EFFICIENCY OF FOG-TYPE DUST COLLECTORS AT LOW DUST LOADINGS

1x R

A THESIS

Presented to

the Faculty of the Graduate Division

by

Charles Reynolds Kernan, Jr.

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Mechanical Engineering

Georgia Institute of Technology

June 1952

ACKNOWLEDGEMENTS

I wish to acknowledge the help and assistance of Mr. F. A. Thomas, Jr. who suggested this problem and who guided the work to its completion. I would, also, like to thank Dr. J. M. DallaValle and Dr. M. J. Goglia for their advice and helpful suggestions during the study.

EFFICIENCY OF FOG-TYPE DUST COLLECTORS

AT LOW DUST LOADINGS

Approved:

Date Approved by Chairman: 25 June 1952

TABLE OF CONTENTS

		Page
Acknowledgments		ii
List of Tables		iv
List of Figures		v
SUMMARY		1
CHAPTER		
I.	INTRODUCTION	2
II.	MECHANISM OF COLLECTION	8
III.	APPARATUS	11
IV.	PROCEDURE	16
V.	DISCUSSION OF RESULTS	20
VI.	CONCLUSIONS AND RECOMMENDATIONS	26
	BIBLIOGRAPHY	30
	APPENDIX A - Method of Handling Data	32
	APPENDIX B - Experimental Results	34

LIST OF TABLES

Table		Page
I.	Data and Results for Fog-Type Dust Collector	35
II.	Efficiency Results	39

LIST OF FIGURES

Figure | Page

1. Sketch of Test Set-Up 12
2. Sketch of Fog-Type Dust Collector 14
3. Concentration Calibration Curve 19
4. Efficiency versus Air Flow 22
5. Efficiency versus Dust Loading 23
6. Inlet Dust Loading versus Air Flow 24
7. Outlet Dust Loading versus Air Flow 25
8. Particle Size Distribution 28

EFFICIENCY OF FOG-TYPE DUST COLLECTORS AT LOW DUST LOADINGS

SUMMARY

An investigation was made of the effectiveness of the fog-type dust collector at low dust loadings. The dust used was Georgia Kaolin clay and the impinger method was used for collecting samples at the collector inlet and discharge. The samples were evaluated by using a Beckman type B spectrophotometer. This proved to be a fast and accurate method for determining the concentrations of the samples.

The performance of the collector was observed at various rates of air flow and dust loadings. The water pressure and rate of flow were held constant.

The collection efficiency reached a maximum at air flow rates of between 450 and 500 cubic feet per minute for the three ranges of low dust loadings used. This led to the conclusion that the optimum air flow rate depends on the physical size of the collector and that the collector must be designed for required air flow rates.

The effect of dust loading on the collection efficiency was slight except for the very low dust loadings. For loadings of from one grain per cubic foot to five grains per cubic foot the efficiency was almost constant.

CHAPTER I

INTRODUCTION

The application of water as a means of separating dust from air is perhaps the oldest of the many methods used at the present time. As early as 1713,[1] a British patent was issued for a wet dust control device. Wet methods have always found great favor in industry and possess many inherent advantages over other methods devised in recent years. However, they were never regarded as completely satisfactory due to relatively low efficiencies of collection obtainable. Until the advent of the high pressure nozzle which permitted better contact between the solid particles and the water droplet, wet methods could only be regarded as satisfactory for the removal of large, easily wetted materials. The high pressure spray, capable of producing a fine, fog-like mist has radically changed opinions regarding the efficiencies of wet methods and we find in modern industry an increasing application of wet collectors for handling difficult dust control problems.

There are many important applications of wet methods in industry. They are to be found extensively in the mining field for suppressing dust produced by drilling operations. But by far the largest application appears to be in handling problems associated with explosives manufacture, in the grinding of magnesium and to a considerable extent in

---

1. P. Drinker and T. Hatch, Industrial Dusts. New York: McGraw-Hill, 1936. p. 172.

handling highly dangerous dusts produced in namufacture of components containing beryllium. In general, wet methods may be divided into three broad classes. These are: (a) pulling dust-laden air through a container of water, (b) passing dust-laden air through a tower packed with many irregular pieces which are kept wet, and (c) passing dust-laden air through high or low pressure sprays.

High pressure spray or fog-type collectors are manufactured in the United States where they are advertised as "Fog-Filters".[2] The manufacturer claims high efficiencies for the collection of fine particulate matter of less than ten microns in size and that the filter is less costly than bag houses or electrostatic precipitators of comparable efficiency.

Object of investigation - The object of this investigation was to determine the effectiveness of high pressure spray in fog-type collectors by determining to what extent varying the air flow and dust loading affects the collection efficiencies in a small collector.

The high pressure spray or fog-type collector, a form of which we are concerned with in this thesis, is a relatively new development in the field of mechanical dust collection. As yet, it has not attained extensive application and has received only limited discussion in engineering literature. There are no design data or performance characteristics for fog-type collectors cited in engineering texts or handbooks or any mention of this type or collection equipment.

2. The R. C. Mahon Company, Detroit 34, Michigan.

With increasing emphasis being placed on air pollution it becomes necessary to develop equipment that will give high efficiencies with light loadings and to determine the effectiveness of existing collectors with these same light loadings. This investigation was undertaken to determine the effectiveness of the fog-type collector with light dust loadings.

Survey of literature - There is little published information regarding the performance of high pressure spray or fog-type collectors. In 1931,[3] Albrecht discussed the deposition of dust on cylinders and applied his findings to fiber filters. He showed that very small particles do not deposit at all on the cylindric surface but are taken around the much larger collector by the air flow. Later in 1931,[4] Sell extended this work and showed experimentally the deposition of dust on cylinders. Sell describes a simple method for visualizing deposition on simple bodies and evaluates the results. Both of these authors considered only inertia as the primary mechanism of collection with application to large particles and collectors and assumed potential flow to gain theoretical information. Ranz,[5] in 1951, showed that for particles in the micron and submicron ranges of size and for collectors applied

---

3. F. Albrecht., "Theoretical Investigation of Dust Deposition From Flowing Air and Its Application to the Theory of the Dust Filter", Physikalische Zeitschrift, 32 (1931). 48-56 Translation by P. J. Domotor, University of Illinois (1951).

4. W. Sell, " Dust Precipitation on Simple Bodies and in Air Filters", Forchung Auf Dem Gebiete Des Ingenieurwesens Ausgabe B, 2 (1931). Nr. 347 Translation by P. J. Domotor, University of Illinois (1951).

5. W. E. Ranz, "The Impaction of Aerosol Particles on Cylindrical and Spherical Collectors", Technical Report No. 3 Engineering Experiment Station University of Illinois (1951).

to the micron range of size, interception, electrostatic attraction, and random molecular motion are important mechanisms of collection, as well as inertia. Ranz analyzed the impaction of small particles on cylindrical and spherical collectors in terms of these forces which affect the motion of a particle and cause it to move from an aerosol onto a collecting surface.

Rodebush presented a general discussion on the filtration of aerosols in 1950.[6] His discussion covers direct interception, effects of Stokes's law deposition, inertial effect, and diffusion of small particles and deals primarily with filters made up of fibers.

The atomization of liquids has long been of interest to investigators and because of the wide field of application, a number of papers have appeared on the subjects of sprays and spray nozzles.

In 1931,[7] Castleman showed that drop size decreases with increasing air speed in a venturi throat. He found that a relative velocity of 390 feet per second produced a minimum mean droplet size of six microns and that velocities above this speed did not change the size distribution appreciably.

