# MAN-MADE MINERAL FIBRE SURVEY AT ELKEM-ROCKWOOL A/S, LARVIK

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# I INTRODUCTION

The question as to whether occupational exposure to Man-made-mineral-fibres (MMMF) is harmful is of current interest; especially as these materials are being increasingly used as substitutes for asbestos. The Joint-European Medical Research Board(JEMBR) has initiated an ambitious programme with the view to establishing the consequences of such exposures. An integral part of this programme consists of working out a strategy, and analytical methods, for recording present total dust/fibre concentrations in the working atmospheres in a number of European MMMF producing plants. The organisation responsible for this aspect of the study is the Institute of Occupational Medicine (IOM), Edinburgh.

One of the countries actively participating in this programme is Norway, where there are six MMMF plants. Four of these were considered suitable subjects for the programme because they keep detailed medical records of workers.

Due to slightly differing methods of sampling and analysis it was considered of interest to compare the procedures used by the two institutes. Such a comparison was carried out during the IOM investigations at Elkem-Rockwool A/S at Moss and Larvik. The results from the YHI-survey at Larvik are presented in this report.

## II METHODS

The dust samples were collected on 37 mmø, 0,8 µm Millipore membrane filters using Casella personal air samplers with an adjusted flow of 2 l/min. The flow was checked with a calibrated external flowmeter before and after sampling. Before sampling the upper part of the filter monitor was removed, thus leaving the whole filter area exposed to air. Then the monitors were mounted in the workers breathing zones. The workers carried the air samplers for 6 - 8 hours of the shift, including the lunch period.

A new filter was used every day. Before and after use the filters were desiccated for 24 hours in a desiccator and weighed with an accuracy of ± 0,1 mg.

After the total dust determinations a segment from each filter was cut and placed dust-side up onto a clean standard microscope slide. The slide was exposed to acetone vapour in order to render the filter transparent, a few drops of triacetine added and a cover glass placed over the specimen. Fibre concentrations were recorded in a Zeiss binocular microscope with positive phase-contrast optics at 500x magnification. This microscope was equipped with a Ph 2 40/0,75 objective with green filter and Kohler illumination. The specimens were surveyed by scanning intermittently across the filter. A random set of samples were counted twice by one person using different graticules. Graticule A is a 200 µm x 200 µm grid divided into 10 µm squares.

Graticule B. Circular graticule, 100 µmø, recommended by IOM (1). In this way one could establish potential personal as well as instrumental differences. The counting proceedures described as below.

Graticule A. All fibres completely within the field were counted. Two adjacent field sides were defined as "counting sides" and all fibres crossing these sides were included. No other fibres were considered.

Graticule B. As specified by IOM (1).

For each sample 40 fields or 100 fibres were counted.

Random samples from each working place were chosen for fibre size evaluations and fibre concentration determination in the scanning electron microscope.

The fibre size evaluations were performed by mounting a piece of the membrane filter on a standard scanning electron microscope (SEM) brass stub. The filter piece was fastened to the stub with carbon cement or silver paint and thereafter covered with a thin layer of carbon or gold by evaporating to make them conductive.

The fibre concentrations were recorded in the SEM at 1500x magnification. Hundred fields were surveyed (0,108 $mm^2$). Fibre size evaluations were made at 1500x (length) and 15000x (diameter) magnification respectively. At least 50 fibres in each sample were evaluated.

(1) W. H. Walton and S.T. Beckett.
Ann. Occup. Hyg. 20 (1977) 19 - 23.

## III RESULTS

Table 1 - 7 contains filter numbers, working places (in English/Norwegian), total dust concentrations ($mg/m^3$), fibre concentrations as determined by optical microscopy (fibres < 3µm and > 3µm in diameter) and finally, the total fibre concentration determined by SEM at 1500x magnification.

No statistically significant difference ($p < 0,05$) between the mean values for the two series (A and B) was observed for the two different graticules, neither for fibres <3µm in diameter nor for the total fibre concentration.

In table 8 and 9 the fibre diameter and length from the SEM size evaluation are given. These results are further illustrated in Figures 1 and 2. The relation between fibre concentration per unit area and magnification is demonstrated in Figure 3. Finally the correlation between the SEM and the OM is given in Figure 4.

