Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

WOOD DUST STUDY REPORT

For Wood Dust Handling Ducts on

Various Types of Woodworking Machinery at

SINGER FURNITURE COMPANY

Sanford, North Carolina

and

WHITE FURNITURE COMPANY

Mebane, North Carolina

Performed by the Source Testing Staff
of the
North Carolina Department
of Natural & Economic Resources
Division of Environmental Management
Air Quality Section
December 21, 22, & 28, 1976

CONTENTS

	Page
Introduction	1
Source Description	2
Sampling Procedures	3
Summary of Results	6
Graphs of Particle Size Versus Percent of Total	8
APPENDIX A - Nomenclature, Equations, and Calculation Summaries	15
APPENDIX B - Report of Sieve Analysis	26
APPENDIX C - Field Data	48
APPENDIX D - Sampling Train Calibration and Operation	61

INTRODUCTION

It was desired that a study be made of wood dust produced in wood working operations prior to revision of North Carolina Administrative Code, Title 15, Chapter 2, Subchapter 2D, Section .0512, titled, "Particulates From Wood Products Finishing Plants."

Samples of wood dust were taken from four ducts at White Furniture Company in Mebane, North Carolina on December 21 and 22, 1976. Samples were taken from three ducts at Singer Furniture in Sanford, North Carolina on December 28, 1976.

Personnel performing the tests were J. R. Jernigan and R. E. Wooten from the Source Testing Staff. B. T. Foust and S. Amerson from the North Central Field Office (North Carolina Division of Environmental Management, Air Quality Section) assisted at White Furniture and at Singer, respectively.

Source Description

The seven ducts sampled were serving woodworking machines as listed below:

At Singer Furniture

1. Planers and Molders
2. Band and Variety Saws
3. Double End Tennon Machine

At White Furniture

1. Rough End Cut-off
2. Finish Planers
3. Molder
4. Sander Line

In some cases, only one machine was connected to the duct sampled. In other cases, several machines were connected but all did not necessarily operate for the full test or during any of it. A list of the machines operating and notes on their approximate schedules are given in Appendix C.

In all cases, sampling was done before the wood dust entered a fan or collection device.

Sampling Procedures

Samples were taken with a Rader sampler. This device consists of a probe with a bore of from, say 1 inch to 1.7 inch, depending on what is available. The probe is attached to a filter holder which is sized for an 8 inch by 10 inch high volume ambient particulate sampler filter. The filter is made of glass fibers. A hose connects from the filter holder to an orifice meter. The pressure drop across the orifice is measured as is the gauge pressure of the orifice (in this case with magnehelic gauges and a water filled U-tube manometer, respectively). A thermometer is inserted into the orifice meter. From this discharge side of the orifice meter, a flexible hose connects to the intake port of a centrifugal fan powered by a universal motor. The motor receives power through a variable transformer so that the fan draft can be adjusted. Thus, it is possible to adjust for isokinetic sampling conditions within the limits of the particular sampling equipment. See Appendix D, Figure 1, for a diagram of the equipment.

The sampling ports were located to make use of straight runs of ducts where possible. A single hole was used in each duct. A velocity traverse was made across the duct in each case. The sampling nozzle was then located at the point of mean velocity. It was hoped that, by this method, dust with a representative size distribution would be collected.

Before use, the equipment (which was borrowed) was calibrated using a Roots Meter (see Appendix D). It was determined that, to obtain isokinetic conditions, it was necessary to simultaneously maintain a particular ratio of orifice pressure to stack pressure (P_m/P_s) and a corresponding orifice pressure drop (ΔH) for the

velocity at the chosen test point (corresponding to the pitot tube pressure differential Δp).

Families of curves were plotted for each nozzle with each of the two orifice meters provided. These curves were straight line plots of P_m/P_s having constant values of 1, .95, .90, .85, and .80. The abscissa was Δp, the pressure drop across the pitot tube (actually a type S pitot tube with a correction factor of .85). The ordinate was ΔH, the pressure drop across the orifice.

Isokinetic conditions could be reached by a process of iteration. When starting, a P_m/P_s of say .95 would be assumed. The corresponding ΔH was determined from the chart. The fan was set to produce the desired ΔH. Then, ΔH and P_m gauge were used (with barometric pressure, P_b) to calculate actual P_m/P_s. A programmable electronic calculator was used to speed this process. If P_m/P_s was not the initially assumed value, the ΔH for the calculated P_m/P_s was set by adjusting the fan. The resulting P_m/P_s was calculated, the corresponding ΔH was read off the chart and compared to the actual and so forth. When, for the actual P_m/P_s, the corresponding actual ΔH and chart value ΔH were the same, sampling was isokinetic.

The length of each sampling run was a hit-or-miss situation. It was desired to obtain a sufficiently large sample for accurate size analysis (by screening, Bacho analyzer, etc.). It was not possible to know for sure if enough material was collected until it was actually analyzed. And, while sampling, it was not possible to know just what volume of dust was collected until the Rader sampler nozzle was removed from the duct and the filter holder opened. In general, sampling was done until isokinetic sampling conditions could no longer be maintained or until it was obvious

from lack of loading of the filter that too little dust was being collected to justify the time involved.

Following each sampling run, the collected wood dust was placed in plastic bags along with its filter and sealed. The dust was gotten into the bags by a combination of scooping, picking up with the fingers, and dry brushing. No liquids were used for wash up since the wood dust would have probably clumped as a result.

It was thought that a certain amount of very fine dust would remain behind in the collecting equipment, clinging to any small rough areas in the nozzle or filter holder. Also, the cleanup brushes were expected to acquire a certain amount of fine dust that would remain with them, after which any additional dust could be easily removed. Since the brushes and collection equipment had been used previously at Bernhardt Furniture Company's Hibriten Plant 3, it was felt that a reasonable coating of fine particles were present and that biasing by removal of fine particles was avoided.

Summary of Results

The following emission rates were determined:

	pmr_c (lb/hr)	pmr_a (lb/hr)	pmr_{avg} (lb/hr)	%I
White Furniture				
Rough-end				
Run 1	22.0	20.9	21.4	95.3
Run 2	27.5	26.3	26.9	95.6
Run 3	14.9	14.2	14.5	95.1
Planers				
Run 1	495	470	482	95
Run 2	800	691	746	86.3
Run 3	1011	946	979	93.6
Molder				
Run 1	76.4	83.4	79.9	109
Run 2	83.9	91.6	87.7	109
Run 3	42.2	46.1	44.1	109
Sanders				
Run 1	1.29	1.34	1.32	104
Singer Furniture				
Finish Planer and Molder				
Run 1	162	176	169	108
Run 2	248	271	260	109
Run 3	216	233	217	108

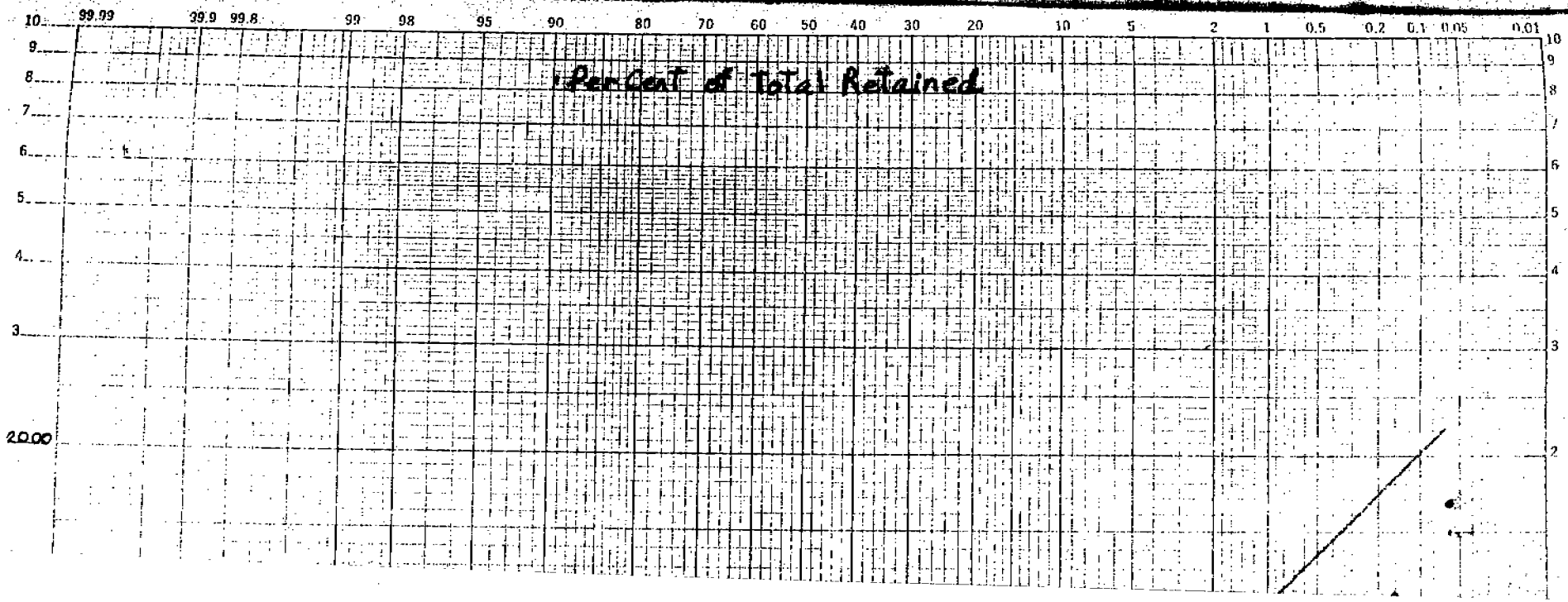
	pmr_c (lb/hr)	pmr_a (lb/hr)	pmr_{avg} (lb/hr)	%I
Band and Variety Saws				
Run 1	12.5	12.8	12.7	102
Run 2	11.8	12.0	11.9	102
Run 3	15.5	15.9	15.7	103
Double End Tennon Machine				
Run 1	102	100	101	98

