PRELIMINARY INDUSTRIAL HYGIENE SURVEYS

Rockwool Industries
Pueblo, Colorado
Belton, Texas

SURVEY DATES
September 18-19, 1974

REPORT BY
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Worker exposures to airborne fibers and trace metals were surveyed at the Rockwool Industries (SIC-3296) in Pueblo, Colorado and Belton, Texas on September 18 and 19, 1974. The company employed 87 workers at Pueblo and 174 at Belton. A first aid program was implemented and local physicians were retained as consultants. Environmental matters were handled by an industrial hygiene consultant, and safety equipment was available for use by workers. Airborne fiber concentrations ranged from 0.11 to 0.60 fibers per cubic centimeter (f/cc) at Pueblo. The highest concentration at Belton was 0.13f/cc. A total of 74 and 90 percent of the fibers were respirable at Pueblo and Belton, respectively. The author concludes that there was significant exposure to respirable slagwood fibers at the facilities and recommend that exposure be kept at a minimum by implementing good work practices, engineering controls, exhaust ventilation systems, vacuum cleaning, respiratory protection and a medical surveillance program.

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INTRODUCTION

As part of the NIOSH industrywide study of the mineral wool industry, preliminary industrial hygiene surveys were conducted at the Pueblo, Colorado and Belton, Texas mineral fiber production facilities of Rockwool Industries. These surveys were conducted by John Dement and David Bayliss of the Division of Field Studies and Clinical Investigations on September 18-19, 1974.

The present surveys included observation of the manufacturing processes and control measures in addition to preliminary air sampling for fiber concentration and fiber size distribution. Also, Mr. Bayliss evaluated personnel records at both plants for possible inclusion in future mortality studies.

Due to the similarity of the Pueblo and Belton facilities, they have been included in a single report. The following paragraphs describe processes in these facilities, industrial hygiene practices, sampling procedures and air sample results.

DESCRIPTION OF THE FACILITIES

The major products of both the Pueblo, Colorado and Belton, Texas plants of Rockwool Industries are thermal insulation materials (both batt products and granulated or blowing wool). According to Mr. Matthews, Vice President of Industry and Market Relations, fibers in these products have an average diameter of approximately 6 μm.

Fiber production at the Pueblo, Colorado facility began in approximately 1951 and the plant presently has a work force of approximately 87 persons and operates 3 shifts per day, 5 days per week. Employees at this plant are represented by the United Steel Workers and Teamsters Unions.

Fiber production at the Belton, Texas facility began in approximately 1955; however, Rockwool Industries has operated this plant only since 1972. Prior to this time it was operated by a local businessman, Mr. Fred Guffy. The present employment of this plant is approximately 147 persons on a 7 day per week basis. There is no employee union at this facility.

MEDICAL, INDUSTRIAL HYGIENE AND SAFETY PROGRAMS

There are no pre-employment or routine medical examinations given at either of these facilities. Both plants have minor first aid facilities and retain local physicians as consultants.

Rockwool Industries does not have an industrial hygienist on staff; however, the company does use the services of a consultant, Mr. Ted Wimberly, who handles all environmental problems. Mr. Wimberly has done some environmental sampling in each of these facilities. The company's Workmen's Compensation carrier, Argonaut Safety Service, does yearly inspections of the plants; however, no air sampling is done.

Safety programs in both of these facilities are the responsibility of Mr. Marshall Jackson, Corporate Safety Director. Mr. Jackson routinly inspects both facilities. Employees are given a safety orientation at the time of their job training. In 1973, there were 27 lost time accidents at the Belton plant. No statistics were available for the Pueblo facility.

Personal protective devices used at these facilities include safety glasses in some areas, ear protection and safety shields for cupola workers (notchers) and safety shoes for maintenance personnel. Disposable filter type dust mask (single strap) are available for each employee. In addition, at the Pueblo plant where lead slag is used as part of the cupola charge, air supplied respirators are worn by the cupola chargers to reduce lead exposures.

According to corporation personnel, the only medical problems noted at these plants, with the exception of transient mechanical dermatitis of new employees due to slagwool fibers, is lead exposures in the cupola charge area at the Pueblo plant. In 1973, several employees were hospitalized with severly high blood lead levels (>80 µg%) and treated with chealting agents. Subsequent to these findings, improvements have been made on the cupola charge area ventilation to bring airborne lead levels below 0.2 $\mu g/m^3$.

