                                        .025      4.1      4.1
 11    11   FITZGERALD         28   0924    0942                                        .014      .85      .85

RUN:  1
 13    13   AYERS               2   0843    0844     22.62   25.10    2.48               .25      825
 13    13   AYERS               2   0844    0845     22.62   25.10    2.48               .25     1028
 13    13   AYERS               2   0845    0846     22.62   25.10    2.48               .25      930
 13    13   AYERS               2   0847    0848     21.64   25.10    3.46                .5     1050
 13    13   AYERS               2   0848    0849     21.62   25.10    3.48                .5     1275
 13    13   AYERS               2   0849    0850     21.64   25.10    3.46                .5     1440
 13    13   AYERS               2   0850    0851     20.78   25.00    4.22               .75     1455
 13    13   AYERS               2   0851    0852     20.75   25.00    4.25               .75     1395
 13    13   AYERS               2   0853    0854     20.13   25.08    4.87                 1     1890                    CHANGING AEROSOL
 13    13   AYERS               2   0854    0855     20.01   24.90    4.89                 1     3300                    CONCENTRATION
 13    13   AYERS               2   0855    0856     19.99   24.90    4.91                 1     3180
 13    13   AYERS               2   0856    0857     19.42   24.90    5.48              1.25     2850
 13    13   AYERS               2   0857    0858     19.43   24.90    5.47              1.25     3345
 13    13   AYERS               2   0858    0859     19.43   24.90    5.47              1.25     3450
RUN:  2
 13    13   AYERS               2   0859    0900     19.43   24.90    5.47              1.25     3075
 13    13   AYERS               2   0900    0901     19.98   24.90    4.92                 1     2895
 13    13   AYERS               2   0902    0903     20.69   24.90    4.21               .75     2025
 13    13   AYERS               2   0903    0904     21.42   24.90    3.48                .5     1875
 13    13   AYERS               2   0905    0906     22.46   24.98    2.44               .25     1175

RUN:  1
 14    14   HUDSON              9   0901    0932                                 .018    .21      428                    F=41
 14    14   HUDSON              9   0901    0932                                 .018    .14      313                    F=41
 14    14   HUDSON              9   0901    0932                                 .018    .11      160                    F=41
 14    14   HUDSON              9   0901    0932                                 .018    .04     4.65                    F=41
 14    14   HUDSON              9   0901    0932                                 .018   .029     1.58                    F=41
 14    14   HUDSON              9   0933    1003                                 .018    .21      422                    F=41
 14    14   HUDSON              9   0933    1003                                 .018    .14      310                    F=41
 14    14   HUDSON              9   0933    1003                                 .018    .11      165                    F=41
 14    14   HUDSON              9   0933    1003                                 .018    .04        5                    F=41
 14    14   HUDSON              9   0933    1003                                 .018   .029     1.63                    F=41
```

EXPERIMENT #: 12

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

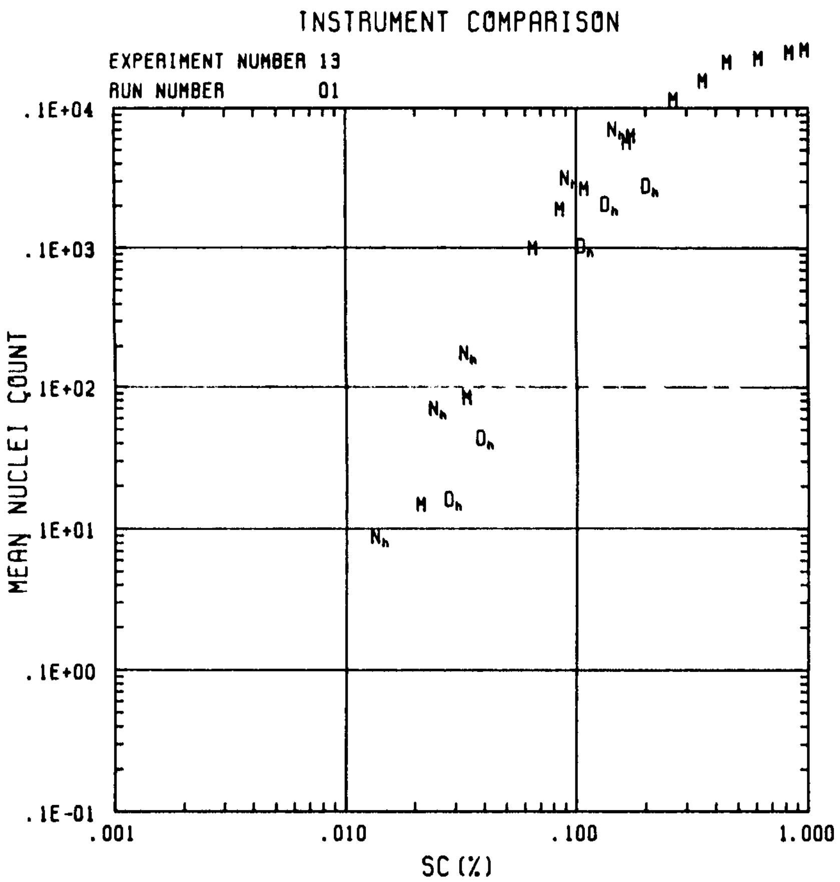
MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	BELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
RUN:	1													
15	15	ROGERS, FRED	23	0923	0924	18.36	25.06	6.70		1.86	2716			BACKGROUND 10 PER CC
15	15	ROGERS, FRED	23	0926	0927	18.63	24.85	6.22	6.21	1.6	1507			AEROSOL WILDLY CHANG
15	15	ROGERS, FRED	23	0929	0930	18.90	24.63	5.73	5.73	1.33	3035			NO AVERAGING
15	15	ROGERS, FRED	23	0933	0934	19.16	24.41	5.25	5.23	1.12	2865			ACCIDENTALLY OMITTED
15	15	ROGERS, FRED	23	0936	0937	19.42	24.19	4.77	4.77	.92	2321			NEW CFD SERVO
15	15	ROGERS, FRED	23	0942	0943	19.69	23.98	4.29	4.29	.74	2087			PARAMETERS
15	15	ROGERS, FRED	23	0946	0947	19.95	23.75	3.80	3.8	.57	1943			N VS. SC SPECTRUM
15	15	ROGERS, FRED	23	0950	0951	20.22	23.54	3.32	3.32	.45	1737			WORTHLESS DUE TO
15	15	ROGERS, FRED	23	0955	0956	20.47	23.31	2.84	2.84	.325	1317			AEROSOL FLUCTUATIONS
RUN:	1													
16	16	HUDSON	9	0849	0853	21.45	26.15	4.70	.0024	.9	1846			
16	16	HUDSON	9	0849	0853	21.80	25.45	3.65	.0024	.54	1648			
16	16	HUDSON	9	0849	0853	22.20	24.95	2.75	.0024	.3	1331			
16	16	HUDSON	9	0857	0859	21.45	26.15	4.70	.0018	.9	2877			
16	16	HUDSON	9	0857	0859	21.80	25.45	3.65	.0018	.54	2303			
16	16	HUDSON	9	0857	0859	22.30	24.95	2.65	.0018	.28	1699			
16	16	HUDSON	9	0903	0905	21.45	26.15	4.70	.0018	.9	2332			
16	16	HUDSON	9	0903	0905	21.80	25.45	3.65	.0018	.54	1945			
16	16	HUDSON	9	0903	0905	22.30	24.95	2.65	.0018	.28	1320			
RUN:	2													
16	16	HUDSON	9	0912	0916	21.45	26.15	4.70	.0024	.9	2199			
16	16	HUDSON	9	0912	0916	21.90	25.50	3.60	.0024	.52	1835			
16	16	HUDSON	9	0912	0916	22.30	24.95	2.65	.0024	.28	1240			
16	16	HUDSON	9	0926	0929	21.35	26.05	4.70	.0018	.9	2537			
16	16	HUDSON	9	0926	0929	21.70	25.40	3.70	.0018	.55	1911			
16	16	HUDSON	9	0926	0929	22.20	24.80	2.60	.0018	.26	1236			
16	16	HUDSON	9	0932	0936	21.35	26.05	4.70	.0024	.9	2403			
16	16	HUDSON	9	0932	0936	21.70	25.40	3.70	.0024	.55	1930			
16	16	HUDSON	9	0932	0936	22.20	24.80	2.60	.0024	.26	1292			
RUN:	3													
16	16	HUDSON	9	0945	0947	21.35	26.05	4.70	.0018	.9	2194			
16	16	HUDSON	9	0945	0947	21.70	25.40	3.70	.0018	.55	1825			
16	16	HUDSON	9	0945	0947	22.20	24.80	2.60	.0018	.26	1257			
16	16	HUDSON	9	0953	0959	21.35	26.05	4.70	.0036	.9	2131			
16	16	HUDSON	9	0953	0959	21.70	25.40	3.70	.0036	.55	1790			
16	16	HUDSON	9	0953	0959	22.20	24.80	2.60	.0036	.26	1232			
RUN:	1													
17	17	FITZGERALD	28	0906	0907					.24	1445	1445		
17	17	FITZGERALD	28	0909	0910					.35	1835	1835		
17	17	FITZGERALD	28	0912	0913					.47	2185.5	2185.5		
17	17	FITZGERALD	28	0916	0917					.72	2405.5	2405.5		
17	17	FITZGERALD	28	0919	0920					.98	2886	2886		
RUN:	1													
18	18	HUDSON	9	0849	0853	23.05	25.70	2.65	.0024	.28	1097			
18	18	HUDSON	9	0857	0859	23.05	25.70	2.65	.0018	.28	1516			
18	18	HUDSON	9	0903	0905	23.05	25.70	2.65	.0018	.28	1354			
18	18	HUDSON	9	0912	0916	22.60	26.15	3.55	.0024	.51	1830			
18	18	HUDSON	9	0926	0929	21.95	26.75	4.80	.0018	.94	2570			
18	18	HUDSON	9	0932	0936	21.75	26.95	5.20	.0024	1.1	2640			
18	18	HUDSON	9	0945	0947	23.20	25.50	2.30	.0018	.21	1156			
18	18	HUDSON	9	0953	0959	23.40	25.30	1.90	.0036	.14	608			
RUN:	1													
20	20	DOMONKOS	4	0940	0950					.65	890			

EXPERIMENT #: 12

NUCLEI MEASUREMENTS

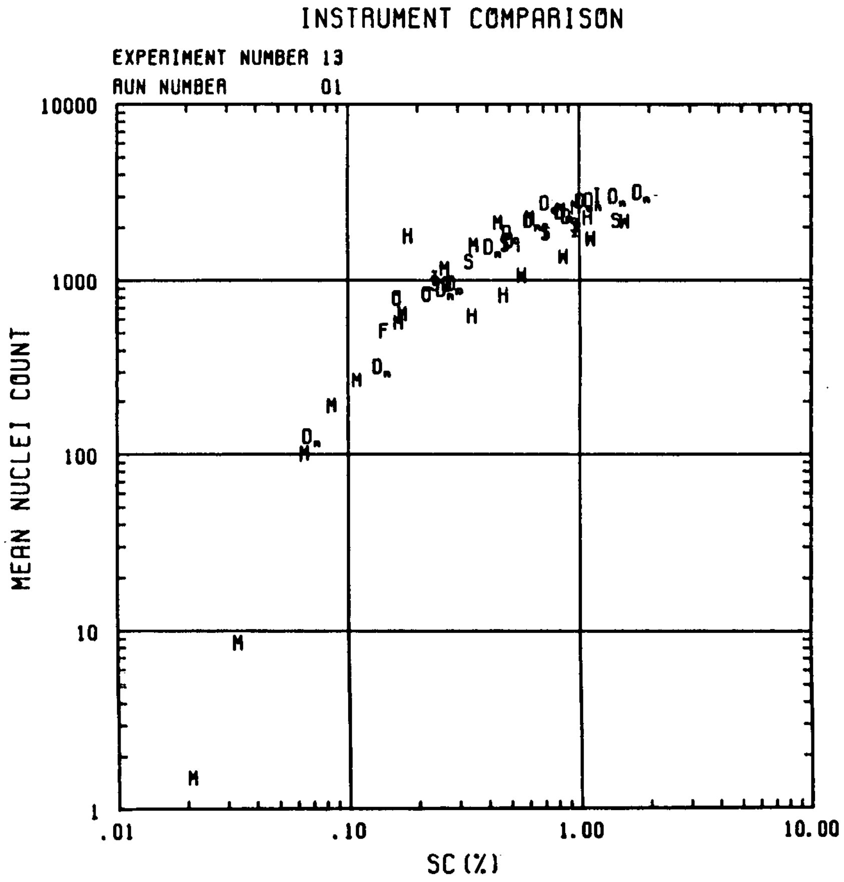
PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
20	20	DOMONKOS	4	0940						.85	1230			
20	20	DOMONKOS	4	0940						1.09	1290			
20	20	DOMONKOS	4	0940						1.54	1370			
RUN:	1													
21	21	TRUEBLOOD	26	0833	0834	20.00	25.00	5.00		1	3152			
21	21	TRUEBLOOD	26	0842	0843	21.62	25.00	3.38		.456	1327			
21	21	TRUEBLOOD	26	0846	0847	22.40	25.00	2.60		.27	958			
21	21	TRUEBLOOD	26	0900	0901	25.00	25.00	0.00		.068	136			
21	21	TRUEBLOOD	26	0900	0901	25.00	25.00	0.00		.089	272			
21	21	TRUEBLOOD	26	0900	0901	25.00	25.00	0.00		.114	405			
21	21	TRUEBLOOD	26	0900	0901	25.00	25.00	0.00		.173	962			
21	21	TRUEBLOOD	26	0912	0913	25.00	25.00	0.00		.022	1.97			
21	21	TRUEBLOOD	26	0912	0913	25.00	25.00	0.00		.035	10.58			
RUN:	2													
21	21	TRUEBLOOD	26	0924	0925	25.00	25.00	0.00		.068	123			
21	21	TRUEBLOOD	26	0924	0925	25.00	25.00	0.00		.089	253			
21	21	TRUEBLOOD	26	0924	0925	25.00	25.00	0.00		.114	372			
21	21	TRUEBLOOD	26	0924	0925	25.00	25.00	0.00		.173	853			
RUN:	1													
24	24	SERPOLAY	25	0840	0847	25.30	28.30	3.00	.77	.34	1080			
24	24	SERPOLAY	25	0855	0905	25.80	29.80	4.00	.77	.59	1960			
24	24	SERPOLAY	25	0910	0915	26.10	30.70	4.60	.77	.75	2290			
24	24	SERPOLAY	25	0930	0940	26.10	28.30	2.20	.77	.18	650			
24	24	SERPOLAY	25	0945	0955	26.20	27.80	1.60	.77	.1	450			
RUN:	1													
25	25	BORYS	3	0840	0846	22.20	23.40	1.20	10.6	.045	184	184	.69	SAMP.VOL X10**5
25	25	BORYS	3	0850	0856	21.90	23.70	1.80	10.6	.125	608	608		
25	25	BORYS	3	0906	0915	21.20	23.80	2.60	10.6	.26	778	778		
25	25	BORYS	3	0920	0925	20.00	23.80	3.80	10.6	.58	1160	1160		
25	25	BORYS	3	0939	0942	19.10	23.60	4.50	5.3	.83	2273	2273		
25	25	BORYS	3	0943	0945	18.30	23.80	5.50	3.18	1.32	2373	2373		
25	25	BORYS	3	0948	0949	16.50	23.70	7.20	2.12	2.19	4032	4032		
RUN:	1													
26	26	HINDMAN	6	0843	0932									INSTRUMENT DOWN. NOTE :ALL DATA FROM EXP F TOFF. LATEX SPHERE CALIBR. USED. ALSO. COUNTS ARE LOW DUE TO SUBSATURATED HAZE CHAMBER.
26	26	HINDMAN	6	0843	0932									
26	26	HINDMAN	6	0843	0932									
26	26	HINDMAN	6	0843	0932									
26	26	HINDMAN	6	0843	0932									
26	26	HINDMAN	6	0843	0932									
26	26	HINDMAN	6	0843	0932									
26	26	HINDMAN	6	0843	0932									
RUN:	1													
27	27	OHTAKE	19	0833	0833				10.5		1.737			125% R.H. NOMINAL


INSTRUMENT COMPARISON

EXPERIMENT NUMBER 13
RUN NUMBER 01

HAZE CHAMBER RESULTS


INSTRUMENT COMPARISON

EXPERIMENT NUMBER 13
RUN NUMBER 01

SDC/CFD RESULTS

```
                                        EXPERIMENT # 13
                                                                                  80/10/10
PURPOSE
-------
 POLYDISPERSE FOR MODERATE K.

DESCRIPTION OF EXPERIMENT
-------------------------
                TIME
  DATE          START   END
  ------------  -----------
  10 OCT,1980   1017   1300

  NUCLEI TYPE
  -----------
   (NH4)2SO4

  GENERATION METHOD
  -----------------
   NANOMIST, 5.5 PSI, PREDILUTION 150 BR., 1.77 G/L SOLUTION.

  SIZE DISTRIBUTION SHAPING
  -------------------------
   NONE

REMARKS
-------
 DILUTION FLOW RATE 590 L/MIN., UNSTABLE, SEE STRIPCHART FOR REFERENCE.

WEATHER SYNOPSIS
----------------
 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
        ROOM CONDITIONS                          OUTSIDE CONDITIONS

 ------------------------------   ----------------------------------------------
 AVG TEMP     AVG RH   AVG PRESS   AVG TEMP   AVG RH   AVG PRESS   AVG WS   AVG WD
   (C)         (%)       (MB)        (C)       (%)       (MB)      (M/S)    (DEG)
 --------     ------   ---------   --------   ------   ---------   ------   ------
   27.0        21.0      850         NA         NA        NA         NA       NA
```

EXPERIMENT #: 13

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
RUN:	1													
2	2	POGERS. DAVE	22	1205	1207	23.90	26.00	2.10		.17		823		
2	2	ROGERS. DAVE	22	1208	1209	23.80	26.20	2.40		.23		867		
RUN:	1													
9	9	GAGIN	5	1144		22.70	28.10	5.40	1.2	1.14	2340			
9	9	GAGIN	5	1147		24.60	28.30	3.70	1.2	.49	850			
9	9	GAGIN	5	1152		25.50	28.50	3.00	1.2	.36	650			
9	9	GAGIN	5	1154		26.10	28.30	2.20	1.2	.19	1840			
RUN:	2													
9	9	GAGIN	5	1159					1.2	.98	2450			
9	9	GAGIN	5	1201					1.2	.44	1030			
9	9	GAGIN	5	1203		25.60	28.10	2.50	1.2	.22	740			
9	9	GAGIN	5	1206		26.30	28.30	2.00	1.2	.16	240			
RUN:	3													
9	9	GAGIN	5	1211		23.20	27.90	4.70	1.2	.85	1440			
9	9	GAGIN	5	1213		24.60	28.20	3.60	1.2	.49	930			
9	9	GAGIN	5	1216		25.10	28.40	3.30	1.2	.42	640			
9	9	GAGIN	5	1218		26.20	28.40	2.20	1.2					
RUN:	1													
10	10	LALA	13	1143		23.00	25.53	2.53	.4	.25	938.9			
10	10	LALA	13	1144		22.54	25.52	2.98	.4	.35	1307.8			
10	10	LALA	13	1145		21.94	25.50	3.56	.4	.5	1583.3			
10	10	LALA	13	1146		21.12	25.47	4.35	.4	.75	1883.7			
10	10	LALA	13	1147		20.42	25.42	5.00	.4	1	1980.9			
10	10	LALA	13	1148		19.28	25.38	6.10	.4	1.5	2176			
10	10	LALA	13	1149		19.15	25.24	6.09	.4	1.5	2363.4			
10	10	LALA	13	1150		20.18	25.18	5.00	.4	1	2251.2			
10	10	LALA	13	1151		20.79	25.12	4.33	.4	.75	1959			
10	10	LALA	13	1152		21.54	25.09	3.55	.4	.5	1749			
10	10	LALA	13	1153		22.10	25.07	2.97	.4	.35	1330.5			
10	10	LALA	13	1154		22.61	25.13	2.52	.4	.25	1036.8			
RUN:	2													
10	10	LALA	13	1158		23.34	25.60	2.26	.4	.2	891.1			
10	10	LALA	13	1159		22.82	25.60	2.78	.4	.3	1330.9			
10	10	LALA	13	1200		22.39	25.58	3.19	.4	.4	1591.9			
10	10	LALA	13	1201		21.98	25.55	3.57	.4	.5	1837.2			
10	10	LALA	13	1202		21.61	25.51	3.90	.4	.6	2019.1			
10	10	LALA	13	1203		21.28	25.48	4.20	.4	.7	2123.6			
10	10	LALA	13	1204		20.95	25.43	4.48	.4	.8	2216.8			
10	10	LALA	13	1205		20.66	25.41	4.75	.4	.9	2214.1			AEROSOL FLUCTUATIONS
10	10	LALA	13	1200		20.38	25.38	5.00	.4	1	2511.9			
10	10	LALA	13	1201		19.24	25.33	6.09	.4	1.5	2561.2			
RUN:	1													
11	11	FITZGERALD	28	1238	1255					.15	740	740		ISOTHERMAL CHAMBER
11	11	FITZGERALD	28	1238	1255					.094	330	330		
11	11	FITZGERALD	28	1238	1255					.034	18.8	18.8		
11	11	FITZGERALD	28	1238	1255					.025	7.4	7.4		
11	11	FITZGERALD	28	1238	1255					.014	.92	.92		
RUN:	1													
13	13	AYERS	2	1145	1146	26.01	28.50	2.49		.25	1058			
13	13	AYERS	2	1147	1148	24.92	28.50	3.58		.5	1680			

EXPERIMENT #: 13

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

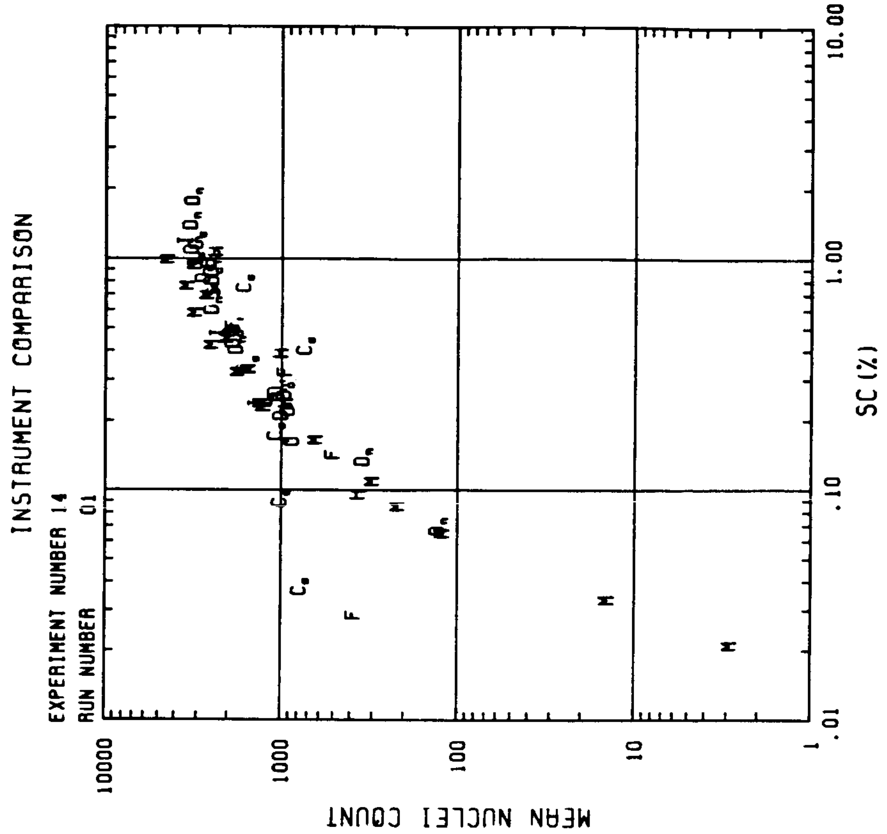
MACH NO.	DUCT NO.	OBSERVER		SAMPLE	TIME	PLATE TEMP			VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
		NAME	NO.	START	END	COLD	HOT (C)	DELTA						
13	13	AYERS	2	1149	1150	24.14	28.50	4.36		.75	1965			
13	13	AYERS	2	1150	1151	23.36	28.40	5.04		1	2025			
13	13	AYERS	2	1151	1152	22.77	28.40	5.63		1.25	3150			
RUN:	2													
13	13	AYERS	2	1152	1153	22.77	28.40	5.63		1.25	3975			PHOTOGRAPHIC RECORDS
13	13	AYERS	2	1153	1154	23.40	28.40	5.00		1	2325			TAKEN
13	13	AYERS	2	1154	1155	23.93	28.30	4.37		.75	2025			
13	13	AYERS	2	1156	1157	24.76	28.30	3.54		.5	1725			
13	13	AYERS	2	1158	1159	25.80	28.30	2.50		.25	1260			
RUN:	3													
13	13	AYERS	2	1242	1243	27.03	29.60	2.57		.25	1283			PHOTOGRAPHIC RECORDS
13	13	AYERS	2	1243	1244	26.05	29.60	3.55		.5	2130			TAKEN
13	13	AYERS	2	1245	1246	25.14	29.50	4.36		.75	2400			
13	13	AYERS	2	1246	1247	24.35	29.40	5.05		1	2850			
13	13	AYERS	2	1247	1248	23.78	29.40	5.62		1.25	3750			
RUN:	1													
14	14	HUDSON	9	1148	1219				.018	.21	283			F=41
14	14	HUDSON	9	1148	1219				.018	.14	209			F=41
14	14	HUDSON	9	1148	1219				.018	.11	106			F=41
14	14	HUDSON	9	1148	1219				.018	.04	4.43			F=41
14	14	HUDSON	9	1148	1219				.018	.029	1.62			F=41
14	14	HUDSON	9	1220	1250				.018	.21	302			F=41
14	14	HUDSON	9	1220	1250				.018	.14	219			F=41
14	14	HUDSON	9	1220	1250				.018	.11	109			F=41
14	14	HUDSON	9	1220	1250				.018	.04	4.69			F=41
14	14	HUDSON	9	1220	1250				.018	.029	1.72			F=41
RUN:	2													
14	14	HUDSON	9	1251	1326				.02	.21	338			F=41
14	14	HUDSON	9	1251	1326				.02	.14	248			F=41
14	14	HUDSON	9	1251	1326				.02	.11	123			F=41
14	14	HUDSON	9	1251	1326				.02	.04	5.55			F=41
14	14	HUDSON	9	1251	1326				.02	.029	2.02			F=41
RUN:	1													
15	15	ROGERS, FRED	23	1158	1159	18.36	25.06	6.70		1.86	3291			BACKGROUND 10 PER CC
15	15	ROGERS, FRED	23	1202	1203	18.74	24.75	6.01		1.46	3114			AVERAGING LAST 4
15	15	ROGERS, FRED	23	1206	1207	19.11	24.44	5.33		1.15	2976			COUNTS PER SS
15	15	ROGERS, FRED	23	1211	1212	19.49	24.13	4.64		.87	2554			
15	15	ROGERS, FRED	23	1215	1216	19.87	23.81	3.94		.63	2275			
15	15	ROGERS, FRED	23	1219	1220	20.25	23.50	3.25		.425	1596			MAY NEED TO REDUCE
15	15	ROGERS, FRED	23	1223	1224	20.63	23.19	2.56		.265	915			MAIN FLOW FOR
15	15	ROGERS, FRED	23	1227	1228	20.99	22.88	1.89		.14	334			LOWEST SS PTS
15	15	ROGERS, FRED	23	1231	1232	21.35	22.56	1.21		.07	131			LAST PNT CH 3
RUN:	1													
16	16	HUDSON	9	1146	1148	21.35	26.10	4.75	.0018	.92	2120			
16	16	HUDSON	9	1146	1148	21.70	25.30	3.60	.0018	.52	1526			
16	16	HUDSON	9	1146	1148	22.20	24.85	2.65	.0018	.28	876			
16	16	HUDSON	9	1155	1200	21.35	26.10	4.75	.003	.92	2496			
16	16	HUDSON	9	1155	1200	21.70	25.30	3.60	.003	.52	1802			
16	16	HUDSON	9	1155	1200	22.20	24.85	2.65	.003	.28	1028			
16	16	HUDSON	9	1206	1209	21.35	26.10	4.75	.0024	.92	2511			
16	16	HUDSON	9	1206	1209	21.70	25.30	3.60	.0024	.52	1830			
16	16	HUDSON	9	1206	1209	22.20	24.85	2.65	.0024	.28	1034			
RUN:	2													
16	16	HUDSON	9	1229	1233	21.35	26.10	4.75	.0024	.92	2622			

NUCLEI MEASUREMENTS

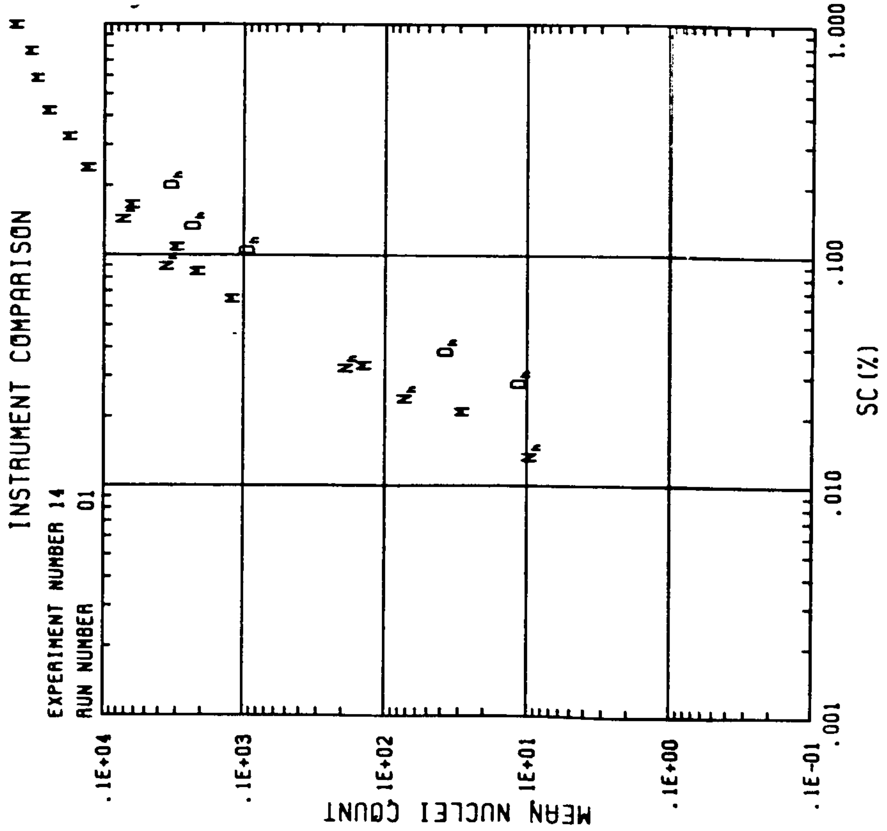
EXPERIMENT #: 13

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
16	16	HUDSON	9	1229	1233	21.70	25.30	3.60	.0024	.52	1941			
16	16	HUDSON	9	1229	1233	22.20	24.85	2.65	.0024	.78	1069			
16	16	HUDSON	9	1238	1242	21.35	26.10	4.75	.003	.92	2898			
16	16	HUDSON	9	1238	1242	21.70	25.30	3.60	.003	.52	2163			
16	16	HUDSON	9	1238	1242	22.20	24.85	2.65	.003	.28	1146			
RUN:	1													
18	18	HUDSON	9	1146	1148	23.15	25.85	2.70	.0018	.29	990			
18	18	HUDSON	9	1155	1200	22.65	26.35	3.70	.003	.51	1910			
18	18	HUDSON	9	1206	1209	22.20	26.80	4.60	.0024	.86	2532			
18	18	HUDSON	9	1229	1233	23.15	25.85	2.70	.0024	1.05	2938			
18	18	HUDSON	9	1238	1242	22.40	26.70	4.30	.003	.74	2847			
RUN:	1													
20	20	DOMONKOS	4	1130	1135					.59	1103			
20	20	DOMONKOS	4	1130	1135					.89	1410			
20	20	DOMONKOS	4	1130	1135					1.17	1780			
20	20	DOMONKOS	4	1130	1135					1.64	2230			
RUN:	1													
21	21	TRUEBLOOD	26	1145	1147	19.98	25.00	5.02		1.01	2727			
21	21	TRUEBLOOD	26	1150	1150	20.48	25.00	4.52		.8717	2610			
21	21	TRUEBLOOD	26	1153	1155	21.00	25.00	4.00		.64	2366			
21	21	TRUEBLOOD	26	1157	1158	21.58	25.00	3.42		.468	2212			
21	21	TRUEBLOOD	26	1201	1202	21.97	25.00	3.03		.367	1634			
21	21	TRUEBLOOD	26	1205	1206	22.38	25.00	2.62		.275	1212			
21	21	TRUEBLOOD	26	1209	1210	22.88	25.00	2.12		.18	663			
21	21	TRUEBLOOD	26	1217	1219	25.00	25.00	0.00		.173	596.9			
21	21	TRUEBLOOD	26	1217	1219	25.00	25.00	0.00		.114	276.3			
21	21	TRUEBLOOD	26	1217	1219	25.00	25.00	0.00		.089	197.7			
21	21	TRUEBLOOD	26	1217	1219	25.00	25.00	0.00		.068	104.1			
21	21	TRUEBLOOD	26	1226	1228	25.00	25.00	0.00		.035	8.84			
21	21	TRUEBLOOD	26	1226	1228	25.00	25.00	0.00		.022	1.55			
21	21	TRUEBLOOD	26	1226	1228	25.00	25.00	0.00		.0133	0			
RUN:	1													
24	24	SERPOLAY	25	1155	1200	27.40	29.40	2.00	.77	.15	530			ONLY ONE MEASUREMENT AT S=000.150
24	24	SERPOLAY	25	1155	1200									
RUN:	1													
26	26	HINDMAN	6	1148	1237									INSTRUMENT DOWN. REPAIRING CHAMBER.
26	26	HINDMAN	6	1148	1237									



SDC/CFD RESULTS



HAZE CHAMBER RESULTS

```
                                        EXPERIMENT # 14                                  80/10/10
PURPOSE
-------
 SAME AS #13.

DESCRIPTION OF EXPERIMENT
-------------------------
                   TIME
  DATE             START   END
  ------------    -----------
  10 OCT.1980     1335    1444

  NUCLEI TYPE
  -----------
   (NH4)2SO4, POLYDISPSERSE.

  GENERATION METHOD
  -----------------
   NANOMIST, 5.5 PSI, PREDILUTION 150 BR., 1.77 G/L SOLUTION.

  SIZE DISTRIBUTION SHAPING
  -------------------------
   NONE

REMARKS
-------
 STABILITY VARIES, SEE STRIPCHART FOR ADJUSTMENTS.

WEATHER SYNOPSIS
----------------
 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
         ROOM CONDITIONS                          OUTSIDE CONDITIONS

 ------------------------------   ---------------------------------------------------
 AVG TEMP    AVG RH    AVG PRESS   AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)        (%)        (MB)        (C)        (%)        (MB)       (M/S)     (DEG)
 --------    ------    ---------   --------    ------    ---------    ------    ------
   27.0       21.0       850         NA          NA         NA          NA        NA
```

EXPERIMENT #: 14

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
RUN: 1														
2	2	POLITOVICH	20	1428	1429	18.90	21.00	2.10		.17		903		
2	2	POLITOVICH	20	1430	1431	19.20	21.60	2.40		.23		950		
RUN: 1														
9	9	GAGIN	5	1347		22.90	28.30	5.40	1.2	1.12	2480			
9	9	GAGIN	5	1349		24.60	27.90	3.30	1.2	.41	1050			
9	9	GAGIN	5	1352		25.40	28.00	2.60	1.2	.25	980			
9	9	GAGIN	5	1355		26.60	28.30	1.70	1.2	.1	380			
RUN: 2														
9	9	GAGIN	5	1358		23.30	28.10	4.80	1.2	.87	1950			
9	9	GAGIN	5	1402		24.60	28.30	3.70	1.2	.49	900			
9	9	GAGIN	5	1405		25.60	28.30	2.70	1.2	.25	640			
9	9	GAGIN	5	1408		26.40	28.10	1.70	1.2	.12	220			
RUN: 3														
9	9	GAGIN	5	1412		22.80	28.00	5.20	1.2	1.08	2670			
9	9	GAGIN	5	1414		24.50	28.00	3.50	1.2	.46	940			
9	9	GAGIN	5	1416		25.60	27.90	2.30	1.2	.19	550			
9	9	GAGIN	5	1418		26.40	28.40	2.00	1.2	.16	300			
RUN: 1														
10	10	LALA	13	1348		23.29	25.83	2.54	.4	.25	1318.6			
10	10	LALA	13	1349		23.26	25.79	2.53	.4	.25	1254.7			
10	10	LALA	13	1350		22.76	25.76	3.00	.4	.35	1649.8			
10	10	LALA	13	1351		22.73	25.72	2.99	.4	.35	1754.7			
10	10	LALA	13	1352		22.10	25.67	3.57	.4	.5	2092.3			
10	10	LALA	13	1353		22.07	25.63	3.56	.4	.5	2070.3			
10	10	LALA	13	1354		21.25	25.60	4.35	.4	.75	2600.3			
10	10	LALA	13	1355		21.20	25.55	4.35	.4	.75	2578.3			
10	10	LALA	13	1356		20.49	25.50	5.01	.4	1	2677.2			
10	10	LALA	13	1356		20.38	25.38	5.00	.4	1	2793.3			
RUN: 2														
10	10	LALA	13	1356		23.11	25.37	2.26	.4	.2	1101.6			
10	10	LALA	13	1357		22.62	25.38	2.76	.4	.3	1708.8			
10	10	LALA	13	1358		22.19	25.37	3.18	.4	.4	1984.3			
10	10	LALA	13	1359		21.81	25.36	3.55	.4	.5	2208.6			
10	10	LALA	13	1400		21.46	25.35	3.89	.4	.6	2479.8			
10	10	LALA	13	1401		21.16	25.36	4.20	.4	.7	2644.5			
10	10	LALA	13	1402		20.84	25.32	4.48	.4	.8	2721.5			
10	10	LALA	13	1403		20.53	25.28	4.75	.4	.9	2783.2			
10	10	LALA	13	1404		20.26	25.25	4.99	.4	1	2802			
10	10	LALA	13	1405		19.13	25.22	6.09	.4	1.5	2880			
RUN: 1														
11	11	FITZGERALD	28	1337	1353					.15	773	773		
11	11	FITZGERALD	28	1337	1353					.094	377	377		
11	11	FITZGERALD	28	1337	1353					.034	19.9	19.9		
11	11	FITZGERALD	28	1337	1353					.025	7.6	7.6		
11	11	FITZGERALD	28	1337	1353					.014	1	1		
RUN: 2														
11	11	FITZGERALD	28	1359	1416					.15	758	758		
11	11	FITZGERALD	28	1359	1416					.094	358	358		
11	11	FITZGERALD	28	1359	1416					.034	19.8	19.8		
11	11	FITZGERALD	28	1359	1416					.025	7.66	7.66		
11	11	FITZGERALD	28	1359	1416					.014	1.06	1.06		

```
                                                                 NUCLEI MEASUREMENTS
EXPERIMENT #: 14                                                                                                                    PROCESSING DATE:  81/09/26
                     OBSERVER                                             PLATE TEMP
MACH  DUCT  ------------------------------   SAMPLE  TIME                                    VOLUME   SUPER   NUCLEI     OBS      EST
NO.   NO.   NAME                      NO.    START   END      COLD     HOT      DELTA     SAMPLED   SAT     COUNT       -        K      REMARKS
                                                                        (C)                 (L)      (%)                N
----  ----  --------------------- ---   -----   ----     ------   ------   ------   -------   ------  ------     -----    -----   -------------------

RUN:  1

 13    13   AYERS                      2    1352    1353     27.23    29.80     2.57               .25    1440
 13    13   AYERS                      2    1353    1354     26.20    29.80     3.60               .5     2400
 13    13   AYERS                      2    1356    1357     25.22    29.60     4.38               .75    2625
 13    13   AYERS                      2    1357    1358     24.50    29.60     5.10              1       3255
 13    13   AYERS                      2    1358    1359     23.87    29.50     5.63              1.25    3675

RUN:  2

 13    13   AYERS                      2    1359    1400     23.89    29.50     5.61              1.25    4050
 13    13   AYERS                      2    1400    1401     24.35    29.40     5.05              1       3000
 13    13   AYERS                      2    1402    1403     24.92    29.30     4.38               .75    2250
 13    13   AYEPS                      2    1405    1406     25.75    29.30     3.55               .5     1995
 13    13   AYERS                      2    1406    1407     23.27    29.20     5.93               .25    1110

RUN:  1

 14    14   HUDSON                     9    1345    1355                                 .0056     .21     396                           F=41
 14    14   HUDSON                     9    1345    1355                                 .0056     .14     291                           F=41
 14    14   HUDSON                     9    1345    1355                                 .0056     .11     145                           F=41
 14    14   HUDSON                     9    1345    1355                                 .0056     .04    6.28                           F=41
 14    14   HUDSON                     9    1345    1355                                 .0056    .029    2.24                           F=41
 14    14   HUDSON                     9    1407    1435                                 .0016     .21     303                           F=55
 14    14   HUDSON                     9    1407    1435                                 .0016     .14     196                           F=55
 14    14   HUDSON                     9    1407    1435                                 .0016     .11      53                           F=55
 14    14   HUDSON                     9    1407    1435                                 .0016     .04    1.61                           F=55
 14    14   HUDSON                     9    1407    1435                                 .0016    .029     .15                           F=55

RUN:  1

 15    15   ROGERS, FRED              23    1337    1338     18.36    25.06     6.70              1.86    3378                           BACKGROUND CNT
 15    15   ROGERS, FRED              23    1341    1342     18.74    24.75     6.01              1.46    3450                           10 PER CC.
 15    15   ROGERS, FRED              23    1345    1346     19.11    24.44     5.33              1.15    3438
 15    15   ROGERS, FRED              23    1350    1351     19.49    24.13     4.64               .87    2912
 15    15   ROGERS, FRED              23    1354    1355     19.87    23.81     3.94               .63    2612                           DROP SIZE PLATEAU
 15    15   ROGERS, FRED              23    1358    1359     20.25    23.50     3.25              .425    1891                           BAD AT LOWER SS.
 15    15   ROGERS, FRED              23    1402    1403     20.63    23.19     2.56              .265    1095                           LOWERED MAIN FLO
 15    15   ROGERS, FRED              23    1406    1407     20.99    22.88     1.89               .14     359                           FROM 1495 TO 1315.
 15    15   ROGERS, FRED              23    1410    1411     21.35    22.56     1.21               .07     136                           LAST FEW MIN
 15    15   ROGERS, FRED              23    1410    1411                                                                                 AEROSOL LOW 15 PCT.

