

SIMRAC

Final Project Report

Title: EVALUATION OF THE SUITABILITY OF USING JET
FANS TO VENTILATE CONTINUOUS MINER
HEADINGS IN COLLIERIES

Author/s: C F MEYER, B A DOYLE, PROF H R PHILIPS

**Research
Agency:** CSIR – MININGTEK

Project No: COL 116

Date: SEPTEMBER 1994

1 INTRODUCTION

A working party under the auspices of the GME developed a set of guidelines for the ventilating of headings in collieries developed by mechanical miners. This guidelines also made provision for the use of jet fans. Because of the lack of documented information on the effectiveness of jet fans with regard to the ventilation of heading faces, the GME prohibited the use of jet fans in mechanical miner headings pending further investigations.

As a result, a special ad-hoc project was approved by SIMRAC, under project number COL116, to determine the effectiveness of jet fans under normal production circumstances (see appendices 1 and 2) and to determine whether the jet fans could satisfy the requirements of the previously developed guidelines. For this purpose a special working group was established to manage and perform the tests required by the project. After completion of the tests, the working group was to report to the GME on the performance of jet fans, within a period of three months, to enable the GME to decide on the future use of jet fans.

This document will describe the planning details of the project, the execution of the tests and the results that were obtained from the individual tests. Professor H R Philips of the University of the Witwatersrand was nominated to act as moderator for the project and to evaluate the results from the tests. The conclusions reached by him will also be given in this report.

2 WORKING GROUP

The working group consisted of representatives from all the mining groups which utilize jet fans, Miningtek and DMEA. The objective of the working group was to decide on the test protocol to be used and the venues for the actual tests. Following the practical work, a report was to be compiled depicting the test results which would be submitted to the GME for his attention and final decision indicating in addition areas of concern requiring further research. The following persons were invited to serve with the working group.

J C Viljoen (Chairman)	Prof H R Philips (Moderator)
J Guthrie	P R Kritzinger
D Rowe	B A Doyle
J A Diedericks	J P Jordaan
L L Bruinette	W Rowe
B van Shalckwyk	C F Meyer
A Stockhuizen	C J Kahts

These persons were responsible for identifying the critical issues that would be addressed during the tests and for scheduling the work, bearing in mind the short time span available. Mr B A Doyle of the DMEA and C F Meyer of VARICON, subcontracted by Miningtek for this project were nominated to perform the actual underground measurements. The other members of the group were invited to attend the underground tests at their own convenience during the test period.

3 TEST PROTOCOL

3.1 TEST PROTOCOL, PERFORMANCE CRITERIA

In evaluating the performance of jet fans, the test protocol had to consider the requirements of the guidelines for ventilating headings for continuous miners and roadheaders. The working party, due to time constraints, recognised that:

- only airflow requirements have to be considered
- methane dilution will not be within the scope of the project
- respirable dust and dust in general will not be part of the project
- ventilating a split is a major concern, but will be researched in future, if the restriction on the use of jet fans has been lifted

3.2 TEST SITE REQUIREMENTS

Because of the time constraint, only a few critical variables were examined in this initial project and a limited number of parameters was measured. Three mines were nominated to host the underground tests for the purpose of covering three different seam heights:

- Gloria Colliery representing a high seam
- Goedehoop Colliery representing a medium seam
- Bosjesspruit Colliery representing a low seam

These mines were officially informed about the decision. They were to be responsible for preparing the test sites and for providing the necessary infrastructure for the tests. A week was set aside for each mine to allow sufficient time for completion of the tests. To ensure that results/observations can be compared, the test protocol provided for standardization of the recording of observations as well as the layout of the headings to be evaluated.

For the tests, two specific face conditions were decided upon:

CONDITION 1: (Partial heading)

One side of the heading (in line with the jet fan position) was to be advanced 35 m from the last through road at the width of the continuous miner. The opposite side of the heading was to be mined to a distance of 25 m from the last through road (Figure 1).

CONDITION 2: (Full heading)

The full heading was to be developed 35 m from the last through road with the continuous miner positioned on the left side of the face of the heading (Figure 2).

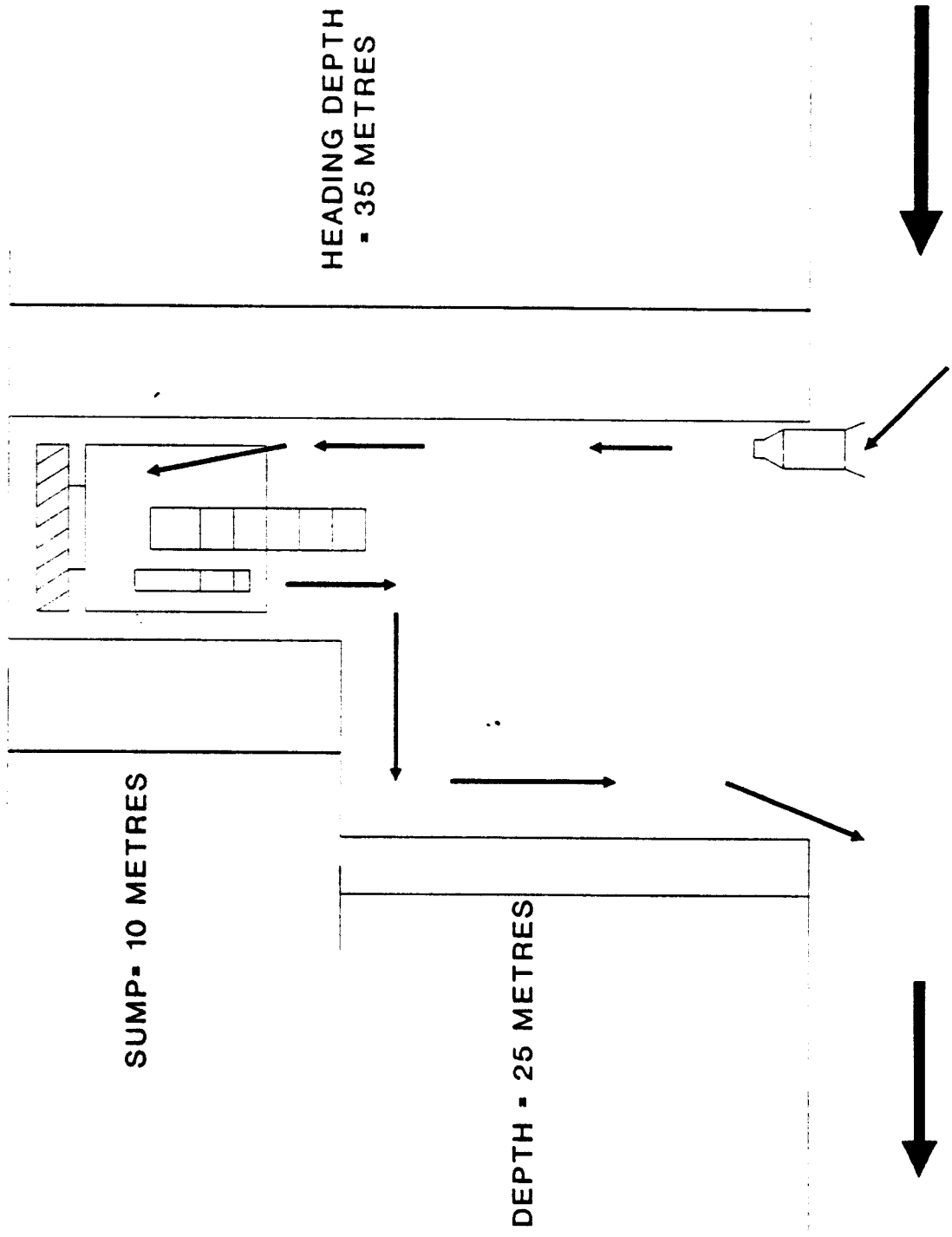


Figure 1: Sketch showing face condition 1.

4/10/11

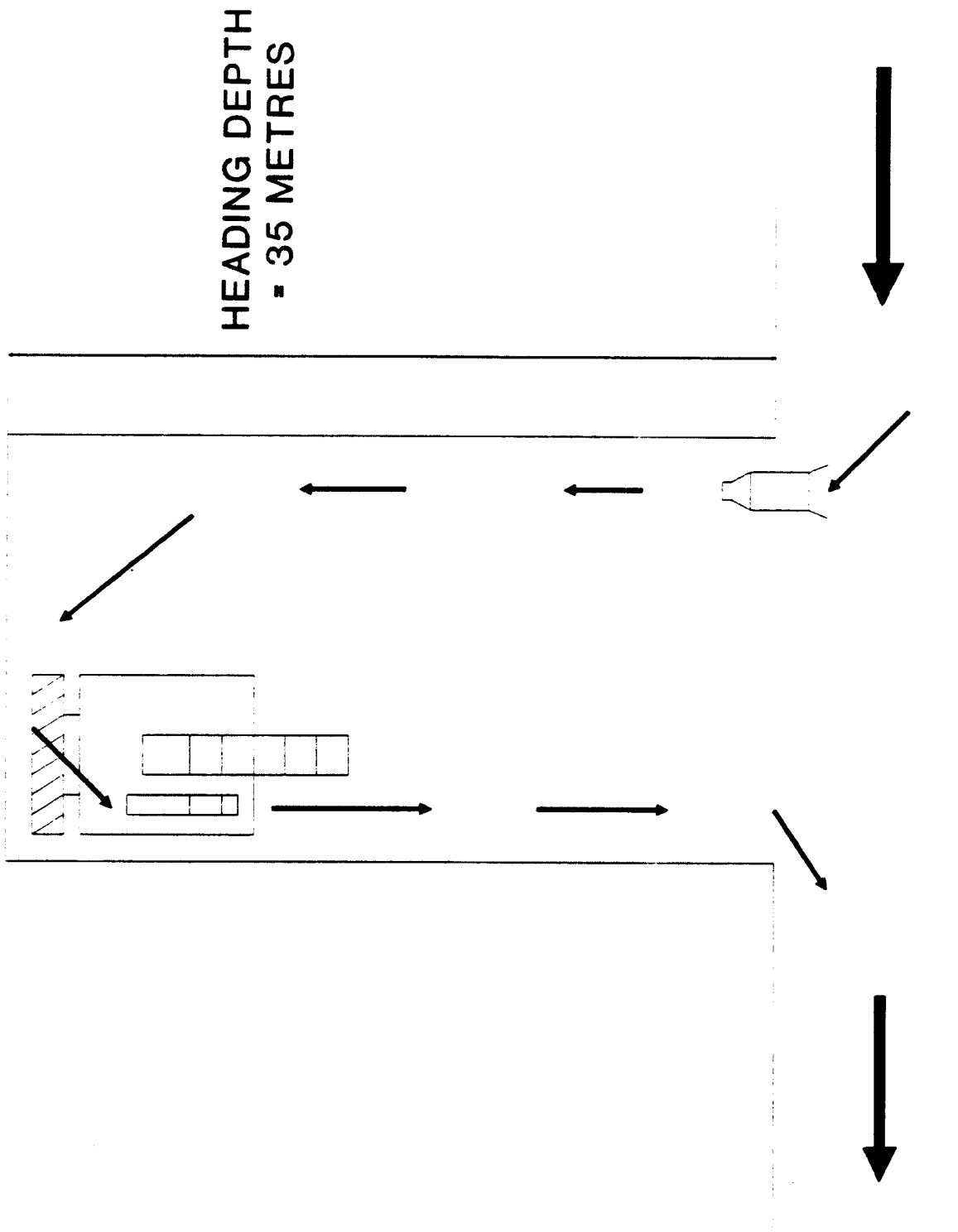


Figure 2: Sketch showing face condition 2.

JET FAN POSITIONS:

All three mines agreed to suspend the fan from the roof for both conditions. Secunda collieries, however, requested an additional test with the fan placed on the floor for both face conditions.

The following ventilation conditions pertained while the performance of the jet fans was evaluated:

- the scrubber fan position not in line with the jet fan position
- the scrubber fan switched on during all the tests
- the continuous miner placed in position, without cutting coal, and without the drum rotating
- the jet fans installed upstream in such a position that no air recirculation occurred around the jet fan
- the systems that were to be tested, must be practical from a ventilation and mining point of view

It was the responsibility of the individual mines to ensure that the roof was well supported before the tests were carried out.

4 MEASURING CRITERIA

- Because of the difficulty in measuring the fresh air entrainment into a heading, as a result of the jet fan vortex action, it was agreed that, where necessary, an entrainment nozzle could be fitted to the front of the jet fan to enable the measurement of some of the entrainment over the fan. It was agreed that the fan should not deliver less than $0,2 \text{ m}^3/\text{s}$ of fresh air per m^2 of face area, into the heading with or without the entrainment nozzle.
- The scrubber fan quantity should not be less than $0,4 \text{ m}^3/\text{s}/\text{m}^2$ of the coal face area. [It was agreed that non-adherence to this requirement would not negatively influence the outcome of evaluating the jet fan performance].
- Not more than 50 % air recirculation would be allowed inside the heading through the scrubber. Quantification of this air recirculation was based on the ratio of the air quantity handled by the scrubber and the fresh air delivered by the jet fan and entrainment nozzle if applicable.
- The jet fan air delivery quantity was to be determined using the pitot tube method. The scrubber fan quantity was to be measured with a vane anemometer.
- The average last through road air velocity was to be set as close to 1,0 m/s flowing past the fan position as could be readily achieved.
- A minimum air velocity of 0,4 m/s was to prevail over the drivers position. Two measuring positions were used; 0,5 m vertically above the drivers cab and 0,5 m horizontally to the side of the cab (Figure 3).

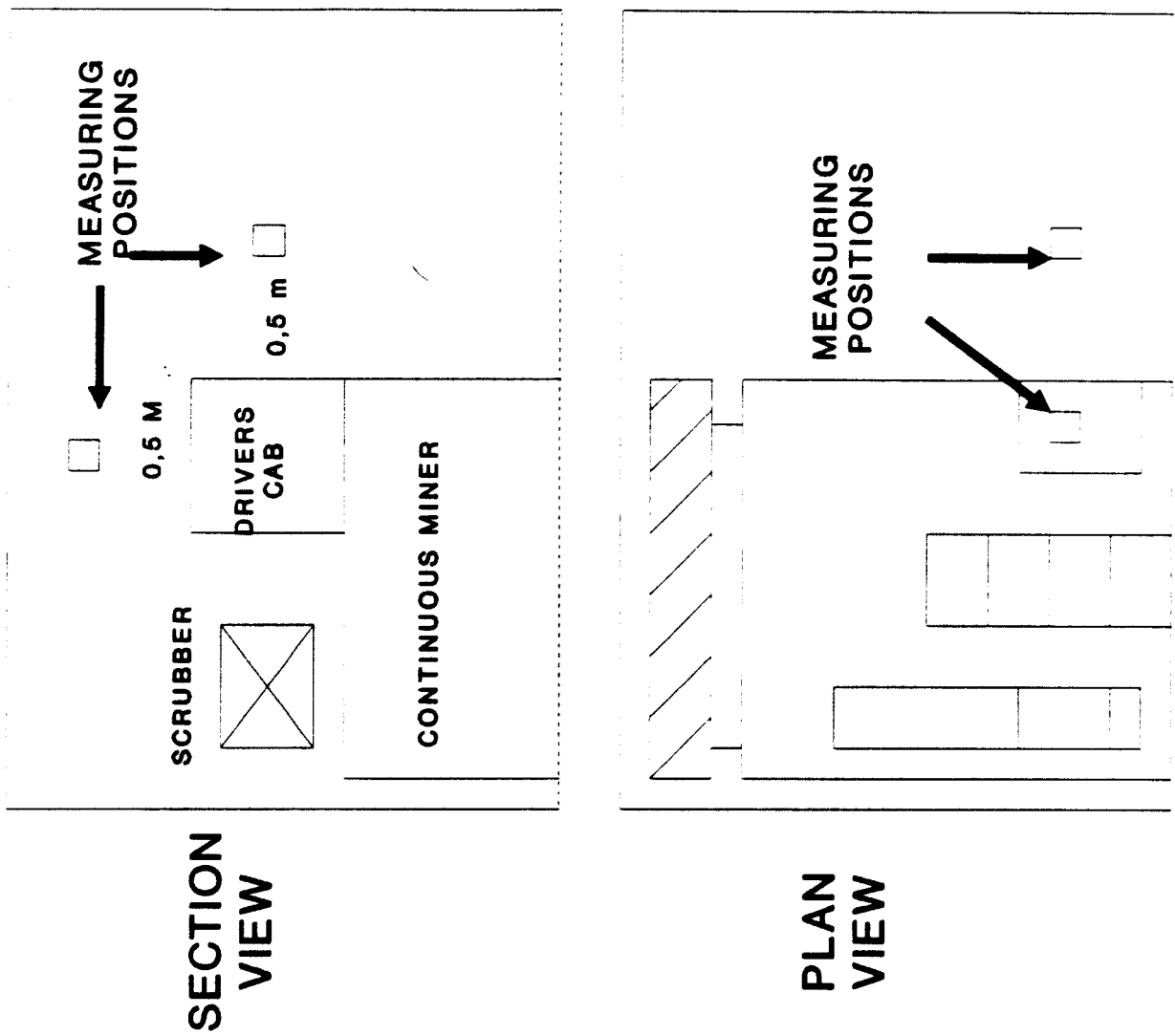


Figure 3: Sketch showing the measuring positions over the drivers cab.

