EUROPEAN COAL AND STEEL COMMUNITY

Community Ergonomic Research

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Technical Report n° 6

UNDERGROUND WORK IN DIFFICULT CLIMATIC CONDITIONS

(EMMA/HENDRIK mine)

Source : Ergonomic team of the Netherlands coal mining industry
Project n° 4

Authors : L. RUWETTE, J.A. KOENE

Reference period : 1.1.1968 - 31.12.1969

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Financial assistance was provided for this study by the European Coal and Steel Community

Introduction

Climatic conditions at various working points of the Emma/Hendrik mine were of such a nature that the relevant provisions and directives had to be applied. It was only to be expected that this situation would not change in the years that followed.

The application of special measures runs up against economic objections. It was therefore humanitarian considerations in the main that led to the decision to carry out a study into the possibility of dealing with the problem of work performed under difficult climatic conditions. All who took part in the study realized that the scope for improvement would be limited owing to the difficulties the coal-mining industry is having to face. Really effective solutions, which would entail considerable investments, could not therefore be entertained.

A search is instead being made for some simple means of easing the individual worker's discomfort during work performed under difficult climatic conditions.

A further consideration was that no evidence could be found of any adverse influence, from the point of view either of the individual worker or of performance, stemming from climatic conditions underground, so that this aspect could not serve as the basis for this study.

The basis for the study was provided by the data compiled by the Ventilation Department of the Emma/Hendrik mine from which tables were prepared showing movements of temperature at critical working points over a fairly long period. Visits to these points and conversations with personnel put to work there, coupled with systematic observation, led to the introduction of a number of modest practical improvements.

CHAPTER I

Climatic conditions underground

Section 1 : General

Climatic conditions underground are characterized in the main by three variables : air temperature, atmospheric humidity and air velocity. These variables govern differences in temperature and vapour pressure, which in turn largely determine the heat transferred by humans to the surrounding air.

Air temperature and atmospheric humidity depend mainly on the heat of the rocks and on the water released by them.

These sources of heat and humidity apart, climatic conditions underground can be influenced by :

- the heat of sorption evolved when air, water vapour and mine gas come into contact with hewn coal;
- the heat and moisture given off by underground workers;
- the transformation of electrical energy into heat;
- the heat and moisture released by hewn coal.

So far as the Netherlands is concerned, the effects of sorption and the heat and moisture given off by underground workers may be neglected as factors influencing climatic conditions.

In order to create an acceptable "climate" for underground workers, an airflow is produced by drawing in air through the downcast shaft and expelling it by fan through the upcast shaft. The two shafts are linked by the underground workings. To ensure that all workings are provided with an adequate quantity of fresh air, the incoming air is split up into a main flow and a number of secondary flows. Air distribution is regulated by means of air doors that force flow in a given direction.

The main purpose of the airflow is to provide the fresh air needed for human respiration. In addition, it thins down and bears away noxious and dangerous gases. Finally, it serves to ensure an acceptable "climate" for workers living and working underground. As already mentioned, climatic conditions depend on the interaction of air temperature, atmospheric humidity and air velocity.

Section 2 : Standards

The Mine Regulations lay down certain standards regarding ventilation.

Under these standards :

ventilation must be such as to supply underground workings at least 3 m^3 fresh air per man per minute.

In the process :

the quantity of fresh air supplied to every single part of the underground workings must be at least 2 m^3 per man per minute.

Air velocity must not exceed 6 m/sec at the face or 8 m/sec in the main and secondary airways serving haulage and transport.

The standards relating to climatic conditions are expressed in terms of a variable known as "effective temperature". This is obtained from simultaneous readings at the same point of wet- and dry-bulb temperatures and air velocity.

Annex 1 shows a nomogram for calculating effective temperatures in ° C.

The Mine Regulations ban persons who work entirely or mainly on a site where the effective temperature is 28° C or higher from staying underground continuously longer than 6 hours.

Workers under 21 years of age may not be put to work on underground sites where the effective temperature is 28° C or higher.

Except in emergencies or where danger threatens, no one is allowed on an underground site where the effective temperature is 32° C or higher.

As regards temperature measurement, these standards lay down that an adequate number of suitable measuring points must be arranged both in the main and in the secondary airways.

Wet- and dry-bulb temperatures and air velocity must be measured at these points at least every 14 days in order to determine effective temperature. So long as this stands at 27° C or higher, readings must be taken daily.