RUN:  1

 16    16   HUDSON                     9    1420    1424     21.35    26.10     4.75     .0024     .92    2347
 16    16   HUDSON                     9    1420    1424     21.70    25.30     3.60     .0024     .52    1789
 16    16   HUDSON                     9    1420    1424     22.20    24.85     2.65     .0024     .28    1026
 16    16   HUDSON                     9    1429    1433     21.35    26.10     4.75     .0024     .92    2727
 16    16   HUDSON                     9    1429    1433     21.70    25.30     3.60     .0024     .52    2041
 16    16   HUDSON                     9    1429    1433     22.20    24.85     2.65     .0024     .28    1160
 16    16   HUDSON                     9    1434    1438     21.35    26.10     4.75     .0024     .92    2839
 16    16   HUDSON                     9    1434    1438     21.70    25.30     3.60     .0024     .52    2064
 16    16   HUDSON                     9    1434    1438     22.20    24.85     2.65     .0024     .28    1198

RUN:  1

 17    17   WOJCIECHOWSKI             27    1340    1341                                           .24    1312      1312
 17    17   WOJCIECHOWSKI             27    1343    1344                                           .35    1598      1598
 17    17   WOJCIECHOWSKI             27    1347    1349                                           .47    2161      2161
 17    17   WOJCIECHOWSKI             27    1352    1353                                           .73    2797      2797
 17    17   WOJCIECHOWSKI             27    1355    1357                                           .98    3295      3295

RUN:  1

 18    18   HUDSON                     9    1327    1337     22.80    26.15     3.35     .0054     .45    1965
```

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                                                            NUCLEI MEASUREMENTS
EXPERIMENT #: 14                                                                                                   PROCESSING DATE:  81/09/26
                   OBSERVER                                          PLATE TEMP
MACH  DUCT  ---------------------   SAMPLE  TIME                                   VOLUME   SUPER   NUCLEI    OBS      EST
NO.   NO.   NAME              NO.   START    END    COLD     HOT     DELTA   SAMPLED   SAT     COUNT      -        K     REMARKS
                                                             (C)              (L)      (%)                N
----  ----  ---------------  ---    -----   ----   ------   ------   ------  -------  ------   ------   -----    -----   --------------------
 18    18   HUDSON             9    1402    1406   23.30    26.65    2.35    .0024      .22     1051
 18    18   HUDSON             9    1420    1424   23.20    25.80    2.60    .0024      .27     1011
 18    18   HUDSON             9    1429    1433   22.25    26.80    4.55    .0024      .84     2608
 18    18   HUDSON             9    1434    1438   22.00    27.00    5.00    .0024       1      2713

RUN:   1

 21    21   TRUEBLOOD         26    1344    1345   19.90    25.00    5.10              1.04   4628.6
 21    21   TRUEBLOOD         26    1348    1349   20.52    25.00    4.48              .803     3595
 21    21   TRUEBLOOD         26    1352    1354   21.08    25.00    3.92              .615     3230
 21    21   TRUEBLOOD         26    1356    1357   21.67    25.00    3.33              .444     2612
 21    21   TRUEBLOOD         26    1402    1403   22.08    25.00    2.92              .341     1852
 21    21   TRUEBLOOD         26    1406    1407   22.50    25.00    2.50               .25     1371
 21    21   TRUEBLOOD         26    1410    1411   22.92    25.00    2.08              .173    687.9
 21    21   TRUEBLOOD         26    1421    1422   25.00    25.00    0.00              .173    640.1
 21    21   TRUEBLOOD         26    1421    1422   25.00    25.00    0.00              .114    315.7
 21    21   TRUEBLOOD         26    1421    1422   25.00    25.00    0.00              .089      225
 21    21   TRUEBLOOD         26    1421    1422   25.00    25.00    0.00              .068    126.1
 21    21   TRUEBLOOD         26    1429    1431   25.00    25.00    0.00              .035     14.8
 21    21   TRUEBLOOD         26    1429    1431   25.00    25.00    0.00              .022     2.97
 21    21   TRUEBLOOD         26    1429    1431   25.00    25.00    0.00             .0133        0

RUN:   1

 24    24   SERPOLAY          25    1340    1355   25.70    26.70    1.00      .77      .03      400
 24    24   SERPOLAY          25    1407    1415   26.10    26.10    2.00      .77      .15      530
 24    24   SERPOLAY          25    1430    1435   26.70    29.70    3.00      .77      .34     1000
 24    24   SERPOLAY          25    1445    1447   27.20    31.00    3.80      .77      .54     1960

RUN:   1

 25    25   BORYS              3    1341    1348   25.50    26.50    1.00     10.6     .038      820      820      .33   VOL SAMP X 10**5
 25    25   BORYS              3    1351    1358   24.60    26.20    1.60     10.6     .092     1061     1061
 25    25   BORYS              3    1407    1414   23.70    25.90    2.20     10.6      .18     1132     1132
 25    25   BORYS              3    1418    1425   22.70    25.80    3.10     10.6      .42      764      764
 25    25   BORYS              3    1428    1432   21.60    25.90    4.30     6.36      .79     1697     1697
 25    25   BORYS              3    1436    1438   20.70    25.90    5.20     3.18      1.2     3206    320.6

RUN:   1

 26    26   HINDMAN            6    1336    1349                                                                     INSTRUMENT DOWN
 26    26   HINDMAN            6    1336    1349                                                                     REPAIRING CHAMBER

RUN:   1

 27    27   OHTAKE            19    1358    1358                                11               .716                   103% R.H. NOMINAL
 27    27   OHTAKE            19    1358    1358                                11                1.1                   114% R.H. NOMINAL
```
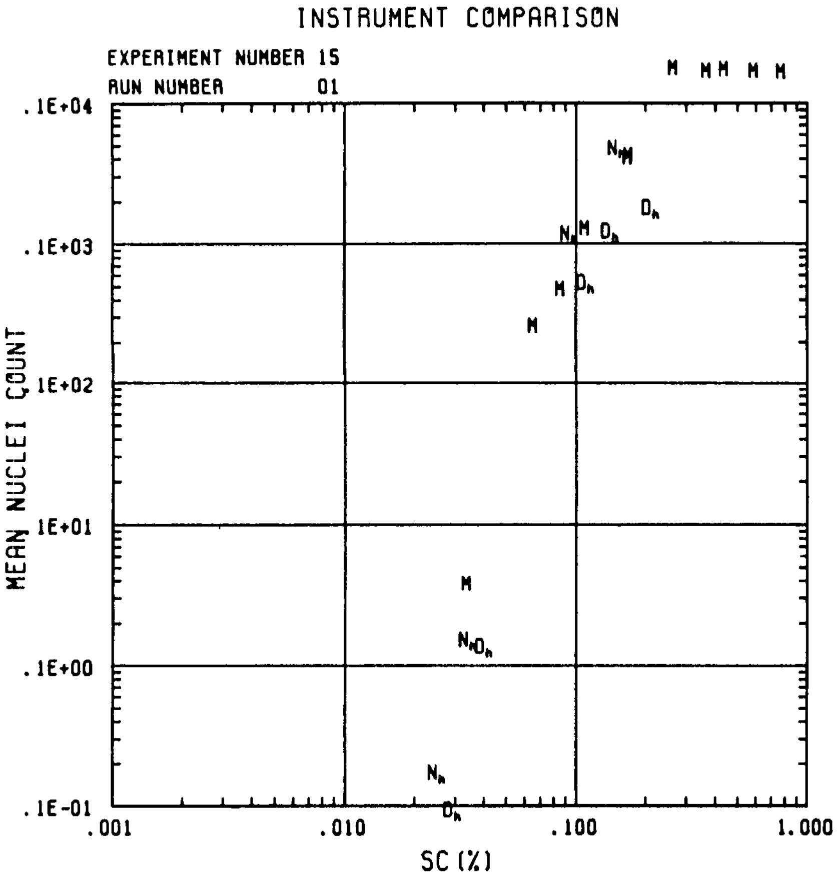
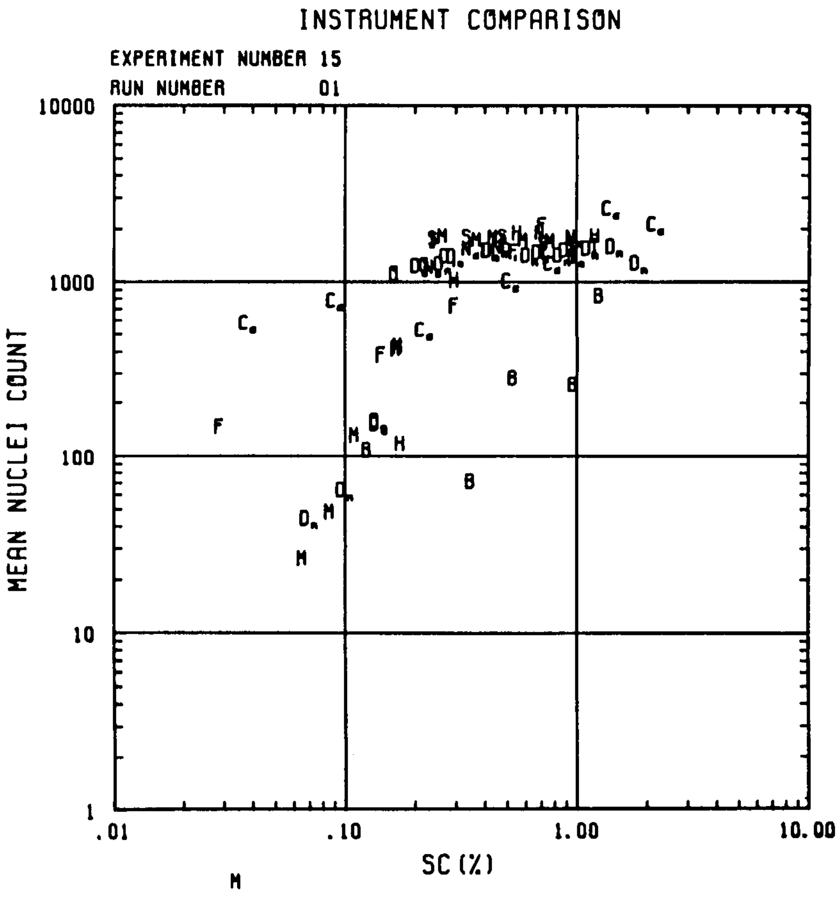


INSTRUMENT COMPARISON

HAZE CHAMBER RESULTS


INSTRUMENT COMPARISON

SDC/CFD RESULTS

```
                                          EXPERIMENT # 15
                                                                                          80/10/10
PURPOSE
-------

 MONODISPERSE AEROSOL WITH SIZE USEFUL TO BOTH HAZE AND CCN INTRUMENTS.
 I.E., Θ APPRUX. = 0.092 UM.

DESCRIPTION OF EXPERIMENT
-------------------------

  DATE          TIME
                START   END
  ------------  -----------
  10 OCT.1980   1455   1630

  NUCLEI TYPE
  -----------

   (NH4)2 SO4

  GENERATION METHOD
  -----------------

   DRI ATOMIZER, 50 PSI, PUMP 2.

  SIZE DISTRIBUTION SHAPING
  -------------------------

   EC, 2780 V., MONODISPERSE FLOWS 6 L/MIN.

REMARKS
-------

 DILUTION FLOW 390 L/MIN.

WEATHER SYNOPSIS
----------------

 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

        ROOM CONDITIONS                          OUTSIDE CONDITIONS

 ------------------------------    ----------------------------------------------------
 AVG TEMP    AVG RH   AVG PRESS    AVG TEMP    AVG RH   AVG PRESS   AVG WS    AVG WD
   (C)        (%)       (MB)         (C)        (%)       (MB)      (M/S)     (DEG)
 --------    ------   ---------    --------    ------   ---------   ------    ------
   27.0       21.0      850          NA          NA        NA         NA        NA
```

```
                                                         NUCLEI MEASUREMENTS
EXPERIMENT #: 15                                                                                                         PROCESSING DATE:  81/09/26
                    OBSERVER                                       PLATE TEMP
MACH  DUCT  ----------------------   SAMPLE  TIME                                    VOLUME    SUPER   NUCLEI     OBS      EST
NO.   NO.   NAME                NO.  START   END     COLD     HOT     DELTA    SAMPLED    SAT     COUNT       -        K      REMARKS
                                                               (C)               (L)      (%)                N
----  ----  ---------------  ---   -----   ----   ------   ------   ------   -------   ------   ------    -----    -----   -------------------

RUN:  1
  2     2   ROGERS, DAVE      22   1544    1545    21.70    23.80     2.10                .17              1138
  2     2   ROGERS, DAVE      22   1547    1549    21.60    24.00     2.40                .23              1279

RUN:  1
  5     5   KITCHEN           12   1555    1555    20.50    24.20     3.70                .55      294
  5     5   KITCHEN           12   1556    1556    21.20    24.20     3.00                .36       74
  5     5   KITCHEN           12   1557    1557    22.40    24.20     1.80                .13      111
  5     5   KITCHEN           12   1559    1559    18.60    24.20     5.60               1.3       857
  5     5   KITCHEN           12   1600    1600    19.40    24.20     4.80               1         268

RUN:  1
  9     9   GAGIN              5   1512            22.70    28.40     5.70      1.2     1.25     1900
  9     9   GAGIN              5   1514            24.30    28.20     3.90      1.2      .58     1970
  9     9   GAGIN              5   1517            25.30    28.20     2.90      1.2      .31     1060
  9     9   GAGIN              5   1520            26.30    28.10     1.80      1.2      .18      120
RUN:  2
  9     9   GAGIN              5   1524            22.60    28.20     5.60      1.2     1.23     2100
  9     9   GAGIN              5   1526            24.40    28.00     3.60      1.2      .49     2400
  9     9   GAGIN              5   1532            26.40    28.30     1.90      1.2      .18      140
RUN:  3
  9     9   GAGIN              5   1536            22.80    28.00     5.20      1.2     1.08     2080
  9     9   GAGIN              5   1538            24.40    28.10     3.70      1.2      .52     2070
  9     9   GAGIN              5   1542            25.40    28.30     2.90      1.2      .31     1000

RUN:  1
 10    10   LALA              13   1512            23.84    26.38     2.54       .4      .25   1915.2
 10    10   LALA              13   1513            23.84    26.38     2.54       .4      .25   1729.2   1822.2
 10    10   LALA              13   1514            23.37    26.38     3.01       .4      .35   1847.2
 10    10   LALA              13   1515            23.36    26.37     3.01       .4      .35   1903.8   1875.5
 10    10   LALA              13   1516            22.76    26.35     3.59       .4      .5    1859.5
 10    10   LALA              13   1517            22.72    26.30     3.58       .4      .5    1853.1   1856.3
 10    10   LALA              13   1518            21.90    26.28     4.38       .4      .75     1676
 10    10   LALA              13   1519            21.75    26.12     4.37       .4      .75     1749   1712.5
 10    10   LALA              13   1520            21.04    26.07     5.03       .4     1        1616
 10    10   LALA              13   1521            20.84    25.86     5.02       .4     1        1616     1616
RUN:  2
 10    10   LALA              13   1527            23.93    26.21     2.28       .4      .2    1606.2
 10    10   LALA              13   1528            23.42    26.21     2.79       .4      .3      1931
 10    10   LALA              13   1529            23.11    26.32     3.21       .4      .4      1846
 10    10   LALA              13   1530            22.70    26.29     3.59       .4      .5    1695.7
 10    10   LALA              13   1531            22.35    26.27     3.92       .4      .6      1788
 10    10   LALA              13   1532            22.02    26.24     4.22       .4      .7    1681.4
 10    10   LALA              13   1533            21.71    26.22     4.51       .4      .8    1675.4
 10    10   LALA              13   1534            21.40    26.18     4.78       .4      .9    1679.6
 10    10   LALA              13   1535            21.11    26.14     5.03       .4     1      1627.4

RUN:  1
 11    11   FITZGERALD        28   1512    1528                                         .15      501      501
 11    11   FITZGERALD        28   1512    1528                                        .094      125      125
 11    11   FITZGERALD        28   1512    1528                                        .034      .16      .16
 11    11   FITZGERALD        28   1512    1528                                        .025     .018     .018
 11    11   FITZGERALD        28   1512    1528                                        .014        0        0

RUN:  1
 13    13   AYERS              2   1512    1513    27.63    30.20     2.57                .25     1770                      PHOTOGRAPHIC RECORDS
```

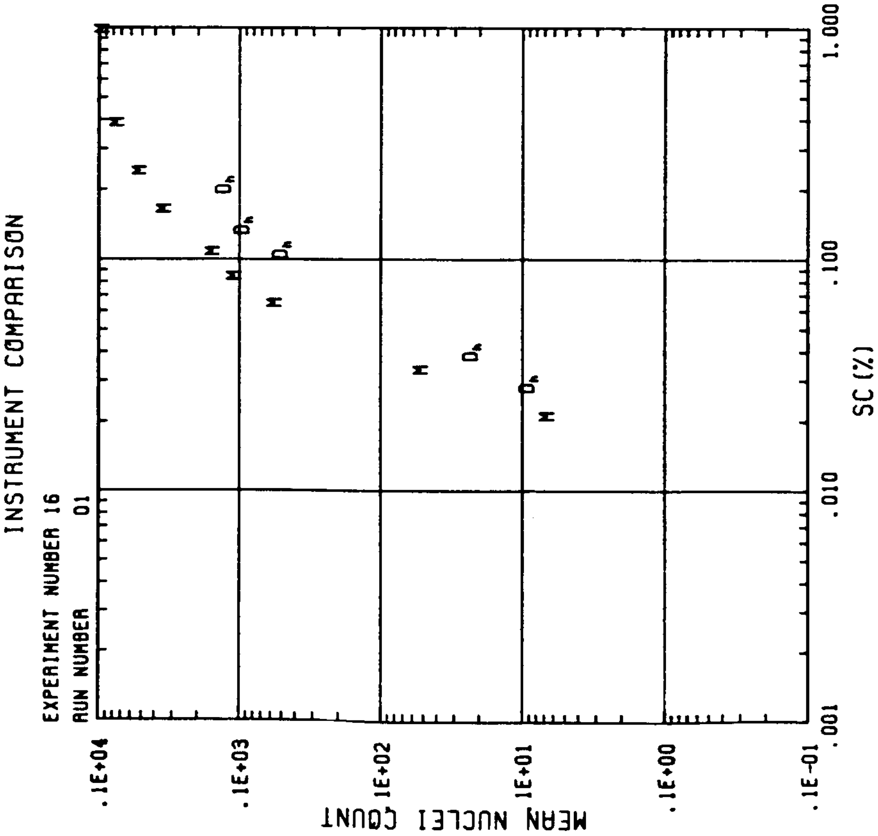
```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 15                                                                                                   PROCESSING DATE:  81/09/26

                    OBSERVER                                   PLATE TEMP
MACH  DUCT  -------------------  SAMPLE TIME                                   VOLUME   SUPER  NUCLEI   OBS    EST
NO.   NO.   NAME            NO.  START   END    COLD     HOT    DELTA  SAMPLED   SAT   COUNT     -      K     REMARKS
                                                         (C)              (L)    (%)              N
----  ----  --------------- ---  -----  ----  ------  ------  ------  -------  ------  ------  -----  -----  --------------------
 13    13   AYERS             2  1513   1514   26.48   30.10    3.62               .5    1755                TAKEN
 13    13   AYERS             2  1515   1516   25.63   30.00    4.37              .75    1545                ALL S. VALVES ARE
 13    13   AYERS             2  1516   1517   24.94   30.08    5.06                1    1673                APPROXIMATE ONLY.
 13    13   AYERS             2  1518   1519   24.25   29.90    5.65             1.25    1635

RUN:   2

 13    13   AYERS             2  1519   1520   24.16   29.80    5.64             1.25    1815                PHOTOGRAPHIC RECORDS
 13    13   AYERS             2  1520   1521   24.64   29.70    5.06                1    1890                TAKEN
 13    13   AYERS             2  1522   1523   25.19   29.60    4.41              .75    1710
 13    13   AYERS             2  1523   1524   26.00   29.60    3.60               .5    1740
 13    13   AYERS             2  1526   1527   26.97   29.50    2.53              .25    1493
 13    13   AYERS             2  1528   1529   27.57   29.50    1.93             .125      92
 13    13   AYERS             2  1529   1530   28.05   29.50    1.45             .075      21

RUN:   3

 13    13   AYERS             2  1608   1609   24.53   30.20    5.67             1.25    1905                PHOTOGRAPHIC RECORDS
 13    13   AYERS             2  1611   1612   25.58   30.00    4.42              .75    1575                TAKEN
 13    13   AYERS             2  1613   1614   26.28   30.00    3.72               .5    1905
 13    13   AYERS             2  1615   1616   27.38   29.90    2.52              .25    1620
 13    13   AYERS             2  1617   1618   27.95   29.90    1.95             .125     114
 13    13   AYERS             2  1618   1619   28.45   29.90    1.45             .075      21
 13    13   AYERS             2  1609   1610   25.03   30.10    5.07                1    1830

RUN:   1

 14    14   HUDSON            9  1522   1555                           .0186      .21     188                F=38.5
 14    14   HUDSON            9  1522   1555                           .0186      .14     127                F=38.5
 14    14   HUDSON            9  1522   1555                           .0186      .11    55.2                F=38.5
 14    14   HUDSON            9  1522   1555                           .0186      .04     .16                F=38.5
 14    14   HUDSON            9  1522   1555                           .0186     .029   .0117                F=38.5
 14    14   HUDSON            9  1556   1628                            .018      .21     191                F=38.5
 14    14   HUDSON            9  1556   1628                            .018      .14     131                F=38.5
 14    14   HUDSON            9  1556   1628                            .018      .11    56.1                F=38.5
 14    14   HUDSON            9  1556   1628                            .018      .04    .125                F=38.5
 14    14   HUDSON            9  1556   1628                            .018     .029   .0074                F=38.5

RUN:   1

 15    15   ROGERS, FRED     23  1513   1514   18.36   25.06    6.70             1.86    1321                REDUCED MAIN FLOW
 15    15   ROGERS, FRED     23  1517   1518   18.74   24.75    6.01             1.46    1636                TO ABOUT 1100 CNTS.
 15    15   ROGERS, FRED     23  1521   1522   19.11   24.44    5.33             1.15    1597                DROP SIZE PLATEAUS
 15    15   ROGERS, FRED     23  1525   1526   19.49   24.13    4.64              .87    1458                BAD FIRST TWO PTS.
 15    15   ROGERS, FRED     23  1530   1531   19.87   23.81    3.94              .63    1470                BACKGROUND 10/CC.
 15    15   ROGERS, FRED     23  1534   1535   20.25   23.50    3.25             .425    1556                DROP SIZE PLATEAU
 15    15   ROGERS, FRED     23  1538   1539   20.63   23.19    2.56             .265    1309                WORSENING AGAIN.
 15    15   ROGERS, FRED     23  1542   1543   20.99   22.88    1.89              .14     162                AVERAGING LAST 4
 15    15   ROGERS, FRED     23  1546   1547   21.35   22.56    1.21              .07      46                COUNTS PER SS
 15    15   ROGERS, FRED     23  1558   1559   21.20   22.72    1.52               .1      66                FOR WHOLE RUN

RUN:   1

 16    16   HUDSON            9  1510   1513   21.35   26.10    4.75     .018      .92    1533
 16    16   HUDSON            9  1510   1513   21.70   25.30    3.60    .0018      .52    1531
 16    16   HUDSON            9  1510   1513   22.20   24.85    2.65    .0018      .28    1399
 16    16   HUDSON            9  1518   1521   21.35   26.10    4.75    .0018      .92    1574
 16    16   HUDSON            9  1518   1521   21.70   25.30    3.60    .0018      .52    1574
 16    16   HUDSON            9  1518   1521   22.20   24.85    2.65    .0018      .28    1419
 16    16   HUDSON            9  1526   1529   21.35   26.10    4.75    .0018      .92    1584
 16    16   HUDSON            9  1526   1529   21.70   25.30    3.60    .0018      .52    1583
 16    16   HUDSON            9  1526   1529   22.20   24.85    2.65    .0018      .28    1508
RUN:   2

 16    16   HUDSON            9  1542   1545   21.35   26.10    4.75    .0018      .92    1611
 16    16   HUDSON            9  1542   1545   21.70   25.30    3.60    .0018      .52    1610
 16    16   HUDSON            9  1542   1545   22.20   24.85    2.65    .0018      .28    1535
```

EXPERIMENT #: 15

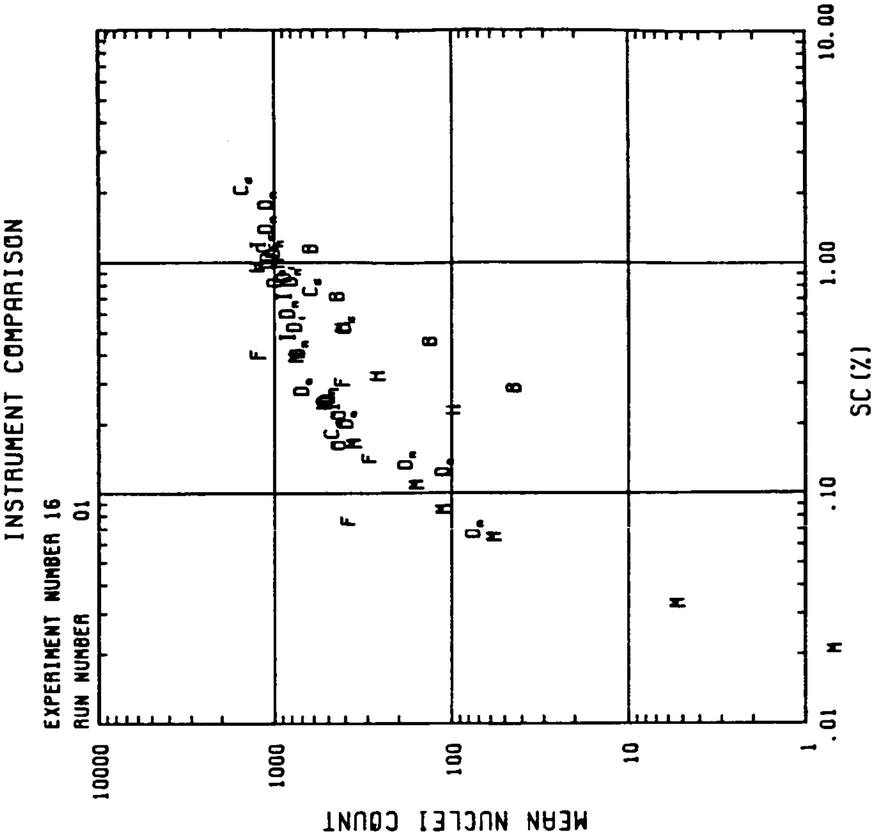
NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	PLATE TEMP DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
16	16	HUDSON	9	1604	1606	21.35	26.10	4.75	.0012	.92	1573			
16	16	HUDSON	9	1604	1606	21.70	25.30	3.60	.0012	.52	1571			
16	16	HUDSON	9	1604	1606	22.20	24.85	2.65	.0012	.28	1355			
16	16	HUDSON	9	1619	1623	21.35	26.10	4.75	.0024	.92	1575			
16	16	HUDSON	9	1619	1623	21.70	25.30	3.60	.0024	.52	1574			
16	16	HUDSON	9	1619	1623	22.20	24.85	2.65	.0024	.28	1362			
RUN:	1													
17	17	WOJCIECHOWSKI	27	1515	1516					.24	1253	1253		
17	17	WOJCIECHOWSKI	27	1518	1519					.35	1589	1589		
17	17	WOJCIECHOWSKI	27	1521	1522					.47	1643	1643		
17	17	WOJCIECHOWSKI	27	1524	1525					.72	1963.5	1963.5		
17	17	WOJCIECHOWSKI	27	1527	1528					.98	1860	1860		
RUN:	1													
18	18	HUDSON	9	1510	1513	22.00	27.00	5.00	.0018	1	1450			
18	18	HUDSON	9	1518	1521	22.45	26.65	4.20	.0018	.7	1510			
18	18	HUDSON	9	1526	1529	22.90	26.15	3.25	.0018	.43	1567			
18	18	HUDSON	9	1542	1545	23.40	25.70	2.30	.0018	.21	1276			
18	18	HUDSON	9	1604	1606	23.15	25.90	2.75	.0012	.3	1448			
18	18	HUDSON	9	1619	1623	23.60	25.50	1.90	.0024	.14	155			
RUN:	1													
21	21	TRUEBLOOD	26	1515	1516	20.52	25.00	4.48		.803	1783.2			
21	21	TRUEBLOOD	26	1519	1520	21.09	25.00	3.91		.612	1802.7			
21	21	TRUEBLOOD	26	1523	1523	21.63	25.00	3.37		.454	1869.2			
21	21	TRUEBLOOD	26	1528	1529	21.90	25.00	3.10		.384	1788.9			
21	21	TRUEBLOOD	26	1531	1532	22.38	25.00	2.62		.275	1901.7			
21	21	TRUEBLOOD	26	1536	1536	22.90	25.00	2.10		.176	449.7			
21	21	TRUEBLOOD	26	1546	1547	25.00	25.00	0.00		.173	428.8			
21	21	TRUEBLOOD	26	1546	1547	25.00	25.00	0.00		.114	135.9			
21	21	TRUEBLOOD	26	1546	1547	25.00	25.00	0.00		.089	50.3			
21	21	TRUEBLOOD	26	1546	1547	25.00	25.00	0.00		.068	27.4			
21	21	TRUEBLOOD	26	1555	1556	25.00	25.00	0.00		.035	.4			
21	21	TRUEBLOOD	26	1555	1556	25.00	25.00	0.00		.022	0			
RUN:	1													
24	24	SERPOLAY	25	1523	1530	27.40	28.40	1.00	.77	.03	150			
24	24	SERPOLAY	25	1537	1548	27.70	29.70	2.00	.77	.15	400			
24	24	SERPOLAY	25	1556	1602	28.00	30.90	2.90	.77	.31	760			
24	24	SERPOLAY	25	1615	1620	28.50	32.50	4.00	.77	.56	1530			
24	24	SERPOLAY	25	1625	1630	28.80	33.40	4.60	.77	.74	2180			
RUN:	1													
25	25	BORYS	3	1520	1528	25.30	26.30	1.00	12.72	.038	601	601		VOL SAMP X 10**5
25	25	BORYS	3	1531	1538	25.00	26.60	1.60	12.72	.091	813	813		
25	25	BORYS	3	1543	1549	24.00	26.40	2.40	10.6	.22	552	552		
25	25	BORYS	3	1555	1559	22.60	26.20	3.60	10.6	.52	1047	1047		
25	25	BORYS	3	1607	1612	21.60	26.00	4.40	8.48	.79	1326	1326		
25	25	BORYS	3	1617	1620	20.40	25.80	5.40	5.3	1.4	2716	2716		
25	25	BORYS	3	1623	1626	18.00	25.30	7.30	4.24	2.18	2193	2193		
RUN:	1													
26	26	HINDMAN	6	1353	1421									INSTRUMENT DOWN.
26	26	HINDMAN	6	1353	1421									REPAIRING CHAMBER.



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

```
                                        EXPERIMENT # 16
                                                                                      80/10/10
PURPOSE
-------

 INSTRUMENT COMPARISON WITH AMBIENT AEROSOL.

DESCRIPTION OF EXPERIMENT
-------------------------

  DATE           TIME
                 START   END
  ------------   -----------

  10 OCT,1980    1635   1726

  NUCLEI TYPE
  -----------

   AMBIENT


  GENERATION METHOD
  -----------------

   NA


  SIZE DISTRIBUTION SHAPING
  -------------------------

   NA

REMARKS
-------

 NONE

WEATHER SYNOPSIS
----------------

 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

         ROOM CONDITIONS                              OUTSIDE CONDITIONS

 --------------------------------     ----------------------------------------------------

 AVG TEMP     AVG RH      AVG PPESS     AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)         (%)          (MB)          (C)        (%)        (MB)       (M/S)     (DEG)
 --------     ------      ---------     --------    ------    ---------    ------    ------

   29.0        20.0         850           NA          NA         NA          4.0      270
```

```
EXPERIMENT #: 16                                       NUCLEI MEASUREMENTS                                                 PROCESSING DATE:  81/09/26
                        OBSERVER                                        PLATE TEMP
MACH  DUCT  ---------------------   SAMPLE  TIME                                     VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME              NO.   START   END    COLD    HOT     DELTA   SAMPLED   SAT     COUNT     -       K      REMARKS
                                                           (C)               (L)     (%)               N
----  ----  ---------------  ---   -----  ----   ------  ------  ------  -------   ------  ------   -----   -----   -------------------
RUN:  1
  2     2   POLITOVICH        20   1656   1657   23.90   26.00    2.10              .17              456
  2     2   POLITOVICH        20   1658   1700   23.80   26.20    2.40              .23              456

RUN:  1
  5     5   KITCHEN           12   1635   1635   22.20   24.90    2.70              .3       46
  5     5   KITCHEN           12   1637   1637   21.50   24.90    3.40              .48     137
  5     5   KITCHEN           12   1638   1638   20.60   24.90    4.30              .75     458
  5     5   KITCHEN           12   1639   1639   19.60   24.90    5.30             1.2      646
RUN:  2
  5     5   KITCHEN           12   1640   1640   20.60   24.90    4.30              .75     330
  5     5   KITCHEN           12   1641   1641   21.60   24.90    3.30              .48     173
  5     5   KITCHEN           12   1642   1642   22.20   24.90    2.70              .3       34
  5     5   KITCHEN           12   1643   1643   20.60   24.90    4.30              .75     256
  5     5   KITCHEN           12   1644   1644   19.60   24.90    5.30             1.2      552
  5     5   KITCHEN           12   1645   1645   20.60   24.90    4.30              .75     343
  5     5   KITCHEN           12   1646   1646   21.60   25.00    3.40              .48     125

RUN:  1
  9     9   GAGIN              5   1636          23.00   28.10    5.10    1.2      1       1310
  9     9   GAGIN              5   1638          24.30   28.10    3.80    1.2       .55     430
  9     9   GAGIN              5   1642          25.10   28.10    3.00    1.2       .34     270
  9     9   GAGIN              5   1650          26.00   28.50    2.50    1.2       .24     100
RUN:  2
  9     9   GAGIN              5   1649          22.70   28.10    5.40    1.2      1.14    1550
  9     9   GAGIN              5   1652          24.30   28.30    4.00    1.2       .61     470
  9     9   GAGIN              5   1654          25.00   28.20    3.20    1.2       .4      300
  9     9   GAGIN              5   1656          26.10   28.10    2.00    1.2       .16     200
RUN:  3
  9     9   GAGIN              5   1701          22.90   27.90    5.00    1.2       .98    1150
  9     9   GAGIN              5   1704          24.40   28.20    3.80    1.2       .55     300
  9     9   GAGIN              5   1708          26.10   28.30    2.20    1.2       .19     150

RUN:  1
 13    13   AYERS              2   1635   1636   28.01   30.50    2.49              .25     488
 13    13   AYERS              2   1640   1641   26.82   30.40    3.58              .5      870
 13    13   AYERS              2   1642   1643   25.98   30.40    4.42              .75     915
 13    13   AYERS              2   1643   1644   25.31   30.40    5.09             1       1140
 13    13   AYERS              2   1644   1645   24.75   30.40    5.65             1.25    1290
RUN:  2
 13    13   AYERS              2   1646   1647   24.64   30.30    5.66             1.25    1140
 13    13   AYERS              2   1648   1649   25.23   30.30    5.07             1       1020
 13    13   AYERS              2   1650   1651   25.78   30.20    4.42              .75    1050
 13    13   AYERS              2   1652   1653   26.64   30.20    3.56              .5      870
 13    13   AYERS              2   1654   1655   27.66   30.20    2.54              .25     675

RUN:  1
 14    14   HUDSON             9   1642   1702                           .0148     .21     124                      F=38.5
 14    14   HUDSON             9   1642   1702                           .0148     .14     89.3                     F=38.5
 14    14   HUDSON             9   1642   1702                           .0143     .11     47.8                     F=38.5
 14    14   HUDSON             9   1642   1702                           .0143     .04     1.99                     F=38.5
 14    14   HUDSON             9   1642   1702                           .0143    .029      .79                     F=38.5
 14    14   HUDSON             9   1703   1728                           .0143     .21     152                      F=38.5
```

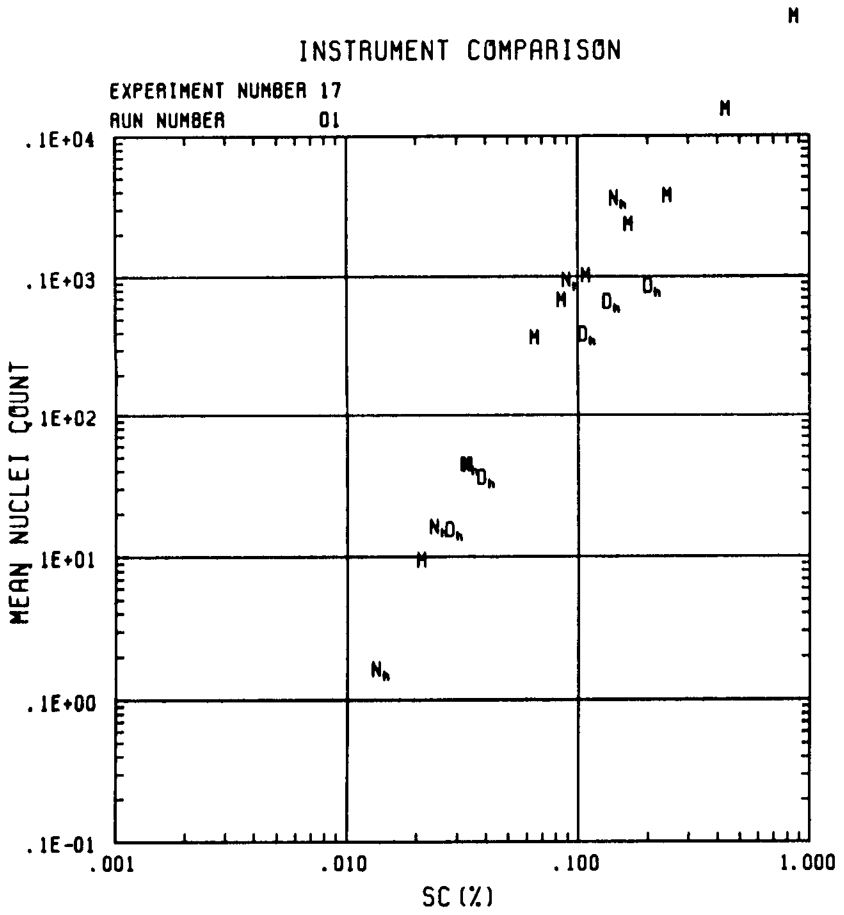
```
EXPERIMENT #: 16                                   NUCLEI MEASUPEMENTS                                              PROCESSING DATE:  81/09/26

                  OBSERVER                                    PLATE TEMP
MACH  DUCT  ------------------  SAMPLE TIME                                 VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME            NO.  START  END     COLD    HOT    DELTA   SAMPLED   SAT    COUNT      -       K     REMARKS
                                                         (C)              (L)     (%)               N
----  ----  --------------- ---  ----- ----   ------  ------  ------  -------  ------  ------   -----   -----   ------------------
 14    14   HUDSON            9  1703  1728                             .0143     .14     112                    F=38.5
 14    14   HUDSON            9  1703  1728                             .0143     .11    60.8                    F=38.5
 14    14   HUDSON            9  1703  1728                             .0143     .04    2.87                    F=38.5
 14    14   HUDSON            9  1703  1728                             .0143    .029    1.14                    F=38.5

RUN:   1

 15    15   ROGERS, FRED     23  1645  1646   18.36   25.06    6.70             1.86    1155                    MAIN FLO ABT 1300
 15    15   ROGERS. FRED     23  1649  1650   18.74   24.75    6.01             1.46    1162                    CNTS. BACKGROUND 10.
 15    15   ROGERS, FRED     23  1653  1654   19.11   24.44    5.33             1.15    1059
 15    15   ROGERS, FRED     23  1657  1658   19.49   24.13    4.64              .87     839
 15    15   ROGERS, FRED     23  1702  1703   19.87   23.81    3.94              .63     870                    AEROSOL CHANGING
 15    15   ROGERS. FRED     23  1706  1707   20.25   23.50    3.25             .425     773                    AS FCN. TIME ?
 15    15   ROGERS, FRED     23  1710  1711   20.63   23.19    2.56             .265     540
 15    15   ROGERS. FRED     23  1714  1715   20.99   22.88    1.89              .14     190
 15    15   ROGERS. FRED     23  1718  1719   21.35   22.56    1.21              .07      78                    MAIN FLO 1287

RUN:   1

 16    16   HUDSON            9  1636  1641   21.40   26.10    4.70     .003      .9     836
 16    16   HUDSON            9  1636  1641   21.70   25.40    3.70     .003     .55     729
 16    16   HUDSON            9  1636  1641   22.20   24.80    2.60     .003     .27     464
 16    16   HUDSON            9  1653  1655   21.40   26.10    4.70    .0012      .9     881
 16    16   HUDSON            9  1653  1655   21.70   25.40    3.70    .0012     .55     780
 16    16   HUDSON            9  1653  1655   22.20   24.80    2.60    .0012     .27     498
 16    16   HUDSON            9  1710  1713   21.40   26.10    4.70    .0018      .9    1032
 16    16   HUDSON            9  1710  1713   21.70   25.40    3.70    .0018     .55     885
 16    16   HUDSON            9  1710  1713   22.20   24.80    2.60    .0018     .27     598
RUN:   2

 16    16   HUDSON            9  1720  1721   21.40   26.10    4.70    .0012      .9    1072
 16    16   HUDSON            9  1720  1721   21.70   25.40    3.70    .0012     .55     924
 16    16   HUDSON            9  1720  1721   22.20   24.80    2.60    .0012     .27     634
 16    16   HUDSON            9  1726  1727   21.40   26.10    4.70    .0012      .9    1125
 16    16   HUDSON            9  1726  1727   21.70   25.40    3.70    .0012     .55     969
 16    16   HUDSON            9  1726  1727   22.20   24.80    2.60    .0012     .27     657

RUN:   1

 18    18   HUDSON            9  1636  1641   23.65   25.45    1.80     .003     .13     116
 18    18   HUDSON            9  1653  1655   23.40   25.70    2.30    .0012     .21     407
 18    18   HUDSON            9  1710  1713   23.20   25.90    2.70    .0018     .29     731
 18    18   HUDSON            9  1720  1721   22.30   26.90    4.60    .0012     .86    1034
 18    18   HUDSON            9  1726  1727   22.00   27.20    5.20    .0012     1.1    1137

RUN:   1

 21    21   TRUEBLOOD        26  1643  1645   19.90   25.00    5.10             1.04  1003.1
 21    21   TRUEBLOOD        26  1650  1651   21.80   25.00    3.20              .41   792.1
 21    21   TRUEBLOOD        26  1656  1657   22.48   25.00    2.52             .254   546.5
 21    21   TRUEBLOOD        26  1708  1710   25.00   25.00    0.00             .173   366.7
 21    21   TRUEBLOOD        26  1708  1710   25.00   25.00    0.00             .114   164.9
 21    21   TRUEBLOOD        26  1708  1710   25.00   25.00    0.00             .089   115.7
 21    21   TRUEBLOOD        26  1708  1710   25.00   25.00    0.00             .068    59.2
 21    21   TRUEBLOOD        26  1718  1721   25.00   25.00    0.00             .035     5.5
 21    21   TRUEBLOOD        26  1718  1721   25.00   25.00    0.00             .022      .7
 21    21   TRUEBLOOD        26  1718  1721   25.00   25.00    0.00            .0133       0

RUN:   1

 24    24   SERPOLAY         25  1640  1650   29.20   32.20    3.00      .77     .32     430                    IMPORTANT FLUCTUATIO
 24    24   SERPOLAY         25  1656  1659   29.40   31.60    2.20      .77     .15     300                    LOW LEVEL AT ABOUT
 24    24   SERPOLAY         25  1705  1710   29.50   31.00    1.50      .77     .08     400                    1647
 24    24   SERPOLAY         25  1725  1728   29.70   33.10    3.40      .77     .42    1280

RUN:   1

 25    25   BORYS             3  1636  1638   18.40   25.50    7.10     4.24    2.15    1591     1591    1.16   VOL SAMP X 10**5
```

EXPERIMENT #: 16

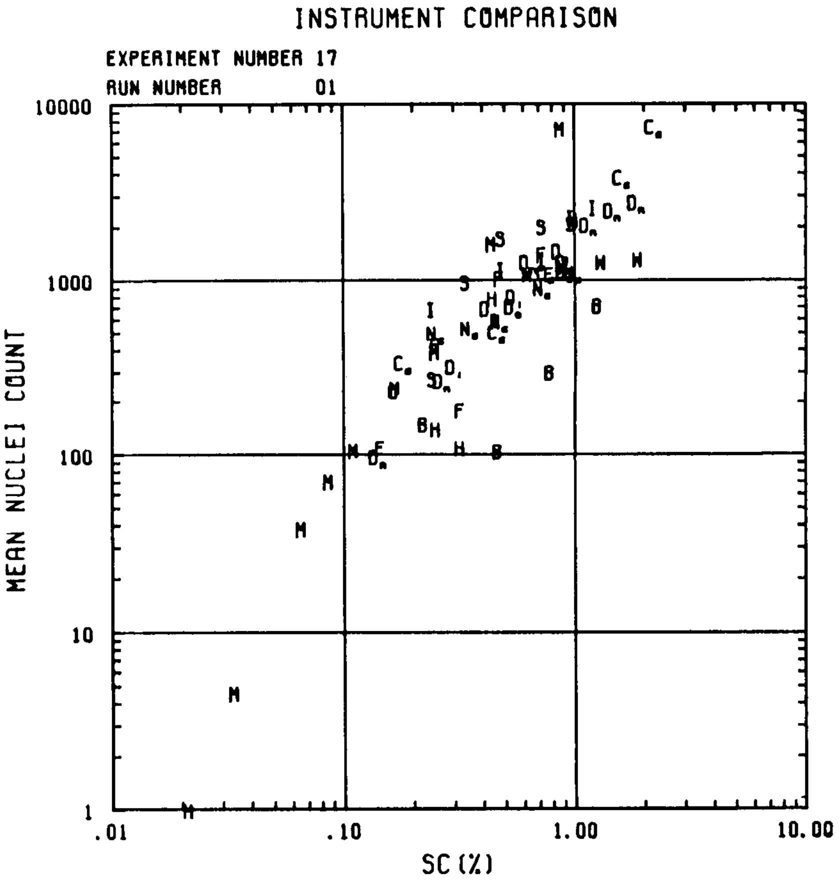
NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
25	25	BORYS	3	1643	1645	20.10	25.60	5.50	8.48	1.22	1185	1185		
25	25	BORYS	3	1650	1656	21.20	25.70	4.50	12.72	.79	648	648		
25	25	BORYS	3	1701	1709	22.50	26.00	3.50	21.2	.54	417	417		
25	25	BORYS	3	1717	1725	24.30	26.60	2.30	21.2	.19	495	495		



HAZE CHAMBER RESULTS



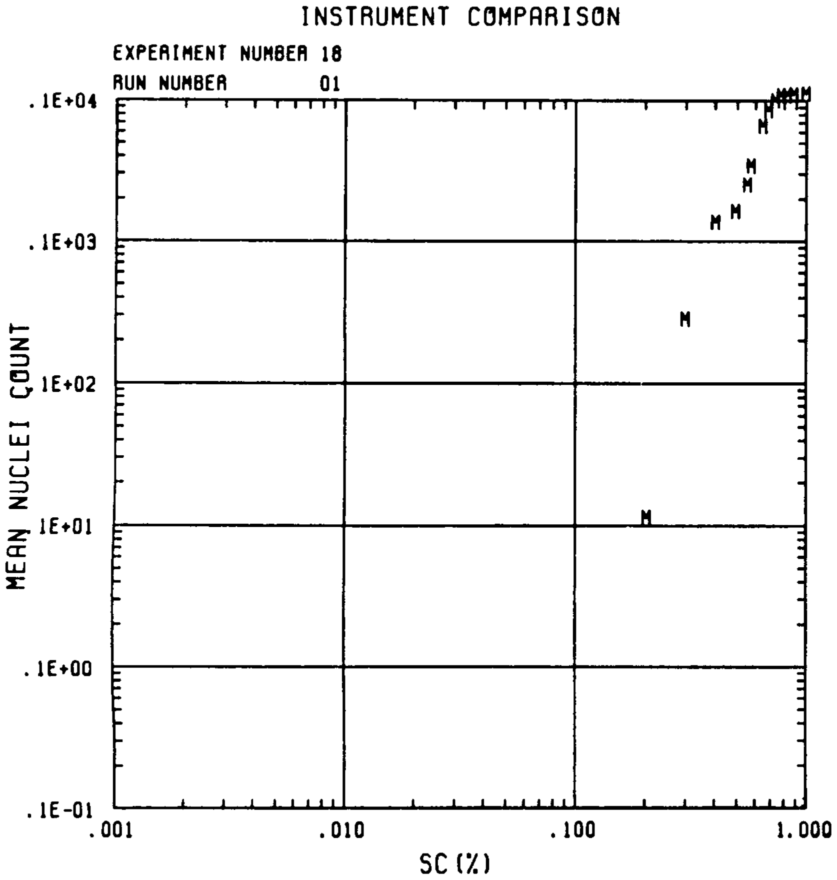
SDC/CFD RESULTS

```
                                                   EXPERIMENT # 17
                                                                                          80/10/10
PURPOSE
-------

 INSTRUMENT COMPARISON WITH AMBIENT AEROSOL.

DESCRIPTION OF EXPERIMENT
-------------------------

                       TIME
  DATE             START   END
  ------------     ----------

  10 OCT.1980      0823   0957

  NUCLEI TYPE
  -----------

   AMBIENT


  GENERATION METHOD
  -----------------

   NA


  SIZE DISTRIBUTION SHAPING
  -------------------------

   NA

REMARKS
-------

 20% R.H.

WEATHER SYNOPSIS
----------------

 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

         ROOM CONDITIONS                                 OUTSIDE CONDITIONS

 --------------------------------      --------------------------------------------------

 AVG TEMP     AVG RH    AVG PRESS      AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)         (%)        (MB)           (C)        (%)        (MB)       (M/S)     (DEG)
 --------     ------    ---------      --------    ------    ---------    ------    ------

   26.0        21.0                                                        <1.0      VAR
```