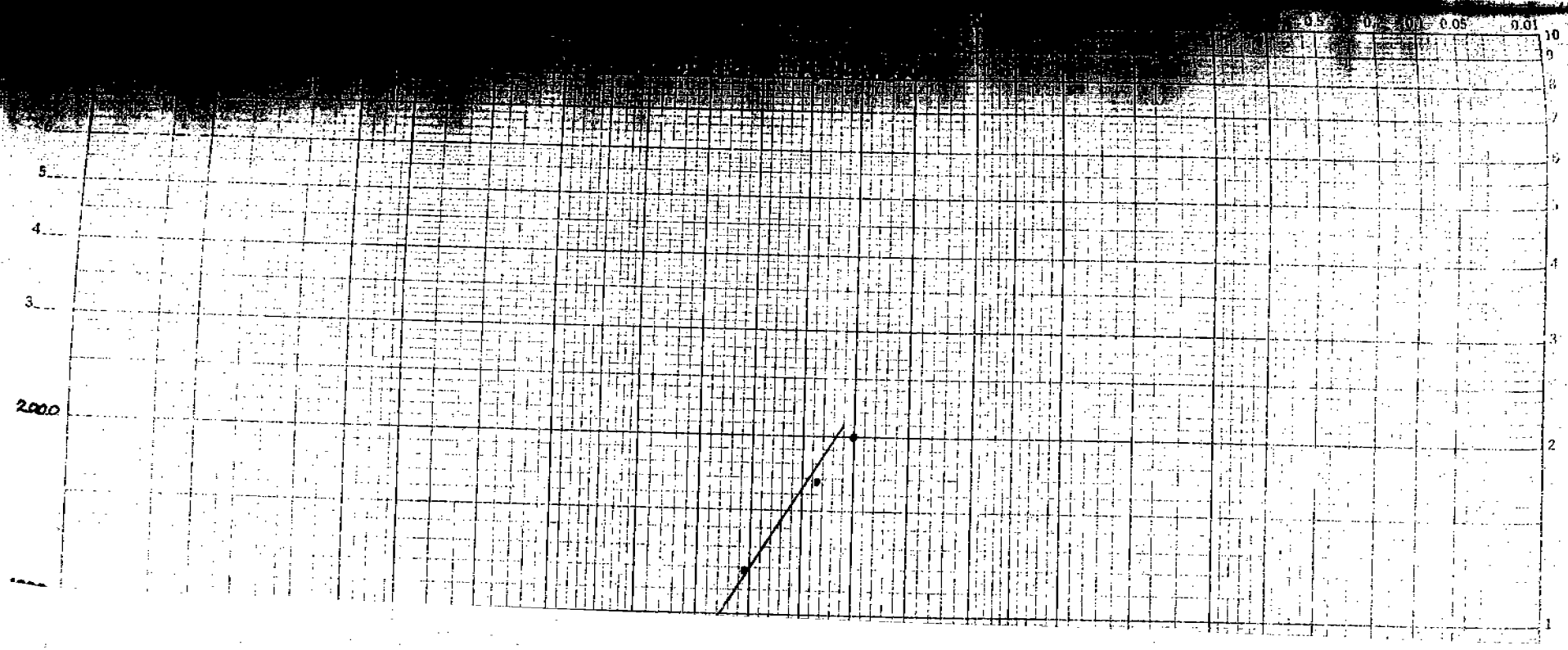
These emission rates should not be considered nearly so accurate as with a properly done EPA Method 5 test.

The following log probability plots show the sum of the size distribution data from all runs on each machine or group of machines tested. See the notes in Appendix C concerning machine operation.

Robert E. Wooten, Jr.

Robert E. Wooten, Jr.
Engineer
Air Quality Section
August 5, 1977


Percent of Total Retained
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
10
9
8
7
6
5
4
3
2
20.00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0.05
0.01
10
9
8
7
6
5
4
3
2
1
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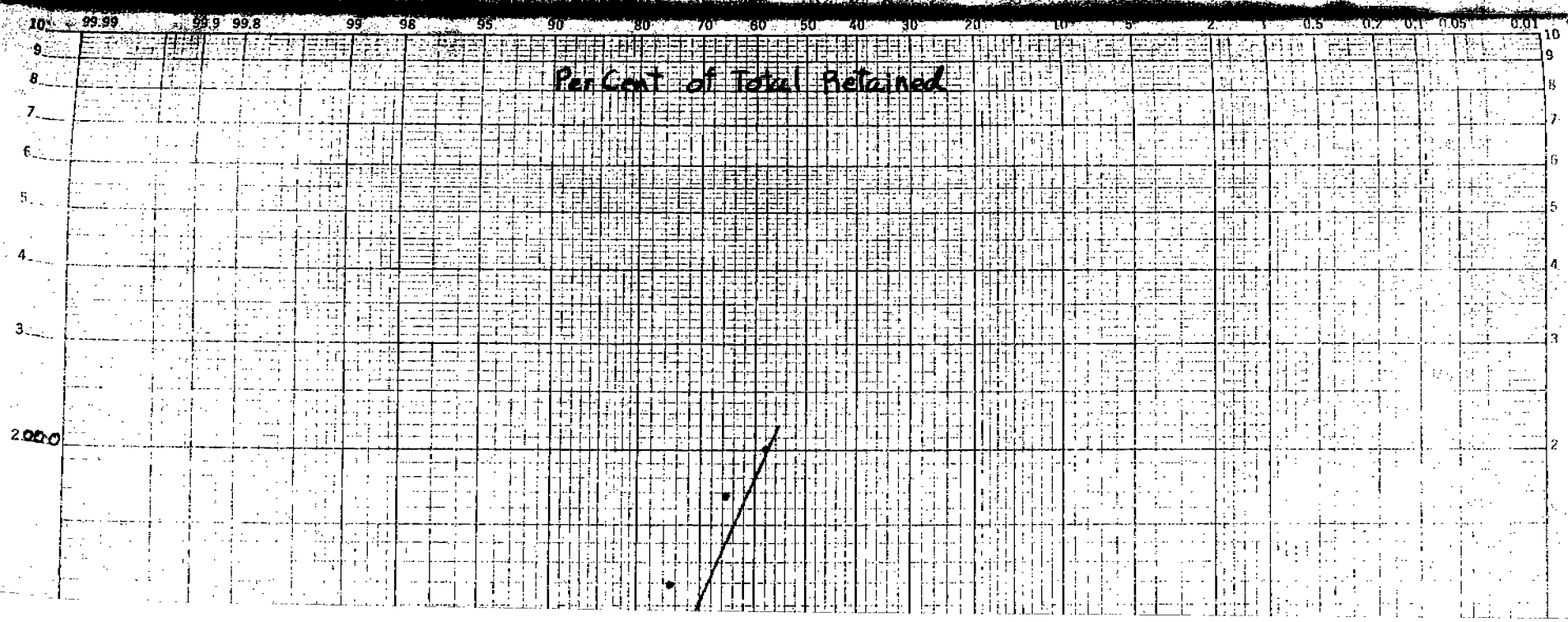
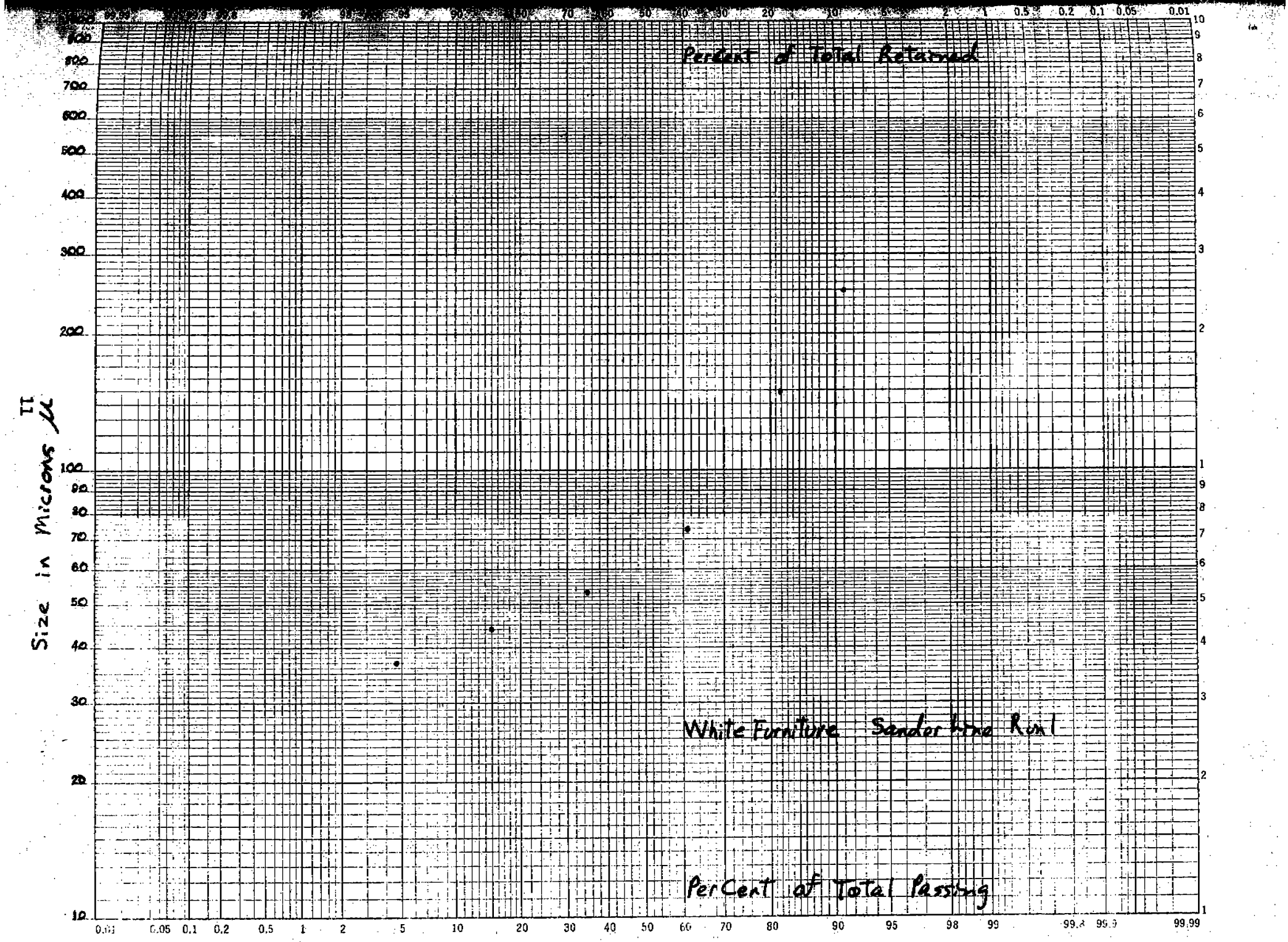
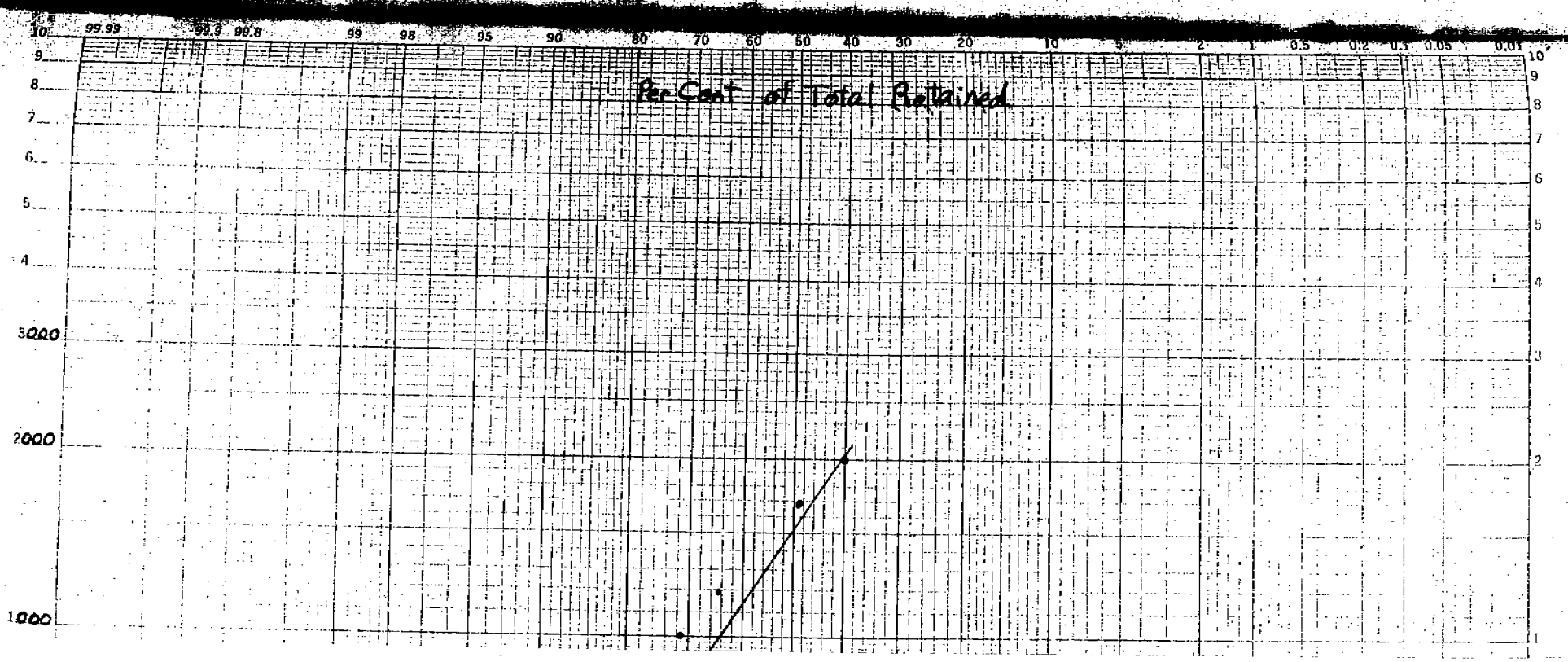