Johnstone investigated,[8] in 1939, the performance of spray towers for gas absorption. He found that the free fall of liquid spray

---

6. W. H. Rodebush, Handbook on Aerosols. Washington, D.C.: Atomic Energy Commission, 1950. pp. 117-122.

7. R. A. Castleman, Jr. "The Mechanism of the Atomization of Liquids", U.S. National Bureau of Standards Journal of Research, 6 (1931). 369-376.

8. H. F. Johnstone. "Absorption of Gases by Liquid Droplets", Industrial and Engineering Chemistry, 31 (1939). 993-1001.

was more effective than wetted surfaces and reported results with droplet sizes down to about 50 microns. In 1949,[9] he extended his work to cover the smaller droplets and the applications of these small droplets to dust collection. Possible effects that would be produced by atomizing liquids were mentioned and these included Brownian motion and electrostatic effects.

Lane,[10] in 1951, reported results of a series of experiments on shattering of liquid droplets with air blasts. His data indicate that a velocity of about 78 to 115 feet per second is required to shatter a 50 micron droplet. Sonic and supersonic velocities failed to reduce the mass median size below 15 microns. Although Lane does not give the size distribution, it is probable that a large percentage of the droplets are of the submicron size.

Another group of investigators have shown interest in physical properties of drops. Of these investigators, Arabadji,[11] in 1949, was able to arrive at an equation which describes the change associated with small polar liquid drops. This change, however, will vary depending upon the content of certain salts and acids and may be less than or of opposite sign from that of the pure liquid.

---

9. H. F. Johnstone and W. H. Roberts. "Deposition of Aerosol Particles from Moving Gas Streams", Industrial and Engineering Chemistry, 41, (1949). 2417-2423.

10. W. R. Lane. "Shatter of Drops in Streams of Air", Industrial and Engineering Chemistry, 43 (1951). 1312-1317.

11. V. T. Arabadji. "The Electrolyzation of Liquids During Their Dispersal Atomization", Kolloid Zhurnal, 7 (1949). 209-210.

In 1951,[12] Ekman and Johnstone describe collection efficiencies for the venturi scrubber in terms of the specific area of drops produced in the venturi throat (square feet of drops per cubic foot of gas). They showed that the mechanism of impaction becomes predominant when the particle diameter is much above 0.1 micron and the impaction efficiency can be increased for any given particle size by increasing the gas velocity and decreasing the size of the impacting object, in this case the water droplets.

Hudson,[13] in 1949, presented some information about the collection of dusts, mists, fumes and odors by the use of high pressure water spray or fog. He tells of the evolution of the "Fog Filter", explains its operations, and gives collection efficiencies for some installations. Hudson indicates the factors for collection in the "Fog Filter" are a high degree of wetting and centrigugal action on the wetted particles.

---

12. F. O. Ekamn and H. F. Johnstone. "Collection of Aerosols in a Venturi Scrubber", Industrial and Engineering Chemistry, 43 (1951). 1358-1363.

13. D. G. Hudson. The Principle of the Fog Filter Unpublished Paper presented at the Tenth Annual Meeting of the American Industrial Hygiene Association, 1949.

CHAPTER II

MECHANISM OF COLLECTION

The mechanism of collection in the fog-type dust collector depends on several factors. These are wetting of the small particles, centrifugal action, combined effects of the wetting and centrifugal action, and random impaction.

The wetting of the particles is more easily accomplished when the water droplets are of small size such as in water fog. These small water droplets wet a non-water soluble particle more readily than a large water droplet.

Small particles with diameters of less than 10 microns are difficult to collect in a cyclone collector because these small particles do not have enough mass to be centrifuged out of the air. A wetted small particle would have more mass than a non-wetted one and small water droplets in the order of magnitude of 10 microns have the ability of wetting these small particles. The fog-type collector takes advantage of this by combining a cyclone action with the wetting ability of small water droplets. Wetting of the small particles not only gives them greater mass but causes agglomeration of the particles. These agglomerates are more readily collected by the centrifugal action.

The small water droplets are generated in the fog-type collector by passing water through nozzles at high pressures. These nozzles are arranged to discharge at a common angle and this action rotates the air mass in the collector about the axis of the collector at a high angular velocity. The air stream enters the collector nearly tangentially and this increases the angular velocity. A sketch of the collector is shown in Figure 2. It is now possible to throw the small wetted particles to the wall of the collector where they become part of the liquid effluent draining to the base of the collector.

No doubt random impaction plays a large part in the mechanism of collection in the fog-type collector. When the diameters of the collecting water droplets and the small dust particles are of the same order of magnitude, there is greater chance for impaction. If the dust particles were small and the water droplets large, the small dust particles would be carried around the large water droplets by the air and there would be very little impaction.

Efficiency - It is well to introduce at this point a criterion of comparison of the performance of dust collectors. Perhaps, the best comparison of various types of dissimilar collection equipment is found in the simple ratio of the weight of dust collected by the apparatus to the total weight of dust imput. Common usage in dealing with performance of collectors in general appears to justify the arbitrary choice of the definition of efficiency of the following form.

$$E = \frac{W_2}{W_1}$$

where: W_2 = weight of dust collected,

W_1 = weight of dust imput.

The ratio W_2/W_1 will be called collection efficiency in this thesis.

Perhaps later after the detailed mechanisms of collection at play in such a unit as this are understood, a definition of efficiency more consistent with these mechanisms would presumably result.

CHAPTER III

APPARATUS

Air was induced by a Buffalo Forge Company paddle-wheel type fan through a 30-inch verticles section of 8-inch diameter duct, a 90-degree elbow and 18 feet of horizontal 8-inch diameter duct.

The dust feeder was located at the entrance of the vertical duct. This arrangement permitted light dust loads of small particles since heavy particles and agglomerates dropped out of the air stream in the vertical section of duct. The 31 diameter mixing length prior to the initial sampling point was considered sufficient to give adequate mixing of the dust and air before sampling.

The clean air stream was discharged through a 10-foot horizontal run of 8-inch diameter duct after passing through a 90-degree elbow. The air was metered by a thin plate orifice and a U-tube manometer. A by-pass system consisting of two 8-inch diameter positive shut-off slide dampers was used to regulate the air flow through the collector. The air was discharged outside the building. A sketch of the test set-up appears in Figure 1.

<u>The fog-type collector</u> - The collector was of sheet steel construction with a diameter of 3 feet and a height of 4 feet. Five rows of six nozzles each were spaced throughout the height of the collector in a parallel horizontal planes to discharge at a common angle of