In addition to this summary of the standards and provisions taken from the Mine Regulations, we set out below for the sake of completeness the internal directives of the Emma/Hendrik mine relating to payment of heat allowance and, where appropriate, a corresponding reduction in working time.

Internal directives on the payment of heat allowance and, where appropriate, a corresponding reduction in working time :

Heat allowance	Extra payment	Reduction of length of stay underground
1. Effective temperature up to 24° C	none	none
2. Effective temperature from 24° C to 26° C and relative humidity below 95 %	none	none
3. Effective temperature from 24° C to 26° C and relative humidity of 95 % or higher	5 %	none
4. Effective temperature from 26° to 27° C	5 %	none
5. Effective temperature from 27° to 28° C	10 %	none
6. Effective temperature from 28° C upwards	5 %	max. 6 hours

Section 3 : Monitoring climatic range

The provision of adequate fresh air supplies in underground workings is the job of the Ventilation Department. It follows that this department exercises a major influence on climatic conditions underground.

One of its duties is to carry out the measurements needed to comply with the provisions and directives on ventilation and climatic conditions. These measurements cover temperature, relative humidity and air velocity.

Temperature is measured with an Assmann psychrometer, which gives readings of wet- and dry-bulb temperatures. These readings are reduced by formula to relative humidity expressed as a percentage.

Air velocity is gauged with an anemometer. The nomogram in Annex 1 shows how the climatic value "effective temperature" is obtained from these three variables.

The Ventilation Department informs the mine management of the results of its measurements on a special form of which an example is shown in Annex 2. This includes a sketch of the airways with the various measuring points numbered. The adjoining table gives the measured or computed values corresponding to the numbered measuring points.

These values are entered in the table in the following sequence:

dry-bulb temperature
wet-bulb temperature
% relative humidity
air velocity in m/sec
effective temperature
air quantity in m^3/min.

Section 4 : Results of Ventilation Department measurements

The complex nature of the ventilation system and the control of climatic conditions are illustrated by a sketch of part of the underground workings of the Emma/Hendrik mine. (See Annex 3).

This shows airways, technical installations and workplaces.

Values obtained during one afternoon shift by the Ventilation Department are given in the table as well as alongside the measuring points.

The direction of airflow is indicated by the arrows.

This sketch and the values accompanying it can do no more than give a general impression of the arrangements for drawing in the fresh air needed to create an acceptable "climate" for underground workers and for its subsequent evacuation.

The quantity of air and its velocity are the important factors in this process.

The use made of these factors, and the way their effects on climatic conditions are followed up through the measurements of the Ventilation Department, determine the extent to which workers can stay on the job underground. Technical facilities and economic resources set limits to these important and wide-ranging efforts to provide underground workers with the best possible climatic conditions.

It is within these limits that we set out on our modest investigation into work carried out at high temperatures.

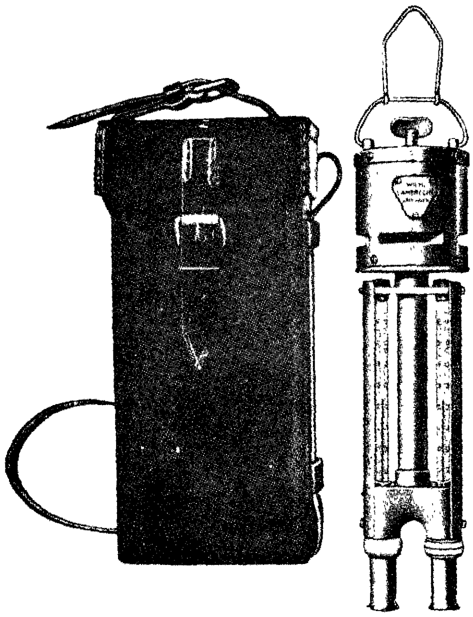

Fig. I-1

Psychrometer

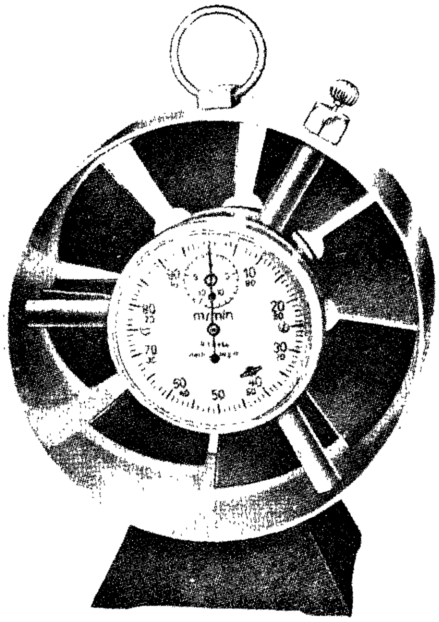

Fig. I-2

Anemometer

CHAPTER II

The problem

Section 1 : General

The study of work under difficult climatic conditions was undertaken at the request of the management of the Emma/Hendrik mine. The temperature at a number of working points was so high that the special measures laid down in the relevant rules and directives had to be applied. This circumstance, which pointed to a difficult work situation, was noted with all the more concern because, as a result of the pit closure process, personnel consist more and more of older persons.