Per Cent of Total Retained
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
10
9
8
7
6
5
4
3
2000


Percent of Total Retained
Size in Microns μ
White Furniture Sander Fine Run
Percent of Total Passing

11


Per Cent of Total Retained
99.99
99.9
99.8
99
98
95
90
80
70
60
50
40
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20
10
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1
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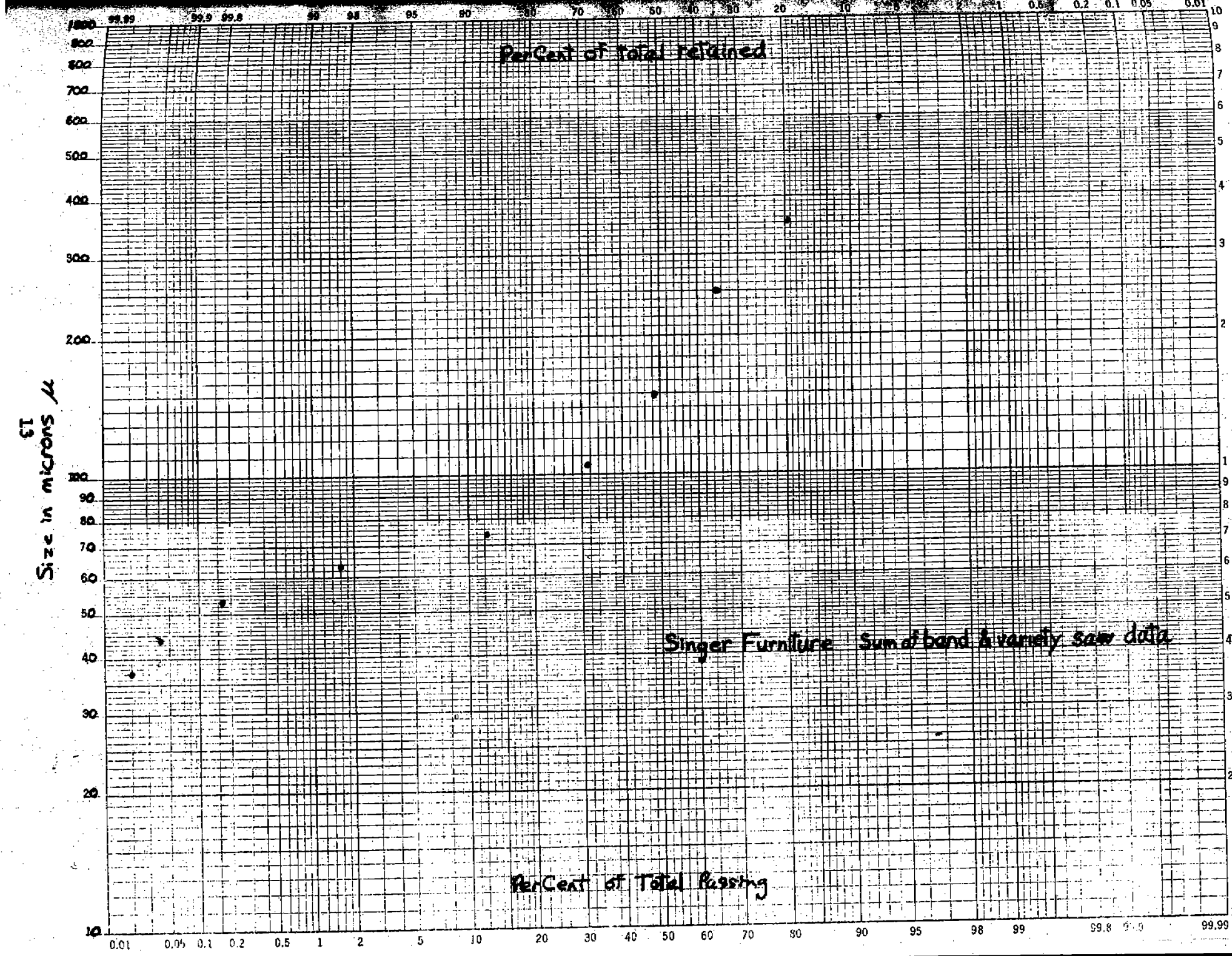
0.2
0.1
0.05
0.01
3000
2000
1000


Percent of total retained
Singer Furniture Sum of band & variety saw data
Percent of Total Passing
Size in microns μ
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
1000 900 800 700 600 500 400 300 200 100 90 80 70 60 50 40 30 20 10
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

6
5
4
3
2000
1000
900

NOMENCLATURE

A_n	(in.^{2}), Cross sectional area of nozzle
A_s	(in.^{2}), Cross sectional area of stack
A'_s	(ft^2), Cross sectional area of stack
$\overline{B}$	(ft^2), Mean value of calibration coefficients for a particular orifice, (Orifice 1 = .006796, Orifice 2 = .003616)
C_p	Pitot tube calibration coefficient
ΔH	(in. H_2O), Average orifice meter reading (also used for individual orifice meter readings when taking data)
%I	Percent Isokineticity
M	(lb/lb mole), Molecular weight of gas
$n_{\Delta p}$	Number of Δp readings
P_b	(in. Hg), Local atmospheric pressure
P_m	(in. H_2O), Orifice meter pressure, an absolute pressure
P_o	(in. H_2O), mean pressure on high pressure side of orifice plate, a gauge pressure.
P_{sg}	(in. H_2O), Gauge static pressure in stack
P_s	(in. Hg), Absolute static pressure in stack
P_{std}	(29.92 in. Hg), Standard pressure
pmr_a	(lb/hr), Pollutant mass rate based on ratio of areas
pmr_{avg}	(lb/hr), Average pollutant mass rate
pmr_c	(lb/hr), Pollutant mass rate based on concentrations
Δp	(in. H_2O), Velocity pressure measured with pitot tube
Q_o	(ft^3/min), Orifice meter flow, actual
$Q_{o\ std}$	(ft^3/min), Orifice meter flow at standard conditions
Q_s	(ft^3/min), Actual stack volume flow rate
Q_{std}	(ft^3/min), Stack volume flow at standard conditions

T_m	(^oR), Mean orifice meter temperature
T_s	(^oR), Mean stack temperature
T_{std}	(530 ^oR), Standard temperature
V_{std}	(ft^3), Volume of orifice meter flow at standard conditions
v_s	(ft/sec), stack velocity
Wt	(grams), Weight of sample before screening
θ	(min), Duration of test run
g_c	(32.17 lbm ft/lbf sec^2), gravitational acceleration correction factor
D_s	(in.), Stack diameter
D_n	(in.), Nozzle diameter
R	(53.34 ft lbf/lbm ^oR), Gas constant

EQUATIONS

(1) Stack Temperature -- ^{o}R

$$T_s = T_m$$

(2) Orifice meter pressure

$$P_m = (13.6)P_b + P_o$$

(3) Orifice meter flow -- (ft^3/min)

$$Q_o = \overline{B}\sqrt{\frac{2\ g_c\ R\ T_m\ \Delta H}{P_m}} \times (60\ sec/min)$$

$\overline{B}$ is the mean of several calibration coefficients for the particular orifice used -- (ft^2)

(4) Orifice meter flow at standard conditions -- (ft^3/min)

$$Q_{o\ std} = Q_o \frac{T_{std}}{T_m} \frac{P_b}{P_{std}}$$

(5) Orifice meter volume at standard conditions -- (ft^3)

$$V_{std} = Q_{o\ std}\ \theta$$

(6) Pressure in stack, Absolute -- P_s(in. Hg)

$$P_s = P_b + \frac{P_{sg}}{13.6}$$

(7) Stack Velocity -- v_s (ft/sec)

$$v_s = K_p\ C_p \sqrt{\frac{T_s}{P_s\ M}}\ \frac{\Sigma\sqrt{\Delta p}}{n_{\Delta p}}$$

K_p = 85.48 (units conversion factor)

(8) Stack volume flow rate -- Q_s (ft^3/min)

$$Q_s = K_1\ v_s\ A'_s \qquad K_1 = 60 \text{ (units conversion)}$$

(9) Stack volume flow rate at standard conditions -- Q_{std} (ft^3/min)

$$Q_{std} = \frac{T_{std}}{P_{std}} \frac{P_s}{T_s} Q_s$$

(10) Pollutant mass rate based on particulate concentration -- pmr_c (lb/hr)

$$pmr_c = K_3 \frac{Wt \; Q_{std}}{V_{std}} \qquad K_3 = 0.1323 \text{ (units conversion)}$$

(11) Pollutant mass rate based on the ratio of the cross sectional area of the stack and the sampling nozzle -- pmr_a (lb/hr)

$$pmr_a = K_3 \frac{Wt \; A_s}{\theta \; A_n} \qquad K_3 = 0.1323 \text{ (units conversion)}$$