- Airflow measurements were to be taken using a grid over the machine at a position 5 m from the face. In each block of the grid, the airflow direction and the air velocity were to be determined and recorded. These measurements were to be taken with the watersprays/sprayfan system not operating.
- Airflow measurements were to be taken against the face also, with the scrubber fan running, and with it not running, for the purpose of determining the effective ventilation distance of the jet fan. (The sketches included in this report, to show the results, clearly demonstrate the positions of the measuring grids used).

5 TEST RESULTS

5.1 GLORIA COLLIERY

The test conditions found at the test site were not exactly according to the test protocol described but, considering the time constraint and the pressure of production, an acceptable situation existed and the results represent the practical situation under normal circumstances.

The test conditions were as follows:

Condition 1:(Partial heading)

- Heading depth = 31,4 m
- Continuous miner used = 12HM17
- Width of partial heading = 3,6 m
- Width of full heading = 6,7 m
- Seam height = 4,9 m
- Jet fan fitted with entrainment nozzle
- Jet fan suspended from the roof in the upstream position
- Last through road air velocity = 0,96 m/s
- Quantity needed by jet fan ($0,2 \text{ m}^3/\text{s}/\text{m}^2$) = $6,6 \text{ m}^3/\text{s}$
- Jet fan used = 18,5 kW
- Inlet size = 570 mm
- Outlet size = 330 mm
- Entrainment nozzle used:
 - Nozzle length = 1680 mm
 - Inlet size = 760 mm
 - Outlet size = 585 mm
- Jet fan quantity with entrainment nozzle = $8,78 \text{ m}^3/\text{s}$
- Jet fan quantity without entrainment nozzle = $4,2 \text{ m}^3/\text{s}$
- Average velocity out of entrainment nozzle = 32,7 m/s
- Scrubber fan quantity = $7,8 \text{ m}^3/\text{s}$ (Needed $13,1 \text{ m}^3/\text{s}$)

Grid measurements over the machine with the scrubber operating

The grid was established 5.0 m from the face of the heading across the continuous miner. The grid was positioned past the scrubber inlet and in front of the drivers cab position. Figure 4 shows an overall view of the heading and the position of the continuous miner and jet fan. The measuring grid over the machine is also shown. The sketch shows the airflow patterns inside the heading at floor, middle and roof levels and it also indicates the relevant airway and heading dimensions.

Figure 5 shows a three-dimensional view of the front section of the heading with the grid over the continuous miner and the measuring positions against the face. The sketch shows the airflow directions through each block of the grid with the individual air velocity measurements tabled on the sketch under "S" values. The rate of airflow inside the heading was not stable and significant fluctuations occurred during the measurements. Because of this it was decided that the minimum and maximum reading for each block be recorded. The sizes of the blocks differed for each heading size. Each heading was divided into a number of equal sized blocks for the measurements. In this case the 3.6 m portion of the heading above the CM was divided into 4 equal blocks across its width, and into 2 blocks over the height. (The letter "S" was just chosen for reference purposes)

The sketch is drawn to scale so as to give the reader the perspective of the open area available for the airflow above the CM. The vectors show the airflow directions to and from the face. The air velocities flowing back and forth through the grid varied between 0,8 m/s and 4,0 m/s.

Face measurements with the scrubber operating

Figure 5 also shows the measurements taken against the face, while the scrubber was operating, and the number of blocks used in the grid for the measurements. The vectors show that the airflow mainly swept the face from right to left. The air velocities are tabled under the "F" values on the sketch. Air velocities ranged between 0,3 m/s and 2,0 m/s. These measurements were taken with the watersprays not working because the hot wire anemometer readings are adversely affected by water vapour. (Once again the letter "F" was just chosen for reference purposes)

GLORIA PARTIAL HEADING

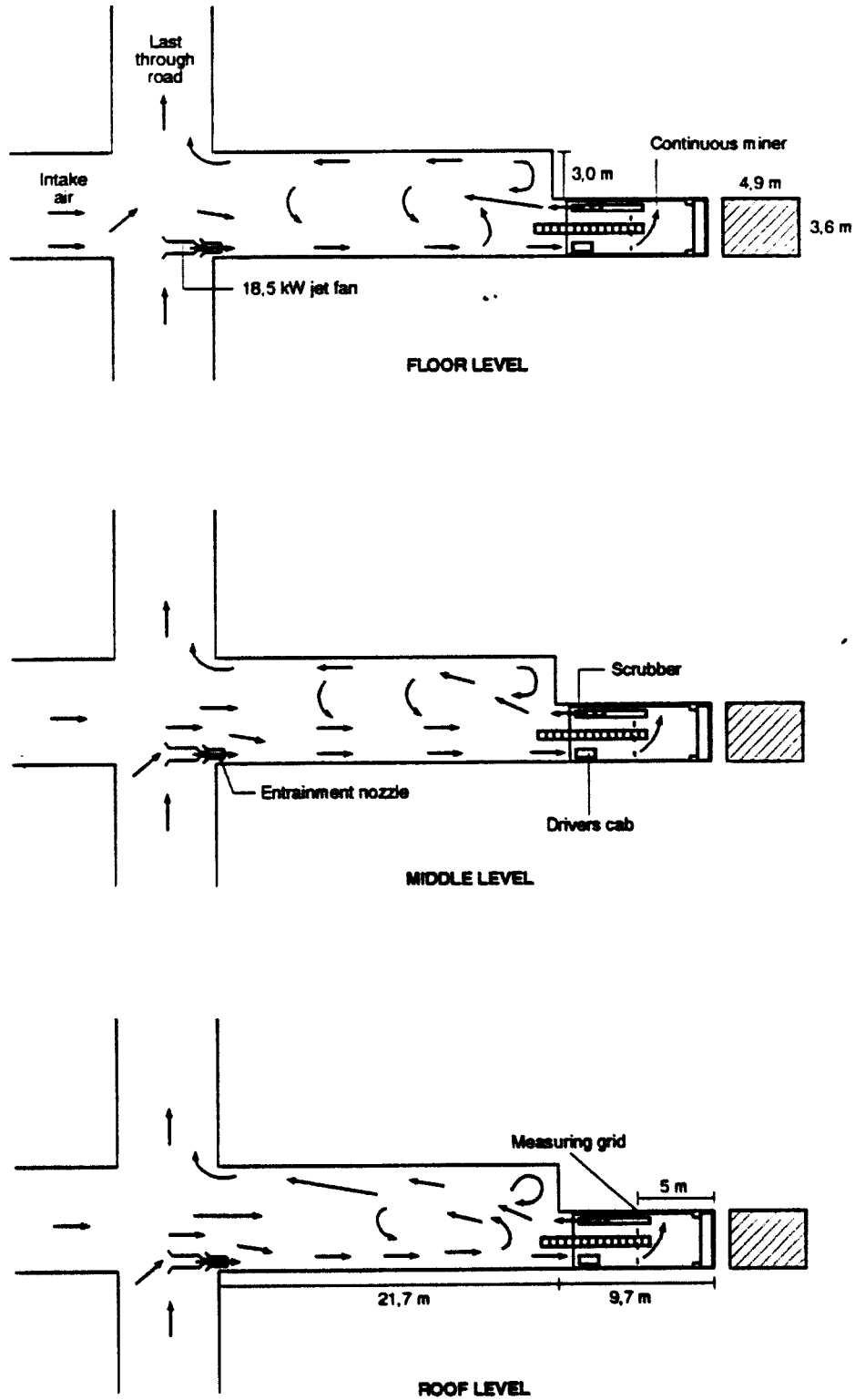
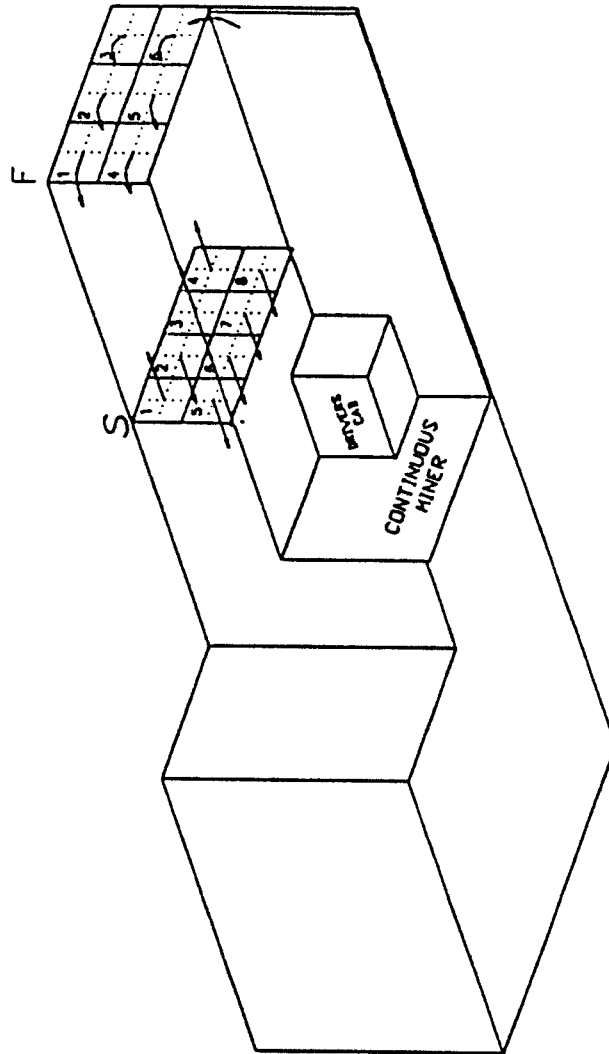


Figure 4: An overall view of the partial heading at Gloria Colliery.

GLORIA COLLIERY
PARTIAL HEADING WITH SCRUBBER ACTIVE



GRID S VALUES

NO.	VEL. RANGE (m/s)
1	2.0 - 4.0
2	1.5 - 3.0
3	1.0 - 3.0
4	1.0 - 2.0
5	1.0 - 4.0
6	1.2 - 2.0
7	1.0 - 3.0
8	0.8 - 1.5

GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.3 - 1.0
2	0.4 - 0.8
3	0.5 - 1.5
4	0.5 - 1.5
5	0.4 - 2.0
6	0.4 - 1.0

Figure 5: Detail of the grid measurements in the partial heading with the scrubber active.

Face measurements without the scrubber

These readings were taken to determine the effective ventilating distance of the jet fan. Figure 6 shows the results of this exercise. The air velocities, as tabled in the sketch, were lower than the previous tests. The airflow direction against the face also changed and flowed from left to right across the face. The air velocities still fluctuated as before but the range of velocities was now between 0,2 m/s and 0,8 m/s.

Airflow over the driver with the scrubber operating

The air velocities were taken at the positions previously indicated in Figure 3 and are reported accordingly. Because the CM was positioned flush against the sidewall, the second velocity, i.e. 0,5 m to the side of the cab, was measured immediately behind the cab. The minimum and maximum air velocities recorded were as follows.

Position on top of the drivers cab = 0,7 m/s to 1,2 m/s.

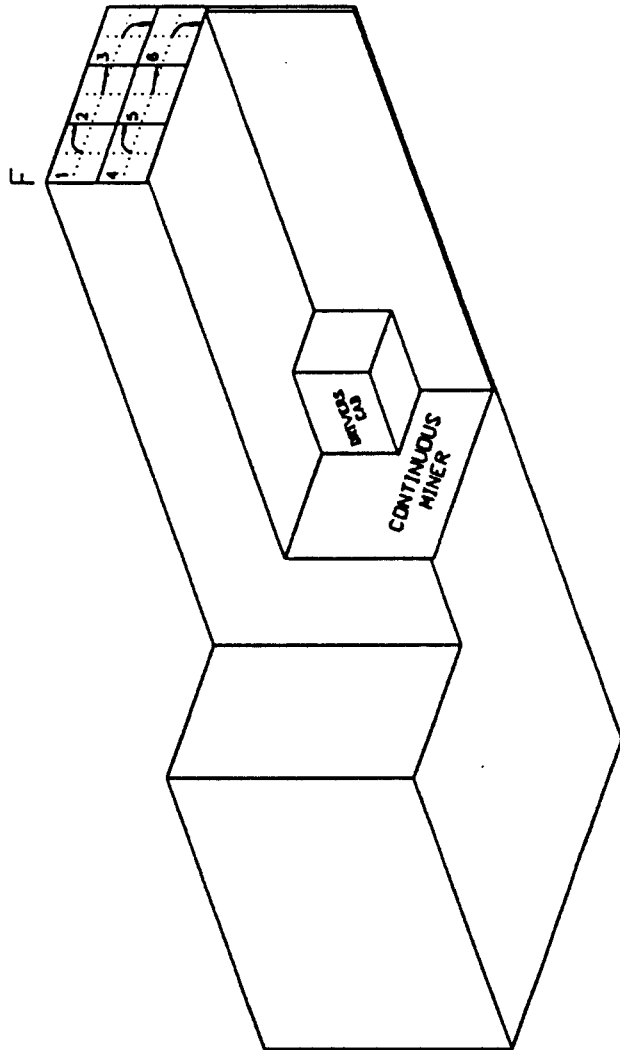
Position at the back of the drivers cab = 1,0 m/s to 4,0 m/s.

In both cases the airflow direction was forward/sideways over the driver towards the face and the scrubber inlet.

Condition 2: (Full heading)

In this case the heading was fully developed and the continuous miner (CM) was placed in the left corner of the face. As this was a different heading to that used in the tests described above, the heading depth and dimensions differed slightly from the partial heading. The same jet fan and nozzle were used, and therefore the jet fan quantity was not measured again. Figure 7 shows the overall airflow patterns in the heading at floor, middle and roof levels, as well as the relevant airway and heading dimensions and the jet fan and CM position.

GLORIA COLLIERY
PARTIAL HEADING WITHOUT SCRUBBER



GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.3 - 0.7
2	0.4 - 0.8
3	0.3 - 0.4
4	0.3 - 0.7
5	0.2
6	0.2

Figure 6: Face measurements in the partial heading without the scrubber.

