EFFECT OF THE MEASURING STRATEGY ON THE DETERMINATION OF THE RESPIRABLE DUST CONCENTRATION IN THE BREATHABLE AIR AT UNDERGROUND WORKPLACES

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INTRODUCTION

The dust conditions at the underground workplaces are permanently discussed worldwide. These discussions are always based on the absolute values of the respirable dust concentrations in the breathable air indicated in mg/m^3 (Figure 1). They provide information on the effective limits for the permissible respirable dust concentrations and on the results of the statutory dust measurements. These values are also used to reflect the state of the pneumoconiosis prevention and dust suppression in the various hardcoal mining countries.

In the following it is intended to show that the respective indicated absolute values are not suitable for a comparison of the dust load of miners in different countries, the reason for this being that the rules for the determination of the values, i.e. the measuring strategies, are not included in the discussions. The existing different measuring strategies have, however, significant effects on the magnitude of the measured absolute values. Thus, there is no uniform basis for an objective comparison. The measuring results are significantly influenced by the following parameters of the measuring strategy:

- the position of the measuring point;
- the time required for an individual measurement; and
- the frequency of the measurements.

Measuring Strategy in Different Countries

According to the measuring strategy effective in the Federal Republic of Germany (FRG) (Figure 2) since 1954 the respirable dust concentration has to be measured at the location of a working area at which the maximum dust concentration has to be expected. In this context it is generally assumed that in working faces this location is situated, seen in ventilation direction, at the face end respectively the end of the working area. Measurements are taken once a month under normal operating conditions. The measurement period corresponds to the time the miners stay at their workplaces. Over a period of five years each the preset limits for the dust exposition of the miners must not be exceeded. Higher individual shift values which have to be compensated over the 5 year period are, however, permissible.

The measuring strategy in the FRG is based on the following considerations:

1. For the people employed in the environment of the measuring point, the measuring result is sufficiently accurate.
2. The impact of dust on people employed on the intake side upstream the measuring point is overrated by the "high risk method."
3. By overrating higher urgency is attributed to the measures for a prevention of dust impact on the employees.
4. One monthly measurement over a 5 year period is sufficient as the dust load of each miner is determined with sufficient accuracy by 60 measurements in five years.

In Great Britain (GB) measuring values of a fixed measuring point located in the return airway approx. 70 m behind the face are used to assess the dust conditions at the workplaces in the face. The fact that it is only there that the measuring results are no longer influenced by the coarse dust or the unequal distribution of the respirable dust in the air is given as a reason for the choice of this location. The partial sedimentation of the dust between the face and the measuring point is considered by correction factors. Measurements are taken in monthly intervals. As in the FRG the time of a measurement corresponds to the time the miners stay at the workplace. The number of measurements in one month depends on the size of the measured individual fine dust concentration. At values < 15 mg/m^3 one measurement per month is sufficient. At values > 8 mg/m^3 the average has to be calculated from up to five subsequent measurements in one week.

The main point in the measuring strategy of the Soviet Union (USSR) is the monitoring of dust suppression in the face. When cutting coal with shearers the air-borne dust concentration with grain sizes of up to 74 μm without preseparator is determined directly behind the shearer, when ploughing the coal it is determined at the face end. The strategy for these dust measurements has the main objective to improve the efficiency of dust suppression measures. The measuring time per measurement amounts to a few minutes during the coalgetting process. The measurement is repeated in monthly intervals if the measuring result shows a value ≤ 10 mg/m^3. At higher values the measurement is repeated directly after improving dust suppression.

The measuring strategy in the United States of America provides for a measurement of the acting respirable dust concentration by means of "personal dust samplers" directly at the employee. For the measurement the person exposed to the highest dust load in the face may be chosen as representative for all employees of one face. This measuring method called "designated occupation" is also based on the "high risk"

	Tolerable Dust Concentration mg/m³	Dust Fraction	Quartz Valuation
RUHR	8.0	respirable	yes
SAAR	4.0	respirable	no
USA	2.0	respirable	yes
GB	5.0	respirable	no
USSR	2.0	inhalable	yes

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Figure 1.