(12) Percent Isokineticity -- %I

$$\%I = \frac{pmr_a}{pmr_c} \times 100$$

(13) Average pollutant mass rate -- pmr_{avg} (lb/hr)

$$pmr_{avg} = \frac{pmr_a + pmr_c}{2}$$

Calculation Summary

White Furniture - Rough End

	Run 1	Run 2	Run 3
ΔH, in. H_2O	1.47	1.48	1.47
P_o, in. H_2O	-26.1	-26.5	-25.0
T_m, ^oR	529	527	521
θ, min	10	11	16
P_b, in. Hg	29.22	29.22	29.22
P_m, in. H_2O	371.3	370.9	372.4
Q_o, ft^3/min	34.57	34.64	34.26
$Q_{o\ std}$, ft^3/min	33.83	34.02	34.04
V_{std}, ft^3	338.3	374.2	544.6
$\Sigma\sqrt{\Delta p}/n\Delta p$	1.37	1.37	1.37
P_{sg}, in. H_2O	-4.0	-4.0	-4.0
P_s, in. Hg	28.93	28.93	28.93
C_p	.85	.85	.85
M	28.84	28.84	28.84
v_s, ft/sec	79.26	79.11	78.66
D_s, in.	6	6	6
A_s', ft^2	.196	.196	.196
Q_s, ft^3/min	934	932	926
Q_{std}, ft^3/min	913	915	920
Wt, grams	61.45	85.06	66.54
pmr_c, lb/hr	22.0	27.5	14.9
A_s, $in.^2$	28.3	28.3	28.3
D_n, in.	1.099	1.099	1.099
A_n, $in.^2$	.949	.949	.949
pmr_a, lb/hr	20.9	26.3	14.2
%I	95.3	95.6	95.1
pmr_{avg}, lb/hr	21.4	26.9	14.5

Calculation Summary

White Furniture - Planers

	Run 1	Run 2	Run 3
ΔH, in. H_2O	.88	.71	.85
P_o, in. H_2O	-17.6	-27.5	-20.6
T_m, ^oR	532	531	530
θ, min	8	4	3
P_b, in. Hg	29.02	29.02	29.02
P_m, in. H_2O	377.1	367.2	374.1
Q_o, ft^3/min	26.62	24.21	26.21
$Q_{o\ std}$, ft^3/min	25.72	23.43	25.43
V_{std}, ft^3	205.8	93.73	76.28
$\Sigma\sqrt{\Delta p}/n\Delta p$	.73	.73	.73
P_{sg}, in. H_2O	-2.7	-2.7	-2.7
P_s, in. Hg	28.82	28.82	28.82
C_p	.85	.85	.85
M	28.84	28.84	28.84
v_s, ft/sec	42.43	42.39	42.35
D_s, in.	15.5	15.5	15.5
A_s', ft^2	1.31	1.31	1.31
Q_s, ft^3/min	3335	3332	3329
Q_{std}, ft^3/min	3200	3203	3207
Wt, grams	240.6	177.0	181.8
pmr_c, lb/hr	495.0	800.2	1011
A_s, $in.^2$	188.7	188.7	188.7
D_n, in.	1.427	1.427	1.427
A_n, $in.^2$	1.599	1.599	1.599
pmr_a, lb/hr	469.6	690.9	946.1
%I	95	86.3	93.6
pmr_{avg}, lb/hr	482	745.5	978.6

Calculation Summary

White Furniture - Molder

	Run 1	Run 2	Run 3
ΔH, in. H_2O	1.40	1.40	1.40
P_o, in. H_2O	-17.4	-17.1	-18.5
T_m, ^oR	529	538	535
θ, min	12	17	21
P_b, in. Hg	29.08	29.08	29.08
P_m, in. H_2O	378.1	378.4	377.0
Q_o, ft^3/min	33.45	33.72	33.69
$Q_{o\ std}$, ft^3/min	32.57	32.29	32.43
V_{std}, ft^3	390.9	548.9	681.1
$\Sigma\sqrt{\Delta p}/n\Delta p$	.80	.80	.80
P_{sg}, in. H_2O	-2.4	-2.4	-2.4
P_s, in. Hg	28.90	28.90	28.90
C_p	.85	.85	.85
M	28.84	28.84	28.84
v_s, ft/sec	46.31	46.70	46.57
D_s, in.	20.5	20.5	20.5
A'_s, ft^2	2.29	2.29	2.29
Q_s, ft^3/min	6363	6417	6399
Q_{std}, ft^3/min	6158	6106	6123
Wt, grams	36.65	56.99	35.46
pmr_c, lb/hr	76.38	83.88	42.17
A_s, $in.^2$	330.1	330.1	330.1
D_n, in.	1.427	1.427	1.427
A_n, $in.^2$	1.599	1.599	1.599
pmr_a, lb/hr	83.41	91.55	46.11
%I	109	109	109
pmr_{avg}, lb/hr	79.9	87.7	44.1

Calculation Summary

White Furniture - Sanders

	Run 1
ΔH, in. H_2O	1.13
P_o, in. H_2O	-16.98
T_m, ^oR	536
θ, min	70
P_b, in. Hg	29.50
P_m, in. H_2O	384.2
Q_o, ft^3/min	30.0
$Q_{o\ std}$, ft^3/min	29.25
V_{std}, ft^3	2047
$\Sigma\sqrt{\Delta p}/n\Delta p$	.754
P_{sg}, in. H_2O	-3
P_s, in. Hg	29.28
C_p	.85
M	28.84
v_s, ft/sec	43.65
D_s, in.	24
A'_s, ft^2	3.14
Q_s, ft^3/min	8223
Q_{std}, ft^3/min	7957
Wt, grams	2.507
pmr_c, lb/hr	1.29
A_s, $in.^2$	452.4
D_n, in.	1.427
A_n, $in.^2$	1.599
pmr_a, lb/hr	1.34
%I	104
pmr_{avg}, lb/hr	1.32

Calculation Summary

Singer Furniture - Finish Planer and Molders

	Run 1	Run 2	Run 3
ΔH, in. H_2O	1.85	1.88	1.85
P_o, in. H_2O	-25.6	-26.0	-21.0
T_m, ^oR	534	535	534
θ, min	18	15.5	4.75
P_b, in. Hg	29.02	29.02	29.02
P_m, in. H_2O	369.1	368.7	373.7
Q_o, ft^3/min	39.10	39.47	38.84
$Q_{o\ std}$, ft^3/min	37.64	37.93	37.39
V_{std}, ft^3	677.5	587.9	177.6
$\Sigma\sqrt{\Delta p}/n\Delta p$	1.58	1.58	1.58
P_{sg}, in. H_2O	-5.3	-5.3	-5.3
P_s, in. Hg	28.63	28.63	28.63
C_p	.85	.85	.85
M	28.84	28.84	28.84
v_s, ft/sec	92.32	92.41	92.32
D_s, in.	16	16	16
A'_s, ft^2	1.40	1.40	1.40
Q_s, ft^3/min	7755	7762	7755
Q_{std}, ft^3/min	7365	7358	7364
Wt, grams	112.8	149.9	39.4
pmr_c, lb/hr	162.2	248.3	216.2
A_s, $in.^2$	201.06	201.06	201.06
D_n, in.	1.099	1.099	1.099
A_n, $in.^2$	.949	.949	.949
pmr_a, lb/hr	175.7	271.1	232.5
%I	108	109	108
pmr_{avg}, lb/hr	168.9	259.7	216.8

Calculation Summary

Singer Furniture - Band & Variety Saws

	Run 1	Run 2	Run 3
ΔH, in. H_2O	1.70	1.70	1.72
P_o, in. H_2O	-21.1	-22.28	-25.12
T_m, ^oR	526	526	524
θ, min	20	24	22
P_b, in. Hg	29.02	29.02	29.02
P_m, in. H_2O	373.57	372.39	369.55
Q_o, ft^3/min	36.96	37.02	37.31
$Q_{o\ std}$, ft^3/min	34.19	34.14	34.27
V_{std}, ft^3	683.8	819.3	754.0
$\Sigma\sqrt{\Delta p}/n\Delta p$	.69	.69	.69
P_{sg}, in. H_2O	-3.0	-3.0	-3.0
P_s, in. Hg	28.80	28.80	28.80
C_p	.85	.85	.85
M	28.84	28.84	28.84
v_s, ft/sec	39.90	39.90	39.82
D_s, in.	12	12	12
A'_s, ft^2	.785	.785	.785
Q_s, ft^3/min	1880	1880	1876
Q_{std}, ft^3/min	1823	1823	1826
Wt, grams	35.4	39.9	48.4
pmr_c, lb/hr	12.49	11.75	15.51
A_s, $in.^2$	113.1	113.1	113.1
D_n, in.	1.623	1.623	1.623
A_n, $in.^2$	2.069	2.069	2.069
pmr_a, lb/hr	12.80	12.02	15.91
%I	102	102	103
pmr_{avg}, lb/hr	12.65	11.89	15.71

Calculation Summary

Singer Furniture - Double End Tenon Machine

	Run 1
ΔH, in. H_2O	1.31
P_o, in. H_2O	-24.14
T_m, ^oR	529
θ, min	13
P_b, in. Hg	29.02
P_m, in. H_2O	370.53
Q_o, ft^3/min	32.67
$Q_{o\ std}$, ft^3/min	29.81
V_{std}, ft^3	387.5
$\Sigma\sqrt{\Delta p}/n\Delta p$	.81
P_{sg}, in. H_2O	-3.2
P_s, in. Hg	28.78
C_p	.85
M	28.84
v_s, ft/sec	46.98
D_s, in.	17
A'_s, ft^2	1.58
Q_s, ft^3/min	4454
Q_{std}, ft^3/min	4293
Wt, grams	69.51
pmr_c, lb/hr	102
A_s, $in.^2$	227
D_n, in.	1.427
A_n, $in.^2$	1.60
pmr_a, lb/hr	100
%I	98
pmr_{avg}, lb/hr	101

Report of Sieve Analysis

Sample White Furniture - Rough End Run 1

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787				
10	12	1680	.0661	.0173	.029	99.971	.029
14	16	1190	.0469				
16	18	1000	.0394				
20	20	833	.0328	1.2143	2.012	97.959	2.041
28	30	595	.0234	4.5276	7.503	90.456	9.544
42	45	354	.0139	14.2778	23.662	66.794	33.206
60	60	250	.0098	15.5390	25.752	41.042	58.958
100	100	149	.0059	7.5130	12.451	28.591	71.409
150	140	105	.0041	5.7551	9.538	19.053	80.947
200	200	74	.0029	7.9797	13.224	5.829	94.171
250	230	63	.0025				
270	270	53	.0021	1.5865	2.629	3.200	96.80
325	325	44	.0017	.7600	1.260	1.940	98.060
	400	37	.0015	.5051	.837	1.103	98.897
Pan < 37μ				.6656	1.103	0.000	100.000
Totals				60.3410	100.000		

Sample Weight Before Screening 61.453 g

Total of Screen Weights 60.341 g

Lost 1.112 g

% Retained 98.190

Report of Sieve Analysis

Sample White Furniture Rough End Run 2

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787				
10	12	1680	.0661	0.0254	.030	99.970	.030
14	16	1190	.0469	0.1078	.128	99.841	.159
16	18	1000	.0394				
20	20	833	.0328	0.5782	.688	99.153	.847
28	30	595	.0234	2.9212	3.478	95.675	4.325
42	45	354	.0139	18.1840	21.648	74.027	25.973
60	60	250	.0098	24.8167	29.545	44.482	55.518
100	100	149	.0059	16.7361	19.925	24.558	75.442
150	140	105	.0041	6.9804	8.310	16.248	83.752
200	200	74	.0029	8.1969	9.759	6.489	93.511
250	230	63	.0025				
270	270	53	.0021	2.3933	2.849	3.640	96.360
325	325	44	.0017	0.9440	1.124	2.516	97.484
	400	37	.0015	1.6023	1.908	.608	99.392
Pan < 37μ				0.5111	.608	0.000	100.000
Totals				83.9974	100.000		

Sample Weight Before Screening 85.055 g.