GLORIA FULL HEADING

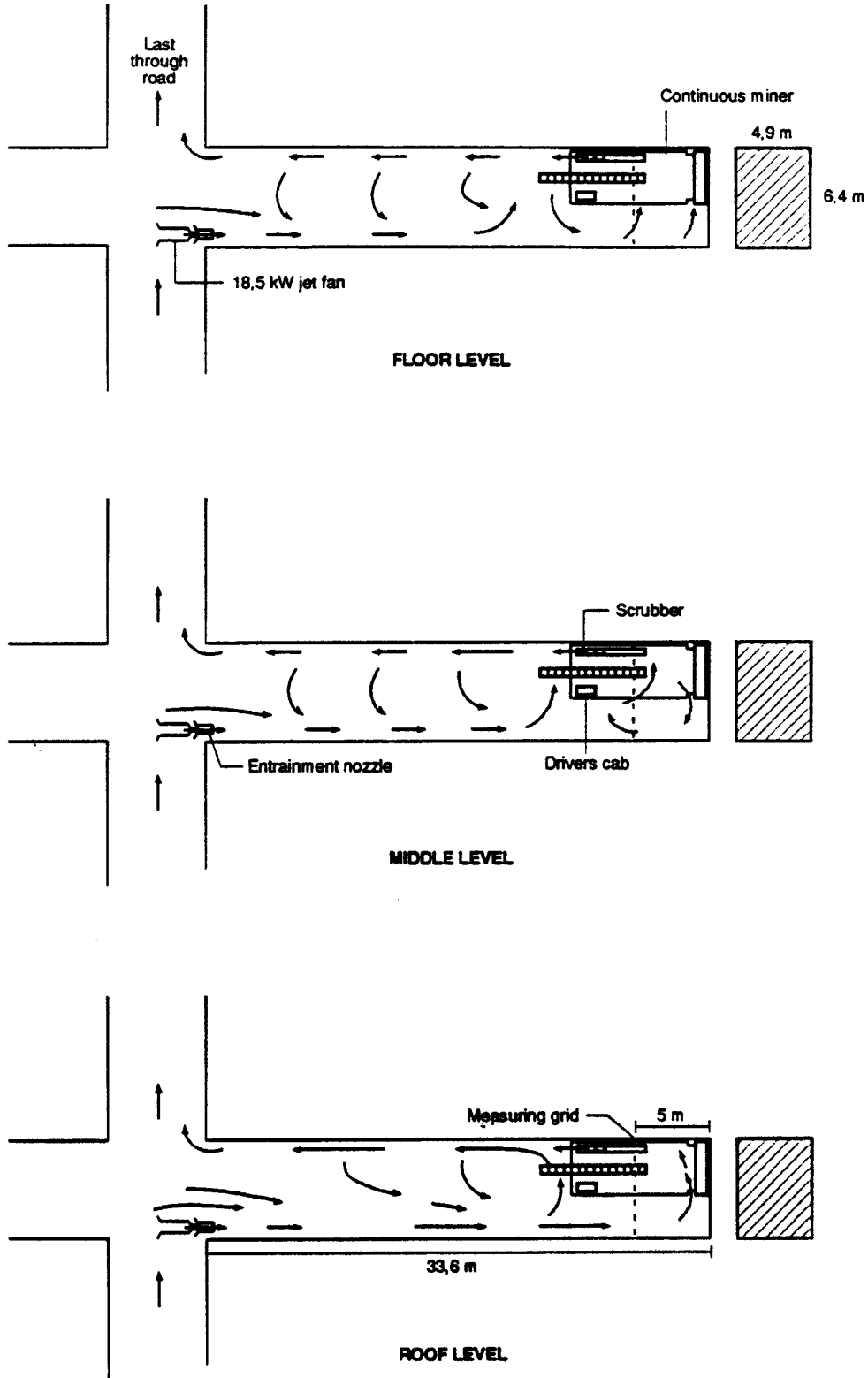


Figure 7: Overall view of the full heading at Gloria Colliery.

The test conditions were as follows:

- Heading depth = 33,6 m
- Heading width = 6,4 m
- Seam height = 4,9 m
- Jet fan quantity with entrainment nozzle = $8,78 \text{ m}^3/\text{s}$
- Jet fan quantity without the nozzle = $4,2 \text{ m}^3/\text{s}$
- Average velocity out of entrainment nozzle = 32,7 m/s
- Quantity required in heading ($0,2 \text{ m}^3/\text{s}/\text{m}^2 \times \text{area}$) = $6,3 \text{ m}^3/\text{s}$
- Scrubber quantity = $7,8 \text{ m}^3/\text{s}$ (Needed $12,5 \text{ m}^3/\text{s}$)
- Last through road air velocity = 0,96 m/s

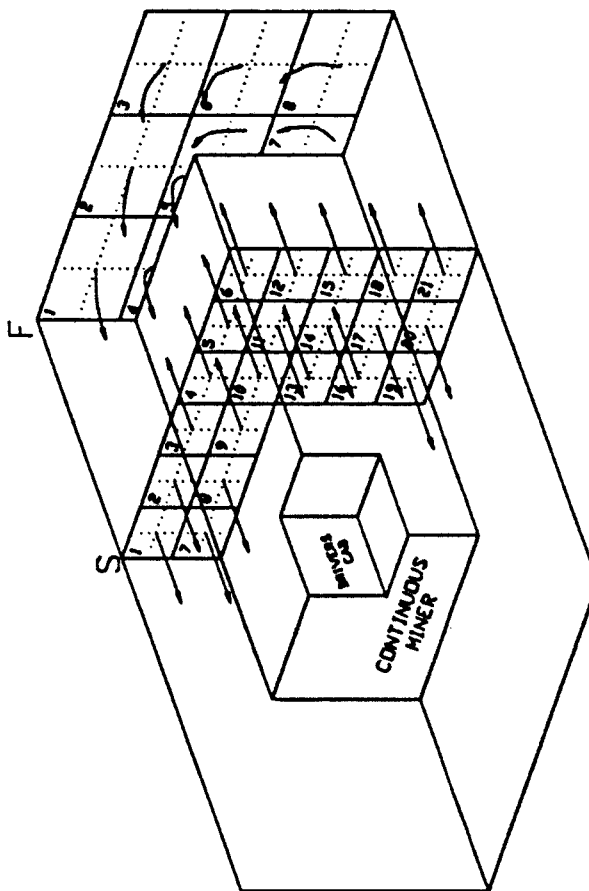
Grid measurements over the machine with the scrubber operating

The grid was installed 5 m from the face position over the CM. The open area above and to the side of the machine was divided into equal sized blocks for the measurements. Across the width of the heading 6 equal blocks were established, 5 equal blocks were established over the height dimension of the heading. Figure 8 shows the three-dimensional sketch of the front section of the face area, with the grid over the machine and the blocks against the face for the face measurements. The airflow directions through the individual blocks are shown by the vectors, the minimum and maximum air velocities measured in each block are tabled under the "S" values on the sketch. The air velocities ranged between 0,3 m/s and 2,5 m/s over the full open area, with most of the airflow being in a forward direction. Due to there being more open area in which airflow could occur, more air flowed over the machine towards the face, than in the previous test.

Face measurements with the scrubber operating

Figure 8 also shows the blocks established against the face and the airflow measurement results. The sketch shows the airflow direction against the face. It shows that the air flowed from right to left across the face to the scrubber inlet position. These measurements were again taken without the watersprays operating. The minimum and maximum air velocities were recorded in each block and these values are given in the sketch under the heading "F" values. The air velocities measured ranged between 0,3 m/s and 2,0 m/s.

GLORIA COLLIERY
FULL HEADING WITH SCRUBBER ACTIVE



GRID S VALUES

NO.	VEL. RANGE (m/s)
1	0.8 - 2.2
2	0.6 - 1.8
3	0.5 - 1.8
4	1.5 - 2.0
5	1.0 - 2.0
6	1.0 - 2.5
7	0.3 - 1.0
8	0.3 - 1.0
9	0.4 - 1.1
10	1.5 - 2.0
11	0.5 - 1.0
12	0.5 - 1.5
13	0.8 - 2.0
14	0.5 - 1.0
15	0.4 - 1.0
16	0.4 - 0.8
17	0.3 - 1.3
18	0.5 - 1.4
19	0.3 - 0.8
20	0.4 - 0.8
21	0.3 - 1.0

GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.3 - 1.0
2	0.3 - 0.6
3	0.5 - 0.8
4	1.0 - 2.0
5	0.4 - 1.0
6	0.4 - 2.0
7	0.4 - 0.7
8	0.5 - 1.0

Figure 8: Details of the grid measurements in the full heading at Gloria Colliery.

Face measurements without the scrubber

Figure 9 shows the measurements recorded against the same face. This was done to determine the effective ventilating distance of the jet fan under these circumstances. The airflow differed from the previous test, when the scrubber was working, and turbulence was detected against the face, this is again shown by the vectors. The air velocities that were measured did not decrease significantly from the previous results, i.e. when the scrubber was running. This shows air from the jet fan reached the face of the heading. The minimum and maximum air velocities measured varied between 0,4 m/s and 1,0 m/s. They are tabled in the sketch.

Airflow over the driver with the scrubber operating

The air velocities were again measured with the hot wire anemometer at the positions as shown on Figure 3. The minimum and maximum air velocities measured at each position were as follows:

Position on top of the drivers cab = 1,0 m/s to 2,0 m/s.

Position to the right of the drivers cab = 0,7 m/s to 2,2 m/s.

In both cases the air flowed sideways and in a forward direction over the drivers cab to the scrubber inlet position.

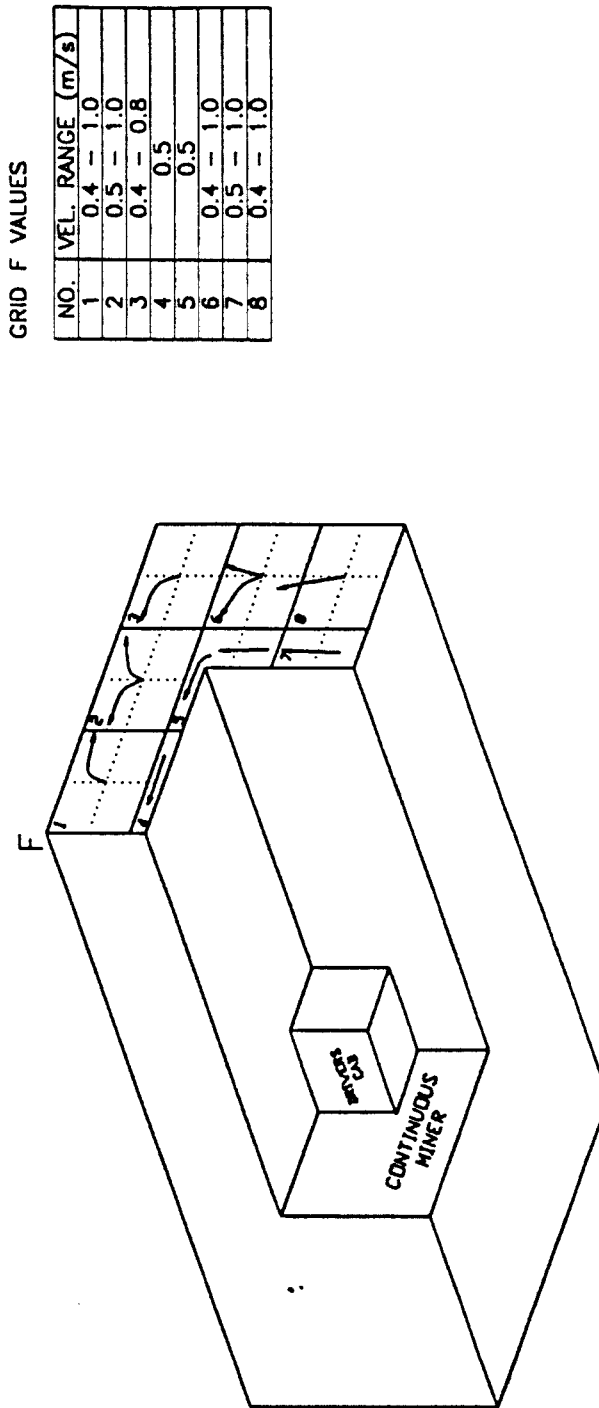
GENERAL REMARKS:

In both these cases, the jet fan delivered sufficient air past the drivers position to satisfy the criteria laid down in the test protocol. Without the scrubber operating in the partial heading, the airflow at the face was less than when the scrubber fan was operating. The open area above the CM restricted the amount of air that reached the face. With the partial heading the air velocities reached a maximum of 0,8 m/s on the face without the scrubber fan operating. The underground observations indicated, that for this particular scenario, the jet fan can ventilate up to 32 metres from the last through road. When the scrubber was started, the airflow improved in the face area and hence air velocities on the face increased.

With the fully developed heading, i.e. condition 2, the jet fan air reached the face when the scrubber fan was switched off, but the pulsating effect of the air, with and without the scrubber, reduced the face ventilating effectiveness of the air.

The jet fan air delivery quantity as measured was found to be in excess of that of the scrubber fan. This could create rollback of dust when the CM is cutting. Future tests should involve the determination of the total amount of air flowing into a heading with the jet fan in operation, because of the pulsating effect of the air when the large 18,5 kW fan was used. An optimum balance between the scrubber fan quantity and total fresh air intake could then be established. Air in and out of the heading was very erratic, with a great deal of turbulence.

GLORIA COLLIERY
FULL HEADING WITHOUT SCRUBBER



GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.4 - 1.0
2	0.5 - 1.0
3	0.4 - 0.8
4	0.5
5	0.5
6	0.4 - 1.0
7	0.5 - 1.0
8	0.4 - 1.0

Figure 9: Face measurements in the full heading without the scrubber at Gloria Colliery.

All the tests were done with the watersprays off. It is generally expected that the air movement on the face will improve when the drum is rotating and the sprays are working. Under these specific test conditions, the requirements of the protocol were satisfied.

5.2 GOEDEHOOP COLLIERY

Typical practical situations again prevailed in the headings, i.e. the airway dimensions were not exactly according to the test protocol.

The test conditions were as follows:

Condition 1: (Partial heading)

- Seam height = 3,9 m
- Heading depth = 34,0 m
- Continuous miner used = 17HM21
- Width of the partial heading = 3,6 m
- Width of the full heading = 7,05 m
- Jet fan fitted with an entrainment nozzle
- Jet fan was suspended from the roof in the upstream position
- Quantity needed by jet fan ($0,2 \text{ m}^3/\text{s}/\text{m}^2 \times \text{area}$) = $5,5 \text{ m}^3/\text{s}$
- Scrubber fan quantity measured = $10,5 \text{ m}^3/\text{s}$ (Needed $10,9 \text{ m}^3/\text{s}$)
- Last through road air velocity = 1,2 m/s
- Jet fan used = 5,5 kW
 - Inlet size = 520 mm
 - Outlet size = 280 mm
- Entrainment nozzle used:
 - Inlet size = 730 mm
 - outlet size = 520 mm
- Jet fan quantity delivered with entrainment nozzle = $5,5 \text{ m}^3/\text{s}$.
- Jet fan quantity delivered without entrainment nozzle = $2,5 \text{ m}^3/\text{s}$.
- Average velocity out of entrainment nozzle = 25,4 m/s

Grid measurements over the machine with the scrubber operating

The grid was established 5 m from the face of the heading over the continuous miner. The scrubber inlet on the machine was situated just over 5 m from the face, which meant that the grid was positioned immediately in front of the scrubber inlet. Figure 10 shows an overall view of the airflow patterns inside the heading at floor, middle and roof levels, as well as the relevant airway and heading dimensions. The sketch also shows the positions of the CM, jet fan and the grid.

GOEDE HOOP PARTIAL HEADING

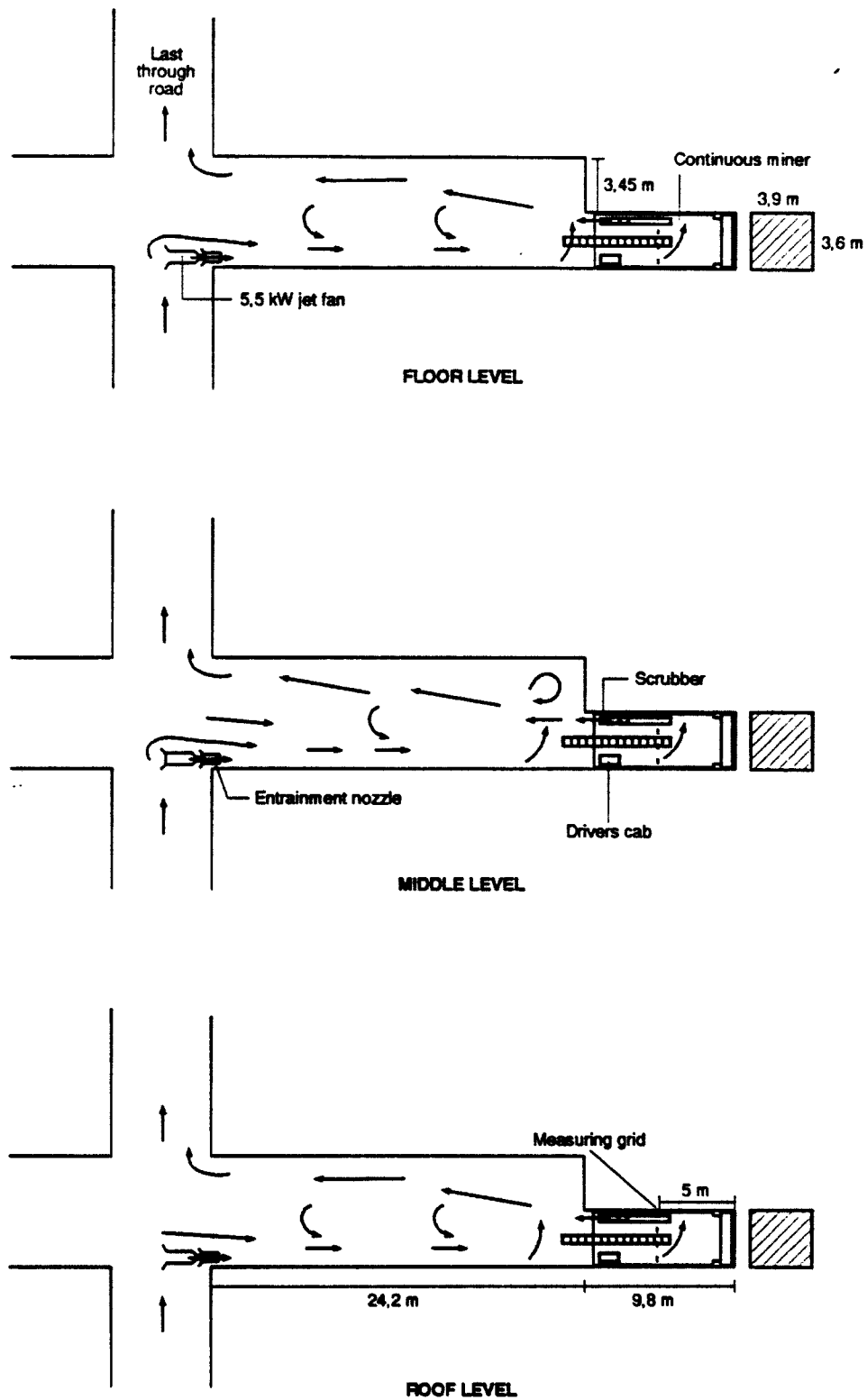


Figure 10: Overall view of the partial heading at Goedehoop Colliery.

