SHIELDALLOY METALLURGICAL CORPORATION

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September 22, 1995

Mohamed M. Shanbaky, Ph.D.
Nuclear Materials Safety Branch
Division of Radiation Safety and Safeguards
U. S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, Pennsylvania 19406-1415

Re: Materials License No. SMB-743

Dear Dr. Shanbaky:

Shieldalloy Metallurgical Corporation (SMC) is in receipt of your letter dated July 21, 1995 requesting additional information with respect to SMC's request to adjust the Derived Air Concentration (DAC) for airborne thorium and uranium activity at SMC's Newfield, New Jersey facility. Attached is our response to your questions. Please contact me at (609) 692-4200 if you have any additional questions.

Sincerely,

C. Scott Eves, RSO
Vice President, Environmental Services

cc: H. N. Schooley
S. Arredondo, Region I

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RETURN ORIGINAL TO
REGION I

IE 07

RESPONSE TO USNRC QUESTIONS
REGARDING ADJUSTMENTS TO DAC FOR AIRBORNE THORIUM AND URANIUM

USNRC Question 1: You are authorized to possess thorium and uranium in any form. In your analyses and calculations, you assign the thorium and uranium aerosol in the workplace to inhalation Class Y. Please state what forms of these materials you use and justification for using Class Y. A clarification of this point is necessary because the DAC for Class W is 50% lower than that for Class Y, and appropriate adjustments must be made depending upon the for that is used.

SMC Response: SMC works only with thorium and uranium in oxide form. The International Commission on Radiological Protection states that, for dose assessment purposes, uranium oxides and thorium oxides are assigned to inhalation Class Y (ICRP Report No. 30, "Limits for Intakes of Radionuclides by Workers", pages 100 and 102). Therefore, SMC assigns all airborne radioactivity measured during licensed operations to inhalation Class Y.

USNRC Question 2: You used isotopic ratios to calculate the thorium and uranium activity from the results of gross alpha counting. This value is the ratio of the concentration of thorium and uranium activity to the total activity of alpha emitters in materials used at your facility, and was determined by isotopic analysis. You did not provide assurances that this ratio will reflect the ratio of emissions from the various alpha emitters in an air sample. This latter ratio may differ from that obtained by isotopic analysis because of the inaccuracies in determining counting efficiency such as self-absorption, geometry and detector efficiency. Please provide a justification for using this scaling method based upon evidence that this ratio will reflect the ratio of emission in an air sample.

SMC Response: The following is the methodology SMC uses to convert gross alpha activity in/on a sample (e.g., air filter or smear) into ^{232}Th activity in/on that sample:

$$A_{Th}(Bq) = A_{\alpha}(Bq) \times 0.076$$

where A_{Th} = the ^{232}Th activity in/on the sample and A_{α} = the measured gross alpha activity in/on the sample. For ^{238}U, the following methodology is used:

$$A_{U}(Bq) = A_{\alpha}(Bq) \times 0.061$$

where A_U = the ^{238}U activity in/on the sample. In the unlikely event of a systematic error in the procedure for determining A_α for a filter (i.e., efficiency, geometry, etc.), the A_{Th} or A_U for that filter will, depending upon the error type, be greater or less than the true ^{232}Th activity on the filter. However, the ratio of A_{Th} to A_α, or A_U to A_α, will not change since the uranium, thorium, and their daughters are intimately combined

(e.g., on an atomic level) in the material and thus are immune from fractionation. Aside from heating, which only occurs during a single stage of ferrocolumbium processing (e.g., during a heat), SMC cannot envision a physical mechanism that would preferentially diminish detection of certain of the alpha-emitting daughters in the thorium series without doing the same for the remainder.[1]

The counting procedure SMC uses to obtain gross alpha activity on an air filter is consistent with industry standards. An alpha source that is traceable to the National Institute of Standards and Technology (NIST), with the same geometry (e.g., size and surface area) as the air filters to be counted, is used to determine the efficiency of a zinc sulfide detector. Corrections are made for background contribution to the gross counting results. Corrections for self-absorption of alphas during the counting process are not necessary since there is negligible dust loading and surface deposition on the filters. Based upon confidence in the counting procedure and confidence in the assessment of the thorium-to-gross alpha and uranium-to-gross alpha ratios, SMC is confident that the "scaling method" results in an acceptable means of estimating airborne thorium and uranium in the workplace.