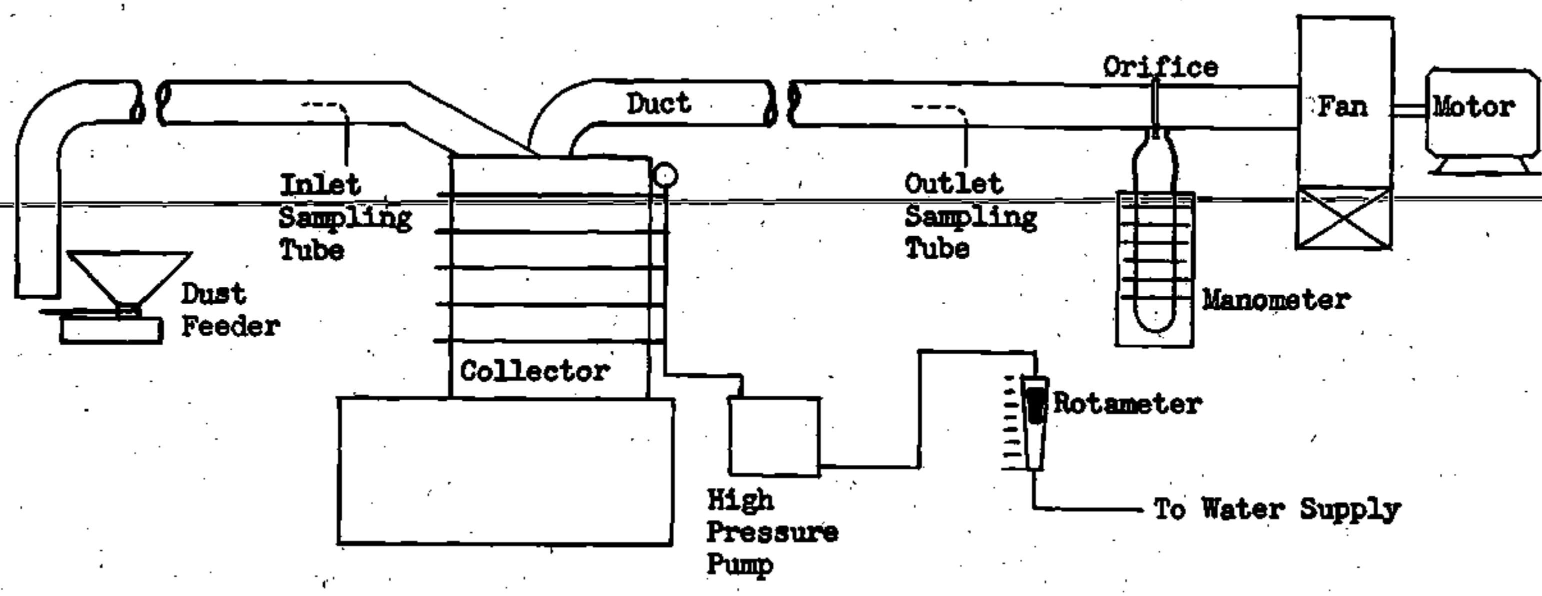

Figure 1

Georgia Institute of Technology
School of Mechanical Engineering
SKETCH OF TEST SET-UP
C. R. Kernan, Jr. June 1952

approximately 45 degrees concurrent with rotation of air in the collector. John Bean number $2\frac{1}{2}$ hard center nozzles were used. A valve on each row of nozzles provided shut-off control of the water flow to the nozzles. A pressure gage with a range of zero to 500 pounds per square inch was installed on the piping for the valves.

The 8-inch diameter air entrance duct was arranged tangential to the outer casing at the top of the collector and at a downward angle from the horizontal. The 8-inch diameter air discharge duct was arranged concentric to the outer casing and extended down into the collector for a distance of 40 inches ending in a bell shaped opening.

At the base of the collector was a large rectangular tank filled with water which served as a water seal and receptacle for the solids removed from the air. A small condensate pump was used to maintain constant a level of liquid in the tank. A sketch of the collector is shown in Figure 2.

High pressure water pump - A Vickers variable delivery piston type pump with handwheel control was used to provide the water at pressures necessary to generate the fog in the collector. This pump was connected between the city water supply and the collector with 3/4-inch diameter steel pipe. A shut off valve and rotameter were installed on the inlet piping. A bypass valve and a pressure relief valve were installed on the high pressure discharge piping between the pump and the collector.

Dust feed - A Jeffrey Traylor electric vibrator dust feeder was used. Dust flow rate was controlled by regulating the area of discharge from

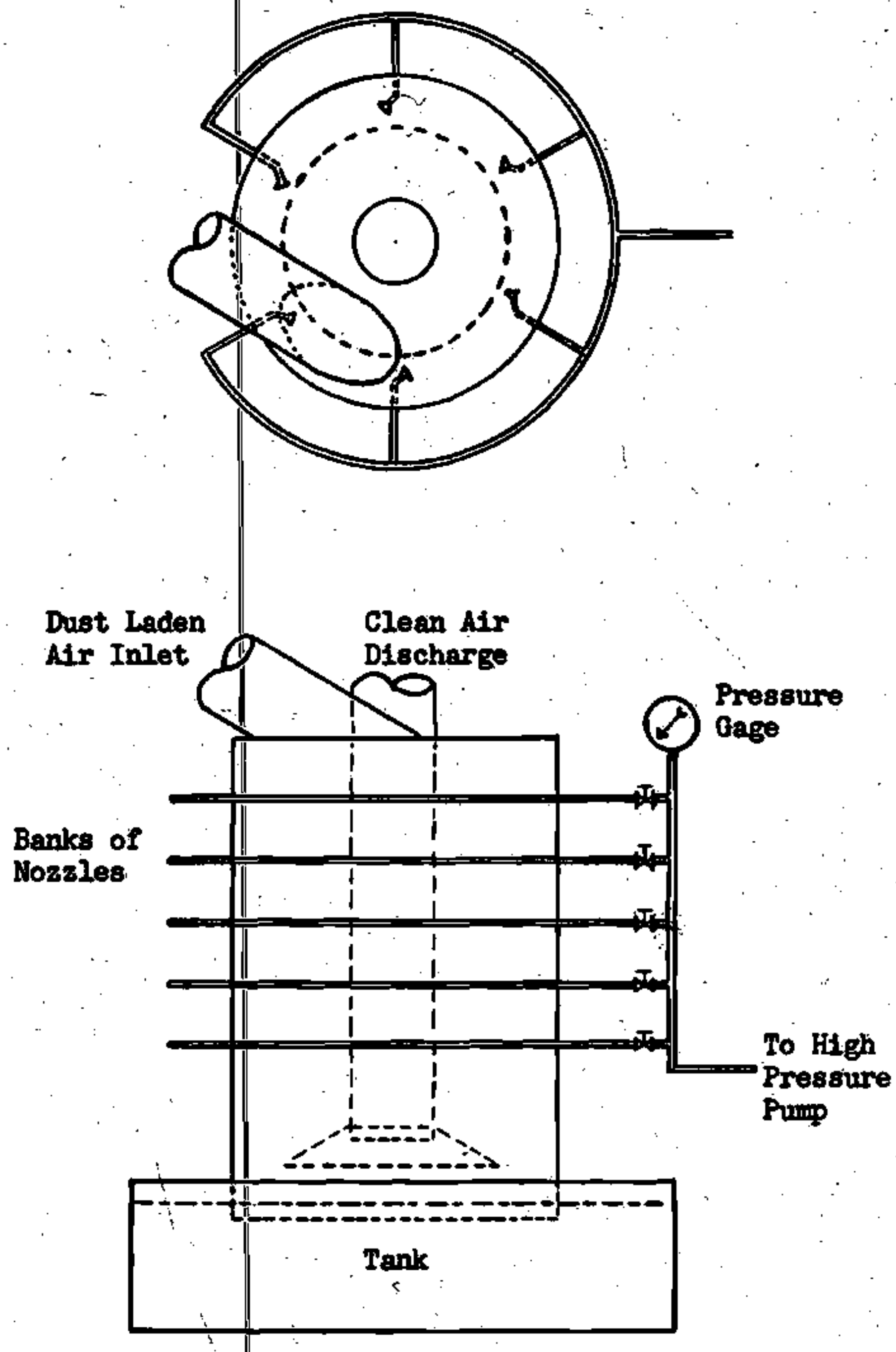

Figure 2

Georgia Institute of Technology
School of Mechanical Engineering
SKETCH OF FOG-TYPE DUST COLLECTOR
C. R. Kernan, Jr.   June 1952

the hopper. Dust was fed into the air stream from a vibrating tray.