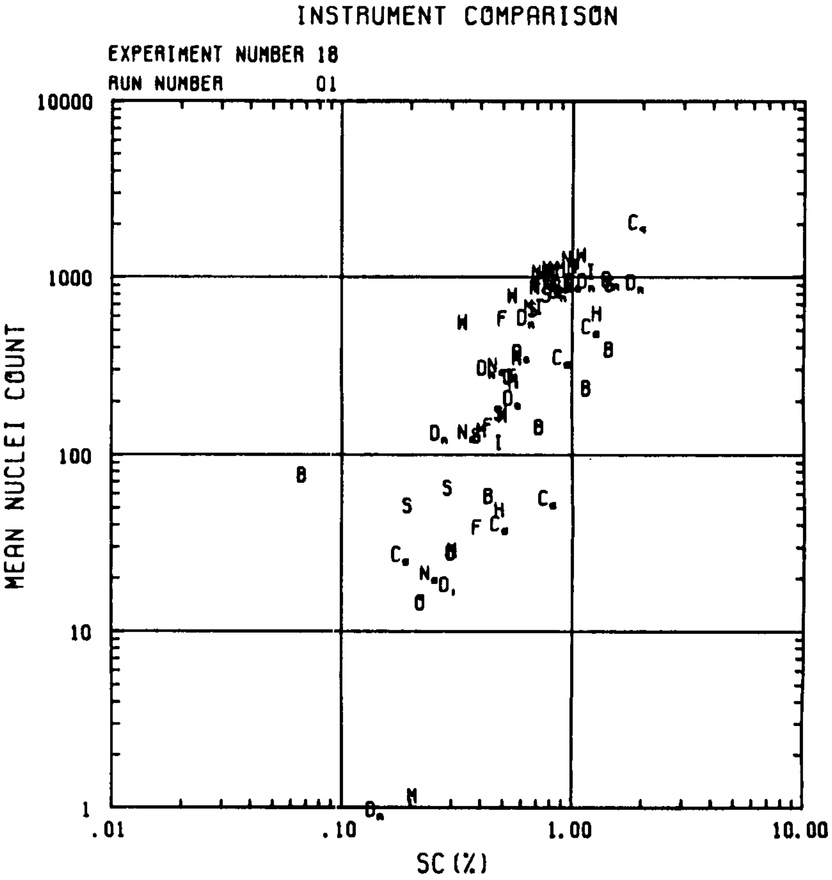
```
                                                              NUCLEI MEASUREMENTS
EXPERIMENT #: 17                                                                                        PROCESSING DATE: 81/09/26
                   OBSERVER                                    PLATE TEMP
MACH  DUCT   -------------------   SAMPLE  TIME                               VOLUME   SUPER   NUCLEI     OBS    EST
NO.   NO.    NAME             NO.  START   END       COLD     HOT     DELTA  SAMPLED    SAT    COUNT       -      K     REMARKS
                                                               (C)             (L)      (%)                 N
----  ----   --------------- ---   -----  ----     ------   ------   ------  -------  ------   ------    -----  -----   ------------------

RUN:  1

   2     2   ROGERS, DAVE     22   0918  0919    22.00   24.10    2.10              .17             235
   2     2   ROGERS, DAVE     22   0920  0921    21.70   24.10    2.40              .23             206

RUN:  1

   5     5   KITCHEN          12   0831  0831    19.20   22.60    3.40              .48       88
   5     5   KITCHEN          12   0832  0832    18.30   22.60    4.30               .8      277
   5     5   KITCHEN          12   0833  0833    17.30   22.60    5.30              1.3      733
   5     5   KITCHEN          12   0834  0834    18.40   22.70    4.30               .8      333
   5     5   KITCHEN          12   0835  0835    19.40   22.80    3.40              .48      125
   5     5   KITCHEN          12   0836  0836    20.40   22.80    2.40              .23       94          1.30
RUN:  2
   5     5   KITCHEN          12   0922  0922    22.00   25.40    3.40              .48      226
   5     5   KITCHEN          12   0923  0923    21.10   25.40    4.30              .75      307
   5     5   KITCHEN          12   0924  0924    20.20   25.50    5.30              1.2      461
   5     5   KITCHEN          12   0925  0925    22.10   25.50    3.40              .48      168

RUN:  1
   9     9   GAGIN             5   0834          22.00   27.10    5.10      1.2   1.03     2240
   9     9   GAGIN             5   0837          23.60   27.10    3.50      1.2    .46      800
   9     9   GAGIN             5   0840          24.30   27.20    2.90      1.2    .33      110
   9     9   GAGIN             5   0844          25.00   27.50    2.50      1.2    .26      140
RUN:  2
   9     9   GAGIN             5   0847          21.80   27.10    5.30      1.2    1.1     1530
   9     9   GAGIN             5   0849          23.60   27.30    3.70      1.2    .52     1160
   9     9   GAGIN             5   0853          24.70   27.30    2.60      1.2    .26       90
RUN:  3
   9     9   GAGIN             5   0901          22.20   27.20    5.00      1.2    .99     1350
   9     9   GAGIN             5   0903          24.30   27.70    3.40      1.2    .44      660
   9     9   GAGIN             5   0907          24.70   27.80    3.10      1.2    .38      290
   9     9   GAGIN             5   0910          25.80   27.90    2.10      1.2    .17      120
RUN:  4
   9     9   GAGIN             5   0917          22.30   27.70    5.40      1.2   1.13     1270
   9     9   GAGIN             5   0920          24.10   27.80    3.70      1.2    .53      330
   9     9   GAGIN             5   0924          24.80   27.90    3.10      1.2    .37      220

RUN:  1
  10    10   LALA             13   0836          21.01   23.50    2.49       .4    .25    268.9
  10    10   LALA             13   0837          20.99   23.48    2.49       .4    .25    287.3
  10    10   LALA             13   0838          20.54   23.48    2.94       .4    .35    870.9
  10    10   LALA             13   0839          20.58   23.52    2.94       .4    .35   1120.1
  10    10   LALA             13   0840          20.02   23.52    3.50       .4     .5     1752
  10    10   LALA             13   0841          20.01   23.52    3.51       .4     .5   1738.9
  10    10   LALA             13   0842          19.23   23.51    4.28       .4    .75   2157.6
  10    10   LALA             13   0843          19.21   23.49    4.28       .4    .75   1928.3
  10    10   LALA             13   0844          18.54   23.46    4.92       .4      1   2329.6
  10    10   LALA             13   0845          18.51   23.43    4.92       .4      1   1919.4                 VERY UNSTABLE AEROSO
RUN:  2
  10    10   LALA             13   0846          21.32   23.82    2.50       .4    .25    365.3
  10    10   LALA             13   0847          21.32   23.81    2.49       .4    .25    371.8
  10    10   LALA             13   0848          20.87   23.82    2.95       .4    .35    546.8
  10    10   LALA             13   0849          20.87   23.82    2.95       .4    .35    647.8
  10    10   LALA             13   0850          20.30   23.81    3.51       .4     .5    948.2
```

```
                                                           NUCLEI MEASUREMENTS
EXPERIMENT #: 17                                                                                              PROCESSING DATE:  81/09/26
                     OBSERVER                                  PLATE TEMP
MACH  DUCT   ------------------   SAMPLE TIME                                  VOLUME   SUPER   NUCLEI    OBS      EST
NO.   NO.    NAME            NO.  START  END      COLD    HOT     DELTA   SAMPLED   SAT     COUNT      -        K      REMARKS
                                                          (C)               (L)     (%)                N
----  ----   --------------- ---  -----  ----    ------  ------  ------  -------  ------   ------    -----   -----   ------------------
 10    10    LALA             13  0851           20.31   23.83    3.52       .4       .5   1602.1
 10    10    LALA             13  0852           19.54   23.83    4.29       .4      .75   2084.2
 10    10    LALA             13  0853           19.53   23.82    4.29       .4      .75   1407.7
 10    10    LALA             13  0854           18.84   23.78    4.94       .4        1   1417.1
 10    10    LALA             13  0855           18.85   23.79    4.94       .4        1   1395.7                    VERY UNSTABLE AEROSO

RUN:  1
 11    11    FITZGERALD       28  0845   0857                                          .15      378      378
 11    11    FITZGERALD       28  0845   0857                                         .094      100      100
 11    11    FITZGERALD       28  0845   0857                                         .034      4.7      4.7
 11    11    FITZGERALD       28  0845   0857                                         .025      1.7      1.7
 11    11    FITZGERALD       28  0845   0857                                         .014      .17      .17
RUN:  2
 11    11    FITZGERALD       28  0910   0927                                          .15      307      307
 11    11    FITZGERALD       28  0910   0927                                         .094       96       96
 11    11    FITZGERALD       28  0910   0927                                         .034      6.8      6.8
 11    11    FITZGERALD       28  0910   0927                                         .025      2.8      2.8
 11    11    FITZGERALD       28  0910   0927                                         .014       .4       .4

RUN:  1
 13    13    AYERS             2  0839   0840    21.89   24.30    2.41                   .25      690
 13    13    AYERS             2  0841   0842    20.91   24.40    3.49                    .5     1170
 13    13    AYERS             2  0842   0843    20.20   24.40    4.20                   .75     1290
 13    13    AYERS             2  0844   0845    19.53   24.40    4.87                     1     2325
 13    13    AYERS             2  0846   0847    18.96   24.40    5.44                  1.25     2625

RUN:  1
 14    14    HUDSON            9  0911   0933                             .014       .21     94.1                    F=40
 14    14    HUDSON            9  0911   0933                             .014       .14     73.5                    F=40
 14    14    HUDSON            9  0911   0933                             .014       .11     43.7                    F=40
 14    14    HUDSON            9  0911   0933                             .014       .04     4.22                    F=40
 14    14    HUDSON            9  0911   0933                             .014      .029     1.82                    F=40
 14    14    HUDSON            9  0934   0957                             .014       .21     85.9                    F=40
 14    14    HUDSON            9  0934   0957                             .014       .14     66.1                    F=40
 14    14    HUDSON            9  0934   0957                             .014       .11     38.2                    F=40
 14    14    HUDSON            9  0934   0957                             .014       .04     3.36                    F=40
 14    14    HUDSON            9  0934   0957                             .014      .029     1.41                    F=40

RUN:  1
 15    15    ROGERS, FRED     23  0925   0926    18.36   25.06    6.70                  1.86     2807                    FIRST POINT NEEDED
 15    15    ROGERS, FRED     23  0928   0929    18.74   24.75    6.01                  1.46     2548                    MAIN FLO READJUST.
 15    15    ROGERS, FRED     23  0931   0932    19.11   24.44    5.33                  1.15     2097                    BACKGROUND LESS
 15    15    ROGERS, FRED     23  0935   0936    19.49   24.13    4.64                   .87     1488                    THAN 10 PER CC.
 15    15    ROGERS, FRED     23  0939   0940    19.87   23.81    3.94                   .63     1290                    ROYCO CAL OK.
 15    15    ROGERS, FRED     23  0943   0944    20.25   23.50    3.25                  .425      698                    SIGNIFICANT AEROSOL
 15    15    ROGERS, FRED     23  0947   0948    20.63   23.19    2.56                  .265      270                    FLUCTUATIONS.
 15    15    ROGERS, FRED     23  0951   0952    20.99   22.88    1.89                   .14       98

RUN:  1
 16    16    HUDSON            9  0931   0938    21.35   26.06    4.70    .0042         .9     1281
 16    16    HUDSON            9  0931   0938    21.70   25.40    3.70    .0042        .55      814
 16    16    HUDSON            9  0931   0938    22.20   24.70    2.50    .0042         .3      328

RUN:  1
 17    17    WOJCIECHOWSKI    27  0905   0907                                          .25      508      508
 17    17    WOJCIECHOWSKI    27  0905   0907                                          .35      540      540
 17    17    WOJCIECHOWSKI    27  0905   0907                                          .47      592      592
```

```
                                                                    NUCLEI MEASUREMENTS
EXPERIMENT #: 17                                                                                                   PROCESSING DATE:  81/09/26
                     OBSERVER                                              PLATE TEMP
MACH  DUCT   -------------------                SAMPLE TIME                                 VOLUME  SUPER   NUCLEI    OBS    EST
NO.   NO.    NAME               NO.  START   END      COLD     HOT     DELTA  SAMPLED   SAT    COUNT      -      K     REMARKS
                                                                    (C)                (L)    (%)                N
----  ----   ---------------   ---  -----  ----   ------  ------  ------  -------  ------  ------  -----  -----   --------------------
  17    17   WOJCIECHOWSKI     27   0905  0907                                       .72     925    925
  17    17   WOJCIECHOWSKI     27   0905  0907                                       .98    1132   1132

RUN:  1

  18    18   HUDSON             9   0921  0924    22.10   26.80    4.70    .0018      .9    1146
  18    18   HUDSON             9   0931  0938    22.65   26.30    3.65    .0042     .54     734
  18    18   HUDSON             9   0951  0955    22.65   26.30    3.65    .0024     .54     715

RUN:  1

  20    20   DOMONKOS           4   0925  0930                                       .65    1095
  20    20   DOMONKOS           4   0925  0930                                       .93    1210
  20    20   DOMONKOS           4   0925  0930                                      1.35    1293
  20    20   DOMONKOS           4   0925  0930                                      1.95    1340

RUN:  1

  21    21   TRUEBLOOD         26   0831  0832    20.25   25.00    4.75             .902    7422
  21    21   TRUEBLOOD         26   0837  0838    21.63   25.00    3.37             .454    1645
  21    21   TRUEBLOOD         26   0846  0847    22.70   25.00    2.30             .256     399
  21    21   TRUEBLOOD         26   0857  0858    25.00   25.00    0.00             .173   248.8
  21    21   TRUEBLOOD         26   0857  0858    25.00   25.00    0.00             .114   107.6
  21    21   TRUEBLOOD         26   0857  0858    25.00   25.00    0.00             .089    72.4
  21    21   TRUEBLOOD         26   0857  0858    25.00   25.00    0.00             .068    39.1
  21    21   TRUEBLOOD         26   0906  0907    25.00   25.00    0.00             .035    4.68
  21    21   TRUEBLOOD         26   0906  0907    25.00   25.00    0.00             .022       1
  21    21   TRUEBLOOD         26   0906  0907    25.00   25.00    0.00            .0133       0

RUN:  1

  24    24   SERPOLAY          25   0830  0840    24.20   26.70    2.50      .77     .26     430                 IMPORTANT FLUCTUATIO
  24    24   SERPOLAY          25   0845  0852    24.70   28.30    3.60      .77     .49    1050                 TILL 0905:
  24    24   SERPOLAY          25   0901  0905    25.40   29.90    4.50      .77     .75    1430                 THEN STABLE.
  24    24   SERPOLAY          25   0915  0920    26.10   30.80    4.70      .77     .81    1100
  24    24   SERPOLAY          25   0937  0943    26.80   29.80    3.00      .77     .33     180
  24    24   SERPOLAY          25   0950  0953    27.10   29.10    2.00      .77     .15     110

RUN:  1

  25    25   BORYS              3   0830  0831    16.40   23.70    7.30     2.12     2.2    7592   7592   1.09   SAMP VOL X10**5
  25    25   BORYS              3   0835  0836    18.00   23.50    5.50     2.12     1.6    3890   3890          MEAS. 1 OFF SCALE
  25    25   BORYS              3   0842  0844    19.50   23.90    4.40     4.24     .75    1132   1132
  25    25   BORYS              3   0849  0853    20.70   24.10    3.40     8.48     .46     513    513
  25    25   BORYS              3   0901  0907    22.40   24.60    2.20     15.9     .18     348    348

RUN:  1

  27    27   OHTAKE            19   0839  0839                               1.1            4.01                 101% NOMINAL
  27    27   OHTAKE            19   0839  0839                               1.1            5.93                 105% NOMINAL
```



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

```
                                  EXPERIMENT # 18
                                                                          80/10/13
PURPOSE
-------

 INSTRUMENT COMPARISON WITH SMALL MONODISPERSE CCN.

DESCRIPTION OF EXPERIMENT
-------------------------
                  TIME
  DATE            START   END
  ------------    -----------
  13 OCT,1980     1010    1130

  NUCLEI TYPE
  -----------
   (NH4)2 SO4, MONODISPEHSE, D=0.04 UM.

  GENERATION METHOD
  -----------------
   DRI ATOMIZER, 70 PSI, 1.77 G/L SOLUTION.

  SIZE DISTRIBUTION SHAPING
  -------------------------
   EC, 634V, MONODISPERSE, FLOW RATE = 5.8 L/MIN. DILUTION FLOW 570 L/MIN.

REMARKS
-------
 NONE

WEATHER SYNOPSIS
----------------
 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
        ROOM CONDITIONS                           OUTSIDE CONDITIONS

 --------------------------------     --------------------------------------------------
 AVG TEMP     AVG RH    AVG PRESS     AVG TEMP     AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)         (%)        (MB)          (C)         (%)        (MB)       (M/S)     (DEG)
 --------     ------    ---------     --------     ------    ---------    ------    ------
   26.0        21.0       848
```

```
EXPERIMENT #: 18                                     NUCLEI MEASUREMENTS
                                                                                                             PROCESSING DATE: 81/09/26
                   OBSERVER                                        PLATE TEMP
MACH  DUCT  --------------------   SAMPLE  TIME                                  VOLUME   SUPER   NUCLEI    OBS      EST
NO.   NO.   NAME              NO.  START   END      COLD     HOT     DELTA    SAMPLED   SAT     COUNT      -        K     REMARKS
                                                             (C)                (L)     (%)                N
----  ----  --------------- ---  -----   ----    ------   ------   ------   -------   ------  ------    -----    -----   --------------------

RUN:  1

  2     2   ROGERS, DAVE      22   1104    1105    23.40    25.50    2.10               .17                  0                LESS THAN 6 PER CC.
  2     2   ROGERS, DAVE      22   1107    1108    23.60    26.00    2.40               .23                 15
  2     2   ROGERS, DAVE      22   1113    1114    23.40    26.20    2.80               .31                 29

RUN:  1

  5     5   KITCHEN           12   1030    1030    25.50    26.90    1.40               .07       79
  5     5   KITCHEN           12   1031    1031    23.50    26.90    3.40               .45       60
  5     5   KITCHEN           12   1032    1032    22.60    26.90    4.30               .75      148
  5     5   KITCHEN           12   1033    1033    21.60    26.90    5.30              1.2       243
  5     5   KITCHEN           12   1034    1034    20.80    26.90    6.10              1.5       406
RUN:  2
  5     5   KITCHEN           12   1036    1036    25.10    27.00    1.90               .14       81
  5     5   KITCHEN           12   1037    1037    23.70    27.00    3.30               .42       46
  5     5   KITCHEN           12   1038    1038    22.30    27.00    4.70               .9        57
  5     5   KITCHEN           12   1039    1039    20.90    27.00    6.10              1.5       443
  5     5   KITCHEN           12   1040    1040    19.50    27.00    7.50              2.4       714
  5     5   KITCHEN           12   1041    1041    22.30    27.00    4.70               .9       114
  5     5   KITCHEN           12   1042    1042    23.80    27.10    3.30               .42       28
  5     5   KITCHEN           12   1043    1043    25.20    27.10    1.90               .14       51

RUN:  1

  9     9   GAGIN              5   1027            22.10    27.90    5.80     1.2     1.32       640
  9     9   GAGIN              5   1029            24.30    27.90    3.60     1.2      .5         50
  9     9   GAGIN              5   1032            25.10    28.10    3.00     1.2      .34         0
  9     9   GAGIN              5   1035            26.00    28.10    2.10     1.2      .16         0
RUN:  2
  9     9   GAGIN              5   1039            22.40    27.80    5.40     1.2     1.13       470
  9     9   GAGIN              5   1041            24.10    27.90    3.80     1.2      .56        60
  9     9   GAGIN              5   1045            25.30    28.00    2.70     1.2      .25         0
  9     9   GAGIN              5   1048            25.90    28.00    2.10     1.2      .16         0
RUN:  3
  9     9   GAGIN              5   1052            22.40    27.90    5.50     1.2     1.15       570
  9     9   GAGIN              5   1055            24.50    28.00    3.50     1.2      .46        50
  9     9   GAGIN              5   1058            25.00    27.90    2.90     1.2      .31         0
  9     9   GAGIN              5   1100            26.20    28.00    1.80     1.2      .18         0

RUN:  1

 10    10   LALA              13   1020            24.01    26.29    2.28      .4      .2        52.8
 10    10   LALA              13   1021            23.57    26.35    2.78      .4      .3        66.7
 10    10   LALA              13   1022            23.15    26.31    3.16      .4      .4       131.5
 10    10   LALA              13   1023            22.73    26.31    3.58      .4      .5       176.3
 10    10   LALA              13   1023            22.33    26.25    3.92      .4      .6       382.4
 10    10   LALA              13   1023            21.97    26.19    4.22      .4      .7       674.4
 10    10   LALA              13   1023            21.63    26.14    4.51      .4      .8       819.9
 10    10   LALA              13   1023            21.31    26.08    4.77      .4      .9       910.7
 10    10   LALA              13   1023            20.98    26.01    5.03      .4     1          931
 10    10   LALA              13   1023            19.86    25.98    6.12      .4     1.5       945.9
RUN:  2

 10    10   LALA              13   1035            23.57    25.84    2.27      .4      .2        57.2
 10    10   LALA              13   1036            23.13    25.90    2.77      .4      .3        80.9
 10    10   LALA              13   1037            22.69    25.89    3.20      .4      .4       123.9
 10    10   LALA              13   1038            22.29    25.86    3.57      .4      .5       237.1
 10    10   LALA              13   1039            21.91    25.81    3.90      .4      .6       444.7
 10    10   LALA              13   1040            21.56    25.77    4.21      .4      .7       710.9
```

NUCLEI MEASUREMENTS

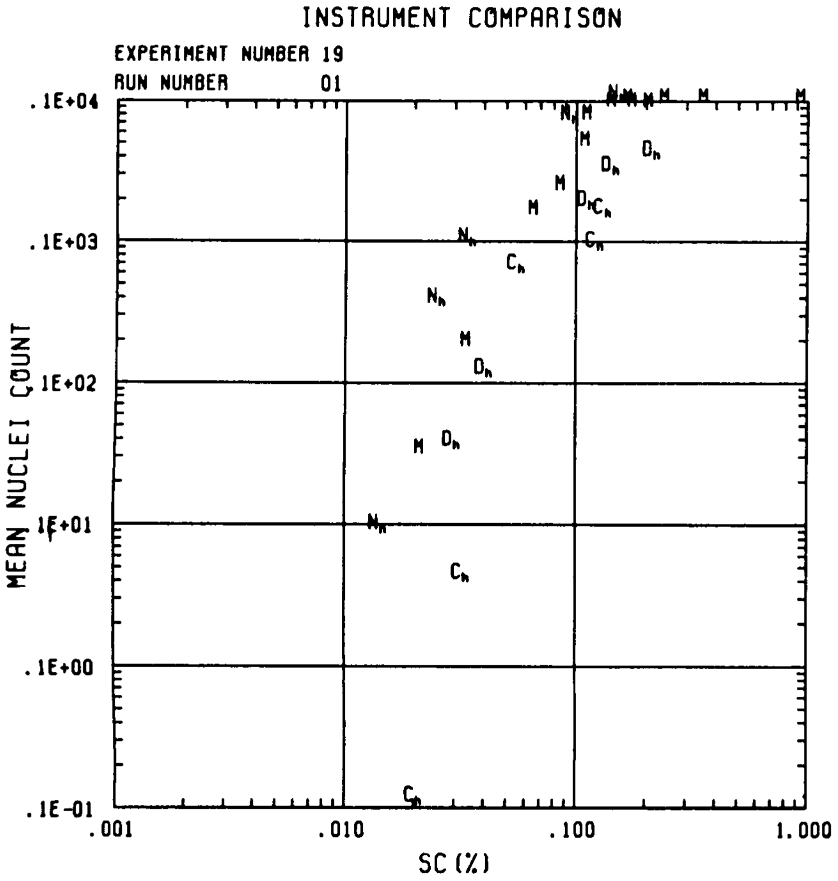
EXPERIMENT #: 18

PROCESSING DATE: 81/09/26

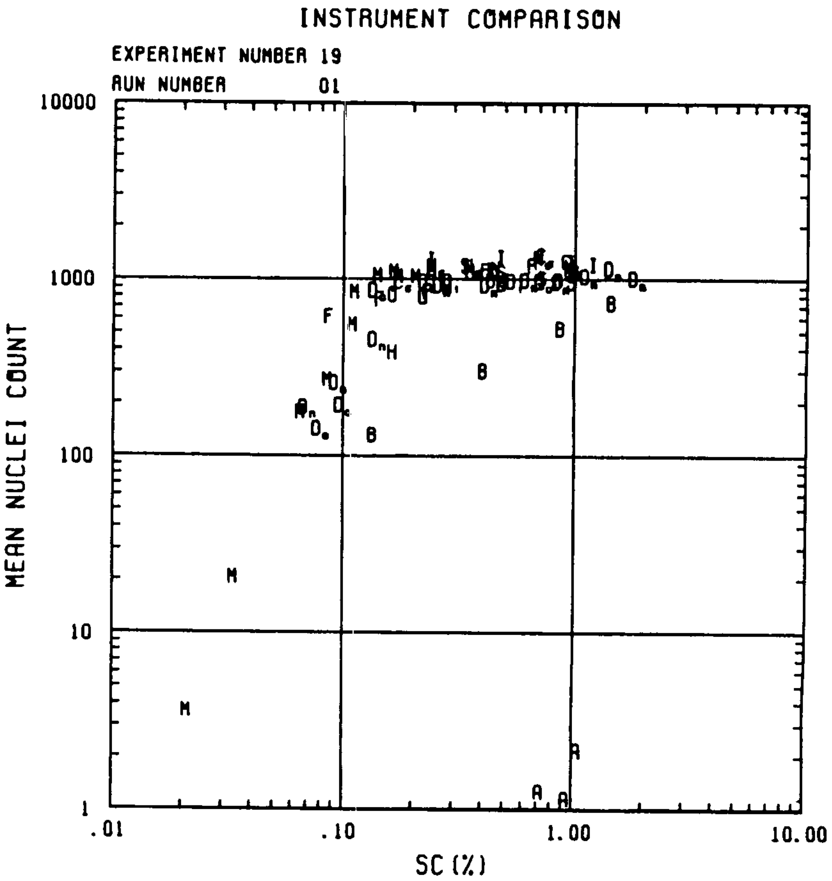
MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	BELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
10	10	LALA	13	1041		21.22	25.72	4.50	.4	.8	846.7			
10	10	LALA	13	1042		20.91	25.67	4.76	.4	.9	891.2			
10	10	LALA	13	1043		20.61	25.62	5.01	.4	1	929.5			
10	10	LALA	13	1044		19.47	25.58	6.11	.4	1.5	930.4			
RUN: 3														
10	10	LALA	13	1120		24.18	26.46	2.28	.4	.2	46.9			
10	10	LALA	13	1121		23.66	26.45	2.79		.3	85.6			
10	10	LALA	13	1122		23.21	26.42	3.21		.4	142.2			
10	10	LALA	13	1123		22.77	26.36	3.59		.5	246.9			
10	10	LALA	13	1124		22.38	26.30	3.92		.6	475.9			
10	10	LALA	13	1125		22.01	26.23	4.22		.7	755.8			
10	10	LALA	13	1126		21.65	26.16	4.51		.8	864			
10	10	LALA	13	1127		21.33	26.11	4.78		.9	952			
10	10	LALA	13	1128		21.01	26.03	5.02		1	934.9			
10	10	LALA	13	1129		19.78	25.90	6.12		1.5	897.2			
RUN: 1														
11	11	FITZGERALD	28	1030	1045					.15	0	0		
11	11	FITZGERALD	28	1030	1045					.094	0	0		
11	11	FITZGERALD	28	1030	1045					.034	0	0		
11	11	FITZGERALD	28	1030	1045					.025	0	0		
11	11	FITZGERALD	28	1030	1045					.014	0	0		
RUN: 1														
13	13	AYERS	2	1025	1026	25.39	27.90	2.51		.25	0			
13	13	AYERS	2	1029	1030	22.24	27.80	5.56		1.25	1110			
13	13	AYERS	2	1026	1027	24.39	27.90	3.51		.5	120			
13	13	AYERS	2	1027	1028	23.54	27.90	4.36		.75	705			
13	13	AYERS	2	1028	1029	22.77	27.80	5.03		1	945			
RUN: 2														
13	13	AYERS	2	1035	1036	25.11	27.60	2.49		.25	0			
13	13	AYERS	2	1036	1037	24.09	27.60	3.51		.5	150			
13	13	AYERS	2	1038	1039	23.29	27.60	4.31		.75	720			
13	13	AYERS	2	1040	1041	22.60	27.60	5.00		1	1200			
13	13	AYERS	2	1041	1042	21.94	27.50	5.56		1.25	1275			
RUN: 3														
13	13	AYERS	2	1110	1111	25.40	27.90	2.50		.25	50			
13	13	AYERS	2	1112	1113	24.36	27.90	3.54		.5	165			
13	13	AYERS	2	1113	1114	23.50	27.80	4.30		.75	855			
13	13	AYERS	2	1115	1116	22.72	27.70	4.98		1	1020			
13	13	AYERS	2	1116	1117	22.12	27.70	5.58		1.25	1260			
RUN: 1														
15	15	ROGERS, FRED	23	1021	1022	18.36	25.06	6.70		1.86	965			BACKGROUND 10 PER
15	15	ROGERS, FRED	23	1025	1026	18.74	24.75	6.01		1.46	1012			CC.
15	15	ROGERS, FRED	23	1029	1030	19.11	24.44	5.33		1.15	979			
15	15	ROGERS, FRED	23	1033	1034	19.49	24.13	4.64		.87	860			AT THIS PNT.
15	15	ROGERS, FRED	23	1037	1038	19.87	23.81	3.94		.63	612			STARTED AVGNG LAST
15	15	ROGERS, FRED	23	1041	1042	20.25	23.50	3.25		.425	317			4 PNTS EA SS.
15	15	ROGERS, FRED	23	1045	1046	20.63	23.19	2.56		.265	137			AT THIS PNT. DROP
15	15	ROGERS, FRED	23	1049	1050	20.99	22.88	1.89		.14	1			SIZE PLATEAU WOR-
15	15	ROGERS, FRED	23	1049	1050									SENING.
15	15	ROGERS, FRED	23	1049	1050									LAST PNT. EST. CNT.
RUN: 1														
16	16	HUDSON	9	1030	1032	21.40	26.05	4.65	.0018	.88	948			
16	16	HUDSON	9	1030	1032	21.70	25.40	3.70	.0018	.55	292			

```
EXPERIMENT #: 18                                       NUCLEI MEASUREMENTS                                  PROCESSING DATE:  81/09/26
                      OBSERVER                                   PLATE TEMP
MACH  DUCT  ------------------  SAMPLE TIME                                 VOLUME    SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME           NO.  START  END     COLD      HOT    DELTA     SAMPLED     SAT    COUNT      -       K      REMARKS
                                                          (C)                 (L)     (%)               N
----  ----  --------------- ---  -----  ----   ------   ------  ------   -------   -----   ------   -----   -----   ------------------
  16    16  HUDSON           9   1030  1032    22.15    24.85    2.70     .0018     .29     19.4
  16    16  HUDSON           9   1038  1041    21.40    26.06    4.65     .0024     .88      966
  16    16  HUDSON           9   1038  1041    21.70    25.40    3.70     .0024     .55      276
  16    16  HUDSON           9   1038  1041    22.15    24.85    2.70     .0024     .29       20
  16    16  HUDSON           9   1044  1047    21.40    26.05    4.65     .0018     .88      961
  16    16  HUDSON           9   1044  1047    21.70    25.40    3.70     .0018     .55      282
  16    16  HUDSON           9   1044  1047    22.15    24.85    2.70     .0018     .29     17.6

RUN:  2

  16    16  HUDSON           9   1050  1053    21.40    26.05    4.65     .0018     .88      974
  16    16  HUDSON           9   1050  1053    21.70    25.40    3.70     .0018     .55      280
  16    16  HUDSON           9   1050  1053    22.15    24.85    2.70     .0018     .29     19.1
  16    16  HUDSON           9   1111  1113    21.40    26.05    4.65     .0012     .88     1028
  16    16  HUDSON           9   1111  1113    21.70    25.40    3.70     .0012     .55      371
  16    16  HUDSON           9   1111  1113    22.15    24.85    2.70     .0012     .29       24


RUN:  1

  17    17  WOJCIECHOWSKI   27   1031  1032                                        .24     22.2    22.2
  17    17  WOJCIECHOWSKI   27   1034  1035                                        .35      138     138
  17    17  WOJCIECHOWSKI   27   1037  1038                                        .47    330.5   330.5
  17    17  WOJCIECHOWSKI   27   1040  1041                                        .73     1095    1095
  17    17  WOJCIECHOWSKI   27   1043  1044                                        .98     1322    1322


RUN:  1

  18    18  HUDSON           9   1030  1032    22.70    26.40    3.70     .0018     .55      214
  18    18  HUDSON           9   1038  1041    22.20    26.70    4.50     .0024     .82      912
  18    18  HUDSON           9   1044  1047    22.20    26.75    4.55     .0018     .84      964
  18    18  HUDSON           9   1050  1053    22.00    27.00    5.00     .0018       1      978
  18    18  HUDSON           9   1111  1113    22.55    26.40    3.85     .0012      .6      388


RUN:  1

  20    20  DOMONKOS         4   1030  1035                                        .35      570
  20    20  DOMONKOS         4   1030  1035                                        .57      810
  20    20  DOMONKOS         4   1030  1035                                        .83     1100
  20    20  DOMONKOS         4   1030  1035                                       1.14     1375


RUN:  1

  21    21  TRUEBLOOD       26   1014  1015    19.90    25.00    5.10              1.04     1191
  21    21  TRUEBLOOD       26   1017  1018    20.19    25.00    4.81              .925     1163
  21    21  TRUEBLOOD       26   1020  1021    20.35    25.00    4.65              .865     1151
  21    21  TRUEBLOOD       26   1024  1025    20.50    25.00    4.50               .81     1155
  21    21  TRUEBLOOD       26   1027  1028    20.62    25.00    4.38              .767     1059
  21    21  TRUEBLOOD       26   1031  1032    20.77    25.00    4.23              .716      905
  21    21  TRUEBLOOD       26   1033  1034    20.89    25.00    4.11              .675      702
  21    21  TRUEBLOOD       26   1036  1037    21.12    25.00    3.88              .602      358
  21    21  TRUEBLOOD       26   1040  1041    21.20    25.00    3.80              .578      266
  21    21  TRUEBLOOD       26   1045  1046    21.40    25.00    3.60              .518    171.7
  21    21  TRUEBLOOD       26   1048  1049    21.76    25.00    3.24               .42    142.9
  21    21  TRUEBLOOD       26   1055  1056    22.20    25.00    2.80              .314     29.6
  21    21  TRUEBLOOD       26   1059  1100    22.70    25.00    2.30              .212      1.2


RUN:  1

  24    24  SERPOLAY        25   1020  1025    27.70    29.20    1.50       .77      .1        0
  24    24  SERPOLAY        25   1031  1035    27.80    30.80    3.00       .77     .33        0
  24    24  SERPOLAY        25   1050  1056    28.10    32.10    4.00       .77     .57      280
  24    24  SERPOLAY        25   1103  1108    28.50    33.10    4.60       .77     .74      930
  24    24  SERPOLAY        25   1116  1126    28.90    32.20    3.30       .77      .4       40
  24    24  SERPOLAY        25   1130  1137    29.00    32.60    3.60       .77     .45      150
  24    24  SERPOLAY        25   1143  1145    29.10    32.90    3.80       .77     .52      600

RUN:  1

  25    25  BORYS            3   1021  1023    19.20    26.00    6.80      4.24     1.9     2121    2121             SAMP VOL X10**5
```

```
                                                       NUCLEI MEASUREMENTS
EXPERIMENT #: 18                                                                                         PROCESSING DATE:  81/09/26
                        OBSERVER                                   PLATE TEMP
MACH  DUCT  -----------------------   SAMPLE TIME                                 VOLUME   SUPER   NUCLEI     OBS     EST
NO.   NO.   NAME                NO.   START   END     COLD     HOT     DELTA    SAMPLED   SAT     COUNT       -       K     REMARKS
                                                                (C)                (L)     (%)                 N
----  ----  ----------------- ---   -----  ----    ------   ------   ------   -------  ------  ------     -----   -----  -------------------
 25    25   BORYS                3    1028   1031    20.60    26.00     5.40      6.36     1.2     542       542
 25    25   BORYS                3    1037   1041    23.70    26.10     2.40     12.72     .78      59        59
 25    25   BORYS                3    1048   1055    22.70    26.20     3.50      21.2     .48      42        42
 25    25   BORYS                3    1107   1116    24.00    26.20     2.20      21.2     .18      28        28
 25    25   BORYS                3    1122   1126    20.70    25.70     5.00      6.36      .9     365       365

RUN:  1

 26    26   HINDMAN              6    1030   1121    26.00    26.00     0.00       1.2     .13       0         0
 26    26   HINDMAN              6    1030   1121    26.00    26.00     0.00               .12       0         0
 26    26   HINDMAN              6    1030   1121    26.00    26.00     0.00              .055       0         0
 26    26   HINDMAN              6    1030   1121    26.00    26.00     0.00              .032       0         0
 26    26   HINDMAN              6    1030   1121    26.00    26.00     0.00               .02       0         0

RUN:  1

 27    27   OHTAKE              19    1000   1000                                  7.3              .87                    97% R.H.
 27    27   OHTAKE              19    1000   1000                                  7.3             1.16                    100% R.H.
 27    27   OHTAKE              19    1000   1000                                  7.3             1.37                    109% R.H. NOMINAL
 27    27   OHTAKE              19    1000   1000                                  7.3             1.37                    121% R.H. NOMINAL
```



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

```
                                        EXPERIMENT # 19
                                                                                  80/10/13
PURPOSE
-------

 INSTRUMENT COMPARISON WITH LARGE MONODISPERSE AEROSOL (FOR INCLUSION OF HAZE
 INSTRUMENT).

DESCRIPTION OF EXPERIMENT
-------------------------

                   TIME
  DATE            START   END
  ------------    -----------

  13 OCT,1980     1130    1320

  NUCLEI TYPE
  -----------

   (NH4)2 SO4, MONODISPOERSE, D=0.14 UM.


  GENERATION METHOD
  -----------------

   DRI ATOMIZER, 70 PSI, 1.77 G/L SOLUTION.


  SIZE DISTRIBUTION SHAPING
  -------------------------

   EC, 5800V, FLOWRATE 6 L/MIN, DILUTION FLOW 310 L/MIN.


REMARKS
-------

 NONE


WEATHER SYNOPSIS
----------------

 NONE


MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

         ROOM CONDITIONS                               OUTSIDE CONDITIONS

 -------------------------------      --------------------------------------------------

 AVG TEMP     AVG RH    AVG PRESS      AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)         (%)        (MB)           (C)        (%)        (MB)       (M/S)     (DEG)
 --------     ------    ---------      --------    ------    ---------    ------    ------

   27.0        21.0        848
```

```
                                                         NUCLEI MEASUREMENTS
EXPERIMENT #: 19                                                                                                      PROCESSING DATE:  81/09/26
                         OBSERVER                            PLATE TEMP
MACH  DUCT  ------------------------    SAMPLE  TIME                              VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME                 NO.    START   END    COLD     HOT    DELTA    SAMPLED   SAT     COUNT      -      K     REMARKS
                                                                (C)              (L)      (%)               N
----  ----  ---------------      ---    -----   ----  ------  ------  ------   -------   ------  ------    -----  -----  --------------------

RUN:   1

  2     2   ROGERS, DAVE          22    1205    1206   21.20   23.40    2.20               .17               853
  2     2   ROGERS, DAVE          22    1209    1210   21.30   23.70    2.40               .23               831
RUN:   2

  2     2   ROGERS, DAVE          22    1224    1225   22.40   24.50    2.10               .17               728
  2     2   ROGERS, DAVE          22    1226    1227   22.40   24.80    2.40               .23               941

RUN:   1

  5     5   KITCHEN               12    1138    1138   24.70   28.00    3.30               .42      359
  5     5   KITCHEN               12    1139    1139   26.10   28.00    1.90               .14      136
  5     5   KITCHEN               12    1140    1140   24.70   28.00    3.30               .42      268
  5     5   KITCHEN               12    1141    1141   23.30   28.00    4.70               .9       541
  5     5   KITCHEN               12    1142    1142   21.90   28.00    6.10              1.5       760
RUN:   2

  5     5   KITCHEN               12    1143    1143   20.50   28.00    7.50              2.4      1052
  5     5   KITCHEN               12    1144    1144   21.90   28.00    6.10              1.5       554
  5     5   KITCHEN               12    1145    1145   23.30   28.00    4.70               .9       486
  5     5   KITCHEN               12    1146    1146   26.10   28.00    1.90               .14      171
  5     5   KITCHEN               12    1150    1150   23.30   28.00    4.70               .9       585
  5     5   KITCHEN               12    1151    1151   21.90   28.00    6.10              1.5       775

RUN:   1

  8     8   MEE                   17    1140           28.60   29.60    1.00              .035      575
  8     8   MEE                   17    1140           27.50   29.60    2.10               .14     1120
  8     8   MEE                   17    1140           26.50   29.60    3.10               .35     1514
  8     8   MEE                   17    1140           25.80   29.60    3.80               .52     1618
  8     8   MEE                   17    1140           25.00   29.60    4.60               .8      2158
  8     8   MEE                   17    1140           24.30   29.60    5.30              1.1      1892
  8     8   MEE                   17    1140           23.50   29.60    6.10              1.4      1916
  8     8   MEE                   17    1140           23.00   29.60    6.60              1.8      2026
  8     8   MEE                   17    1140           22.50   29.60    7.10              1.9      2082

RUN:   1

  9     9   GAGIN                  5    1144           21.70   26.70    5.00      1.2     1.02      1150
  9     9   GAGIN                  5    1147           23.20   26.70    3.50      1.2      .5        980
  9     9   GAGIN                  5    1150           24.60   27.40    2.80      1.2      .29       940
  9     9   GAGIN                  5    1153           25.40   27.60    2.20      1.2      .17       400
RUN:   2

  9     9   GAGIN                  5    1157           21.70   27.30    5.60      1.2                990
  9     9   GAGIN                  5    1159           23.70   27.30    3.60      1.2                900
  9     9   GAGIN                  5    1202           24.80   27.50    2.70      1.2                900
  9     9   GAGIN                  5    1206           25.80   27.50    1.70      1.2                340
RUN:   3

  9     9   GAGIN                  5    1209           22.20   27.10    4.90      1.2      .93      1400
  9     9   GAGIN                  5    1212           23.80   27.60    3.80      1.2      .54       950
  9     9   GAGIN                  5    1216           24.90   27.70    2.80      1.2      .29       880
  9     9   GAGIN                  5    1218           25.80   27.50    1.70      1.2      .13       340
RUN:   4

  9     9   GAGIN                  5    1222           22.10   27.40    5.30      1.2     1.09      1200
  9     9   GAGIN                  5    1224           23.60   27.80    4.20      1.2      .66       880
  9     9   GAGIN                  5    1228           24.90   27.70    2.80      1.2      .29       790
  9     9   GAGIN                  5    1231           26.00   27.50    1.50      1.2      .12       410
RUN:   5

  9     9   GAGIN                  5    1237           22.80   27.70    4.90      1.2      .93      1090
```

EXPERIMENT #: 19

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER		SAMPLE START	TIME END	PLATE TEMP			VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
		NAME	NO.			COLD	HOT (C)	DELTA						
9	9	GAGIN	5	1240		24.20	27.70	3.50	1.2	.47	910			
9	9	GAGIN	5	1242		25.20	27.60	2.40	1.2	.23	810			
9	9	GAGIN	5	1247		25.70	27.80	2.10	1.2	.17	380			
RUN: 6														
9	9	GAGIN	5	1249		22.30	27.60	5.30	1.2	1.07	1420			
9	9	GAGIN	5	1251		23.70	27.40	3.70	1.2	.51	1230			
9	9	GAGIN	5	1255		25.30	28.00	2.70	1.2	0	0			
9	9	GAGIN	5	1259		26.20	28.00	1.80	1.2	.18	400			
RUN: 1														
10	10	LALA	13	1140		23.94	26.50	2.56	.4	.25	1114.1			
10	10	LALA	13	1141		23.93	26.48	2.55		.25	1257.9	1186		
10	10	LALA	13	1142		23.43	26.44	3.01		.35	1218.3			
10	10	LALA	13	1143		23.39	26.40	3.01		.35	1241.9	1230.1		
10	10	LALA	13	1144		22.77	26.36	3.59		.5	1104.5			
10	10	LALA	13	1145		22.72	26.31	3.59		.5	1167.7	1136.1		
10	10	LALA	13	1146		21.88	26.26	4.38		.75	1046.1			
10	10	LALA	13	1147		21.85	26.22	4.37		.75	1033.3	1039.7		
10	10	LALA	13	1148		21.13	26.16	5.03		1	982.4			
10	10	LALA	13	1149		21.07	26.10	5.03		1	999.7	991.1		
RUN: 2														
10	10	LALA	13	1201		23.61	26.15	2.54	.4	.25	1183.8			
10	10	LALA	13	1202		23.58	26.12	2.54		.25	1184.6	1184.2		
10	10	LALA	13	1203		23.09	26.09	3.00		.35	1125.7			
10	10	LALA	13	1204		23.07	26.07	3.00		.35	1185	1156.8		
10	10	LALA	13	1205		22.47	26.05	3.58		.5	1040.5			
10	10	LALA	13	1206		22.44	26.02	3.58		.5	1176.1	1108.3		
10	10	LALA	13	1207		21.63	26.00	4.37		.75	1020.9			
10	10	LALA	13	1208		21.60	25.96	4.36		.75	1004.6	1012.8		
10	10	LALA	13	1209		20.90	25.92	5.02		1	994.2			
10	10	LALA	13	1210		20.85	25.87	5.02		1	942.6	968.4		
RUN: 1														
11	11	FITZGERALD	28	1151	1157					.15	1234	1234		WATER IN ROYCO
11	11	FITZGERALD	28	1151	1157					.094	870	870		
11	11	FITZGERALD	28	1151	1157					.034	117.4	117.4		
11	11	FITZGERALD	28	1151	1157					.025	43.5	43.5		
11	11	FITZGERALD	28	1151	1157					.014	1.09	1.09		
RUN: 1														
13	13	AYERS	2	1150	1151	25.91	28.40	2.49		.25	1335			
13	13	AYERS	2	1151	1152	24.83	28.40	3.57		.5	1365			
13	13	AYERS	2	1153	1154	24.09	28.40	4.31		.75	1005			
13	13	AYERS	2	1154	1155	23.31	28.30	4.99		1	1290			
13	13	AYERS	2	1156	1157	22.70	28.30	5.60		1.25	1245			
RUN: 2														
13	13	AYERS	2	1157	1158	22.58	28.20	5.62		1.25	1260			
13	13	AYERS	2	1159	1200	23.19	28.20	5.01		1	1380			
13	13	AYERS	2	1200	1201	23.22	28.20	4.98		1	1290			
13	13	AYERS	2	1201	1202	23.19	28.20	5.01		1	1305			
13	13	AYERS	2	1202	1203	23.85	28.20	4.35		.75	1275			
13	13	AYERS	2	1203	1204	23.88	28.20	4.32		.75	1275			
13	13	AYERS	2	1204	1205	24.64	28.20	3.56		.5	1140			
13	13	AYERS	2	1206	1207	25.70	28.20	2.50		.25	1275			
RUN: 1														
14	14	HUDSON	9	1156	1223				.016	.21	500			F=40

EXPERIMENT #: 19

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

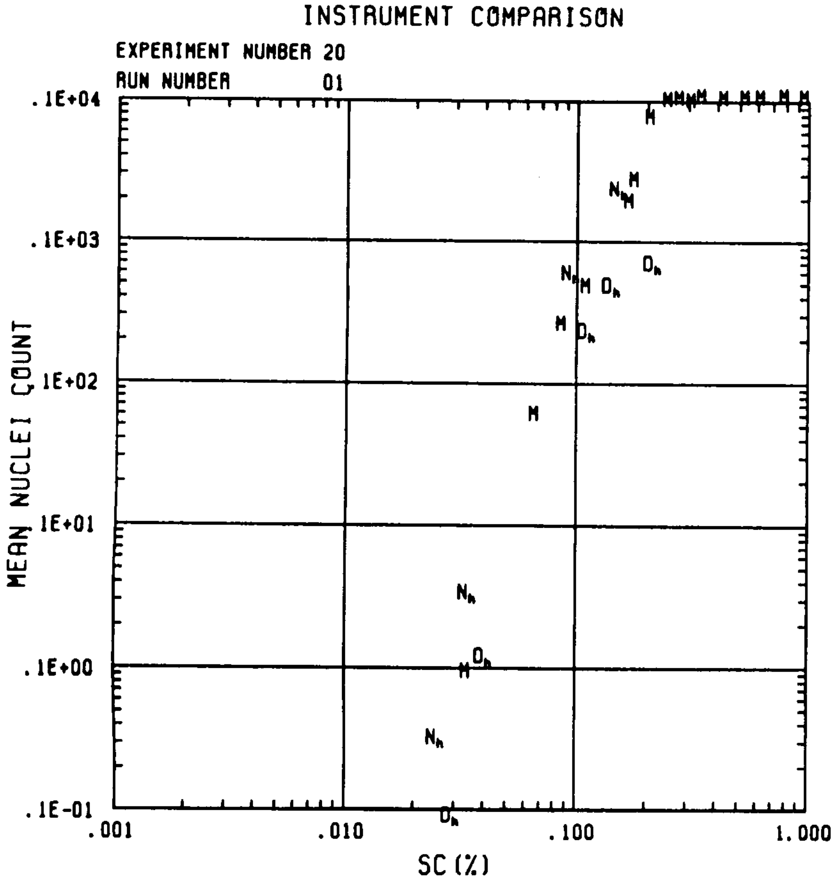
MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	PLATE TEMP DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
14	14	HUDSON	9	1156	1223				.016	.14	403			F=40
14	14	HUDSON	9	1156	1223				.016	.11	245			F=40
14	14	HUDSON	9	1156	1223				.016	.04	18.3			F=40
14	14	HUDSON	9	1156	1223				.016	.029	5.91			F=40
14	14	HUDSON	9	1224	1250				.016	.21	476			F=40
14	14	HUDSON	9	1224	1250				.016	.14	357			F=40
14	14	HUDSON	9	1224	1250				.016	.11	187			F=40
14	14	HUDSON	9	1224	1250				.016	.04	9.14			F=40
14	14	HUDSON	9	1224	1250				.016	.029	2.62			F=40
RUN:	2													
14	14	HUDSON	9	1251	1318				.016	.21	562			
14	14	HUDSON	9	1251	1318				.016	.14	444			
14	14	HUDSON	9	1251	1318				.016	.11	226			
14	14	HUDSON	9	1251	1318				.016	.04	12.2			
14	14	HUDSON	9	1251	1318				.016	.029	3.63			
RUN:	1													
15	15	ROGERS, FRED	23	1144	1145	18.36	26.06	6.70		1.86	1044			EACH PNT. IS AUG
15	15	ROGERS, FRED	23	1148	1149	18.74	24.75	6.01		1.46	1196			OF LAST 4 AT EACH
15	15	ROGERS, FRED	23	1152	1153	19.11	24.44	5.33		1.15	1077			SS. BACKGROUND IS
15	15	ROGERS, FRED	23	1157	1158	19.49	24.13	4.64		.87	996			10 PER CC AT SS
15	15	ROGERS, FRED	23	1200	1201	19.87	23.81	3.94		.63	1015			OF 1 PER CENT.
15	15	ROGERS, FRED	23	1204	1205	20.25	23.50	3.25		.425	959			GOOD DROP SIZE PLAT
15	15	ROGERS, FRED	23	1208	1209	20.63	23.19	2.56		.265	960			LAST 3 PNTS.
15	15	ROGERS, FRED	23	1213	1214	20.99	22.88	1.89		.14	470			LOWERED MAIN FLO.
15	15	ROGERS, FRED	23	1217	1218	21.35	22.56	1.21		.07	193			LAST 3 PNTS.
15	15	ROGERS, FRED	23	1233	1234	21.41	22.71	1.30		.095	269			
RUN:	1													
16	16	HUDSON	9	1145	1149	21.40	26.05	4.65	.0024	.88	1038			
16	16	HUDSON	9	1145	1149	21.70	25.40	3.70	.0024	.55	1036			
16	16	HUDSON	9	1145	1149	22.15	24.85	2.70	.0024	.29	1036			
16	16	HUDSON	9	1204	1206	21.40	26.05	4.65	.0018	.88	1003			
16	16	HUDSON	9	1204	1206	21.70	25.40	3.70	.0018	.55	1002			
16	16	HUDSON	9	1204	1206	22.15	24.85	2.70	.0018	.29	1002			
16	16	HUDSON	9	1223	1226	21.40	26.05	4.65	.0018	.88	999			
16	16	HUDSON	9	1223	1226	21.70	25.40	3.70	.0018	.55	998			
16	16	HUDSON	9	1223	1226	22.15	24.85	2.70	.0018	.29	998			
RUN:	2													
16	16	HUDSON	9	1233	1236	21.40	26.05	4.65	.0024	.88	1008			
16	16	HUDSON	9	1233	1236	21.70	25.40	3.70	.0024	.55	1006			
16	16	HUDSON	9	1233	1236	22.15	24.85	2.70	.0024	.29	1006			
16	16	HUDSON	9	1314	1317	21.40	26.05	4.65	.0018	.88	1046			
16	16	HUDSON	9	1314	1317	21.70	25.40	3.70	.0018	.55	1045			
16	16	HUDSON	9	1314	1317	22.15	24.85	2.70	.0018	.29	1045			
RUN:	1													
17	17	WOJCIECHOWSKI	27	1147	1149					.25	1243	1243		
17	17	WOJCIECHOWSKI	27	1152	1154					.36	1243	1243		
17	17	WOJCIECHOWSKI	27	1156	1157					.47	1184	1184		
17	17	WOJCIECHOWSKI	27	1159	1200					.72	1376	1376		
17	17	WOJCIECHOWSKI	27	1201	1202					.98	1219	1219		
RUN:	1													
18	18	HUDSON	9	1145	1149	22.45	26.70	4.25	.0024	.73	1004			
18	18	HUDSON	9	1153	1158	22.90	26.25	3.35	.003	.45	1020			
18	18	HUDSON	9	1204	1206	23.40	25.80	2.40	.0018	.23	1004			
18	18	HUDSON	9	1223	1226	23.90	25.30	1.40	.0018	.08	146			
18	18	HUDSON	9	1233	1236	23.90	25.50	1.60	.0024	.1	198			