ELKEM-ROCKWOOL A/S, LARVIK

| TABLE I | | | Optical microscopy fibres /ml /Optisk mikroskop | | SEM |
|---|---|---|---|---|---|
| Filter No. | Working place/Prøvested | Total dust conc./total støv mg/m$^2$ | Fibre conc. /fiber konsentrasjon Ø< 3µm | Fibre conc. /fiber konsentrasjon Ø >3µm | Total fibre /total fiber konsentrasjon fibres/ml |
| | PRE-PRODUCTION/FØR PRODUKSJON | | | | |
| 104 | Raw-material/Rå-meteriale - Thor Thoresen | 3,2 | 0,02 | 0,01 | |
| 78 | Binderman/Blanding av binde- | 1,2 | C 0,03 | 0,03 | |
| 92 | middel - Harald Nordbotten | 2,0 | 0,03 | 0,02 | 0,12 |
| 88A | Furnace/Ovnsmann | 7,5 | A - | - | |
| 94 | - Anton Bøe | 1,5 | 0,05 | 0,04 | 0,18 |
| 87 | - Bjørn Andresen | 5,8 | A - | - | |
| 120 | | 1,2 | 0,04 | 0,02 | |
| | A: To much dust to be counted<br>C: Filter destroyed | | | | |

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| TABLE 2 | | | Optical microscopy fibres /ml /Optisk mikroskop | | SEM |
|---|---|---|---|---|---|
| Filter No. | Working place/Prøvested | Total dust conc./total støv mg/m$^3$ | Fibre conc. /fiber konsentrasjon Ø <3 µm | Fibre conc. /fiber konsentrasjon Ø >3 µm | Total fibre /total fiber konsentrasjon fibres/ml |
| | PRODUCTION/PRODUKSJON | | | | |
| 82 | P. managers ass./Ass. prod. sjef - Kjell Bering | 1,6 | C 0,02 | 0,02 | |
| 79 | Foreman/Formann - Erling Andersen | 0,9 | 0,04 | 0,02 | 0,16 |
| 110 | | 1,8 | 0,03 | 0,03 | |
| 81 | Foreman ass./Assisterende formann - Trana | 1,5 | 0,08 | 0,03 | 0,53 |
| 97 | Prod. foreman/Produksjons-formann - Hermod Trana | 1,4 | 0,04 | 0,04 | |
| 96 | Line-end man/Operatør - R. Wirgenes | 1,6 | 0,06 | 0,08 | |
| 100 | ved sager på - A. Stenbakken | 2,6 | 0,06 | 0,03 | |
| 90 | enden av linja. - Ø. Grønning | 1,5 | 0,06 | 0,07 | 0,36 |
| 61 | | 1,2 | 0,07 | 0,07 | |
| 83 | General/Generellt - R. Wirgenes | 1,6 | G 0,07 | 0,02 | |
| 84 | - S. Vollebekk | 2,4 | 0,14 | 0,11 | |
| | G: Pump stopped | | | | |

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TABLE 3

| Filter No. | Working place/Prøvested | Total dust conc./total støv mg/m$^3$ | Optical microscopy fibres /ml /Optiske mikroskop: Fibre conc. /fiber konsentrasjon Ø <3 µm | Optical microscopy fibres /ml /Optiske mikroskop: Fibre con. /fiber konsentrasjon Ø >3 µm | SEM: Total fibre /total fiber konsentrasjon fibres/ml |
|---|---|---|---|---|---|
| | PRODUCTION/PRODUKSJON | | | | |
| 64 | Production/Produksjon - Sverre Vollebekk | 3,6 | 0,14 | 0,08 | |
| 18 | - Bjørn Grønning | 3,8 | 0,14 | 0,13 | 0,80 |
| 67 | | 0,9 | 0,06 | 0,01 | |
| 109 | Cavity wool/ - S. Halvorsen | 0,9 | 0,09 | 0,09 | 0,42 |
| 53 | shredding - Hans J. Hansen | 2,4 | B 0,12 | 0,05 | |
| 85 | Spinning chamber/ - Tom Larsen | 1,6 | 0,07 | 0,05 | 0,51 |
| 98 | Spinnemaskin - Ø. Grønning | | E - | - | |
| 15 | - R. Wirgenes | 1,9 | BI 0,09 | 0,04 | |
| 105 | | 1,8 | 0,06 | 0,04 | |

B: Loose dust on filter surface
E: Same marking as 86
I: Large difference between pump time and real time.