Apart from the fact that high temperatures were recorded during the measurements carried out by the Ventilation Department, there were no definite signs that this work situation has an adverse effect on workers or on their performance.

The management's desire for a more searching study of these conditions was based mainly on humanitarian considerations. The aim was to provide a measure of relief to those working in hot surroundings. The data compiled by the Ventilation Department was made available to us for the purpose of this study. If necessary that department would also lend us a hand. The Medical Department also expressed its readiness to assist us in our work.

The better to define the problem under study, it was proposed to determine the physiological and psychological factors linked to work performed at high effective temperatures. It was also decided to establish what theoretical scope exists for improving climatic conditions, while making due allowance for the economic and personal advantages and drawbacks entailed.

The matter of clothing worn in hot workings was also to be considered.

Finally it may be asked to what extent the improvement of the work situation can be facilitated by changes in organization and working methods.

As far as research methods are concerned, these could take the form of evaluation of the data measured by the Ventilation Department, observation of men at work and conversations with personnel assigned to hot workings.

Section 2 : Tackling the problem

The results of measurements taken by the Ventilation Department were followed up over a number of months and plotted on charts to get an idea about temperatures and any changes in temperature at the various working points.

The following data were used :

Dry-bulb temperature
Wet-bulb temperature
Air velocity
Effective temperature.

To these was added mean external temperature on the days the measurements were taken. Annexes 4a to 4m give these data for a district. The correlation between climatic values as regards their influence on effective temperature was obvious, but - with the exception of air velocity - afforded in theory scant basis for the improvement of climatic conditions at working points.

On the other hand it became quite clear that the real problems in the Emma/Hendrik mine were confined to working points exposed to secondary ventilation. This is a type of ventilation in which a fan diverts part of the main airflow through a duct, forcing it to a dead end at which it emerges from the duct. It then returns to its point of departure and rejoins the main airflow with which it becomes merged.

Other high-temperature working points were of less importance for the execution of work but were factors to be taken into account in getting to the workings. To investigate this aspect, temperatures were taken at a large number of working points in a district with its supply and loader gates. The results are given in Annexes 5a and 5b. Annex 5a shows a sketch of the district with numbered measuring points. Annex 5b contains the measured data. The gradual rise of temperature to fairly high values clearly emerges. These measurements also showed us which points were important from the point of view of the length of stay and work performed by underground personnel.

Section 3 : Conclusion regarding the various problems

Working points at which, because of climatic conditions, the situation could not be regarded as all that it could be were localized. Particularly close attention could then pe paid to persons put to work at these points. First of all the Medical Department considered whether or not it ought to raise any objection to personnel being put to work at these particular points.

Secondly, we tried to find out, through conversations and observation, what were the real difficulties workers experienced at these working points that could be attributed to climatic conditions. These inquiries did not yield any obvious contra-indications. This is not to say that the workers concerned were totally indifferent to the temperatures in which they had to work. When transferred temporarily to other working points with better climatic conditions, they were only too well aware of the difference. When they were questioned about their experiences at their workplace it was mainly personal discomforts that were brought to the fore.

This came out during conversations in which workers were questioned about various aspects.

For instance it was suggested to them that they should wear shorts instead of the usual miner's clothing. This suggestion aroused not the slightest interest. It appeared, however, that soiled clothing was felt to be a decided nuisance.

Another nuisance complained of was the cold draught from the ventilation ducts or fans when it was directed on their backs.

Questioned about the duration of their stay and work in high-temperature surroundings, they brought up the matter of the abrupt jump in percentage rates of heat allowance. This could depend on a rise of a mere 0.1° C. "The difference in heat was not noticeable but the extra rate paid was."

This remark did not imply any distrust of the measurements carried out by the Ventilation Department. Measurements are taken in the presence of the miners to whom their results are familiar.

Our observations appear to confirm those of other researchers (METZ, 1962) (LAVENNE, 1965) in that clearly negative effects under the given circumstances are not discernible.