EXPERIMENT #: 19

NUCLEI MEASUREMENTS

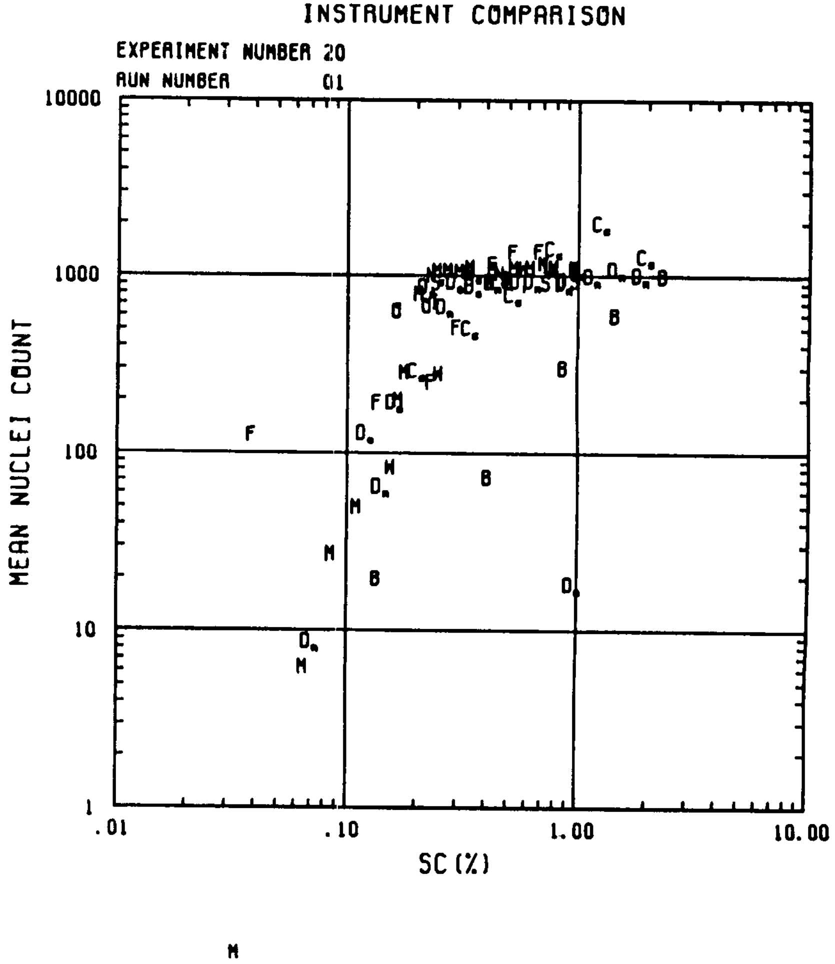
PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	PLATE TEMP DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
18	18	HUDSON	9	1314	1317	23.75	25.66	1.90	.0018	.14	897			
RUN: 1														
21	21	TRUEBLOOD	26	1132	1133	20.05	25.00	4.95		.98	1165			
21	21	TRUEBLOOD	26	1146	1147	21.97	25.00	3.03		.367	1158			
21	21	TRUEBLOOD	26	1151	1152	22.50	25.00	2.50		.25	1164			
21	21	TRUEBLOOD	26	1200	1201	22.69	25.00	2.31		.213	1086			
21	21	TRUEBLOOD	26	1204	1205	22.88	25.00	2.12		.18	1091			
21	21	TRUEBLOOD	26	1207	1208	23.08	25.00	1.92		.147	1099			
21	21	TRUEBLOOD	26	1211	1212	23.30	25.00	1.70		.116	883			
21	21	TRUEBLOOD	26	1223	1224	25.00	25.00	0.00		.173	1164			
21	21	TRUEBLOOD	26	1223	1224	25.00	25.00	0.00		.114	578.4			
21	21	TRUEBLOOD	26	1223	1224	25.00	25.00	0.00		.089	280			
21	21	TRUEBLOOD	26	1223	1224	25.00	25.00	0.00		.068	185			
21	21	TRUEBLOOD	26	1231	1232	25.00	25.00	0.00		.035	21.5			
21	21	TRUEBLOOD	26	1231	1232	25.00	25.00	0.00		.022	3.72			
21	21	TRUEBLOOD	26	1231	1232	25.00	25.00	0.00		.0133	0			
RUN: 1														
24	24	SERPOLAY	25	1150	1157	29.20	30.70	1.50	.77	.09	630			
24	24	SERPOLAY	25	1205	1215	29.20	31.70	2.50	.77	.24	890			
24	24	SERPOLAY	25	1224	1230	29.40	32.80	3.40	.77	.43	1160			
24	24	SERPOLAY	25	1237	1241	29.60	34.00	4.40	.77	.68	1230			
24	24	SERPOLAY	25	1247	1252	29.80	34.40	4.60	.77	.73	1300			
24	24	SERPOLAY	25	1310	1312	30.10	32.10	2.00	.77	.15	800			
RUN: 1														
25	25	BORYS	3	1142	1145	20.60	25.50	4.90	5.3	.95	1301	1301		VOL SAMP X10**5
25	25	HORYS	3	1150	1153	21.20	25.60	4.40	8.48	.74	1415	1415		
25	25	BORYS	3	1157	1205	22.30	26.70	3.40	10.6	.46	1160	1160		
25	25	HORYS	3	1208	1216	23.70	26.00	2.30	10.6	.18	1004	1004		
RUN: 1														
26	26	HINDMAN	6	1210	1312	26.00	26.00	0.00	1.9	.13	190	190		+/-4.7
26	26	HINDMAN	6	1210	1312	26.00	26.00	0.00	1.9	.12	110	110		+/-4.2
26	26	HINDMAN	6	1210	1312	26.00	26.00	0.00	1.9	.055	76	76		+/-24
26	26	HINDMAN	6	1210	1312	26.00	26.00	0.00	1.9	.032	.49	.49		+/-0.042
26	26	HINDMAN	6	1210	1312	26.00	26.00	0.00	1.9	.02	.013	.013		+/-0.0032
RUN: 1														
27	27	OHTAKE	19	1140	1140				3.7	.75	1.3			75%
27	27	OHTAKE	19	1140	1140					.97	1.19			97%
27	27	OHTAKE	19	1140	1140				3.7	1.09	2.23			109% NOMINAL


INSTRUMENT COMPARISON

EXPERIMENT NUMBER 20
RUN NUMBER 01

HAZE CHAMBER RESULTS


INSTRUMENT COMPARISON

EXPERIMENT NUMBER 20
RUN NUMBER 01

SDC/CFD RESULTS

```
                                        EXPERIMENT # 20
                                                                              80/10/13
PURPOSE
-------

 INSTRUMENT COMPARISON WITH AEROSOL SIZE SUITABLE FOR CCN AND HAZE CHAMBERS.

DESCRIPTION OF EXPERIMENT
-------------------------

  DATE          TIME
                START   END
  ------------  -----------

  13 OCT,1980   1358   1545

  NUCLEI TYPE
  -----------

   (NH4)2 SO4, MONODISPERSE, D=0.08 UM.

  GENERATION METHOD
  -----------------

   DRI ATOMIZER, 70 PSI, 1.77 G/L SOLUTION.

  SIZE DISTRIBUTION SHAPING
  -------------------------

   EC, 222V, FLOWRATE 4.4 L/MIN., DILUTION FLOW 370 L/MIN.

REMARKS
-------

 NONE

WEATHER SYNOPSIS
----------------

 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

          ROOM CONDITIONS                          OUTSIDE CONDITIONS

 --------------------------------    ----------------------------------------------------

 AVG TEMP    AVG RH    AVG PRESS     AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)        (%)        (MB)          (C)        (%)        (MB)       (M/S)     (DEG)
 --------    ------    ---------     --------    ------    ---------    ------    ------

   29.0       21.0       848
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                                                         NUCLEI MEASUREMENTS
EXPERIMENT #: 20                                                                                               PROCESSING DATE: 81/09/26

                  OBSERVER                                  PLATE TEMP
MACH  DUCT  -----------------------  SAMPLE  TIME                                VOLUME   SUPER  NUCLEI    OBS    EST
NO.   NO.   NAME               NO.   START   END     COLD     HOT      DELTA    SAMPLED   SAT    COUNT      -      K     REMARKS
                                                              (C)                (L)      (%)               N
----  ----  ---------------    ---   -----   ----   ------   ------   ------   -------   -----  ------   -----   -----  ------------------

RUN:  1

  2     2   POLITOVICH          20   1444    1445   24.50    26.60     2.10               .17              662
  2     2   POLITOVICH          20   1446    1447   24.20    26.60     2.40               .23              706

RUN:  1

  5     5   KITCHEN             12   1357    1357   25.60    27.50     1.90               .14               19
  5     5   KITCHEN             12   1358    1358   24.20    27.50     3.30               .42               90
  5     5   KITCHEN             12   1359    1359   22.80    27.50     4.70               .9               328
  5     5   KITCHEN             12   1400    1400   21.40    27.50     6.10              1.5               654
  5     5   KITCHEN             12   1401    1401   19.90    27.40     7.50              2.4              1038
  5     5   KITCHEN             12   1402    1402   21.30    27.40     6.10              1.5               576
  5     5   KITCHEN             12   1403    1403   22.80    27.50     4.70               .9               296
  5     5   KITCHEN             12   1404    1404   24.20    27.50     3.30               .42               59
  5     5   KITCHEN             12   1405    1405   25.60    27.50     1.90               .14               22

RUN:  2

  5     5   KITCHEN             12   1406    1406   22.80    27.50     4.70               .9     304
  5     5   KITCHEN             12   1408    1408   22.80    27.50     4.70               .9     257
  5     5   KITCHEN             12   1410    1410   25.60    27.50     1.90               .14     11
  5     5   KITCHEN             12   1411    1411   24.20    27.50     3.30               .42     19
  5     5   KITCHEN             12   1412    1412   22.80    27.50     4.70               .9     310
  5     5   KITCHEN             12   1413    1413   21.50    27.60     6.10              1.5     743
  5     5   KITCHEN             12   1414    1414   20.00    27.50     7.50              2.4     884

RUN:  1

 10    10   LALA                13   1400           23.88    26.43     2.55               .25    976
 10    10   LALA                13   1401           23.84    26.38     2.54               .25    905.4   940.7
 10    10   LALA                13   1402           23.34    26.34     3.00               .35   1000
 10    10   LALA                13   1403           23.30    26.31     3.01               .35   1019.6  1009.8
 10    10   LALA                13   1404           22.68    26.27     3.59               .5    1012.6
 10    10   LALA                13   1405           22.64    26.22     3.58               .5    1002.1  1007.4
 10    10   LALA                13   1406           21.80    26.17     4.37               .75    972.1
 10    10   LALA                13   1407           21.76    26.13     4.37               .75    917.9    945
 10    10   LALA                13   1408           21.05    26.08     5.03              1       993
 10    10   LALA                13   1409           21.00    26.03     5.03              1       933.6   963.3

RUN:  2

 10    10   LALA                13   1407           23.88    26.16     2.28               .2     728.4
 10    10   LALA                13   1408           23.29    26.07     2.78               .3    1014
 10    10   LALA                13   1409           22.86    26.06     3.20               .4    1108
 10    10   LALA                13   1410           22.46    26.04     3.58               .5    1038.3
 10    10   LALA                13   1411           22.10    26.01     3.91               .6     936.2
 10    10   LALA                13   1412           21.77    25.99     4.22               .7    1006.5
 10    10   LALA                13   1413           21.45    25.95     4.50               .8     974.9
 10    10   LALA                13   1414           21.16    25.93     4.77               .9    1009.1
 10    10   LALA                13   1415           20.87    25.89     5.02              1       993.9

RUN:  1

 11    11   FITZGERALD          28   1404    1421                                        .15     252     252
 11    11   FITZGERALD          28   1404    1421                                        .094     63.8    63.8
 11    11   FITZGERALD          28   1404    1421                                        .034      .36     .36
 11    11   FITZGERALD          28   1404    1421                                        .025      .034    .034
 11    11   FITZGERALD          28   1404    1421                                        .014     0       0

RUN:  2

 11    11   FITZGERALD          28   1426    1443                                        .15     227     227
 11    11   FITZGERALD          28   1426    1443                                        .094     54.1    54.1
 11    11   FITZGERALD          28   1426    1443                                        .034      .36     .36
 11    11   FITZGERALD          28   1426    1443                                        .025      .069    .069
 11    11   FITZGERALD          28   1426    1443                                        .014     0       0
```
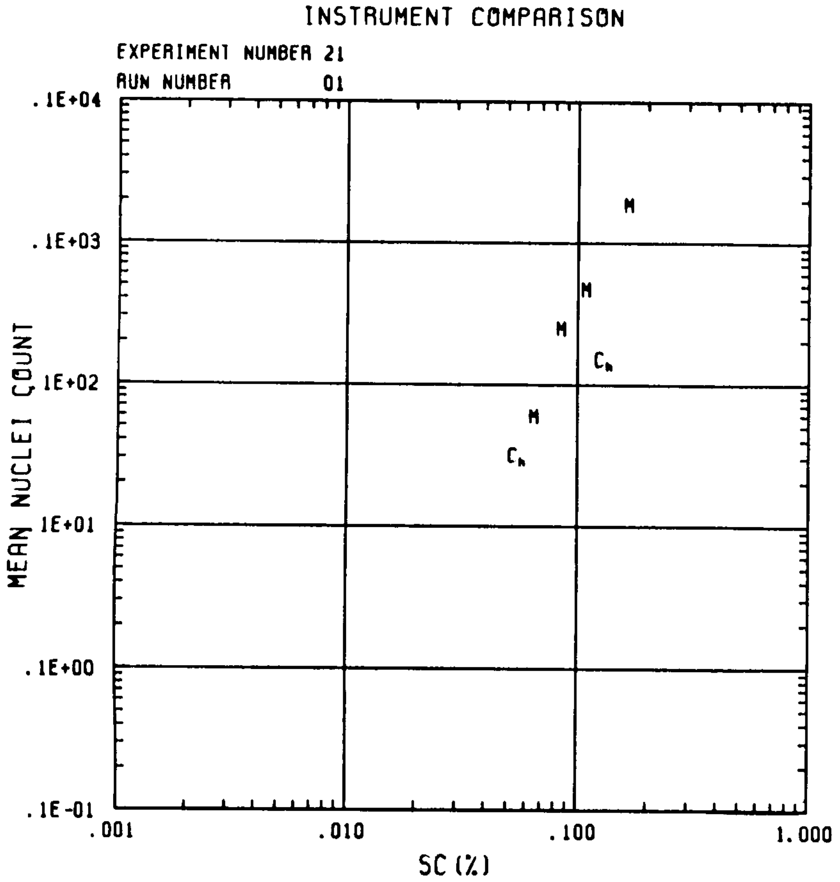
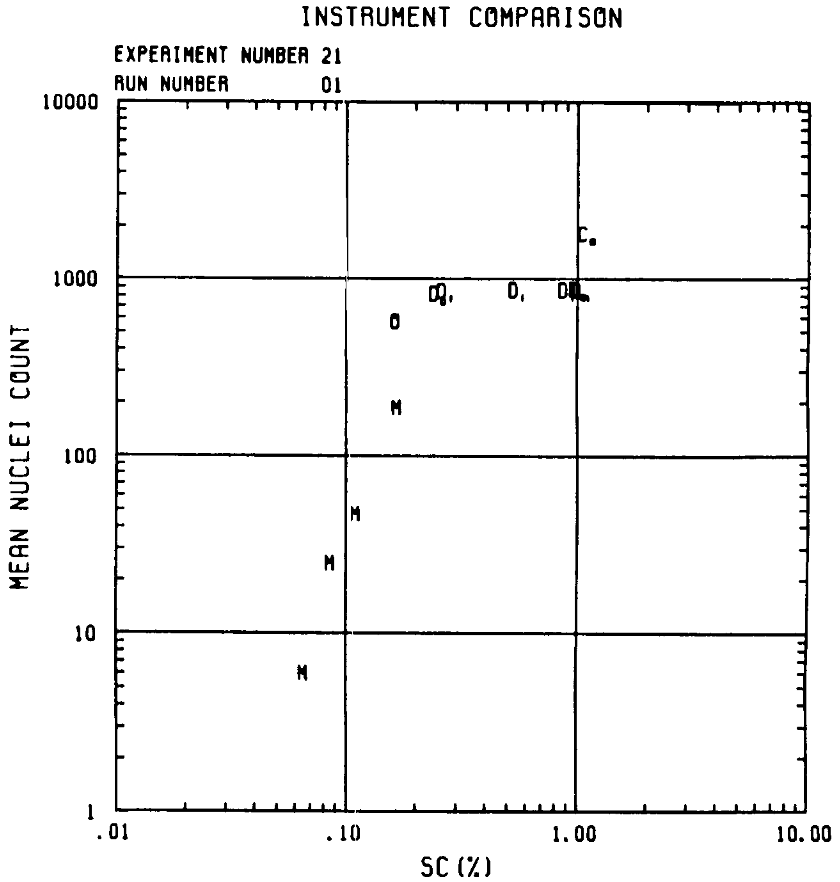

```
                                                       NUCLEI MEASUREMENTS
EXPERIMENT #: 20                                                                                      PROCESSING DATE: 81/09/26
                 OBSERVER                         PLATE TEMP
MACH  DUCT  -------------------  SAMPLE TIME                          VOLUME   SUPER   NUCLEI   OBS    EST
NO.   NO.   NAME            NO.  START   END   COLD    HOT    DELTA   SAMPLED   SAT    COUNT     -      K    REMARKS
                                                       (C)              (L)     (%)              N
----  ----  --------------- ---  -----  ----  ------  ------  ------  -------  ------  ------  -----  -----  --------------------

RUN:  1

  13    13  STEIN            31   1359  1400   26.42   28.90    2.48              .25     735
  13    13  STEIN            31   1402  1403   25.12   28.70    3.58               .5     975
  13    13  STEIN            31   1405  1406   24.22   28.60    4.38              .75    1185
  13    13  STEIN            31   1408  1409   23.54   28.60    5.06                1    1125

RUN:  2

  13    13  STEIN            31   1415  1416   23.26   28.30    5.04                1    1500
  13    13  STEIN            31   1416  1417   23.96   28.30    4.34              .75    1260
  13    13  STEIN            31   1419  1420   24.66   28.20    3.54               .5     975
  13    13  STEIN            31   1423  1424   25.69   28.20    2.51              .25     825

RUN:  3

  13    13  STEIN            31   1426  1427   25.80   28.30    2.50              .25    1020
  13    13  STEIN            31   1429  1430   24.74   28.30    3.56               .5    1050
  13    13  STEIN            31   1433  1434   23.93   28.30    4.37              .75    1275
  13    13  STEIN            31   1435  1436   23.29   28.30    5.01                1     960
  13    13  STEIN            31   1438  1439   22.73   28.30    5.57             1.25    1725

RUN:  4

  13    13  AYERS             2   1453  1454   23.32   28.30    4.98                1    1275
  13    13  AYERS             2   1455  1456   22.73   28.30    5.57             1.25    1200
  13    13  AYERS             2   1456  1457   22.70   28.30    5.60             1.25    1200
  13    13  AYERS             2   1458  1459   23.42   28.40    4.98                1    1290
  13    13  AYERS             2   1500  1501   23.37   28.40    5.03                1    1200
  13    13  AYERS             2   1502  1503   24.08   28.40    4.32              .75    1215
  13    13  AYERS             2   1503  1504   24.05   28.40    4.35              .75    1095
  13    13  AYERS             2   1506  1507   24.89   28.40    3.51               .5    1223
  13    13  AYERS             2   1507  1508   24.89   28.40    3.51               .5    1110
  13    13  AYERS             2   1510  1511   26.04   28.50    2.46              .25     930
  13    13  AYERS             2   1511  1512   26.00   28.50    2.50              .25     795
  13    13  AYERS             2   1512  1513   25.98   28.50    2.52              .25    1110


RUN:  1

  14    14  HUDSON            9   1420  1447                             .016     .21    77.4                   F=40
  14    14  HUDSON            9   1420  1447                             .016     .14    55.5                   F=40
  14    14  HUDSON            9   1420  1447                             .016     .11    27.6                   F=40
  14    14  HUDSON            9   1420  1447                             .016     .04     .19                   F=40
  14    14  HUDSON            9   1420  1447                             .016    .029    .016                   F=40
  14    14  HUDSON            9   1448  1515                             .016     .21    71.9                   F=40
  14    14  HUDSON            9   1448  1515                             .016     .14    47.5                   F=40
  14    14  HUDSON            9   1448  1515                             .016     .11    21.4                   F=40
  14    14  HUDSON            9   1448  1515                             .016     .04     .06                   F=40
  14    14  HUDSON            9   1448  1515                             .016    .029    .003                   F=40

RUN:  1

  15    15  ROGERS, FRED     23   1412  1413   18.36   25.06    6.70             1.86    1043                   BACKGROUND 10 PER
  15    15  ROGERS, FRED     23   1416  1417   18.74   24.75    6.01             1.46    1133                   CC.
  15    15  ROGERS, FRED     23   1420  1421   19.11   24.44    5.33             1.15    1037                   AVERAGING LAST 4
  15    15  ROGERS, FRED     23   1424  1425   19.49   24.13    4.64              .87     948                   COUNTS PER SS.
  15    15  ROGERS, FRED     23   1428  1429   19.87   23.81    3.94              .63     966                   MAIN FLO 1300 CNTS.
  15    15  ROGERS, FRED     23   1433  1434   20.25   23.50    3.25             .425     959                   AND CONSTANT.
  15    15  ROGERS, FRED     23   1437  1438   20.63   23.19    2.56             .265     694
  15    15  ROGERS, FRED     23   1441  1442   20.99   22.88    1.89              .14      67                   COUNT FLUCTUATIONS.
  15    15  ROGFRS, FRED     23   1445  1446   21.35   22.56    1.21              .07       9                   DROP SIZE PLAT BAD
  15    15  ROGERS, FRED     23   1502  1503   21.41   22.71    1.30              .95      19                   LAST 4 PTS.

RUN:  1

  16    16  HUDSON            9   1415  1418   21.40   26.05    4.65    .0018     .88     991
  16    16  HUDSON            9   1415  1418   21.70   25.40    3.70    .0018     .55     990
```

```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 20                                                                                                PROCESSING DATE:  81/09/26
                    OBSERVER                                       PLATE TEMP
MACH  DUCT  ------------------------  SAMPLE TIME                                    VOLUME   SUPER  NUCLEI    OBS     EST
NO.   NO.   NAME                NO.   START   END    COLD     HOT      DELTA   SAMPLED   SAT    COUNT      -       K      REMARKS
                                                               (C)              (L)      (%)                N
----  ----  ---------------- ---   -----  ----    ------   ------   ------  -------   ------  ------   -----   -----   ------------------
 16    16   HUDSON              9    1415   1418    22.15    24.85    2.70    .0018     .29      984
 16    16   HUDSON              9    1427   1429    21.40    26.05    4.65    .0018     .88      978
 16    16   HUDSON              9    1427   1429    21.70    25.40    3.70    .0018     .55      976
 16    16   HUDSON              9    1427   1429    22.15    24.85    2.70    .0018     .29      970
 16    16   HUDSON              9    1450   1453    21.40    26.05    4.65    .0018     .88      958
 16    16   HUDSON              9    1450   1453    21.40    26.05    4.65    .0018     .55      957
 16    16   HUDSON              9    1450   1453    22.15    24.85    2.70    .0018     .29      943
RUN:  2

 16    16   HUDSON              9    1458   1500    21.40    26.10    4.70    .0012      .9      958
 16    16   HUDSON              9    1458   1500    21.70    25.40    3.70    .0012     .55      957
 16    16   HUDSON              9    1458   1500    22.20    24.10    1.90    .0012     .29      943
 16    16   HUDSON              9    1513   1516    21.40    26.10    4.70    .0024      .9      927
 16    16   HUDSON              9    1513   1516    21.70    25.40    3.70    .0024     .55      926
 16    16   HUDSON              9    1513   1516    22.20    24.90    2.70    .0024     .29      915

RUN:  1

 17    17   WOJCIECHOWSKI      27    1422   1423                                         .24     1040     1040
 17    17   WOJCIECHOWSKI      27    1427   1429                                         .35     1075     1075
 17    17   WOJCIECHOWSKI      27    1431   1432                                         .47     1070     1070
 17    17   WOJCIECHOWSKI      27    1434   1436                                         .73     1228     1228
 17    17   WOJCIECHOWSKI      27    1437   1439                                         .99     1140     1140

RUN:  1

 18    18   HUDSON              9    1415   1418    23.60    25.95    2.35    .0018     .22      899
 18    18   HUDSON              9    1427   1429    23.40    26.10    2.70    .0018     .29      961
 18    18   HUDSON              9    1450   1453    23.85    25.60    1.75    .0018     .12      133
 18    18   HUDSON              9    1458   1500    23.75    25.80    2.05    .0012     .16      198
 18    18   HUDSON              9    1513   1516    23.30    26.25    2.95    .0024     .35      906

RUN:  1

 20    20   DOMONKOS            4    1430   1435                                         .16       85
 20    20   DOMONKOS            4    1430   1435                                         .26      290
 20    20   DOMONKOS            4    1430   1435                                         .43      950
 20    20   DOMONKOS            4    1430   1435                                          .6     1150

RUN:  1

 21    21   TRUEBLOOD          26    1400   1401    20.00    25.00    5.00                1    1143.9
 21    21   TRUEBLOOD          26    1404   1405    20.50    25.00    4.50              .81    1164.8
 21    21   TRUEBLOOD          26    1408   1409    21.00    25.00    4.00              .64    1140.3
 21    21   TRUEBLOOD          26    1411   1412    21.30    25.00    3.70             .548    1138.9
 21    21   TRUEBLOOD          26    1415   1415    21.68    25.00    3.32             .441    1136.2
 21    21   TRUEBLOOD          26    1418   1418    22.02    25.00    2.98             .355    1159.2
 21    21   TRUEBLOOD          26    1421   1422    22.18    25.00    2.82             .318    1099.5
 21    21   TRUEBLOOD          26    1424   1425    22.34    25.00    2.66             .283    1121.7
 21    21   TRUEBLOOD          26    1427   1428    22.48    25.00    2.52             .254    1116.9
 21    21   TRUEBLOOD          26    1435   1436    22.70    25.00    2.30             .212     825.9
 21    21   TRUEBLOOD          26    1438   1439    22.86    25.00    2.14             .183     296.6
 21    21   TRUEBLOOD          26    1452   1454    25.00    25.00    0.00             .173     207.8
 21    21   TRUEBLOOD          26    1452   1454    25.00    25.00    0.00             .114      51.4
 21    21   TRUEBLOOD          26    1452   1454    25.00    25.00    0.00             .089      28.1
 21    21   TRUEBLOOD          26    1452   1454    25.00    25.00    0.00             .068       6.5
 21    21   TRUEBLOOD          26    1529   1531    25.00    25.00    0.00             .035        .1

RUN:  1

 24    24   SERPOLAY           25    1402   1407    29.70    30.70    1.00      .77     .04      130
 24    24   SERPOLAY           25    1419   1425    29.70    31.70    2.00      .77     .14      200
 24    24   SERPOLAY           25    1426   1431    29.70    32.20    2.50      .77     .24      260
 24    24   SERPOLAY           25    1435   1440    29.70    32.70    3.00      .77     .31      530
 24    24   SERPOLAY           25    1450   1455    30.00    33.50    3.50      .77     .44     1200
```

```
                                                    NUCLEI MEASUREMENTS
EXPERIMENT #: 20                                                                                PROCESSING DATE: 81/09/26
                OBSERVER                                 PLATE TEMP
MACH  DUCT  ------------------------  SAMPLE  TIME                            VOLUME   SUPER   NUCLEI    OBS    EST
NO.   NO.   NAME                NO.   START   END    COLD    HOT    DELTA   SAMPLED   SAT     COUNT      -      K     REMARKS
                                                              (C)             (L)      (%)               N
----  ----  ----------------  ---   -----   ----   ------  ------  ------  -------  ------  ------   -----  -----  -------------------
 24    24   SERPOLAY           25   1505    1510    30.20   34.20    4.00      .77     .54    1410
 24    24   SERPOLAY           25   1520    1528    30.50   35.00    4.50      .77     .7     1430

RUN:  1

 25    25   BORYS               3   1400    1405    19.00   26.00    7.00      5.3    1.95    1330    1330                 VOL SAMP X10**5
 25    25   BORYS               3   1410    1415    20.50   25.90    5.40      5.36   1.25    2065    2065
 25    25   BORYS               3   1422    1428    23.70   26.10    2.40      6.36    .78    1485    1485
 25    25   BORYS               3   1431    1435    22.60   26.20    3.60     10.6     .52     806     806
 25    25   BORYS               3   1441    1443    23.50   26.50    3.00     10.6     .34     523     523
 25    25   BORYS               3   1452    1453    24.50   26.80    2.30     15.9     .2      301     301

RUN:  1

 27    27   OHTAKE             19   1438    1438                               1.8             .277                        107% NOMINAL
```



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

```
                                        EXPERIMENT # 21                                        80/10/13

PURPOSE
-------
 TIME VARIATION TEST TO DETERMINE REPRODUCABILITY OF INSTRUMENT.

DESCRIPTION OF EXPERIMENT
-------------------------
              TIME
  DATE        START   END
  ----------- ----------
  13 OCT,1980 1545   1726

  NUCLEI TYPE
  -----------
   SAME AS 20

  GENERATION METHOD
  -----------------
   SAME AS 20

  SIZE DISTRIBUTION SHAPING
  -------------------------
   SAME AS 20

REMARKS
-------
 NONE

WEATHER SYNOPSIS
----------------
 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
        ROOM CONDITIONS                              OUTSIDE CONDITIONS

 -------------------------------    -------------------------------------------------.
 AVG TEMP     AVG RH    AVG PRESS   AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)         (%)        (MB)        (C)        (%)        (MB)       (M/S)     (DEG)
 --------     ------    ---------   --------    ------    ---------    ------    ------
   28.0        21.0        848
```

EXPERIMENT #: 21

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS N	EST K	REMARKS
RUN: 1														
2	2	POLITOVICH	20	1545		19.90	22.00	2.10		.17		612		
2	2	POLITOVICH	20	1547		20.10	22.20	2.10		.17		656		
2	2	POLITOVICH	20	1549		20.40	22.50	2.10		.17		559		
2	2	POLITOVICH	20	1551		20.80	22.90	2.10		.17		588		
2	2	POLITOVICH	20	1553		21.20	23.30	2.10		.17		582		
2	2	POLITOVICH	20	1555		21.50	23.60	2.10		.17		632		
2	2	POLITOVICH	20	1557		21.60	23.70	2.10		.17		647		
2	2	POLITOVICH	20	1559		21.80	23.90	2.10		.17		582		
2	2	POLITOVICH	20	1601		22.00	24.10	2.10		.17		553		
2	2	POLITOVICH	20	1603		22.10	24.20	2.10		.17		523		
2	2	POLITOVICH	20	1605		22.30	24.40	2.10		.17		685		
2	2	POLITOVICH	20	1607		22.50	24.60	2.10		.17		685		
2	2	POLITOVICH	20	1609		22.50	24.60	2.10		.17		597		
2	2	POLITOVICH	20	1611		22.60	24.70	2.10		.17		523		
2	2	POLITOVICH	20	1613		22.70	24.80	2.10		.17		676		
2	2	POLITOVICH	20	1615		22.90	25.00	2.10		.17		538		
2	2	POLITOVICH	20	1617		23.10	25.20	2.10		.17		564		
2	2	POLITOVICH	20	1619		23.10	25.20	2.10		.17		632		
2	2	POLITOVICH	20	1621		23.20	25.30	2.10		.17		656		
2	2	POLITOVICH	20	1623		23.30	25.40	2.10		.17		479		
2	2	POLITOVICH	20	1625		23.30	25.40	2.10		.17		529		
RUN: 1														
5	5	KITCHEN	12	1545	1626	21.10	26.30	5.20		1		578.59		STD. DEV. = 64.23
5	5	KITCHEN	12	1631	1709	24.50	27.00	2.50		.25				COUNT AROUND
5	5	KITCHEN	12	1631	1709									NOISE LEVEL=100CM-3
RUN: 1														
10	10	LALA	13	1545		22.11	27.18	5.07	.4	1	902.1			
10	10	LALA	13	1546		22.01	27.08	5.07	.4	1	866	884.1		
10	10	LALA	13	1547		21.91	26.98	5.07	.4	1	920.3			
10	10	LALA	13	1548		21.81	26.87	5.06	.4	1	907.6	914		
10	10	LALA	13	1549		21.73	26.78	5.05	.4	1	910.2			
10	10	LALA	13	1550		21.63	26.68	5.05	.4	1	870.1	890.2		
10	10	LALA	13	1551		21.57	26.62	5.05	.4	1	911.7			
10	10	LALA	13	1552		21.48	26.52	5.04	.4	1	881	896.3		
10	10	LALA	13	1553		21.47	26.51	5.04	.4	1	876.6			
10	10	LALA	13	1554		21.41	26.45	5.04	.4	1	827.4	852		
10	10	LALA	13	1555		21.38	26.42	5.04	.4	1	884.6			
10	10	LALA	13	1556		21.30	26.34	5.04	.4	1	931.4	908		
10	10	LALA	13	1557		21.30	26.34	5.04	.4	1	863.4			
10	10	LALA	13	1558		21.23	26.27	5.04	.4	1	916	890		
10	10	LALA	13	1559		21.24	26.27	5.03	.4	1	1003.1			
10	10	LALA	13	1600		21.16	26.20	5.04	.4	1	935.1	969.1		
10	10	LALA	13	1601		21.17	26.21	5.04	.4	1	886.4			
10	10	LALA	13	1602		21.10	26.13	5.03	.4	1	893.1	889.8		
10	10	LALA	13	1603		21.13	26.16	5.03	.4	1	909.4			
10	10	LALA	13	1604		21.07	26.10	5.03	.4	1	937	923.2		
10	10	LALA	13	1605		21.11	26.14	5.03	.4	1	934.6			
10	10	LALA	13	1606		21.05	26.08	5.03	.4	1	839.8	887.2		
10	10	LALA	13	1607		21.09	26.12	5.03	.4	1	929.1			
10	10	LALA	13	1608		21.03	26.06	5.03	.4	1	855.1	892.1		
10	10	LALA	13	1609		21.09	26.12	5.03	.4	1	929.6			
10	10	LALA	13	1610		21.04	26.06	5.02	.4	1	885.6	907.6		
10	10	LALA	13	1611		21.09	26.12	5.03	.4	1	947.9			
10	10	LALA	13	1612		21.04	26.07	5.03	.4	1	942.2	936.1		
10	10	LALA	13	1613		21.08	26.11	5.03	.4	1	967.2			
10	10	LALA	13	1614		21.04	26.06	5.02	.4	1	919.6	943.4		
10	10	LALA	13	1614		21.09	26.12	5.03	.4	1	892.9			
10	10	LALA	13	1615		21.04	26.07	5.03	.4	1	880.6	886.8		
10	10	LALA	13	1616		21.13	26.16	5.03	.4	1	959.5			
10	10	LALA	13	1617		21.08	26.11	5.03	.4	1	920.2	939.9		
10	10	LALA	13	1618		21.16	26.19	5.03	.4	1	873.4			
10	10	LALA	13	1619		21.11	26.14	5.03	.4	1	893.1	883.3		

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                                                 NUCLEI MEASUREMENTS
EXPERIMENT #: 21                                                                                   PROCESSING DATE: 81/09/26
                   OBSERVER                                    PLATE TEMP
MACH  DUCT  -------------------  SAMPLE TIME                                 VOLUME   SUPER  NUCLEI   OBS    EST
NO.   NO.   NAME             NO.  START  END    COLD    HOT    DELTA  SAMPLED  SAT    COUNT     -      K     REMARKS
                                                        (C)             (L)    (%)              N
----  ----  ---------------  ---  -----  ----  ------  ------  ------ -------  ------ ------  ------  -----  -------------------
 10    10   LALA             13   1620         21.21   26.25   5.04     .4       1    910.2
 10    10   LALA             13   1621         21.17   26.20   5.03     .4       1    916.4   913.3
 10    10   LALA             13   1622         21.27   26.30   5.03     .4       1    927.6
 10    10   LALA             13   1623         21.22   26.26   5.04     .4       1    929.1   928.4
 10    10   LALA             13   1624         21.33   26.37   5.04     .4       1    905.4                N AVG. = 906.7
 10    10   LALA             13   1625         21.34   26.38   5.04     .4       1    905.7   905.6        STD. DEV. = 26.5

RUN:  2

 10    10   LALA             13   1627         23.87   26.42   2.55     .4     .25   1034
 10    10   LALA             13   1628         23.92   26.47   2.55     .4     .25   1044    1039
 10    10   LALA             13   1629         24.08   26.63   2.55     .4     .25   1114.8
 10    10   LALA             13   1630         24.09   26.64   2.55     .4     .25   1028.9  1071.9
 10    10   LALA             13   1631         24.26   26.82   2.56     .4     .25   1053.2
 10    10   LALA             13   1632         24.26   26.82   2.56     .4     .25   1003.9  1028.6
 10    10   LALA             13   1633         24.40   26.96   2.56     .4     .25   1095.9
 10    10   LALA             13   1634         24.37   26.93   2.56     .4     .25   1060.9  1078.4
 10    10   LALA             13   1635         24.48   27.04   2.56     .4     .25   1008.3
 10    10   LALA             13   1636         24.45   27.01   2.56     .4     .25   1041.8  1025.1
 10    10   LALA             13   1637         24.53   27.09   2.56     .4     .25   1052.5
 10    10   LALA             13   1638         24.49   27.05   2.56     .4     .25    986.7  1019.6
 10    10   LALA             13   1639         24.47   27.03   2.56     .4     .25   1112
 10    10   LALA             13   1640         24.44   27.00   2.56     .4     .25   1065.5  1088.8
 10    10   LALA             13   1641         24.52   27.08   2.56     .4     .25   1070.8
 10    10   LALA             13   1642         24.47   27.03   2.56     .4     .25   1000.4  1035.6
 10    10   LALA             13   1643         24.52   27.08   2.56     .4     .25   1044.3
 10    10   LALA             13   1644         24.47   27.03   2.56     .4     .25   1021.1  1032.8
 10    10   LALA             13   1645         24.52   27.08   2.56     .4     .25   1058.1
 10    10   LALA             13   1646         24.47   27.03   2.56     .4     .25    990    1024.1
 10    10   LALA             13   1647         24.52   27.08   2.56     .4     .25    998.4
 10    10   LALA             13   1648         24.47   27.03   2.56     .4     .25    984.5   991.5
 10    10   LALA             13   1649         24.50   27.06   2.56     .4     .25   1076.4
 10    10   LALA             13   1650         24.42   26.98   2.56     .4     .25   1060.6  1068.5
 10    10   LALA             13   1651         24.38   26.94   2.56     .4     .25   1040.6
 10    10   LALA             13   1652         24.35   26.91   2.56     .4     .25   1054    1047.4
 10    10   LALA             13   1653         24.42   26.98   2.56     .4     .25   1093.6
 10    10   LALA             13   1654         24.40   26.96   2.56     .4     .25    999.3  1046.5
 10    10   LALA             13   1655         24.35   26.91   2.56     .4     .25    955.8
 10    10   LALA             13   1656         24.33   26.88   2.55     .4     .25   1049.3  1002.6
 10    10   LALA             13   1657         24.35   26.90   2.55     .4     .25    951.9
 10    10   LALA             13   1658         24.32   26.87   2.55     .4     .25    999.8   975.9
 10    10   LALA             13   1659         24.35   26.91   2.56     .4     .25   1045.7
 10    10   LALA             13   1700         24.32   26.88   2.56     .4     .25    984.6  1015.2
 10    10   LALA             13   1701         24.37   26.93   2.56     .4     .25    997.5
 10    10   LALA             13   1702         24.34   26.90   2.56     .4     .25    986.3   991.9
 10    10   LALA             13   1703         24.40   26.96   2.56     .4     .25    973.6
 10    10   LALA             13   1704         24.35   26.91   2.56     .4     .25   1039.6  1006.6
 10    10   LALA             13   1705         24.41   26.97   2.56     .4     .25    942.2
 10    10   LALA             13   1706         24.37   26.93   2.56     .4     .25   1029.1   987.7
 10    10   LALA             13   1707         24.38   26.94   2.56     .4     .25    918.5
 10    10   LALA             13   1708         24.35   26.91   2.56     .4     .25    932.5   925.5
 10    10   LALA             13   1709         24.36   26.92   2.56     .4     .25   1000.9
 10    10   LALA             13   1710         24.33   26.88   2.55     .4     .25    925.2   963.1
 10    10   LALA             13   1711         24.38   26.94   2.56     .4     .25   1005.8
 10    10   LALA             13   1712         24.30   26.90   2.60     .4     .25   1044.5  1022.7
 10    10   LALA             13   1713         24.41   26.97   2.56     .4     .25    997.1                N AVG. = 1020.4
 10    10   LALA             13   1714         24.32   26.88   2.56     .4     .25   1007.1  1002.1       STD. DEV. = 37.9

RUN:  1

 13    13   AYERS             2   1545   1625                                    1            1197.9       38 POINTS (1 POINT
 13    13   AYERS             2   1545   1625                                                              PER MINUTE)
 13    13   AYERS             2   1545   1625                                                              STD. DEV. = 79.9
RUN:  2

 13    13   AYERS             2   1550   1630                                  .25             933.9       40 POINTS (1 POINT
 13    13   AYERS             2   1550   1630                                                              PER MINUTE)
 13    13   AYERS             2   1550   1630                                                              STD. DEV. = 96.8

RUN:  1

 15    15   ROGERS, FRED     23   1605   1606  24.03   25.06   1.03           1.03    894                  BACKGROUND 10 PER
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EXPERIMENT #: 21                                  NUCLEI MEASUREMENTS                                          PROCESSING DATE:  81/09/26
                       OBSERVER                                     PLATE TEMP
MACH  DUCT  ------------------------   SAMPLE  TIME                                  VOLUME   SUPER   NUCLEI    OBS    EST
NO.   NO.   NAME                 NO.   START    END    COLD     HOT    DELTA   SAMPLED   SAT     COUNT      -      K     REMARKS
                                                                (C)              (L)     (%)                N
----  ----  ---------------- ---  -----  ----   ------  ------  ------  -------  ------  ------  -----  -----  ------------------
 15    15   ROGERS, FRED      23   1605   1606                                                                       CC. AVERAGING OVER
 15    15   ROGERS, FRED      23   1606   1607   24.03   25.06    1.03             1.03     895                      1 MINUTE.
 15    15   ROGERS, FRED      23   1607   1608   24.03   25.06    1.03             1.03     901                      GOOD DROP SIZE
 15    15   ROGERS, FRED      23   1608   1609   24.03   25.06    1.03             1.03     898                      PLATEAUS.
 15    15   ROGERS, FRED      23   1609   1610   24.03   25.06    1.03             1.03     886                      MAIN FLOW ABOUT
 15    15   ROGERS, FRED      23   1610   1611   24.03   25.06    1.03             1.03     897                      1300 COUNTS.
 15    15   ROGERS, FRED      23   1611   1612   24.03   25.06    1.03             1.03     891                      ROOM TEMP 27.75 C.
 15    15   ROGERS, FRED      23   1612   1613   24.03   25.06    1.03             1.03     898
 15    15   ROGERS, FRED      23   1613   1614   24.03   25.06    1.03             1.03     903

RUN:  2

 15    15   ROGERS, FRED      23   1614   1615   24.03   25.06    1.03             1.03     902                      AVERAGING OVER
 15    15   ROGERS, FRED      23   1615   1616   24.03   26.06    1.03             1.03     887                      1 MINUTE.
 15    15   ROGERS, FRED      23   1616   1617   24.03   25.06    1.03             1.03     899
 15    15   ROGERS, FRED      23   1617   1618   24.03   25.06    1.03             1.03     889
 15    15   ROGERS, FRED      23   1618   1619   24.03   25.06    1.03             1.03     899
 15    15   ROGERS, FRED      23   1619   1620   24.03   25.06    1.03             1.03     890
 15    15   ROGERS, FRED      23   1621   1622   24.03   25.06    1.03             1.03     906
 15    15   ROGERS, FRED      23   1622   1623   24.03   25.06    1.03             1.03     881
 15    15   ROGERS, FRED      23   1636   1637   20.70   23.19    2.49             .247     506
 15    15   ROGERS, FRED      23   1638   1639   20.70   23.19    2.49             .247     487

RUN:  3

 15    15   ROGERS, FRED      23   1640   1641   20.70   23.19    2.49             .247     481                      POOR DROP SIZE PLAT.
 15    15   ROGERS, FRED      23   1642   1643   20.70   23.19    2.49             .247     483                      MAIN FLOW MAY
 15    15   ROGERS, FRED      23   1644   1645   20.70   23.19    2.49             .247     464                      BE TOO HIGH AT
 15    15   ROGERS, FRED      23   1646   1647   20.70   23.19    2.49             .247     472                      1310 COUNTS.
 15    15   ROGERS, FRED      23   1648   1649   20.70   23.19    2.49             .247     478                      READING ROYCO
 15    15   ROGERS, FRED      23   1650   1651   20.70   23.19    2.49             .247     493                      CHANNEL 2. MAY
 15    15   ROGERS, FRED      23   1652   1653   20.70   23.19    2.49             .247     484                      BE APPLYING EXCES-
 15    15   ROGERS, FRED      23   1654   1655   20.70   23.19    2.49             .247     486                      SIVE BACKGROUND
 15    15   ROGERS, FRED      23   1656   1657   20.70   23.19    2.49             .247     480                      CORRECTION AT THIS
 15    15   ROGERS, FRED      23   1658   1659   20.70   23.19    2.49             .247     480                      LOWER SS.
RUN:  4

 15    15   ROGERS, FRED      23   1700   1701   20.70   23.19    2.49             .247     500                      AVERAGING OVER
 15    15   ROGERS, FRED      23   1702   1703   20.70   23.19    2.49             .247     492                      ONE MINUTE.
 15    15   ROGERS, FRED      23   1704   1705   20.70   23.19    2.49             .247     499
 15    15   ROGERS, FRED      23   1706   1707   20.70   23.19    2.49             .247     491
 15    15   ROGERS, FRED      23   1708   1709   20.70   23.19    2.49             .247     488
 15    15   ROGERS, FRED      23   1710   1711   20.70   23.19    2.49             .247     495
 15    15   ROGERS, FRED      23   1712   1713   20.70   23.19    2.49             .247     493


RUN:  1

 16    16   HUDSON             9   1545   1625   21.40   26.10    4.70     1.3       .9      903                      STAND. DEV 9
 16    16   HUDSON             9   1545   1625   21.70   25.40    3.70     1.3      .55      903                      STAND. DEV 9
 16    16   HUDSON             9   1545   1625   22.20   24.90    2.70     1.3      .27      896                      STAND DEV 10
 16    16   HUDSON             9   1635   1715   21.40   26.10    4.70     1.3       .9      880                      STAND DEV 8
 16    16   HUDSON             9   1635   1715   21.70   25.40    3.70     1.3      .55      879                      STAND DEV 8
 16    16   HUDSON             9   1635   1715   22.20   24.90    2.70     1.3      .27      870                      STAND DEV. 9


RUN:  1

 18    18   HUDSON             9   1545   1625   22.30   27.30    5.00     1.3        1      913                      STAND DEV. 10
 18    18   HUDSON             9   1635   1715   23.55   26.05    2.50     1.3      .25      851                      STAND DEV 21


RUN:  1

 21    21   ALOFS              1   1548   1549   25.00   25.00    0.00             .173    194.2
 21    21   ALOFS              1   1548   1549   25.00   25.00    0.00             .114     49.2
 21    21   ALOFS              1   1548   1549   25.00   25.00    0.00             .089     25.7
 21    21   ALOFS              1   1548   1549   25.00   25.00    0.00             .068     6.15
RUN:  2

 21    21   ALOFS              1   1553   1554   25.00   25.00    0.00             .173      196
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                                                               NUCLEI MEASUREMENTS
EXPERIMENT #: 21                                                                                                           PROCESSING DATE:  81/09/26
                      OBSERVER                                   PLATE TEMP
MACH  DUCT  -------------------  SAMPLE  TIME                                 VOLUME   SUPER   NUCLEI    OBS      EST
NO.   NO.   NAME             NO.  START   END    COLD    HOT    DELTA   SAMPLED   SAT     COUNT      -        K     REMARKS
                                                         (C)              (L)     (%)                N
----  ----  ---------------- ---  -----   ----  ------  ------  ------  -------  ------  ------    -----    -----  -------------------
 21    21   ALOFS             1   1553    1554   25.00   25.00   0.00              .114      52
 21    21   ALOFS             1   1553    1554   25.00   25.00   0.00              .089      28
 21    21   ALOFS             1   1553    1554   25.00   25.00   0.00              .068    6.67

RUN:  3

 21    21   ALOFS             1   1558    1559   25.00   25.00   0.00              .173   198.4
 21    21   ALOFS             1   1558    1559   25.00   25.00   0.00              .114    51.3
 21    21   ALOFS             1   1558    1559   25.00   25.00   0.00              .089    27.3
 21    21   ALOFS             1   1558    1559   25.00   25.00   0.00              .068    8.12

RUN:  4

 21    21   ALOFS             1   1603    1604   25.00   25.00   0.00              .173     193
 21    21   ALOFS             1   1603    1604   25.00   25.00   0.00              .114      47
 21    21   ALOFS             1   1603    1604   25.00   25.00   0.00              .089    24.7
 21    21   ALOFS             1   1603    1604   25.00   25.00   0.00              .068    6.76

RUN:  5

 21    21   ALOFS             1   1608    1609   25.00   25.00   0.00              .173     190
 21    21   ALOFS             1   1608    1609   25.00   25.00   0.00              .114    46.9
 21    21   ALOFS             1   1608    1609   25.00   25.00   0.00              .089   26.76
 21    21   ALOFS             1   1608    1609   25.00   25.00   0.00              .068    6.39

RUN:  6

 21    21   ALOFS             1   1612    1613   25.00   25.00   0.00              .173     194
 21    21   ALOFS             1   1612    1613   25.00   25.00   0.00              .114    47.9
 21    21   ALOFS             1   1612    1613   25.00   25.00   0.00              .089    26.6
 21    21   ALOFS             1   1612    1613   25.00   25.00   0.00              .068     6.4