Sampling - A Willson impinger pump, an all glass impinger and a pitot sampling tube were used to collect the samples at both collector inlet and discharge. The sampling tubes, which were made from $\frac{1}{4}$-inch diameter copper tubing, were located one foot upstream from the collector and five feet upstream from the orifice. Sampling at duct center line was used at both sampling locations.

The samples were transferred to small glass jars and later analysed with a Beckman type B spectrophotometer.

CHAPTER IV

PROCEDURE

Method of test - The fan was started and the by-pass dampers adjusted to give the required air flow for the run. The dust feeder was then turned on and adjusted to the desired feed rate. It was then turned off until the beginning of each run.

The high pressure pump was then started. The water flow and pressure were regulated by means of the handwheel control on the pump, and using a rotameter as an indicator by controlling the number of banks of nozzles. The small condensate pump was then started to prevent overflow of the tank. The water flow and pressure were held constant throughout all of a series of runs. It was necessary to adjust the air flow after starting the pump since the tangential spray discharge will in itself act as an air mover.

The sampling tubes were inserted in the ducts and connected to the impingers after steady flow was obtained.

The air flow and water flow and pressure were rechecked during the runs.

With everything in order, the dust feeder was placed in operation and the two impinger pumps were started simultaneously and timed with a stopwatch.

At the end of the run, five minutes for the first two series of runs and three minutes for the last two, impinger pumps and the dust feeder were stopped; the high pressure water pump was shut down; and the fan stopped - in that order.

Sampling procedures as given in an information circular of the United States Department of the Interior - Bureau of Mines were used,[14] with the exception of isokinetic conditions. The time of sampling was the same as the length of the run. The samples were removed from the impingers and stored in glass sample jars to await evaluation in the laboratory. Sampling tubes were cleaned by blowing them out with compressed air after each run to prevent any dust remaining in the tubes being collected in the next sample.

This procedure was repeated for each run. Four series of tests were made with four runs to a series making a total of sixteen runs. A test was made at 200, 400, 600 and 750 cubic feet per minute while the dust loading was varied for each run in the series.

Evaluation of samples - Since a pure dust was fed into the system and the samples were mixtures of only water and Georgia Kaolin clay of known size distribution, the spectrophotometric method could be used for determining the concentrations of the samples.

Several solutions of different know concentrations were prepared and compared with distilled water in a Beckman type B spectrophotometer. Measurements of optical density were made. The resulting values of op-

---

14. C. E. Brown and H. H. Schrenk. "A Technique for the Use of the Impinger Method", Information Circular 7026 United States Department of the Interior - Bureau of Mines. (1938).

tical density were plotted against the respective known concentrations to obtain a calibration curve for the dust used. This curve was used to evaluate unknown concentrations of the samples taken.

The samples were compared with distilled water and the optical density of each was recorded. The concentrations of the samples were obtained from the calibration curve. For example, a sample with an optical density of 0.56 would have a concentration of 0.61 grams of dust per liter of water. This gives a dust loading of 3.14 grains of dust per cubic foot of air.

The calibration curve is shown in Figure 3.

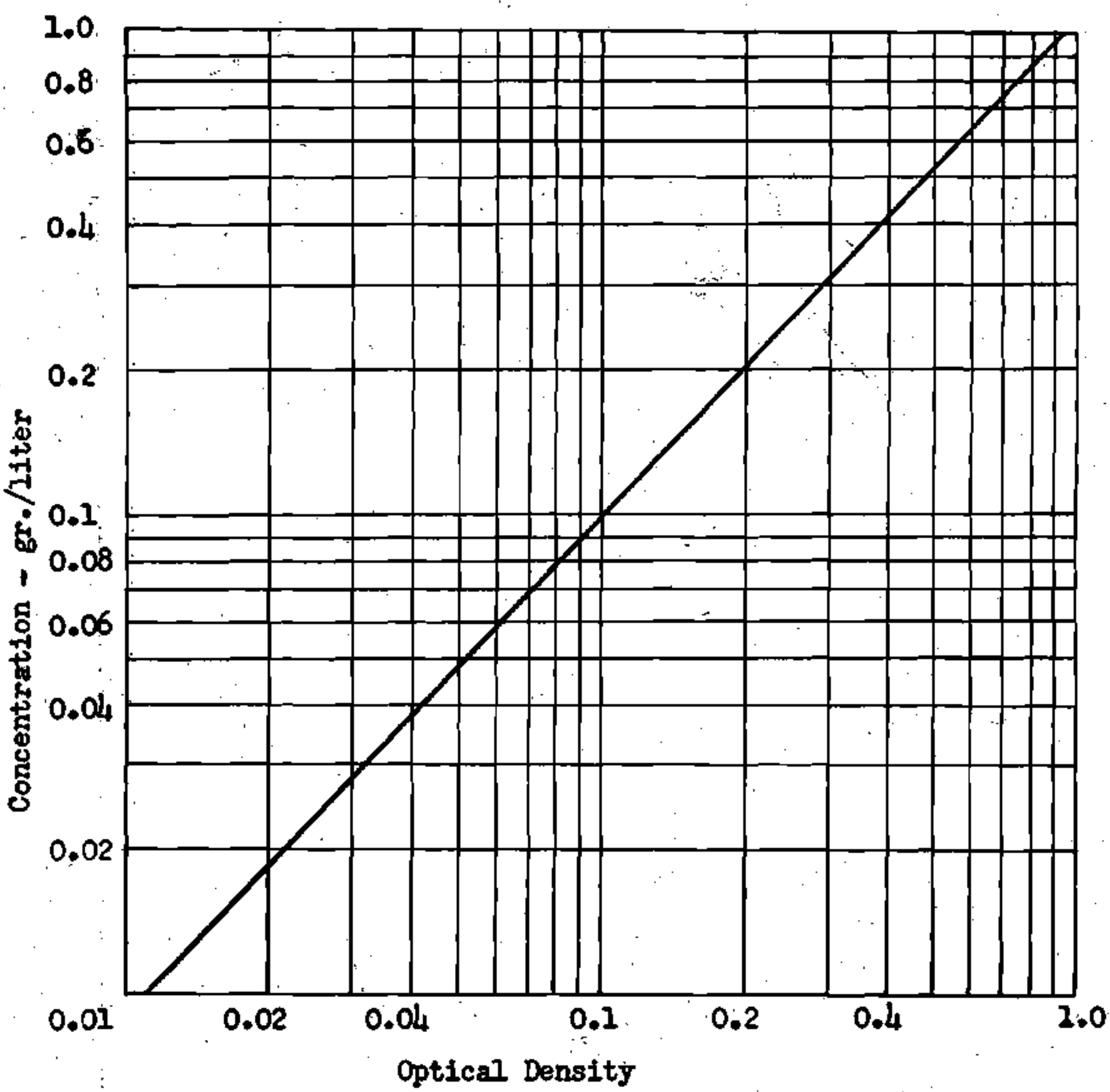

Figure 3

Georgia Institute of Technology
School of Mechanical Engineering
CONCENTRATION CALIBRATION CURVE
C. R. Kernan, Jr. June 1952

CHAPTER V

DISCUSSION OF RESULTS

Data for the fog-type dust collector were taken in order to determine the effect of certain variables on the efficiency of the collection. These factors were by no means the only ones thought to affect the collection. However, the number of variables that could be investigated was limited by the time available and the scope of a work of this kind. The factors selected for study were air flow and light dust loads.