USNRC Question 3: You stated in your discussion of the analysis of the sampling results that the AMAD was calculated by calculating the mean particle size for the distribution. The correct quantity however, is the median size. Please clarify this point by providing details on the method used to calculate the AMAD.

SMC Response: The median of a set of measurements is defined as that value that falls in the middle when the measurements are arranged in order of magnitude. Attachment 2 of our May 11, 1995 letter clearly demonstrates that the individual measurements of particle size are, in fact, the median diameter of each distribution.[2] Since more than one assessment of median diameter was made, a simple average (mean) of the median diameters from each location was taken to represent a single AMAD for that location.[3] These were the values presented in Item 3 of our May 11, 1995 letter, and reported in units of activity median aerodynamic diameter.

USNRC Question 4: In addition to our concerns regarding calculation of the AMAD, we also note that the Graseby/Anderson Model Mark III particle fractionating sampler that you used is susceptible to many errors that would result in nonrepresentative particle size distributions. These include changes in air flow

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1 During a heat, the gaseous daughters of thorium and uranium are emitted. However, this action serves to reduce the thorium- or uranium-to-gross alpha ratio when the emissions are collected. Consequently, use of the above thorium-to-gross alpha and uranium-to-gross alpha ratios for all measurement conditions results in a conservative assessment of dose.

2 Schooly, N.E., and C. S. Eves, Shieldalloy Metallurgical Corporation, written communication to Thomas T. Martin, Regional Administrator, USNRC, May 15, 1995.

3 The median of the measured particle size distributions are normally distributed about some mean value. Therefore, this approach is statistically acceptable.

rates, operating pressure, collection plate spacing, loss of sample due to movement of the sampler, calibration of the sampler, and other factors. The method is also subject to substantial errors due to particle bounce if proper precautions are not taken. The above concerns are heightened by the fact that data analysis was conducted offsite, thus involving transportation of the samples. Please describe the methods used to obtain the samples, the operating procedures for calibration and sampling, the precautions taken during transportation, the methods used to minimize particle bounce and their effects on alpha counting, and the qualifications of the person(s) who operated the sampler and shipped the samples for analysis. Error estimates for the activity determined for each stage should also be provided.

SMC Response: The potential errors referenced in Question 4 are equally applicable to any form of air monitoring, whether there is a size fractionating device in line with the collection media or not. However, it is important to note that the majority of these potential errors (e.g., loss of sample due to movement of the sampler, particle bounce, transportation losses) will result in preferential selection of small particles over large particles if they were to occur.[4] Improper plate spacing is not possible due to the design of the device. The operating flow is monitored similar to the way in which air flow rate is monitored during conventional air sampling. As long flow is maintained, air will be drawn through the system. Attachment 2 contains a description of and operating instructions for the Graseby/Anderson sampler.

It is important to note that the critical information for determining particle size by this methodology is the relative alpha activity per stage. The airborne concentration of alpha emitters (e.g., pCi per liter) during the sampling period is of little importance. Therefore, knowledge of the air flow rate through the system is also of limited importance.

After the sample is collected, the filters are removed from the sampler assembly. Each filter is placed in a separate collection container, the containers are sealed and then placed in a transport container for shipment. The filters remain in the containers until they are removed at the commercial analytical laboratory. The laboratory determined the alpha activity on each filter by direct counting of the dissolved filter and the activity from the container wash-out.

Sample collection and shipping for this effort was performed by a consultant to SMC (the former SMC RSO) who has a number of years of experience of experience in collecting/handling/shipping air samples for a variety of radiological and stable contaminants.

The filters used on the stages of the sampler were glass fiber. This filter type is designed to prevent loss of larger particles due to "particle bounce" during sample collection through the trapping action of the fibers.

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[4] As a result, the internal doses, as calculated using the modified DAC, will be conservative (e.g., overestimated).

The counting error associated with analysis of alpha activity on each stage is included herein as Attachment 1.

USNRC Question 5: Please provide assurances that the air sampling data, particularly the particle size distribution data, is representative of the type of aerosols that workers are exposed to at each work location. Although some information was provided, it was insufficient to provide this assurance.

SMC Response: The Graseby/Anderson sampler was placed in the vicinity of the mixing/blending operation and the tapping operation, as close as possible to where personnel were likely to be positioned.[5] The mixing/blending operations themselves do not fractionate by particle size or in any other way distort the physical and chemical properties of the airborne radioactive constituents produced. Furthermore, the density and deposition velocity of the materials in use are not conducive to wide dispersion as a result of unusual airflow patterns.