RUN:  7

 21    21   ALOFS             1   1615    1615   25.00   25.00   0.00              .173     186
 21    21   ALOFS             1   1615    1616   25.00   25.00   0.00              .114    49.3
 21    21   ALOFS             1   1615    1616   25.00   25.00   0.00              .089    28.4
 21    21   ALOFS             1   1615    1616   25.00   25.00   0.00              .068    6.69

RUN:  8

 21    21   ALOFS             1   1619    1620   25.00   25.00   0.00              .173   187.7
 21    21   ALOFS             1   1619    1620   25.00   25.00   0.00              .114    47.5
 21    21   ALOFS             1   1619    1620   25.00   25.00   0.00              .089    24.8
 21    21   ALOFS             1   1619    1620   25.00   25.00   0.00              .068    6.54

RUN:  9

 21    21   ALOFS             1   1622    1623   25.00   25.00   0.00              .173     193
 21    21   ALOFS             1   1622    1623   25.00   25.00   0.00              .114    50.6
 21    21   ALOFS             1   1622    1623   25.00   25.00   0.00              .089    26.8
 21    21   ALOFS             1   1622    1623   25.00   25.00   0.00              .068    6.32

RUN: 10

 21    21   ALOFS             1   1624    1625   25.00   25.00   0.00              .173   187.8
 21    21   ALOFS             1   1624    1625   25.00   25.00   0.00              .114      45
 21    21   ALOFS             1   1624    1625   25.00   25.00   0.00              .089    24.1
 21    21   ALOFS             1   1624    1625   25.00   25.00   0.00              .068     6.1

RUN: 11

 21    21   ALOFS             1   1627    1628   25.00   25.00   0.00              .173   191.3
 21    21   ALOFS             1   1627    1628   25.00   25.00   0.00              .114    52.3
 21    21   ALOFS             1   1627    1628   25.00   25.00   0.00              .089    28.9
 21    21   ALOFS             1   1627    1628   25.00   25.00   0.00              .068    7.68

RUN: 12

 21    21   ALOFS             1   1629    1630   25.00   25.00   0.00              .173   189.9
 21    21   ALOFS             1   1629    1630   25.00   25.00   0.00              .114    50.7
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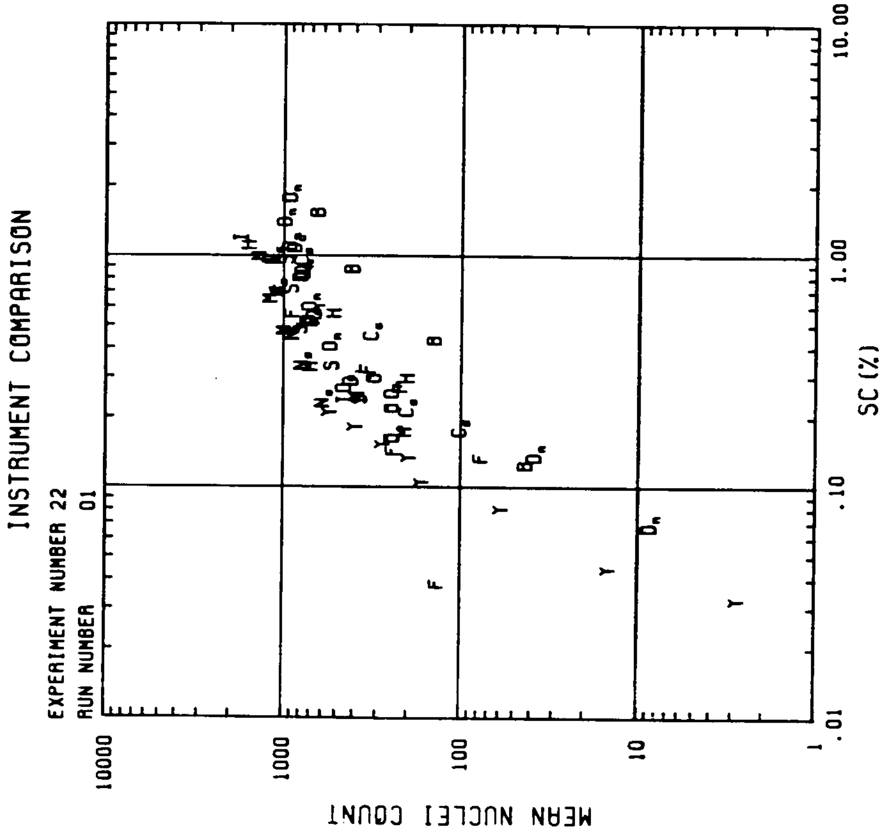
                                                                  NUCLEI MEASUREMENTS
EXPERIMENT #: 21                                                                                                                 PROCESSING DATE: 81/09/26
                        OBSERVER                                      PLATE TEMP
MACH  DUCT  -------------------------   SAMPLE  TIME                                      VOLUME   SUPER   NUCLEI    OBS      EST
NO.   NO.   NAME                  NO.   START   END      COLD     HOT      DELTA   SAMPLED  SAT     COUNT     -        K       REMARKS
                                                                  (C)              (L)      (%)               N
----  ----  ---------------  ---   -----  ----    ------   ------   ------  -------  ------  ------    -----    -----   -------------------
 21    21   ALOFS                  1    1629    1630     25.00    25.00    0.00              .089    26.6
 21    21   ALOFS                  1    1629    1630     25.00    25.00    0.00              .068    7.15
RUN: 13
 21    21   ALOFS                  1    1631    1632     25.00    25.00    0.00              .173     188
 21    21   ALOFS                  1    1631    1632     25.00    25.00    0.00              .114    45.3
 21    21   ALOFS                  1    1631    1632     25.00    25.00    0.00              .089    21.5
 21    21   ALOFS                  1    1631    1632     25.00    25.00    0.00              .068    5.08
RUN: 14
 21    21   ALOFS                  1    1634    1635     25.00    25.00    0.00              .173     185
 21    21   ALOFS                  1    1634    1635     25.00    25.00    0.00              .114    46.4
 21    21   ALOFS                  1    1634    1635     25.00    25.00    0.00              .089    24.9
 21    21   ALOFS                  1    1634    1635     25.00    25.00    0.00              .068    5.97
RUN: 15
 21    21   ALOFS                  1    1637    1638     25.00    25.00    0.00              .173   197.4
 21    21   ALOFS                  1    1637    1638     25.00    25.00    0.00              .114    51.2
 21    21   ALOFS                  1    1637    1638     25.00    25.00    0.00              .089    29.6
 21    21   ALOFS                  1    1637    1638     25.00    25.00    0.00              .068    7.56
RUN: 16
 21    21   ALOFS                  1    1641    1642     25.00    25.00    0.00              .173     184
 21    21   ALOFS                  1    1641    1642     25.00    25.00    0.00              .114    44.5
 21    21   ALOFS                  1    1641    1642     25.00    25.00    0.00              .089    23.9
 21    21   ALOFS                  1    1641    1642     25.00    25.00    0.00              .068    5.56
RUN: 17
 21    21   ALOFS                  1    1644    1645     25.00    25.00    0.00              .173   187.1
 21    21   ALOFS                  1    1644    1645     25.00    25.00    0.00              .114    48.8
 21    21   ALOFS                  1    1644    1645     25.00    25.00    0.00              .089    26.7
 21    21   ALOFS                  1    1644    1645     25.00    25.00    0.00              .068     5.6
RUN: 18
 21    21   ALOFS                  1    1650    1651     25.00    25.00    0.00              .173     184
 21    21   ALOFS                  1    1650    1651     25.00    25.00    0.00              .114    48.6
 21    21   ALOFS                  1    1650    1651     25.00    25.00    0.00              .089    25.8
 21    21   ALOFS                  1    1650    1651     25.00    25.00    0.00              .068     6.2
RUN: 19
 21    21   ALOFS                  1    1654    1655     25.00    25.00    0.00              .173   186.5
 21    21   ALOFS                  1    1654    1655     25.00    25.00    0.00              .114    51.9
 21    21   ALOFS                  1    1654    1655     25.00    25.00    0.00              .089    25.8
 21    21   ALOFS                  1    1654    1655     25.00    25.00    0.00              .068     6.7
RUN: 20
 21    21   ALOFS                  1    1658    1659     25.00    25.00    0.00              .173     189
 21    21   ALOFS                  1    1658    1659     25.00    25.00    0.00              .114    48.4
 21    21   ALOFS                  1    1658    1659     25.00    26.00    0.00              .089    26.8
 21    21   ALOFS                  1    1658    1659     25.00    25.00    0.00              .068     5.7
RUN: 21
 21    21   ALOFS                  1    1701    1702     25.00    25.00    0.00              .173   187.4
 21    21   ALOFS                  1    1701    1702     25.00    25.00    0.00              .114    52.5
 21    21   ALOFS                  1    1701    1702     25.00    25.00    0.00              .089    28.4
 21    21   ALOFS                  1    1701    1702     25.00    25.00    0.00              .068     7.3
RUN: 22
 21    21   ALOFS                  1    1704    1705     25.00    25.00    0.00              .173   186.3
 21    21   ALOFS                  1    1704    1705     25.00    25.00    0.00              .114    48.6
 21    21   ALOFS                  1    1704    1705     25.00    25.00    0.00              .089    26.5
```

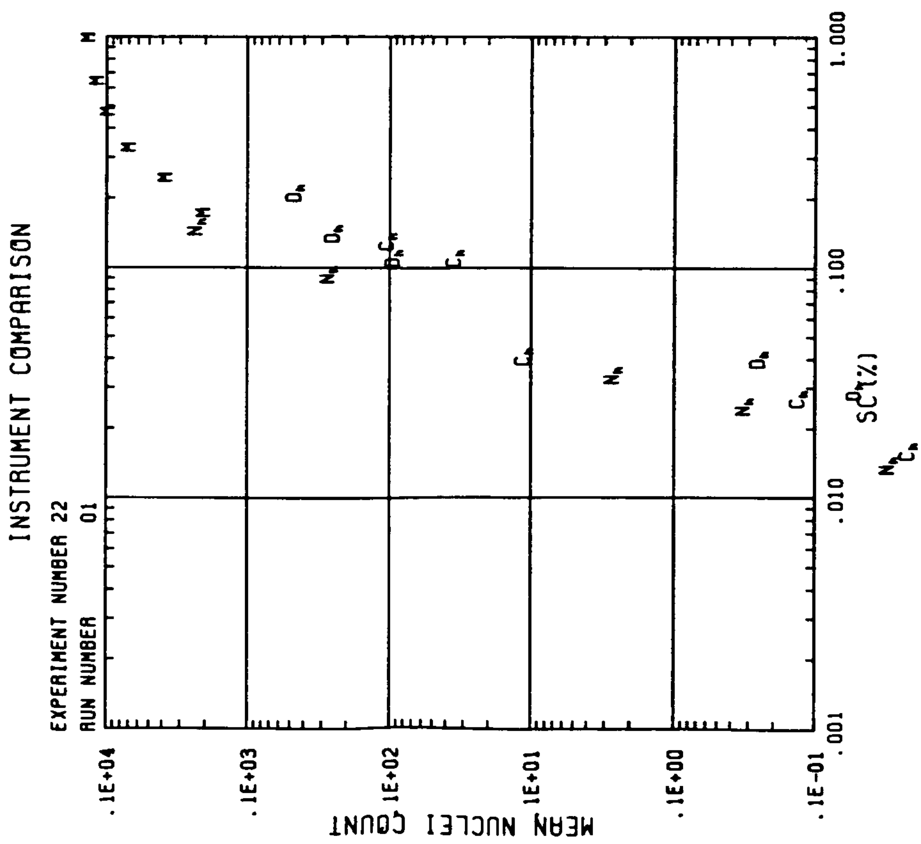
```
                                                           NUCLEI MEASUREMENTS
EXPERIMENT #: 21                                                                                                 PROCESSING DATE:  81/09/26
                      OBSERVER                                      PLATE TEMP
MACH  DUCT  ------------------------  SAMPLE TIME                                      VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME                NO.   START   END     COLD     HOT     DELTA   SAMPLED   SAT     COUNT      -       K     REMARKS
                                                               (C)               (L)      (%)              N
----  ----  ----------------   ---    -----  ----   ------   ------   ------   -------   ------  ------   -----   -----   --------------------
 21    21   ALOFS                1    1704   1705    25.00    25.00     0.00              .068      6.3
RUN: 23
 21    21   ALOFS                1    1707   1708    25.00    25.00     0.00              .173    198.3
 21    21   ALOFS                1    1707   1708    25.00    25.00     0.00              .114     53.6
 21    21   ALOFS                1    1707   1708    25.00    25.00     0.00              .089     27.4
 21    21   ALOFS                1    1707   1708    25.00    25.00     0.00              .068        7
RUN: 24
 21    21   ALOFS                1    1711   1712    25.00    25.00     0.00              .173      189
 21    21   ALOFS                1    1711   1712    25.00    25.00     0.00              .114     48.9
 21    21   ALOFS                1    1711   1712    25.00    25.00     0.00              .089       26
 21    21   ALOFS                1    1711   1712    25.00    25.00     0.00              .068      7.4
RUN: 25
 21    21   ALOFS                1    1714   1715    25.00    25.00     0.00              .173    185.1
 21    21   ALOFS                1    1714   1715    25.00    25.00     0.00              .114     47.3
 21    21   ALOFS                1    1714   1715    25.00    25.00     0.00              .089     25.1
 21    21   ALOFS                1    1714   1715    25.00    25.00     0.00              .068      5.7

RUN:  1
 25    25   BORYS                3                   21.60    26.70     5.10       5.3     1.1     1856     1856            STD. DEV.=246
 25    25   BORYS                3                                                                                         VOL SAMP X10**5
 25    25   BORYS                3                                                                                         INST. CALIB.
RUN:  2
 25    25   BORYS                3                   24.30    26.90     2.60      10.6     .26      317      317            STD. DEV.=35
 25    25   BORYS                3                                                                                         VOL SAMP X10**5
 25    25   BORYS                3                                                                                         INST CALIB.

RUN:  1
 26    26   HINDMAN              6    1546   1626    26.00    26.00     0.00       3.4     .13     15.6     15.6            +/- 4.5
 26    26   HINDMAN              6    1627   1751    26.00    26.00     0.00       1.9    .055      3.3      3.3            +/- 1.0
```



SDC/CFD RESULTS



HAZE CHAMBER RESULTS

```
                                  EXPERIMENT # 22                                  80/10/14

PURPOSE
-------
 INSTRUMENT COMPARISON WITH POLYDISPERSE AEROSOL, MEDIUM CONC.

DESCRIPTION OF EXPERIMENT
-------------------------
  DATE          TIME
                START   END
  ------------  -----------
  14 OCT,1980   1020   1233

  NUCLEI TYPE
  -----------
   (NH4)2 SO4

  GENERATION METHOD
  -----------------
   DRI ATOMIZER, 30 PSI, 0.065 G/L SOLUTION, HIGH DILUTION.

  SIZE DISTRIBUTION SHAPING
  -------------------------
   NONE

REMARKS
-------
 1020-1040 DRIFT UP 10%, 1040 DROP APPROX. 20%, 1052 UROP APPROX. 20%.

WEATHER SYNOPSIS
----------------
 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
         ROOM CONDITIONS                          OUTSIDE CONDITIONS

 --------------------------------   ----------------------------------------------------

 AVG TEMP     AVG RH    AVG PRESS    AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)         (%)        (MB)         (C)        (%)        (MB)       (M/S)     (DEG)
 --------     ------    ---------    --------    ------    ---------    ------    ------

   25.0        22.0       849
```

```
EXPERIMENT #: 22                                         NUCLEI MEASUREMENTS
                                                                                                          PROCESSING DATE:  81/09/26
                   OBSERVER                              PLATE TEMP
MACH  DUCT  -------------------  SAMPLE  TIME                                  VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME            NO.  START   END     COLD     HOT     DELTA   SAMPLED   SAT    COUNT      -       K     REMARKS
                                                          (C)               (L)     (%)               N
----  ----  --------------- ---  -----  ----    ------   ------   ------  -------  ------  ------    -----   -----  ------------------
RUN:  1

   2     2  ROGERS, DAVE     22  1057   1058     19.00    21.10    2.10               .17              259
   2     2  ROGERS, DAVE     22  1059   1100     18.90    21.30    2.40               .23              256
   2     2  ROGERS, DAVE     22  1102   1103     18.80    21.60    2.80               .31              323
RUN:  2

   2     2  ROGERS, DAVE     22  1128   1129     20.50    24.60    2.10               .17              244
   2     2  ROGERS, DAVE     22  1130   1131     20.20    22.60    2.40               .23              309
   2     2  ROGERS, DAVE     22  1132   1133     19.90    22.70    2.80               .31              338

RUN:  1

   5     5  KITCHEN          12  1029   1029     21.60    23.50    1.90               .13       45
   5     5  KITCHEN          12  1030   1030     20.20    23.50    3.30               .45      148
   5     5  KITCHEN          12  1031   1031     18.80    23.50    4.70               .92      429
   5     5  KITCHEN          12  1032   1032     17.50    23.50    6.00              1.6       678
RUN:  2

   5     5  KITCHEN          12  1034   1034     17.40    23.50    6.10              1.6       885
   5     5  KITCHEN          12  1035   1035     18.80    23.50    4.70               .92      222
   5     5  KITCHEN          12  1036   1036     20.30    23.60    3.30               .45      143
   5     5  KITCHEN          12  1037   1037     21.70    23.60    1.90               .13       52
   5     5  KITCHEN          12  1038   1038     20.30    23.60    3.30               .45      142
   5     5  KITCHEN          12  1039   1039     18.90    23.60    4.70               .92      408
   5     5  KITCHEN          12  1040   1040     17.50    23.60    6.10              1.6       785               1.00
RUN:  3

   5     5  KITCHEN          12  1113   1113     22.00    23.90    1.90               .13       59
   5     5  KITCHEN          12  1115   1115     19.20    23.90    4.70               .92      235
   5     5  KITCHEN          12  1116   1116     17.80    23.90    6.10              1.6       581
   5     5  KITCHEN          12  1117   1117     16.40    23.90    7.50              2.4       721
   5     5  KITCHEN          12  1118   1118     17.80    23.90    6.10              1.6       554
   5     5  KITCHEN          12  1119   1119     19.20    23.90    4.70               .92      341
   5     5  KITCHEN          12  1120   1120     20.60    23.90    3.30               .45      148

RUN:  1

   7     7  LEAITCH          14  1108   1109               8.00             .283      .22              572           HOT TEMPERATURE
   7     7  LEAITCH          14  1115   1116               7.70             .283      .19              411           IS ACTUALLY
   7     7  LEAITCH          14  1123   1124               7.40             .283      .16              288           DIFFERENCE BETWEEN
   7     7  LEAITCH          14  1131   1132               7.10             .283      .14              203           TUBE AND AMBIENT.
   7     7  LEAITCH          14  1138   1139               6.80             .283      .11              173           INPUT HUMDITY
   7     7  LEAITCH          14  1148   1149               6.40             .283      .084              61           IS 70%
   7     7  LEAITCH          14  1208   1209               5.75             .283      .046              15
   7     7  LEAITCH          14  1228   1229               5.30             .283      .034             2.9

RUN:  1

   9     9  GAGIN             5  1032            22.30    27.80    5.50     1.2      1.16     1650
   9     9  GAGIN             5  1035            24.10    28.00    3.90     1.2       .59      540
   9     9  GAGIN             5  1038            25.10    28.00    2.90     1.2       .31      210
RUN:  2

   9     9  GAGIN             5  1049            22.50    27.80    5.30     1.2      1.09     1250
   9     9  GAGIN             5  1055            24.60    27.90    3.30     1.2       .41      350
   9     9  GAGIN             5  1058            25.80    25.80    0.00     1.2       .17      140
RUN:  3

   9     9  GAGIN             5  1102            22.40    27.80    5.40     1.2      1.13     1360
   9     9  GAGIN             5  1105            23.90    27.90    4.00     1.2       .62      500
   9     9  GAGIN             5  1108            24.80    28.00    3.20     1.2       .4       140
```

EXPERIMENT #: 22

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
9	9	GAGIN	5	1112		25.80	28.10	2.30	1.2	.19	70			
RUN:	4													
9	9	GAGIN	5	1116		22.30	27.80	5.50	1.2	1.16	1200			
9	9	GAGIN	5	1118		24.10	27.80	3.70	1.2	.53	360			
9	9	GAGIN	5	1121		25.10	27.70	2.60	1.2	.26	80			
9	9	GAGIN	5	1126		25.40	27.60	2.20	1.2	.17	120			
RUN:	1													
10	10	LALA	13	1028		21.28	23.77	2.49	.4	.25	412.4			
10	10	LALA	13	1029		21.27	23.77	2.50	.4	.25	368.9	390.7		
10	10	LALA	13	1030		20.82	23.76	2.94	.4	.35	546			
10	10	LALA	13	1031		20.80	23.75	2.95	.4	.35	571.4	558.7		
10	10	LALA	13	1032		20.21	23.78	3.51	.4	.5	853.2			
10	10	LALA	13	1033		20.18	23.69	3.51	.4	.5	835.1	844.2		
10	10	LALA	13	1034		19.37	23.65	4.28	.4	.75	905.6			
10	10	LALA	13	1035		19.34	23.62	4.28	.4	.75	990.7	948.2		
10	10	LALA	13	1036		18.65	23.58	4.93	.4	1	1005.3			
10	10	LALA	13	1037		18.60	23.53	4.93	.4	1	1012.7	1009		
RUN:	2													
10	10	LALA	13	1038		21.51	23.75	2.24	.4	.2	306.7			
10	10	LALA	13	1039		21.01	23.74	2.73	.4	.3	482.6			
10	10	LALA	13	1040		20.57	23.72	3.15	.4	.4	754.6			
10	10	LALA	13	1041		20.18	23.69	3.51	.4	.5	831.2			
10	10	LALA	13	1042		19.82	23.66	3.84	.4	.6	975.1			
10	10	LALA	13	1043		19.50	23.64	4.14	.4	.7	1022.1			
10	10	LALA	13	1044		19.17	23.59	4.42	.4	.8	985.1			
10	10	LALA	13	1045		18.88	23.56	4.68	.4	.9	1115.8			
10	10	LALA	13	1046		18.58	23.51	4.93	.4	1	1108			
10	10	LALA	13	1047		17.47	23.47	6.00	.4	1.5	892			CHANGING AEROSOL]
RUN:	3													
10	10	LALA	13	1114		22.07	24.58	2.51		.25	315.5			AFTER 1052
10	10	LALA	13	1115		22.00	24.51	2.51		.25	312.2	313.9		
10	10	LALA	13	1116		21.50	24.47	2.97		.35	462.1			
10	10	LALA	13	1117		21.46	24.42	2.96		.35	493.8	478		
10	10	LALA	13	1118		20.84	24.37	3.53		.5	591.2			
10	10	LALA	13	1119		20.80	24.33	3.53		.5	624.7	608		
10	10	LALA	13	1120		19.97	24.28	4.31		.75	722.2			
10	10	LALA	13	1121		19.92	24.23	4.31		.75	707.5	714.9		
10	10	LALA	13	1122		19.21	24.17	4.96		1	756.8			
10	10	LALA	13	1123		19.16	24.11	4.95		1	738.9	747.9		
RUN:	4													
10	10	LALA	13	1124		21.83	24.07	2.24	.4	.2	200			AFTER 1052
10	10	LALA	13	1125		21.35	24.08	2.73	.4	.3	354.2			
10	10	LALA	13	1126		20.91	24.07	3.16	.4	.4	533			
10	10	LALA	13	1127		20.53	24.06	3.52	.4	.5	599.7			
10	10	LALA	13	1128		20.17	24.02	3.85	.4	.6	634			
10	10	LALA	13	1129		19.84	24.00	4.16	.4	.7	659.2			
10	10	LALA	13	1130		19.52	23.95	4.43	.4	.8	706.5			
10	10	LALA	13	1131		19.22	23.92	4.70	.4	.9	767.6			
10	10	LALA	13	1132		18.94	23.88	4.94	.4	1	723.5			
10	10	LALA	13	1133		17.81	23.84	6.03	.4	1.5	794.5			
RUN:	1													
11	11	FITZGERALD	28	1033	1052					.15	247	247		
11	11	FITZGERALD	28	1033	1052					.094	28.8	28.8		
11	11	FITZGERALD	28	1033	1052					.034	.28	.28		
11	11	FITZGERALD	28	1033	1052					.025	.034	.034		
11	11	FITZGERALD	28	1033	1052					.014	.003	.003		
RUN:	2													
11	11	FITZGERALD	28	1105	1125					.15	154	154		

```
EXPERIMENT #: 22                                         NUCLEI MEASUREMENTS
                                                                                                              PROCESSING DATE:  81/09/26
                       OBSERVER                                               PLATE TEMP
MACH  DUCT  -------------------------  SAMPLE TIME                                          VOLUME   SUPER   NUCLEI    OBS      EST
NO.   NO.   NAME                  NO.  START   END      COLD     HOT     DELTA   SAMPLED   SAT     COUNT      -        K     REMARKS
                                                                 (C)               (L)      (%)               N
----  ----  ------------------   ---   -----  ----    ------   ------   ------  -------  ------   ------   -----    -----   --------------------
 11    11   FITZGERALD            28   1105   1125                                          .094       21      21
 11    11   FITZGERALD            28   1105   1125                                          .034      .29     .29
 11    11   FITZGERALD            28   1105   1125                                          .025     .029    .029
 11    11   FITZGERALD            28   1105   1125                                          .014    .0011   .0011

RUN:  1

 13    13   AYERS                  2   1034   1035    22.72    25.20     2.48                .25      591
 13    13   AYERS                  2   1036   1037    21.70    25.20     3.50                 .5     1125
 13    13   AYERS                  2   1037   1038    20.95    25.20     4.25                .75     1440
 13    13   AYERS                  2   1039   1040    20.29    25.20     4.91                  1     1440
 13    13   AYERS                  2   1040   1041    19.74    25.20     5.46               1.25     2565
 13    13   AYERS                  2   1041   1042    19.74    25.10     5.36               1.25     2490
 13    13   AYERS                  2   1042   1043    20.17    25.10     4.93                  1     1110
 13    13   AYERS                  2   1043   1044    20.13    25.00     4.87                  1     1185
 13    13   AYERS                  2   1045   1046    20.73    25.00     4.27                .75      968
 13    13   AYERS                  2   1046   1047    20.78    25.00     4.22                .75      975
 13    13   AYERS                  2   1048   1049    21.51    25.00     3.49                 .5      885
 13    13   AYERS                  2   1049   1050    21.56    25.00     3.44                 .5      803
 13    13   AYERS                  2   1051   1052    22.53    25.00     2.47                .25      413
 13    13   AYERS                  2   1052   1053    22.63    25.10     2.47                .25      413
 13    13   AYERS                  2   1058   1059    19.75    25.20     5.45               1.25     1125
 13    13   AYERS                  2   1059   1100    19.70    25.20     5.50               1.25     1065
RUN:  2

 13    13   AYERS                  2   1143   1144    24.50    27.00     2.50                .25      462
 13    13   AYERS                  2   1144   1145    24.56    27.00     2.44                .25      540
 13    13   AYERS                  2   1145   1146    23.43    27.00     3.57                 .5      780
 13    13   AYERS                  2   1146   1147    23.45    27.00     3.55                 .5      810
 13    13   AYERS                  2   1147   1148    22.61    26.90     4.29                .75      795
 13    13   AYERS                  2   1148   1149    22.61    26.90     4.29                .75      960
 13    13   AYERS                  2   1148   1149    22.60    26.90     4.30                .75      870
 13    13   AYERS                  2   1149   1150    21.93    26.90     4.97                  1     1365
 13    13   AYERS                  2   1150   1151    21.82    26.80     4.98                  1     1095
 13    13   AYERS                  2   1150   1151    21.87    26.80     4.93                  1      885
 13    13   AYERS                  2   1151   1152    21.85    26.80     4.95                  1     1200
 13    13   AYERS                  2   1152   1153    21.84    26.80     4.96                  1     1050
 13    13   AYERS                  2   1153   1154    21.24    26.80     5.56               1.25     1223
 13    13   AYERS                  2   1154   1155    21.29    26.80     5.51               1.25     1223
 13    13   AYERS                  2   1155   1156    21.23    26.80     5.57               1.25     1350

RUN:  1

 14    14   HUDSON                 9   1058   1128                               .0187       .21    50.88                    F=41
 14    14   HUDSON                 9   1058   1128                               .0187       .14    27.55                    F=41
 14    14   HUDSON                 9   1058   1128                               .0187       .11    10.55                    F=41
 14    14   HUDSON                 9   1058   1128                               .0187       .04     .028                    F=41
 14    14   HUDSON                 9   1058   1128                               .0187      .029     .005                    F=41
 14    14   HUDSON                 9   1129   1159                               .0188       .21    48.56                    F=41
 14    14   HUDSON                 9   1129   1159                               .0188       .14    25.86                    F=41
 14    14   HUDSON                 9   1129   1159                               .0188       .11     9.59                    F=41
 14    14   HUDSON                 9   1129   1159                               .0188       .04     .028                    F=41
 14    14   HUDSON                 9   1129   1159                               .0188      .029     .007                    F=41
 14    14   HUDSON                 9   1201   1230                               .0187       .21    51.14                    F=41
 14    14   HUDSON                 9   1201   1230                               .0187       .14    26.79                    F=41
 14    14   HUDSON                 9   1201   1230                               .0187       .11     9.71                    F=41
 14    14   HUDSON                 9   1201   1230                               .0187       .04     .025                    F=41
 14    14   HUDSON                 9   1201   1230                               .0187      .029     .004                    F=41

RUN:  1

 15    15   KOCMOND               30   1113   1114    18.36    26.06     6.70               1.86      909                    BACKGROUND NOW KNOWN
 15    15   KOCMOND               30   1118   1119    18.74    24.75     6.01               1.46     1035                    AS FCN OF SS.
 15    15   KOCMOND               30   1122   1123    19.11    24.44     5.33               1.15      972                    MEASUREMENTS STARTED
 15    15   KOCMOND               30   1126   1127    19.49    24.13     4.64                .87      823                    AT 1110. DROP SIZE
 15    15   KOCMOND               30   1130   1131    19.87    23.81     3.94                .63      752                    PLAT POOR AT HIGHEST
 15    15   KOCMOND               30   1134   1135    20.25    23.50     3.25               .425      571                    SS POINT. AVERAGING
```

FXPERIMFNT #: 22

NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER		SAMPLE START	TIME END	PLATE TEMP			VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
		NAME	NO.			COLD	HOT (C)	DELTA						
15	15	KOCMOND	30	1138	1139	20.63	23.19	2.56		.265	259			OVER 4 PNTS EA SS.
15	15	KOCMOND	30	1142	1143	20.99	22.88	1.89		.14	40			AVG LAST 2 PNTS.
15	15	KOCMOND	30	1146	1147	21.35	22.56	1.21		.07	9			AVG LAST 2 PNTS.
15	15	KOCMOND	30	1207	1208	18.36	25.06	6.70		1.86	1018			RAISED MAIN FLO.
RUN: 1														
16	16	HUDSON	9	1054	1057	21.40	26.10	4.70	.0024	.9	783			
16	16	HUDSON	9	1054	1057	21.70	25.50	3.80	.0024	.58	680			
16	16	HUDSON	9	1054	1057	22.20	24.95	2.75	.0024	.3	429			
16	16	HUDSON	9	1146	1148	21.40	26.05	4.65	.0018	.9	836			
16	16	HUDSON	9	1146	1148	21.70	25.50	3.80	.0018	.58	701			
16	16	HUDSON	9	1146	1148	22.20	25.00	2.80	.0018	.3	437			
16	16	HUDSON	9	1153	1154	21.40	26.05	4.65	.0012	.9	852			
16	16	HUDSON	9	1153	1154	21.70	25.50	3.80	.0012	.58	713			
16	16	HUDSON	9	1153	1154	22.20	25.00	2.80	.0012	.3	446			
RUN: 2														
16	16	HUDSON	9	1200	1203	21.40	26.05	4.65	.0024	.9	848			
16	16	HUDSON	9	1200	1203	21.70	25.50	3.80	.0024	.58	731			
16	16	HUDSON	9	1200	1203	22.20	25.00	2.80	.0024	.3	452			
16	16	HUDSON	9	1210	1213	21.40	26.05	4.65	.0018	.9	863			
16	16	HUDSON	9	1210	1213	21.70	25.50	3.80	.0018	.58	712			
16	16	HUDSON	9	1210	1213	22.20	25.00	2.80	.0018	.3	446			
16	16	HUDSON	9	1224	1226	21.40	26.05	4.65	.0018	.9	873			
16	16	HUDSON	9	1224	1226	21.70	25.50	3.80	.0018	.58	720			
16	16	HUDSON	9	1224	1226	22.20	25.00	2.80	.0018	.3	456			
RUN: 1														
17	17	WOJCIECHOWSKI	27	1039	1043					.24	631.5	631.5		
17	17	WOJCIECHOWSKI	27	1044	1046					.35	828.8	828.8		
17	17	WOJCIECHOWSKI	27	1047	1049					.47	932.4	932.4		
17	17	WOJCIECHOWSKI	27	1050	1051					.73	1139.6	1139.6		
17	17	WOJCIECHOWSKI	27	1052	1054					1	1228.4	1228.4		AFTER CONC CHANGE
17	17	WOJCIECHOWSKI	27	1052	1054									1052
RUN: 2														
17	17	WOJCIECHOWSKI	27	1134	1136					.24	384.8	384.8		
17	17	WOJCIECHOWSKI	27	1137	1138					.35	828.8	828.8		
17	17	WOJCIECHOWSKI	27	1139	1142					.47	932.4	932.4		
17	17	WOJCIECHOWSKI	27	1143	1147					.73	1139.6	1139.6		
17	17	WOJCIECHOWSKI	27	1149	1151					1	1228.4	1228.4		
RUN: 1														
18	18	HUDSON	9	1054	1057	22.85	26.50	3.65	.0024	.54	740			
18	18	HUDSON	9	1146	1148	22.40	27.05	4.65	.0018	.84	843			
18	18	HUDSON	9	1153	1154	22.10	27.35	5.25	.0012	1.12	913			
18	18	HUDSON	9	1200	1203	22.80	26.50	3.70	.0024	.55	760			
18	18	HUDSON	9	1210	1213	23.30	25.95	2.65	.0018	.28	479			
18	18	HUDSON	9	1224	1226	23.60	25.70	2.10	.0018	.17	255			
RUN: 1														
21	21	TRUEBLOOD	26	1026	1027	19.89	25.00	5.11		1.04	1444			
21	21	TRUEBLOOD	26	1031	1032	20.88	25.00	4.12		.679	1249			
21	21	TRUEBLOOD	26	1034	1035	21.48	25.00	3.52		.495	1048			
21	21	TRUEBLOOD	26	1039	1040	22.05	25.00	2.95		.348	743			
21	21	TRUEBLOOD	26	1042	1043	22.46	25.00	2.54		.258	405			
21	21	TRUEBLOOD	26	1047	1048	22.88	25.00	2.12		.18	218			
RUN: 2														
21	21	TRUEBLOOD	26	1104	1105	25.00	25.00	0.00		.173	178			

```
                                              NUCLEI MEASUREMENTS
EXPERIMENT #: 22                                                                                  PROCESSING DATE:  81/09/26
                   OBSERVER                               PLATE TEMP
MACH  DUCT  --------------------  SAMPLE TIME                           VOLUME   SUPER    NUCLEI    OBS     EST
NO.   NO.   NAME             NO.  START   END   COLD    HOT     DELTA   SAMPLED  SAT      COUNT      -       K      REMARKS
                                                        (C)               (L)    (%)               N
----  ----  ---------------- ---  -----  ----   ------  ------  ------  -------  ------   ------   -----   -----   -------------------
 21    21   TRUEBLOOD        26   1104   1105   25.00   25.00    0.00             .114     45.2
 21    21   TRUEBLOOD        26   1104   1105   25.00   25.00    0.00             .089     22.3
 21    21   TRUEBLOOD        26   1104   1105   25.00   25.00    0.00             .068     7.84
 21    21   TRUEBLOOD        26   1112   1114   25.00   25.00    0.00             .035      .33
 21    21   TRUEBLOOD        26   1112   1114   25.00   25.00    0.00             .022        0
 21    21   TRUEBLOOD        26   1135          19.91   25.00    5.09            1.036     1017
 21    21   TRUEBLOOD        26   1140          20.72   25.00    4.28             .733      902
 21    21   TRUEBLOOD        26   1144          21.57   25.00    3.43             .47       691
 21    21   TRUEBLOOD        26   1148          22.00   25.00    3.00             .36       472
 21    21   TRUEBLOOD        26   1152          22.58   25.00    2.42             .234    267.8
 21    21   TRUEBLOOD        26   1157          22.92   25.00    2.08             .173      170

RUN:   1

 24    24   SERPOLAY         25   1025   1034   25.30   26.30    1.00     .77     .04       200                     CONCENTRATION
 24    24   SERPOLAY         25   1039   1045   25.40   27.40    2.00     .77     .15       250                     VARIATIONS
 24    24   SERPOLAY         25   1057   1105   25.70   28.70    3.00     .77     .34       350
 24    24   SERPOLAY         25   1115   1120   26.00   30.00    4.00     .77     .59       930
 24    24   SERPOLAY         25   1130   1135   26.40   30.90    4.50     .77     .75      1080
 24    24   SERPOLAY         25   1145   1150   26.70   30.50    3.80     .77     .55       720
 24    24   SERPOLAY         25   1155   1160   26.90   29.60    2.70     .77     .28       230
 24    24   SERPOLAY         25   1210   1212   27.00   28.90    1.90     .77     .14        80
 24    24   SERPOLAY         25   1225   1227   26.90   28.00    1.10     .77     .04        80

RUN:   1

 25    25   BORYS             3   1101   1107   21.50   23.90    2.40    21.2     .22       212      212     .92    VOL SAMP X 10**5
 25    25   BORYS             3   1147   1153   21.90   24.10    2.20    21.2     .18       106      106
 25    25   BORYS             3   1202   1208   20.40   23.90    3.50    15.9     .47       339      339
 25    25   BORYS             3   1223   1225   19.00   23.90    4.90    10.6     .99       835      835

RUN:   1

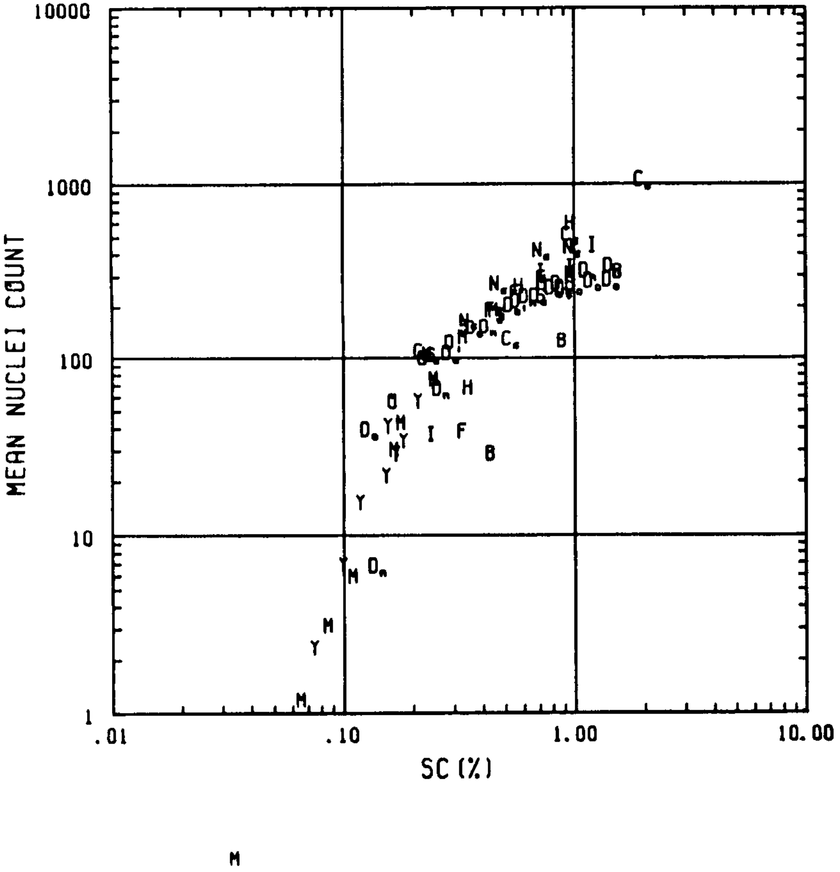
 26    26   HINDMAN           6   1150   1216   26.00   26.00    0.00     1.4     .13        11       11             +/-0.45
 26    26   HINDMAN           6   1150   1216   26.00   26.00    0.00     1.4     .11       3.7      3.7             +/-0.19
 26    26   HINDMAN           6   1150   1216   26.00   26.00    0.00     1.4    .041       1.2      1.2             +/-0.08
 26    26   HINDMAN           6   1150   1216   26.00   26.00    0.00     1.4    .027      .014     .014             +/-0.0043
 26    26   HINDMAN           6   1150   1216   26.00   26.00    0.00     1.4    .016     .0022    .0022             +/-0.0016

RUN:   1

 27    27   OHTAKE           19   1031   1031                             5.5              1.43                     100% R.H.
 27    27   OHTAKE           19   1031   1031                             5.5              1.71                     106% R.H. NOMINAL
 27    27   OHTAKE           19   1123   1123                             5.5              1.54                     100% R.H.
 27    27   OHTAKE           19   1123   1123                             5.5               .91                     105% R.H. NOMINAL
```

INSTRUMENT COMPARISON

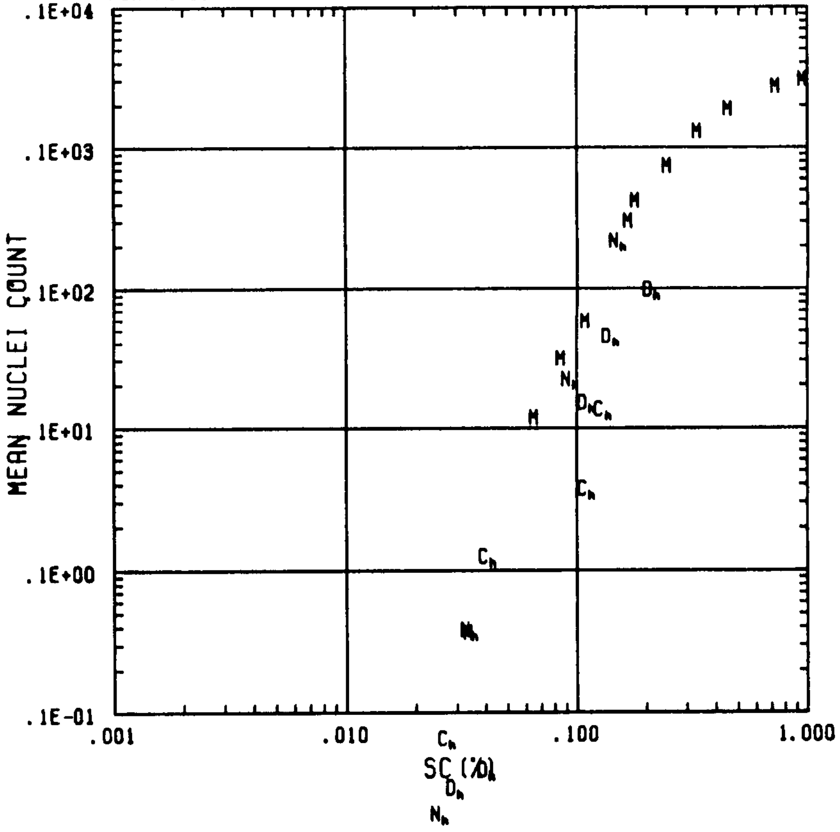
EXPERIMENT NUMBER 23
RUN NUMBER 01



SDC/CFD RESULTS

INSTRUMENT COMPARISON

EXPERIMENT NUMBER 23
RUN NUMBER 01



HAZE CHAMBER RESULTS

```
                                             EXPERIMENT # 23
                                                                                     80/10/14
PURPOSE
-------

 INSTRUMENT COMPARISON WITH LOW CONCENTRATION POLYDISPERSE ARTIFICAL AFROSOL.

DESCRIPTION OF EXPERIMENT
-------------------------
                    TIME
  DATE              START   END
  ------------      -----------

  14 OCT,1980       1323   1516

  NUCLEI TYPE
  -----------

   (NH4)2 SO4, POLYDISPERSE.

  GENERATION METHOD
  -----------------

   DRI ATOMIZER, 40 PSI, HIGH DILUTION, 0.065 G/L SOLUTION.