DESCRIPTION OF THE PROCESSES

Slagwool fibers are formed by basically the same process in both the Pueblo and Belton plants. In this process, high silica slags from copper and lead smelters and iron slag from blast furnaces are layer charged with coke in a conventional water cooled cupola with a capacity of approximately 3000 lbs. Iron and lead slags are used at Pueblo whereas copper and iron slags are used at Belton.

Fibers are formed by the so call "rotary process". In this process, a molten slag stream is directed into a spinning disc where centrifugal force causes the molten slag to be thrown from the rim of the disc forming primary fibers. These primary fibers are then met by either a high velocity steam jet or by high velocity air streams where the primary fibers are attenuated to the final fiber diameters. In both plants steam attenuation is used to form loose blowing wool whereas the fibers used to make fiber batts are producted by the air attenuation process. According to plant management, mean fiber diameters are typically on the order of 6-9 µm.

After formation, fibers to be used in fiber batts are sprayed with a phenol-formaldehyde binder and collected onto a moving conveyer thus forming a continuous blanket. The blanket next passes through a curing oven (400-500°F) causing the phenol-formaldehyde binder to polymerize. After curing, the blankets are cut and trimmed to proper dimension and packaged. In addition, moisture bariers (asphalt plus kraft paper or aluminum foil) may be placed on one side of the batt.

After the fibers are formed, blowing wools receive only a light oil lubrication. Shot (unfiberized slag) is first removed from the fiber and the fiber pneumatically conveyed to storage hoppers for bagging. Fibers are bagged in 50 lb. quantities using automatic bagging machines.

INSPECTION OF THE PLANT

Potential Safety and Health Hazards: the following are potential health and safety hazards noted during these surveys:

1. Skin and respiratory exposures to slagwool fibers.
2. Respiratory exposure to phenol and formaldehyde in binder curing areas.
3. Carbon monoxide and metal fume exposures incupola charge areas.
4. High noise exposures in fiber forming areas.

Housekeeping

In general, housekeeping at the Pueblo plant was considered satisfactory; however, conditions at the Belton plant were not considered satisfactory. At Belton, waste fibers were found six to eight inches deep in some areas. In addition, leaks in the cupola cooling system caused water accumulation in working areas thereby creating a possible safety hazard. Nearly all floor cleaning in both plants is done with hand brooms.

SURVEY PROCEDURES

The major portion of these surveys was devoted to observation of manufacturing procedures and exposure control practices. Bulk samples of both blowing wool and fiber batt were collected at both Pueblo and Belton. In addition, a limited number of air samples were collected for evaluation of worker exposures to airborne fibers. Air samples were collected in the workers breathing zones on 37mm millipore type AA cellulose ester membrane filters (0.8μm pore size) at a calibrated sampling rate of 2.0 lpm with an open filter face.

Laboratory evaluation of the collected air samples was done using the phase contrast optical microscopic fiber count method recommended for asbestos.[1] A Zeitz phase contrast microscope was used for these counts at a magnification of 400X (objective NA=0.65). All fibers were simultaneously counted and sized by comparsion with a calibrated portion eyepiece reticule.

In addition to sizing airborne fibers, fiber diameter distributions and trace metal levels were determined for all four collected bulk samples. Diameter distributions were done using phase contrast microscopy as described above for air samples. At least 200 randomly selected fibers were sized for each sample. Trace metal levels for the bulk fiber products were determined using atomic absorption spectroscopy following an acid digestion.

RESULTS AND DISCUSSION

Fiber Bulk Samples

Fiber diameter distributions for the product fiber samples are shown in Figures 1-4 and summarized in Table 1. These distributions were found to follow excellent log normal distributions with relatively small geometric standard deviations. Geometric mean fiber diameters for the fiber batts were found to be 7.3 μm at Pueblo and 6.6 μm at Belton. Geometric mean fiber diameters for the blowing wools were slightly smaller at 5.3 μm for Pueblo and 5.4 μm at Belton. These diameters are slightly smaller than those seen for typical fiber glass insulation samples.

Results of the trace metals analyses of the bulk samples are shown in Table 2. Major contaminants are seen to be Co, Cr, Mn, Ni and Pb; however, it would be anticipated that large deviations in these values would occur from day-to-day due to variations in slag and coke composition.