Total of Screen Weights 83.997 g.

Lost 1.058 g

% Retained 98.75 %

Report of Sieve Analysis

Sample White Furniture - Rough End Run 3

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787				
10	12	1680	.0661	0.0810	.123	99.877	.123
14	16	1190	.0469	0.0903	.137	99.739	.261
16	18	1000	.0394				
20	20	833	.0328	0.5623	.856	98.884	1.116
28	30	595	.0234	2.4755	3.767	95.116	4.884
42	45	354	.0139	13.6592	20.787	74.329	25.671
60	60	250	.0098	17.3461	26.398	47.931	52.069
100	100	149	.0059	10.8056	16.444	31.487	68.513
150	140	105	.0041	7.4846	11.390	20.096	79.904
200	200	74	.0029	6.5421	9.956	10.140	89.860
250	230	63	.0025				
270	270	53	.0021	2.5453	3.874	6.267	93.733
325	325	44	.0017	.3305	.503	5.764	94.236
	400	37	.0015	.6792	1.034	4.730	95.270
Pan < 37μ				3.1081	4.730	0.000	100.000
Totals				65.7098	100.000		

Sample Weight Before Screening 66.536 g

Total of Screen Weights 65.710 g

Lost .826 g

% Retained 98.758

Report of Sieve Analysis

Sample White Furniture - Sum of Rough End Runs 1, 2 & 3

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787				
10	12	1680	.0661	0.1237	.059	99.941	.059
14	16	1190	.0469	0.1981	.094	99.847	.153
16	18	1000	.0394				
20	20	833	.0328	2.3548	1.121	98.726	1.274
28	30	595	.0234	9.9243	4.725	94.001	5.999
42	45	354	.0139	46.1210	21.957	72.044	27.956
60	60	250	.0098	57.7018	27.471	44.573	55.427
100	100	149	.0059	35.0547	16.689	27.884	72.116
150	140	105	.0041	20.2201	9.626	18.258	81.742
200	200	74	.0029	22.7187	10.816	7.442	92.558
250	230	63	.0025				
270	270	53	.0021	6.5251	3.106	4.335	95.665
325	325	44	.0017	2.0345	.969	3.367	96.633
	400	37	.0015	2.7866	1.327	2.040	97.960
Pan < 37μ				4.2848	2.040	0.000	100.000
Totals				210.0482	100.000		

Sample Weight Before Screening 213.044 g

Total of Screen Weights 210.048 g

Lost 2.996 g

% Retained 98.594

Report of Sieve Analysis

Sample White Furniture - Planers Run 1

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	96.6512	40.359	59.641	40.359
10	12	1680	.0661	16.4191	6.856	52.785	47.215
14	16	1190	.0469	32.5815	13.605	39.180	60.820
16	18	1000	.0394				
20	20	833	.0328	26.6581	11.132	28.049	71.951
28	30	595	.0234	19.7400	8.243	19.806	80.194
42	45	354	.0139	21.6865	9.056	10.750	89.250
60	60	250	.0098	11.3845	4.754	5.996	94.004
100	100	149	.0059	6.5440	2.733	3.264	96.736
150	140	105	.0041				
200	200	74	.0029	5.8496	2.443	.821	99.179
250	230	63	.0025				
270	270	53	.0021	.8500	.355	.466	99.534
325	325	44	.0017	.5423	.226	.240	99.760
	400	37	.0015	.3374	.141	.099	99.901
Pan < 37μ				.2368	.099	0.000	100.000
Totals				239.4810	100.000		

Sample Weight Before Screening 240.6 g

Total of Screen Weights 239.5 g

Lost 1.1 g

% Retained 99.5

Report of Sieve Analysis

Sample White Furniture - Planers Run 2

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	71.3788	40.380	59.620	40.380
10	12	1680	.0661	12.0329	6.807	52.813	47.187
14	16	1190	.0469	23.8431	13.488	39.324	60.676
16	18	1000	.0394				
20	20	833	.0328	20.9238	11.837	27.487	72.513
28	30	595	.0234	16.9853	9.609	17.878	82.122
42	45	354	.0139	15.8865	8.987	8.891	91.109
60	60	250	.0098	7.5049	4.246	4.646	95.354
100	100	149	.0059	4.2953	2.430	2.216	97.784
150	140	105	.0041				
200	200	74	.0029	3.0093	1.702	.513	99.487
250	230	63	.0025				
270	270	53	.0021	.4749	.269	.245	99.755
325	325	44	.0017	.2343	.133	.112	99.888
	400	37	.0015	.1123	.064	.048	99.952
Pan < 37μ				.0857	.048	0.000	100.000
Totals				176.7671	100.000		

Sample Weight Before Screening 177.0~~775~~ g

Total of Screen Weights 176.8 g

Lost .2 g

% Retained 99.9

Report of Sieve Analysis

Sample White Furniture Planers Run 3

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	71.6172	39.5946	60.4054	39.5946
10	12	1680	.0661	12.3679	6.8378	53.5676	46.4324
14	16	1190	.0469	25.7360	14.2285	39.3391	60.6609
16	18	1000	.0394				
20	20	833	.0328	22.6300	12.5113	26.8278	73.1722
28	30	595	.0234	16.5626	9.1569	17.6709	82.3291
42	45	354	.0139	16.7118	9.2394	8.4316	91.5684
60	60	250	.0098	7.2765	4.0229	4.4087	95.5913
100	100	149	.0059	5.0140	2.7721	1.6366	98.3634
150	140	105	.0041				
200	200	74	.0029	2.2785	1.2597	.3769	99.6231
250	230	63	.0025				
270	270	53	.0021	.4448	.2459	.1310	99.8690
325	325	44	.0017	.1326	.0733	.0577	99.9423
	400	37	.0015	.0852	.0471	.0106	99.9894
Pan < 37μ				.0191	.0106	.0000	100.000
Totals				180.8762	100.0000		

Sample Weight Before Screening 181.8 g

Total of Screen Weights 180.9 g

Lost 0.9 g

% Retained 99.5

Report of Sieve Analysis

Sample White Furniture - Sum of Planers Data, Runs 1, 2 & 3

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	239.6472	40.134	59.866	40.134
10	12	1680	.0661	40.8199	6.836	53.030	46.970
14	16	1190	.0469	82.1606	13.759	39.271	60.729
16	18	1000	.0394				
20	20	833	.0328	70.2119	11.758	27.513	72.487
28	30	595	.0234	53.2879	8.924	18.589	81.411
42	45	354	.0139	54.2848	9.091	9.498	90.502
60	60	250	.0098	26.1659	4.382	5.116	94.884
100	100	149	.0059	15.8533	2.655	2.461	97.539
150	140	105	.0041				
200	200	74	.0029	11.1374	1.865	.595	99.405
250	230	63	.0025				
270	270	53	.0021	1.7697	.296	.299	99.701
325	325	44	.0017	.9092	.152	.147	99.853
	400	37	.0015	.5349	.090	.057	99.943
Pan < 37μ				.3416	.057	0.000	100.000
Totals				597.1243	100.000		

Sample Weight Before Screening 599.4 g

Total of Screen Weights 597.1 g

Lost 2.3 g

% Retained 99.6

Report of Sieve Analysis

Sample White Furniture Molder Run 1

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	23.4151	64.697	35.303	64.697
10	12	1680	.0661	2.6495	7.321	27.983	72.017
14	16	1190	.0469	3.1668	8.750	19.233	80.767
16	18	1000	.0394				
20	20	833	.0328	1.6729	4.622	14.610	85.390
28	30	595	.0234	0.9880	2.730	11.880	88.120
42	45	354	.0139	0.9021	2.493	9.388	90.612
60	60	250	.0098	0.7190	1.987	7.401	92.599
100	100	149	.0059	1.0529	2.909	4.492	95.508
150	140	105	.0041	0.5776	1.596	2.896	97.104
200	200	74	.0029	0.4490	1.241	1.656	98.344
250	230	63	.0025				
270	270	53	.0021	0.2962	.818	.837	99.163
325	325	44	.0017	0.1594	.440	.397	99.603
	400	37	.0015	0.0685	.189	.208	99.792
Pan < 37μ				0.0751	.208	0.000	100.000
Totals				36.1921	100.000		

Sample Weight Before Screening 36.6536 g

Total of Screen Weights 36.1921 g

Lost .462 g

% Retained 98.74

Report of Sieve Analysis

Sample White Furniture Molder Run 2

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	35.3849	62.476	37.524	62.476
10	12	1680	.0661	4.7926	8.462	29.062	70.938
14	16	1190	.0469	5.7788	10.203	18.859	81.141
16	18	1000	.0394				
20	20	833	.0328	3.2076	5.663	13.195	86.805
28	30	595	.0234	1.8520	3.270	9.925	90.075
42	45	354	.0139	1.4433	2.548	7.377	92.623
60	60	250	.0098	0.9741	1.720	5.657	94.343
100	100	149	.0059	1.0885	1.922	3.735	96.265
150	140	105	.0041	0.9056	1.599	2.136	97.864
200	200	74	.0029	0.5215	.921	1.216	98.784
250	230	63	.0025	~~0.~~			
270	270	53	.0021	0.3785	.668	.547	99.453
325	325	44	.0017	0.1805	.319	.229	99.771
	400	37	.0015	0.1075	.190	.039	99.961
Pan < 37μ				0.0220	.039	0.000	100.000
Totals				56.6374	100.000		

Sample Weight Before Screening 56.994 g

Total of Screen Weights 56.637 g

Lost 0.357 g

% Retained 99.37

Report of Sieve Analysis

Sample White Furniture Molders Run 3

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	15.2549	43.553	56.447	43.553
10	12	1680	.0661	2.1096	6.023	50.424	49.576
14	16	1190	.0469	3.2386	9.246	41.177	58.823
16	18	1000	.0394				
20	20	833	.0328	2.6224	7.487	33.690	66.310
28	30	595	.0234	1.5773	4.503	29.187	70.813
42	45	354	.0139	1.9116	5.458	23.729	76.271
60	60	250	.0098	1.4266	4.073	19.656	80.344
100	100	149	.0059	2.4859	7.097	12.559	87.441
150	140	105	.0041				
200	200	74	.0029	2.2821	6.515	6.044	93.956
250	230	63	.0025				
270	270	53	.0021	.9150	2.612	3.431	96.569
325	325	44	.0017	.5001	1.428	2.003	97.997
	400	37	.0015	.3813	1.089	.915	99.085
Pan < 37μ				.3204	.915	0.000	100.000
Totals				35.0258	100.000		

Sample Weight Before Screening 35.463 g

Total of Screen Weights 35.026 g

Lost .437 g

% Retained 98.8

Report of Sieve Analysis

Sample White Furniture Sum of Molder Data, Runs 1, 2 & 3

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	74.0549	57.921	42.079	57.921
10	12	1680	.0661	9.5517	7.471	34.608	65.392
14	16	1190	.0469	12.1842	9.530	25.079	74.921
16	18	1000	.0394	~~7.50~~			
20	20	833	.0328	7.5029	5.868	19.210	80.790
28	30	595	.0234	4.4173	3.455	15.756	84.244
42	45	354	.0139	4.2570	3.330	12.426	87.574
60	60	250	.0098	3.1197	2.440	9.986	90.014
100	100	149	.0059	4.6273	3.619	6.367	93.633
150	140	105	.0041	1.4832	1.160	5.207	94.793
200	200	74	.0029	3.2526	2.544	2.663	97.337
250	230	63	.0025				
270	270	53	.0021	1.5897	1.243	1.419	98.581
325	325	44	.0017	.8400	.657	.762	99.238
	400	37	.0015	.5573	.436	.327	99.673
Pan < 37μ				.4175	.327	0.000	100.000
Totals				127.8553	100.000		