  SIZE DISTRIBUTION SHAPING
  -------------------------

   NONE

REMARKS
-------

 NONE

WEATHER SYNOPSIS
----------------

 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

        ROOM CONDITIONS                                OUTSIDE CONDITIONS

 -------------------------------      -------------------------------------------------
 AVG TEMP     AVG RH     AVG PRESS      AVG TEMP     AVG RH     AVG PRESS     AVG WS     AVG WD
   (C)         (%)         (MB)           (C)          (%)         (MB)        (M/S)      (DEG)
 --------     ------     ---------      --------     ------     ---------     ------     ------

   25.0        21.0        849
```

```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 23                                                                                                          PROCESSING DATE:  81/09/26
               OBSERVER                                            PLATE TEMP
MACH  DUCT  ------------------------  SAMPLE  TIME                                  VOLUME   SUPER   NUCLEI     OBS      EST
NO.   NO.   NAME                 NO.  START   END     COLD     HOT     DELTA   SAMPLED   SAT     COUNT       -        K      REMARKS
                                                                (C)                (L)     (%)                N
----  ----  --------------- ---      -----   ----   ------   ------   ------   -------   ------  ------     -----    -----   -------------------

RUN:  1

  2     2   ROGERS, DAVE         22   1336    1337    22.20    24.30    2.10               .17                 59
  2     2   ROGERS, DAVE         22   1339    1340    22.00    24.40    2.40               .23                103

RUN:  2

  2     2   POLITOVICH           20   1412    1413    22.50    24.60    2.10               .17                 53
  2     2   POLITOVICH           20   1415    1416    22.20    24.60    2.40               .23                106

RUN:  1

  5     5   KITCHEN              12   1322    1322    18.80    22.10    3.30               .45      38
  5     5   KITCHEN              12   1323    1323    17.40    22.10    4.70               .92     157
  5     5   KITCHEN              12   1324    1324    16.00    22.10    6.10              1.6      355
  5     5   KITCHEN              12   1326    1326    16.00    22.10    6.10              1.6      301
  5     5   KITCHEN              12   1327    1327    17.40    22.10    4.70               .92     104
  5     5   KITCHEN              12   1328    1328    18.90    22.20    3.30               .45      22

RUN:  1

  7     7   LEAITCH              14   1322    1323              7.60                      .176               29.7              HOT TEMPERATURE
  7     7   LEAITCH              14   1332    1333              8.55                      .256               76                IS ACTUALLY
  7     7   LEAITCH              14   1343    1344              8.30                      .22                58.9              DIFFERENCE BETWEEN
  7     7   LEAITCH              14   1355    1356              7.95                      .19                35                TUBE AND AMBIENT.
  7     7   LEAITCH              14   1406    1407              7.60                      .164               42.5              INPUT HUMIDITY
  7     7   LEAITCH              14   1410    1411              7.55                      .16                22.3              IS 70%
  7     7   LEAITCH              14   1426    1427              7.05                      .124               15.7
  7     7   LEAITCH              14   1436    1437              6.70                      .104                7
  7     7   LEAITCH              14   1446    1447              6.35                      .078                2.4

RUN:  1

  8     8   MEE                  17   1400            25.20    27.50    2.30               .2      220
  8     8   MEE                  17   1400            24.80    27.50    2.70               .3      300
  8     8   MEE                  17   1400            23.40                                .65     481
  8     8   MEE                  17   1400            22.30                               1.1      373
  8     8   MEE                  17   1400            21.60                               1.4      518
  8     8   MEE                  17   1400            20.40                               2        450

RUN:  1

  9     9   GAGIN                 5   1327            23.10    28.20    5.10      1.2     1        620
  9     9   GAGIN                 5   1331            24.50    28.50    4.00      1.2      .6      270
  9     9   GAGIN                 5   1335            25.40    28.50    3.10      1.2      .36      70

RUN:  2

  9     9   GAGIN                 5   1347            23.50    28.50    5.00      1.2      .98     560
  9     9   GAGIN                 5   1352            24.60    28.50    3.90      1.2      .57     350
  9     9   GAGIN                 5   1355            25.50    28.40    2.90      1.2      .33     100
  9     9   GAGIN                 5   1359            26.30    28.60    2.30      1.2      .19     100

RUN:  3

  9     9   GAGIN                 5   1425            23.40    28.50    5.10      1.2     1.01     600
  9     9   GAGIN                 5   1427            24.70    28.50    3.80      1.2      .57     300
  9     9   GAGIN                 5   1430            25.60    28.50    2.90      1.2      .3       60
  9     9   GAGIN                 5   1439            26.40    28.60    2.20      1.2      .19      70

RUN:  1

 10    10   LALA                 13   1325            22.60    25.12    2.52       .4      .25     105.9
 10    10   LALA                 13   1326            22.54    25.06    2.52       .4      .25     108.6     107.3
 10    10   LALA                 13   1327            22.04    25.02    2.98       .4      .35     155.7
```

```
                                                            NUCLEI MEASUREMENTS
EXPERIMENT #: 23                                                                                                  PROCESSING DATE:  81/09/26
                        OBSERVER                                    PLATE TEMP
MACH   DUCT  -------------------   SAMPLE  TIME                                      VOLUME   SUPER    NUCLEI     OBS      EST
NO.    NO.   NAME            NO.   START    END    COLD      HOT     DELTA   SAMPLED    SAT     COUNT       -        K     REMARKS
                                                             (C)                (L)      (%)                N
----   ----  --------------- ---   -----   ----   ------   ------   ------  -------   ------   ------   -----    -----   -------------------
 10     10   LALA             13   1328           21.98    24.96    2.98       .4      .35    161.5    158.6
 10     10   LALA             13   1329           21.36    24.90    3.54       .4       .5    192.3
 10     10   LALA             13   1330           21.29    24.84    3.55       .4       .5    179.9    186.1
 10     10   LALA             13   1331           20.45    24.78    4.33       .4      .75    221.2
 10     10   LALA             13   1332           20.39    24.71    4.32       .4      .75    254.1    237.7
 10     10   LALA             13   1333           19.63    24.60    4.97       .4        1    293.1
 10     10   LALA             13   1334           19.56    24.52    4.96       .4        1    268.7    280.9
RUN:   2

 10     10   LALA             13   1335           22.33    24.58    2.25       .4       .2    102.2
 10     10   LALA             13   1336           21.80    24.54    2.74       .4       .3    135.1
 10     10   LALA             13   1337           21.38    24.54    3.16       .4       .4    194.1
 10     10   LALA             13   1338           20.95    24.48    3.53       .4       .5    199.6
 10     10   LALA             13   1339           20.59    24.46    3.87       .4       .6    241.1
 10     10   LALA             13   1340           20.23    24.40    4.17       .4       .7    258.4
 10     10   LALA             13   1341           19.91    24.35    4.44       .4       .8    238.3
 10     10   LALA             13   1342           19.59    24.30    4.71       .4       .9    304.9
 10     10   LALA             13   1343           19.29    24.24    4.95       .4        1    245.8
 10     10   LALA             13   1344           18.15    24.19    6.04       .4      1.5    252.7
RUN:   3

 10     10   LALA             13   1344           18.10    24.14    6.04       .4      1.5    303.4
 10     10   LALA             13   1345           19.11    24.06    4.95       .4        1   310.75
 10     10   LALA             13   1346           19.27    23.97    4.70       .4       .9    264.6
 10     10   LALA             13   1347           19.49    23.92    4.43       .4       .8    243.5
 10     10   LALA             13   1348           19.73    23.88    4.15       .4       .7    262.7
 10     10   LALA             13   1349           20.13    23.98    3.85       .4       .6    221.2
 10     10   LALA             13   1350           20.40    23.91    3.51       .4       .5    205.5
 10     10   LALA             13   1351           20.74    23.91    3.17       .4       .4    204.2
 10     10   LALA             13   1352           21.14    23.88    2.74       .4       .3    161.3
 10     10   LALA             13   1353           21.66    23.89    2.23       .4       .2     81.2

RUN:   1

 11     11   FITZGERALD       28   1409   1426                                          .15       23       23
 11     11   FITZGERALD       28   1409   1426                                         .094      2.3      2.3
 11     11   FITZGERALD       28   1409   1426                                         .034      .04      .04
 11     11   FITZGERALD       28   1409   1426                                         .025     .002     .002
 11     11   FITZGERALD       28   1409   1426                                         .014        0        0
RUN:   2

 11     11   FITZGERALD       28   1336   1352                                          .15     22.4     22.4
 11     11   FITZGERALD       28   1336   1352                                         .094     2.04     2.04
 11     11   FITZGERALD       28   1336   1352                                         .034      .04      .04
 11     11   FITZGERALD       28   1336   1352                                         .025    .0028    .0028
 11     11   FITZGERALD       28   1336   1352                                         .014        0        0

RUN:   1

 13     13   AYERS             2   1345   1346    25.51    28.00    2.49               .25       51
 13     13   AYERS             2   1347   1348    25.50    28.00    2.50               .25       26
 13     13   AYERS             2   1359   1400    23.95    27.50    3.55                .5      192
 13     13   AYERS             2   1400   1401    23.95    27.50    3.55                .5      174
 13     13   AYERS             2   1401   1402    23.07    27.40    4.33               .75      293
 13     13   AYERS             2   1402   1403    23.11    27.40    4.29               .75      390
 13     13   AYERS             2   1403   1404    23.08    27.40    4.32               .75      300
 13     13   AYERS             2   1404   1405    23.09    27.40    4.31               .75      375
 13     13   AYERS             2   1405   1406    23.10    27.40    4.30               .75      293
 13     13   AYERS             2   1406   1407    22.31    27.30    4.99                 1      345
 13     13   AYERS             2   1407   1408    22.30    27.30    5.00                 1      353
 13     13   AYERS             2   1408   1409    22.30    27.30    5.00                 1      360
 13     13   AYERS             2   1409   1410    22.30    27.30    5.00                 1      345
 13     13   AYERS             2   1410   1411    21.73    27.30    5.57              1.25      540
 13     13   AYERS             2   1411   1412    21.73    27.30    5.57              1.25      435
 13     13   AYERS             2   1413   1414    21.68    27.20    5.52              1.25      375
 13     13   AYERS             2   1414   1415    21.68    27.20    5.52              1.25      510
```

```
                                                              NUCLEI MEASUREMENTS
EXPERIMENT #: 23                                                                                                        PROCESSING DATE:  81/09/26
                  OBSERVER                                   PLATE TEMP
MACH  DUCT  -------------------        SAMPLE  TIME                                  VOLUME   SUPER   NUCLEI   OBS    EST
NO.   NO.   NAME                 NO.   START   END     COLD     HOT      DELTA    SAMPLED   SAT     COUNT     -      K      REMARKS
                                                                (C)                (L)     (%)               N
----  ----  -------------- ---   -----   ----    ------   ------   ------   -------   ------  ------   -----  -----   -------------------

RUN:  1

 14    14   HUDSON           9    1451    1517                                .0166     .21    10.25                       F=41
 14    14   HUDSON           9    1451    1517                                .0166     .14     4.75                       F=41
 14    14   HUDSON           9    1451    1517                                .0166     .11     1.56                       F=41
 14    14   HUDSON           9    1451    1517                                .0166     .04     .004                       F=41
 14    14   HUDSON           9    1451    1517                                .0166    .029     .003                       F=41

RUN:  1

 15    15   ROGERS, FRED    23    1331    1332    18.74    24.75     6.01               1.46      356                       USING HIGHER MAIN
 15    15   ROGERS, FRED    23    1335    1336    19.11    24.44     5.33               1.15      331                       FLOW, USING THIS
 15    15   ROGERS, FRED    23    1339    1340    19.49    24.13     4.64                .87      283                       MORNINGS BACKGROUND
 15    15   ROGERS, FRED    23    1343    1344    19.87    23.81     3.94                .63      239                       AS FCN OF SS, MULT
 15    15   ROGERS, FRED    23    1347    1348    20.25    23.50     3.25               .425      157                       TIMES 2,
 15    15   ROGERS, FRED    23    1351    1352    20.63    23.19     2.56               .265       69                       LOWERING MAIN FLO.
 15    15   ROGERS, FRED    23    1355    1356    20.99    22.88     1.89                .14        7

RUN:  1

 16    16   HUDSON           9    1326    1329    21.35    26.05     4.70     .0024      .9      263
 16    16   HUDSON           9    1326    1329    21.70    25.50     3.80     .0024     .58      226
 16    16   HUDSON           9    1326    1329    22.20    24.95     2.75     .0024      .3      132
 16    16   HUDSON           9    1335    1339    21.35    26.05     4.70     .0024      .9      260
 16    16   HUDSON           9    1335    1339    21.70    25.50     3.80     .0024     .58      212
 16    16   HUDSON           9    1335    1339    22.20    24.95     2.75     .0024      .3      125
 16    16   HUDSON           9    1345    1348    21.35    26.05     4.70     .0024      .9      259
 16    16   HUDSON           9    1345    1348    21.70    25.50     3.80     .0024     .58      232
 16    16   HUDSON           9    1345    1348    22.20    24.95     2.75     .0024      .3      123
RUN:  2

 16    16   HUDSON           9    1355    1359    21.35    26.05     4.70     .0024      .9      261
 16    16   HUDSON           9    1355    1359    21.70    25.50     3.80     .0024     .58      216
 16    16   HUDSON           9    1355    1359    22.20    24.95     2.75     .0024      .3      123
 16    16   HUDSON           9    1406    1410    21.35    26.05     4.70     .0024      .9      266
 16    16   HUDSON           9    1406    1410    21.70    25.50     3.80     .0024     .58      222
 16    16   HUDSON           9    1406    1410    22.20    24.95     2.75     .0024      .3      126
 16    16   HUDSON           9    1416    1418    21.35    26.06     4.70     .0018      .9      264
 16    16   HUDSON           9    1416    1418    21.70    25.50     3.80     .0018     .58      220
 16    16   HUDSON           9    1416    1418    22.20    24.95     2.75     .0018      .3      124
RUN:  3

 16    16   HUDSON           9    1438    1441    21.35    26.05     4.70     .0024      .9      263
 16    16   HUDSON           9    1438    1441    21.70    25.50     3.80     .0024     .58      220
 16    16   HUDSON           9    1438    1441    22.20    24.95     2.75     .0024      .3      122
 16    16   HUDSON           9    1447    1451    21.35    26.05     4.70     .0024      .9      265
 16    16   HUDSON           9    1447    1451    21.70    25.50     3.80     .0024     .58      219
 16    16   HUDSON           9    1447    1451    22.20    24.95     2.75     .0024      .3      124
 16    16   HUDSON           9    1458    1501    21.35    26.06     4.70     .0024      .9      265
 16    16   HUDSON           9    1458    1501    21.70    25.50     3.80     .0024     .58      214
 16    16   HUDSON           9    1458    1501    22.20    24.95     2.75     .0024      .3      122

RUN:  1

 17    17   WOJCIECHOWSKI   27    1349    1350                                          .24    108.5   108.5
 17    17   WOJCIECHOWSKI   27    1352    1354                                          .35    172.6   172.6
 17    17   WOJCIECHOWSKI   27    1356    1357                                          .47    281.2   281.2
 17    17   WOJCIECHOWSKI   27    1400    1402                                          .72    434.1   434.1
 17    17   WOJCIECHOWSKI   27    1404    1405                                          .98    453.8   453.8

RUN:  1

 18    18   HUDSON           9    1326    1329    22.25    27.25     5.00     .0024       1      279
 18    18   HUDSON           9    1335    1339    22.45    27.15     4.70     .0024      .9      266
```

```
EXPERIMENT #: 23                                         NUCLEI MEASUREMENTS
                                                                                                           PROCESSING DATE:  81/09/26
                     OBSERVER                                          PLATE TEMP
MACH  DUCT  --------------------  SAMPLE  TIME                                      VOLUME   SUPER   NUCLEI     OBS     EST
NO.   NO.   NAME             NO.  START    END     COLD      HOT     DELTA  SAMPLED    SAT    COUNT       -       K     REMARKS
                                                             (C)                (L)     (%)               N
----  ----  ---------------- ---  -----   ----   ------   ------    ------  -------  ------  ------    -----   -----  --------------------
  18    18  HUDSON             9   1345  1348   22.95   26.60    3.65    .0024     .54     213
  18    18  HUDSON             9   1355  1359   23.40   26.10    2.70    .0024     .29     110
  18    18  HUDSON             9   1406  1410   23.70   25.85    2.15    .0024     .13      41
  18    18  HUDSON             9   1416  1418   23.25   26.30    3.05    .0018     .37     155
  18    18  HUDSON             9   1430  1432   22.50   27.00    4.50    .0018     .82     269
  18    18  HUDSON             9   1438  1441   22.05   27.50    5.45    .0024     1.2     292
  18    18  HUDSON             9   1447  1451   22.70   26.85    4.15    .0024      .7     241
  18    18  HUDSON             9   1458  1501   21.80   27.75    5.95    .0024    1.45     298

RUN:   1

  21    21  TRUEBLOOD         26   1326  1328   20.00   25.00    5.00                1   321.6
  21    21  TRUEBLOOD         26   1330  1332   20.65   25.00    4.35             .757   285.6
  21    21  TRUEBLOOD         26   1335  1336   21.58   25.00    3.42             .468     198
  21    21  TRUEBLOOD         26   1338  1340   22.07   25.00    2.93             .343   136.8
  21    21  TRUEBLOOD         26   1342  1343   22.47   25.00    2.53             .256    78.7
  21    21  TRUEBLOOD         26   1347  1348   22.85   25.00    2.15             .185    44.5
  21    21  TRUEBLOOD         26   1401  1404   25.00   25.00    0.00             .173    31.7
  21    21  TRUEBLOOD         26   1401  1404   25.00   25.00    0.00             .114    6.17
  21    21  TRUEBLOOD         26   1401  1404   25.00   25.00    0.00             .089    3.24
  21    21  TRUEBLOOD         26   1401  1404   25.00   25.00    0.00             .068    1.23
  21    21  TRUEBLOOD         26   1401  1404   25.00   25.00    0.00             .035    .038

RUN:   1

  24    24  SERPOLAY          25   1401  1406   26.10   27.10    1.00      .77     .04       0
  24    24  SERPOLAY          25   1415  1420   26.10   26.10    2.00      .77     .15       0
  24    24  SERPOLAY          25   1425  1430   26.20   29.20    3.00      .77     .34      40
  24    24  SERPOLAY          25   1437  1442   26.40   29.90    3.50      .77     .45     200
  24    24  SERPOLAY          25   1450  1455   26.60   30.60    4.00      .77     .58     250
  24    24  SERPOLAY          25   1505  1512   26.90   31.40    4.50      .77     .75     300

RUN:   1

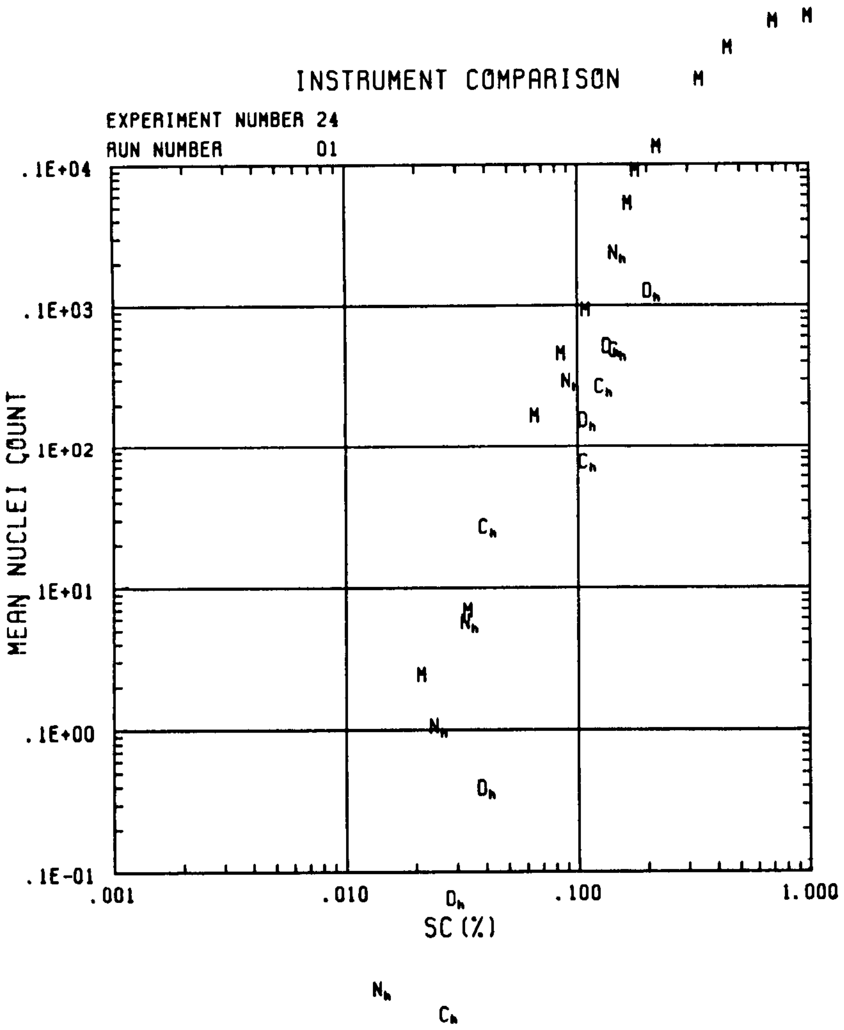
  25    25  BORYS              3   1403  1406   22.00   24.40    2.40     21.2     .22     113     113    .86  VOL SAMP X 10**5
  25    25  BORYS              3   1423  1426   20.80   24.40    3.60     21.2     .53     134     134
  25    25  BORYS              3   1430  1436   19.30   24.10    4.80     10.6     .96     537     537
  25    25  BORYS              3   1500  1510   17.10   24.00    6.90      5.3    1.99    1103    1103

RUN:   1

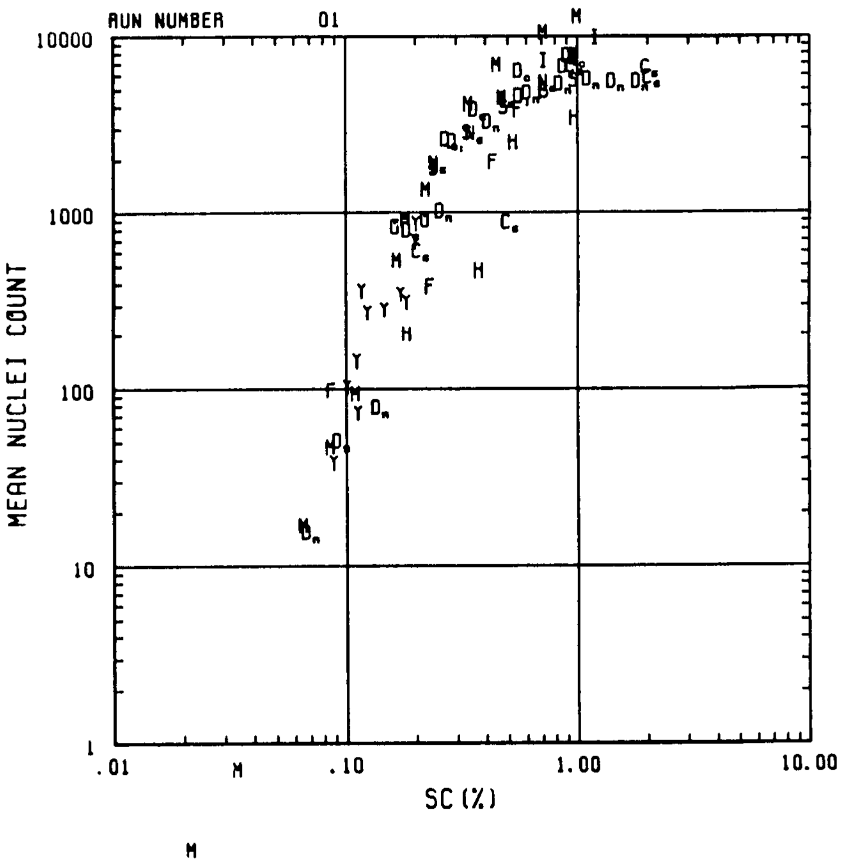
  26    26  HINDMAN            6   1339  1405   26.00   26.00    0.00      1.4     .13     1.4     1.4
  26    26  HINDMAN            6   1339  1405   26.00   26.00    0.00      1.4     .11     .39     .39
  26    26  HINDMAN            6   1339  1405   26.00   26.00    0.00      1.4    .041     .13     .13
  26    26  HINDMAN            6   1339  1405   26.00   26.00    0.00      1.4    .027   .0067   .0067
  26    26  HINDMAN            6   1339  1405   26.00   26.00    0.00      1.4    .016       0       0

RUN:   1

  27    27  OHTAKE            19   1424  1425                              5.5             .19                  97% R.H.
  27    27  OHTAKE            19   1424  1425                              5.5             .24                  98% R.H.
  27    27  OHTAKE            19   1424  1425                              5.5             .24                  103% R.H. NOMINAL
```


INSTRUMENT COMPARISON

HAZE CHAMBER RESULTS


INSTRUMENT COMPARISON

SDC/CFD RESULTS

```
                                         EXPERIMENT # 24
                                                                                   80/10/14
PURPOSE
-------
 TEST HIGH PARTICLE CONCENTRATION EFFECTS.

DESCRIPTION OF EXPERIMENT
-------------------------

  DATE           TIME
                 START   END
  ------------   -----------

  14 OCT,1980    1525   1800

  NUCLEI TYPE
  -----------

   (NH4)2 SO4, POLYDISPERSE, HIGH CONC.

  GENERATION METHOD
  -----------------

   DRI ATOMIZER, 50 PSI, 0.065 G/L SOLUTION.

  SIZE DISTRIBUTION SHAPING
  -------------------------

   NONE

REMARKS
-------

 NONE

WEATHER SYNOPSIS
----------------

 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

         ROOM CONDITIONS                          OUTSIDE CONDITIONS

 ------------------------------     ---------------------------------------------------

 AVG TEMP     AVG RH     AVG PRESS    AVG TEMP     AVG RH     AVG PRESS     AVG WS     AVG WD
   (C)         (%)         (MB)         (C)          (%)         (MB)         (M/S)      (DEG)
 --------     ------     ---------    --------     ------     ---------     ------     ------

   24.0        21.0        849
```

```
                                              NUCLEI MEASUREMENTS
EXPERIMENT #: 24                                                                                        PROCESSING DATE:  81/09/26
                 OBSERVER                                  PLATE TEMP
MACH  DUCT  ------------------   SAMPLE TIME                              VOLUME   SUPER  NUCLEI    OBS    EST
NO.   NO.   NAME            NO.  START  END    COLD    HOT     DELTA   SAMPLED   SAT    COUNT      -      K    REMARKS
                                                        (C)              (L)      (%)              N
----  ----  --------------- ---  -----  ----  ------  ------  ------  -------  ------  ------  -----  -----  -------------------
RUN:  1
  2     2   ROGERS, DAVE    22   1624   1625  22.00   24.10   2.10               .17             864
  2     2   ROGERS, DAVE    22   1628   1629  21.80   24.20   2.40               .23             948

RUN:  1
  7     7   LEAITCH         14   1553   1554           7.70             .283     .19             326                HOT TEMPERATURE IS
  7     7   LEAITCH         14   1603   1604           7.60             .283     .18             359                ACTUALLY DIFFERENCE
  7     7   LEAITCH         14   1611   1612           7.75             .283    .208             711                BETWEEN TUBE
  7     7   LEAITCH         14   1620   1621           7.60             .283     .21             895                AND AMBIENT
  7     7   LEAITCH         14   1630   1631           7.20             .283    .152             293                INPUT HUMIDITY
  7     7   LEAITCH         14   1639   1640           6.85             .283    .122             372                IS 72-80 %
  7     7   LEAITCH         14   1649   1651           6.80             .566     .13             283
  7     7   LEAITCH         14   1659   1660           6.55             .283    .116             146
  7     7   LEAITCH         14   1709   1710           6.05             .283    .106             104
  7     7   LEAITCH         14   1718   1719           5.65             .283    .118            74.6
  7     7   LEAITCH         14   1730   1731           5.30             .283    .092            39.2

RUN:  1
  8     8   MEE             17                25.00   27.20   2.20                .2
  8     8   MEE             17                24.00   27.20   3.20                .4
  8     8   MEE             17                23.40   27.20   3.80                 0
  8     8   MEE             17                23.00   27.20   4.20                .7
  8     8   MEE             17                22.60   27.20   4.60               .85
  8     8   MEE             17                22.20   27.20   5.00                 1
  8     8   MEE             17                22.10   27.20   5.10               1.1
  8     8   MEE             17                21.70   27.20   5.50               1.2
  8     8   MEE             17                21.50   27.20   5.70               1.3

RUN:  1
  9     9   GAGIN            5   1552         22.40   27.50   5.10      1.2     1.01    3580
  9     9   GAGIN            5   1602         24.50   28.30   3.80      1.2      .55    2600
  9     9   GAGIN            5   1606         25.30   28.50   3.20      1.2      .39     490
  9     9   GAGIN            5   1610         26.30   28.50   2.20      1.2      .19     210
RUN:  2
  9     9   GAGIN            5   1614         23.00   26.40   5.40      1.2     1.15    4530
  9     9   GAGIN            5   1617         24.50   28.50   4.00      1.2       .6    1750
  9     9   GAGIN            5   1621         25.30   28.40   3.10      1.2      .36     210
  9     9   GAGIN            5   1625         26.20   28.60   2.40      1.2      .21     170

RUN:  1
 10    10   LALA            13   1552         21.84   24.35   2.51       .4      .25  1901.4
 10    10   LALA            13   1553         21.85   24.36   2.51       .4      .25  1840.4  1870.9
 10    10   LALA            13   1554         21.42   24.38   2.96       .4      .35  2939.3
 10    10   LALA            13   1555         21.42   24.38   2.96       .4      .35  3025.6  2982.5
 10    10   LALA            13   1556         20.80   24.33   3.53       .4       .5  4159.7
 10    10   LALA            13   1557         20.80   24.33   3.53       .4       .5  4172.6  4166.2
 10    10   LALA            13   1558         20.02   24.33   4.31       .4      .75  5140.6
 10    10   LALA            13   1559         20.00   24.31   4.31       .4      .75  5093.3    5117
 10    10   LALA            13   1600         19.31   24.27   4.96       .4        1  5866.7
 10    10   LALA            13   1601         19.29   24.25   4.96       .4        1  5790.3  5828.5
RUN:  2
 10    10   LALA            13   1602         22.11   24.36   2.25       .4       .2  1114.1
 10    10   LALA            13   1603         21.61   24.35   2.74       .4       .3  2423.1
 10    10   LALA            13   1604         21.18   24.34   3.16       .4       .4  3362.2
 10    10   LALA            13   1605         20.79   24.32   3.53       .4       .5  4136.1
 10    10   LALA            13   1606         20.44   24.30   3.86       .4       .6  4674.4
 10    10   LALA            13   1607         20.11   24.27   4.16       .4       .7    5004
```

```
EXPERIMENT #: 24                                                      NUCLEI MEASUREMENTS
                                                                                                                         PROCESSING DATE:  81/09/26
                        OBSERVER                                        PLATE TEMP
MACH  DUCT  -------------------  SAMPLE  TIME                                      VOLUME   SUPER   NUCLEI    OBS      EST
NO.   NO.   NAME            NO.  START   END     COLD     HOT     DELTA   SAMPLED   SAT     COUNT      -       K      REMARKS
                                                           (C)               (L)     (%)               N
----  ----  --------------- ---  -----   ----   ------   ------   ------  -------  ------   ------   -----   -----   --------------------
 10    10   LALA             13  1608            19.79    24.23    4.44       .4      .8     5218
 10    10   LALA             13  1609            19.50    24.21    4.71       .4      .9   5609.3
 10    10   LALA             13  1610            19.22    24.17    4.95       .4       1   5633.4
 10    10   LALA             13  1611            18.10    24.13    6.03       .4     1.5   5916.9
RUN:   3
 10    10   LALA             13  1612            21.93    24.17    2.24       .4      .2   1083.3
 10    10   LALA             13  1613            21.42    24.16    2.74       .4      .3   2332.2
 10    10   LALA             13  1614            20.99    24.15    3.16       .4      .4   3338.5
 10    10   LALA             13  1615            20.60    24.13    3.53       .4      .5   4103.3
 10    10   LALA             13  1616            20.25    24.11    3.86       .4      .6   4685.5
 10    10   LALA             13  1617            19.91    24.07    4.16       .4      .7   5125.6
 10    10   LALA             13  1618            19.62    24.06    4.44       .4      .8   5319.7
 10    10   LALA             13  1619            19.28    23.98    4.70       .4      .9   5564.9
 10    10   LALA             13  1620            19.00    23.95    4.95       .4       1   5631.2
 10    10   LALA             13  1621            17.88    23.91    6.03       .4     1.5   5953.9

RUN:   1
 11    11   FITZGERALD       28  1603    1644                                         .15      250      250
 11    11   FITZGERALD       28  1603    1644                                        .094       31       31
 11    11   FITZGERALD       28  1603    1644                                        .034       .6       .6
 11    11   FITZGERALD       28  1603    1644                                        .025      .11      .11
 11    11   FITZGERALD       28  1603    1644                                        .014    .0015    .0015

RUN:   1
 13    13   AYERS             2  1601    1602    26.60    29.10    2.50                .25     1901
 13    13   AYERS             2  1602    1603    26.50    29.00    2.50                .25     1901
 13    13   AYERS             2  1603    1604    25.30    28.90    3.60                 .5     4455
 13    13   AYERS             2  1604    1605    25.22    28.80    3.58                 .5     4635
 13    13   AYERS             2  1606    1607    24.43    28.80    4.37                .75     8100
 13    13   AYERS             2  1607    1608    24.33    28.70    4.37                .75     7050
 13    13   AYERS             2  1608    1609    23.56    28.60    5.04                  1     8340
 13    13   AYERS             2  1609    1610    23.60    28.60    5.00                  1     7920
 13    13   AYERS             2  1610    1611    22.88    28.50    5.62               1.25    10575
 13    13   AYERS             2  1611    1612    22.81    28.40    5.59               1.25    10200
RUN:   2
 13    13   AYERS             2  1619    1620    25.68    28.20    2.52                .25     1850
 13    13   AYERS             2  1620    1621    25.72    28.20    2.48                .25     1953
 13    13   AYERS             2  1621    1622    24.66    28.20    3.54                 .5     4230
 13    13   AYERS             2  1622    1623    24.54    28.10    3.56                 .5     4620
 13    13   AYERS             2  1623    1624    23.75    28.10    4.35                .75     7125
 13    13   AYERS             2  1624    1625    23.74    28.10    4.36                .75     7170
 13    13   AYERS             2  1625    1626    23.01    28.08    4.99                  1     7425
 13    13   AYERS             2  1626    1627    22.88    27.90    5.02                  1     7365
 13    13   AYERS             2  1627    1628    22.31    27.90    5.59               1.25     8715
 13    13   AYERS             2  1628    1629    22.29    27.90    5.61               1.25     9390
RUN:   3
 13    13   AYERS             2  1645    1646    25.29    27.80    2.51                .25     2312
 13    13   AYERS             2  1646    1647    25.35    27.80    2.45                .25     2235
 13    13   AYERS             2  1648    1649    24.28    27.80    3.52                 .5     4605
 13    13   AYERS             2  1649    1650    24.28    27.80    3.52                 .5     4305
 13    13   AYERS             2  1651    1652    23.37    27.70    4.33                .75     7380
 13    13   AYERS             2  1652    1653    23.41    27.70    4.29                .75     7020
 13    13   AYERS             2  1653    1654    22.61    26.60    3.99                  1     7455
 13    13   AYERS             2  1654    1655    22.59    26.60    4.01                  1     7575
 13    13   AYERS             2  1655    1656    22.03    26.60    4.57               1.25     9450
 13    13   AYERS             2  1656    1657    22.03    26.60    4.57               1.25    10230

RUN:   1
 14    14   HUDSON            9  1607    1637                               .0189     .21      142                       F=41
```

```
                                                        NUCLEI MEASUREMENTS
EXPERIMENT #: 24                                                                                                    PROCESSING DATE:  81/09/26

                  OBSERVER                                    PLATE TEMP
MACH  DUCT  --------------------  SAMPLE TIME                                  VOLUME   SUPER   NUCLEI     OBS     EST
NO.   NO.   NAME             NO.  START   END     COLD    HOT    DELTA  SAMPLED   SAT    COUNT       -       K     REMARKS
                                                          (C)             (L)     (%)                N
----  ----  ---------------- ---  -----  ----   ------  ------  ------  -------  ------  ------    -----   -----   --------------------
 14    14   HUDSON             9  1607   1637                            .0189     .14    58.1                     F=41
 14    14   HUDSON             9  1607   1637                            .0189     .11    17.5                     F=41
 14    14   HUDSON             9  1607   1637                            .0189     .04    .043                     F=41
 14    14   HUDSON             9  1607   1637                            .0189    .029    .007                     F=41
 14    14   HUDSON             9  1638   1708                            .0189     .21   124.5                     F=41
 14    14   HUDSON             9  1638   1708                            .0189     .14    49.9                     F=41
 14    14   HUDSON             9  1638   1708                            .0189     .11    14.8                     F=41
 14    14   HUDSON             9  1638   1708                            .0189     .04    .039                     F=41
 14    14   HUDSON             9  1638   1708                            .0189    .029   .0062                     F=41

RUN:   2

 14    14   HUDSON             9  1709   1751                            .0182     .21   104.1                     F=41
 14    14   HUDSON             9  1709   1751                            .0182     .14    41.1                     F=41
 14    14   HUDSON             9  1709   1751                            .0182     .11      12                     F=41
 14    14   HUDSON             9  1709   1751                            .0182     .04    .035                     F=41
 14    14   HUDSON             9  1709   1751                            .0182    .029   .0073                     F=41


RUN:   1

 15    15   ROGERS, FRED      23  1709   1710    18.36   25.06    6.70             1.86    5792                     .12/.62 REPLACED
 15    15   ROGERS, FRED      23  1713   1714    18.74   24.75    6.01             1.46    5796                     CAPILLARY, HIGH
 15    15   ROGERS, FRED      23  1717   1718    19.11   24.44    5.33             1.15    5921                     SS PNTS AT HIGH
 15    15   ROGERS, FRED      23  1721   1722    19.49   24.13    4.64              .87    5592                     MAIN FLOW.
 15    15   ROGERS, FRED      23  1725   1726    19.87   23.81    3.94              .63    4984
 15    15   ROGERS, FRED      23  1723   1730    20.25   23.50    3.25             .425    3396                     LOWERED MAIN FLOW.
 15    15   ROGERS, FRED      23  1733   1734    20.63   23.19    2.56             .265    1064                     LOWERED MAIN FLOW.
 15    15   ROGERS, FRED      23  1737   1738    20.99   22.88    1.89              .14      81                     LOWERED MAIN FLOW.
 15    15   ROGERS, FRED      23  1741   1742    21.35   22.56    1.21              .07      16                     TO 1070 CNTS.
 15    15   ROGERS, FRED      23  1801   1802    21.41   22.71    1.30             .095      52


RUN:   1

 16    16   HUDSON             9  1552   1554    21.35   26.05    4.70   .0018       .9    6951
 16    16   HUDSON             9  1552   1554    21.70   25.50    3.80   .0018      .58    4092
 16    16   HUDSON             9  1552   1554    22.20   24.95    2.75   .0018       .3    2404
 16    16   HUDSON             9  1609   1612    21.35   26.05    4.70   .0008       .9    7013
 16    16   HUDSON             9  1609   1612    21.70   25.50    3.80   .0008      .58    5033
 16    16   HUDSON             9  1609   1612    22.20   24.95    2.75   .0008       .3    2719
 16    16   HUDSON             9  1619   1620    21.35   26.05    4.70   .0005       .9    7206
 16    16   HUDSON             9  1619   1620    21.70   25.50    3.80   .0005      .58    5150
 16    16   HUDSON             9  1619   1620    22.20   24.95    2.75   .0005       .3    2782

RUN:   2

 16    16   HUDSON             9  1629   1632    21.30   26.05    4.75   .0004      .92    5917
 16    16   HUDSON             9  1629   1632    21.70   25.50    3.80   .0004      .58    4622
 16    16   HUDSON             9  1629   1632    22.20   24.90    2.70   .0004      .29    2398
 16    16   HUDSON             9  1638   1640    21.30   26.05    4.75   .0003      .92    6350
 16    16   HUDSON             9  1638   1640    21.70   26.50    3.80   .0003      .58    4974
 16    16   HUDSON             9  1638   1640    22.20   24.90    2.70   .0003      .29    2538
 16    16   HUDSON             9  1655   1658    21.30   26.05    4.75   .0004      .92    6393
 16    16   HUDSON             9  1655   1658    21.70   25.50    3.80   .0004      .58    4981
 16    16   HUDSON             9  1655   1658    22.20   24.90    2.70   .0004      .29    2497

RUN:   3

 16    16   HUDSON             9  1711   1713    21.30   26.05    4.75   .0004      .92    6371
 16    16   HUDSON             9  1711   1713    21.70   25.50    3.80   .0004      .58    5071
 16    16   HUDSON             9  1711   1713    22.20   24.90    2.70   .0004      .29    2546
 16    16   HUDSON             9  1720   1722    21.30   26.05    4.75   .0004      .92    6439
 16    16   HUDSON             9  1720   1722    21.70   25.50    3.80   .0004      .58    5146
 16    16   HUDSON             9  1720   1722    22.20   24.90    2.70   .0004      .29    2598
 16    16   HUDSON             9  1729   1732    21.30   26.05    4.75   .0004      .92    6305
 16    16   HUDSON             9  1729   1732    21.70   25.50    3.80   .0004      .58    4821
 16    16   HUDSON             9  1729   1732    22.20   24.90    2.70   .0004      .29    2542

RUN:   4

 16    16   HUDSON             9  1737   1740    21.30   26.05    4.75   .0004      .92    6346
```

```
                                                               NUCLEI MEASUREMENTS
EXPERIMENT #: 24                                                                                              PROCESSING DATE:  81/09/26
                      OBSERVER                                         PLATE TEMP
MACH  DUCT  -------------------------  SAMPLE  TIME                                     VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME                  NO.  START   END     COLD     HOT      DELTA    SAMPLED  SAT     COUNT      -      K      REMARKS
                                                                 (C)                (L)     (%)               N
----  ----  ----------------     ---   -----   ----   ------   ------   ------   -------  ------   ------   -----   -----  --------------------
 16    16   HUDSON                 9   1737    1740    21.70    25.50     3.80    .0004     .58     4732
 16    16   HUDSON                 9   1737    1740    22.20    24.90     2.70    .0004     .29     2534

RUN:   1

 17    17   WOJCIECHOWSKI         27   1555    1556                                         .25     1983     1983
 17    17   WOJCIFCHOWSKI         27   1558    1600                                         .36     2935     2935
 17    17   WOJCIFCHOWSKI         27   1602    1603                                         .49     4662     4662
 17    17   WOJCIECHOWSKI         27   1605    1606                                         .74     5742     5742

RUN:   1

 18    18   HUDSON                 9   1609    1612    22.30    27.10     4.80    .0018     .94     8269
 18    18   HUDSON                 9   1619    1620    22.30    27.10     4.80    .0006     .94     7993
 18    18   HUDSON                 9   1629    1632    22.30    27.10     4.80    .0008     .94     8009
 18    18   HUDSON                 9   1638    1640    22.85    26.65     3.80    .0005     .58     6598
 18    18   HUDSON                 9   1655    1658    23.35    26.00     2.65    .0008     .28     2699
 18    18   HUDSON                 9   1711    1713    23.60    25.80     2.20     .001     .19      833
 18    18   HUDSON                 9   1720    1722    23.20    26.25     3.05    .0008     .37     4011
 18    18   HUDSON                 9   1729    1732    22.25    27.25     5.00    .0008      1      7837
 18    18   HUDSON                 9   1737    1740    22.25    27.25     5.00    .0018      1      7924

RUN:   1

 21    21   TRUEBLOOD             26   1552    1553    19.89    25.00     5.11             1.04    13472
 21    21   TRUEBLOOD             26   1556    1557    20.70    25.00     4.30              .74    11017
 21    21   TRUEBLOOD             26   1600    1601    21.58    25.00     3.42             .468     7174
 21    21   TRUEBLOOD             26   1603    1604    22.02    25.00     2.98             .355     4315
 21    21   TRUEBLOOD             26   1606    1608    22.59    25.00     2.41             .232     1405
 21    21   TRUEBLOOD             26   1611    1612    22.83    25.00     2.17             .188      962
 21    21   TRUEBLOOD             26   1620    1621    25.00    25.00     0.00             .173      558
 21    21   TRUEBLOOD             26   1620    1621    25.00    25.00     0.00             .114     97.4
 21    21   TRUEBLOOD             26   1620    1621    25.00    25.00     0.00             .089     48.3
 21    21   TRUEBLOOD             26   1620    1621    25.00    25.00     0.00             .068     17.6
 21    21   TRUEBLOOD             26   1620    1621    25.00    25.00     0.00             .035     .725
 21    21   TRUEBLOOD             26   1626    1628    25.00    25.00     0.00             .022     .255

RUN:   1

 24    24   SERPOLAY              25   1615    1620    26.80    26.30     1.50      .77     .09      100
 24    24   SERPOLAY              25   1625    1630    26.70    29.20     2.50      .77     .24      400
 24    24   SERPOLAY              25   1630    1640    26.70    30.20     3.50      .77     .45     2010
 24    24   SERPOLAY              25   1648    1652    26.80    30.80     4.00      .77     .58     3990
 24    24   SERPOLAY              25   1658    1701    26.90    31.40     4.50      .77     .74     5050

RUN:   1

 25    25   BORYS                  3   1629    1638    21.60    23.90     2.30     15.9     .21      632      632    1.01   SAMP VOL X 10**5
 25    25   BORYS                  3   1643    1652    19.90    23.60     3.70     15.9     .51      919      919
 25    25   BORYS                  3   1700    1706    18.40    23.30     4.90     10.6     .97     7120     7120
 25    25   BORYS                  3   1713    1715    16.30    23.30     7.00     2.12    2.08     6082     6082
 25    25   HORYS                  3   1713    1714    16.40    23.30     6.90     1.06    2.05     6932     6932

RUN:   1

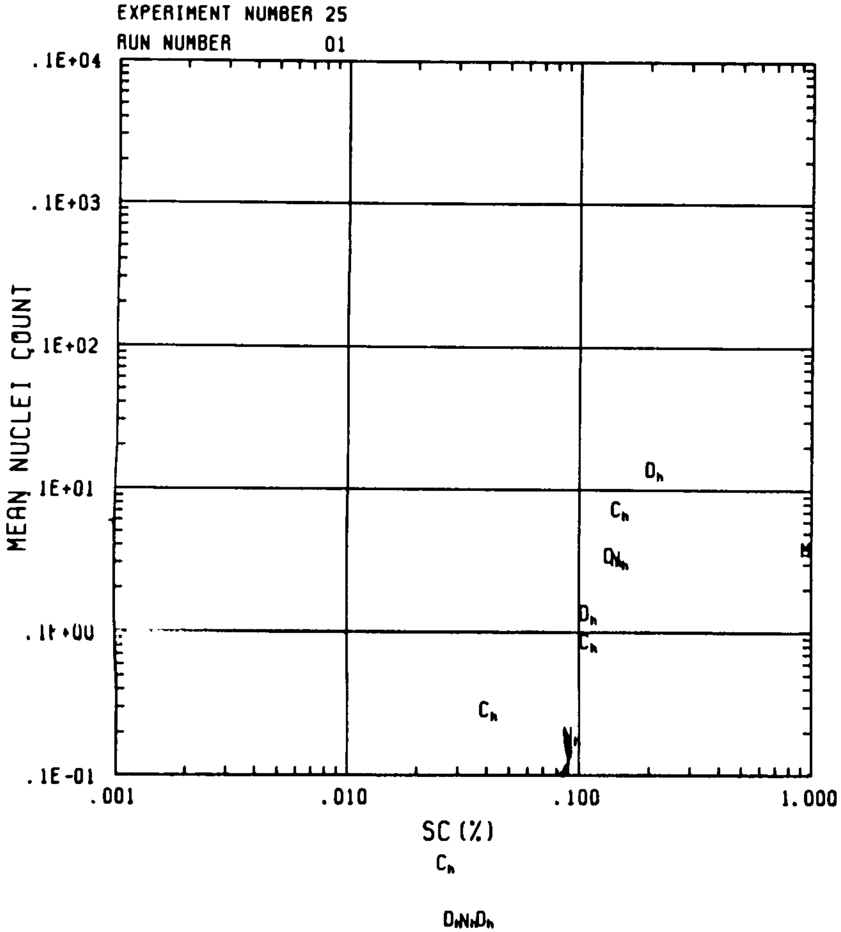
 26    26   HINDMAN                6   1600    1625    26.00    26.00     0.00      1.4     .13       28       28
 26    26   HINDMAN                6   1600    1625    26.00    26.00     0.00      1.4     .11        8        8
 26    26   HINDMAN                6   1600    1625    26.00    26.00     0.00      1.4    .041      2.8      2.8
 26    26   HINDMAN                6   1600    1625    26.00    26.00     0.00      1.4    .027     .001     .001
 26    26   HINDMAN                6   1600    1625    26.00    26.00     0.00      1.4    .016        0        0
 26    26   HINDMAN                6   1731    1747    26.00    26.00     0.00      1.4     .15       51       51

RUN:   1

 27    27   OHTAKE                19   1601    1601                                .73              9.43                   95% R.H.
```

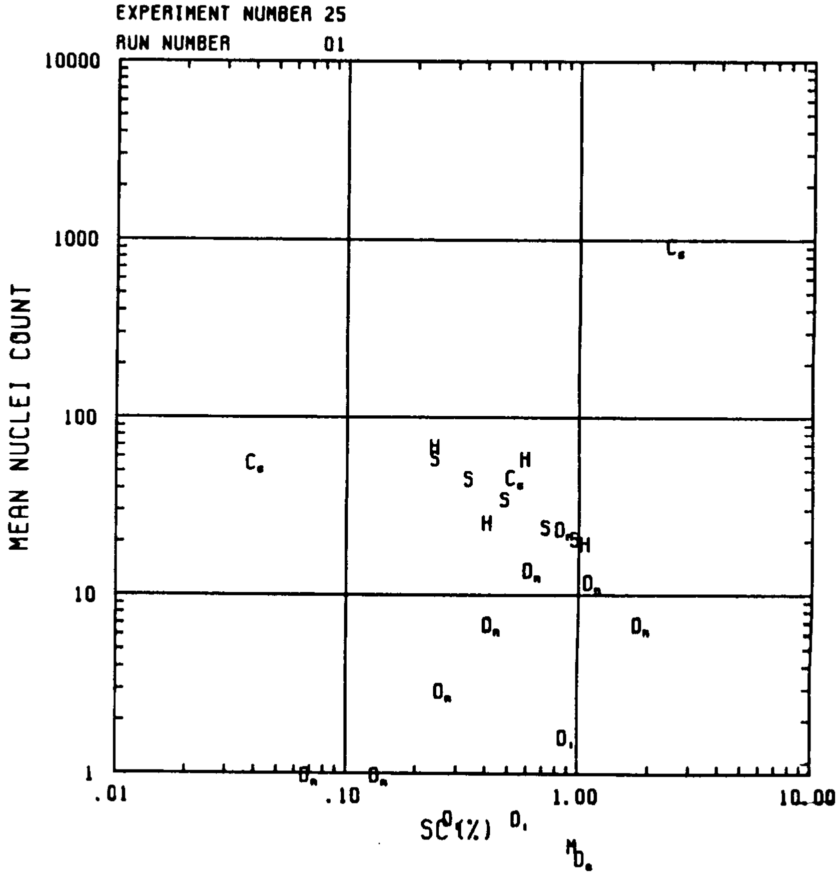
```
                                                              NUCLEI MEASUREMENTS
EXPERIMENT #: 24                                                                                          PROCESSING DATE:  81/09/26
                     OBSERVER                                   PLATE TEMP
MACH  DUCT  ---------------------  SAMPLE  TIME                                VOLUME   SUPER   NUCLEI    OBS    EST
NO.   NO.   NAME              NO.  START   END     COLD    HOT     DELTA   SAMPLED   SAT    COUNT      -      K     REMARKS
                                                           (C)              (L)      (%)               N
----  ----  ----------------  ---  -----   ----   ------  ------  ------  --------  ------  ------   -----  -----  --------------------
 27    27   OHTAKE             19  1601    1601                                .73             10.48                101% R.H. NOMINAL
```

INSTRUMENT COMPARISON



HAZE CHAMBER RESULTS

INSTRUMENT COMPARISON



SDC/CFD RESULTS

```
                                        EXPERIMENT # 25                                   80/10/15
PURPOSE
-------
 CLEAN AIR FOR NOISE CHECK IN INSTRUMENT.