Although many of the metals listed in Table 2 are considered carcinogens, their availability in the pulmonary environment is unknown; however, the solubility would be expected to be quite low. Similar concentrations of metals are typically seen with bulk asbestos fiber samples; however, the proven carcinogenicity of these fiber is presently thought to be due to its fibrous nature rather than to carcinogenic metal contamination.[11,12]

Air Samples

Before discussing the specific results of air samples collected during this survey, a brief discussion of fiber respirability is appropriate. Although the respirability of airborne fibers is not clearly understood, this characteristic is thought to be chiefly diameter dependent and fibers greater than 10 μm in diameter certainly have little chance of deep pulmonary penetration. Timbrell's[2] work suggests that the two major mechanisms of fiber deposition in the upper airways (settlement under

gravity and inertial deposition) are chiefly dependent upon particle free falling speed (i.e. equivalent Stoke's diameter) and fibers with densities less than 3.5 g/cm^3 and less than 3.5 µm in diameter may escape deposition by these two mechanisms and penetrate deeply into the lungs. Timbrell's work further suggests that the limitation on the lengths of fibers which reach the deep pulmonary air spaces is imposed by the nasal hairs and small diameters of the respiratory bronchioles. Timbrell and Skidmore[3] in a more recent inhalation experiment with rats, using fibrous glass of 0.75-1.5 µm in diameter and lengths up to 100 µm, found a few fibers up to 50 µm in length in the lungs of rats sacrificed during exposure, although the bulk of all fibers found were less than 20 µm in length.

Another study conducted by Gross, et al.,[4] concerned itself with fiber size distributions in the lungs of previous fibrous glass workers. Postmortem examinations were made of lung sections of 20 fiber glass workers who had been exposed to fibrous glass dust for between 16 and 32 years. In this study, approximately 95 percent of all fibers observed were less than approximately 40 µm in length. Occasionally, fibers 50 to 60 µm in length were observed; however, it must be pointed out that these size distributions were made following the lung clearing process therefore no statement can be made regarding initial deposition of fibers.

In contrast to the above quoted articles, Murphy[5] reported a case of acute pulmonary involvement following a short period of fibrous glass exposure. A lower lobectomy was performed and careful pathological studies demonstrated the presence of glass fibers up to 14 µm in diameter and 60 µm in length in the terminal bronchioles. In addition, Balber[6] reports finding fibers 100 µm to 200 µm in length in the alveolar regions of asbestos workers at autopsy.

As can be seen, considerable difference of opinion exists as to the true nature of a respirable fiber. For purposes of this discussion, based on the above cited studies, "potentially" respirable slagwool fibers shall be defined as those less than 3.5 µm in diameter and less than 50 µm in length.

Results of the airborne fiber concentration determinations are shown in Table 3. At Pueblo, concentrations are seen to range from 0.11 to 0.60 fibers/cc while concentrations at the Belton plant were considerably lower with the highest concentration being only 0.13 fibers/cc. Results of the airborne fiber diameter and length determinations for Pueblo are shown in Table 4. Median airborne fiber diameter and length were found to be 1.9 and 14 µm, respectively. Based on the above definition of fiber respirability, 74% of the airborne fibers at Pueblo and 90% of the airborne fibers at Belton could be considered respirable.

There are presently little data available relating human experience with respirable mineral fiber exposures such as found in these operations. All human experience to date has been with fibers at significantly lower concentrations[7,8,9,10] than observed at the Pueblo facility. Studies of the health effects on these workers have produced essentially negative results.

However, recent animal studies conducted by Stanton[11] and Friedrichs[12] have demonstrated that small diameter fibrous glass is carcinogenic when injected into the pleural cavity of rats. The significance of these studies in relation to the types of fibers being made at Pueblo and Belton are yet unknown. NIOSH has underway a retrospective mortality study of a cohort engaged in slagwool production; however, results of this study are not presently available.

CONCLUSIONS AND RECOMMENDATIONS

From the observations made during this survey and the results of the measurements which were made, the following conclusions are drawn and recommendations for improvements made:

1. There appears to be significant exposure to respirable slagwool fibers especially at the Pueblo facility. While no data presently exist to indicate respiratory problems due to such exposures, it must be emphasized that human experience with respirable slagwool fibers is limited. It would appear prudent that exposures to respirable slagwool fibers be kept at an absolute minimum by the use of good work practices and engineering controls. The use of brooms and hand brushes for cleaning should be eliminated in favor of much cleaner vacuum methods. In addition, those persons handling bulk fiber such as baggers and fiber batt handlers should be required to wear respiratory protection unless they have existing health problems which prohibits this, in which case they probably should be removed from this work environment.