The air flow was held constant for each series of runs. An attempt was made to have the same dust loading for corresponding runs of each series. This was very nearly impossible as it was difficult to control the rate of dust feed accurately with the dust feeding arrangement used.

The difficulty in setting the dust loadings at desired values made it necessary to arbitrarily set up three ranges of loadings to evaluate the data. The range of zero to one grain of dust per cubic foot of air flow is called the low range of dust loadings, whereas the ranges of one to two and two to six grains of dust per cubic foot of air flow are called middle range and high range respectively. These ranges are designated LR, MR and HR, respectively, to better illustrate the curves. All three ranges fall well within the region of light dust loads for collectors.

The effect of varying the air flow on the efficiency of collection was observed to be the factor of greater importance; see Figure 4. These curves have dust loading as a parameter, each plot representing the effect of air flow for a particular range of dust loadings. Each of the curves is concave downward with a maximum at some value between 450 and 550 cubic feet per minute air flow. There appears to be no great effect of air flow for the different ranges of dust loadings as the curvature does not differ greatly.

It was thought that the effect of varying dust loads would be the more important factor. As can be seen from the plot of efficiency versus dust loading, Figure 5, the curve flattens out at a value of 95 per cent and remains fairly constant for the middle and high range of dust loadings. The effect was very pronounced in the low range as can be seen from the plot.

Figures 6 and 7 are plots of dust loading versus air flow for the three ranges of dust loadings. The ranges of the dust loadings at the inlet were used to identify the ranges at the outlet and these are designated LR, MR and HR on the curves. This was done to obtain data for the curves in Figure 4. It is observed that no points appear at 200 cubic feet per minute for the high range of dust loadings. This is attributed to difficulty encountered in regulating the dust feeder. More runs would have been made to secure data for these points had the high pressure water pump not failed.

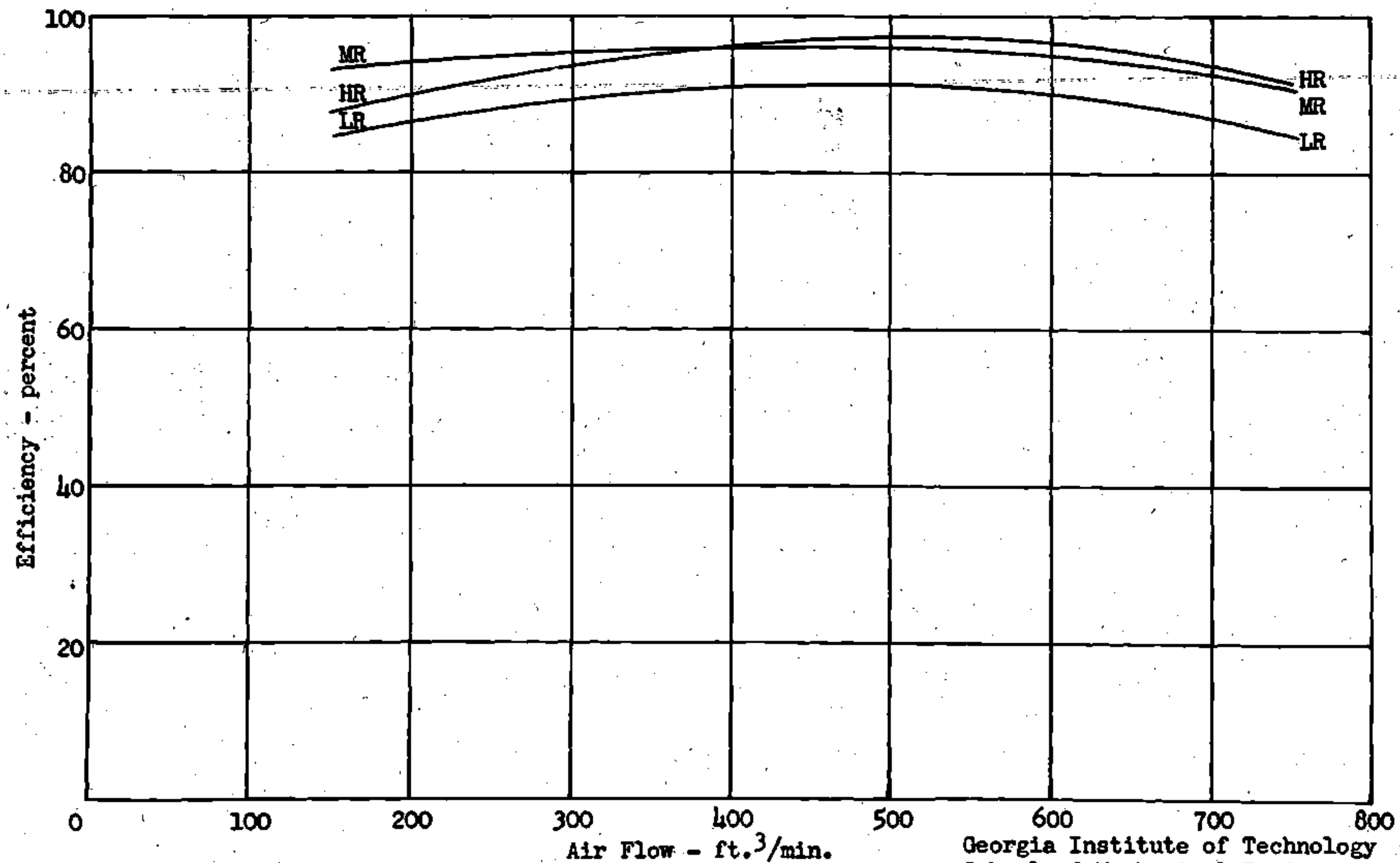

Figure 4

Georgia Institute of Technology
School of Mechanical Engineering
EFFICIENCY versus AIR FLOW
C. R. Kernan, Jr. June 1952