The data acquired for the particle size assessment are as representative as the conventional stationary air sampling data that have been acquired in these work areas over the years, and that are typically used throughout the nuclear industry.[6] Therefore, SMC is confident that the measurements of particle size adequately and conservatively reflect the particle sizes in the breathing zone of workers.

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5 Because of the physical size of the sampling device and our desire to not impede the movements of the worker, it was not possible to place the sampling head as close to the source of emissions as the worker (e.g., within 30 cm. of the head of the worker, as recommended in Section 3.1, of NUREG-1400, "Air Sampling in the Work Place"). Consequently, the data from this assessment reflect significantly smaller particle sizes than would be expected if the collection locations were closer to the source due to the increased proximal deposition of larger particles over smaller particles. As a result, the internal doses, as calculated using the modified DAC, will be conservative (e.g., overestimated).

6 Hickey, E. E., G. A. Stoetzel, D. J. Strom, C. R. Cicotte, C. M. Wiblin and S. A. McGuire, "Air Sampling in the Workplace", NUREG-1400, Section 3.0, September, 1993.

ATTACHMENT 1
PARTICLE SIZE DATA FROM D.111 OPERATIONS

Location	Stage	Effective Cut Diameter (microns)	Total Activity (pCi)	Percent of Total Activity	Cumulative (Percent Less Than)
Vicinity of scale, 10 feet from hopper	0	13.6 and above	5.90 ± 1.2	8.81	91.19
	1	8.6	3.76 ± 0.98	5.61	85.58
	2	5.6	2.94 ± 0.86	4.39	81.19
	3	4.0	5.5 ± 1.2	8.21	72.98
	4	2.5	11.0 ± 1.7	16.42	56.55
	5	1.3	10.6 ± 1.6	15.83	40.73
	6	1.8	17.7 ± 2.2	26.43	14.3
	7	.54	6.1 ± 1.2	9.11	5.2
	Final	Less than 0.54	3.48 ± 0.93	5.2	0
		TOTAL	66.98		
Vicinity of scale, 10 feet from hopper	0	13.6 and above	3.37 ± 0.88	9.2	90.80
	1	8.6	3.17 ± 0.88	8.65	82.15
	2	5.6	2.21 ± 0.76	6.03	76.11
	3	4.0	2.48 ± 0.81	6.77	69.34
	4	2.5	3.00 ± 0.87	8.19	61.15
	5	1.3	5.20 ± 1.1	14.20	46.96
	6	1.8	5.50 ± 1.1	15.02	31.94
	7	.54	5.70 ± 1.1	15.56	16.38
	Final	Less than 0.54	6.00 ± 1.2	16.38	0
		TOTAL	36.63		

Location	Stage	Effective Cut Diameter (microns)	Total Activity (pCi)	Percent of Total Activity	Cumulative (Percent Less Than)
Vicinity of scale, 10 feet from hopper	0	13.6 and above	3.93 ± 0.98	13.18	86.82
	1	8.6	2.71 ± 0.84	9.09	77.73
	2	5.6	3.42 ± 0.94	11.47	66.25
	3	4.0	2.76 ± 0.82	9.26	56.99
	4	2.5	2.34 ± 0.77	7.85	49.14
	5	1.3	3.26 ± 0.91	10.94	38.21
	6	1.8	2.66 ± 0.84	8.92	29.29
	7	.54	3.03 ± 0.90	10.16	19.12
	Final	Less than 0.54	5.70 ± 1.2	19.12	0
		TOTAL	29.81		
Outside entrance to control room on second floor.	0	13.6 and above	4.60 ± 0.69	9.21	90.79
	1	8.6	5.70 ± 1.2	11.41	79.38
	2	5.6	3.02 ± 0.87	6.05	73.33
	3	4.0	4.10 ± 1.0	8.21	65.13
	4	2.5	3.47 ± 0.95	6.95	58.18
	5	1.3	5.40 ± 1.2	10.81	47.37
	6	1.8	3.09 ± 0.80	6.19	41.18
	7	.54	3.47 ± 0.81	6.95	34.23
	Final	Less than 0.54	17.1 ± 2.2	34.23	0
		TOTAL	49.95		