2. Local exhaust ventilation should be installed at all fiber bagging stations and at the batt fiber trim saws.

3. Good medical practice dictates close medical surveillance of those involved in these operations. It is recommended that a medical surveillance program be initiated in these facilities similar to that outlined in the current asbestos standard (Federal Register, Volume 37, October 18, 1972, Section 1910.93a). This program includes both pre-employment and annual examinations, consisting of chest roentgenogram (14" x 17" posterior-anterior), a history to elicit symptomatology of respiratory disease, and pulmonary function tests (FVC and FEV_1).

REFERENCES

1. "Criteria for a Recommended Standard: Occupational Exposure to Asbestos", USDHEW, Public Health Service, National Institute for Occupational Safety and Health, 1972.

2. Timbrell, V., "The Inhalation of Fibrous Dusts". Annals of the New York Academy of Sciences, Volume 132, Art I, pp. 225-253, 1965.

3. Timbrell, V. and J. W. Skidmore, "The Effects of Shape on Particle Penetration and Retention in Animal Lungs". Proc. Third Int. Conf. Inhaled Particles and Vapors, pp. 49-57, Unwin Bros. London (1971).

4. Gross, P., Jiri Tuma and R.T.P. deTreville, "Lungs of Workers Exposed to Fiber Glass: A Study of Their Pathologic Changes and Their Dust Content". Arch. Env. Health, Vol. 23, pp. 67-71, July 1971.

5. Murphy, George B., "Fiber Glass Pneumoconiosis", Arch. Env. Health, Vol. 3, pp. 102-108, December 1961.

6. Balber, J.L., Discussion, Proc. Third International Conference Inhaled Particles and Vapors, p. 57, Unwin Bros. London (1971).

7. Wright, George B., "Airborne Fibrous Glass Particles: Chest Roentgenograms of Persons With Prolonged Exposure". Arch. Environ. Health, Vol. 16, February 1968.

8. Murphy, George B., "Fiber Glass Pneumoconiosis", Arch. Env. Health, Vol. III, December 1961.

9. Nasr, A.N.M., T.M. Ditchek and P.A. Schottens, "The Prevalence of Radiographic Abnormalities in the Chests of Fiber Glass Workers", J. Occup. Med. 13:371-376, 1971.

10. Utidjian, H.M.D. and R.T.P. deTreville, "Fibrous Glass Manufacture and Health: Report of an Epidemiological Study: Part I and II". Read before the 35th annual meeting of the Industrial Health Foundation, Pittsburgh, Pennsylvania, 1970.

11. Stanton, M.F. and C. Wrench, "Mechanisms of Mesothelioma Induction With Asbestos and Fibrous Glass", J. Natl. Cancer Inst. 48:797-821, 1972.

12. Pott, F. and K. H. Friedrichs, "Tumors in Rats After Intraperitoneal Injection of Fibrous Dusts, Die Naturwissenschaften, 59:318, 1972.

TABLE 1

Summary of Fiber Distributions in Bulk Fiber Products, Rockwool Industries, Pueblo, Colorado and Belton, Texas

Plant and Fiber Product*	Geometric Mean Dia.	Geometric Standard Deviation
Pueblo		
Fiber Batt	7.3	1.8
Blowing Wool	5.3	1.8
Belton		
Fiber Batt	6.6	1.7
Blowing Wool	5.4	1.7

* Greater than 200 fibers sized for each product.

TABLE 2

Results of Trace Metal Analyses of
Product Fiber Bulk Samples, Rockwool
Industries, Pueblo, Colorado and Belton, Texas

Trace Metal	Concentration, PPM			
	Pueblo		Belton	
	Blowing Wool	Fiber Batt	Blowing Wool	Fiber Batt
Be	<1	<1	<1	<1
Cd	1	6	5	7
Co	39	107	120	259
Cr	163	231	389	109
Mn	3,876	14,475	1,937	2,350
Ni	36	83	126	315
Pb	681	621	546	674
Zn	11	<1	6	7

TABLE 3

Airborne Fiber Concentrations (fibers/cc), Rockwool Industries, Pueblo, Colorado and Belton, Texas