Sample Weight Before Screening 129.1 g

Total of Screen Weights 127.9 g

Lost 1.2 g

% Retained 99.0

Report of Sieve Analysis

Sample White Furniture - Sander line Run 1

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787				
10	12	1680	.0661				
14	16	1190	.0469				
16	18	1000	.0394				
20	20	833	.0328				
28	30	595	.0234				
42	45	354	.0139				
60	60	250	.0098	.1593	7.002	92.998	9.002
100	100	149	.0059	.2542	11.174	81.824	18.176
150	140	105	.0041				
200	200	74	.0029	.4788	21.046	60.778	39.222
250	230	63	.0025				
270	270	53	.0021	.5826	25.609	35.169	64.831
325	325	44	.0017	.4555	20.022	15.147	84.853
	400	37	.0015	.2386	10.488	4.659	95.341
Pan < 37μ				.1060	4.659	0.000	100.000
Totals				2.2750	100.000		

Sample Weight Before Screening 2.507 g

Total of Screen Weights 2.275 g

Lost .232 g

% Retained 90.746

Report of Sieve Analysis

Sample Singer Furniture Finish Planer & Molders Run 1

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	41.424	37.134	62.866	37.134
10	12	1680	.0661	10.6655	9.561	53.305	46.695
14	16	1190	.0469	18.2242	16.337	36.969	63.031
16	18	1000	.0394	8.4887	7.610	29.359	70.641
~~20~~	~~20~~	710 ~~833~~	~~.0328~~	11.1162	9.965	19.394	80.606
28	30	595	.0234	3.5636	3.195	16.200	83.800
42	45	354	.0139	6.7678	6.067	10.133	89.867
60	60	250	.0098	3.4759	3.116	7.017	92.983
100	100	149	.0059	2.8376	2.544	4.473	95.527
150	140	105	.0041	2.1034	1.886	2.588	97.412
200	200	74	.0029	1.9955	1.789	.799	99.201
250	230	63	.0025	.6955	.623	.176	99.824
270	270	53	.0021	.1877	.168	.007	99.993
325	325	44	.0017	.0070	.006	.001	99.999
	400	37	.0015	.0010	.0009	.00009	99.9991
Pan < 37μ				.0001	.00009	0.00000	100.000
Totals				111.5537	100.000		

Sample Weight Before Screening 112.8 g

Total of Screen Weights 111.6 g

Lost 1.2 g

% Retained 98.9

Report of Sieve Analysis

Sample Singer Furniture Finish Planer & Molders Run 2

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	57.2230	39.7123	60.288	39.712
10	12	1680	.0661	12.5527	8.711	51.576	48.424
14	16	1190	.0469	22.0737	15.319	36.257	63.743
16	18	1000	.0394	10.1323	7.032	29.225	70.775
~~20~~	~~20~~	710 ~~833~~	~~.0328~~	13.9797	9.702	19.524	80.476
28	30	595	.0234	4.6247	3.210	16.314	83.686
42	45	354	.0139	8.8812	6.163	10.151	89.849
60	60	250	.0098	4.1190	2.859	7.292	92.708
100	100	149	.0059	3.8392	2.664	4.628	95.372
150	140	105	.0041	2.3671	1.643	2.985	97.015
200	200	74	.0029	2.7584	1.914	1.071	98.929
250	230	63	.0025	1.1904	.826	.245	99.755
270	270	53	.0021	.3350	.232	.012	99.988
325	325	44	.0017	.0147	.010	.002	99.998
	400	37	.0015	.0017	.001	.0007	99.9993
Pan < 37μ				.0010	.0007	0.0000	100.0000
Totals				144.0938	100.0000		

Sample Weight Before Screening 149.9 g

Total of Screen Weights 144.1 g

Lost 5.8 g

% Retained 96.1

Report of Sieve Analysis

Sample Singer Furniture Finish Planer & Molders Run 3

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	19.3359	50.2235	49.776	50.224
10	12	1680	.0661	3.2734	8.502	41.274	58.726
14	16	1190	.0469	4.9532	12.866	28.409	71.591
16	18	1000	.0394	2.3529	6.111	22.297	77.703
~~20~~	~~20~~	~~833~~ 710	~~.0328~~	2.9703	7.715	14.582	85.418
28	30	595	.0234	0.8584	2.230	12.352	87.648
42	45	354	.0139	2.2478	5.838	6.514	93.486
60	60	250	.0098	1.0620	2.758	3.755	96.245
100	100	149	.0059	0.7062	1.834	1.921	98.079
150	140	105	.0041	0.4249	1.104	.817	99.183
200	200	74	.0029	0.2854	.741	.076	99.924
250	230	63	.0025	0.0290	.075	.0008	99.9992
270	270	53	.0021	0.0003	.0008	0.0000	100.0000
325	325	44	.0017	0.0000	0	0	100
	400	37	.0015	0.0000	0	0	100
Pan < 37μ				0.0000	0	0	100
Totals				38.4997	100.000		

Sample Weight Before Screening 39.4 g

Total of Screen Weights 38.5 g

Lost .9 g

% Retained 97.7

Report of Sieve Analysis

Sample Singer Furniture Sum of Finish Planers & Molders Data - Runs 1, 2 & 3

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787	117.9829	40.110	59.890	40.110
10	12	1680	.0661	26.4916	9.006	50.884	49.116
14	16	1190	.0469	45.2511	15.384	35.500	64.500
16	18	1000	.0394	20.9739	7.130	28.369	71.631
20	20	833	.0328	28.0662	9.542	18.828	81.172
28	30	595	.0234	9.0467	3.076	15.752	84.248
42	45	354	.0139	17.8968	6.084	9.668	90.332
60	60	250	.0098	8.6569	2.943	6.725	93.275
100	100	149	.0059	7.3830	2.510	4.215	95.785
150	140	105	.0041	4.8954	1.664	2.551	97.449
200	200	74	.0029	5.0393	1.713	.837	99.163
250	230	63	.0025	1.9149	.651	.186	99.814
270	270	53	.0021	.5230	.178	.009	99.991
325	325	44	.0017	.0217	.007	.001	99.999
	400	37	.0015	.0027	.0009	.0004	99.9996
Pan < 37μ				.0011	.0004	.0000	100.0000
Totals				294.1472	100.000		

Sample Weight Before Screening 302.1 g

Total of Screen Weights 294.1 g

Lost 8.0 g

% Retained 97.4

Report of Sieve Analysis

Sample Singer Furniture - Band & Variety Saws Run1

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787				
10	12	1680	.0661				
14	16	1190	.0469				
16	18	1000	.0394				
20	20	833	.0328				
28	30	595	.0234	2.3930	6.980	93.020	6.980
42	45	354	.0139	4.3885	12.800	80.220	19.780
60	60	250	.0098	6.6650	19.440	60.780	39.220
100	100	149	.0059	6.1937	18.065	42.715	57.285
150	140	105	.0041	7.1925	20.979	21.736	78.264
200	200	74	.0029	4.9119	14.327	7.409	92.591
250	230	63	.0025	1.6286	4.750	2.659	97.341
270	270	53	.0021	.7245	2.113	.546	99.454
325	325	44	.0017	.1416	.413	.133	99.867
	400	37	.0015	.0222	.065	.068	99.932
Pan < 37μ				.0234	.068	0.000	100.000
Totals				34.2849	100.000		

Sample Weight Before Screening 35.4 g

Total of Screen Weights 34.3 g

Lost 1.1 g

% Retained 96.9

Report of Sieve Analysis

Sample Singer Furniture – Band & Variety Saws Run 2

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787				
10	12	1680	.0661				
14	16	1190	.0469				
16	18	1000	.0394				
20	20	833	.0328				
28	30	595	.0234	2.7887	7.197	92.803	7.197
42	45	354	.0139	4.5864	11.837	80.966	19.034
60	60	250	.0098	5.1152	13.202	67.764	32.236
100	100	149	.0059	5.3883	13.906	53.858	46.142
150	140	105	.0041	6.1240	15.805	38.053	61.947
200	200	74	.0029	8.0026	20.654	17.399	82.601
250	230	63	.0025	6.3130 *	16.293	1.106	98.894
270	270	53	.0021	0.4271	1.102	.004	99.996
325	325	44	.0017	0.0011	.003	.001	99.999
	400	37	.0015	0.0004	.001	0.000	100.000
Pan < 37μ				0.0000	0.000	0.000	100.000
Totals				38.7468	100.000		

Sample Weight Before Screening 39.8~~760~~ g

Total of Screen Weights 38.7~~468~~ g

Lost 1.2~~292~~ g

% Retained 97.0~~582~~

* Slight accidental loss of sample during weighing

Report of Sieve Analysis

Sample Singer Furniture - Band and Variety saws Run 3

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787				
10	12	1680	.0661				
14	16	1190	.0469				
16	18	1000	.0394				
20	20	833	.0328				
28	30	595	.0234	3.1674	6.663	93.337	6.663
42	45	354	.0139	6.0493	12.725	80.613	19.387
60	60	250	.0098	7.3949	15.555	65.058	34.942
100	100	149	.0059	7.9353	16.692	48.366	51.634
150	140	105	.0041	7.3913	15.547	32.819	67.181
200	200	74	.0029	10.0686	21.179	11.639	88.361
250	230	63	.0025	4.9740	10.463	1.177	98.823
270	270	53	.0021	.5496	1.156	.021	99.979
325	325	44	.0017	.0075	.016	.005	99.995
	400	37	.0015	.0016	.003	.001	99.999
Pan < 37μ				.0007	.001	0.000	100.000
Totals				47.5402	100.000		

Sample Weight Before Screening 48.368 g

Total of Screen Weights 47.540 g

Lost .828 g

% Retained 98.29

Report of Sieve Analysis

Sample Singer Furniture - Sum of Band & Variety Saws' Runs 1, 2, & 3

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787				
10	12	1680	.0661				
14	16	1190	.0469				
16	18	1000	.0394				
20	20	833	.0328				
28	30	595	.0234	8.3491	6.925	93.075	6.925
42	45	354	.0139	15.0242	12.461	80.615	19.385
60	60	250	.0098	19.1751	15.903	64.711	35.289
100	100	149	.0059	19.5173	16.187	48.524	51.476
150	140	105	.0041	20.7078	17.175	31.349	68.651
200	200	74	.0029	22.9831	19.062	12.288	87.712
250	230	63	.0025	12.9156	10.712	1.576	98.424
270	270	53	.0021	1.7012	1.411	.165	99.835
325	325	44	.0017	.1502	.125	.040	99.960
	400	37	.0015	.0242	.020	.020	99.980
Pan < 37μ				.0241	.020	0.000	100.000
Totals				120.5719	100.000		

Sample Weight Before Screening 123.7 g

Total of Screen Weights 120.6 g

Lost 3.1 g

% Retained 97.5

Report of Sieve Analysis

Sample Singer Furniture - Double End Tennon Machine Run1

Tyler Mesh	U.S. No.	μ Size	Inch Size	Weight in grams	% of Total	% of Total Passing	% of Total Retained
9	10	2000	.0787				
10	12	1680	.0661	.3287	.483	99.517	.483
14	16	1190	.0469				
16	18	1000	.0394	.5225	.767	98.750	1.250
20	20	833	.0328	.2201	.323	98.427	1.573
28	30	595	.0234	1.0694	1.570	96.857	3.143
42	45	354	.0139	6.2936	9.241	87.615	12.385
60	60	250	.0098	20.7918	30.530	57.086	42.914
100	100	149	.0059	18.0258	26.468	30.617	69.383
150	140	105	.0041	10.1187	14.858	15.760	84.240
200	200	74	.0029	7.3406	10.779	4.981	95.019
250	230	63	.0025	.9779	1.436	3.545	96.455
270	270	53	.0021	1.4332	2.104	1.441	98.559
325	325	44	.0017	.8153	1.197	.244	99.756
	400	37	.0015	.1284	.189	.055	99.945
Pan < 37μ				.0374	.055	.000	100.000
Totals				68.1034	100.000		

Sample Weight Before Screening 69.511 g.