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| TABLE 4 | | | Optical microscopy fibres /ml /Optiske mikroskop | | SEM |
|---|---|---|---|---|---|
| Filter No. | Working place/Prøvested | Total dust conc./total støv mg/m$^3$ | Fibre conc. /fiber konsentrasjon Ø <3 µm | Fibre conc. /fiber konsentrasjon Ø >3 µm | Total fibre /total fiber konsentrasjon fibres/ml |
| | SECONDARY PROCESS/ ETTERBEHANDLING | | | | |
| 71 | Precicion- Fritz Jacobsen saw/Presisjons- | 0,7 | D 0,01 | 0,01 | |
| 69 | - Harald Jacobsen | 1,2 | 0,02 | 0,01 | 0,11 |
| 114 | sying - Fritz Jacobsen | 1,5 | 0,01 | <0,01 | |
| 107 | Leca saw/Symaskin Leca- | | | | |
| | - Runar Svendsen | 4,7 | H 0,05 | 0,04 | |
| 52 | | 1,6 | G 0,09 | 0,06 | 0,43 |
| 119 | - Johan Hansen | 1,9 | A - | - | |
| 113 | Special saw/Spesial | 0,8 | 0,10 | 0,05 | |
| 102 | sying - Harald Christian- | 1,8 | 0,10 | 0,07 | |
| 65 | sen | 1,2 | 0,09 | 0,04 | 0,36 |
| 111 | - Anne Johansen | 2,5 | A | | |
| | D: The top of the monitor not removed during sampling<br>H: Pump had been taken off for some time | | | | |

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| TABLE 5 | | | Optical microscopy fibres /ml /Optiske mikroskop | | SEM |
|---|---|---|---|---|---|
| Filter No. | Working place/Prøvested | Total dust conc./total støv mg/m$^3$ | Fibre conc. /fiber konsentrasjon Ø <3 µm | Fibre conc. /fiber konsentrasjon Ø >3 µm | Total fibre /total fiber konsentrasjon fibres/ml |
| | SECONDARY PROCESS/ ETTERBEHANDLING | | | | |
| 66 | Lamella m/c/Operatør | 3,8 | A - | - | |
| 108 | lamella - Gerd T. Hansen | 1,5 | 0,07 | 0,06 | 0,55 |
| 106 | (Leca piper etter kl.9) | | | | |
| | - Berit Lunde | 2,1 | 0,07 | 0,08 | |
| 56 | Cavity wool,packing | | | | |
| | - S. Halvorsen | 1,3 | 0,12 | 0,07 | |
| | MAINTENANCE/VEDLIKEHOLD | | | | |
| 103 | Foreman/Formann | | | | |
| | - Kjell Thorsen | 1,1 | 0,03 | 0,05 | |
| 93 | | 1,2 | 0,02 | 0,03 | 0,19 |
| 72 | | 1,2 | 0,03 | 0,02 | |
| 57 | Electrician/Elektriker | | | | |
| | - Willy Hansen | 1,0 | 0,05 | 0,02 | 0,28 |
| 98 | Spinner mechanic/ | | | | |
| | - Bjørn Thorsen | | E - | - | |
| 70 | mekaniker, spinnemaskin | 2,2 | 0,21 | 0,08 | 1,00 |

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| TABLE 6 | | | Optical microscopy fibres /ml /Optiske mikroskop | | SEM |
|---|---|---|---|---|---|
| Filter No. | Working place/Prøvested | Total dust conc./total støv mg/m$^3$ | Fibre conc. /fiber konsentrasjon Ø <3 µm | Fibre conc. /fiber konsentrasjon Ø >3 µm | Total fibre /total fiber konsentrasjon fibres/ml |
| | MAINTENANCE/VEDLIKEHOLD | | | | |
| 118 | Greaser/Smører - Gunnar Jacobsen | 1,2 | 0,06 | 0,05 | |
| 112 | Mechanic/Mekaniker - Thor Tinnseth | 3,0 | 0,06 | 0,06 | 0,47 |
| 99 | - Einar Andersen | 3,5 | 0,04 | 0,04 | |
| | QUALITY CONTROL/KVALITETS-KONTROLL | | | | |
| 80 | Lab. ass./Laboratorie assi- | 2,0 | 0,04 | 0,03 | 0,35 |
| 115 | stent - Widar Baarnes | 1,1 | 0,04 | 0,03 | |
| 101 | | 1,2 | 0,05 | 0,03 | |
| | DISTRIBUTION/LAGER | | | | |
| 91 | Warehouseman I/ Lagerarbei- | | | | |
| | der I - Olav Nilsen | 1,8 | C 0,06 | 0,05 | 0,33 |
| 60 | | 2,4 | 0,13 | 0,11 | |
| 62 | - Ivar Skjærvø | 3,1 | D 0,10 | 0,05 | |
| 117 | - Hans Andersen | 1,0 | 0,06 | 0,06 | |
| 95 | | 2,0 | 0,04 | 0,07 | 0,77 |
| 51 | - Leif Molteberg | 2,1 | 0,06 | 0,04 | |