Location	Stage	Effective Cut Diameter (microns)	Total Activity (pCi)	Percent of Total Activity	Cumulative (Percent Less Than)
Outside entrance to control room on second floor.	0	13.6 and above	190.0 ± 16	39.6	60.4
	1	8.6	13.6 ± 3.7	2.83	57.57
	2	5.6	9 ± 2.8	1.88	55.69
	3	4.0	12.4 ± 3.5	2.58	53.11
	4	2.5	8.3 ± 2.8	1.73	51.38
	5	1.3	19.8 ± 4.1	4.13	47.25
	6	1.8	32.5 ± 5.4	6.77	40.48
	7	.54	42.2 ± 5.9	8.8	31.68
	Final	Less than 0.54	152.0 ± 14	21.68	0
		TOTAL	479.8		

ATTACHMENT 2
GRASEBY/ANDERSON SAMPLER

GRASEBY ANDERSEN

IN-STACK PARTICLE FRACTIONATING SAMPLER

This sampler collects and automatically sizes all stack particulates in situ.*

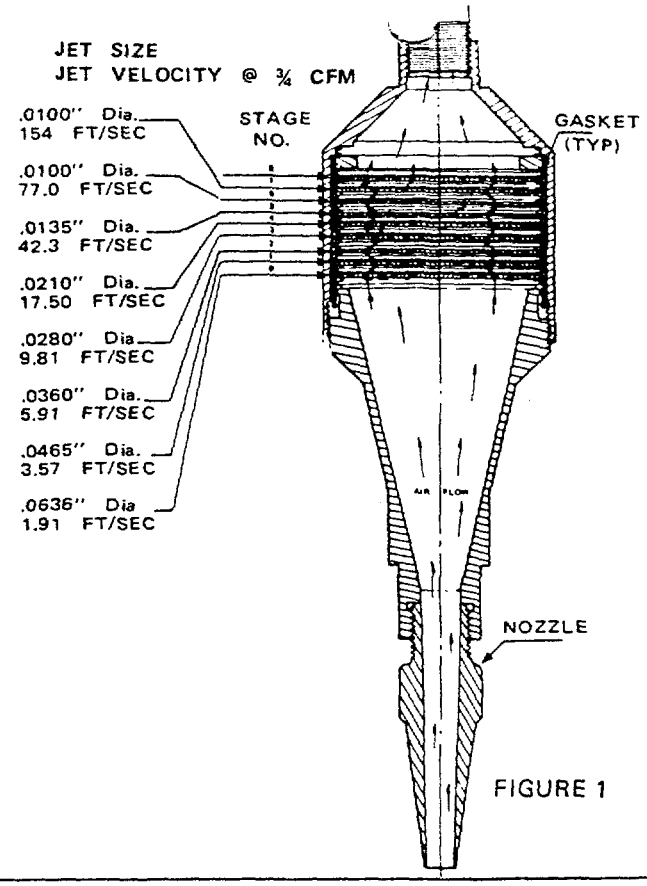


FIGURE 1

• FEATURES

- Fractionates and collects all stack particulates into ten aerodynamic size ranges (including preseparator and backup filter) (See Table I).
- Optional stainless steel preseparator and standard backup filter holder for absolute collection of large (>10 microns) and small (<0.4 microns) particles respectively.
- Constant pressure drop — accurate flow measurement
- Stainless steel case, plates, holder and spacers permit use in stack temperatures up to 1500°F
- Multi-jet multi-stage inertial impactor-patented concept
- Inertial separation incorporates size, shape, and density of particles into aerodynamic dimensions
- Eliminates need for tedious microscopic sizing and counting
- Precision: 99.5%
- Simple to operate, highly versatile, easily cleaned, all parts interchangeable
- Easy adaptation to the "EPA type" pitobe
- Applicable in all stack concentrations up to 1 grain/SCF. Optional preseparator permits sampling in higher grain loadings.
- Flow rates from 0.1 to 0.75 ACFM permit any normal inlet nozzle velocity desired by using the six standard gooseneck nozzle sizes (½" , ⅜" , 5/16" , ¼" , 3/16" , ⅛"). Straight nozzles and elbow adapters are available
- Compact in size, 10" maximum length (including nozzle) x 2.8" diameter, permits direct insertion into stack through standard 3" opening; preseparator will fit through 3" port also
- Available in 6 and 8 stage, high and low temperature and low corrosion configurations.
- Andersen sampler can be placed in any position for accurate collection and sizing

• APPLICATION

The Andersen Stack Sampling Head is designed to adapt to other commercially available stack trains containing an "EPA type" pitobe. This sampler is useful for in-stack sampling when grain loading and/or particle size distribution is required. Fractionating particles aerodynamically in-stack provides information that is not available with other stack samplers. This information is important in determining the following:

1. Particle behavior after leaving the stack
2. Area of environmental deposition
3. Probable point of respiratory deposition
4. Type of control equipment needed to collect the particles
5. Collection efficiency of existing control equipment

*Meets requirements of OSHA for respirable/non-respirable segregation.