The conclusion drawn from our study was therefore that means should be sought of relieving this sensation of individual discomfort.

CHAPTER III

Report on certain measures

Although personal discomforts in hot surroundings stood in the foreground in conversations with workers, mention should be made of certain activities undertaken by the Ventilation and Technical Departments with a view to improving working conditions.

Manrider

Even on the journey in the manrider from shaft to face where temperatures were very high at certain points, the heat became more and more noticeable. It was felt not only by workers at the points in question but also by remaining personnel, including face workers. The return journey was also made in narrow cars.

In a series of measurements carried out by the Ventilation Department in the manrider the following temperatures were recorded :

Ventilation Dept. Emma/Hendrik

Sheet No.	A	B	C	D
	E	F	G	H

Date	Shift	Roadway No.
	1	

District	Seam	Level	Panel

Name	Toka
	No.

Temperatures in manrider District Q,
5th S.W. cross-cut 700 m level

1 : in incoming airflow
2-5 : in outgoing airflow
No. of persons in truck : 13
Air velocity measured
1 and 2 with measuring tube
3 to 5 with anemometer

1. Between air doors (from pt 2160 to pt 2210) past entraining point - stop

in outgoing airflow:

2. before entraining point - stop
3. travelling from entraining point at old T° with airflow in direction of shaft
4. travelling from old T° to 4th S.W. cross-cut with airflow in direction of shaft
5. travelling from 4th S.W. cross-cut to 1st S.W. cross-cut, with airflow in direction of shaft

T e m p e r a t u r e s

No.	Dry temp.	Wet temp.	% rel. hum.	air vel. m/s	Eff. temp.	Qtty m^3/s	Site
1	25.5	22.0	73	0.1	23.0	Stop (1–2)	
2	28.2	26.0	84	0.6	25.0		
3	28.6	26.8	86	0.3	26.4	In motion (3–5)	
4	28.8	26.6	84	0.4	26.1		
5	28.9	27.0	86	0.3	26.6		
6							
7							
8							
9							
10							
11							
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26							
27							
28							

Table III-1 : Details of temperatures measured in manriding truck

One way of improving climatic conditions in the manrider was to speed up the airflow. This was achieved by enlarging the ventilation orifices at the front of the manrider.

To avoid the nuisance of an excessive current of air, a hinged flap-valve, which could be raised or lowered as desired, was installed.

The enlarged orifice and flap-valve are shown in Fig. III-1.

In the course of trial journeys towards the hot workings temperatures in an ordinary truck and in one fitted with an enlarged ventilation orifice were compared.

Table III-2 shows the results in each case.

In view of the favourable reaction of personnel and the results of the measurements carried out, orifices were enlarged on 15 trucks circulating on the route in question.

Ventilation at the end of the loader gate

The Ventilation Department was able to improve climatic conditions at the end of the loader gate of a coal face.

Originally this was ventilated by means of a 35 C.V.* electric fan and a combination fan.

* Approx. 70 h.p.