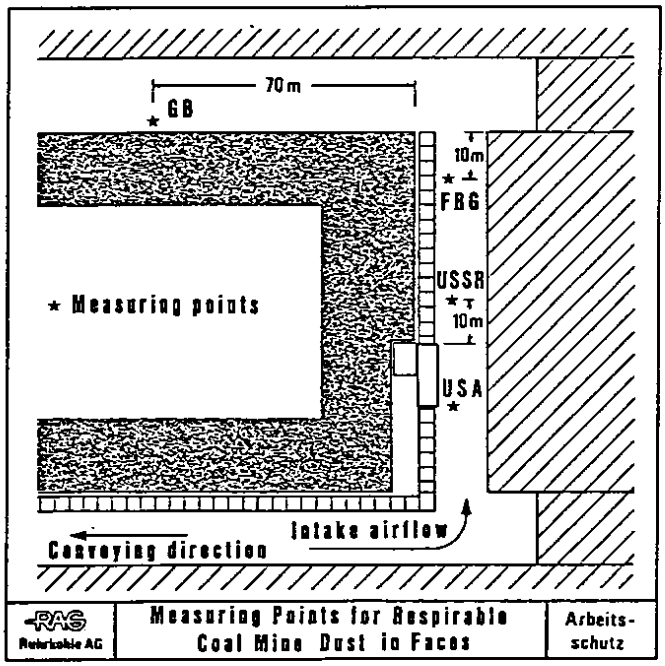

Figure 2.

process as the measuring strategy in the FRG. In faces the workplace of the shearer operator is mainly chosen as "designated occupation." This is justified if nobody is employed behind the shearer for more than two hours during the shift.

The respirable dust concentration at the workplace or the measuring point is assessed in two-monthly intervals by the averege of 5 measurements taken in 5 subsequent production shifts. If the limit is exceeded additional measurements have to be carried out in the following production shifts and a new average has to be calculated from 5 subsequent measuring values. The measuring series is interrupted if one average reaches or remains below the limit. The measuring time of each individual measurement corresponds to the shift length, i.e. working time plus travelling time.

The effect of the measuring strategy on the size of the measuring values can be illustrated by means of an example for respirable dust measurements in 10 faces of Ruhrkohle AG (Figure 3).

In each of these faces several measuring points were installed in regular intervals. The respirable dust concentration was measured over a longer time period in the first production shift of each day with the miners at their workplaces. In the diagram the monthly averages of the respirable dust concentrations in mg/m^3 are listed on the ordinate, the face length in % on the abscissa.

At the face entry, i.e. at face meter "0", the respirable dust concentration in the intake air of the face was listed.

In nine of the ten faces the respirable dust concentrations increase in different magnitudes towards the face end where they reached their highest values. The different increase is governed by work sequence, machine type, support, ventilation volume, ventilation velocity, etc. In one case—i.e. face 8—in contrast, the initial concentration is already so high that the sedimentation over the face length is higher than the concentration increase caused by the coalgetting operations.

According to the measuring strategy of the USA all employees in the face would be exposed to the dust concentrations of the intake air flow, i.e., the initial values of the graphs on the extreme left of the diagram, under the prerequisite that:

1. The shearer operator stands on the intake air side in front of the machine;
2. The dust produced by coalgetting is blown away from the site of the shearer operator; and
3. Bypasses the chock fitters.

A possible slight increase in the dust concentrations in the intake air flow towards the workplace of the operator by turbulences is negligible in this approach.

Applying the German measuring strategy these velues are contrasted by the concentrations of the fixed measuring points which in contrast to the USA are, however, located at the face end. This means (Figure 4) that in a comparison of the values up to 9 times higher values have to be assigned to the employees due to the German measuring strategy with the measuring point at the face end compared to the American strategy. Even in case of a subdivision of the face into two monitoring sections with measuring points in the center and at the end of the face up to 6 times higher values are still calculated for the employees in the lower face section according to the German measuring strategy. On average the concentrations at the face entry and the face end differ by the

factor 3.9 and the concentrations at the face entry and the face center still by the factor 2.4.

The determination of the measuring values in Great Britain is again significantly different from the determination of the measuring values in the USA and the FRG. On the one hand additional dust sources between the face and the measuring point are registered, on the other the measuring result is corrected by a factor for sedimentation which was developed specifically for British mines. It may, however, hardly be applied worldwide.

CONCLUSION

From the mentioned comparison it may be derived that both the dust limits and the absolute respirable dust concentration figures cannot be referred to in a comparative representation of the dust conditions in different countries.

Also the dust suppression measures applied in the different countries have to be seen under this aspect. The measuring strategies of the FRG, GB and the USSR call for measures reducing the dust concentration in the entire return air section. In the United States dust suppression may center on the intake air section up to the coalgetting machine (Figure 5). This becomes particularly clear in the "shearer clearer" process. The dust produced by the coalgetting operations is kept away from the measuring point. Without doubt this process has the advantage of reducing the dust load for machine operators and chock fitters.