Sample #	Job or Sample Location	Air Volume Liters	Fiber Conc. fibers/cc
	Pueblo		
PB-1	Fiber Batt Take-off	96	0.60
PB-2	Fiber Batt Take-off	108	0.54
PB-3	Fiber Batt Packer	130	0.16
PB-5	Fiber Batt Packer	132	0.11
PB-6	Blowing Wool Bagger	132	0.26
	Belton		
B-1	Fiber Batt Take-off	68	0.05
B-2	Fiber Batt Take-off	76	0.00
B-3	Blowing Wool Bagger	58	0.04
B-4	Blowing Wool Bagger	66	0.13

TABLE 4

Summary of Airborne Fiber Size Distributions,
Rockwool Industries, Pueblo, Colorado*

Size Parameter	Measure
Diameter	
Count Median Dia., µm	1.9
% Fibers ≤3.5 µm	79
Length	
Count Median Length, µm	14
% Fibers ≤50 µm	75

*Insufficient fibers were observed on the samples at Belton, Texas to determine a statistically valid size distribution.

FIG. 1 FIBER DIAMETER DISTRIBUTION

ROCKWOOL INDUSTRIES, PUEBLO, COLO.

GRANULATED WOOL

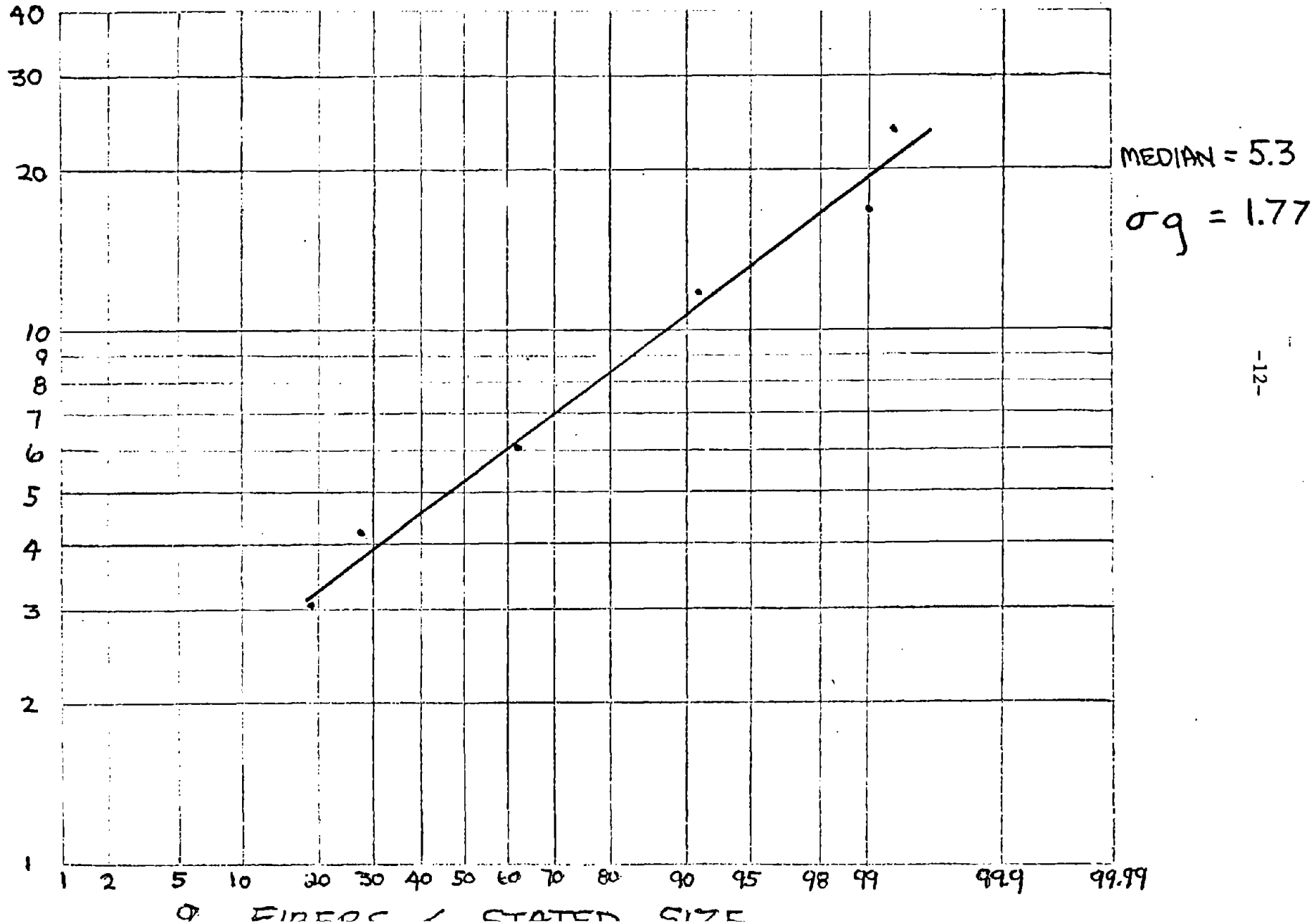
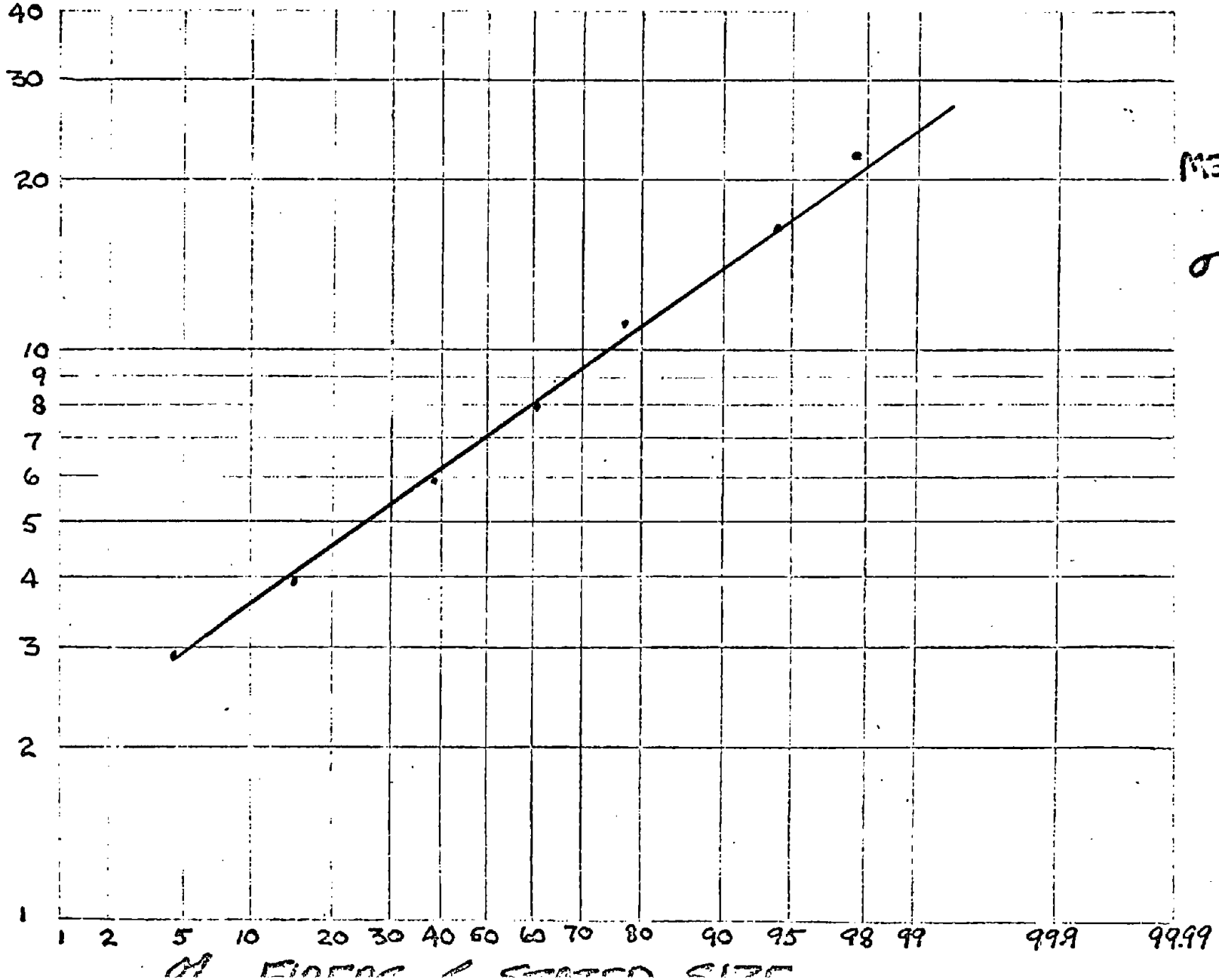


FIG. 2 FIBER DIAMETER DISTRIBUTION

ROCKWOOL INDUSTRIES — PUEBLO, COLO.