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| TABLE 7 | | | Optical microscopy fibres /ml /Optiske mikroskop | | SEM |
|---|---|---|---|---|---|
| Filter No. | Working place/Prøvested | Total dust conc./total støv mg/m$^3$ | Fibre conc. /fiber konsentrasjon Ø <3 µm | Fibre conc. /fiber konsentrasjon Ø >3 µm | Total fibre /total fiber konsentrasjon fibres/ml |
| | DISTRIBUTION/LAGER | | | | |
| 116 | Warehouseman(2)/Lagerarb. (2) - L. Molteberg | 4,0 | 0,12 | 0,10 | |
| | STATIC CASELLA/STASJONÆR | | | | |
| 59 | Lamella m/c | 1,2 | 0,01 | 0,01 | 0,12 |
| 68 | | 1,7 | F 0,06 | 0,04 | |
| 54 | Secondary process,down stairs /Etterbehandling, nede | 0,8 | 0,06 | 0,04 | 0,20 |
| 73 | | 1,5 | F 0,02 | 0,01 | |
| 63 | End line/Ved enden av linja | 1,2 | 0,11 | 0,05 | 0,43 |
| | F: Pump not recharged effectively | | | | |

TABLE 8

% WITH LENGTH (µm) WITHIN EACH GROUP

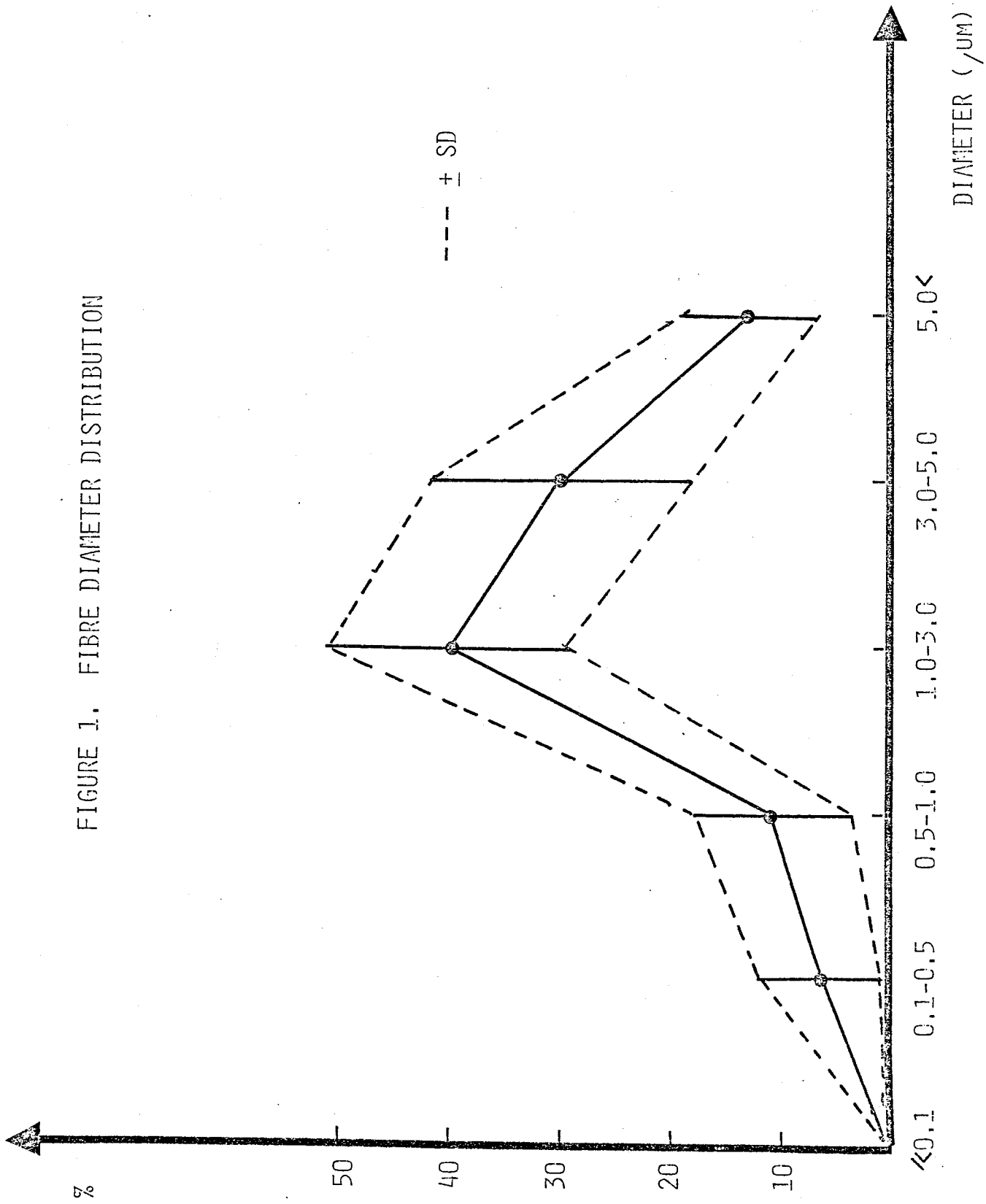
| Filter No. | Work Place | < 5 | 5 - 10 | 10 - 20 | 20 - 50 | 50 - 100 | > 100 |
|---|---|---|---|---|---|---|---|
| 63 | End line/Ved enden av linja | 2 | 4 | 14 | 30 | 32 | 18 |
| 59 | Lamella m/c (Static Casella) | - | 10 | 30 | 25 | 25 | 10 |
| 57 | Electrician/Elektriker | - | 12 | 9 | 40 | 28 | 11 |
| 54 | Secondary Process/Down stairs/ Etterbehandling nede | - | 3 | 15 | 29 | 18 | 35 |