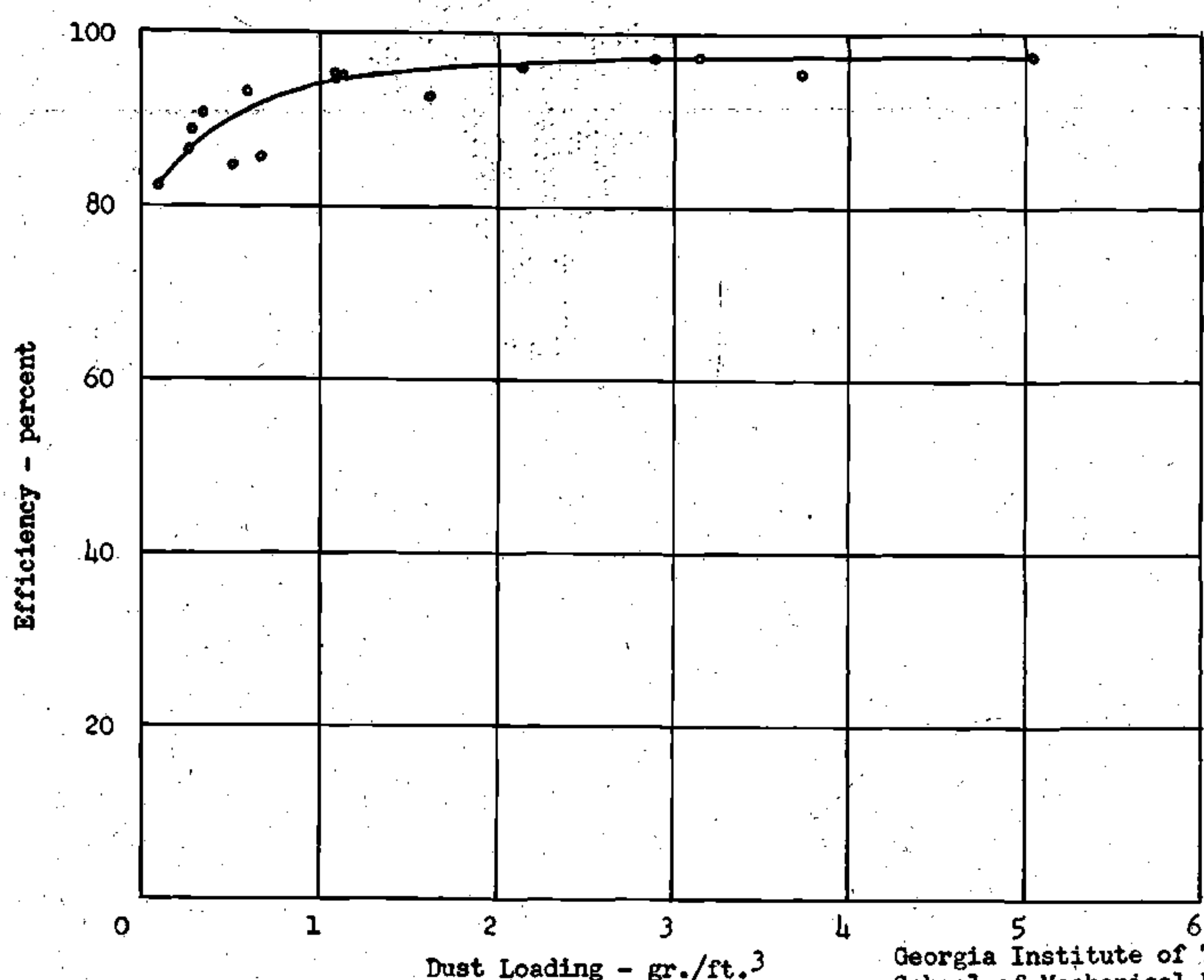

Figure 5

Georgia Institute of Technology
School of Mechanical Engineering

EFFICIENCY versus DUST LOADING

C. R. Kernan, Jr. June 1952

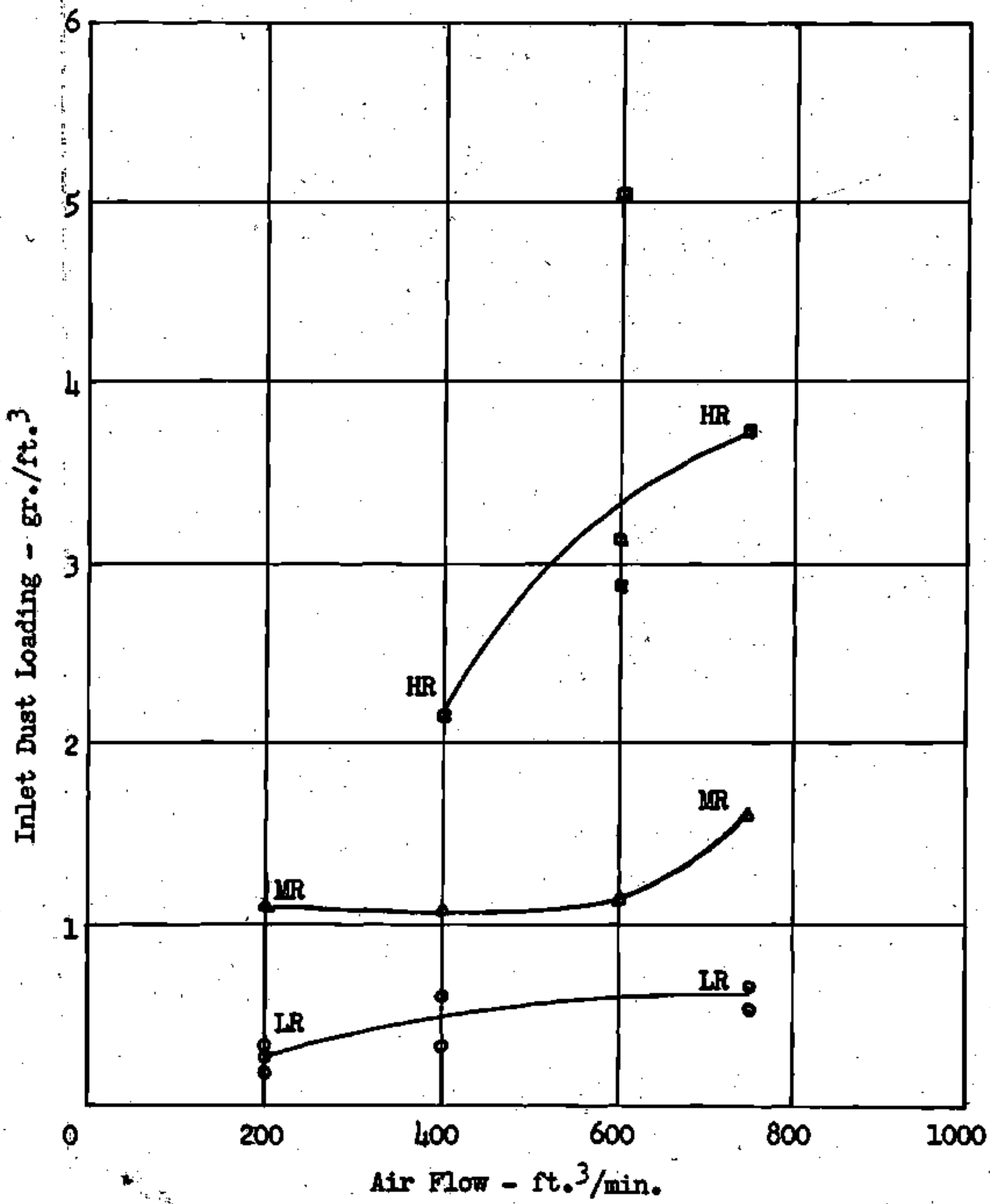

Figure 6

Georgia Institute of Technology
School of Mechanical Engineering
INLET DUST LOADING versus AIR FLOW
C. R. Kernan, Jr. June 1952