Total of Screen Weights 68.103 g.

Lost 1.408 g.

% Retained 97.975

FIELD DATA

White Furniture - Planers

Duct diameter = 15 1/2 in.

Static pressure = -2.7 in.

Insertion of pitot tube into duct (in.)	Pressure drop Δp (in. H_2O)
2.5	.50
5.0	.50
7.5	.55
10	.55
12.5	.55

mean Δp is .53

probe was placed 8 inches into duct

White Furniture - Molder

Duct diameter = 20 1/2 in.

Static pressure = -2.4 in.

Insertion of pitot tube into duct (in.)	Pressure drop Δp (in. H_2O)
2	1.75
4	1.05
6	.65
8	.30
10	.30
12	.35
14	.45
16	.60
18	.60
19	.80

mean Δp is .69

probe was placed 6 inches into duct

White Furniture - Rough End

Duct diameter = 6 in.

Static pressure = -4.0 in.

Insertion of pitot tube into duct (in.)	Pressure drop Δp (in. H_2O)
1	3.4
2	2.6
3	2.0
4	1.1
5	.90

mean Δp is 2.0 in. H_2O

probe was placed 3 inches into duct

White Furniture - Sander Line

Duct diameter = 24 in.

Static pressure = -3 in.

Insertion of pitot tube into duct (in.)	Pressure drop Δp (in. H_2O)
2	.80
4	.55
6	.55
8	.60
10	.63
12	.59
14	.53
16	.51
18	.52
20	.50
22	.50

mean Δp is .57 in. H_2O

probe was placed 12 inches into duct

Singer Furniture - Finish Planer and Molders

Duct diameter = 16 in.

Static pressure = -5.3 in. H_2O

Insertion of pitot tube into duct (in.)	Pressure drop Δp (in. H_2O)
2	3.0
4	3.2
6	3.2
8	2.4
10	2.0
12	1.8
14	2.0

mean Δp is 2.51 in. H_2O

probe was placed 7 3/4 inches into duct

Singer Furniture - Band and Variety Saws

Duct diameter = 12 in.

Static pressure = -3.0 in. H_2O

Insertion of pitot tube into duct (in.)	Pressure drop Δp (in. H_2O)
2	.25
4	.30
6	.60
8	.70
10	.65

mean Δp is .50 in. H_2O

probe was placed about 5 1/4 inches into duct

Singer Furniture - Double End Tennon Machine

Duct diameter = 17 in.

Static pressure = -3.2 in.

Insertion of pitot tube into duct (in.)	Pressure drop Δp (in. H_2O)
2	.65
4	.70
6	.60
8	.65
10	.65
12	.70
14	.65
16	.60

mean Δp is .65 in. H_2O

probe was placed about 9 inches into duct

White Furniture - Mebane

Planers - December 21, 1976
Orifice #1
Probe - stainless steel, 1.427 in. diameter
Barometric Pressure 29.02 in. Hg
Sampling point 8 inches inside duct
15 1/2 inches duct diameter
$\overline{\Delta p}$ = .53 inches H_2O

Run 1

Filter 54853
Start 9:40 A.M.

θ	T_m	P_o	ΔH
1	72	13.5	1.0
3	72	13.9	1.0
6	72	14.8	1.0
8	72	42.6	.05

Run 2

Filter 54854
Start 10:10 A.M.

θ	T_m	P_o	ΔH
1	70	13.3	1.0
2	72	14.6	1.05
3	72	40	.75
4	72	42	.05

Run 3

Filter 39455
Start 10:31 A.M.

θ	T_m	P_o	ΔH
1	70	13.5	1.0
2	70	15.3	1.5
3	72	33	.05

White Furniture - Mebane

Molder - December 21, 1976
Orifice #1
Probe - stainless steel, 1.427 in. diameter
Barometric Pressure 29.08 in. Hg
Sampling point 6 inches inside duct
20 1/2 inch duct diameter
$\overline{\Delta p}$ = .69 in. H_2O

Run 1

Filter 54856
Start 11:33 A.M.

θ	T_m	P_o	ΔH
1	66	16.5	1.45
2	68	16.5	1.40
3	68	16.6	1.40
4	68	16.8	1.40
5	68	17.3	1.40
6	70	17.3	1.40
7	70	17.5	1.40
8	70	17.7	1.40
9	70	17.9	1.40
10	70	18.1	1.40
11	70	18.3	1.40
12	70	18.5	1.40

Run 2

Filter 54857
Start 1:06 P.M.

θ	T_m	P_o	ΔH
1	78	15.3	1.40
2	78	16.5	1.40
4	78	16.6	1.40
6	78	16.8	1.40
8	78	17.1	1.40
10	78	17.5	1.40
11	78	17.5	1.40
Shut down for machine adjustment--Restart 1:22 P.M.			
11	78	17.4	1.40
13	78	18.1	1.40
15	78	18.3	1.40
17	78	18.5	1.40

Run 3

Filter 54858
Start 1:42 P.M.

θ	T_m	P_o	ΔH
1	70	16.3	1.40
3	74	16.5	1.40
6	76	17.3	1.40
9	76	18.2	1.40
12	76	19.2	1.40
15	76	20.2	1.40
18	76	21.4	1.40
21	76	22.6	1.40

White Furniture - Mebane

Rough-End Cut-off - December 21-22, 1976
Orifice #1
Probe - galvanized steel, 1.099 in. diameter
Barometric Pressure 29.22 in. Hg
Selected sampling point was 3 inches inside duct
6 inches duct diameter
$\overline{\Delta p}$ = 2 inches H_2O

Run 1

Filter 54899
Start 3:05 P.M.

θ	T_m	P_o	ΔH
1	68	20.6	1.45
3	68	22.4	1.45
5	70	24.5	1.45
6	70	25.3	1.45
7	70	28.5	1.50
8	70	31	1.50
9	70	32.2	1.50
10	70	33.5	1.50

Run 2

Filter 54898
Start 3:31 P.M.

θ	T_m	P_o	ΔH
1	62	19.5	1.45
2	62	21.3	1.45
4	64	23.7	1.45
5	68	25	1.45
6	70	26.4	1.50
8	70	29	1.50
9	70	31.7	1.50
10	70	32.7	1.50
11	70	34.6	1.50

Run 3

Filter 54897
Start 8:44 A.M.

θ	T_m	P_o	ΔH
1	60	19.3	1.45
2	60	19.5	1.45
4	60	19.7	1.45
5	60	19.9	1.45
Stopped--then restarted at 9:06 A.M.			
5	60	19.9	1.45
6	62	20.4	1.45
8	62	23.2	1.45
9	62	25.4	1.45
10	62	27.2	1.50
11	62	28.1	1.50
12	62	28.3	1.50
14	62	31.1	1.50
15	62	33.5	1.50
16	62	35.6	1.45

White Furniture - Mebane

Sanders - December 22, 1976
Orifice #1
Probe - stainless steel, 1.427 in. diameter
Barometric Pressure 29.50 in. Hg
Selected sampling point was 12 inches inside duct
24 inches duct diameter
$\overline{\Delta p}$ = .57 in. H_2O

Run 1

Filter 54896
Start 10:17 A.M.

θ	T_m	P_o	ΔH
1	74	14.3	1.10
3	74	14.3	1.10
6	76	14.8	1.10
10	76	14.9	1.10
15	76	15.3	1.13
20	76	16.2	1.13
25	76	16.3	1.13
30	76	16.7	1.13
40	76	17.6	1.15
50	76	18.8	1.15
60	78	19.8	1.15
70	78	21.0	1.15

Singer Furniture - Sanford

Finish Planer and Molders - December 28, 1976
Orifice #1
Probe - galvanized steel, 1.099 in. diameter
Barometric pressure 29.02 in. Hg
Selected sampling point was 7 3/4 inches into duct
16 inches diameter duct
$\overline{\Delta p}$ = 2.51 in. H_2O

Run 1

Filter 54895
Start 8:24 A.M.

θ	T_m	P_o	ΔH
1	72	21.5	1.85
2	72	23.1	1.85
4	74	24.5	1.85
5	74	25.9	1.85
6	74	26.7	1.85
8	74	26.7	1.85
10	74	26.5	1.85
12	74	26.5	1.85
14	74	26.6	1.85
16	74	26.7	1.85
18	74	26.7	1.85

Run 2

Filter 54894
Start 9:02 A.M.

θ	T_m	P_o	ΔH
1	72	20.3	1.85
2	74	23.0	1.85
4	74	23.7	1.85
6	76	25.4	1.87
8	76	26.8	1.90
10	76	28.5	1.90
12	76	30.1	1.90
14	76	32.0	1.92
15	76	32.2	1.92

Run 3

Filter 54893
Start 9:35 A.M.

θ	T_m	P_o	ΔH
1	74	21	1.85
3	74	21	1.85
4	74	21	1.85
4'45" plugged			

Singer Furniture - Sanford

Band and Variety Saws - December 28, 1976
Orifice #1
Probe - stainless steel, 1.623 in. diameter
Barometric pressure 29.02 in. Hg
Selected sampling point 5 1/4 inches into duct
12 inches duct diameter
$\overline{\Delta p}$ = .5 in. H_2O

Run 1

Filter 54892
Start 10:35 A.M.

θ	T_m	P_o	ΔH
1	66	17	1.70
2	66	18.5	1.70
4	66	18.5	1.70
6	66	19.1	1.70
8	66	19.9	1.70
10	66	21.2	1.70
12	66	22.4	1.70
14	66	23.6	1.70
16	66	24.6	1.70
18	66	25.8	1.70
20	66	26.5	1.70

Run 2

Filter 54891
Start 11:13 A.M.

θ	T_m	P_o	ΔH
1	66	17.2	1.70
2	66	17.3	1.70
4	66	18.4	1.70
6	66	18.9	1.70
8	66	20.1	1.70
10	66	21.5	1.70
12	66	22.8	1.70
14	66	23.6	1.70
16	66	24.7	1.70
18	66	26.2	1.70
20	66	27.4	1.70
22	66	28.4	1.75
24	66	30.1	1.75

Run 3

Filter 54890
Start 1:25 P.M.