| 52 | Leca Saw/Symaskin Leca | - | 4 | 8 | 24 | 38 | 26 |
| 18 | Production/Produksjon | - | 6 | 6 | 42 | 26 | 20 |
| 80 | Lab. assistent | 2 | 2 | 18 | 24 | 20 | 34 |
| 70 | Spinner Mechanic/Mekaniker Spinnemaskin | 2 | 4 | 30 | 26 | 20 | 18 |
| 69 | Precision saw/Presisjonssag | - | 12 | 24 | 41 | 12 | 11 |
| 79 | Foreman/Formann | - | 20 | 15 | 50 | 10 | 5 |
| 81 | Foreman assistent/Assisterende formann | - | 14 | 26 | 22 | 28 | 10 |
| 65 | Special saw/Spesial sag/ Christensen | - | - | 14 | 40 | 22 | 24 |
| 85 | Spinning chamber/Spinnemaskin | - | 6 | 6 | 38 | 28 | 22 |
| 90 | Line and man/Operatør for sager ved linjeslutt | - | 14 | 14 | 26 | 28 | 18 |
| 91 | Warehouseman/Lagerarbeider/Nilssen | - | 8 | 17 | 33 | 42 | - |
| 92 | Binderman/Blanding Bindemiddel I | - | 12 | 16 | 36 | 20 | 16 |
| 93 | Foreman/Formann/Thorsen | - | - | 10 | 19 | 19 | 52 |
| 94 | Furnace/Ovnsmann | - | 6 | 7 | 20 | 27 | 40 |
| 95 | Warehouseman/Lagerarbeider | - | 6 | 18 | 30 | 22 | 24 |
| 108 | Lamella m/c/Operatør Lamella | - | 4 | 26 | 34 | 24 | 12 |
| 109 | Cavity wool/Shredding/Halvorsen | - | 2 | 6 | 40 | 30 | 22 |
| 112 | Mechanic/Tinnseth | - | 4 | 6 | 34 | 28 | 28 |
| | Mean ($\bar{x}$) | 0.3 | 7.0 | 15.2 | 32.0 | 24.9 | 20.7 |
| | Standard Deviation ($\pm$ SD) | 0.7 | 5.2 | 7.9 | 8.3 | 7.4 | 12.1 |
| | Range (R) | 0-2 | 0-20 | 6-30 | 19-50 | 10-42 | 0-52 |

