Further work is intended to establish by more sensitive measurements whether there is any need to introduce a correction to allow for the departure of practical regulators from a sharp-edged orifice.

REFERENCES

WEEKS, W. S. *Ventilation of Mines.* McGraw-Hill, New York and London. 1926.

British Standard Code B.S. 1042. 1943. " Flow measurement." With amendments to 1951.

WALKER, LEWIS, MCADAM AND GILLILAND. *Principles of Chemical Engineering.* McGraw-Hill, New York and London. 1937.

BADGER AND BANCHERO. *Introduction to Chemical Engineering.* McGraw-Hill, New York and London. 1955.

PERRY, J. H. *Chemical Engineers' Handbook.* McGraw-Hill, New York and London. 1950.

MADISON, R. D. *Fan Engineering.* Buffalo Forge Co. Buffalo, New York. 1949.

A NOTE ON THE EXPOSURE-RESPONSE CURVE OF SOUTH AFRICAN GOLD MINERS

by J. P. Rees

The object of this paper is to see what can be learnt from an exposure-response curve, particulary in regard to the effect of average dust conditions on the incidence of silicosis.

In 1955 Theodore Hatch published a short paper entitled " Permissible Dustiness "* in which he gave an exposure-response curve for South African gold miners.

Hatch's Curve

The exposure-response curve obtained by Dr. Hatch is reproduced from his paper in Fig. 1. It is plotted on log probability paper. By " exposure " is meant the product of the length of time (or service) and the mean dust measurement. The records of certifications of silicosis are examined, and the exposure of each individual certification is noted. From these data the cumulative percentage of certifications is plotted against the figure for the exposure.

Hatch said, " There is a remarkable conformance in Fig. 1 with the logarithmic dosage-response relationship found in other areas of toxicology, and it thus supports the analytical procedure suggested by Roach for establishing levels of permissible dustiness.

" According to the fitted line, one case of first-stage silicosis would be expected in a group of 100 men whose accumulated dust exposure amounted to (8 mgms./m^3) $\times$ years. To keep within this limit over a work span of, say, 30 years would require that the dust concentration be maintained below 0·27 mgms./m^3."

Although he drew this conclusion and some others, he qualified them by saying, " In the absence of more detailed knowledge respecting dust concentrations and occupational histories for this large group of underground workers, it is not proper to draw any quantitative conclusions from this analysis of South African data."

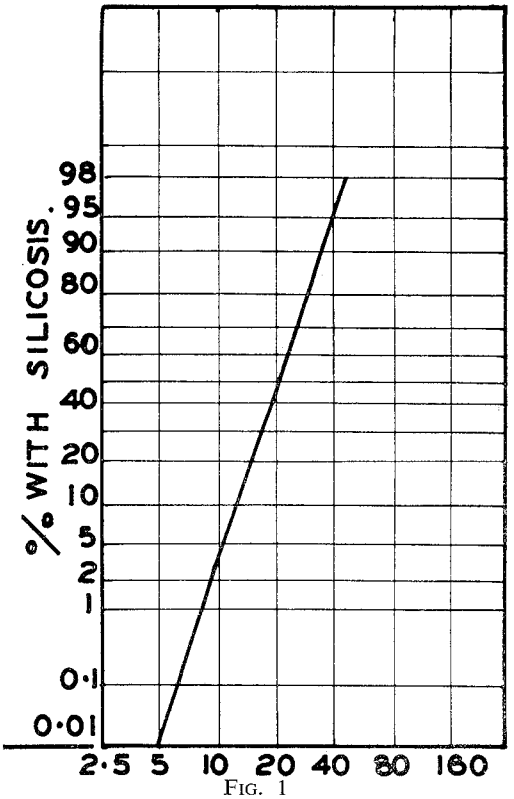

FIG. 1

* American Industrial Hygiene Association Quarterly, *16*:1 March, 1955.

A Fresh Curve

There is now available fresh information respecting dust concentrations and length of service, and with the help of those I propose to carry this enquiry a little further than Hatch did. The nature of the diagnosis by the Silicosis Board was altered in January, 1954, by making it responsive to the first signs of silicosis. Hatch's curve is, therefore, slightly out of date.

The chief difficulty about drawing a fiesh curve is that I do not know what is the average dust concentration to which gold miners are exposed. The present system of routine dust sampling does not produce this information. However, the routine dust sampling by the mines does indicate that the dust conditions have not increased or decreased to a considerable extent during the last thirty years. This is quite different from the conditions during the years covered by Dr. Hatch's curve. During those early years the dust concentrations were falling appreciably and he had to make suitable corrections and adjustments. There is no strong case for attempting to make adjustments to the data I shall use. I shall assume that the dust concentration has remained constant.

I shall give the mean dust condition the numerical value of one. The exposure is then numerically equal to the years of service.

Fig. 2 shows a plot on log probability paper of the cumulative incidence of silicosis against the years of service. The data is for " New Rand Miners " and is taken from the Government Mining Engineer's Reports for 1954 and 1955—Table III. The years are 1951–1955 and the data is given in Table I.

TABLE I.

Years of Service	Accumulated Incidence per cent.		Mean*
	1951–54	1952–55	
6	0·012	0·03	0·02
12	0·17	0·30	0·25
18	1·3	1·6	1·45
24	6·9	7·7	7·3
30	23·2	9·5	16·3
(40)?	51·0	38·0	44·5

*This is not a mean for 1951–55. It is nearer the true mean for 1952–53.