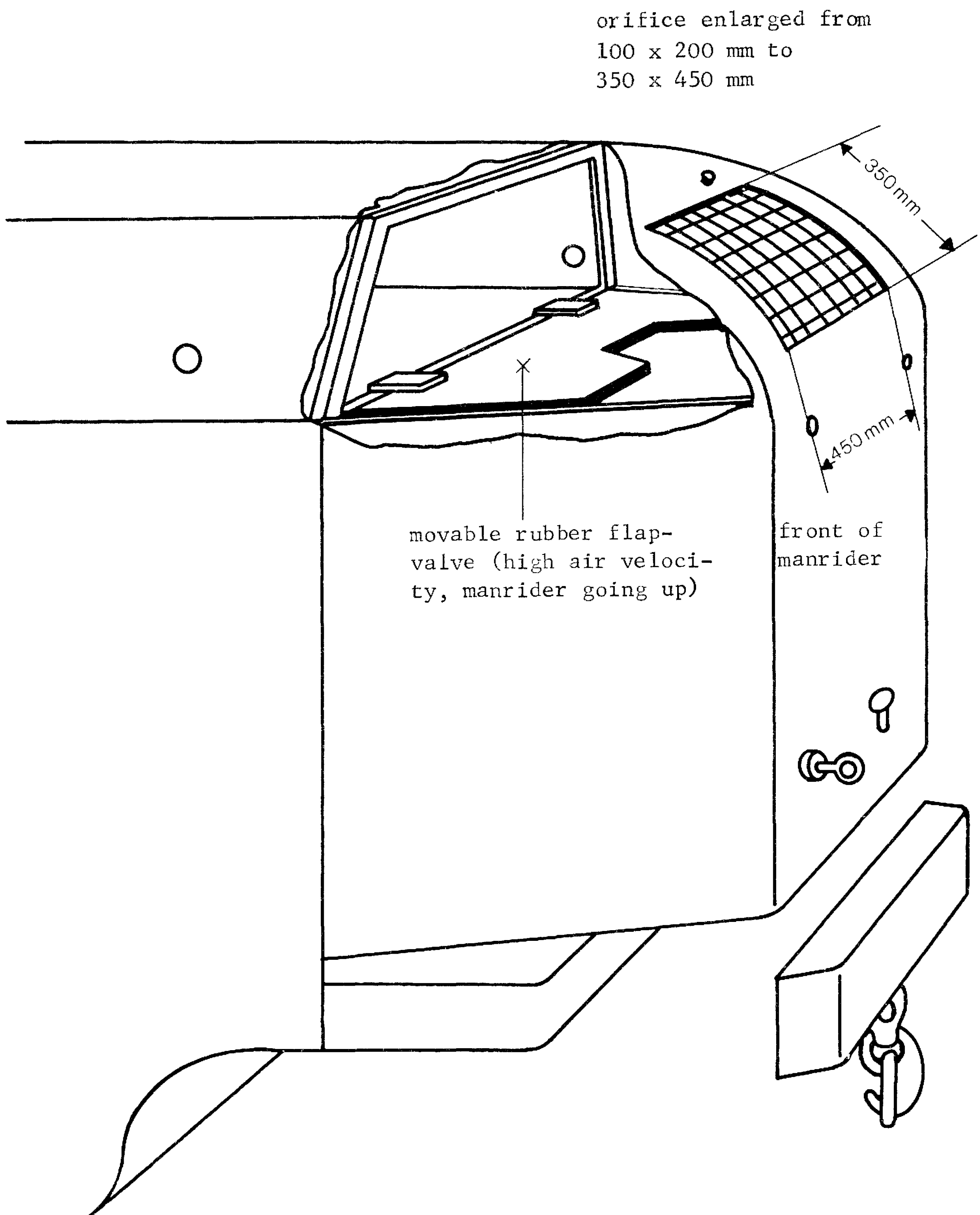

Fig. III-1

Sketch of enlarged ventilation orifice on manrider

Temperature measurements in manrider from 700 m level loading point to 5th SW cross-cut. MP 2300 and return															
				Ordinary truck						Truck with enlarged ventilation orifice					
Point	Site at 700 m level	Meas. point	Remark	Td	Tw	% rel.h	Air vel m/s	Eff. T	m^3	Td	Tw	% rel.h	Air vel m/s	Eff. T	m^3
1	Loadg pt shaft 700 m	tel. cabin	stop	20	14.5	54	0.1	16.8	3600	20.2	14.2	51	0.2	16.2	3600
2	1st SW cross-cut - 4th S cross-cut W	700-2000	moving	26.2	24.5	87	0.7	22.6	2500	26	25.5	96	1.8	20.2	2500
3	4th S cross-cut W - loadg pt T in 5th S cross-cut W	0-1000	moving	27.5	25	81	0.7	23.8	3400	27.5	25.5	85	2.3	20.8	3400
4	Loadg pt T in 5th S cross-cut W - loadg pt Q 5th S cross-cut W	1000-1600	moving	27.8	25.3	81	0.8	23.8	2840	28	26	85	2	22.2	2840
5	Loadg pt Q in 5th S cross-cut W	1600	stop	28	25.5	81	0.7	24.2	2840	28.2	26	84	1.2	23.8	2840
6	End of run MP : 2100	2100	stop	27.8	24.1	73	0.05	25.3	120	27.6	24.5	77	0.1	25.2	120
7	End of run MP : 2100	2100	stop	27.2	23.8	75	0.05	24.8	120	25.4	24.3	91	0.1	24.2	120
8	Loadg pt Q in 5th S cross-cut W	1600	stop	28.1	25.7	81	0.3	25.6	2840	27.8	25.6	84	0.5	24.7	2840
9	Loadg pt Q in 5th S cross-cut W - loadg pt T 5th SW	1600-1000	moving	28.5	26	81	0.4	25.6	2840	27.8	25.6	84	0.4	25	2840
10	Loadg pt T in 5th S cross-cut W - 4th S cross-cut W	1000-0	moving	28	26	85	0.3	25.7	3400	27.9	25.9	85	0.5	24.8	3400
11	4th S cross-cut W - 1st S cross-cut W : in main cross-cut W	2000-700	moving	28	26	85	0.2	26.1	2500	27.6	25.1	81	0.5	24.3	2500
12	Loadg pt shaft 700 m	tel. cabin	stop	25.2	20.8	67	0.2	21.8	3600	23.2	18.8	66	0.6	18.0	3600
13	5th S cross-cut W 700 m	280	moving	26.3	24.5	85	0.8	22.4	3400	27.0	25.5	88	2.4	20.2	3400
14	5th S cross-cut W 700 m	815	moving	27.5	25	81	0.9	23.2	3400	27.8	25.6	84	2.5	21.0	3400
15	5th S cross-cut W 700 m	280	stop	28	26.1	86	0.35	25.6	3400	27.5	25.8	87	0.7	24.2	3400
16	5th S cross-cut W 700 m	815	stop	28.1	25.8	83	0.6	24.7	3400	27.7	25.4	83	1.5	22.6	3400
	Temperatures outside truck			1st measurement						2nd measurement					
17	5th S cross-cut W 700 m	815	in cross-cut	27.5	25.8	87	7	18.2	3400	27.7	25.5	83	7	18.0	3400
18	5th S cross-cut W 700 m	280	in cross-cut	28	25	78	6.8	18.4	3400	27.5	26	89	6.8	18.0	3400