Figure 11 shows the grid over the continuous miner in a three-dimensional manner, with the continuous miner in position. Because of the space available, the grid could only be established above the CM. A total number of 11 equally sized blocks was established in this open area and these are shown in the sketch. The airflow directions in each block were determined and are shown on the sketch. The minimum and maximum air velocities inside each block were measured with the hot wire anemometer. These values are tabled in Figure 11 under the heading "S" values. As before, the airflow rate fluctuated and therefore the minimum and maximum velocities were recorded.

The air velocities in the grid ranged between 0,3 m/s to 4,0 m/s. The air flowed in a forward direction through the grid. The air from the jet fan and the air from the scrubber opposed each other directly. This was due to the size of the continuous miner and the position of the jet fan. The fan and the scrubber on the CM, in this particular scenario, were positioned at the same level and were close to being directly opposite each other. This resulted in only the air handled by the scrubber flowing through the grid to the face and scrubber inlet. The air tended to take the shortest route to the scrubber inlet without reaching the face.

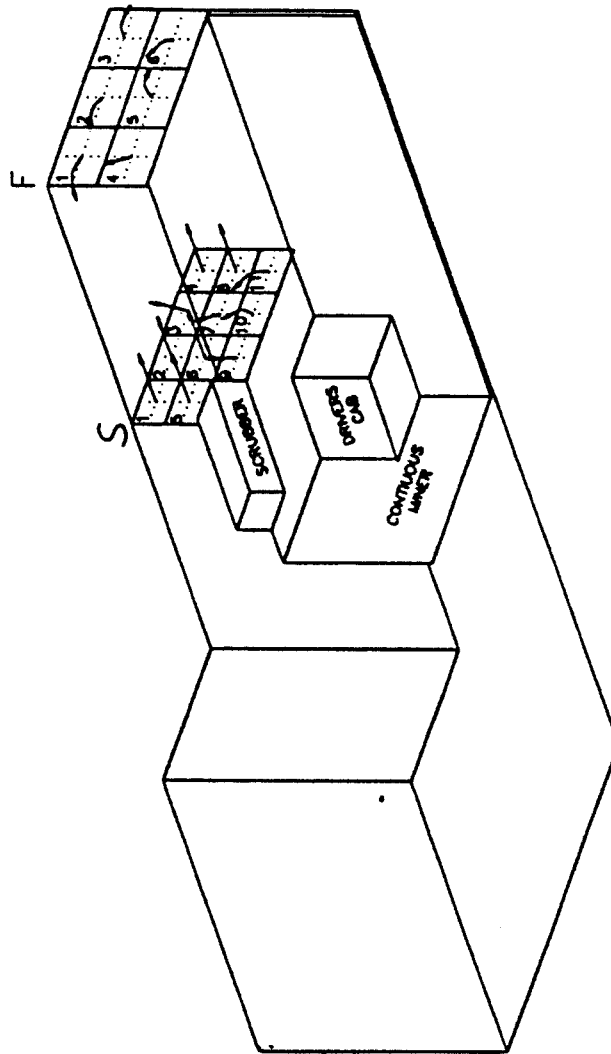
Face measurements with the scrubber operating

Figure 11 also shows the measurement positions against the face and the results of these measurements. Because of the reasons mentioned above, the air velocities against the face were very low. The airflow direction was from right to left across the face. The lowest air velocity that was measured, was 0,2 m/s which represents practically no airflow, to a maximum of 0,4 m/s. The air velocities measured are tabled in the sketch under the heading "F" values. These measurements were taken without the sprayfan system operating.

Face measurements without the scrubber

To determine the effective ventilating distance of the jet fan under these circumstances, the scrubber fan was switched off and measurements were taken against the face. The air velocities were not very different from the velocities measured with the scrubber fan working. The velocities ranged between 0,2 m/s and 0,5 m/s. The 0,2 m/s represents practically no airflow at that position. Figure 12 shows the results from these measurements. The airflow direction is shown to be mostly from left to right across the face. The air from the fan effectively reached a distance of 32 m from the last through road, which is just past the drivers position. The sprayfan system was switched off.

GOEDEHOOP COLLIERY
PARTIAL HEADING WITH SCRUBBER



GRID S VALUES

NO.	VEL. RANGE (m/s)
1	1.5 - 3.0
2	1.0 - 1.5
3	2.0 - 2.5
4	0.5 - 2.0
5	2.0 - 4.0
6	1.0 - 1.8
7	1.0 - 2.0
8	0.3 - 2.0
9	1.0 - 2.0
10	1.0 - 2.0
11	0.4 - 1.0

GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.2
2	0.2 - 0.3
3	0.2 - 0.3
4	0.2
5	0.2 - 0.3
6	0.3 - 0.4

Figure 11: Details of the grid measurements in the partial heading with the scrubber active at Goedehoop Colliery.

GOEDEHOOP COLLIERY
PARTIAL HEADING WITHOUT SCRUBBER

GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.2
2	0.2 - 0.3
3	0.2
4	0.3 - 0.5
5	0.4
6	0.3 - 0.4

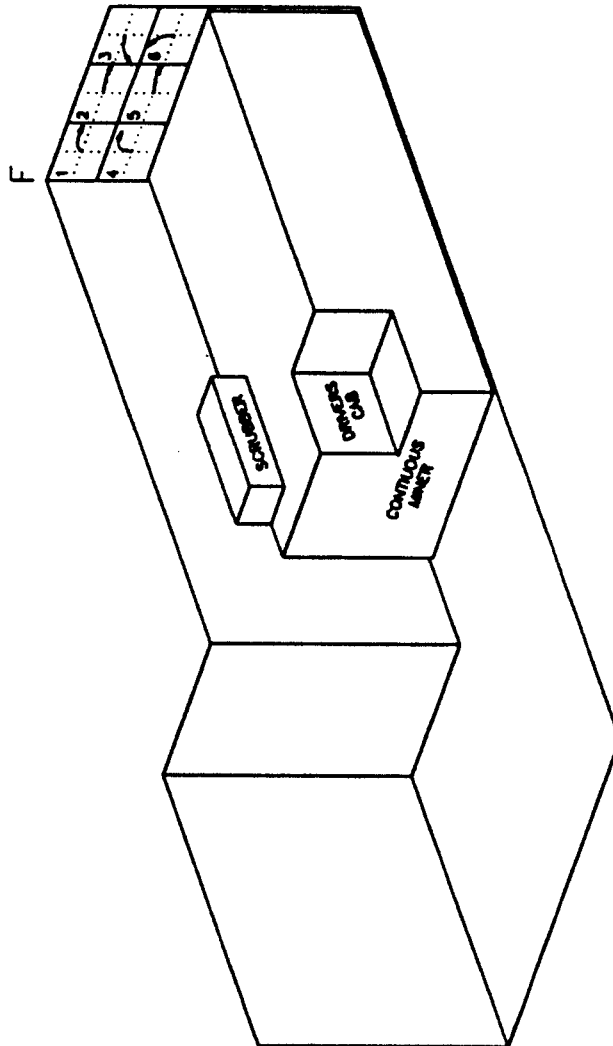


Figure 12: Face measurements in the partial heading without the scrubber at Goedehoop Colliery.

Airflow over the driver with the scrubber operating

The airflow was measured over the driver while the scrubber fan was operating to represent the practical production situation. Figure 3 shows the two positions that were suggested for measuring these air velocities, but as with the partial heading, the air flowing over the top of the driver and the velocity immediately at the back of the cab were measured. Because of the fluctuation of the velocities, the minimum and maximum velocities were recorded.

Position on top of the drivers cab = 1,0 m/s to 3,0 m/s

Position at the back of the drivers cab = 1,0 m/s to 2,0 m/s

In both cases the airflow was in a forward direction over the driver cab.

Condition 2: (Full heading)

In this second scenario, the full heading was developed with the continuous miner (CM) positioned in the left corner of the face. The grid was again established over the CM, 5 m from the face of the heading, immediately in front of the scrubber inlet. Figure 13 shows the overall view of the airflow patterns inside the heading at floor, middle and floor levels. This sketch shows the positions of the jet fan, CM and the measuring grid as well as the relevant airway and heading dimensions.

The test conditions were as follows:

- Seam height = 4,5 m
- Heading depth = 39 m
- Heading width = 6,75 m
- Jet fan suspended from the roof in the upstream position
- Entrainment nozzle fitted to jet fan
- Quantity needed by the jet fan ($0,2 \text{ m}^3/\text{s}/\text{m}^2 \times \text{area}$) = $6,0 \text{ m}^3/\text{s}$
- Jet fan quantity delivered without the nozzle = $2,5 \text{ m}^3/\text{s}$
- Jet fan quantity delivered with the nozzle = $5,9 \text{ m}^3/\text{s}$
- Average velocity out of entrainment nozzle = 28,9 m/s
- Last through road air velocity = 1,2 m/s
- Scrubber quantity measured = $10,5 \text{ m}^3/\text{s}$ (Needed $12,2 \text{ m}^3/\text{s}$)

GOEDE HOOP FULL HEADING

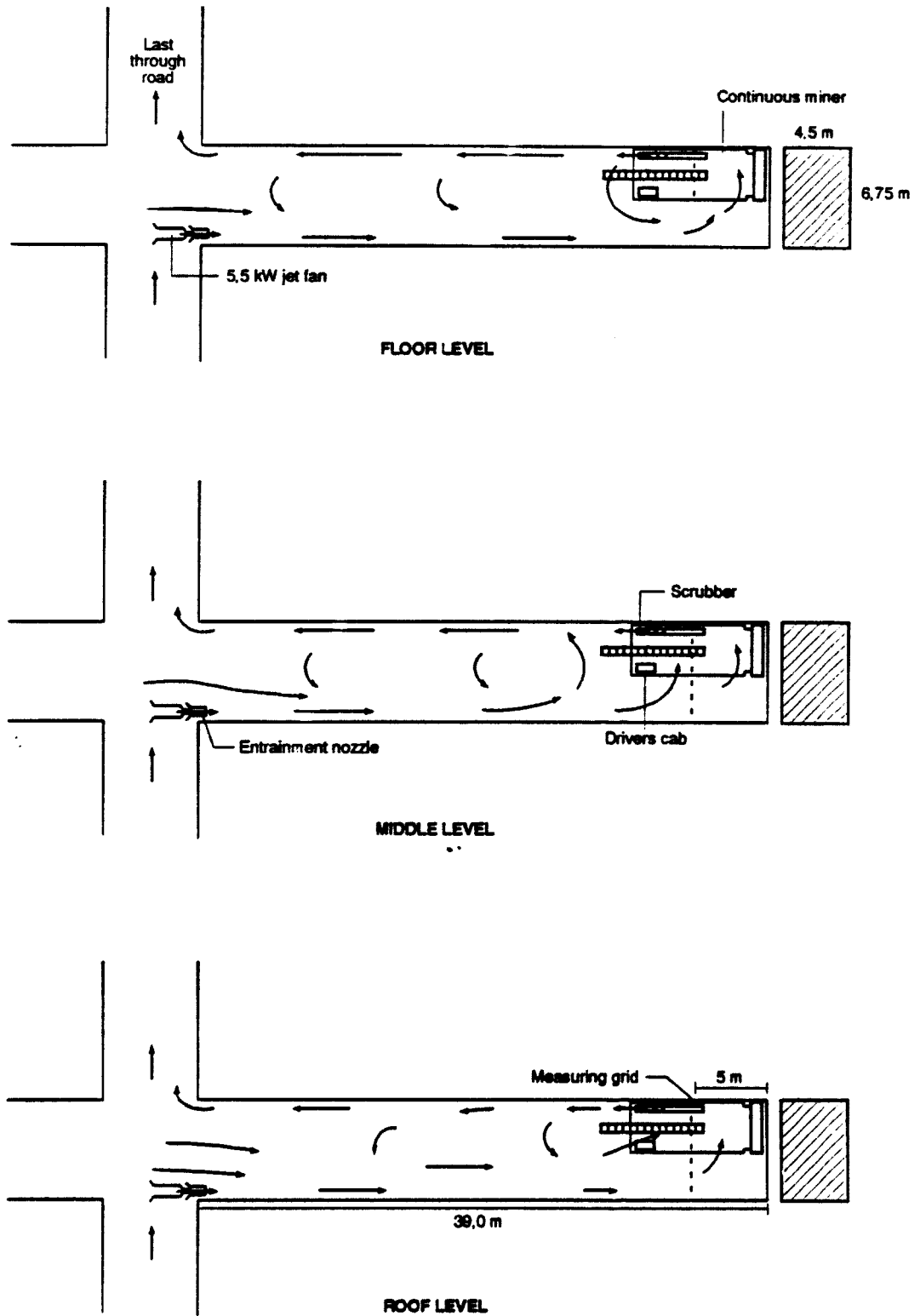


Figure 13: Overall view of the full heading at Goedehoop Colliery.

Grid measurements over the machine with the scrubber operating

The heading was developed further than the required 35 m which influenced the effective range of the jet fan and the airflow measurements through the grid. The results, however, were still useful and a value judgement can be made about the effectiveness of the system at distances beyond 35 m.

The grid was again established 5 m from the face position over the continuous miner (CM) and, as before, immediately in front of the scrubber inlet. The open area on top, and to the side of the CM was divided into 21 equally sized blocks to form the grid. Inside each block the airflow direction was determined and the air velocity was measured with the hot wire anemometer. Figure 14 shows the grid over the CM, the CM inside the heading and the vectors showing the direction of the airflow inside each block. According to the vectors, the airflow through most of the blocks was in a forward direction towards the face area. Air did flow back through the grid through some of the blocks, which might indicate that excess air is flows back from the face. It could, however, mean that this return air is joining up with the intake air in the other blocks. The minimum and maximum velocities that were measured inside the blocks are tabled in the sketch under the "S" values. The velocities ranged between 0,4 m/s and 7,0 m/s. The high velocities are due to the high scrubber quantity.

Face measurements with the scrubber operating

Figure 14 also shows the measurement positions against the face and the results of the measurements. The airflow directions are shown with vectors and the air velocities are tabled under the "F" values. With the scrubber running, the airflow was from right to left across the face towards the inlet of the scrubber. The air velocities ranged between 0,3 m/s to 1,2 m/s, as is shown in the sketch.

Face measurements without the scrubber

To determine whether the air from the jet fan can in fact reach the face under these operating conditions, the scrubber was switched off and the face measurements recorded again. Tests that were performed on jet fans in the past, indicated that a jet fan could easily ventilate to a distance of 35 m in an empty heading.