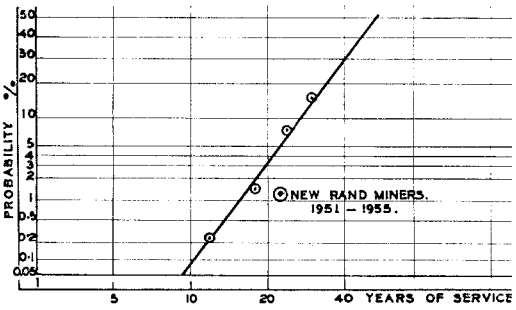

FIG. 2

From the graph we can see that it is probable that 3 per cent. of men working under the prevailing conditions will be certified as having the earliest signs of silicosis after 20 years' service, if they remain at work. If they all leave after ten years' service, then very few will get silicosis. Obviously the average length of service plays a large part in determining the actual number of certifications, and from Table III of the G.M.E.'s Report for 1954, it can be computed that the average length of service was then only about ten years. A short length of service such as this is an important factor in reducing the number of persons who got silicosis, and any lengthening of the average period of service would increase the number of silicotics and the cost of silicosis to the industry.

The Effect of a Reduction in Dust Content in the Air

Everyone engaged in dust prevention must be interested in the question:—

What would be the effect of a reduction in the average dust conditions on the incidence of silicosis?

In order to obtain an answer that indicates approximately what is likely to be the effect, Table III of the G.M.E.'s report, already referred to, must be examined. It will be seen that the largest number of certifications occur after about 20 years of service, or after an exposure of 20 on Fig. 2. From Fig. 2 we see that after an exposure of 20 the incidence of silicosis is about 3 per cent. If the average exposure is 15 the incidence will be below 1 per cent., i.e. it will probably be more than halved. Thus a considerable reduction can be achieved by reducing the average dust concentration to only a small extent (say 25 per cent.), all other circumstances remaining the same. The methods used to measure

the dustiness must be suitable methods. Whether the konimeter is a suitable instrument does not come within the scope of this paper to discuss.

The Average Response

The average response is the figure that should be used to measure the relative toxicity of different dusts. Comparing published figures (Hatch *loc. cit.*) the dust in these mines is exceptionally dangerous. It may be ten or twenty times as dangerous as dust in coal mines. The average response should also be used to measure the improvement in the incidence of the disease. The curve (Fig. 2) shows that the period of service necessary, to-day, to contract silicosis is on the average about 45 years. This, of course, is very much longer than the average period in the early days. Though it is difficult to obtain comparative figures, the figures do suggest that the average or general atmosphere breathed in the mines is less toxic now than it used to be. This is a worthy reflection on the great effort that has been put into dust prevention.

The Normal Curve

In order to be able to continue the discussion of the exposure-response curve, it is advisable to think of it as a normal curve in which the number of certifications is plotted for equal periods of exposure. That is, instead of the cumulative number of certifications after say 12 years, the percentage from 6–12 years, 12–18 years and so on is plotted. The data are insufficient to produce a complete curve, but so far as they go they conform to a normal curve. The shape of the " normal " curve is well known and is illustrated in Fig. VI of " Statistics in Mine Ventilation," (P. C. Pirow—*M.V.S.*, Vol. 10, No. 11, November, 1957, p. 270). There is a mean exposure at which men get silicosis and there are deviations from the mean—some men get silicosis in a short time and some in a long time.

Factors Producing the Normal Curve

The scatter of data around a mean shown on the normal curve is typical of random errors. Roach suggests* that the scatter results from:—

1. Errors in estimating the dust level.
2. Errors in estimating the time of exposure.
3. Errors in diagnosis.
4. Differences in rate of work.
5. Differences in individual response to dust.

The last two factors are not errors, and taken together they may be called differences in susceptibility of individuals.

It is possible that the vast majority of those who contract silicosis do so because they are more susceptible than the average person, but I have no information about the relative importance of the different factors.

In conclusion, I should like to say that I fully support efforts to obtain more data and hope that the views expressed here will be helpful. I acknowledge with gratitude help received from Mr. R. S. J. du Toit in the preparation of this short paper.

* " A method of relating the incidences of pneumoconiosis to airborne dust exposure." *S.A. Roach —Br. Jul. Ind. Medicine*, Vol. 10, No. 4, Oct. 1953.

MINUTES OF THE SPECIAL GENERAL MEETING HELD AT KELVIN HOUSE, JOHANNESBURG, ON SATURDAY, 30th APRIL, AT 9 A.M.

Present

Mr. P. H. Kitto (President) (in the Chair) and 43 members.

The notice convening the meeting was taken as read.

The President, in declaring the meeting open, welcomed members and said that this Special General Meeting of the Society had been called to consider an amendment to Clause 15.02 of the Constitution.

The President explained that the Council considered that the period allowed to members in which to pay their subscriptions should be reduced from 12 to 6 months, with a period of grace of 3 months. He said that the list of members owing subscriptions for the years 1958/59 and 1959/60 was exceptionally large and amounted to almost £300, of which approximately £100 represented the amount of assessment paid to the