. Compliance with state and federal regulations

Location of the Stack Head is determined by individual stack characteristics. The most important criteria is to select sampling points whose effluents are representative of the entire stack. Normally, sampling is performed downstream from collection equipment to monitor collection efficiencies. Even wet plumes may be sampled by preheating and holding Stack Head temperature above the dew point.

• DESIGN

The Andersen Stack Sampling Head has been designed to operate with existing stack trains containing the "EPA type" pitobe by means of a minor modification to the pitobe. This permits use of existing stack samplers with or without the Andersen impactor depending upon the necessity of particle sizing for specific tests.

The Stack Head consists of a stainless steel case and ½ " NPT female pipe fittings. It is designed to be inserted directly into the stack (standard 3 inch opening) where high temperature and/or corrosive conditions may exist.

The Mark III (Figure 2) Andersen Stack Sampler contains nine jet plates, each having a pattern of precision-drilled orifices. Special collection substrates, (e.g., glass fiber, aluminum foil, etc., Fig. 3), placed on the jet/collection plates, permit lighter tare weights for gravimetric analyses and a variety of collection materials for chemical analyses. The Sampler may be used with or without the collection substrate. The nine plates, separated by 2.5 millimeter stainless steel spacers, the preseparator and the backup filter divide the sampler into ten fractions or particle size ranges. The jets on each plate are arranged in modified concentric circles which are offset on each succeeding plate. The size of the orifices is the same on a given plate, but is smaller for each succeeding downstream plate. Therefore, as the sample is drawn through the sampler at a constant flow rate, the jets of air flowing through any particular plate direct the particulates toward the collection substrate on the downstream plate directly below the circles of jets on the plate above. Since the jet diameters decrease from plate to plate, the velocities increase such that whenever the velocity imparted to a particle is sufficiently great, its inertia will overcome the aerodynamic drag of the turning airstream and the particle will be impacted on the collection substrate. Otherwise, the particle remains in the airstream and proceeds to the next plate. Since the particle deposit areas are directly below the jets, seven of the plates act as both a jet stage and a collection plate. Thus, No. 0 plate is only a jet stage and No. 7 plate is only a collection plate. All component parts are 310 stainless steel. The temperature limitation of the sampler is approximately 1500 degrees Fahrenheit without glass filter collection media, 1000°F with glass fiber collection media.

A stainless steel preseparator has been designed to fit directly into the upstream end of the stack head and should be used whenever sampling in stacks which have particles larger than 10 microns. The preseparator-impactor assembly will fit through a standard 3" port.

The Stack Sampler is designed to operate at 0.75 ACFM or less. An optimum flow rate is around 0.5 ACFM (Table I shows the effective cutoff diameter for each stage at various flow rates at 70°F).

The Andersen Stack Sampler is also available with teflon gaskets, aluminum plates and in six stage configurations for use in low temperature, non-corrosive atmospheres, or in low grain loading applications.

• OPERATION

A vacuum source is used to draw a sample of the stack's effluent stream through the Andersen Sampler. All particulates entrained in the air stream are inertially impacted on the preweighed collection surfaces. The size ranges of particles deposited on each stage are shown in Table I. It is recommended that the preseparator be used to remove the larger particles when conditions warrant and it is neces-