GOEDEHOOP COLLIERY
FULL HEADING WITH SCRUBBER ACTIVE

GRID S VALUES		GRID F VALUES	
NO.	VEL. RANGE (m/s)	NO.	VEL. RANGE (m/s)
1	0.5 - 1.5	1	0.3 - 0.5
2	0.5 - 1.5	2	0.4 - 0.8
3	1.0 - 2.5	3	0.3 - 0.6
4	2.0 - 2.5	4	0.3 - 0.7
5	1.0 - 2.2	5	0.4 - 1.2
6	0.4 - 1.0	6	0.3 - 0.5
7	SCRUBBER	7	0.3 - 0.5
8	0.5 - 2.0	8	0.3 - 0.4
9	0.4 - 7.0		
10	0.7 - 1.5		
11	1.0 - 2.0		
12	0.4 - 0.6		
13	1.0 - 2.5		
14	0.5 - 1.2		
15	0.5 - 1.2		
16	0.9 - 2.5		
17	0.4 - 1.2		
18	0.4 - 1.0		
19	1.0 - 2.0		
20	1.0 - 2.0		
21	0.4 - 1.0		

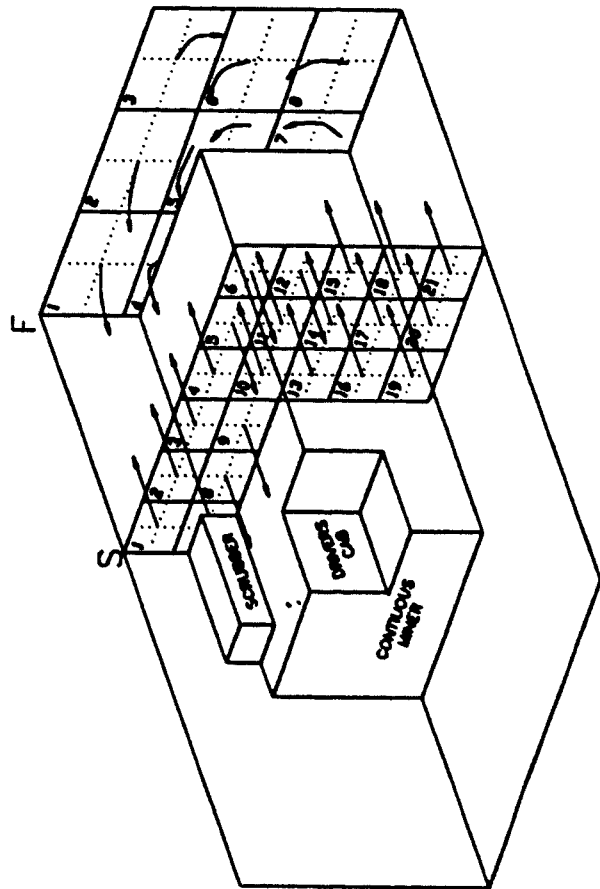


Figure 14: Details of the grid measurements in the full heading with the scrubber active at Goedehoop Colliery.

The results from these measurements are shown on Figure 15. The airflow vectors, indicating the airflow direction, show that the airflow direction had reversed and was flowing from left to right across the face of the heading. The air velocities, which are tabled under the "F" values, show that areas existed where very little airflow occurred, but also show areas where the velocity was as high as 1,0 m/s. The airflow was not evenly distributed across the face, but was turbulent at some positions, which could explain the high measurements at certain positions. The jet fan was observed to be effective at a distance of 37 m from the last through road under these conditions.

Airflow over the driver with the scrubber operating

As determined by the protocol, the air velocity over the driver was measured at the two positions as shown in Figure 3 with the hot wire anemometer. The minimum and maximum velocities were recorded at each position and were as follows:

Position on top of drivers cab = 0,4 to 1,5 m/s

Position to the side of the drivers cab = 0,5 to 1,5 m/s

GENERAL REMARKS:

With the partial heading, difficulty was experienced with the supply of fresh air to the face area. Even with the scrubber operating, the conditions on the face were not as expected. With the sprayfan system working, the situation will improve and the airflow pattern in and out of this small area will also improve. Because of the size of the CM and scrubber, the effective ventilating area of the heading and the face area makes it difficult to position the jet fan in order to avoid the conflict between the two airstreams. Perhaps it would have been better to place the jet fan on the floor for this particular scenario. This would have enabled the air from the jet fan to flow in underneath and perhaps on the side of the CM to the face. Another alternative is to redirect or deflect the air from the scrubber outlet, which would allow the air from the jet fan to enter the face area over the CM.

The full heading results demonstrated that, when the air from the jet fan is allowed to enter the face area, the conditions on the face are much better than with the partial heading. Even though the air from the jet fan only reached up to 37 m, the combination of the jet fan and scrubber systems ensured adequate airflow conditions on the face. Up to this point none of the sprayfan systems used on the two mines, satisfied the required $0,4 \text{ m}^3/\text{s}/\text{m}^2$ of face area, but still the required $0,4 \text{ m/s}$ over the driver was exceeded. The air quantities delivered by the jet fans were of the order of the required $0,2 \text{ m}^3/\text{s}/\text{m}^2$ of face area. The last through road air velocity was according to requirements.

GOEDEHOOP COLLIERY
 FULL HEADING WITHOUT SCRUBBER

GRID F VALUES

NO.	VEL. RANGE (m/B)
1	0.2 - 0.3
2	0.3 - 0.8
3	0.3
4	0.2 - 0.8
5	0.3 - 0.6
6	0.3 - 0.6
7	0.2
8	0.5 - 1.0

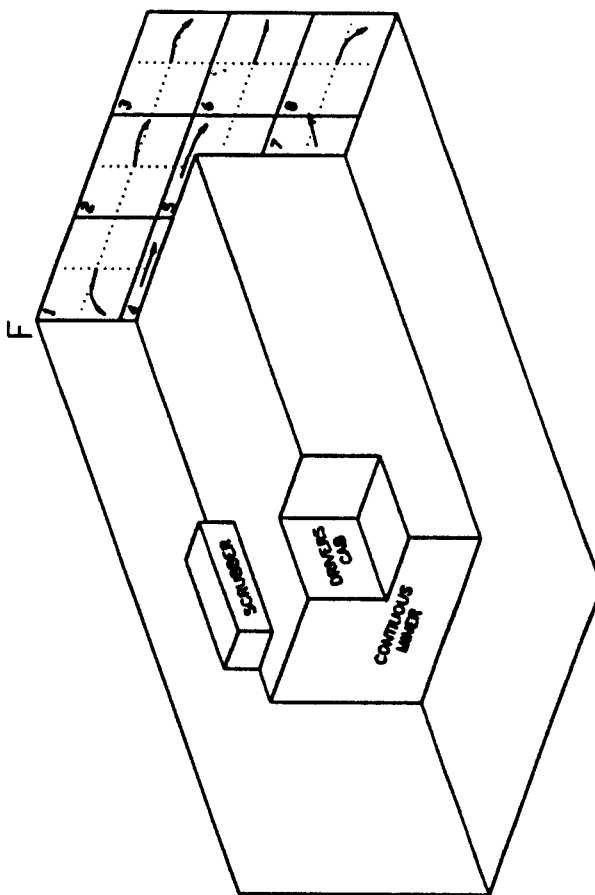


Figure 15: Face measurements in the full heading without the scrubber at Goedehoop Colliery.

5.3 BOSJESSPRUIT COLLIERY

This colliery the last of the test sites used to determine the effectiveness of jet fans. As was the situation at the other mines, the test conditions were not exactly according to the test protocol requirements, but the conditions were representative of normal production conditions. Additional tests were undertaken, in that the fan was placed both on the floor and suspended from the roof for both heading conditions. The results from both the fan positions will be discussed.

After completion of the protocol tests, additional tests were done at Bosjesspruit Colliery utilizing a 4 kW jet fan in the position normally used by Secunda mines. Tests were done with and without the entrainment nozzle and also using a 7,5 kW jet fan without the entrainment nozzle. The results from these and other tests that were performed at Bosjesspruit colliery are discussed in Appendix 3 at the end of the report.

The test conditions were as follows:

Condition 1: (Partial heading)

- Seam height = 2,7 m
- Width of partial heading = 3,45 m
- Width of the full heading = 6,6 m
- Heading depth = 35,9 m
- Last through road air velocity = 1,49 m/s
- Jet fan suspended from roof and placed on the floor
- Jet fan fitted with the entrainment nozzle
- Continuous miner used = 12HM9
- Jet fan used = 7,5 kW
- Inlet size = 550 mm
- Outlet size = 200 mm
- Fan length = 1960 mm
- Entrainment nozzle length = 1,4 m
- Inlet size = 980 mm
- Outlet size = 500 mm
- Quantity needed by the jet fan ($0,2 \text{ m}^3/\text{s}/\text{m}^2$) = $3,6 \text{ m}^3/\text{s}$
- Jet fan quantity with entrainment nozzle = $4,95 \text{ m}^3/\text{s}$
- Jet fan quantity without entrainment nozzle = $2,1 \text{ m}^3/\text{s}$
- Scrubber fan quantity = $2,9 \text{ m}^3/\text{s}$ (Needed = $7,1 \text{ m}^3/\text{s}$)
- Average air velocity out of entrainment nozzle = 25,2 m/s

Grid measurements over the machine with the scrubber operating

As before the grid was established at 5 metres from the face of the heading over the continuous miner (CM). The grid was placed past the scrubber inlet and in front of the drivers cab. Figure 16 shows the overall view of the heading with the prevailing airflow patterns at floor, middle and roof levels. The sketch also shows the relevant airway and heading dimensions and the positions of the grid, CM and jet fan. These airflow patterns are the same irrespective of whether the fan was suspended from the roof or was placed on the floor.

With the jet fan suspended from the roof and the fan placed on the floor, the airflow patterns through the grid and over the machine and against the face were the same. Figure 17 shows the grid over the continuous miner and the measurements against the face while the fan was suspended from the roof. Air velocities through the grid varied between 0,5 m/s and 1,6 m/s with all of the air flowing in a forward direction. The air velocity readings are tabled in the sketch under the "S" values. The face measurements are tabled under the "F" values. The face measurements were not very promising, as the air took the shortest route to the scrubber inlet. There was a steady flow of air from right to left across the face, but the air velocities were between 0,2 m/s and 0,5 m/s, which represents a slow movement of air.

Figure 18 shows the airflow conditions for the fan placed on the floor. The airflow direction is still forward through the grid and the airflow direction on the face is again from right to left across the face. The air velocities measured were different both through the grid and on the face. The velocities ranged between 0,3 m/s and 2,0 m/s through the grid and between 0,2 m/s and 0,7 m/s on the face. These values are again tabled under the "S" and "F" values in the sketch.

Face measurements without the scrubber operating

With the scrubber fan switched off and the jet fan in both positions, the air did not reach the face past the CM. The flow of air that was measured on the face, could be due to the movement of the personnel taking the readings or convection. Readings of between 0,2 m/s and 0,3 m/s were recorded, but under these circumstances can not be regarded as airflow. The airflow directions and air velocity readings for the two jet fan positions are given in Figures 19 and 20.

SASOL PARTIAL HEADING

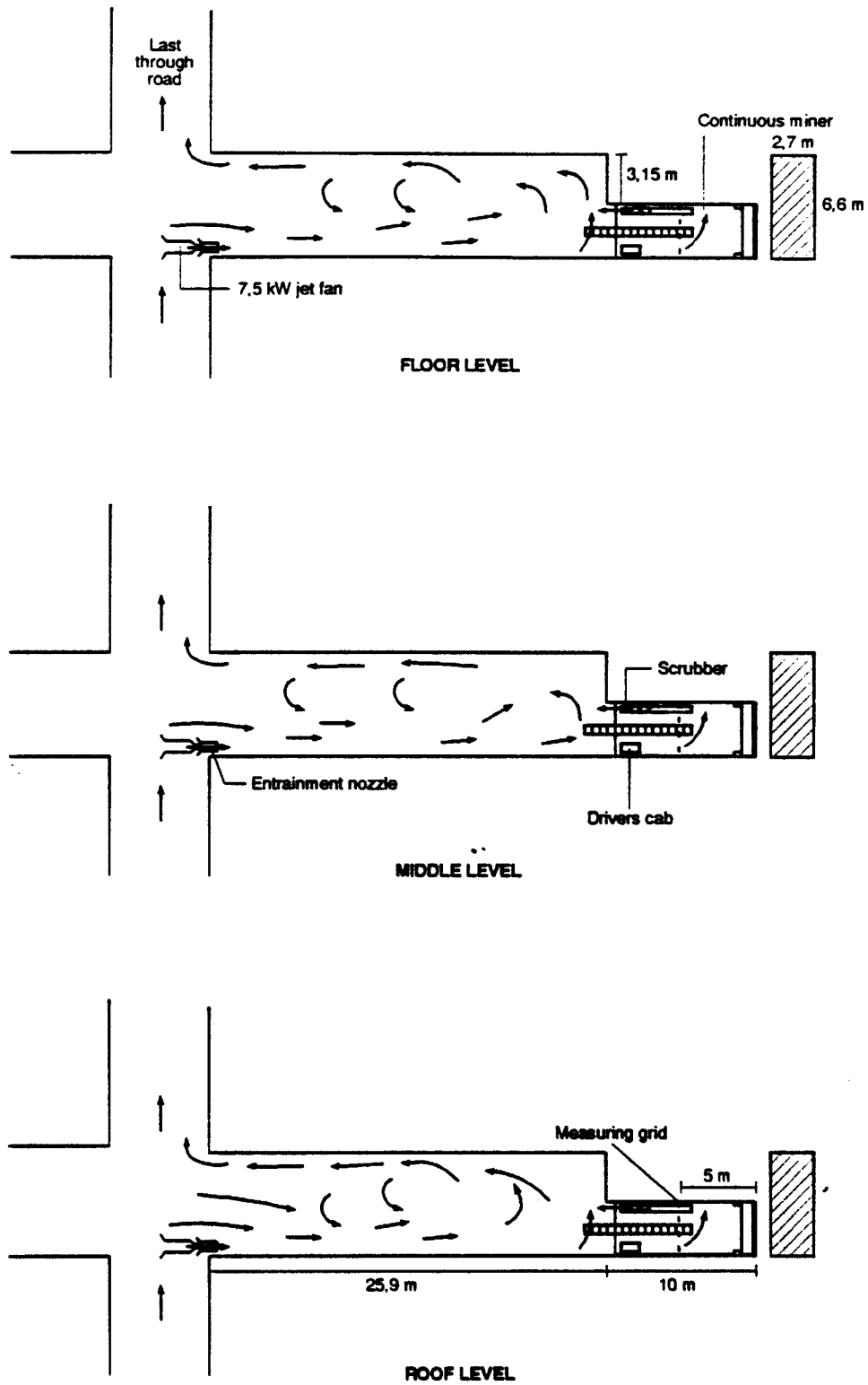


Figure 16: Overall view of the partial heading at Bosjesspruit Colliery.

**BOSJESSPRUIT COLLIERY
PARTIAL HEADING WITH SCRUBBER
FAN SUSPENDED FROM ROOF**

GRID S VALUES

NO.	VEL. RANGE (m/s)
1	0.5-1.1
2	0.5-1.0
3	0.6-1.4
4	0.8-1.2
5	0.5-1.5
6	0.5-1.6
7	0.9-1.5

GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.2-0.4
2	0.2-0.5
3	0.2-0.4
4	0.2
5	0.2-0.4
6	0.2-0.5

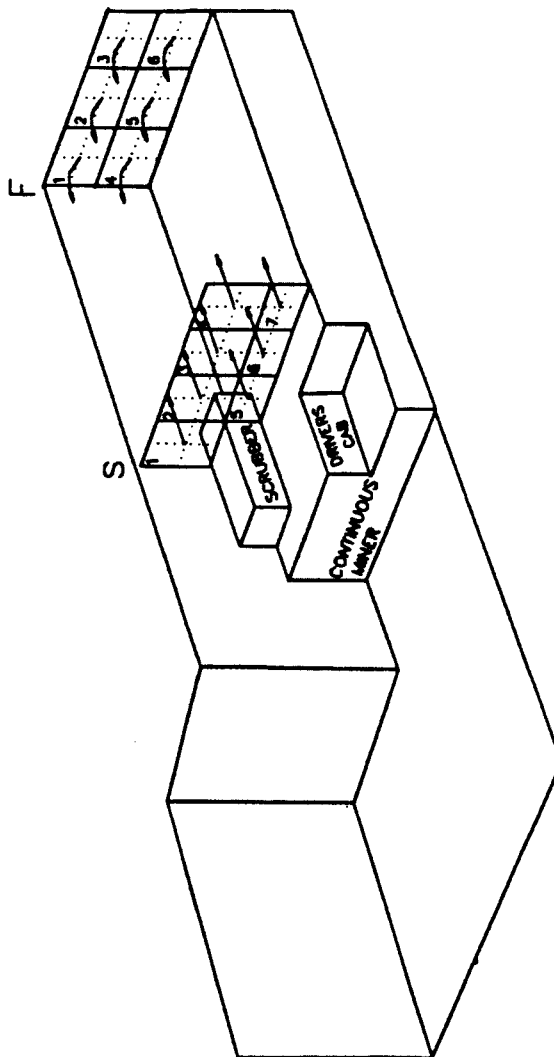
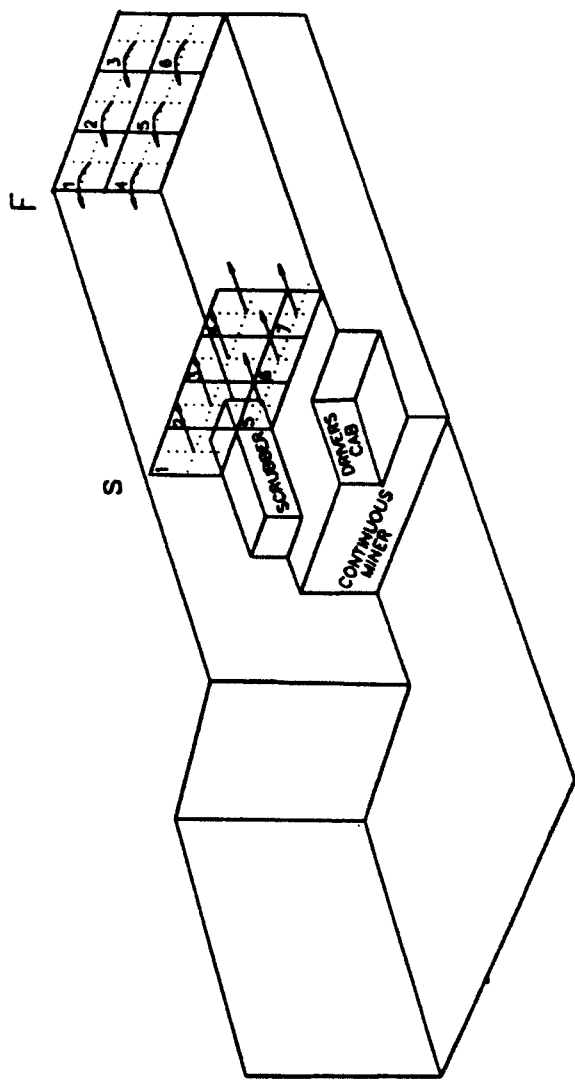


Figure 17:

Details of the grid measurements in the partial heading with the scrubber active at Bosjesspruit Colliery - fan suspended from roof.