Notes : 1) pts 17 and 18 measured outside truck in 5th SW cross-cut 700 m.
2) pts 6 and 7 end of run in 5th S cross-cut W 700 m.
At this point manrider halted for 30 min.
3) manrider was made up of a Diesel locomotive and two trucks.

Table III-2 : Details of temperature measurements in an ordinary manriding truck and in a truck with enlarged ventilation orifice

The combination fan consists of a compressed-air ventilator coupled to an electric fan. The ventilator is set in operation by means of an electro-magnet directly the voltage breaks down so that the fan stops. The compressed-air ventilator can also be turned on by hand. The quantity of air at the end of the loader gate was 380 m^3/min. The Ventilation Department carried out a trial during which ventilation of the gate end was provided by the combination fan alone. Compressed air pressure amounted to approximately 5 kg/cm^2-gauge.

After the electric fan had been switched off, the air quantity amounted to 100 to 150 m^3/min. Temperature was measured for a week during the stripping shift towards 8 a.m. and midday. The results, expressed in ° C effective temperature, are plotted in Fig. III-2. From this it can be seen that the effective temperature recorded during the one-week trial period was approximately 3.5° C lower than before that period.

The same numbering is used for measuring points as that shown in Annex 4a. It is worth noting that the combination fan consumed approximately 8000 m^3 compressed air every 24 hours as compared with 620 kW for the electric fan. The results of this experiment were so striking that it was decided to ventilate the gate-end with the combination fan alone.

Sealing-off of free water

Among the activities of the Ventilation Department should be mentioned the extreme care taken in suspending ventilation ducts and sealing off free water.

Careful maintenance of the ventilation ducts ensures the trouble-free supply of fresh air to the face. The covering over of free water serves to prevent as far as possible the evaporation of water seeping through the walls and drained off by gutters. The gutters were therefore covered over with concrete slabs over a length of 1630 m. These steps were taken not with any specific problem in view but in the light of the general knowledge acquired regarding factors influencing climatic conditions (SADEE, 1969).

Working clothing

The remarks made about soiled clothing were carefully looked into. Wet clothes are dried in the Emma/Hendrik mine. Miners hand in their wet things at the end of the shift and are given dry clothing when they report for the next shift. One of the complaints made by personnel assigned to hot workings was that, after drying, their clothing gave off an unpleasant odour. The management thereupon arranged for such personnel to be issued with freshly cleaned clothing once a week.

Waiting at the shaft

Another simple measure was to see that on completion of their shift in hot workings the personnel concerned did not have to wait at the shaft in sweaty clothing.