TABLE I

50% EFFECTIVE CUT DIAMETER

PARTICLE DENSITY = 1.0 gm/cc

AIR TEMP = 70.0°F

FLOW ACFM	STAGE NO. 0	CYCLONIC PRESEPARATOR	STAGE NO. 1	STAGE NO. 2	STAGE NO. 3	STAGE NO. 4	STAGE NO. 5	STAGE NO. 6	STAGE NO. 7
0.1	29.9	22.4	18.7	12.7	8.7	5.6	2.9	1.8	1.2
0.2	21.3	16.0	13.3	9.0	6.2	4.0	2.0	1.3	0.87
0.3	17.4	13.0	10.8	7.4	5.0	3.2	1.6	1.0	0.69
0.4	15.0	11.3	9.4	6.4	4.3	2.8	1.4	0.87	0.59
0.5	13.4	10.1	8.4	5.7	3.9	2.5	1.2	0.77	0.52
0.6	12.3	9.2	7.6	5.2	3.5	2.3	1.1	0.70	0.47
0.7	11.4	8.5	7.1	4.8	3.3	2.1	1.0	0.64	0.43
0.75	10.9	8.2	6.8	4.6	3.2	2.0	1.0	0.61	0.41

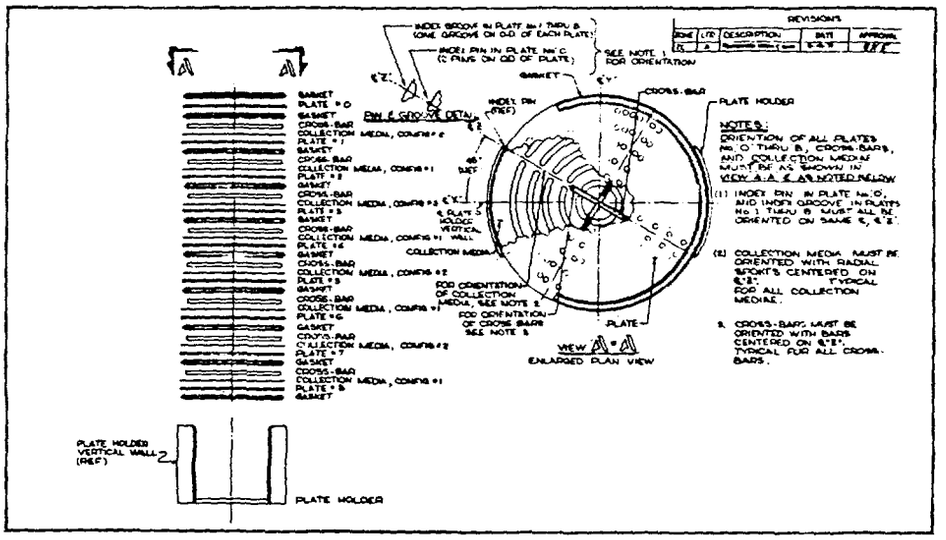


FIGURE 2
Shows glass fiber collection media with appropriate dimensions. In order to hold this media on the orifice-collection plates, stainless steel crossbars are used.

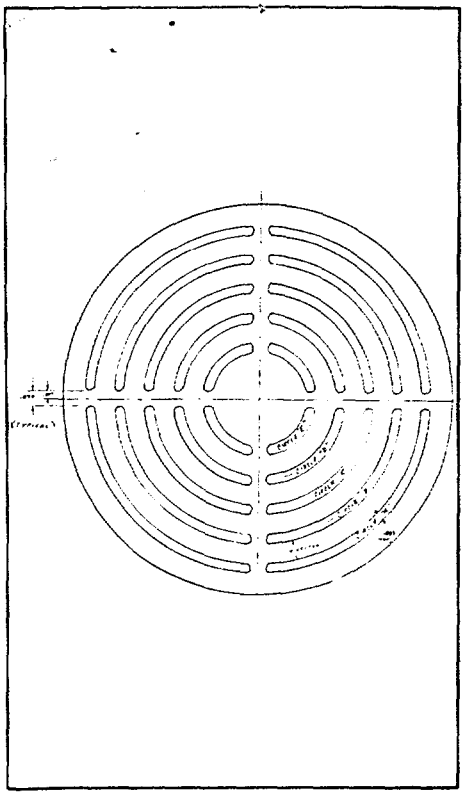


FIGURE 3

sary to use a backup filter always to ensure total collection.

Normally, whenever gravimetric analyses are to be performed, glass fiber collection media is used with the Mark III because of its non-hygroscopic properties. However, other collection substrates may be used if warranted by specific analytical requirements.

Since most particulates do have hygroscopic characteristics, all collection media used in the impactor should be preconditioned prior to weighing — both before and after a sampling cycle — in a desiccator.

For proper fractionation and sizing, the impactor should be operated at/or below 0.75 ACFM. Since the bulk of the sample (on a weight basis) is normally collected in the fractionator, the flow rate will remain constant throughout the sampling period.