**BOSJESSPRUIT COLLIERY
PARTIAL HEADING WITH SCRUBBER
FAN PLACED ON FLOOR**



GRID S VALUES FLOOR

NO.	VEL. RANGE (m/s)
1	0.3-0.5
2	1.0-1.5
3	1.5-2.0
4	1.5-2.0
5	0.4-1.5
6	0.5-1.4
7	0.5-1.0

GRID F VALUES FLOOR

NO.	VEL. RANGE (m/s)
1	0.2-0.4
2	0.2-0.7
3	0.2-0.7
4	0.3-0.6
5	0.3-0.5
6	0.3-0.5

Figure 18: Details of the grid measurements in the partial heading with the scrubber active at Bosjesspruit Colliery - fan placed on the floor.

**BOSJESSPRUIT COLLIERY
PARTIAL HEADING WITHOUT SCRUBBER
FAN SUSPENDED FROM ROOF**

GRID F VALUES ROOF

NO.	VEL.	RANGE (m/s)
1		0.2-0.3
2		0.2-0.3
3		0.2-0.3
4		0.2
5		0.2
6		0.2

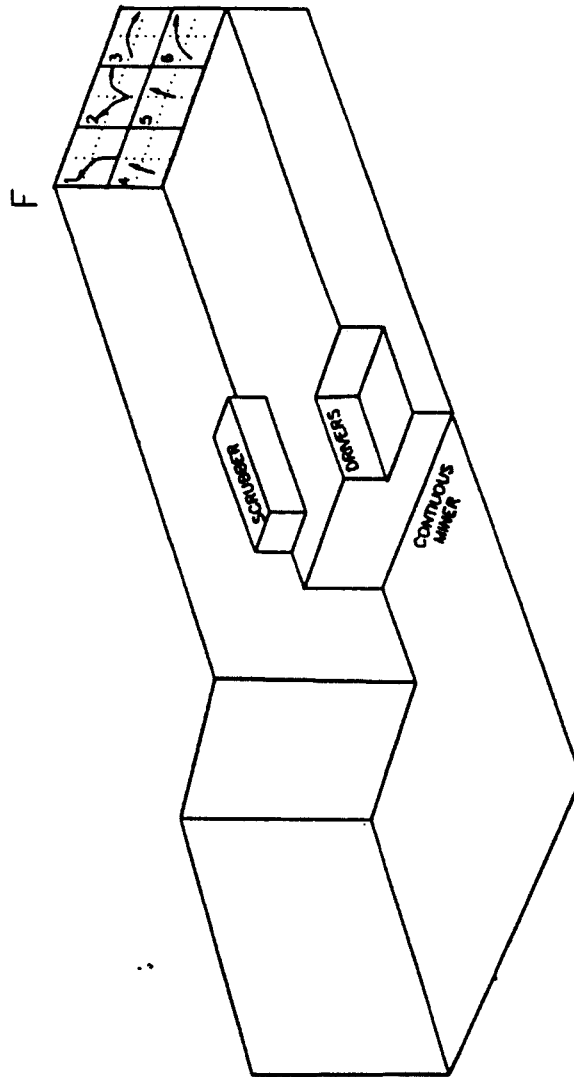


Figure 19:

Face measurements in the partial heading without the scrubber at Bosjesspruit Colliery - fan suspended from the roof.

**BOSJESSPRUIT COLLIERY
PARTIAL HEADING WITHOUT SCRUBBER
FAN PLACED ON FLOOR**

GRID F VALUES

NO.	VEL.	RANGE (m/s)
1	0.2	0.3
2	0.2	0.3
3	0.2	0.3
4	0.2	
5	0.2	
6	0.2	

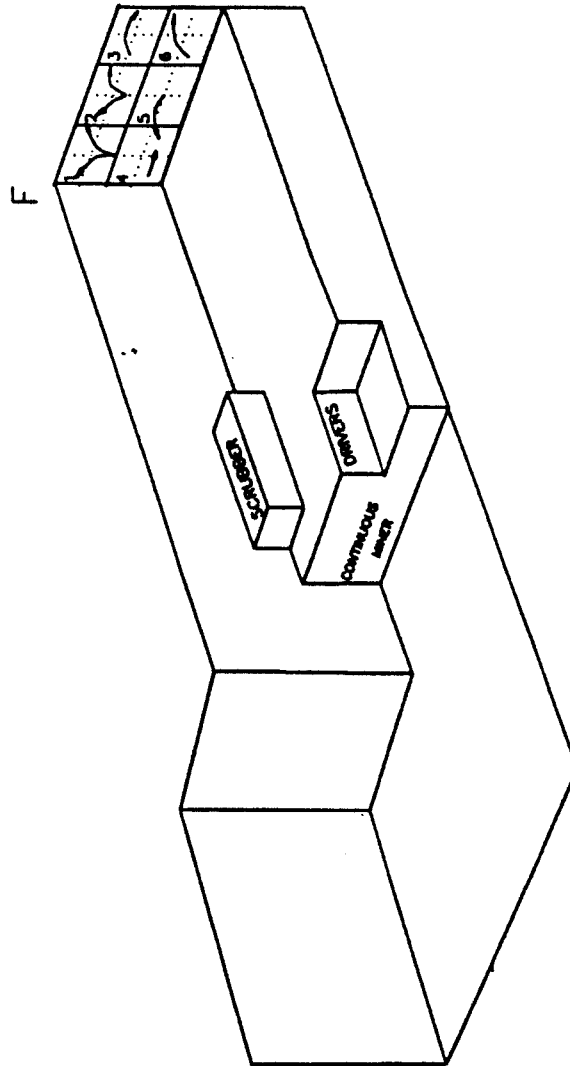


Figure 20: Face measurements in the partial heading without the scrubber at Bosjesspruit Colliery - fan placed on the floor.

Airflow over the driver with the scrubber operating

While the scrubber was operating, airflow measurements were taken over the drivers cab. Because of the fact that the CM position allowed no space to the side, the readings were taken on top of the cab and to the left of the cab position for both the fan positions.

Jet fan suspended from the roof:

Measurement on top of drivers cab = 1,0 m/s to 1,5 m/s

Measurement to the left of the cab = 0,5 to 1,4 m/s

Jet fan placed on the floor:

Measurement on top of drivers cab = 1,5 m/s to 2,2 m/s

Measurement to the left of the cab = 0,5 m/s to 1,4 m/s

In both situations the airflow was in a forward direction.

Condition 2: (Full heading)

- Seam height = 2,63 m
- Heading width = 5,8 m
- Heading depth = 34,0 m
- Jet fan fitted with entrainment nozzle
- Jet fan used = 7,5 kW
- Air quantity needed by jet fan ($0,2 \text{ m}^3/\text{s}/\text{m}^2$) = $3,05 \text{ m}^3/\text{s}$
- Total quantity through the entrainment nozzle = $4,65 \text{ m}^3/\text{s}$
- Average air velocity through entrainment nozzle = 23,7 m/s
- Scrubber quantity = $2,9 \text{ m}^3/\text{s}$ (Needed $6,1 \text{ m}^3/\text{s}$)

Grid measurements over the machine with the scrubber operating

As was the case with the partial heading, the results for both fan positions will be discussed simultaneously as the airflow patterns were exactly the same for both conditions. This scenario shows the CM placed in the left corner of the face of a full heading developed 34 m from the last through road. The grid was again positioned 5 m from the face over the continuous miner. Figure 21 gives an overall view of the airflow patterns in the heading at the floor, middle and roof levels as well as the grid position. These airflow patterns were the same for both the fan positions.

SASOL FULL HEADING

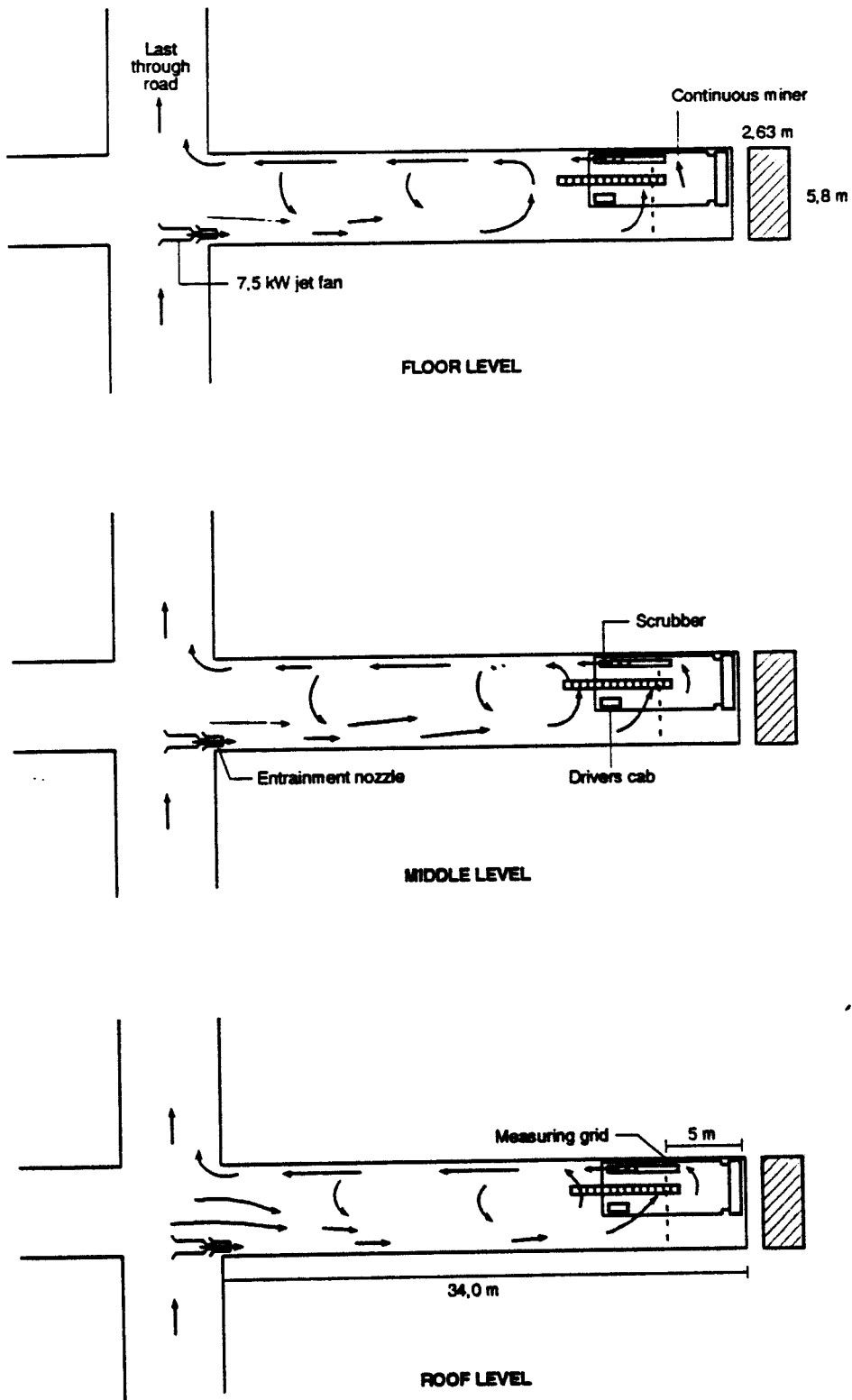


Figure 21: Overall view of the full heading at Bosjesspruit Colliery.

The results show that with the jet fan suspended from the roof, most of the air flowed in a forward direction through the grid to the intake of the scrubber. The air velocities ranged between 0,3 m/s and 2,0 m/s. The air velocities measured in each block of the grid are tabled in Figure 22 under the "S" values and the face measurements are tabled under the "F" values. Figure 22 shows the grid and the face measurements in a three-dimensional fashion. The readings on the face indicated a flow from right to left across the face at velocities ranging between 0,2 m/s and 0,9 m/s. These readings were better than with the partial heading, but still not good enough for face ventilation purposes. This situation will, however, improve when the sprayfan system is operating.

Figure 23 shows the results when the fan is placed on the floor. The airflow patterns through the grid and on the face remained the same for both fan positions. The air velocities through the grid ranged between 0,3 m/s and 3,0 m/s, which is slightly different from the previous results. The air velocities on the face ranged between 0,2 m/s and 0,6 m/s, which represents a slow flow of air across the face. All the readings can be seen in Figure 23.

Face measurements without the scrubber operating

With the scrubber fan switched off, the air from the jet fan, in the two positions, could not reach the face of the heading. The movement of the air was recorded as accurately as possible and air velocity readings taken. The velocity readings ranged between 0,2 m/s and 0,3 m/s which proves that airflow was virtually nil at the face. Figures 24 and 25 show these results for the two jet fan positions.

Airflow over the driver with the scrubber fan operating

The airflow measurements over the drivers cab were taken with the scrubber fan operating for both the fan positions. The readings were taken on top of the cab and to the right of the cab as per the test protocol.