TABLE 9

% WITH DIAMETER (µm) WITHIN EACH GROUP

| Filter No. | Work Place | ≤ 0,1 | 0,1 - 0,5 | 0,5 - 1 | 1 - 3 | 3 - 5 | > 5 |
|---|---|---|---|---|---|---|---|
| 63 | End line/Ved enden av linja | - | 4 | 2 | 48 | 32 | 14 |
| 59 | Lamella m/c (Static Casella) | - | 15 | 10 | 35 | 40 | - |
| 57 | Electrician/Elektriker | - | 5 | 14 | 53 | 21 | 7 |
| 54 | Secondary Process/Down stairs /Etterbehandling nede | - | 3 | - | 29 | 56 | 12 |
| 52 | Leca saw/Symaskin Leca | - | 4 | 24 | 26 | 38 | 8 |
| 18 | Production/Produksjon | - | - | 10 | 36 | 34 | 20 |
| 80 | Lab. assistent | - | 4 | 6 | 44 | 34 | 12 |
| 70 | Spinner mechanic/Mekaniker spinnemaskin | - | 8 | 12 | 52 | 20 | 8 |
| 69 | Precicion saw/Presisjonssag | - | 18 | 12 | 59 | - | 11 |
| 79 | Foreman/Formann | - | 5 | 20 | 40 | 25 | 10 |
| 81 | Foremann assistent/Assisterende formann | - | 8 | 4 | 52 | 32 | 4 |
| 65 | Special saw/Spesial sag/Christensen | - | 8 | 8 | 46 | 32 | 6 |
| 85 | Spinning chamber/Spinnemaskin | - | 16 | 4 | 24 | 32 | 22 |
| 90 | Line end man/Operatør for sager ved linjeslutt | - | 4 | 28 | 24 | 30 | 14 |
| 91 | Warehouseman/Lagerarbeider/ Nilsen | - | 17 | 8 | 58 | 9 | 8 |
| 92 | Binderman/Blanding bindemiddel | - | 6 | 20 | 40 | 20 | 14 |
| 93 | Foreman/Formann/Thorsen | - | 3 | 7 | 26 | 48 | 16 |
| 94 | Furnace/Ovnsmann | - | 3 | 10 | 43 | 27 | 17 |
| 95 | Warehouseman/Lagerarbeider/ Andersen | - | 8 | 10 | 34 | 26 | 22 |
| 108 | Lamella m/c/Operatør Lamella | - | 4 | 12 | 42 | 28 | 14 |
| 109 | Cavity wool/Shredding/Halvorsen | - | - | 12 | 36 | 36 | 16 |
| 112 | Mechanic/Tinnseth | - | - | 4 | 36 | 38 | 22 |
| | Mean ($\bar{x}$) | - | 6.5 | 10.8 | 40.1 | 29.9 | 12.6 |
| | Standard Deviation (± SD) | - | ± 5.4 | 7.1 | 10.7 | 11.9 | 6.0 |
| | Range (R) | - | 0-18 | 0-28 | 24-59 | 0-56 | 0-22 |