Normal sampling periods vary from a few minutes to several hours in heavy and light grain loading situations respectively. Ten milligrams of particulate matter on any one plate represents an approximate upper limit because of reentrainment problems. Overloading the sampler can be detected easily by visual inspection and occurs more often during the first test at an unfamiliar stack. Reentrainment is minimized by use of the preseparator.

After the sampling cycle has been completed, the sampler is disassembled (Figure 4). The collection media and plates are removed and then desiccated. After desiccating, the collection media can be weighed for net particulate accumulations, or the particulate matter can be extracted by an appropriate solvent and analyzed chemically for the various components of interest.

It should be noted that whenever a sample has been collected, the particle sizing has already been completed. To determine the nature of the size distribution, simply perform the required gravimetric and/or chemical analyses.

• DATA PRESENTATION

To determine the concentration of particulates for any size range, first determine the percentage of total particles for each stage. Then the cumulative percentage is determined beginning with the last stage of the impactor (See Table II).

From Figure 5 it can be seen that approximately 84% of this hypothetical sample is respirable. More than 20% of the sample is submicron. By plotting the effective cutoff diameter (ECD) and the cumulative percent on logarithmic probability graph paper, then the particle concentration by weight for any specific size can be determined. (Figure 5).

TABLE II
TEMP. ≈ 300° F

FLOW RATE (ACFM)	STAGE	TARE (g)*	FINAL (g)	NET (mg)	%	CUM % LESS THAN	ECD (microns)
0.6	0	0.1000	0.1060	6.00	12.0	88.0	13.6 and above
0.6	1	0.1000	0.1020	2.00	4.0	84.0	8.6
0.6	2	0.1000	0.1010	1.00	2.0	82.0	5.6
0.6	3	0.1000	0.1030	3.00	6.0	76.0	4.0
0.6	4	0.1000	0.1060	6.00	12.0	64.0	2.5
0.6	5	0.1000	0.1080	8.00	16.0	48.0	1.3
0.6	6	0.1000	0.1100	10.00	20.0	28.0	0.80
0.6	7	0.1000	0.1100	10.00	20.0	8.0	0.54
0.6	Backup filter	0.1100	0.1040	4.00	8.0	0	0.54
				50.00			

*NOTE: Collection substrates will seldom weigh exactly the same.