BATT WOOL



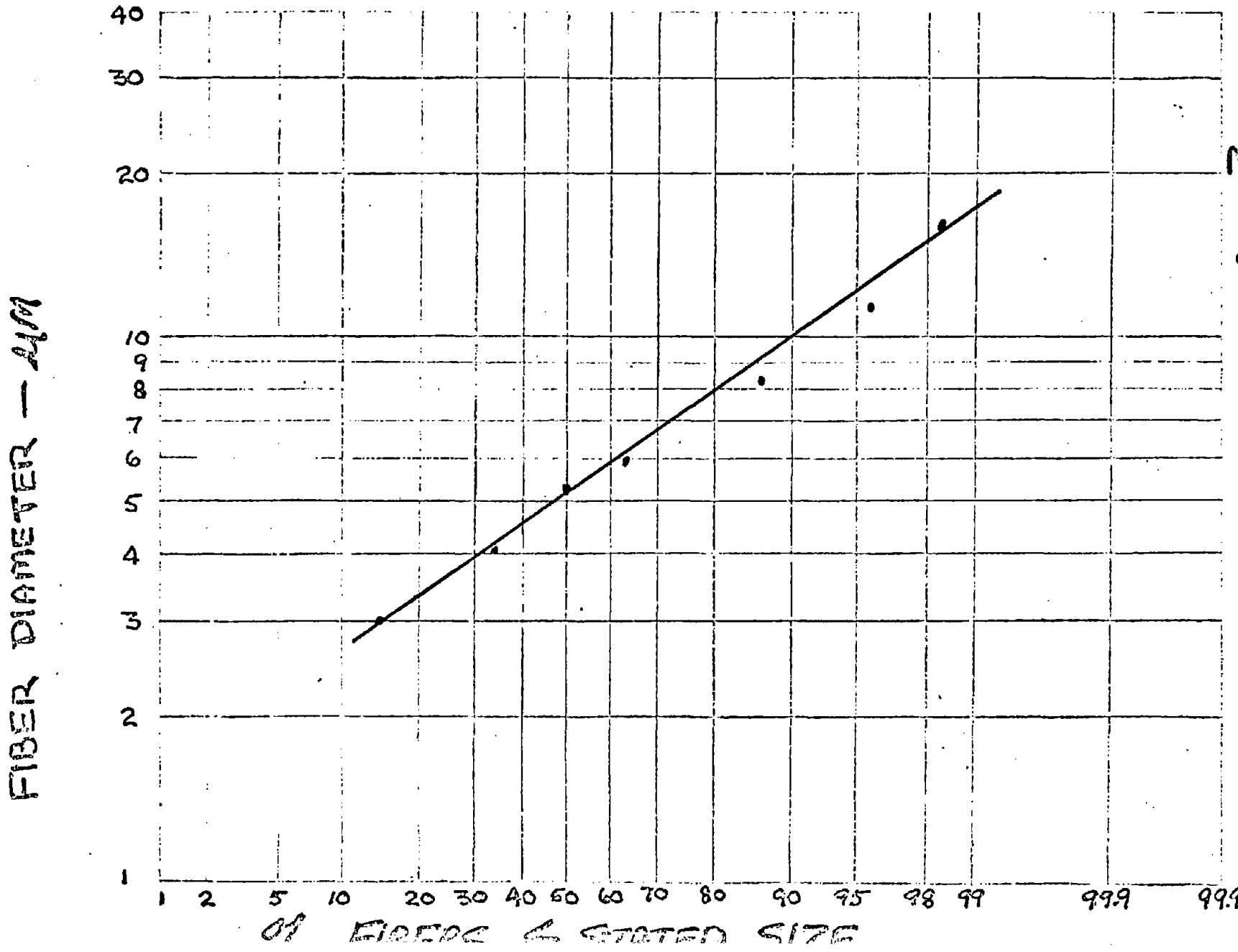
MEDIAN = 7.

σ_g = 1.7

FIG. 3 FIBER DIAMETER DISTRIBUTION

ROCKWOOL INDUSTRIES — BELTON, TEXAS

BLOWING WOOL



MEDIAN = 5.4

σ_g = 1.61

FIG. 4 FIBER DIAMETER DISTRIBUTION

ROCKWOOL INDUSTRIES - BELTON, TEXAS

FIBER BATT