FIGURE 1. FIBRE DIAMETER DISTRIBUTION



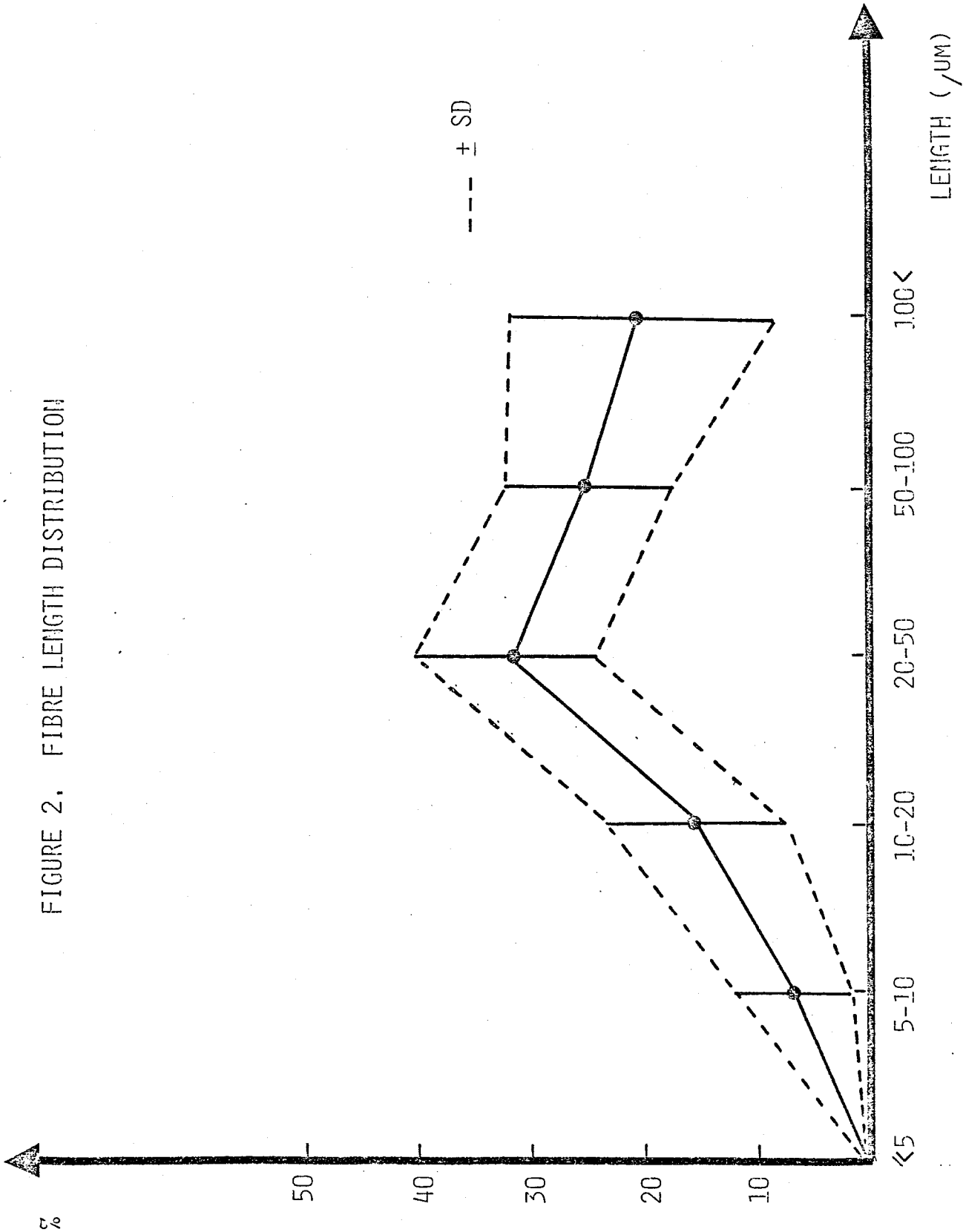
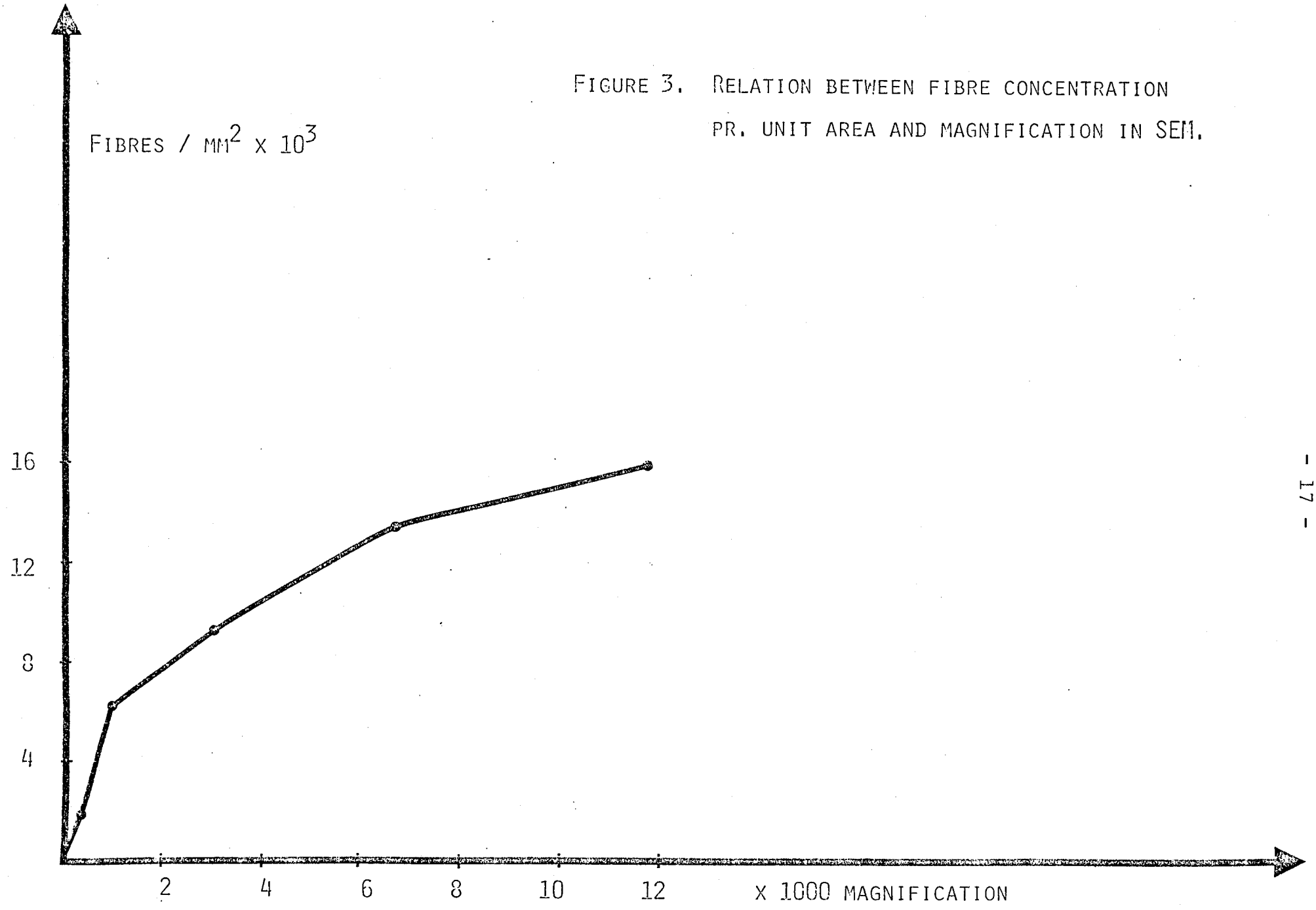



FIGURE 2. FIBRE LENGTH DISTRIBUTION

FIGURE 3. RELATION BETWEEN FIBRE CONCENTRATION PR. UNIT AREA AND MAGNIFICATION IN SEM.