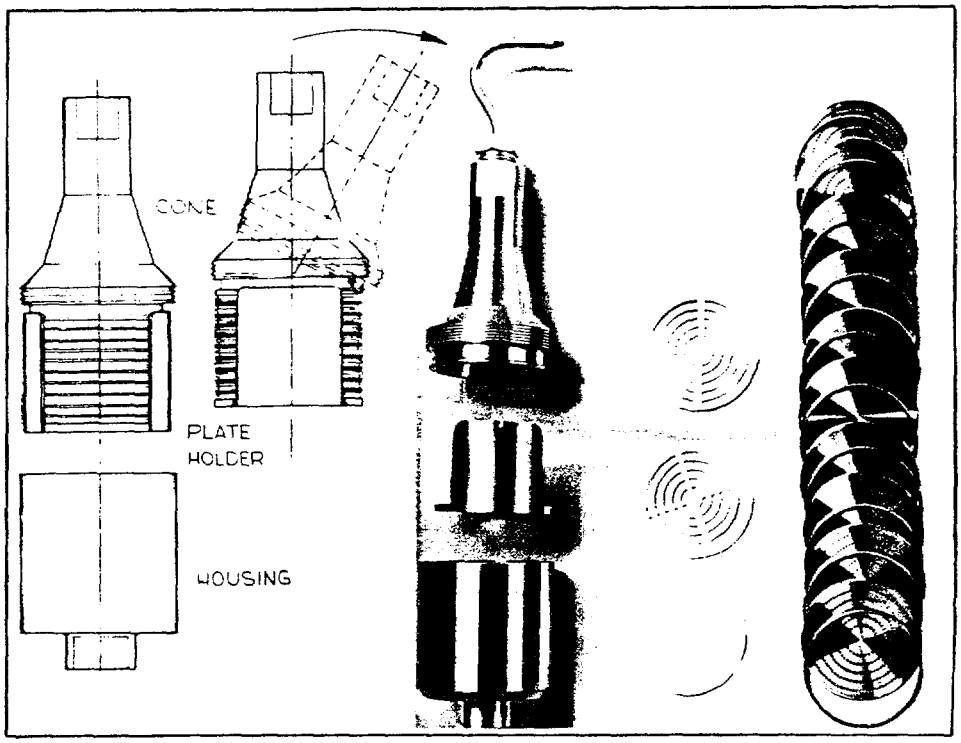


FIGURE 4

Company: _____

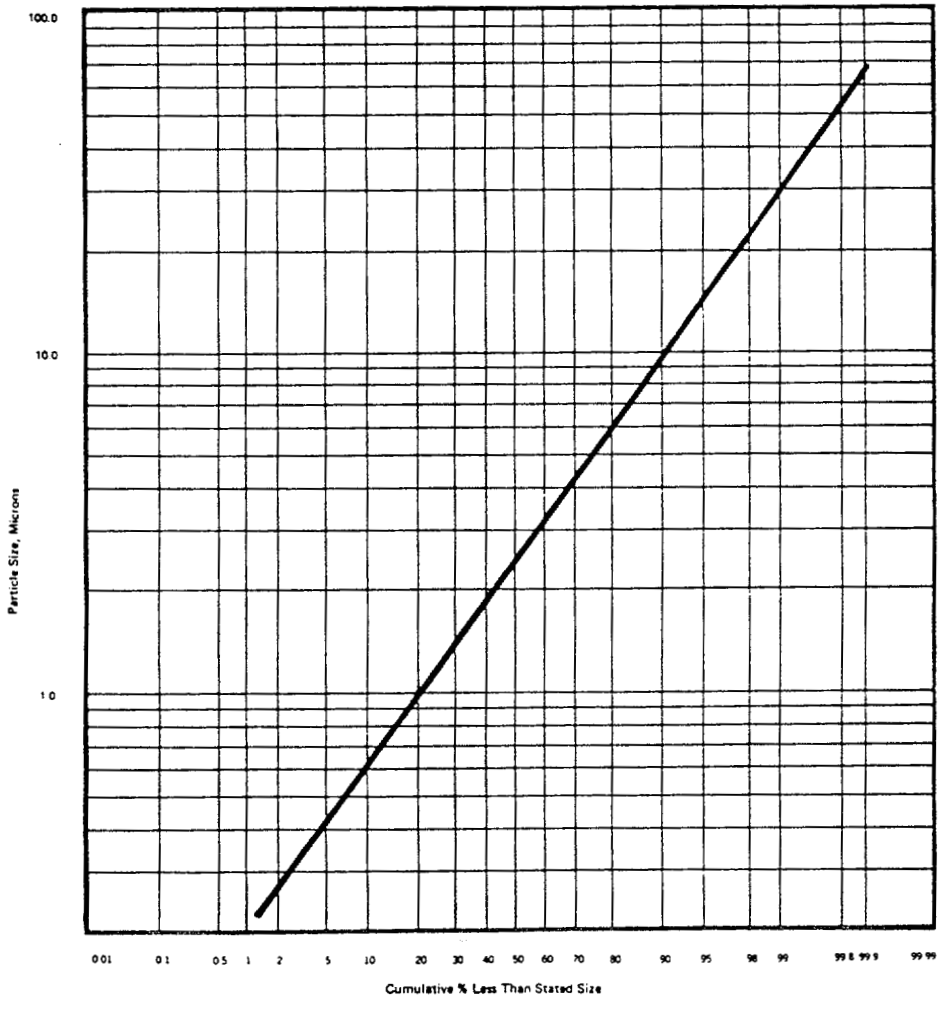
Application: _____

Particle Size Distribution Data:

FIGURE 5
PARTICLE SIZE DIAMETER

1. Source. _____
2. Method of Determination: _____
3. Data: _____

Particle Diameter (Microns)	Percent in Size Range	Cumulative Percent Less Than
13.6	12.0	88.0
8.6	4.0	84.0
5.6	2.0	82.0
4.0	6.0	76.0
2.5	12.0	64.0
1.3	16.0	48.0
0.8	20.0	28.0
0.54	20.0	8.0
0.54	8.0	0



• ORDERING INFORMATION

Specify all units by full name and catalog number.

• OTHER SAMPLING EQUIPMENT

Andersen manufactures and supplies a complete line of multi-orifice, multi-stage impactors for sampling in all environmental areas in addition to a line of air pollution control equipment. Write or call the toll free number for details on other Andersen Equipment.

GRASEBY ANDERSEN

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Bulletin 176-2