DESCRIPTION OF EXPERIMENT
-------------------------
                     TIME
  DATE               START   END
  ------------      ----------
  15 OCT,1980       0820    0921

  NUCLEI TYPE
  -----------
   NA

  GENERATION METHOD
  -----------------
   NA

  SIZE DISTRIBUTION SHAPING
  -------------------------
   NA

REMARKS
-------
 NONE

WEATHER SYNOPSIS
----------------
 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------
        ROOM CONDITIONS                            OUTSIDE CONDITIONS

 -------------------------------     ---------------------------------------------------
 AVG TEMP    AVG RH    AVG PRESS     AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)        (%)        (MB)          (C)        (%)        (MB)       (M/S)     (DEG)
 --------    ------    ---------     --------    ------    ---------    ------    ------
   27.0       22.0       847
```

```
                                                  NUCLEI MEASUREMENTS
EXPERIMENT #: 25                                                                                           PROCESSING DATE:  81/09/26
                   OBSERVER                                  PLATE TEMP
MACH  DUCT   ------------------   SAMPLE TIME                                VOLUME    SUPER  NUCLEI     OBS     EST
NO.   NO.    NAME            NO.  START  END      COLD     HOT    DELTA    SAMPLED     SAT    COUNT      -       K      REMARKS
                                                           (C)               (L)       (%)               N
----  ----   --------------- ---  -----  ----   ------  ------   ------   -------   ------   ------   -----   -----   ------------------

RUN:  1

   8     8   MEE              17  0850          24.70   25.30     .60                .01       0
   8     8   MEE              17  0850          23.90   25.30    1.40                .07       0
   8     8   MEE              17  0850          23.20   25.30    2.10                .18      24
   8     8   MEE              17  0850          22.40   25.30    2.90                 .3      20
   8     8   MEE              17  0850          22.00   25.30    3.30                .42      10
   8     8   MEE              17  0850          21.10   25.30    4.20                 .7      17
   8     8   MEE              17  0850          20.80   25.30    4.50                .75       8
   8     8   MEE              17  0850          20.10   25.30    5.20                1.1      20
   8     8   MEE              17  0850          19.70   25.30    5.60                1.3      19
   8     8   MEE              17  0850          19.50   25.30    5.80                1.4       6
   8     8   MEE              17  0850          18.90   25.30    6.40                1.6      11
   8     8   MEE              17  0850          18.80   25.30    6.50                1.7       6
   8     8   MEE              17  0850          18.20   25.30    7.10                2.1       5
   8     8   MEE              17  0850          18.00   25.30    7.30                2.4       5
   8     8   MEE              17  0850  0900    18.30   25.30    7.00                  2       0

RUN:  1

   9     9   GAGIN             5  0949          22.20   27.50    5.30      1.2      1.11      20
   9     9   GAGIN             5  0952          23.50   27.40    3.90      1.2       .61      60
   9     9   GAGIN             5  0954          24.20   27.40    3.20      1.2       .42      26
   9     9   GAGIN             5  0957          25.20   27.50    2.30      1.2       .25      70
RUN:  2

   9     9   GAGIN             5  0902          22.40   27.50    5.10      1.2      1.01      40
   9     9   GAGIN             5  0904          23.40   27.40    4.00      1.2       .64      50
   9     9   GAGIN             5  0906          24.20   27.60    3.40      1.2       .44      16
   9     9   GAGIN             5  0908          25.30   27.50    2.20      1.2        .2       1

RUN:  1

  10    10   LALA             13  0823          19.82   22.28    2.46       .4       .25    57.1
  10    10   LALA             13  0824          19.92   22.39    2.47       .4       .25    63.8      60
  10    10   LALA             13  0825          19.58   22.50    2.92       .4       .35    46.4
  10    10   LALA             13  0826          19.38   22.60    3.22       .4       .35    46.3      46
  10    10   LALA             13  0827          19.22   22.71    3.49       .4        .5    35.9
  10    10   LALA             13  0828          19.33   22.81    3.48       .4        .5    34.8      35
  10    10   LALA             13  0829          18.65   22.91    4.26       .4       .75      24
  10    10   LALA             13  0850          18.72   22.98    4.26       .4       .75    25.7      25
  10    10   LALA             13  0831          18.15   23.06    4.91       .4         1    21.1
  10    10   LALA             13  0832          18.19   23.10    4.91       .4         1    21.1      21

RUN:  1

  11    11   FITZGERALD       28  0910  0920                                         .15     .34     .34
  11    11   FITZGERALD       28  0910  0920                                        .094     .02     .02
  11    11   FITZGERALD       28  0910  0920                                        .034   .0006   .0006
  11    11   FITZGERALD       28  0910  0920                                        .025       0       0
  11    11   FITZGERALD       28  0910  0920                                        .014       0       0

RUN:  1

  13    13   AYERS             2  0830  0831    17.40   22.80    5.40               1.25       0
  13    13   AYERS             2  0832  0833    17.95   22.80    4.85                  1       0
  13    13   AYERS             2  0834  0835    18.59   22.80    4.21                .75       0
  13    13   AYERS             2  0836  0837    19.35   22.80    3.45                 .5       0
  13    13   AYERS             2  0840  0841    20.59   23.00    2.41                .25       0

RUN:  1

  14    14   HUDSON            9  0914  0938                                         .21    1.44                 F=41
  14    14   HUDSON            9  0914  0938                                         .14     .36                 F=41
```

```
EXPERIMENT #: 25                                       NUCLEI MEASUREMENTS                                          PROCESSING DATE:  81/09/26

                    OBSERVER                                      PLATE TEMP
MACH  DUCT  -------------------  SAMPLE TIME                                  VOLUME   SUPER   NUCLEI    OBS    EST
NO.   NO.   NAME            NO.  START   END    COLD     HOT    DELTA   SAMPLED   SAT     COUNT      -      K     REMARKS
                                                         (C)             (L)      (%)               N
----  ----  --------------- ---  -----  ----   ------   ------   ------  -------  ------   ------   -----  -----  --------------------
 14    14   HUDSON            9  0914   0938                                         .11      .14                 F=41
 14    14   HUDSON            9  0914   0938                                         .04     .001                 F=41
 14    14   HUDSON            9  0914   0938                                        .029     .001                 F=41

RUN:   1

 15    15   ROGERS. FRED     23  0833   0834   18.36    25.06     6.70              1.86        7                 MAIN FLOW ABOUT
 15    15   ROGERS, FRED     23  0833   0834                                                                    1600 COUNTS.
 15    15   ROGERS, FRED     23  0841   0842   19.11    24.44     5.33              1.15       12                 THESE VALUES ARE
 15    15   ROGERS, FRED     23  0845   0846   19.49    24.13     4.64               .87       24                 THE HIGHEST YET
 15    15   ROGERS, FRED     23  0849   0850   19.87    23.81     3.94               .63       14                 OBSERVED DURING THE
 15    15   ROGERS, FRED     23  0854   0855   20.25    23.50     3.25              .425        7                 WORKSHOP.
 15    15   ROGERS, FRED     23  0858   0859   20.63    23.19     2.56              .265        3
 15    15   ROGERS, FRED     23  0902   0903   20.99    22.88     1.89               .14        1
 15    15   ROGERS, FRED     23  0906   0907   21.35    22.56     1.21               .07        1

RUN:   1

 16    16   HUDSON            9  0904   0913   21.45    26.15     4.70     .005       .9     1.67
 16    16   HUDSON            9  0904   0913   21.80    25.56     3.75     .005      .57      .57
 16    16   HUDSON            9  0904   0913   22.40    25.05     2.65     .005      .29      .57

RUN:   1

 17    17   NRL              32  0825                                                .25                0
 17    17   NRL              32  0825                                                .35                0
 17    17   NRL              32  0825                                                .47                0
 17    17   NRL              32  0825                                                .72                0
 17    17   NRL              32  0825                                                .98                0
 17    17   NRL              32  0825   0830                                           2                0

RUN:   1

 18    18   HUDSON            9  0904   0913   22.45    27.60     5.15     .005     1.08      .34

RUN:   1

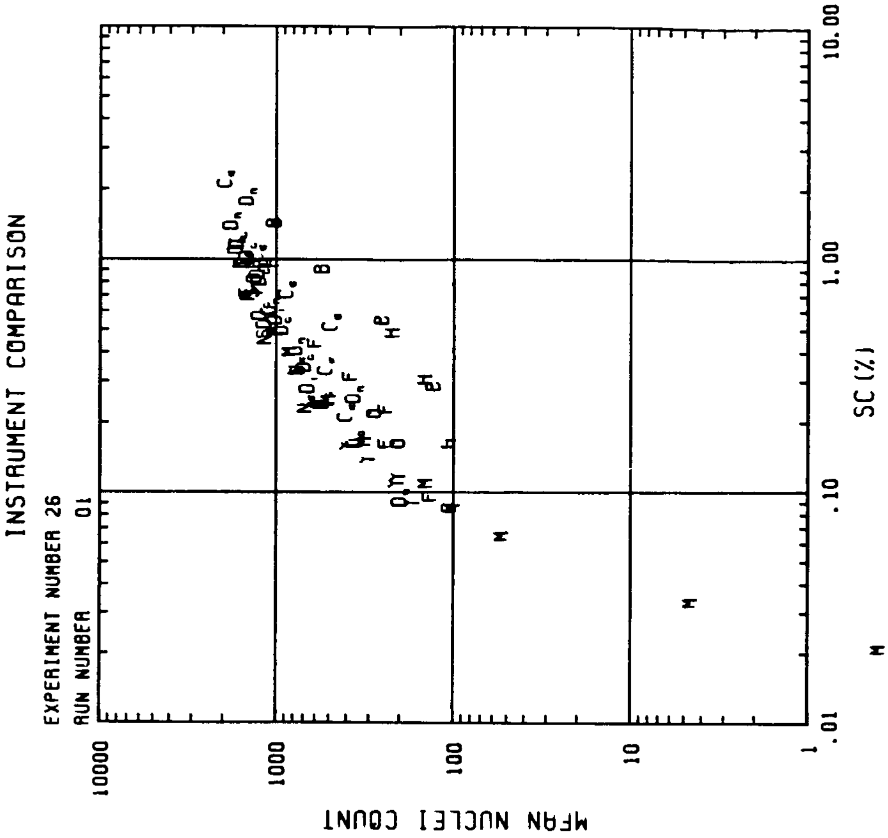
 21    21   ALOFS             1  0842   0846   20.00    25.00     5.00                 1     .307
 21    21   ALOFS             1  0846   0850   20.00    25.00     5.00                 1     .497
 21    21   ALOFS             1  0850   0854   20.00    25.00     5.00                 1     .639
 21    21   ALOFS             1  0854   0858   20.00    25.00     5.00                 1     .355
 21    21   ALOFS             1  0858   0902   20.00    25.00     5.00                 1     .331
 21    21   ALOFS             1  0902   0906   20.00    25.00     5.00                 1     .402
 21    21   ALOFS             1  0906   0910   20.00    25.00     5.00                 1     .402
 21    21   ALOFS             1  0910   0914   20.00    25.00     5.00                 1     .284

RUN:   1

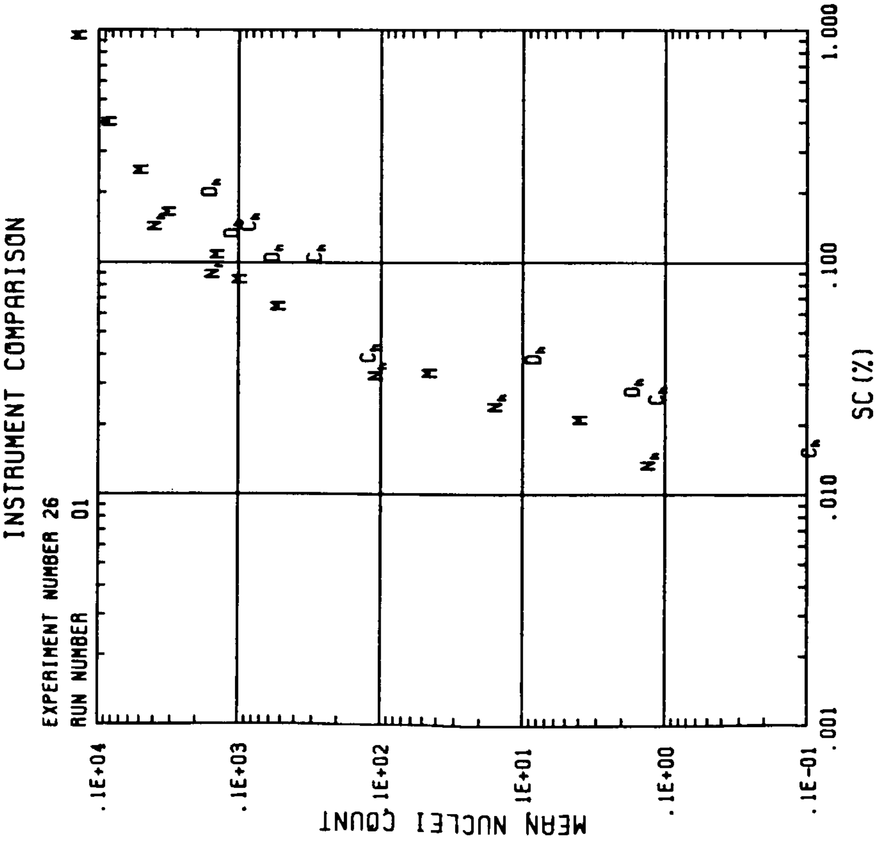
 25    25   BORYS             3  0857   0900   22.80    23.80     1.00     10.6      .04       57       57        VOL SAMP X 10**5
 25    25   BORYS             3  0905   0908   16.10    23.80     7.70     4.24     2.55      955      955
 25    25   BORYS             3  0910   0913   20.40    24.00     3.60     2.12      .53       47       47        ACTUALLY < 47

RUN:   1

 26    26   HINDMAN           6  0832   0857   26.00    26.00     0.00      1.2      .15      .76      .76
 26    26   HINDMAN           6  0832   0857   26.00    26.00     0.00      1.2      .11      .09      .09
 26    26   HINDMAN           6  0832   0857   26.00    26.00     0.00      1.2     .041      .03      .03
 26    26   HINDMAN           6  0832   0857   26.00    26.00     0.00      1.2     .027    .0025    .0025
 26    26   HINDMAN           6  0832   0857   26.00    26.00     0.00      1.2     .016        0        0
```



SDC/CFD RESULTS



HAZE CHAMBER RESULTS

EXPERIMENT # 26

80/10/15

PURPOSE

INSTRUMENT COMPARISON WITH AMBIENT AIR.

DESCRIPTION OF EXPERIMENT

DATE	TIME START	END
15 OCT.1980	0936	1130

NUCLEI TYPE

NA

GENERATION METHOD

NA

SIZE DISTRIBUTION SHAPING

NA

REMARKS

AIR THROUGH OPEN WINDOW IN AEROSOL LAB DUCT ELBOWS IN LAB OPENED.

WEATHER SYNOPSIS

NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT

ROOM CONDITIONS			OUTSIDE CONDITIONS				
AVG TEMP (C)	AVG RH (%)	AVG PRESS (MB)	AVG TEMP (C)	AVG RH (%)	AVG PRESS (MB)	AVG WS (M/S)	AVG WD (DEG)
28.0	22.0	847					

```
                                                     NUCLEI MEASUREMENTS
EXPERIMENT #: 26                                                                                               PROCESSING DATE:  81/09/26
                       OBSERVER                                       PLATE TEMP
MACH  DUCT  --------------------  SAMPLE  TIME                                      VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME             NO.  START   END     COLD     HOT     DELTA   SAMPLED   SAT    COUNT      -      K     REMARKS
                                                           (C)               (L)     (%)               N
----  ----  --------------- ---   -----   ----   ------   ------   ------  -------  ------  ------   -----   -----  --------------------
RUN:  1

  2     2   POLITOVICH       20   1015    1017   22.70    24.80    2.10               .17             216
  2     2   POLITOVICH       20   1018    1019   22.60    25.00    2.40               .23             294

RUN:  1

  5     5   KITCHEN          12   1005    1005   25.50    27.10    1.60               .09     110                    PHOTOCELL AMP.
  5     5   KITCHEN          12   1006    1006   24.40    27.10    2.70               .3      150                    RESET
  5     5   KITCHEN          12   1007    1007   23.50    27.20    3.70               .58     170
  5     5   KITCHEN          12   1008    1008   22.50    27.30    4.80               .95     630
  5     5   KITCHEN          12   1010    1010   22.60    27.40    4.80               .95     520
  5     5   KITCHEN          12   1011    1011   23.70    27.40    3.70               .58     360
  5     5   KITCHEN          12   1012    1012   24.70    27.40    2.70               .3      120
  5     5   KITCHEN          12   1020    1020   21.60    27.50    5.90              1.5     1080

RUN:  1

  7     7   LEAITCH          14   0931    0932             8.50            .283     .25             542            HOT TEMPERATURE IS
  7     7   LEAITCH          14   0937    0938             7.95            .283     .166            411            ACTUALLY TEMPERATURE
  7     7   LEAITCH          14   0945    0946             7.60            .283     .146            315            DIFFERENCE BETWEEN
  7     7   LEAITCH          14   0953    0954             7.15            .283     .122            212            TUBE AND AMBIENT
  7     7   LEAITCH          14   0959    0960             7.05            .283     .114            217
  7     7   LEAITCH          14   1007    1008             6.70            .283     .094            178
RUN:  2
  7     7   LEAITCH          14   1033    1034             5.45            .283     .045            163
  7     7   LEAITCH          14   1035    1036             5.25            .283     .036            143
  7     7   LEAITCH          14   1037    1038             5.20            .283     .034            128
  7     7   LEAITCH          14   1039    1040             5.00            .283     .03             115
  7     7   LEAITCH          14   1041    1042             4.90            .283     .026            109
  7     7   LEAITCH          14   1043    1044             4.75            .283     .023             85
  7     7   LEAITCH          14   1048    1049             4.45            .283     .018             76
  7     7   LEAITCH          14   1052    1053             4.25            .283     .014             62

RUN:  1

  8     8   MEE              17   0945           27.10    28.90    1.80               .12       0
  8     8   MEE              17   0945           25.40    28.90    3.50               .5       50
  8     8   MEE              17   0945           25.00    28.90    3.90               .6      518
  8     8   MEE              17   0945           24.60    28.90    4.30               .8      696
  8     8   MEE              17   0945           24.10    28.90    4.80               .9      637
  8     8   MEE              17   0945           23.70    28.90    5.20              1       2493
  8     8   MEE              17   0945           23.40    28.90    5.50              1.2     2142
  8     8   MEE              17   0945           23.20    28.90    5.70              1.3     3038
  8     8   MEE              17   0945           22.90    28.90    6.00              1.4     2042
  8     8   MEE              17   0945    0955   22.10    28.90    6.80              1.9     4420

RUN:  1

  9     9   GAGIN             5   0945           22.30    27.40    5.10     1.2     1.01    1100
  9     9   GAGIN             5   0948           23.80    27.40    3.60     1.2      .51     230
  9     9   GAGIN             5   0952           24.60    27.50    2.90     1.2      .32     150
  9     9   GAGIN             5   0954           25.50    27.60    2.10     1.2      .17     110
RUN:  2
  9     9   GAGIN             5   0959           22.30    27.50    5.20     1.2     1.08     950
  9     9   GAGIN             5   1001           23.60    27.40    3.80     1.2      .55     310
  9     9   GAGIN             5   1005           24.50    27.50    3.00     1.2      .35     120
  9     9   GAGIN             5   1008           25.60    27.40    1.80     1.2      .13     140
RUN:  3

  9     9   GAGIN             5   1015           22.00    27.50    5.50     1.2     1.18     880
```

```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 26                                                                                             PROCESSING DATE:  81/09/26
                    OBSERVER                                    PLATE TEMP
MACH  DUCT  -------------------  SAMPLE  TIME                                     VOLUME   SUPER   NUCLEI      OBS    EST
NO.   NO.   NAME            NO.  START    END       COLD     HOT    DELTA   SAMPLED     SAT    COUNT        -      K   REMARKS
                                                             (C)               (L)     (%)                   N
----  ----  --------------- ---  -----   ----   ------  ------  ------   -------  ------  ------   ------  -----  -------------------
   9     9  GAGIN             5  1017            23.70   27.40    3.70      1.2     .51     320
   9     9  GAGIN             5  1020            24.70   27.50    2.80      1.2     .32     170
   9     9  GAGIN             5  1024            25.60   27.70    2.10      1.2      .1     110

RUN:  4

   9     9  GAGIN             5  1038            22.40   27.50    5.10      1.2    1.01     890
   9     9  GAGIN             5  1041            23.70   27.50    3.80      1.2     .58     250
   9     9  GAGIN             5  1044            24.70   27.70    3.00      1.2     .35     110
   9     9  GAGIN             5  1047            25.60   27.60    2.00      1.2      .1     100

RUN:  1

  10    10  LALA             13  0937            19.82   22.28    2.46       .4     .25   619.8
  10    10  LALA             13  0938            19.92   22.39    2.47       .4     .25   586.9    603.4
  10    10  LALA             13  0939            19.59   22.50    2.91       .4     .35   815.8
  10    10  LALA             13  0940            19.68   22.60    2.92       .4     .35   765.3    790.6
  10    10  LALA             13  0941            19.22   22.71    3.49       .4      .5   947.9
  10    10  LALA             13  0942            19.33   22.81    3.48       .4      .5  1487.4   1217.7
  10    10  LALA             13  0943            18.65   22.91    4.26       .4     .75    1343
  10    10  LALA             13  0944            18.72   22.98    4.26       .4     .75  1522.5   1432.8
  10    10  LALA             13  0945            18.15   23.06    4.91       .4       1  1210.2
  10    10  LALA             13  0946            18.19   23.10    4.91       .4       1  1336.5   1273.4         N=1520.7 S**0.60
RUN:  2
  10    10  LALA             13  0947            23.52   26.06    2.54              .25   683.7
  10    10  LALA             13  0948            23.04   26.04    3.00              .35   803.3
  10    10  LALA             13  0949            22.45   26.02    3.57               .5     989
  10    10  LALA             13  0950            21.63   25.99    4.36              .75  1102.2
  10    10  LALA             13  0951            20.94   25.96    5.02                1  1214.4
  10    10  LALA             13  0952            23.38   25.92    2.54              .25   624.8    654.3
  10    10  LALA             13  0953            22.94   25.94    3.00              .35   771.2    787.3
  10    10  LALA             13  0954            22.37   25.94    3.57               .5    1021     1005
  10    10  LALA             13  0955            21.56   25.92    4.36              .75  1158.2   1130.2
  10    10  LALA             13  0956            20.86   25.88    5.02                1  1176.5   1195.5         N=1261 S**0.44
RUN:  3
  10    10  LALA             13  1034            24.66   27.23    2.57       .4     .25   778.3
  10    10  LALA             13  1035            24.61   27.17    2.56       .4     .25     763    770.7
  10    10  LALA             13  1036            24.10   27.12    3.02       .4     .35   916.5
  10    10  LALA             13  1037            24.07   27.10    3.03       .4     .35   919.5      918
  10    10  LALA             13  1038            23.44   27.05    3.61       .4      .5  1213.8
  10    10  LALA             13  1039            23.40   27.01    3.61       .4      .5    1166   1189.9
  10    10  LALA             13  1040            22.56   26.96    4.40       .4     .75  1395.1
  10    10  LALA             13  1041            22.51   26.91    4.40       .4     .75  1321.1   1358.1
  10    10  LALA             13  1042            21.80   26.86    5.06       .4       1  1412.3
  10    10  LALA             13  1043            21.76   26.82    5.06       .4       1  1475.3   1443.8         N=1521.1 S**0.47
RUN:  4
  10    10  LALA             13  1040            24.41   26.97    2.56       .4     .25   830.1
  10    10  LALA             13  1041            24.39   26.95    2.56       .4     .25   846.2    838.2
  10    10  LALA             13  1042            23.91   26.93    3.02       .4     .35  1033.3
  10    10  LALA             13  1043            23.90   26.92    3.02       .4     .35   991.8   1012.6
  10    10  LALA             13  1044            23.30   26.90    3.60       .4      .5  1216.2
  10    10  LALA             13  1045            23.28   26.88    3.60       .4      .5  1190.4   1203.3
  10    10  LALA             13  1046            22.47   26.86    4.39       .4     .75  1319.8
  10    10  LALA             13  1047            22.44   26.83    4.39       .4     .75  1432.8   1376.3
  10    10  LALA             13  1048            21.82   26.88    5.06       .4       1  1516.5
  10    10  LALA             13  1049            21.78   26.84    5.06       .4       1  1450.2   1483.4         N=1533.0 S**0.41

RUN:  1

  11    11  FITZGERALD       28  0950    1008                                         .15     420      420
  11    11  FITZGERALD       28  0950    1008                                        .094     163      163
  11    11  FITZGERALD       28  0950    1008                                        .034    11.3     11.3
  11    11  FITZGERALD       28  0950    1008                                        .025    1.62     1.62
```

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                                                             NUCLEI MEASUREMENTS
FXPERIMENT #: 26                                                                                                    PROCESSING DATE:  81/09/26
                      OBSERVER                                        PLATE TEMP
MACH  DUCT  ------------------------  SAMPLE  TIME                                   VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME                 NO.  START   END     COLD     HOT     DELTA    SAMPLED   SAT     COUNT      -       K     REMARKS
                                                               (C)               (L)      (%)                N
----  ----  ---------------      ---  -----   ----   ------   ------   ------   -------  ------  -------   -----   -----  --------------------
 11    11   FITZGERALD           28   0950    1008                                        .014     .136    .136

RUN:  1

 13    13   AYERS                 2   0943    0944   22.79    25.20    2.41                .25      693
 13    13   AYERS                 2   0944    0945   22.77    25.20    2.43                .25      540
 13    13   AYERS                 2   0945    0946   21.70    25.20    3.50                .5      1058
 13    13   AYERS                 2   0946    0947   21.72    25.20    3.48                .5      1073
 13    13   AYERS                 2   0947    0948   21.05    25.30    4.25                .75     1365
 13    13   AYERS                 2   0948    0949   21.03    25.30    4.27                .75     1373
 13    13   AYERS                 2   0949    0950   20.36    25.30    4.94               1        1575
 13    13   AYERS                 2   0950    0951   20.36    25.30    4.94               1        1590
 13    13   AYERS                 2   0951    0952   19.83    25.30    5.47               1.25     1545
 13    13   AYERS                 2   0952    0953   19.84    25.30    5.46               1.25     1935
 13    13   AYERS                 2   0953    0954   19.90    25.40    5.50               1.25     1725

RUN:  2

 13    13   AYERS                 2   1059    1100   26.40    28.90    2.50                .25      720
 13    13   AYERS                 2   1100    1101   25.33    28.90    3.57                .5      1365
 13    13   AYERS                 2   1102    1103   24.53    28.90    4.37                .75     1725
 13    13   AYERS                 2   1103    1104   23.73    28.80    5.07               1        2070
 13    13   AYERS                 2   1104    1105   23.17    28.80    5.63               1.25     2370

RUN:  1

 14    14   HUDSON                9   1001    1030                              .0187      .21      168                     F=42
 14    14   HUDSON                9   1001    1030                              .0187      .14      117.5                   F=42
 14    14   HUDSON                9   1001    1030                              .0187      .11       62.2                   F=42
 14    14   HUDSON                9   1001    1030                              .0187      .04        1.09                  F=42
 14    14   HUDSON                9   1001    1030                              .0187      .029        .234                 F=42
 14    14   HUDSON                9   1031    1101                              .0194      .21      176.9                   F=42
 14    14   HUDSON                9   1031    1101                              .0194      .14      120.3                   F=42
 14    14   HUDSON                9   1031    1101                              .0194      .11       60.8                   F=42
 14    14   HUDSON                9   1031    1101                              .0194      .04         .67                  F=42
 14    14   HUDSON                9   1031    1101                              .0194      .029        .12                  F=42

RUN:  2

 14    14   HUDSON                9   1102    1130                              .0187      .21      206.2                   F=42
 14    14   HUDSON                9   1102    1130                              .0187      .14      141.7                   F=42
 14    14   HUDSON                9   1102    1130                              .0187      .11       72.2                   F=42
 14    14   HUDSON                9   1102    1130                              .0187      .04         .81                  F=42
 14    14   HUDSON                9   1102    1130                              .0187      .029        .15                  F=42

RUN:  1

 15    15   KOCMOND              30   0939    0940   18.36    25.06    6.70               1.86     1546                     MAIN FLOW ABOUT
 15    15   KOCMOND              30   0943    0944   18.74    24.75    6.01               1.46     1900                     1570 COUNTS.
 15    15   KOCMOND              30   0947    0948   19.11    24.44    5.33               1.15     1784
 15    15   KOCMOND              30   0951    0952   19.49    24.13    4.64                .87     1382                     DROP SIZE PLAT, GOOD
 15    15   KOCMOND              30   0955    0956   19.87    23.81    3.94                .63     1142                     AITKEN COUNT RISING
 15    15   KOCMOND              30   0959    1000   20.25    23.50    3.25                .425     820                     ABT. 5 PER CENT PER
 15    15   KOCMOND              30   1003    1004   20.63    23.19    2.56                .265     382                     MIN. SLOWED MF.
 15    15   KOCMOND              30   1003    1004                                                                         USING THIS MORNINGS
 15    15   KOCMOND              30   1003    1004                                                                         BACKGROUND.
 15    15   KOCMOND              30   1041    1042   21.41    22.71    1.30                .095     210                     MAIN FLO 2330.

RUN:  2

 15    15   ROGERS, FRED         23   1058    1059   18.74    24.76    6.01               1.46     1837                     SECOND RUN AT
 15    15   ROGERS, FRED         23   1102    1103   19.11    24.44    5.33               1.15     1749                     HIGHER MAIN FLOW,
 15    15   ROGERS, FRED         23   1106    1107   19.49    24.13    4.64                .87     1590                     ABOUT 2300 CNTS.
 15    15   ROGERS, FRED         23   1110    1111   19.87    23.81    3.94                .63     1344                     GOOD DROP SIZE PLAT.
 15    15   ROGERS, FRED         23   1114    1115   20.25    23.50    3.25                .425     967
 15    15   ROGERS, FRED         23   1118    1119   20.63    23.19    2.56                .265     598                     DROP SIZE PLAT GOING
 15    15   ROGERS, FRED         23   1122    1123   20.99    22.88    1.89                .14      364                     BAD.
 15    15   ROGERS, FRED         23   1126    1127   21.35    22.56    1.21                .07      285
```

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                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 26                                                                                                PROCESSING DATE:  81/09/26
                      OBSERVER                                PLATE TEMP
MACH  DUCT  ------------------------  SAMPLE  TIME                                    VOLUME   SUPER   NUCLEI     OBS     EST
NO.   NO.   NAME                 NO.  START   END     COLD     HOT     DELTA   SAMPLED   SAT    COUNT       -       K     REMARKS
                                                               (C)              (L)      (%)                N
----  ----  -------------------  ---  -----   ----   ------   ------  ------  -------  ------  ------    -----   -----  --------------------

RUN:  1

 16    16   HUDSON                 9  0936    0943   21.30    26.05    4.75    .0042      .9    1369
 16    16   HUDSON                 9  0936    0943   21.65    25.40    3.75    .0042     .57    1174
 16    16   HUDSON                 9  0936    0943   22.20    24.90    2.70    .0042     .29     915
 16    16   HUDSON                 9  0955    0959   21.30    26.05    4.75    .0024      .9    1310
 16    16   HUDSON                 9  0955    0959   21.65    25.40    3.75    .0024     .57    1007
 16    16   HUDSON                 9  0955    0959   22.20    24.90    2.70    .0024     .29     587
 16    16   HUDSON                 9  1008    1012   21.30    26.05    4.75    .0024      .9    1308
 16    16   HUDSON                 9  1008    1012   21.65    25.40    3.75    .0024     .57     986
 16    16   HUDSON                 9  1008    1012   22.20    24.90    2.70    .0024     .29     571
RUN:  2

 16    16   HUDSON                 9  1018    1022   21.30    26.05    4.75    .0024      .9    1442
 16    16   HUDSON                 9  1018    1022   21.65    25.40    3.75    .0024     .57    1086
 16    16   HUDSON                 9  1018    1022   22.20    24.90    2.70    .0024     .29     636
 16    16   HUDSON                 9  1035    1038   21.30    26.05    4.75    .0024      .9    1490
 16    16   HUDSON                 9  1035    1038   21.65    25.40    3.75    .0024     .57    1105
 16    16   HUDSON                 9  1035    1038   22.20    24.90    2.70    .0024     .29     669
 16    16   HUDSON                 9  1045    1049   21.30    26.05    4.75    .0024      .9    1473
 16    16   HUDSON                 9  1045    1049   21.65    25.40    3.75    .0024     .57    1121
 16    16   HUDSON                 9  1045    1049   22.20    24.90    2.70    .0024     .29     656
RUN:  3

 16    16   HUDSON                 9  1101    1105   21.30    26.05    4.75    .0024      .9    1574
 16    16   HUDSON                 9  1101    1105   21.65    25.40    3.75    .0024     .57    1172
 16    16   HUDSON                 9  1101    1105   22.20    24.90    2.70    .0024     .29     710
 16    16   HUDSON                 9  1114    1116   21.30    26.05    4.75    .0018      .9    1571
 16    16   HUDSON                 9  1114    1116   21.65    25.40    3.75    .0018     .57    1118
 16    16   HUDSON                 9  1114    1116   22.20    24.90    2.70    .0018     .29     713
 16    16   HUDSON                 9  1123    1126   21.30    26.05    4.75    .0018      .9    1529
 16    16   HUDSON                 9  1123    1126   21.65    25.40    3.75    .0018     .57    1107
 16    16   HUDSON                 9  1123    1126   22.20    24.90    2.70    .0018     .29     700
RUN:  4

 16    16   HUDSON                 9  1130    1132   21.30    26.05    4.75    .0012      .9    1544
 16    16   HUDSON                 9  1130    1132   21.65    25.40    3.75    .0012     .57    1179
 16    16   HUDSON                 9  1130    1132   22.20    24.90    2.70    .0012     .29     725

RUN:  1

 17    17   WOJCIECHOWSKI         27  0944    0945                                        .24     720      720
 17    17   WOJCIECHOWSKI         27  0947    0948                                        .35   804.1    804.1
 17    17   WOJCIECHOWSKI         27  0949    0950                                        .47  1213.6   1213.6
 17    17   WOJCIECHOWSKI         27  0951    0952                                        .73  1519.5   1519.5
 17    17   WOJCIECHOWSKI         27  0953    0954                                          1  1657.6   1657.6

RUN:  1

 18    18   HUDSON                 9  0936    0943   22.45    27.60    5.15    .0042    1.08    1537
 18    18   HUDSON                 9  0955    0959   22.45    27.00    4.55    .0024     .84    1303
 18    18   HUDSON                 9  1008    1012   22.90    26.50    3.60    .0024     .52     977
 18    18   HUDSON                 9  1018    1022   23.40    25.90    2.50    .0024     .25     577
 18    18   HUDSON                 9  1035    1038   23.65    25.75    2.10    .0024     .17     381
 18    18   HUDSON                 9  1045    1049   23.20    26.20    3.00    .0024     .36     733
 18    18   HUDSON                 9  1101    1105   22.80    26.65    3.85    .0024      .6    1300
 18    18   HUDSON                 9  1114    1116   23.05    26.75    3.70    .0018     .55    1227
 18    18   HUDSON                 9  1123    1126   22.40    27.40    5.00    .0018       1    1638
 18    18   HUDSON                 9  1130    1132   22.15    27.55    5.40    .0012     1.2    1749

RUN:  1

 21    21   TRUEBLOOD             26  0938    0939   20.00    25.00    5.00                1    1448
 21    21   TRUEBLOOD             26  0943    0944   21.75    25.00    3.25             .422     886
```

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                                                       NUCLEI MEASUREMENTS
EXPERIMENT #: 26                                                                                       PROCESSING DATE: 81/09/26
                  OBSERVER                                    PLATE TEMP
MACH  DUCT  ------------------   SAMPLE  TIME                                    VOLUME   SUPER   NUCLEI    OBS    EST
NO.   NO.   NAME           NO.   START   END      COLD     HOT      DELTA   SAMPLED  SAT     COUNT      -      K     REMARKS
                                                           (C)                 (L)    (%)                N
----  ----  -------------- ---   -----   ----    ------   ------   ------   -------  ------  ------   -----  -----  -------------------
 21    21   TRUEBLOOD       26   0948    0949    22.44    25.00     2.56              .262   530.8
 21    21   TRUEBLOOD       26   0958    0959    25.00    25.00     0.00              .173     335
 21    21   TRUEBLOOD       26   0958    0959    25.00    25.00     0.00              .114   150.7
 21    21   TRUEBLOOD       26   0958    0959    25.00    25.00     0.00              .089   104.3
 21    21   TRUEBLOOD       26   0958    0959    25.00    25.00     0.00              .068    55.8
 21    21   TRUEBLOOD       26   1005    1006    25.00    25.00     0.00              .035    4.77
 21    21   TRUEBLOOD       26   1005    1006    25.00    25.00     0.00              .022    .411
 21    21   TRUEBLOOD       26   1005    1006    25.00    25.00     0.00             .0133       0

RUN:  2

 21    21   TRUEBLOOD       26   1025    1026    19.88    25.00     5.12             1.049    1817
 21    21   TRUEBLOOD       26   1031    1032    21.80    25.00     3.20               .41     837
 21    21   TRUEBLOOD       26   1037    1038    22.48    25.00     2.52              .254     523
 21    21   TRUEBLOOD       26   1046    1047    25.00    25.00     0.00              .173     368
 21    21   TRUEBLOOD       26   1046    1047    25.00    25.00     0.00              .114   167.4
 21    21   TRUEBLOOD       26   1046    1047    25.00    25.00     0.00              .089   113.5
 21    21   TRUEBLOOD       26   1046    1047    25.00    25.00     0.00              .068    59.9
 21    21   TRUEBLOOD       26   1053    1054    25.00    25.00     0.00              .033    5.85
 21    21   TRUEBLOOD       26   1053    1054    25.00    25.00     0.00              .022    .659
 21    21   TRUEBLOOD       26   1053    1054    25.00    25.00     0.00             .0133       0

RUN:  1

 24    24   SERPOLAY        25   0955    1000    24.90    26.40     1.50       .77      .1     110
 24    24   SERPOLAY        25   1005    1010    25.20    27.70     2.50       .77     .24     250
 24    24   SERPOLAY        25   1020    1025    25.90    29.40     3.50       .77     .46     650
 24    24   SERPOLAY        25   1038    1043    26.60    31.10     4.50       .77     .73    1480
 24    24   SERPOLAY        25   1045    1050    26.80    31.50     4.70       .77     .75    1540
 24    24   SERPOLAY        25   1055    1100    27.20    30.60     3.40       .77     .46     600
 24    24   SERPOLAY        25   1105    1110    27.40    30.40     3.00       .77     .33     400
 24    24   SERPOLAY        25   1117    1124    27.70    29.80     2.10       .77     .17     250
 24    24   SERPOLAY        25   1127    1133    27.80    29.40     1.60       .77      .1     170

RUN:  1

 25    25   BORYS            3   1011    1020    21.70    26.10     4.40      10.6     .22     424     424     .54   VOL SAMP X 10**5
 25    25   BORYS            3   1028    1037    22.70    26.40     3.70      8.48     .54     513     513
 25    25   BORYS            3   1041    1048    21.50    26.50     5.00       5.3    1.06    1358    1358
 25    25   BORYS            3   1045    1053    19.00    26.40     7.40      2.12    2.21    2051    2051
 25    25   BORYS            3   1058    1106    22.20    26.50     4.30      6.36     .74     919     919
 25    25   HORYS            3   1111    1116    23.40    26.40     3.00      8.48     .35     548     548

RUN:  1

 26    26   HINDMAN          6   0947    1032    27.00    27.00     0.00       2.8     .15      90      90           +/- 2.9
 26    26   HINDMAN          6   0947    1032    27.00    27.00     0.00       2.8     .11      31      31           +/- 1.4
 26    26   HINDMAN          6   0947    1032    27.00    27.00     0.00       2.8    .041      13      13           +/- 0.62
 26    26   HINDMAN          6   0947    1032    27.00    27.00     0.00       2.8    .027     .12     .12           +/- 0.013
 26    26   HINDMAN          6   0947    1032    27.00    27.00     0.00       2.8    .016     .01     .01           +/- 0.003

RUN:  1

 27    27   OHTAKE          19   1050    1050                                                 6.3                  75% R.H.
 27    27   OHTAKE          19   1050    1050                                                9.23                  106% R.H. NOMINAL
 27    27   OHTAKE          19   1050    1050                                               12.28                  125% R.H. NOMINAL
```
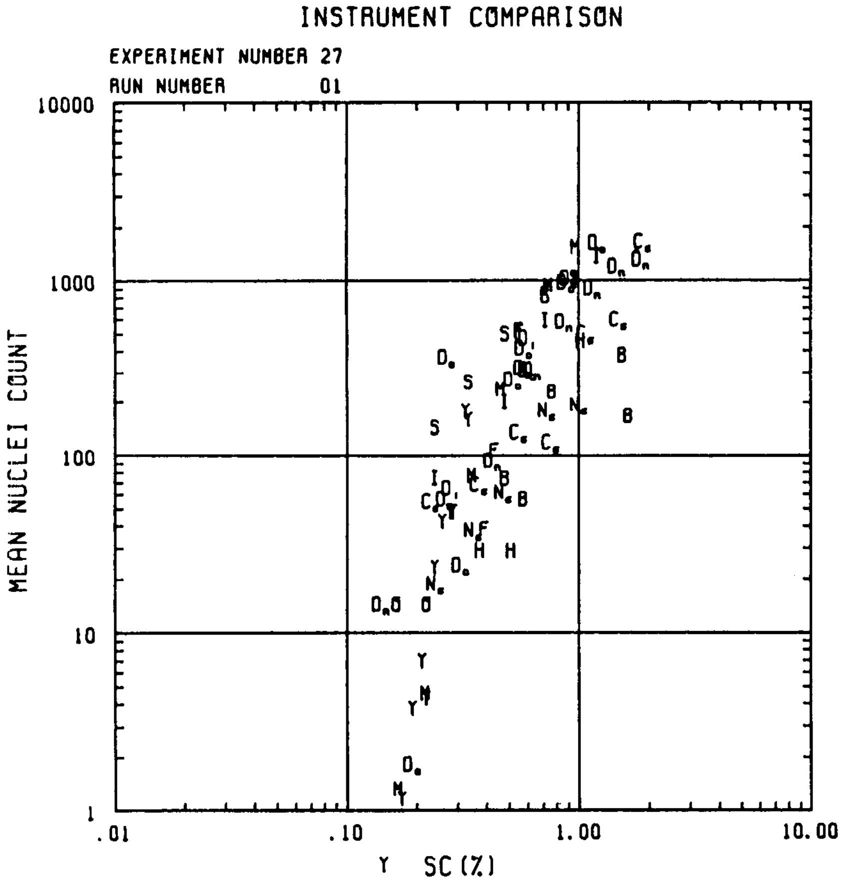
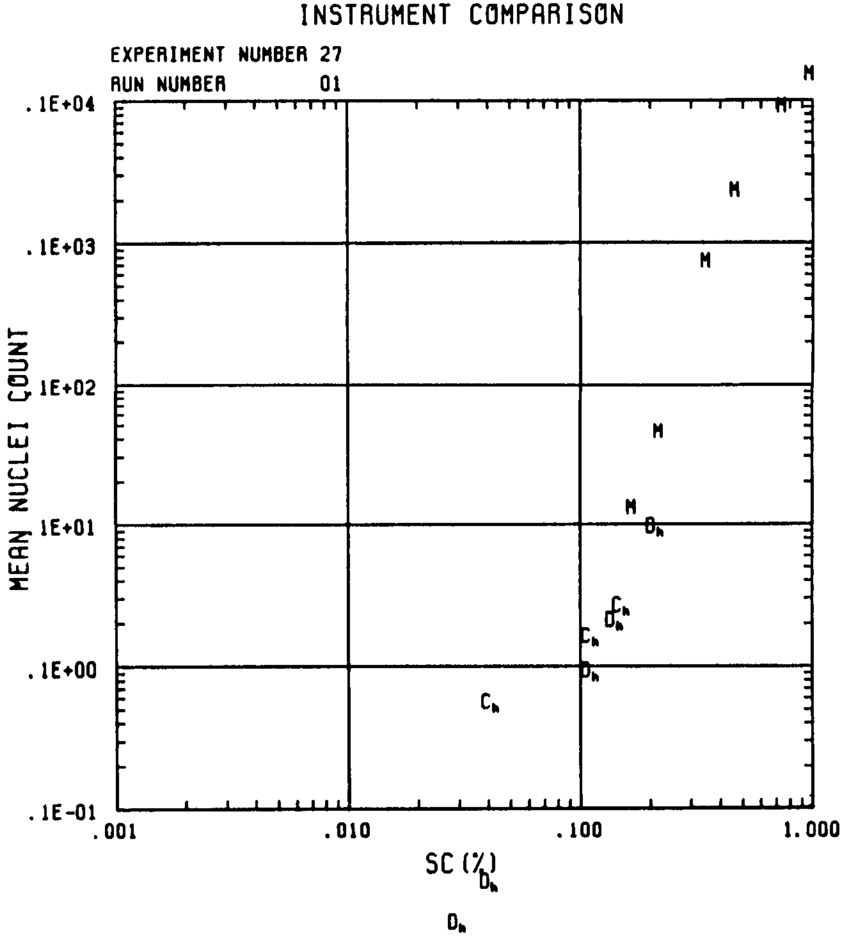



SDC/CFD RESULTS



HAZE CHAMBER RESULTS

EXPERIMENT # 27

80/10/15

PURPOSE

INSTRUMENT COMPARISON WITH INSOLUBLE, WETTABLE AEROSOL.

DESCRIPTION OF EXPERIMENT

DATE	TIME START	END
15 OCT,1980	1151	1415

NUCLEI TYPE

AGI

GENERATION METHOD

THERMAL, N2 CARRIER GAS, HIGH DILUTION.

SIZE DISTRIBUTION SHAPING

NA

REMARKS

SLOW UPWARD DRIFT OF TOTAL NUMBER CONC.