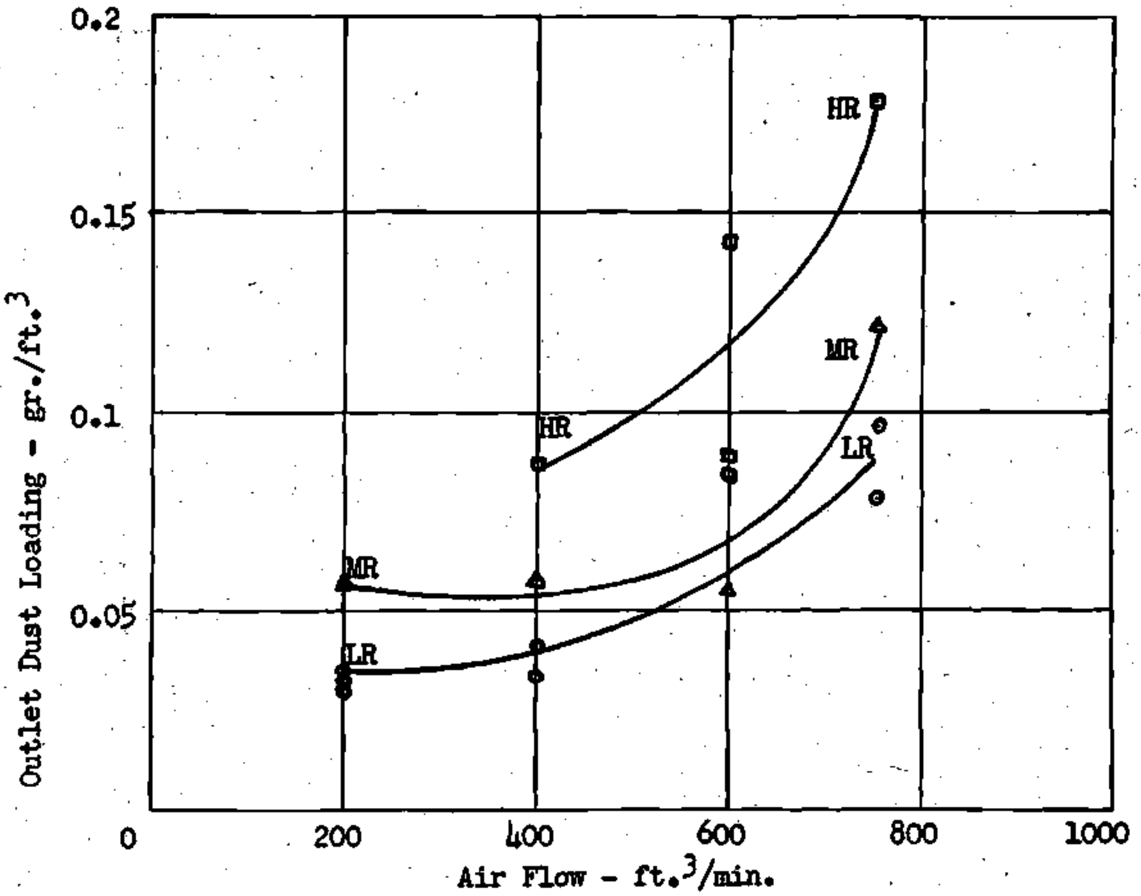

Figure 7

Georgia Institute of Technology
School of Mechanical Engineering
OUTLET DUST LOADING versus AIR FLOW
C. R. Kernan, Jr. June 1952

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions - If one considers the collection efficiency in the light of the results obtained in this study, the following conclusion may be drawn. The maximum collection efficiency occurred at an air flow of from 450 to 500 cubic feet per minute. This seems to indicate that the geometry of the fog-type dust collector is a factor that must be considered and the collector must operate at its designed rate of air flow for peak efficiencies. Lacking data for comparison one might conclude from these results of the effects of varying the air flow that for higher rates of air flow, a larger collector would be required.

Since the effect of varying the dust loading produced essentially a high constant efficiency of collection except in the low range of the light dust loadings, one might conclude that the fog-type dust collector is very effective for the light dust loadings encountered in air pollution control. The fog-type dust collector with an average collection efficiency of 90 per cent in the low range and 95 per cent in the middle and high ranges compares most favorably with other types of equipment used for collection at light dust loadings.

Recommendations - Only two of the many variables thought to affect the effectiveness of the fog-type collector have been investigated and these results are not conclusive without further investigation. A trend has been extablished and the recommendation is made that several of the other variables be investigated to establish their individual effect.

The effect of heavier dust loadings on efficiency must be examined. Also, a higher capacity fan would be desirable to extend the range of air flows.

One of the controlling variables, and perhaps the most important, is the water pressure at the nozzles. This investigator was limited to maintaining a constant water pressure because of inadequate equipment. The recommendation is made that a suitable high pressure water pump and high pressure flow measuring device be obtained. The effects of higher water pressures to produce smaller spray droplets (which should be measured) and of increasing water flow rates should be examined.

Different dusts could be used in further investigations. In this study the dust consisted of Georgia Kaolin clay with a median particle size of 5 microns as determined by the sedimentation method.[15] The size analysis was performed by the Micromeritics Laboratory at the Georgia Institute of Technology. The size distribution curve is shown in Figure 8. An entire thesis could be submitted on the effects of dusts of various densities, size, settling velocity, specific surface and so forth.

---

15. J. M. DallaValle, Micromeritics. Second Edition; New York: Pitman Publishing Corporation, 1948. pp. 80-84.

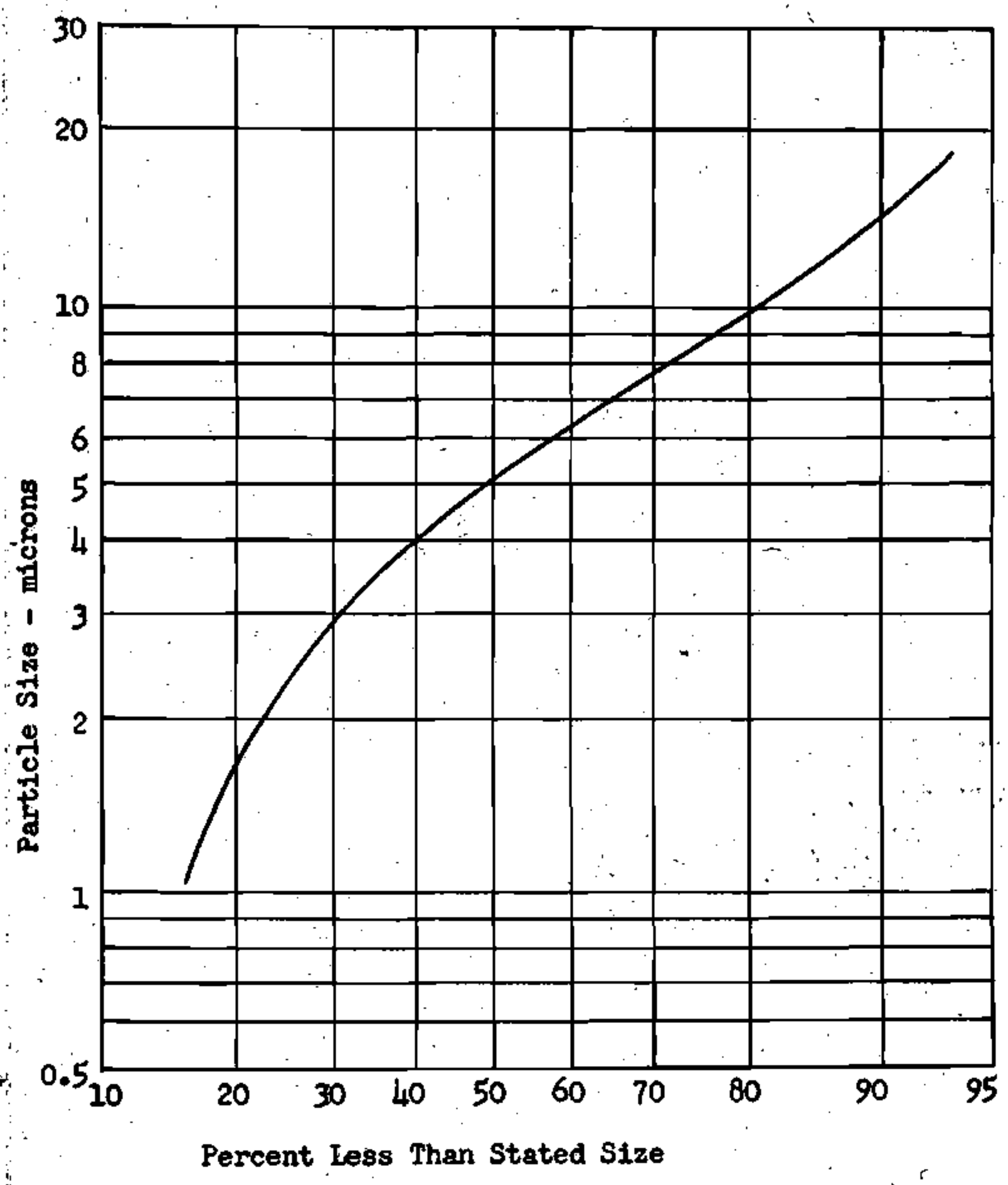

Figure 8

Georgia Institute of Technology
School of Mechanical Engineering
PARTICAL SIZE DISTRIBUTION
C. R. Kernan, Jr. June 1952

Of the various air contaminants only dust has been studied. The effects of using mists, vapors, odors and smokes are yet to receive attention.