Jet fan placed on the floor:

Measurement on top of the drivers cab = 0,6 m/s to 3,0 m/s

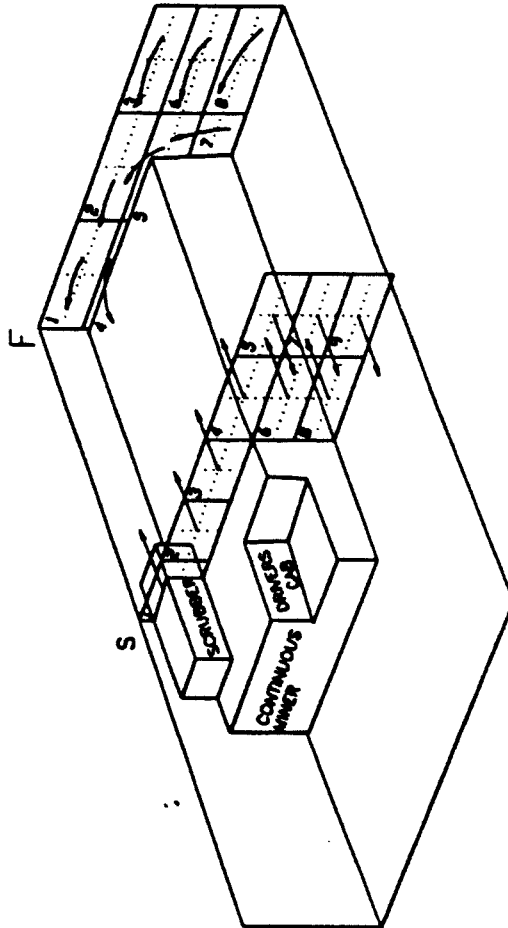
Measurement to the right of the cab = 0,6 m/s to 2,0 m/s

Jet fan suspended from the roof:

Measurement on top of the drivers cab = 0,5 m/s to 1,0 m/s

Measurement to the right of the cab = 1,0 m/s to 1,5 m/s

BOSJESSPRUIT COLLIERY
 FULL HEADING WITH SCRUBBER ACTIVE
 FAN SUSPENDED FROM ROOF



GRID F VALUES

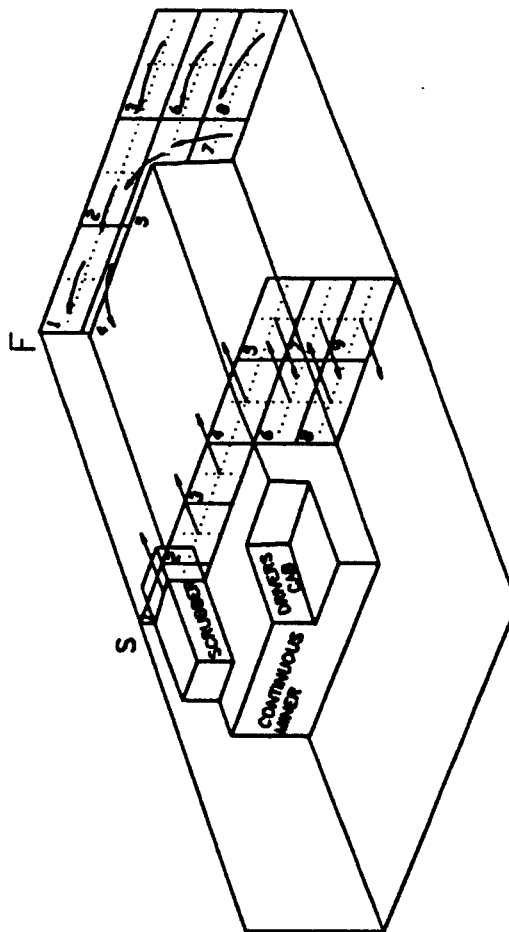
NO.	VEL. RANGE (m/s)
1	0.2-0.4
2	0.2
3	0.2
4	0.2-0.7
5	0.2-0.6
6	0.2-0.6
7	0.4-0.9
8	0.2-0.4

GRID S VALUES

NO.	VEL. RANGE (m/s)
1	0.3-0.6
2	1.0-2.0
3	0.5-1.5
4	0.5-2.0
5	0.5-1.5
6	0.6-1.0
7	0.5-1.0
8	0.3-1.5
9	0.5-1.0

Figure 22: Details of grid measurements in the full heading with the scrubber active at Bosjesspruit Colliery - fan suspended from roof.

**BOSJESSPRUIT COLLIERY
FULL HEADING WITH SCRUBBER ACTIVE
FAN PLACED ON FLOOR**



GRID F VALUES

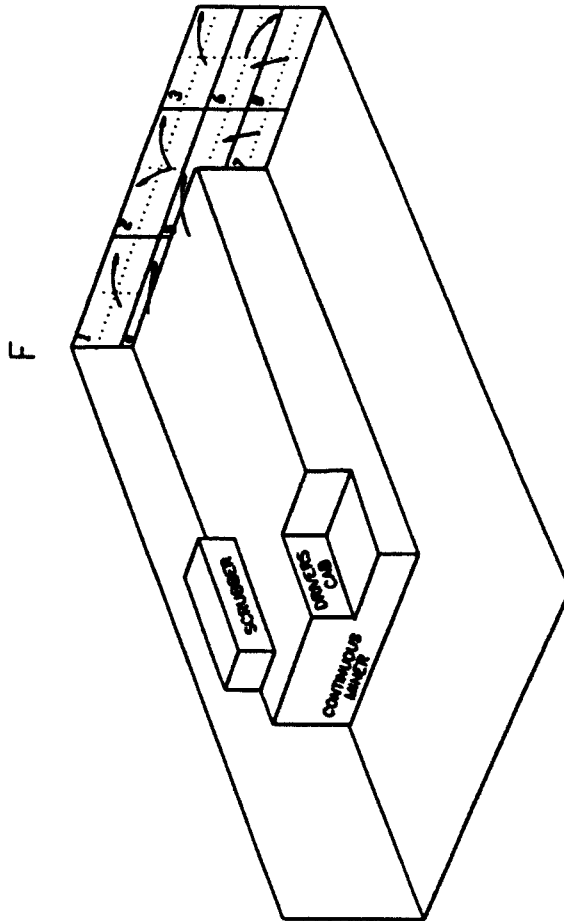
NO.	VEL. RANGE (m/s)
1	0.2-0.4
2	0.2-0.5
3	0.2-0.5
4	0.2-0.4
5	0.2-0.4
6	0.2-0.6
7	0.2
8	0.2-0.4

GRID S VALUES

NO.	VEL. RANGE (m/s)
1	0.5-1.0
2	0.5-2.0
3	1.0-3.0
4	0.5-2.0
5	0.5-1.0
6	0.4-1.5
7	0.3-0.6
8	0.4-1.0
9	0.4-1.2

Figure 23: Details of the grid measurements in the full heading with the scrubber active at Bosjesspruit Colliery - fan placed on the floor.

BOSJESSPRUIT COLLIERY
FULL HEADING WITHOUT SCRUBBER
FAN SUSPENDED FROM ROOF

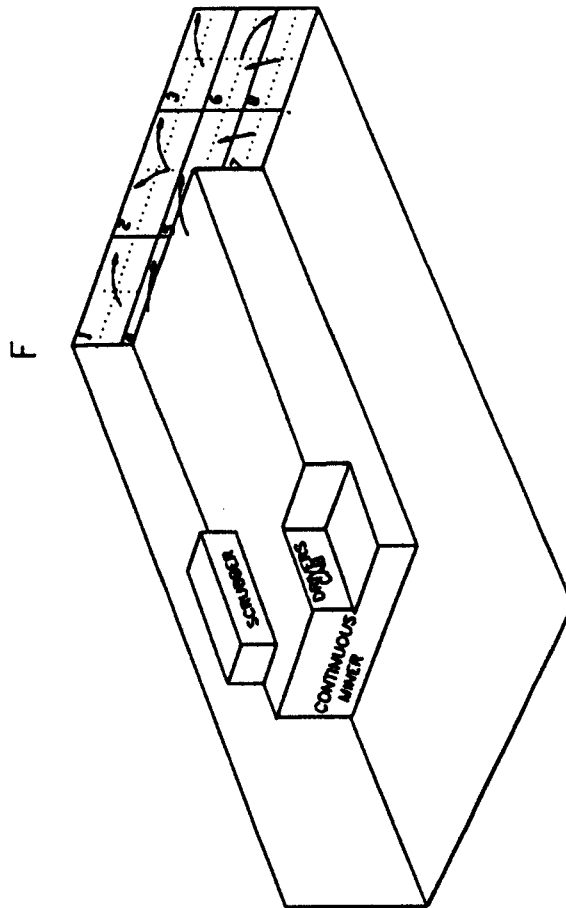


GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.2
2	0.2
3	0.2
4	0.2
5	0.2
6	0.2
7	0.2
8	0.3

Figure 24: Face measurements in the full heading without the scrubber at Bosjesspruit Colliery - fan suspended from roof.

BOSJESSPRUIT COLLIERY
FULL HEADING WITHOUT SCRUBBER
FAN PLACED ON FLOOR



GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.2
2	0.2
3	0.2
4	0.2
5	0.2
6	0.3
7	0.2
8	0.2

Figure 25: Face measurements in the full heading without the scrubber at Bosjesspruit Colliery - fan placed on the floor.

GENERAL REMARKS

With this low seam height, the position of the jet fan is not really important as the flow patterns and the results do not differ when the fan is located at either roof or floor. It seems that the effective use of jet fans will be dictated by the seam heights, as the results show that the effective distance reached by the air from the jet fan is less than with the higher seams. The reason for this will have to be determined during further investigations into the use of jet fans. The results from these last tests showed that the air from the jet fan reached the CM, after which the scrubber fan took over and the air was drawn into the heading to the scrubber inlet. Because of the fact that no additional air flowed towards the face area, the airflow on the face of the heading was very slow and unacceptable. This means that additional systems, such as a sprayfan system, are needed in the face area to effectively ventilate the face. Another reason for the poor airflow performance in the face area, is the fact that the scrubber fan was only handling $2,9 \text{ m}^3/\text{s}$, which is way below the required $6 \text{ m}^3/\text{s}$. With a higher scrubber fan quantity, the conditions inside the face area might have been better.

In Appendix 3, the additional tests, undertaken on behalf of Bosjesspruit Colliery on the use of jet fans, are discussed. Smaller fans were used with and without the entrainment nozzle and the airflow conditions were recorded in the same way as during the official tests.

6 OBSERVATIONS AND RECOMMENDATIONS

The purpose of this project was to determine whether jet fans should be used to ventilate continuous miner headings in such a manner that it would satisfy the guidelines.

The following observations were made:

- The results indicated that the seam height may well influence the air penetration capabilities of the fans, regardless of the fan positions and the fan volumes. This may well be a function of quantity and/or air velocity vs seam height.
- The entrainment nozzle that was used, although necessary for entrainment measurement, seems to be impractical and it can also be very dangerous, because of the size and weight of the nozzle.
- The determination of the total amount of air entrainment into the heading was a problem.
- It is important that the jet fan should be placed in such a position that the air column from the jet fan and the scrubber fan are not opposing each other.
- Future research should be conducted into the air requirements for lower seam heights. During the additional tests that were conducted (Appendix 3), it was observed that fans with quantities lower than the required $0,2 \text{ m}^3/\text{s}/\text{m}^2$ of face area, achieved better results than the fans with larger quantities.
- Methods of determining the total amount of air flowing into the heading must be developed to be able to optimize the quantities delivered by the two systems in use in the heading.

- The results have shown that, when the jet fan and scrubber fan quantities are close together, the flow pattern and the conditions on the face were better than when the jet fan was delivering much more air than the scrubber.
- While the scrubber and jet fan system was operational, airflow was measured at a distance of 35 m from the last through road.
- In all cases the airflow over the driver position was measured to be more than 0,4 m/s.
- The jet fans were able to deliver the required $0,2 \text{ m}^3/\text{s}/\text{m}^2$ of face area.
- The 50 % air recirculation figure was not exceeded.
- The tests showed that jet fans can be placed on the floor, provided that the inlet of the fan is placed at least 1,0 m into the last through road on the upstream side of the heading, to prevent air recirculation.

At this stage, because the requirements as depicted in the guidelines, which ensures the safety of underground personnel, have been met, it is recommended that the continued use of jet fans to ventilate continuous miner headings be allowed.

In granting this approval, the following operational procedures need to be considered:

- the jet fan should be placed in such a position where it does not recirculate
- the jet fan must be placed in the upstream position of the heading
- the outlet of the jet fan and the outlet of the scrubber fan must not be directly in line with each other
- the fan is only to be used in conjunction with the scrubber system and a waterspray or sprayfan system. No cutting should be allowed when the scrubber and waterspray/sprayfan systems are not operational

7 FUTURE RESEARCH WORK PROPOSED

The results from these investigations, and the general observations that were made during the tests, have served to identify areas, regarding the effective uses of jet fans, that urgently need to be investigated further. These areas include the following:

- At what distance of development to start the jet fan
- The effect of different seam heights on the air penetration distances vs different jet fan positions.
- The development of an effective method for the measuring of fresh air entrainment and the effect of different air velocities and quantities on fresh air entrainment.
- The effect of different last through road air velocities on the fresh air entrainment and air recirculation patterns around the jet fan.
- The effect of the jet fan on dust and methane concentrations.
- Investigation of the effect, of delivering lower air quantities into the heading, on airflow patterns, air penetration, air velocities around the driver and the effect on dust and methane readings. This includes lower scrubber quantities as well. ($0,2 \text{ m}^3 / \text{s/m}^2$ and $0,4 \text{ m}^3 / \text{s/m}^2$)
- Look at redesigning the outlet of the jet fan for better aerodynamics.
- The ventilation of split development
- The design of fans and the effective testing of new and used fans

Only after these areas have been investigated and the answers evaluated, can proper guidelines be supplied to the industry regarding the use of jet fans.

8 ACKNOWLEDGEMENTS

The working group on jet fans wishes to thank everybody, mining personnel, environmental and others, that were involved in making this project a success, with special thanks to the following people:

George Dyman (Gloria)
 Martin Fourie (Gloria)
 Robin Berry (Goedehoop)
 Hennie Bester (Goedehoop)
 Andre Neethling (Bosjesspruit)
 Willie Matthysen (Bosjesspruit)
 Johan Diedericks (Secunda Mines)

9 COMMENTS BY MODERATOR

The programme of test work, as agreed by the Working Group on jet fans, is a preliminary investigation of the problem carried out in a very short time.

The tests were successfully conducted at three specified mines and under conditions as close to the test protocol as practical conditions allowed.

The test results have been presented in this report and the recommendations, although based on very little data, are compatible with the observations. Provided the safeguards indicated in the recommendations are met, it appears that the criteria laid down by the Working Group have been or can be met by jet fans.

Finally, we have now obtained actual data on airflow, air velocities and directions of airflow when using jet fans under typical operational conditions. It is recommended that in any discussion of jet fans versus ducting and fans, similar data should be obtained for ducted systems under typical conditions i.e. with torn ducts, poor joints, etc.

Huw R Philips

24 September 1994

(The original signed fax from Prof. Philips is attached at the end of this report)

Huw R Philips
Professor of Mining Engineering
University of the Witwatersrand

APPENDIX 1

Republiek
van
Suid Afrika



Republic
of
South Africa

DEPARTEMENT VAN MINERAAL- EN ENERGIESAKE
DEPARTMENT OF MINERAL AND ENERGY AFFAIRS

MYNOMGEWINGSBEHEER
MYNOPMETING, EKSAMENS

MINE ENVIRONMENTAL CONTROL
MINE SURVEYING, EXAMINATIONS

The Chairman
SIMCOAL
Amcoal
55 Marshall Street
JOHANNESBURG
2000

PRIVAATSAK X7
PRIVATE BAG X7

BRAAMFONTEIN

2017

Tel. No. 339-4414

Fax No. 339-4671

Navrac
Enquiries

Uitbreiding
Extention

Datum
Date 1994.07.29

*In u antwoord meld asseblief verwysingno.
In your reply please quote reference No.*

GME 16/2/17

ATTENTION: MR H C VAN ZY

Dear Sir

SIMRAC RESEARCH - AIRJET FANS

Due to the doubt presently being expressed both locally and internationally, on the effectiveness of airjet fans beir used to ventilate coal winning workings, especially where continuous miners and road headers are used, addition research work must be undertaken to validate these systems.

This work should be conducted underground, in working sections, to ascertain operational conditions. It shoul also be done in parallel with the CFD work currently in progress.

The following is recommended:

1. TITLE OF PROJECT:

The ventilating effectiveness of airjet fans in workings being mined with mechanical miners.

2. PRIMARY OUTPUT:

- 2.1 Airjet fan design and operational characteristics.
- 2.2 Application of airjet fans in ventilation systems for headings.
- 2.3 Methods to contain methane and dust concentrations to acceptable statutory limits.

3. ENVISAGED SCOPE OF RESEARCH PROJECT:

- 3.1 Fan Dimensions.

- 3.2 Fan operating characteristics.
- 3.3 Tables showing maximum penetration distances for effective ventilation at various seam heights and widths, and at varying fan discharge air velocities. The quantity of air, ex the airjet fan, which actually reaches the working face position must also be ascertained.
- 3.4 Determine optimum positioning of the fan to:
 - 3.4.1 Minimise interference and damage of the appliance e.g. by shuttle cars etc.
 - 3.4.2 Encourage air entrainment from the last through road.
 - 3.4.3 Prevent air recirculation back into the inlet of the fan.
 - 3.4.4 Operate in conjunction with the on board dust scrubbers.
 - 3.4.5 Obviate the effect of interposing objects on the effectiveness of airjet ventilation.
- 3.5 The optimum last through road velocity, at various seam heights.
- 3.6 The system must be so designed so as to contain working environmental conditions within the statutory limits for both methane and dust.
 - 3.6.1 Dust must be effectively controlled, where generated, and not be permitted to escape from the heading uncontrolled and untreated.
 - 3.6.2 Flammable gas must be diluted by the provision of sufficient fresh air.
- 4. **THE ABOVE WORK MUST BE CONDUCTED WITH THE FOLLOWING PARAMETERS IN PLACE:**
 - 4.1 Outlet air volume supplied by the airjet fan to equal $0,2 \text{ m}^3/\text{s}/\text{m}^2$ of face area.
 - 4.2 The minimum discharge air quantity of the scrubber unit, fitted to the mechanical miner to equal $0,4 \text{ m}^3/\text{s}/\text{m}^2$ of face area.