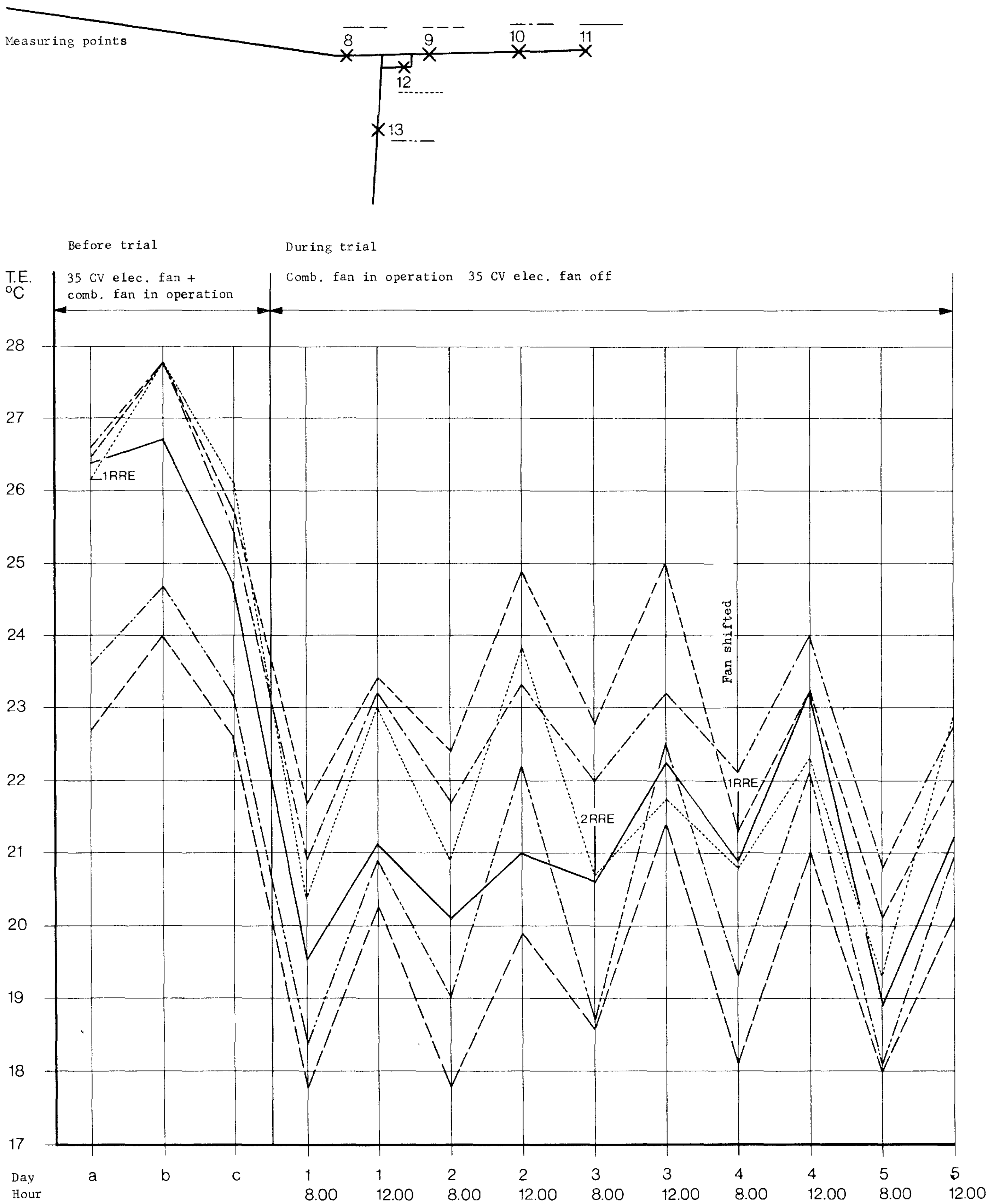

Fig. III-2 : Temperature measurement before and during a trial period of ventilation with combination fan

At the end of a shift underground workers travel by manrider to the shaft where they queue up in the roadways before being taken by cage to the surface.

The temperature in the vicinity of the shaft can be much lower than at the working points they have left. Having to wait in cooler surroundings in sweaty clothing even for a few minutes is considered to be very unpleasant.

The management therefore issued instructions that personnel from hot workings should be given priority for the ascent.

Distribution of tea

For the same personnel tea, sugared and with the addition of citric acid, is specially prepared. The tea is taken to the hot workings in 10-litre containers.

Simple though these measures be, they demonstrate to personnel the concern the management feels for the well-being of workers who must perform their jobs under difficult conditions.

Conclusions

Although no specific problems clearly attributable to climatic conditions emerged from this study - had they done so, the study could have been conducted on more precise lines - we feel nonetheless that we have carried out the wish expressed by the management of the Emma/Hendrik mine.

Perhaps such problems are already being forestalled by the careful watch kept by the Medical Department on personnel assigned to hot workings.