Face No.	USA / FRG Head - Tail	USA / FRG Head - Centre
1	1 : 2.1	1 : 1.6
2	1 : 5.4	1 : 2.8
3	1 : 2.7	1 : 1.7
4	1 : 4.3	1 : 2.0
5	1 : 6.0	1 : 3.1
6	1 : 3.1	1 : 1.8
7	1 : 8.8	1 : 6.0
8	1 : 0.7	1 : 0.8
9	1 : 2.3	1 : 1.9
10	1 : 3.4	1 : 2.3
	⌀ 1 : 3.9	⌀ 1 : 2.4

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Figure 4.

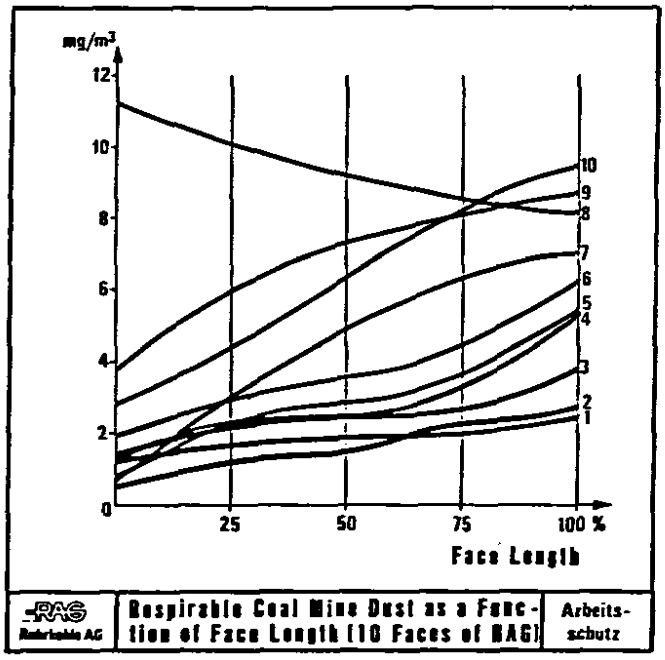

Figure 3.

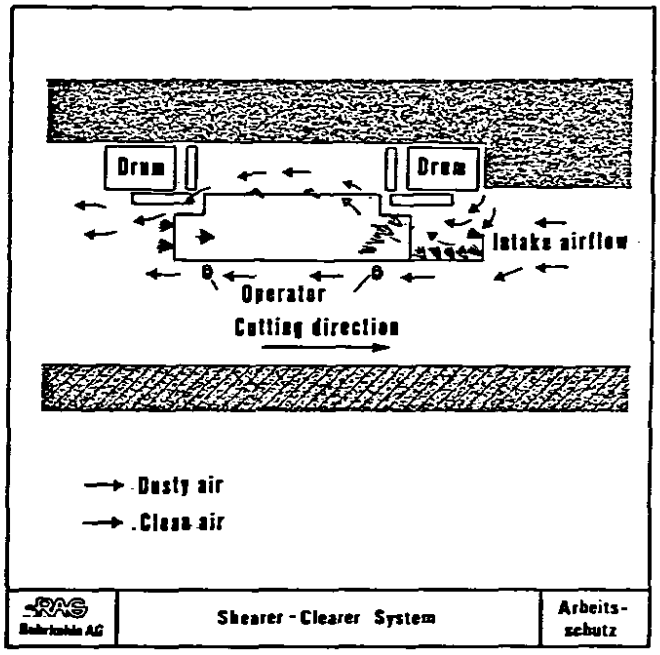

Figure 5.

These comments were intended to show that:

1. The different measuring strategies will inevitably have to result indifferent limits;
2. The measuring values and limits determined by one measuring strategy can only be compared in its scope of validity;
3. Identical absolute values of the different countries do not describe also identical dust conditions or dust impact;
4. Limits provide for a statement on the pneumoconiosis risk of the employees only in their scope of validity.

The comments of Dr. Bauer (FRG) on the impact of different measuring devices, tyndallometer, cycloneseparator, horizontal elutriator, on the result of respirable dust measurements underline the mentioned reservations against a comparison of measuring values and limits.

These comments are not intended to be an assessing statement on the measuring strategies but are only meant to explain the fact that measuring values and limits cannot be compared as long as they are based on different measuring strategies.

The uncritical comparison of measuring values and limits from different measuring strategy scopes involves two dangers:

1. That a race towards actually desirable but technically not feasible limits is started; and
2. That the statement on the pneumoconiosis risk of a mining region in relation to the dust impact is wrong if risk determinations are taken over from other measuring strategy scopes.

For an international comparison of the dust load to which the miners in the hardcoal mines are exposed, it is thus required to use identical reference measuring equipment and to apply an identical reference measurement strategy.

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