Yours faithfully



J B RAATH
GOVERNMENT MINING ENGINEER

APPENDIX 2

an **AMCOAL** company

Amcoals Colliery and Industrial Operations Limited

Incorporated in the Republic of South Africa
Reg. No. 01/06730/06

44 Main Street Johannesburg 2001
PO Box 61587 Marshalltown 2107
Telex 4-87167 SA
Telegraph Anmercosa
Telephone 638-9111

In reply please quote

HCvZ102/BH

02 August 1994

Department of Mineral and Energy Affairs
private Bag X7
BRAAMFONTEIN
2017

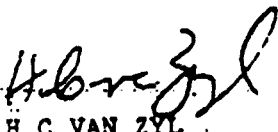
ATTENTION: MR J B RAATH - GOVERNMENT MINING ENGINEER

SIMRAC RESEARCH - AIRJET FANS

I refer to your letter ref GME16/2/1/20 dated 1994.07.29.

This proposal has been submitted and approved by SIMCOL and work has already started to give effect to the requirements of this project.

Yours faithfully,



H C VAN ZYL
SENIOR DIVISIONAL MINING ENGINEER

Directors: D Rankin (Chairman) J P Bloemsa I W Boyd (British) E F Carr H N Dreyer
R A Laybourne (British) J S Leslie (British) A E Redman (British) H R Reid
D J Ritson H B Stacey C Sutherland K J Trueman (British) R R L G Whittaker
R S Wicks (British) D B Wiggill

AMCOAL

APPENDIX 3

ADDITIONAL TESTS PERFORMED AT SECUNDA COLLIERIES

The tests involved the use of two different size jet fans in a partial heading with the continuous miner placed in the partially developed heading.

The test conditions were the following:

- Depth of partial heading = 39,8 m
- Width of partial heading = 3,45 m
- Continuous miner used = 12HM9
- Jet fans used = 7,5 kW and 4 kW
- Tests done without and with the entrainment nozzle
- Seam height = 2,7 m
- Quantity needed by jet fans ($0,2 \text{ m}^3/\text{s}/\text{m}^2$) = $3,6 \text{ m}^3/\text{s}$
- Quantity delivered by 4 kW jet fan without nozzle = $1,9 \text{ m}^3/\text{s}$
Average air velocity through the fan = 38,81 m/s
- Quantity delivered by 4 kW jet fan with nozzle = $4,4 \text{ m}^3/\text{s}$
Average air velocity delivered by the nozzle = 22,7 m/s
- Quantity delivered by 7,5 kW jet fan with nozzle = $4,95 \text{ m}^3/\text{s}$
Average air velocity out of nozzle = 25,2 m/s
- Quantity delivered by 7,5 kW jet fan without nozzle = $2,1 \text{ m}^3/\text{s}$
Average air velocity = 60,2 m/s
- Scrubber fan quantity = $2,9 \text{ m}^3/\text{s}$ (Needed = $7,13 \text{ m}^3/\text{s}$)
- Both jet fans placed 1,0 m into the last through road

TEST RESULTS**7,5 kW JET FAN PLACED ON THE FLOOR**

The tests with the entrainment nozzle have been discussed in the main report. This additional test without the nozzle was done to determine whether the entrainment nozzle had a negative or positive influence on the results.

Only the effective reach of the air was determined as a check to see whether the higher air velocity and lower volume would increase the air penetration distance while the scrubber was operating and not operating. Figure 26 shows the three-dimensional view of the partial heading with the measuring positions on the face with the scrubber running. The results show the air flowing from right to left across the face to the intake of the scrubber. The air velocities ranged between 0,2 m/s and 0,6 m/s on the face and are tabulated in the sketch. The results show that there are minor differences in the airflow conditions in the face area with the fan operating without the entrainment nozzle.

BOSJESSPRUIT COLLIERY
 PARTIAL HEADING WITHOUT SCRUBBER
 FAN PLACED ON FLOOR
 7.5 kW JET FAN WITHOUT
 ENTRAINMENT NOZZLE

GRID F VALUES FLOOR

NO.	VEL. RANGE (m/s)
1	0.3-0.5
2	0.2-0.5
3	0.2-0.3
4	0.3-0.5
5	0.2-0.6
6	0.2-0.4

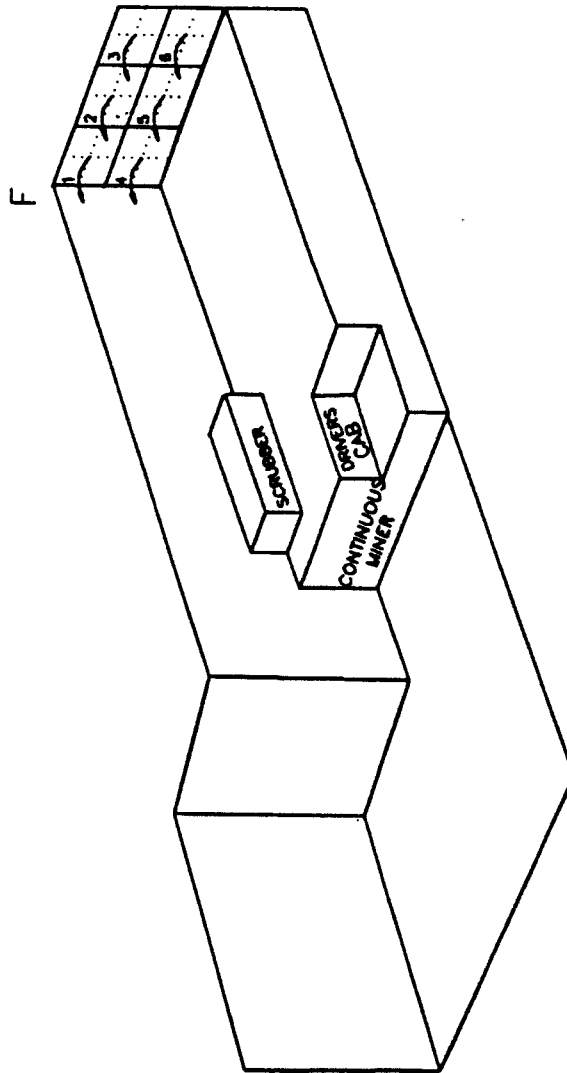


Figure 26: Face measurements in the partial heading using the 7,5 kW jet fan without the entrainment nozzle.

When the scrubber fan was switched off, no airflow could be detected on the face and therefore the results were not recorded. The total reach of the air from the jet fan was again to the back of the CM, which is approximately 30 m.

Airflow over the drivers cab with the scrubber operating

One air velocity was taken above the drivers cab to compare with the previous test results where the jet fan was used with the entrainment nozzle.

Measurement on top of drivers cab = 0,8 m/s to 2,0 m/s

4 kW JET FAN PLACED ON THE FLOOR WITHOUT THE ENTRAINMENT NOZZLE

The fan was placed 1,0 m into the last through road and was directed towards the face of the heading at an angle to blow the air in over the CM. The air velocity out of the fan was measured at 38,81 m/s and the quantity at 1,91 m³/s which is far below the required 3,6 m³/s. To enable comparison with the official test results in the main body of the report, the grid was measured over the machine and the measurements were taken at the face with the scrubber working and not working.

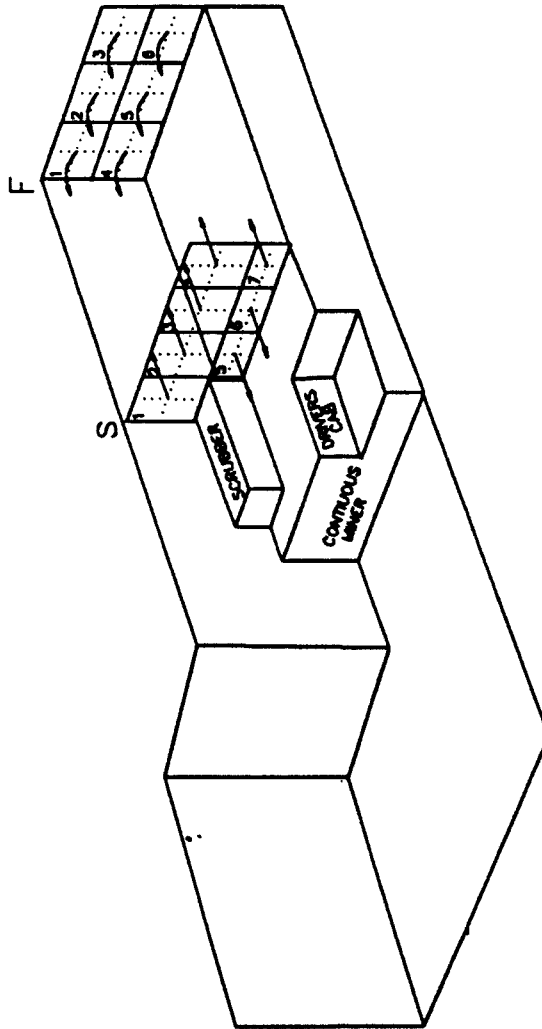
Grid measurements over the CM with the scrubber operating

Figure 27 shows the three-dimensional view of the grid over the machine and the measurement positions on the face. The blocks are again numbered and so are the positions on the face. The results are tabulated in the sketch and the airflow directions are shown in the sketch by means of vectors.

The vectors show that the general flow of air through the grid was forward but in some areas the flow of air was backwards, which means that more air than the required 2,9 m³/s for the scrubber was flowing into the face area from the fan. This was better than was found with the previous fan that was used. The air velocities ranged between 0,2 m/s and 2,6 m/s, which is much higher than was measured with the larger fans. The face measurements show that the air was still flowing from right to left across the face of the heading and that the air velocities ranged between 0,2 m/s and 0,8 m/s. Although the results do not indicate a significant increase in the airflow conditions on the face, observations underground gave the impression that the conditions were somewhat better than before.

When the scrubber fan was switched off to determine the effective ventilating distance of the jet fan, the results again showed, however, that the air only reached the 30 m mark at the back of the CM and therefore these readings were not recorded.

BOSJESSPRUIT COLLIERY
 PARTIAL HEADING WITH SCRUBBER
 FAN PLACED ON FLOOR
 4 kW JET FAN WITHOUT
 ENTRAINMENT NOZZLE



GRID S VALUES

NO.	VEL. RANGE (m/s)
1	0.3-0.8
2	0.3-1.0
3	0.8-1.5
4	1.0-2.6
5	0.2-1.0
6	0.3-0.7
7	0.3-1.2

GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.2-0.3
2	0.2-0.8
3	0.2-0.7
4	0.3-0.6
5	0.3-0.8
6	0.2-0.7

Figure 27: Details of the grid measurements in the partial heading using the 4 kW jet fan without the entrainment nozzle.

Airflow over the drivers cab with the scrubber operating

Again only one position was measured on top of the drivers cab to compare with previous results.

Measurement on top of the drivers cab = 1,0 m/s to 2,0 m/s

These results show that even with a small fan with a low quantity, the required airflow conditions can still be achieved in the face area and over the driver.

4 kW JET FAN PLACED ON THE FLOOR WITH THE ENTRAINMENT NOZZLE

The same exercise was repeated but with the same entrainment nozzle fitted as was used in the other tests. The grid was again measured over the CM and the face measurements were conducted with and without the scrubber. The air velocity delivered by the nozzle was now measured as 22,7 m/s and the air quantity as 4,4 m³/s, which was more than the required 3,6 m³/s.

Grid measurements over the machine with the scrubber operating

The grid was established 5 m from the face of the heading and the measurements taken in each block of the grid. Figure 28 shows the grid, the face measurements and the resulting air velocities under the "F" and "S" values. The airflow vectors show that the general flow of air was into the face area through the grid and that only a small amount of air flowed back through the grid. The air velocities ranged between 0,3 m/s and 2,2 m/s which is almost the same as the results without the entrainment nozzle. The face measurements indicated the flow from right to left across the face, as before, with the air velocities ranging between 0,2 m/s and 0,7 m/s.

When the scrubber fan was switched off the airflow again did not reach the face and the effective distance was again 30 m from the fan outlet.

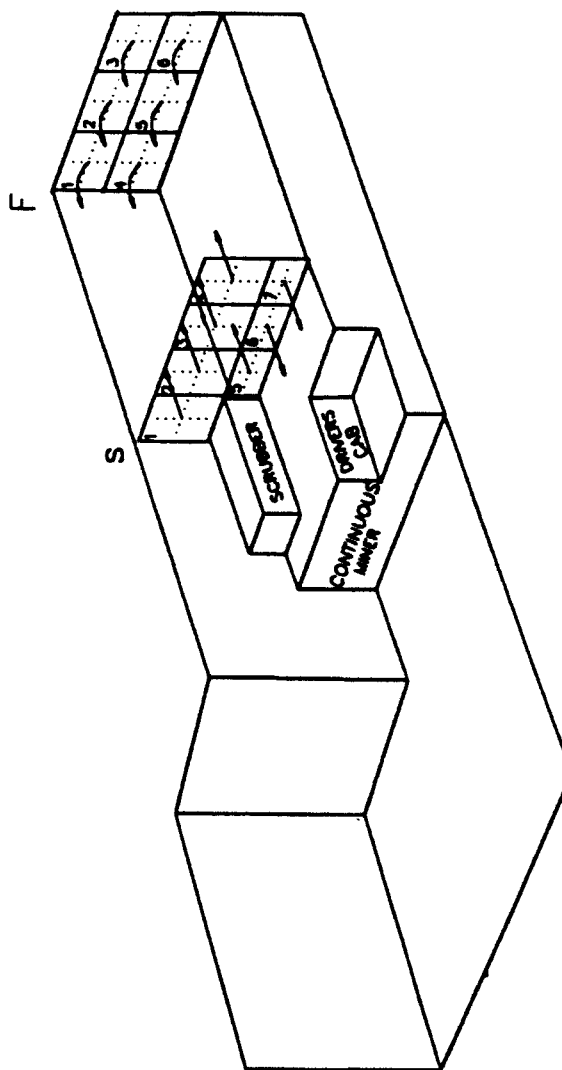
It seems that in future the seam height will dictate the jet fan that should be used in relation to air velocity/quantity and penetration distance.

Airflow over the drivers cab with the scrubber operating

The result of the measurement on top of the drivers cab was = 1,0 m/s to 2,2 m/s

Altering the position of the fan on the floor, to determine the point where recirculation occurs, showed that when the heading is developed smoothly and the corners in the last through road are very close to being 90°, the fan inlet can be placed flush with the last through road without recirculating. However, when the corners are cut to allow the movement of large machinery, the jet fan inlet must be placed at least 1,0 m into the last through road.

BOSJESSPRUIT COLLIERY
 PARTIAL HEADING WITH SCRUBBER
 FAN PLACED ON FLOOR
 4 kW JET FAN WITH
 ENTRAINMENT NOZZLE



GRID S VALUES

NO.	VEL. RANGE (m/s)
1	0.4-1.0
2	0.5-1.5
3	1.0-2.0
4	1.5-2.2
5	0.3-1.8
6	0.3-0.9
7	0.3-1.2

GRID F VALUES

NO.	VEL. RANGE (m/s)
1	0.3-0.5
2	0.3-0.6
3	0.2-0.6
4	0.3-0.7
5	0.3-0.6
6	0.2-0.6

Figure 28: Details of the grid measurements in the partial heading using the 4 kW jet fan with the entrainment nozzle.

9) COMMENT BY MODERATOR.

The programme of test work, as agreed by the Working Group: Air Jet Fans, is a preliminary investigation of the problem carried out in a very short time.

The tests were successfully conducted at the three specified mines and under conditions as close to the test Protocol as practical conditions allowed.

The test results have been presented in this report and the recommendations, although based on very little data, are compatible with the observations. Provided the safeguards indicated in the recommendations

are met, it appears that the criteria laid down by the Working Group have been or can be met by Jet Fans.

Finally, we have now obtained actual data on airflow, air velocities and directions of airflow when using Jet Fans under typical operational conditions. It is recommended that in any discussion of Jet Fans versus Ducting and Fans, similar data should be obtained for ducted systems under typical conditions i.e. with torn ducts, poor joints, etc.

How R Phillips

24 Sept - 1994.

HOW R PHILLIPS

PROFESSOR OF MINING ENGINEERING
UNIVERSITY OF THE WITWATERSRAND