WEATHER SYNOPSIS

NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT

ROOM CONDITIONS			OUTSIDE CONDITIONS				
AVG TEMP (C)	AVG RH (%)	AVG PRESS (MB)	AVG TEMP (C)	AVG RH (*)	AVG PRESS (MB)	AVG WS (M/S)	AVG WD (DEG)
25.0	22.0	848					

```
                                                       NUCLEI MEASUREMENTS
EXPERIMENT #: 27                                                                                           PROCESSING DATE:  81/09/26
                  OBSERVER                                    PLATE TEMP
MACH  DUCT  -------------------   SAMPLE  TIME                                VOLUME   SUPER   NUCLEI    OBS    EST
NO.   NO.   NAME              NO.  START   END     COLD     HOT     DELTA     SAMPLED   SAT    COUNT      -      K     REMARKS
                                                            (C)                 (L)     (%)               N
----  ----  --------------- ---   -----  ----   ------   ------   ------   -------  ------  ------    -----  -----  -------------------

RUN:   1

  2     2   POLITOVICH        20   1316   1317    23.10    25.20     2.10                .17                15
  2     2   POLITOVICH        20   1320   1321    22.80    25.20     2.40                .23                15

RUN:   1

  5     5   KITCHEN           12   1245   1245    23.70    27.50     3.80                 .6       77
  5     5   KITCHEN           12   1246   1246    23.70    27.50     3.80                 .6       40
  5     5   KITCHEN           12   1247   1247    21.20    27.50     6.30                1.7      173
  5     5   KITCHEN           12   1248   1248    21.40    27.50     6.10                1.6      394
  5     5   KITCHEN           12   1249   1249    23.20    27.50     4.30                 .8      241
  5     5   KITCHEN           12   1250   1250    23.90    27.50     3.60                 .5      103
  5     5   KITCHEN           12   1251   1251    23.90    27.50     3.60                 .5       50

RUN:   1

  7     7   LEAITCH           14   1313   1314              7.35               .283      .22                7.2
  7     7   LEAITCH           14   1317   1318              7.30               .283       .2                3.9
  7     7   LEAITCH           14   1321   1322              7.10               .283      .18                1.2
  7     7   LEAITCH           14   1327   1328              6.85               .283      .15                 .8
  7     7   LEAITCH           14   1333   1334              6.75               .283      .15                 .4
  7     7   LEAITCH           14   1339   1340              6.65               .283      .15                 .3
  7     7   LEAITCH           14   1231   1232              8.65               .283      .35                165          HOT TEMPERATURE IS
  7     7   LEAITCH           14   1235   1236              8.60               .283      .34                198          ACTUALLY DIFFERENCE
  7     7   LEAITCH           14   1239   1240              8.60               .283      .34                165          BETWEEN TUBE AND
  7     7   LEAITCH           14   1245   1246              8.05               .283       .3               49.3          AMBIENT
  7     7   LEAITCH           14   1249   1250              8.00               .283      .27               45.7
  7     7   LEAITCH           14   1253   1254              8.00               .283      .29               49.3
  7     7   LEAITCH           14   1255   1256              7.85               .283      .27               41.8
  7     7   LEAITCH           14   1301   1302              7.70               .283      .25               21.2
  7     7   LEAITCH           14   1305   1306              7.55               .283      .25               27.1
  7     7   LEAITCH           14   1309   1310              7.35               .283      .23                4.4

RUN:   1

  8     8   MEE               17   1220           25.30    30.50     5.20                  1      285
  8     8   MEE               17   1220           25.00    30.50     5.50                1.4      550
  8     8   MEE               17   1220           24.20    30.50     6.30                1.5      900
  8     8   MEE               17   1220           24.00    30.50     6.50                1.6     1376
  8     8   MEE               17   1220           23.60    30.50     6.90                1.8     1367
  8     8   MEE               17   1220           23.40    30.50     7.10                1.9     1554
  8     8   MEE               17   1220           23.20    30.50     7.30                  2     1800
  8     8   MEE               17   1220           25.70    30.50     4.80                .85      270
  8     8   MEE               17   1220   1230    26.70    30.50     3.80                .55       55

RUN:   1

  9     9   GAGIN              5   1223           22.10    27.30     5.20       1.2     1.06      470
  9     9   GAGIN              5   1226           23.10    27.00     3.90       1.2      .53       30
  9     9   GAGIN              5   1228           24.10    27.30     3.20       1.2      .39       30
  9     9   GAGIN              5   1231           25.60    27.30     1.70       1.2      .17        0

RUN:   2

  9     9   GAGIN              5   1236           22.00    27.10     5.10       1.2     1.03      450
  9     9   GAGIN              5   1240           24.00    27.40     3.40       1.2      .45       20
  9     9   GAGIN              5   1244           25.40    27.40     2.00       1.2      .17        0

RUN:   3

  9     9   GAGIN              5   1252           22.30    27.10     4.80       1.2       .9      430
  9     9   GAGIN              5   1254           23.50    27.30     3.80       1.2      .58       20
  9     9   GAGIN              5   1257           24.30    27.20     2.90       1.2      .33       60
  9     9   GAGIN              5   1259           25.30    27.20     1.90       1.2       .1       40

RUN:   1

 10    10   LALA              13   1214           24.70    27.26     2.56        .4      .25      176
```

```
                                                          NUCLEI MEASUREMENTS
EXPERIMENT #: 27                                                                                          PROCESSING DATE: 81/09/26
                 OBSERVER                                   PLATE TEMP
MACH  DUCT  -------------------  SAMPLE TIME                                  VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME            NO.  START   END     COLD    HOT     DELTA    SAMPLED   SAT     COUNT      -       K      REMARKS
                                                          (C)                (L)      (%)               N
----  ----  --------------- ---  -----  ----    ------  ------   ------   -------  ------   ------   -----   -----   -------------------
 10    10   LALA             13  1215            24.62   27.19    2.57        .4     .25    119.6    147.8
 10    10   LALA             13  1216            24.10   27.13    3.03        .4     .35    291.8
 10    10   LALA             13  1217            24.03   27.06    3.03        .4     .35    256.7    274.3
 10    10   LALA             13  1218            23.39   26.99    3.60        .4      .5    552.6
 10    10   LALA             13  1219            23.32   26.92    3.60        .4      .5    484.3    518.5
 10    10   LALA             13  1220            22.45   26.85    4.40        .4     .75      893
 10    10   LALA             13  1221            22.38   26.77    4.39        .4     .75      820    856.5
 10    10   LALA             13  1222            21.64   26.69    5.05        .4       1   1125.3
 10    10   LALA             13  1223            21.56   26.61    5.05        .4       1   1025.5   1075.5

RUN:  2

 10    10   LALA             13  1224            23.74   26.53    2.79                 .3    125.6
 10    10   LALA             13  1225            23.26   26.48    3.22                 .4      227
 10    10   LALA             13  1226            22.82   26.40    3.58                 .5    405.8
 10    10   LALA             13  1227            22.40   26.32    3.92                 .6      518
 10    10   LALA             13  1228            22.01   26.24    4.23                 .7      657
 10    10   LALA             13  1229            21.64   26.15    4.51                 .8    761.1
 10    10   LALA             13  1230            21.30   26.08    4.78                 .9    922.4
 10    10   LALA             13  1231            20.97   26.00    5.03                  1    961.6
 10    10   LALA             13  1232            19.79   25.91    6.12                1.5   1147.4
 10    10   LALA             13  1233            18.77   25.81    7.04                  2   1366.9

RUN:  3

 10    10   LALA             13  1235            22.92   25.69    2.77                 .3       90
 10    10   LALA             13  1235            22.46   25.66    3.20                 .4    186.7
 10    10   LALA             13  1235            22.04   25.61    3.57                 .5    363.7
 10    10   LALA             13  1235            21.61   25.51    3.90                 .6    429.5
 10    10   LALA             13  1235            21.26   25.46    4.20                 .7    575.3
 10    10   LALA             13  1235            20.92   25.40    4.48                 .8    672.3
 10    10   LALA             13  1235            20.60   25.35    4.75                 .9    722.9
 10    10   LALA             13  1235            20.29   25.29    5.00                  1    765.7
 10    10   LALA             13  1235            19.14   25.23    6.09                1.5   1006.7
 10    10   LALA             13  1235            18.17   25.17    7.00                  2     1237

RUN:  4

 10    10   LALA             13  1245            22.16   24.91    2.75                 .3     64.1
 10    10   LALA             13  1245            21.80   24.97    3.17                 .4    151.5
 10    10   LALA             13  1245            21.51   25.06    3.55                 .5      243
 10    10   LALA             13  1245            21.12   25.00    3.88                 .6    369.9
 10    10   LALA             13  1245            20.77   24.96    4.19                 .7    460.8
 10    10   LALA             13  1245            20.45   24.92    4.47                 .8    636.4
 10    10   LALA             13  1245            20.17   24.90    4.73                 .9      669
 10    10   LALA             13  1245            19.86   24.84    4.98                  1      810
 10    10   LALA             13  1245            18.71   24.78    6.07                1.5     1086
 10    10   LALA             13  1245            17.75   24.72    6.97                  2     1192


RUN:  1

 13    13   AYERS             2  1243   1244     27.03   29.60    2.57                .25       77
 13    13   AYERS             2  1245   1246     25.91   29.50    3.59                 .5      210
 13    13   AYERS             2  1246   1247     25.05   29.40    4.35                .75      615
 13    13   AYERS             2  1248   1249     24.22   29.30    5.08                  1     1035
 13    13   AYERS             2  1249   1250     23.52   29.20    5.68               1.25     1425

RUN:  2

 13    13   AYERS             2  1256   1257     26.46   29.00    2.54                .25        0                             PHOTOGRAPHIC RECORDS
 13    13   AYERS             2  1258   1259     25.37   28.90    3.53                 .5      276                             TAKEN.
 13    13   AYERS             2  1300   1301     24.56   28.90    4.34                .75      648
 13    13   AYERS             2  1301   1302     23.77   28.80    5.03                  1     1065
 13    13   AYERS             2  1302   1303     23.07   28.70    5.63               1.25     1320


RUN:  1

 14    14   HUDSON            9  1233   1306                              .023     .21     .974
 14    14   HUDSON            9  1233   1306                              .023     .14     .171
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EXPERIMENT #: 27                                       NUCLEI MEASUREMENTS                                          PROCESSING DATE:  81/09/26
                     OBSERVER                                   PLATE TEMP
MACH  DUCT   -------------------   SAMPLE TIME                                  VOLUME    SUPER    NUCLEI     OBS      EST
NO.   NO.    NAME             NO.   START  END     COLD      HOT    DELTA     SAMPLED    SAT     COUNT        -        K     REMARKS
                                                            (C)                (L)     (%)                   N
----  ----   ---------------  ---   -----  ----   ------   ------   ------    -------  ------   ------     -----   -----   -------------------
  14    14   HUDSON            9   1233   1306                               .023      .11      .071
  14    14   HUDSON            9   1233   1306                               .023      .04      .003
  14    14   HUDSON            9   1233   1306                               .023     .029         0
  14    14   HUDSON            9   1307   1339                              .0201      .21     1.076
  14    14   HUDSON            9   1307   1339                              .0201      .14      .274
  14    14   HUDSON            9   1307   1339                              .0201      .11      .124
  14    14   HUDSON            9   1307   1339                              .0201      .04     .0032
  14    14   HUDSON            9   1307   1339                              .0201     .029     .0016

RUN:  2

  14    14   HUDSON            9   1340   1411                              .0208      .21      .806
  14    14   HUDSON            9   1340   1411                              .0208      .14      .134
  14    14   HUDSON            9   1340   1411                              .0208      .11      .064
  14    14   HUDSON            9   1340   1411                              .0208      .04     .0088
  14    14   HUDSON            9   1340   1411                              .0208     .029         0

RUN:  1

  15    15   ROGERS, FRED     23   1225   1226   18.36    25.06     6.70              1.86      1367                  MAIN FLOW ABOUT 2300
  15    15   ROGERS, FRED     23   1229   1230   18.74    24.75     6.01              1.46      1249                  USING THIS MORNINGS
  15    15   ROGERS, FRED     23   1233   1234   19.11    24.44     5.33              1.15       941                  BACKGROUND, USING
  15    15   ROGERS, FRED     23   1236   1237   19.49    24.13     4.64               .87       613                  SMALLER CAPILLARY
  15    15   ROGERS, FRED     23   1240   1241   19.87    23.81     3.94               .63       326                  GOOD DROP SIZE PLATS
  15    15   ROGERS, FRED     23   1244   1245   20.25    23.50     3.25              .425        97
  15    15   ROGERS, FRED     23   1248   1249   20.63    23.19     2.56              .265        59                  SIZE PLAT GOING BAD.
  15    15   ROGERS, FRED     23   1253   1254   20.99    22.88     1.89               .14        15                  MAIN FLOW ABT. 2300.
RUN:  2

  15    15   ROGERS, FRED     23   1333   1334   18.36    25.06     6.70              1.86      1711                  SECOND RUN AT LOWER
  15    15   ROGERS, FRED     23   1337   1338   18.74    24.75     6.01              1.46      1538                  MAIN FLOW, ABT. 1800
  15    15   ROGERS, FRED     23   1341   1342   19.11    24.44     5.33              1.15       986                  AVERAGING LAST 4
  15    15   ROGERS, FRED     23   1345   1346   19.49    24.13     4.64               .87       543                  COUNTS PER SS.
  15    15   ROGERS, FRED     23   1348   1349   19.87    23.81     3.94               .63       236                  USING SMALER
  15    15   ROGERS, FRED     23   1352   1353   20.25    23.50     3.25              .425        83                  CAPILLARY.
  15    15   ROGERS, FRED     23   1356   1357   20.63    23.19     2.56              .265        16
  15    15   ROGERS, FRED     23   1400   1401   20.99    22.88     1.89               .14         9

RUN:  1

  16    16   HUDSON            9   1217   1220   21.25    26.00     4.75    .0024      .91      1205
  16    16   HUDSON            9   1217   1220   21.65    25.50     3.85    .0024       .6       559
  16    16   HUDSON            9   1217   1220   22.20    24.85     2.65    .0024      .28      87.7
  16    16   HUDSON            9   1231   1233   21.25    26.00     4.75    .0018      .91      1053
  16    16   HUDSON            9   1231   1233   21.65    25.50     3.85    .0018       .6       480
  16    16   HUDSON            9   1231   1233   22.20    24.85     2.65    .0018      .28        64
  16    16   HUDSON            9   1243   1245   21.25    26.00     4.75    .0018      .91       952
  16    16   HUDSON            9   1243   1245   21.65    25.50     3.85    .0018       .6       436
  16    16   HUDSON            9   1243   1245   22.20    24.85     2.65    .0018      .28      51.8
RUN:  2

  16    16   HUDSON            9   1250   1251   21.25    26.00     4.75    .0012      .91       953
  16    16   HUDSON            9   1250   1251   21.65    25.50     3.85    .0012       .6       406
  16    16   HUDSON            9   1250   1251   22.20    24.85     2.65    .0012      .28      43.4
  16    16   HUDSON            9   1255   1257   21.25    26.00     4.75    .0018      .91       936
  16    16   HUDSON            9   1255   1257   21.65    25.50     3.85    .0018       .6       391
  16    16   HUDSON            9   1255   1257   22.20    24.85     2.65    .0018      .28      42.5
  16    16   HUDSON            9   1301   1303   21.25    26.00     4.75    .0018      .91       913
  16    16   HUDSON            9   1301   1303   21.65    25.50     3.85    .0018       .6       339
  16    16   HUDSON            9   1301   1303   22.20    24.85     2.65    .0018      .28      32.9
RUN:  3

  16    16   HUDSON            9   1310   1312   21.30    26.05     4.75    .0018      .91       871
  16    16   HUDSON            9   1310   1312   21.65    25.40     3.75    .0018      .57       404
  16    16   HUDSON            9   1310   1312   22.25    24.85     2.60    .0018      .28      39.5
  16    16   HUDSON            9   1329   1331   21.30    26.05     4.75    .0018      .91       882
```
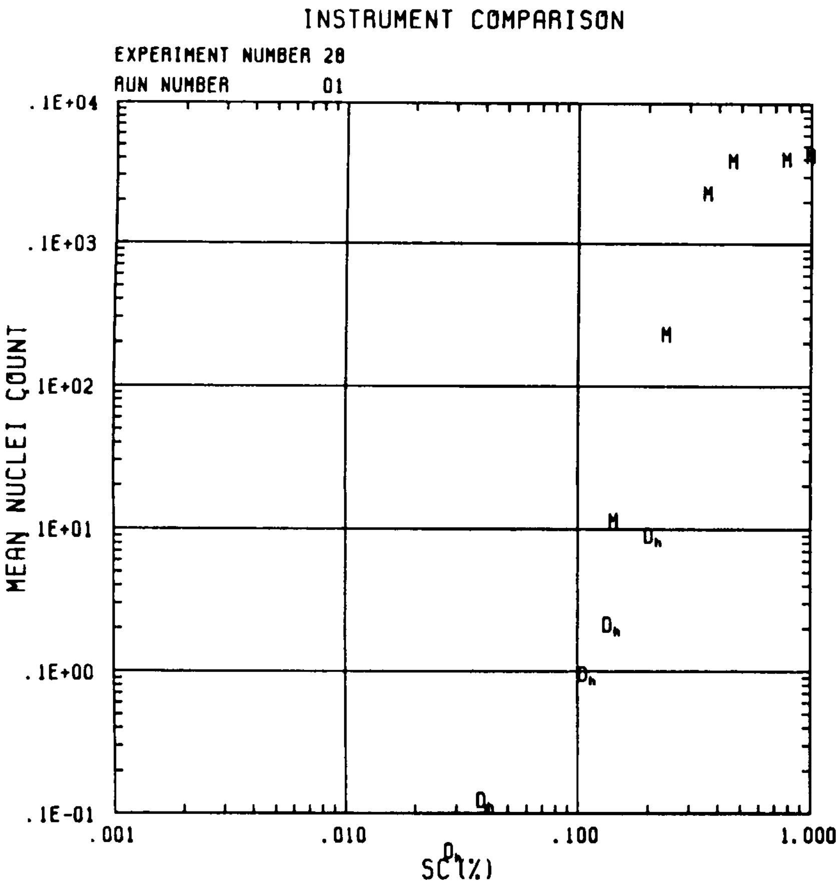

```
EXPERIMENT #: 27                              NUCLEI MEASUREMENTS                                    PROCESSING DATE:  81/09/26

                   OBSERVER                                  PLATE TEMP
MACH  DUCT   -------------------  SAMPLE TIME                              VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.    NAME             NO.  START  END      COLD     HOT    DELTA  SAMPLED    SAT    COUNT      -      K     REMARKS
                                                            (C)             (L)      (%)               N
----  ----   --------------- ---  -----  ----    ------  ------  ------  -------  ------  ------   -----   -----  --------------------
  16    16   HUDSON           9   1329  1331   21.65   25.40   3.75   .0018     .57     366
  16    16   HUDSON           9   1329  1331   22.25   24.85   2.60   .0018     .28    33.7
  16    16   HUDSON           9   1343  1349   21.30   26.05   4.75   .0036     .91     898
  16    16   HUDSON           9   1343  1349   21.65   25.40   3.75   .0036     .57     338
  16    16   HUDSON           9   1343  1349   22.25   24.85   2.60   .0036     .28      28

RUN:  4

  16    16   HUDSON           9   1358  1402   21.30   26.00   4.70   .0024      .9     997
  16    16   HUDSON           9   1358  1402   21.65   25.40   3.75   .0024     .57     360
  16    16   HUDSON           9   1358  1402   22.10   24.80   2.70   .0024     .29    31.4
  16    16   HUDSON           9   1411  1412   21.30   26.00   4.70   .0012      .9     982
  16    16   HUDSON           9   1411  1412   21.65   25.40   3.75   .0012     .57     331
  16    16   HUDSON           9   1411  1412   22.10   24.80   2.70   .0012     .29    25.7

RUN:  1

  17    17   WOJCIECHOWSKI   27   1235  1236                                      .24             19.7
  17    17   WOJCIECHOWSKI   27   1237  1239                                      .35             39.5
  17    17   WOJCIECHOWSKI   27   1240  1242                                      .47             64.1
  17    17   WOJCIECHOWSKI   27   1243  1246                                      .73            187.5
  17    17   WOJCIECHOWSKI   27   1247  1250                                        1            202.2
RUN:  2

  17    17   WOJCIECHOWSKI   27   1328  1329                                      .24       0        0
  17    17   WOJCIECHOWSKI   27   1329  1330                                      .35       0        0
  17    17   WOJCIECHOWSKI   27   1330  1331                                      .47      74       74
  17    17   WOJCIECHOWSKI   27   1332  1333                                      .72   152.9    152.9
  17    17   WOJCIECHOWSKI   27   1334  1335                                      .98   226.9    226.9

RUN:  1

  18    18   HUDSON           9   1217  1220   22.15   27.55   5.40   .0024     1.2    1707
  18    18   HUDSON           9   1231  1233   22.40   27.05   4.65   .0018     .88    1021
  18    18   HUDSON           9   1243  1245   22.90   26.50   3.60   .0018     .52     286
  18    18   HUDSON           9   1250  1251   22.80   26.55   3.75   .0012     .57     333
  18    18   HUDSON           9   1255  1257   22.80   26.70   3.90   .0018     .58     394
  18    18   HUDSON           9   1301  1303   22.25   24.85   2.60   .0018     .27     385
  18    18   HUDSON           9   1310  1312   22.85   26.70   3.85   .0018      .6     324
  18    18   HUDSON           9   1329  1331   23.35   26.15   2.80   .0018     .31      25
  18    18   HUDSON           9   1343  1349   23.60   25.80   2.20   .0036     .19     1.9
  18    18   HUDSON           9   1358  1402   22.70   26.50   3.80   .0024     .58     463
RUN:  2

  18    18   HUDSON           9   1411  1412   21.50   28.00   6.50   .0012    1.75    2530

RUN:  1

  21    21   TRUEBLOOD       26   1216  1217   19.98   25.00   5.02            1.01    1622
  21    21   TRUEBLOOD       26   1220  1221   20.60   25.00   4.40            .774     981
  21    21   TRUEBLOOD       26   1225  1226   21.53   25.00   3.47            .482     250
  21    21   TRUEBLOOD       26   1230  1231   22.00   25.00   3.00             .36    79.6
  21    21   TRUEBLOOD       26   1234  1235   22.62   25.00   2.38            .227    4.75
  21    21   TRUEBLOOD       26   1238  1239   22.92   25.00   2.08            .173    1.39
RUN:  2

  21    21   TRUEBLOOD       26   1300  1301   19.76   25.00   5.24           1.098    1522
  21    21   TRUEBLOOD       26   1303  1304   20.37   25.00   4.63            .857     884
  21    21   TRUEBLOOD       26   1308  1309   20.72   25.00   4.28            .733     545
  21    21   TRUEBLOOD       26   1311  1312   21.05   25.00   3.95            .624     354
  21    21   TRUEBLOOD       26   1316  1317   21.48   25.00   3.52            .496     118
  21    21   TRUEBLOOD       26   1319  1320   22.05   25.00   2.95            .348    29.7
  21    21   TRUEBLOOD       26   1324  1325   22.50   25.00   2.50             .25    2.18

RUN:  1

  24    24   SERPOLAY        25   1245  1250   26.80   28.30   1.50     .77     .09       0
```

EXPERIMENT #: 27

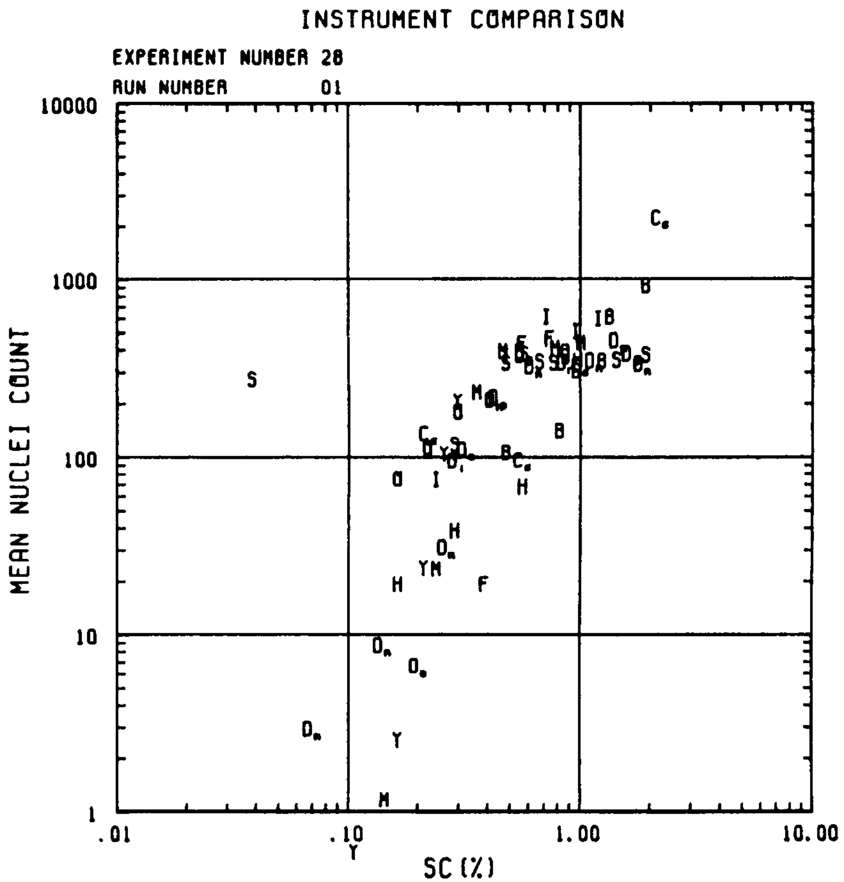
NUCLEI MEASUREMENTS

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	PLATE TEMP DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
24	24	SERPOLAY	25	1304	1310	26.90	30.40	3.50	.77	.45	110			
24	24	SERPOLAY	25	1315	1318	26.90	30.90	4.00	.77	.58	530			
24	24	SERPOLAY	25	1325	1330	27.10	31.70	4.60	.77	.75	870			
24	24	SERPOLAY	25	1340	1347	27.30	31.30	4.00	.77	.57	540			
24	24	SERPOLAY	25	1355	1400	27.40	30.40	3.00	.77	.33	0			
24	24	SERPOLAY	25	1402	1408	27.40	30.70	3.30	.77	.41	40			
RUN: 1														
25	25	BORYS	3	1244	1255	23.20	25.60	2.40	10.6	.23	57	57	.82	VOL SAMP X 10**5
25	25	BORYS	3	1301	1312	21.30	25.00	3.70	10.6	.55	141	141		
25	25	BORYS	3	1315	1326	19.70	24.70	5.00	10.6	1.07	523	523		
25	25	BORYS	3	1331	1338	17.30	24.10	6.80	4.24	1.9	1733	1733		
25	25	BORYS	3	1341	1349	18.00	23.90	5.90	5.3	1.49	622	622		
25	25	BORYS	3	1356	1400	19.60	23.90	4.30	8.48	.76	124	124		
25	25	BORYS	3	1412	1415	20.90	23.90	3.00	10.6	.37	71	71		
RUN: 1														
26	26	HINDMAN	6	1226	1243	26.00	26.00	0.00	1.4	.15	.28	.28		
26	26	HINDMAN	6	1226	1243	26.00	26.00	0.00	1.4	.11	.17	.17		
26	26	HINDMAN	6	1226	1243	26.00	26.00	0.00	1.4	.041	.059	.059		
26	26	HINDMAN	6	1226	1243	26.00	26.00	0.00	1.4	.027	0	0		
26	26	HINDMAN	6	1226	1243	26.00	26.00	0.00	1.4	.016	0	0		
RUN: 2														
26	26	HINDMAN	6	1314	1331	26.00	26.00	0.00	1.4	.15	.62	.62		
26	26	HINDMAN	6	1314	1331	26.00	26.00	0.00	1.4	.11	.31	.31		
26	26	HINDMAN	6	1314	1331	26.00	26.00	0.00	1.4	.041	.12	.12		
26	26	HINDMAN	6	1314	1331	26.00	26.00	0.00	1.4	.027	0	0		
26	26	HINDMAN	6	1314	1331	26.00	26.00	0.00	1.4	.016	0	0		
RUN: 1														
27	27	OHTAKE	19	1321	1321				1.83		4			100%
27	27	OHTAKE	19	1321	1321				1.83		3.25			105% NOMINAL, FROM
27	27	OHTAKE	19	1321	1321									DARK PICTURE



HAZE CHAMBER RESULTS



SDC/CFD RESULTS

```
                                   EXPERIMENT # 28
                                                                        80/10/15
PURPOSE
-------
 INSOLUBLE MONODISPERSE AEROSOL TO COMPARE PLATEAUX.

DESCRIPTION OF EXPERIMENT
-------------------------

  DATE           TIME
                 START   END
  ------------   -----------
  15 OCT,1980    1535   1642

  NUCLEI TYPE
  -----------
   AGI

  GENERATION METHOD
  -----------------
   THERMAL, N2 CARRIER, TA BOAT.

  SIZE DISTRIBUTION SHAPING
  -------------------------
   EC, 4357V, 6 L/MIN. AEROSOL FLOW.

REMARKS
-------
 QUASIPERIODIC FLUCTUATIONS +/- 10%, APPROX. 7 MIN. PERIOD.

WEATHER SYNOPSIS
----------------
 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

         ROOM CONDITIONS                           OUTSIDE CONDITIONS

 --------------------------------     ---------------------------------------------------
 AVG TEMP    AVG RH    AVG PRESS      AVG TEMP    AVG RH    AVG PRESS    AVG WS    AVG WD
   (C)        (%)        (MB)           (C)        (%)        (MB)       (M/S)     (DEG)
 --------    ------    ---------      --------    ------    ---------    ------    ------
   25.0       22.0       847
```

```
                                                   NUCLEI MEASUREMENTS
EXPERIMENT #: 28                                                                                        PROCESSING DATE:  81/09/26
                   OBSERVER                                    PLATE TEMP
MACH  DUCT  ------------------          SAMPLE  TIME                             VOLUME   SUPER   NUCLEI    OBS     EST
NO.   NO.   NAME               NO.      START   END     COLD    HOT     DELTA    SAMPLED  SAT     COUNT      -      K      REMARKS
                                                                (C)               (L)     (%)               N
----  ----  ---------------  ---      -----   ----    ------  ------  ------   -------  ------  ------    -----  -----  -------------------
RUN:  1

  2     2   ROGERS, DAVE      22      1600    1601    22.40   24.50    2.10                .17               78
  2     2   ROGERS, DAVE      22      1602    1603    22.20   24.60    2.40                .23              118
  2     2   ROGERS, DAVE      22      1604    1605    22.00   24.80    2.80                .31              186

RUN:  1

  5     5   KITCHEN           12      1525    1525    15.50   21.10    5.60               1.4      637
  5     5   KITCHEN           12      1526    1526    17.60   21.10    3.50                .5      110
  5     5   KITCHEN           12      1527    1527    17.60   21.10    3.50                .5      111
  5     5   KITCHEN           12      1528    1528    16.60   21.10    4.50                .85     147
  5     5   KITCHEN           12      1529    1529    15.80   21.10    5.30               1.3      370
  5     5   KITCHEN           12      1535    1535    15.80   21.10    5.30               1.3      353
  5     5   KITCHEN           12      1548    1548    14.30   21.10    6.80                 2      956

RUN:  1

  7     7   LEAITCH           14      1546    1547             8.78              .283      .31              213           HOT TEMPERATURE IS
  7     7   LEAITCH           14      1548    1549             8.55              .283      .27              107           ACTUALLY DIFFERENCE
  7     7   LEAITCH           14      1553    1554             7.45              .283      .17              2.6           BETWEEN TUBE TEMP.
  7     7   LEAITCH           14      1604    1605             6.85              .283      .11               .6           AND AMBIENT.
  7     7   LEAITCH           14      1622    1623             8.15              .283      .22             24.4           INITIAL RELATIVE
  7     7   LEAITCH           14      1622    1623                                                                        HUMIDITY IS 71%

RUN:  1

  8     8   MEE               17      1535            22.30   26.30    4.00      .2        .65      245
  8     8   MEE               17      1535            22.00   26.30    4.30                .8       445
  8     8   MEE               17      1535            21.70   26.30    4.60                .9      1363
  8     8   MEE               17      1535            21.20   26.30    5.10               1.1      1600
  8     8   MEE               17      1535            20.80   26.30    5.50               1.3      1362
  8     8   MEE               17      1535            20.30   26.30    6.00                .15     1690
  8     8   MEE               17      1535            19.10   26.30    7.20               2.2      1500

RUN:  1

  9     9   GAGIN              5      1544            21.70   26.70    5.00     1.2       1.02      360
  9     9   GAGIN              5      1547            23.20   27.00    3.80     1.2        .59       70
  9     9   GAGIN              5      1549            24.50   27.20    2.70     1.2        .3        40
  9     9   GAGIN              5      1553            25.20   27.30    2.10     1.2        .17       20
RUN:  2

  9     9   GAGIN              5      1558            21.70   26.80    5.10     1.2       1.05      540
  9     9   GAGIN              5      1600            23.00   27.30    4.30     1.2        .72       50
  9     9   GAGIN              5      1603            24.40   27.20    2.80     1.2        .33       20
  9     9   GAGIN              5      1607            25.10   27.00    1.90     1.2        .11       20
RUN:  3

  9     9   GAGIN              5      1610            21.40   27.20    5.80     1.2       1.35      360
  9     9   GAGIN              5      1612            22.60   27.20    4.60     1.2        .85      300
  9     9   GAGIN              5      1614            23.30   26.90    3.60     1.2        .5       140
RUN:  4

  9     9   GAGIN              5      1623            22.60   27.00    4.40     1.2        .76      450
  9     9   GAGIN              5      1625            23.30   27.30    4.00     1.2        .62       40
  9     9   GAGIN              5      1628            23.80   27.20    3.40     1.2        .46       30
  9     9   GAGIN              5      1630            25.20   27.30    2.10     1.2        .17       20

RUN:  1

 10    10   LALA              13      1535            21.48   24.22    2.74                .3      122.7
```

```
                                                            NUCLEI MEASUREMENTS
EXPERIMENT #: 28                                                                                                           PROCESSING DATE:  81/09/26
                       OBSERVER                                       PLATE TEMP
MACH  DUCT  ------------------------   SAMPLE TIME                                     VOLUME   SUPER  NUCLEI   OBS    EST
NO.   NO.   NAME                 NO.   START   END    COLD     HOT     DELTA   SAMPLED  SAT    COUNT    -      K     REMARKS
                                                                (C)             (L)      (%)             N
----  ----  ---------------     ---    -----  ----   ------   ------  ------  -------  ------  ------  -----  -----  -------------------
 10    10   LALA                 13    1536           21.04    24.20    3.16             .04   280.3
 10    10   LALA                 13    1537           20.64    21.17     .53             .5    350.2
 10    10   LALA                 13    1538           20.28    24.14    3.86             .6    395.5
 10    10   LALA                 13    1539           19.96    24.12    4.16             .7      353
 10    10   LALA                 13    1540           19.65    24.09    4.44             .8    349.3
 10    10   LALA                 13    1541           19.37    24.07    4.70             .9    379.3
 10    10   LALA                 13    1542           19.10    24.05    4.95             1     316.3
 10    10   LALA                 13    1543           17.99    24.02    6.03            1.5    362.9
 10    10   LALA                 13    1544           17.06    23.99    6.93             2     387.1

RUN:  2

 10    10   LALA                 13    1545           21.42    24.16    2.74             .3    128.5
 10    10   LALA                 13    1546           21.02    21.18     .16             .4    323.3
 10    10   LALA                 13    1547           20.64    24.17    3.53             .5    344.5
 10    10   LALA                 13    1548           20.31    24.16    3.85             .6    382.1
 10    10   LALA                 13    1549           19.99    24.15    4.16             .7    404.6
 10    10   LALA                 13    1550           19.71    24.15    4.44             .8    403.1
 10    10   LALA                 13    1551           19.43    24.14    4.71             .9    348.5
 10    10   LALA                 13    1552           19.17    24.12    4.95             1     383.8
 10    10   LALA                 13    1553           18.05    24.08    6.03            1.5    367.2
 10    10   LALA                 13    1554           17.14    24.08    6.94             2     311.1

RUN:  1

 13    13   AYERS                 2    1536   1537    25.43    27.90    2.47             .25      77
 13    13   AYERS                 2    1538   1539    24.23    27.80    3.57             .5      383
 13    13   AYERS                 2    1539   1540    23.45    27.80    4.35             .75     630
 13    13   AYERS                 2    1540   1541    22.73    27.70    4.97             1       450
 13    13   AYERS                 2    1541   1542    22.73    27.70    4.97             1       540
 13    13   AYERS                 2    1542   1543    22.73    27.70    4.97             1       570
 13    13   AYERS                 2    1544   1545    21.94    27.50    5.56            1.25     630
 13    13   AYERS                 2    1555   1556    21.95    27.50    5.55            1.25     600

RUN:  2

 13    13   AYERS                 2    1547   1548    21.80    27.40    5.60            1.25     540
 13    13   AYERS                 2    1548   1549    21.76    27.30    5.54            1.25     750
 13    13   AYERS                 2    1549   1550    22.29    27.30    5.01             1       450
 13    13   AYERS                 2    1550   1551    22.86    27.20    4.34             .75     465
 13    13   AYERS                 2    1552   1553    23.65    27.20    3.55             .5      375
 13    13   AYERS                 2    1554   1555    24.71    27.20    2.49             .25      26

RUN:  1

 14    14   HUDSON                9    1535   1607                             .0208     .21    .934
 14    14   HUDSON                9    1535   1607                             .0208     .14    .222
 14    14   HUDSON                9    1535   1607                             .0208     .11    .099
 14    14   HUDSON                9    1535   1607                             .0208     .04   .0128
 14    14   HUDSON                9    1535   1607                             .0208    .029   .0056

RUN:  1

 15    15   KOCMOND              30    1537   1538    18.36    25.06    6.70            1.86     348                  MAIN FLOW ABT. 1820.
 15    15   KOCMOND              30    1541   1542    18.74    24.75    6.01            1.46     466
 15    15   KOCMOND              30    1545   1546    19.11    24.44    5.33            1.15     361                  AEROSOL FLUCTUATIONS
 15    15   KOCMOND              30    1549   1550    19.49    24.13    4.64             .87     352
 15    15   KOCMOND              30    1552   1553    19.87    23.81    3.94             .63     335
 15    15   KOCMOND              30    1556   1557    20.25    23.50    3.25            .425     217
 15    15   KOCMOND              30    1600   1601    20.63    23.19    2.56            .265      32
 15    15   KOCMOND              30    1606   1607    20.99    22.88    1.89             .14       9
 15    15   KOCMOND              30    1610   1611    21.35    22.56    1.21             .07       3
RUN:  2

 15    15   ROGERS, FRED         23    1628   1629    18.36    25.06    6.70            1.86     363                  SECOND RUN WITH
 15    15   ROGERS, FRED         23    1632   1633    18.74    24.75    6.01            1.46     335                  HIGHER MAIN FLOW,
 15    15   ROGERS, FRED         23    1636   1637    19.11    24.44    5.33            1.15     332                  ABOUT 2280.
```

```
                                                        NUCLEI MEASUREMENTS
EXPERIMENT #: 28                                                                                                  PROCESSING DATE:  81/09/26
                      OBSERVER                                          PLATE TEMP
MACH  DUCT  ------------------       SAMPLE TIME                                     VOLUME   SUPER   NUCLEI     OBS       EST
NO.   NO.   NAME               NO.   START   END     COLD     HOT      DELTA  SAMPLED   SAT     COUNT       -         K     REMARKS
                                                              (C)                (L)      (%)                N
----  ----  ---------------- ---   -----  ----    ------   ------   ------  -------  ------   ------    -----     -----   --------------------
 15    15   ROGERS, FRED       23   1640   1641    19.49    24.13     4.64              .87      306                       SWITCHED TO HIGHER
 15    15   ROGERS, FRED       23   1640   1641                                                                            FLOW CAPILLARY.

RUN:  1

 16    16   HUDSON              9   1532   1535    21.30    26.00     4.70    .0024      .9      401
 16    16   HUDSON              9   1532   1535    21.65    25.40     3.75    .0024     .57      391
 16    16   HUDSON              9   1532   1535    22.10    24.80     2.70    .0024     .29       99
 16    16   HUDSON              9   1545   1548    21.30    26.00     4.70    .0018      .9      415
 16    16   HUDSON              9   1545   1548    21.65    25.40     3.75    .0018     .57      400
 16    16   HUDSON              9   1545   1548    22.10    24.80     2.70    .0018     .29      108
 16    16   HUDSON              9   1555   1557    21.30    26.00     4.70    .0018      .9      390
 16    16   HUDSON              9   1555   1557    21.65    25.40     3.75    .0018     .57      378
 16    16   HUDSON              9   1555   1557    22.10    24.80     2.70    .0018     .29       89
RUN:  2

 16    16   HUDSON              9   1604   1608    21.30    26.00     4.70    .0024      .9      386
 16    16   HUDSON              9   1604   1608    21.65    25.40     3.75    .0024     .57      373
 16    16   HUDSON              9   1604   1608    22.10    24.80     2.70    .0024     .29       82
 16    16   HUDSON              9   1628   1633    21.30    26.00     4.70     .003      .9      363
 16    16   HUDSON              9   1628   1633    21.65    25.40     3.75     .003     .57      335
 16    16   HUDSON              9   1628   1633    22.10    24.80     2.70     .003     .29       49

RUN:  1

 18    18   HUDSON              9   1532   1535    21.50    27.90     6.40    .0024    1.65      396
 18    18   HUDSON              9   1545   1548    22.90    26.65     3.75    .0018     .57      405
 18    18   HUDSON              9   1555   1557    23.35    26.20     2.85    .0018     .32      115
 18    18   HUDSON              9   1604   1608    23.65    25.90     2.25    .0024      .2      6.8
 18    18   HUDSON              9   1628   1633    23.20    26.50     3.30     .003     .44      224

RUN:  1

 21    21   TRUEBLOOD          26   1537   1538    19.88    25.00     5.12             1.048      454
 21    21   TRUEBLOOD          26   1540   1541    20.48    25.00     4.52              .817      423
 21    21   TRUEBLOOD          26   1546   1547    21.52    25.00     3.48              .484      408
 21    21   TRUEBLOOD          26   1550   1551    21.94    25.00     3.06              .374      241
 21    21   TRUEBLOOD          26   1554   1555    22.50    25.00     2.50               .25     24.3
 21    21   TRUEBLOOD          26   1601   1602    23.07    25.00     1.93              .149      1.2
RUN:  2

 21    21   TRUEBLOOD          26   1613   1614    20.02    25.00     4.98              .992      390
 21    21   TRUEBLOOD          26   1617   1618    20.69    25.00     4.31              .743      362
 21    21   TRUEBLOOD          26   1621   1622    21.48    25.00     3.52              .496      359
 21    21   TRUEBLOOD          26   1625   1626    21.92    25.00     3.08              .379      161
 21    21   TRUEBLOOD          26   1629   1630    22.50    25.00     2.50               .25     13.4
 21    21   TRUEBLOOD          26   1636   1637    23.00    26.00     2.00               .16       .3

RUN:  1

 24    24   SERPOLAY           25   1600   1604    25.40    27.90     2.50      .77     .25        0
 24    24   SERPOLAY           25   1612   1615    25.60    28.90     3.30      .77      .4       20
 24    24   SERPOLAY           25   1620   1628    25.70    29.70     4.00      .77     .59      450
 24    24   SERPOLAY           25   1634   1638    26.00    30.60     4.60      .77     .77      480

RUN:  1

 25    25   BORYS               3   1606   1616    21.10    23.50     2.40     10.6     .22      141       141              VOL SAMP X 10**5
 25    25   BORYS               3   1622   1630    19.90    23.60     3.70     10.6     .56       99        99
 25    25   BORYS               3   1634   1639    18.60    23.50     4.90     10.6       1      340       340
 25    25   BORYS               3   1642   1647    16.10    23.30     7.20     3.18     2.2     2315      2315

RUN:  1

 26    26   HINDMAN             6   1602   1617    26.00    26.00     0.00      1.4     .15        0         0
```

NUCLEI MEASUREMENTS

EXPERIMENT #: 28

PROCESSING DATE: 81/09/26

MACH NO.	DUCT NO.	OBSERVER NAME	OBSERVER NO.	SAMPLE START	TIME END	PLATE TEMP COLD	PLATE TEMP HOT (C)	DELTA	VOLUME SAMPLED (L)	SUPER SAT (%)	NUCLEI COUNT	OBS - N	EST K	REMARKS
26	26	HINDMAN	6	1602	1617	26.00	26.00	0.00	1.4	.11	0	0		
26	26	HINDMAN	6	1602	1617	26.00	26.00	0.00	1.4	.041	0	0		
26	26	HINDMAN	6	1602	1617	26.00	26.00	0.00	1.4	.027	0	0		
26	26	HINDMAN	6	1602	1617	26.00	26.00	0.00	1.4	.016	0	0		
RUN: 2														
26	26	HINDMAN	6	1618	1632	26.00	26.00	0.00	1.2	.15	.2	.2		
26	26	HINDMAN	6	1618	1632	26.00	26.00	0.00	1.2	.11	.19	.19		
26	26	HINDMAN	6	1618	1632	26.00	26.00	0.00	1.2	.041	.12	.12		
26	26	HINDMAN	6	1618	1632	26.00	26.00	0.00	1.2	.027	.058	.058		
26	26	HINDMAN	6	1618	1632	26.00	26.00	0.00	1.2	.016	.024	.024		
RUN: 1														
27	27	OHTAKE	19	1544	1545				5.5		.84			95%
27	27	OHTAKE	19	1544	1545				5.5		2.34			104% R.H. NOMINAL

```
                                          EXPERIMENT # 29
                                                                                80/10/15
PURPOSE
-------

 COMPARE INSTRUMENTS WITH HYDROPHOBIC AEROSOL.

DESCRIPTION OF EXPERIMENT
-------------------------
               TIME
  DATE         START   END
  ------------ -----------

  15 OCT,1980  1644   1750

  NUCLEI TYPE
  -----------

   PARAFFIN (HOUSEHOLD TYPE).

  GENERATION METHOD
  -----------------

   N2 JET INTO LIQUID PARAFFIN SURFACE.

  SIZE DISTRIBUTION SHAPING
  -------------------------

   NA

REMARKS
-------

 VERY BROAD DISTRIBUTION.

WEATHER SYNOPSIS
----------------

 NONE

MEAN WEATHER CONDITIONS DURING EXPERIMENT
-----------------------------------------

        ROOM CONDITIONS                            OUTSIDE CONDITIONS

 --------------------------------    --------------------------------------------------

 AVG TEMP    AVG RH   AVG PRESS      AVG TEMP   AVG RH   AVG PRESS   AVG WS   AVG WD
   (C)        (%)       (MB)           (C)       (%)       (MB)      (M/S)    (DEG)
 --------    ------   ---------      --------   ------   ---------   ------   ------
```

```
                                                              NUCLEI MEASUREMENTS
EXPERIMENT #: 29                                                                                                           PROCESSING DATE:  81/09/26
                    OBSERVER                                     PLATE TEMP
MACH  DUCT  --------------------      SAMPLE  TIME                                  VOLUME   SUPER   NUCLEI    OBS    EST
NO.   NO.   NAME                NO.   START   END    COLD     HOT    DELTA   SAMPLED   SAT     COUNT      -      K     REMARKS
                                                               (C)              (L)      (%)               N
----  ----  --------------- ---   -----  ----  ------  ------  ------  -------  ------  ------  -----  -----  -------------------

RUN:  1

 2     2    POLITOVICH         20    1731   1732   23.60   25.70   2.10                .17              169
 2     2    POLITOVICH         20    1735   1736   23.30   25.80   2.50                .24              235

RUN:  1

 7     7    LEAITCH            14    1656   1657           9.90            .283      .48               28
 7     7    LEAITCH            14    1706   1707           9.85            .283      .48               43
 7     7    LEAITCH            14    1716   1717           9.60            .283      .42               50
 7     7    LEAITCH            14    1726   1727           9.15            .283      .36               40

RUN:  1

 9     9    GAGIN               5    1725          21.80   27.20   5.40     1.2     1.17       0
 9     9    GAGIN               5    1727          23.20   26.90   3.70     1.2      .53       0
 9     9    GAGIN               5    1729          23.90   27.00   3.10     1.2      .3        0
 9     9    GAGIN               5    1732          25.10   27.20   2.10     1.2      .17       0

RUN:  1

10    10    LALA               13    1707          22.49   25.26   2.77      .4      .3     36.4
10    10    LALA               13    1708          22.05   25.23   3.18      .4      .4     21.5
10    10    LALA               13    1709          21.64   25.19   3.55      .4      .5     36.9
10    10    LALA               13    1710          21.26   25.16   3.89      .4      .6     20.1
10    10    LALA               13    1711          20.10   25.10   5.00      .4      .7     19.8
10    10    LALA               13    1712          20.57   25.04   4.47      .4      .8     18.02
10    10    LALA               13    1713          20.25   24.98   4.73      .4      .9       34
10    10    LALA               13    1714          19.86   24.84   4.98      .4     1         25
10    10    LALA               13    1715          18.72   24.79   6.07      .4     1.5     18.5                        NO COUNTS ABOVE
10    10    LALA               13    1716          17.72   24.69   6.97      .4     2       11.3                        NOISE LEVEL

RUN:  1

13    13    AYERS               2    1712   1719                                                                     NO PARTICLES IN
13    13    AYERS               2    1712   1719                                                                     RANGE 0.25 TO 1.25%

RUN:  1

15    15    ROGERS, FRED       23    1709   1710   18.36   25.06   6.70             1.86     110                        MAIN FLOW ABT 2280.
15    15    ROGERS, FRED       23    1713   1714   18.74   24.75   6.01             1.46      93                        MAY BE SEEING ONLY
15    15    ROGERS, FRED       23    1717   1718   19.11   24.44   5.33             1.15     100                        LARGE WAX PARTICLES.
15    15    ROGERS, FRED       23    1721   1722   19.49   24.13   4.64              .87     117
15    15    ROGERS, FRED       23    1726   1727   19.87   23.81   3.94              .63     115
15    15    ROGERS, FRED       23    1730   1731   20.25   23.50   3.25              .425    118
15    15    ROGERS, FRED       23    1734   1735   20.63   23.19   2.56              .265    121
15    15    ROGERS, FRED       23    1738   1739   20.99   22.88   1.89              .14     106

RUN:  1

18    18    HUDSON              9    1701   1703   23.20   26.45   3.25    .0018      .42     1.52
18    18    HUDSON              9    1709   1711   21.85   27.80   5.95    .0018     1.45     1.78
18    18    HUDSON              9    1754   1758   23.60   25.85   2.25    .0018      .2       .03

RUN:  1

24    24    SERPOLAY           25    1705   1708   26.30   28.40   2.10     .77      .17      340
24    24    SERPOLAY           25    1712   1715   26.30   28.80   2.50     .77      .25      340
24    24    SERPOLAY           25    1720   1722   26.30   29.30   3.00     .77      .34      340
24    24    SERPOLAY           25    1725   1730   26.20   28.10   1.90     .77      .14      310
24    24    SERPOLAY           25    1735   1739   26.20   27.70   1.50     .77      .09      150

RUN:  1

25    25    BORYS               3    1714   1716   16.00   22.90   6.90     4.24     2.15     1132    1132            VOL SAMP X 10**5
```

```
                                                                NUCLEI MEASUREMENTS
EXPERIMENT #: 29                                                                                                              PROCESSING DATE:  81/09/26
                  OBSERVER                                            PLATE TEMP
MACH  DUCT  ---------------------     SAMPLE  TIME                                        VOLUME   SUPER   NUCLEI    OHS     EST
NO.   NO.   NAME              NO.     START   END      COLD       HOT      DELTA   SAMPLED   SAT     COUNT      -      K      REMARKS
                                                                  (C)                (L)     (%)                N
----  ----  ---------------- ---     -----   ----    ------    ------    ------   -------   ------  ------    -----   -----  --------------------
 25    25   BORYS              3      1726    1728    17.80     22.80      5.00      10.6     1.08     410      410

RUN:   1

 26    26   HINDMAN            6      1716    1733    26.00     26.00      0.00       1.4      .15     203      203            +/-3.0
 26    26   HINDMAN            6      1716    1733    26.00     26.00      0.00       1.4      .11      44       44            +/-0.6
 26    26   HINDMAN            6      1716    1733    26.00     26.00      0.00       1.4     .041      12       12            +/-0.16
 26    26   HINDMAN            6      1716    1733    26.00     26.00      0.00       1.4     .027    .038     .038            +/-0.0066
 26    26   HINDMAN            6      1716    1733    26.00     26.00      0.00       1.4     .016       0        0            0

RUN:   1

 27    27   OHTAKE            19      1710    1710                                  6.7                0                     75%
 27    27   OHTAKE            19      1710    1710                                  6.7                0                     118% NOMINAL
```

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.
NASA CP-2212

2. GOVERNMENT ACCESSION NO.

3. RECIPIENT'S CATALOG NO.

4. TITLE AND SUBTITLE
The Third International Cloud Condensation Nuclei Workshop

5. REPORT DATE
November 1981

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Edited by W. C. Kocmond, C. F. Rogers, and S. W. Rea

8. PERFORMING ORGANIZATION REPORT #

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Desert Research Institute
University of Nevada System
Reno, Nevada 89557

10. WORK UNIT NO.

11. CONTRACT OR GRANT NO.
NAS8-33820

12. SPONSORING AGENCY NAME AND ADDRESS
National Aeronautics and Space Administration
Washington, D.C. 20546

13. TYPE OF REPORT & PERIOD COVERED
Conference Publication

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
The compilation of this document was monitored by R. E. Smith, Atmospheric Sciences Division, Space Sciences Laboratory, NASA/Marshall Space Flight Center.

16. ABSTRACT

Accurate knowledge of cloud condensation nuclei size distributions is paramount to improving our understanding of cloud microphysical phenomena. The problems associated with obtaining this knowledge are large and varied; therefore, many technique development efforts to resolve these problems are in progress around the globe. The objective of the Third International Cloud Condensation Nuclei Workshop was to bring a large number of the development efforts together to insure an exchange of results and progress being made in the hope that the attainment of satisfactory solutions could be accelerated. At this stage it appears as if the workshop was very successful.

The complexity and magnitude of the workshop were such that it could be successfully accomplished only under the combined sponsorship of the National Aeronautics and Space Administration and the National Science Foundation. The workshop was supported by contract NAS8-33820; this document constitutes the final report under the contract.

17. KEY WORDS

18. DISTRIBUTION STATEMENT
Unclassified-Unlimited

19. SECURITY CLASSIF. (of this report)
Unclassified

20. SECURITY CLASSIF. (of this page)
Unclassified

21. NO. OF PAGES
288

22. PRICE
NTIS

MSFC - Form 3292 (Rev. December 1972)

For sale by National Technical Information Service, Springfield, Virginia 22151

☆U.S. GOVERNMENT PRINTING OFFICE: 1981—546-071/109