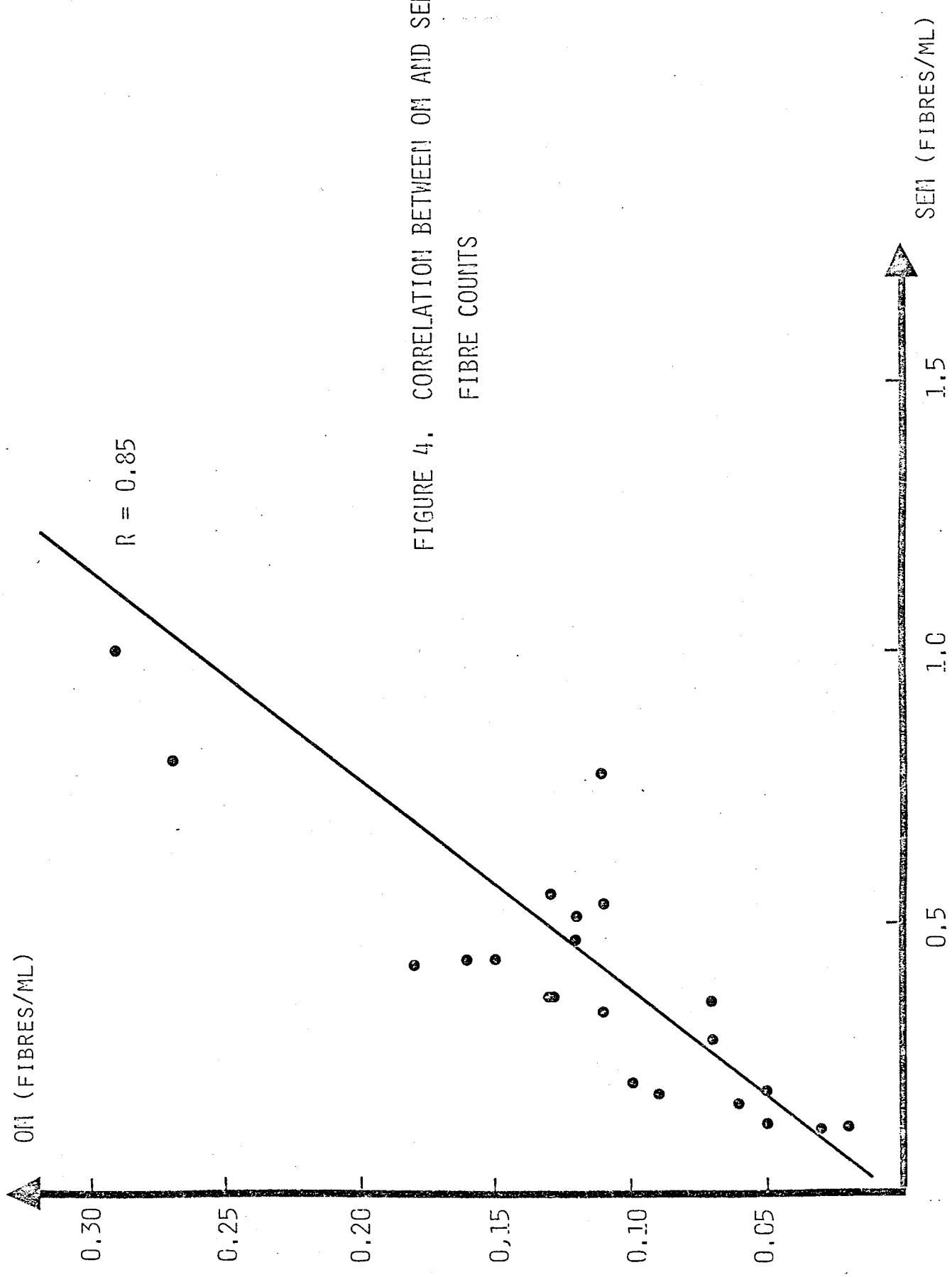



FIGURE 4. CORRELATION BETWEEN OM AND SEM FIBRE COUNTS