BIBLIOGRAPHY

Albrecht, F. "Theoretical Investigation of Dust Depostion From Flowing Air and Its Application to the Theory of the Dust Filter" Physikalische Zeitschrift, 32 (1931). 48-56 Translation by P. J. Domotor, University of Illinois (1951).

Arabadji, V. T., "The Electrolyzation of Liquids During Their Dispersal Atomization", Kolloid Zhurnal, 7 (1949). 209-210.

Brown, C. E. and H. H. Schrenk, "A Technique for the Use of the Impinger Method", Information Circular 7026 United States Department of the Interior - Bureau of Mines. (1938).

Castleman, R. A., Jr., "The Mechanism of the Atomization of Liquids", U.S. National Bureau of Standards Journal of Research, 6 (1931). 369-376

DallaValle, J. M., Micromeritics. Second Edition; New York: Pitman Publishing Corporation, 1948, 555 pp.

Drinker, P. and T. Hatch, Industrial Dusts. New York: McGraw-Hill, 1936, 317 pp.

Ekman, F. O. and H. F. Johnstone. "Collection of Aerosols in a Venturi Scrubber", Industrial and Engineering Chemistry, 43 (1951). 1358-1363.

Hudson, D. G., The Principle of the Fog Filter, Unpublished Paper presented at the Tenth Annual Meeting of the American Industrial Hygiene Association, 1949.

Johnstone, H. F., "Absorption of Gases by Liquid Droplets", Industrial and Engineering Chemistry, 31 (1939). 993-1001.

Johnstone, H. F. and W. H. Roberts, "Deposition of Aerosol Particles from Moving Gas Streams", Industrial and Engineering Chemistry, 41, (1949). 2417-2423.

Lane, W. R., "Shatter of Drops in Streams of Air", Industrial and Engineering Chemistry. 43 (1951). 1312-1317.

Ranz, W. E., "The Impaction of Aerosol Particles on Cylindrical and Spherical Collectors", Technical Report No. 3, Engineering Experiment Station University of Illinois (1951). 35 pp.

Rodebush, W. H., Handbook on Aerosols. Washington, D. C.: Atomic Energy Commission, 1950, 147 pp.

Sell, W., "Dust Precipitation on Simple Bodies and in Air Filters", Forchung Auf Dem Gebiete Des Ingenieurwesens Ausgabe B, 2 (1931). Nr. 347 Translation by P. J. Domotor, University of Illinois (1951).

APPENDIX A

METHOD OF HANDLING DATA

METHOD OF HANDLING DATA

The samples were compared with distilled water in the spectrophotometer to obtain the optical density of each. The concentrations of the samples in grams of dust per liter of water were obtained from the calibration curve shown in Figure 3 which was prepared as indicated in Chapter IV.

The dust loading in grains of dust per cubic foot of air was then calculated by dividing the concentration by the number of cubic feet of air pulled through the impinger and, then, multiplying by 15.43 grains per gram.

The efficiencies were calculated on a weight basis as explained in Chapter II. This efficiency is the ratio of the weight of dust collected to the total weight of dust imput.

APPENDIX B

EXPERIMENTAL RESULTS

TABLE I

Data and Results for Fog-Type Dust Collector

Air Flow - 200 $ft.^3/min.$
Water Pressure - 400 $lb./in.^2$
Water Flow - $7\frac{1}{2}$ gal./min.

Run Number	Duration (minutes)	Optical Density	Sample Concentration (gm./l)	Dust Loading ($gr./ft.^3$)
		Inlet		
1	5	0.058	0.056	0.173
2	5	0.084	0.082	0.254
3	5	0.092	0.090	0.278
4	5	0.340	0.356	1.10
		Outlet		
1	5	0.011	0.0100	0.0309
2	5	0.012	0.0108	0.0334
3	5	0.011	0.0100	0.0309
4	5	0.020	0.0185	0.0572

TABLE I (Continued)

Data and Results for Fog-Type Dust Collector

Air Flow - 400 ft.^{3}/min.
Water Pressure - 400 lb./in.^{2}
Water Flow - $7\frac{1}{2}$ gal./min.

Run Number	Duration (minutes)	Optical Density	Sample Concentration (gm./l.)	Dust Loading (gr./ft.^{3})
		Inlet		
1	5	0.112	0.110	0.343
2	5	0.189	0.193	0.597
3	5	0.375	0.356	1.10
4	5	0.642	0.696	2.15
		Outlet		
1	5	0.0130	0.0107	0.0331
2	5	0.0145	0.0132	0.0406
3	5	0.0210	0.0194	0.0600
4	5	0.0305	0.0285	0.0882

TABLE I (Continued)

Data and Results for Fog-Type Dust Collector

Air Flow - 600 ft.^{3}/min.
Water Pressure - 400 lb./in.^{2}
Water Flow - 7½ gal./min.

Run Number	Duration (minutes)	Optical Density	Sample Concentration (gm./l.)	Dust Loading (gr./ft.^{3})
		Inlet		
1	3	0.211	0.215	1.14
2	3	0.521	0.560	2.88
3	3	0.560	0.611	3.14
4	3	0.894	0.980	5.03
		Outlet		
1	3	0.012	0.0110	0.0566
2	3	0.018	0.0185	0.0848
3	3	0.019	0.0175	0.0900
4	3	0.030	0.0280	0.144

TABLE I (Continued)

Data and Results for Fog-Type Dust Collector

Air Flow - 750 $ft.^3$/min.
Water Pressure - 400 lb./$in.^2$
Water Flow - 7½ gal./min.

Run Number	Duration (minutes)	Optical Density	Sample Concentration (gm./l.)	Dust Loading (gr./$ft.^3$)
		Inlet		
1	3	0.103	0.102	0.523
2	3	0.128	0.130	0.667
3	3	0.305	0.319	1.64
4	3	0.672	0.730	3.75
		Outlet		
1	3	0.0170	0.0155	0.0796
2	3	0.0205	0.0190	0.0976
3	3	0.0258	0.0241	0.124
4	3	0.0370	0.0350	0.180

TABLE II

Efficiency Results

Run Number	200 ft.^{3}/min. Series	400 ft.^{3}/min. Series	600 ft.^{3}/min. Series	750 ft.^{3}/min. Series
1	82.2	90.4	95.0	84.8
2	86.8	93.2	97.1	85.4
3	88.8	94.5	97.2	92.5
4	95.0	96.0	97.3	95.2

NOTE: Dust loadings are given in Table I.