θ	T_m	P_o	ΔH
1	62	19.6	1.70
2	64	20.6	1.70
4	64	21.4	1.70
6	64	22.6	1.70
8	64	23.5	1.70
10	64	24.9	1.70
12	64	25.9	1.70
14	64	27.4	1.70
16	64	28.6	1.75
18	66	30.0	1.75
20	66	31.1	1.75
22	66	32.6	1.80

Singer Furniture - Sanford

Double End Tennon Machine - December 28, 1976
Orifice #1
Probe - stainless steel, 1.427 in. diameter
Barometric pressure 29.02 in. Hg
Sampling point was 9 inches into duct
17 in. duct diameter
$\overline{\Delta p}$ = .65 in. H_2O

Run 1

Filter 54889
Start 2:35 P.M.

θ	T_m	P_o	ΔH
1	68	19.1	1.30
3	68	20.7	1.30
5	68	25.2	1.30
7	70	25.2	1.30
9	70	25.6	1.35
11	70	31	1.35
12	70	32.1	1.25
13	70	32.1	1.25

Sampling was stopped after the machine operator exhausted his supply of panels to cut.

Notes on Machine Operation

White Furniture

Planers

There were two finish planers on the duct tested. Wood was being cut.

Run 1: One planer operated
Run 2: Both planers operated
Run 3: One planer operated for the full run, the other operated for part of the run.

Molder

There was one molder on the duct tested. Test runs were performed with the machine operating at a normal production pace. Wood was being cut.

Rough-End Cut-off

There were two circular saws. Both saws operated during the first two test runs. One saw operated during the third run. Rough sawn lumber was cut.

Sanding Line

There were one horizontal string sander and two vertical spindle sanders on the duct tested. The string sander was in use during all of the test run. One of the other sanders was operated during the test.

Singer Furniture

Finish Planer and Molders

The planer was not operated during any of the test runs. One molder was operated during Run 1. For Runs 2 and 3, one molder was operated nearly full time and the other about 50% to 75% of the time. Wood was cut.

Band and Variety Saws

One band saw and one variety saw were in use. The variety saw was operated nearly full time during the three runs. The band saw was operated about 75% of the time during the three runs. The variety saw was cutting mostly wood. The band saw was cutting medium density particle board.

Double End Tennon Machine

The double end tennon machine was cutting medium density particle board during all of the test run. Saws and dado blades were in use.

Sampling Train Calibration and Operation

Terms:

v_s (ft/sec), Velocity in stack

V_n (ft/sec), Velocity in nozzle

C_p pitot tube calibration coefficient, the type-s tube used was assumed to have a coefficient of .85

Δp (in. H_2O), Pressure drop across pitot tube

R ($53.34 \frac{ft\ lbf}{lbm\ ^oR}$), Gas constant

T_s (^oR), Stack temperature

g_c ($32.17 \frac{lbm\ ft}{lbf\ sec^2}$), Gravitational acceleration correction factor

P_s (in. H_2O), Absolute stack static pressure

Q_n (ft^3/sec), Flow through nozzle

A_n (ft^2), Area of nozzle

Q_m (ft^3/sec), Flow through orifice meter

T_m (^oR), Orifice meter temperature

P_m (in. H_2O), Absolute pressure in orifice meter measured on high pressure side of orifice plate

K Orifice meter correction factor

A_m (ft^2), Orifice area

ρ ($\frac{in.\ H_2O\ lbm}{ft\ lbf}$), Density of gas

P_1 (in. H_2O), Pressure on high pressure side of orifice

P_2 (in. H_2O), Pressure on low pressure side of orifice

ΔH (in. H_2O), Orifice pressure drop

d (in.), Diameter of nozzle

B (ft^2), Calibration coefficient for orifice meter

Theory

A sketch showing the general sampling train arrangement is shown in Figure 1. For calibration, the fan was replaced by a Roots Meter (lobed rotor) followed by a fan with variable transformer. The vacuum in the Roots Meter was measured with a manometer.

To have isokinetic sampling, it is necessary that the velocity of stack gas going into the nozzle be the same as the velocity in the stack (or duct).

$$v_s = V_n$$

The velocity in the stack is measured by a pitot tube. The equation for velocity based on pitot tube pressure drop is:

$$v_s = C_p \sqrt{\frac{2\ \Delta p\ \ R\ \ T_s\ \ g_c}{P_s}}$$

The volumetric flow through the nozzle is related to the nozzle velocity and size and is equal to the flow through the orifice meter on a mass basis. On a volume basis, adjustments for pressure and temperature are required. So:

$$Q_n = V_n\ A_n = v_s\ A_n$$

$$v_s\ A_n = Q_m\ \frac{T_s}{T_m}\ \frac{P_m}{P_s}$$

The flow through the orifice meter is found from the equation:

$$Q_m = K\ A_m \sqrt{\frac{2\ g_c}{\rho}}\ \sqrt{P_1 - P_2}$$

where,

$$\rho = \frac{P_m}{R\ T_m}$$

$$\sqrt{P_1 - P_2} = \sqrt{\Delta H}$$

so,

$$Q_m = K\ A_m \sqrt{\frac{2\ g_c\ R\ T_m\ \Delta H}{P_m}}$$

Therefore, at isokinetic conditions, we can say:

$$A_n\ C_p \sqrt{\frac{2\ \Delta p\ R\ T_s\ g_c}{P_s}} = K\ A_m \sqrt{\frac{2\ g_c\ R\ T_m\ \Delta H}{P_m}} \left(\frac{T_s}{T_m}\right) \left(\frac{P_m}{P_s}\right)$$

As a further simplification, for any given orifice meter, the value of A_m will be constant so we can define a calibration factor:

$$B = K\ A_m$$

The equation for isokinetic sampling can thus be simplified to:

$$\Delta H = .4457\ \frac{d^4}{B^2}\ \frac{P_s}{P_m}\ \Delta p \quad \text{having noted that } T_s \approx T_m$$

For a given orifice, nozzle, and point in a duct, d, B, and Δp would be known. To have isokinetic sampling requires that:

$$\Delta H\ \frac{P_m}{P_s} = .4457\ \frac{d^4}{B^2}\ \Delta p$$

The value of P_m/P_s will change as ΔH changes. Thus, isokinetic conditions can be reached by a process of iteration.

Calibration

The orifice meter was calibrated using the equation:

$$Q_m = B \sqrt{\frac{2\ g_c\ R\ T_m\ \Delta H}{P_m}}$$

The flow through the train was set at various values of ΔH and held at that value while the Roots Meter was timed as it measured off a particular volume of air. The values of barometric pressure, orifice meter temperature, orifice pressure, Roots Meter pressure, time, Roots Meter volume, and orifice pressure drop were recorded. For each ΔH, the corresponding B was calculated.

The equation:

$$\Delta p = \frac{\Delta H}{.4457} \quad \frac{B^2}{d^4} \quad \frac{P_m}{P_s}$$

was then used to calculate values of Δp for each ΔH used in calibration, with P_m/P_s taking values of 1, .95, .9, .85, and .8. The resulting numbers were then plotted to provide a family of curves which could be used to establish isokinetic sampling conditions. One of the plots is shown as Figure 2.

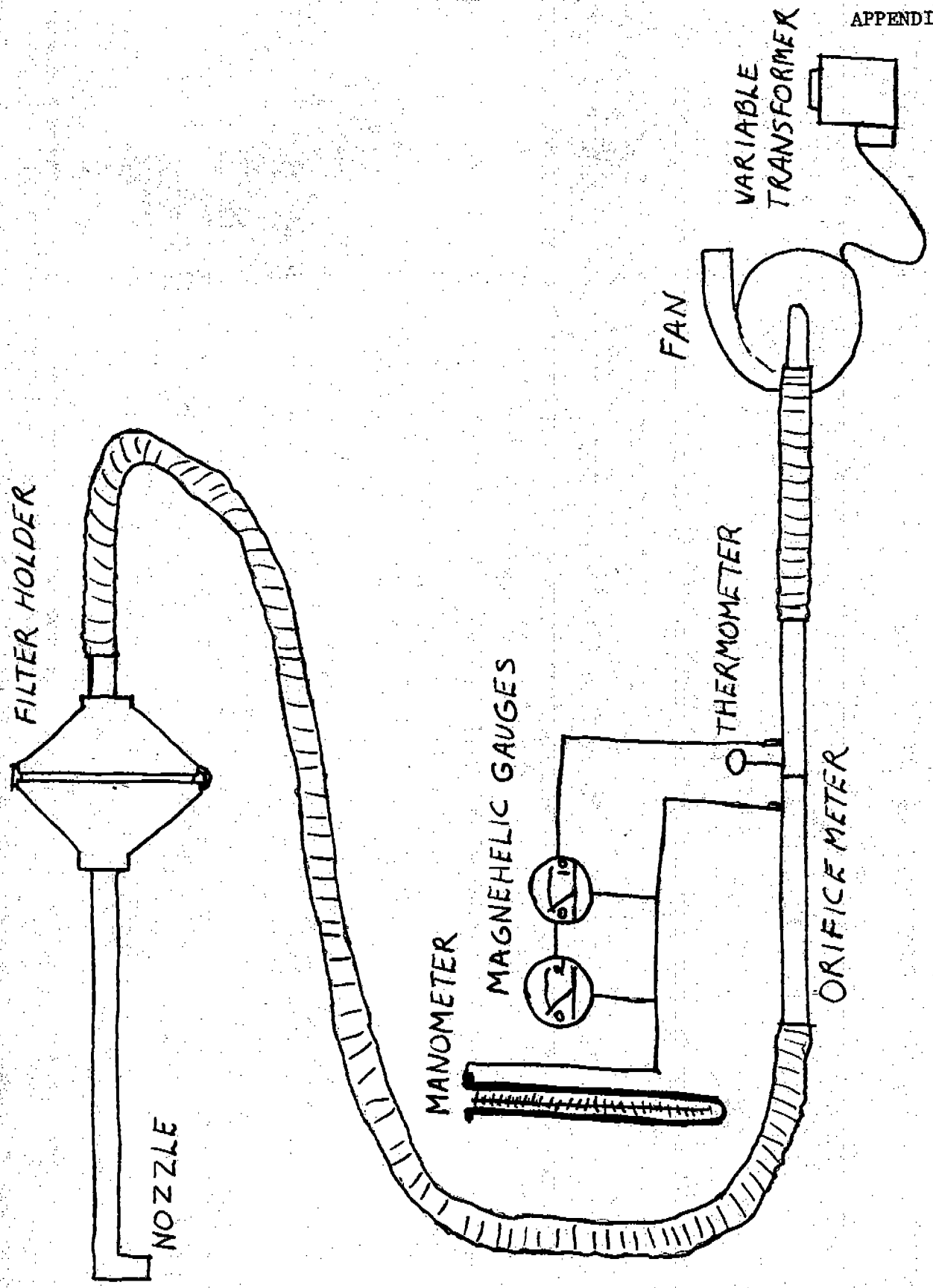

FILTER HOLDER
NOZZLE
MANOMETER
MAGNEHELIC GAUGES
THERMOMETER
ORIFICE METER
FAN
VARIABLE TRANSFORMER

Figure 1