The simple measures taken and the conversations held with the miners themselves bore out the interest felt in their work situation, an interest which they duly appreciated.

The study brought out the importance of paying daily attention to ventilation and climatic conditions underground.

In this way many serious problems are avoided.

Measures to ensure optimum climatic conditions at all underground points present technical difficulties and cannot be entertained from the economic point of view owing to the present situation of the coal-mining industry.

What has been found possible, however, even in the present situation, is to show particular care for, and attention to, workers who have to perform their jobs under less favourable climatic conditions.

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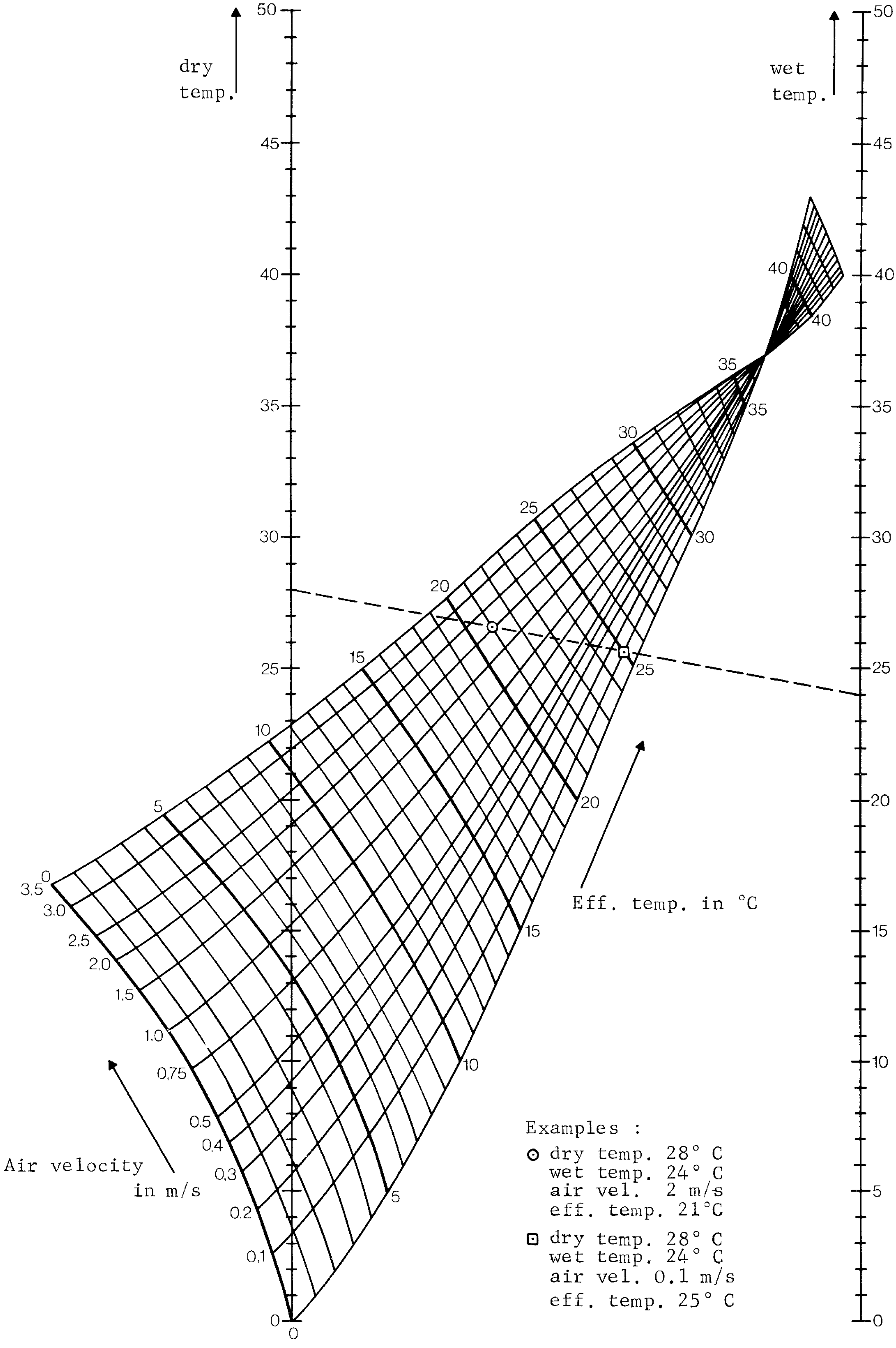

Annex 1 : Nomogram for the determination of effective temperature in °C. Basic scale

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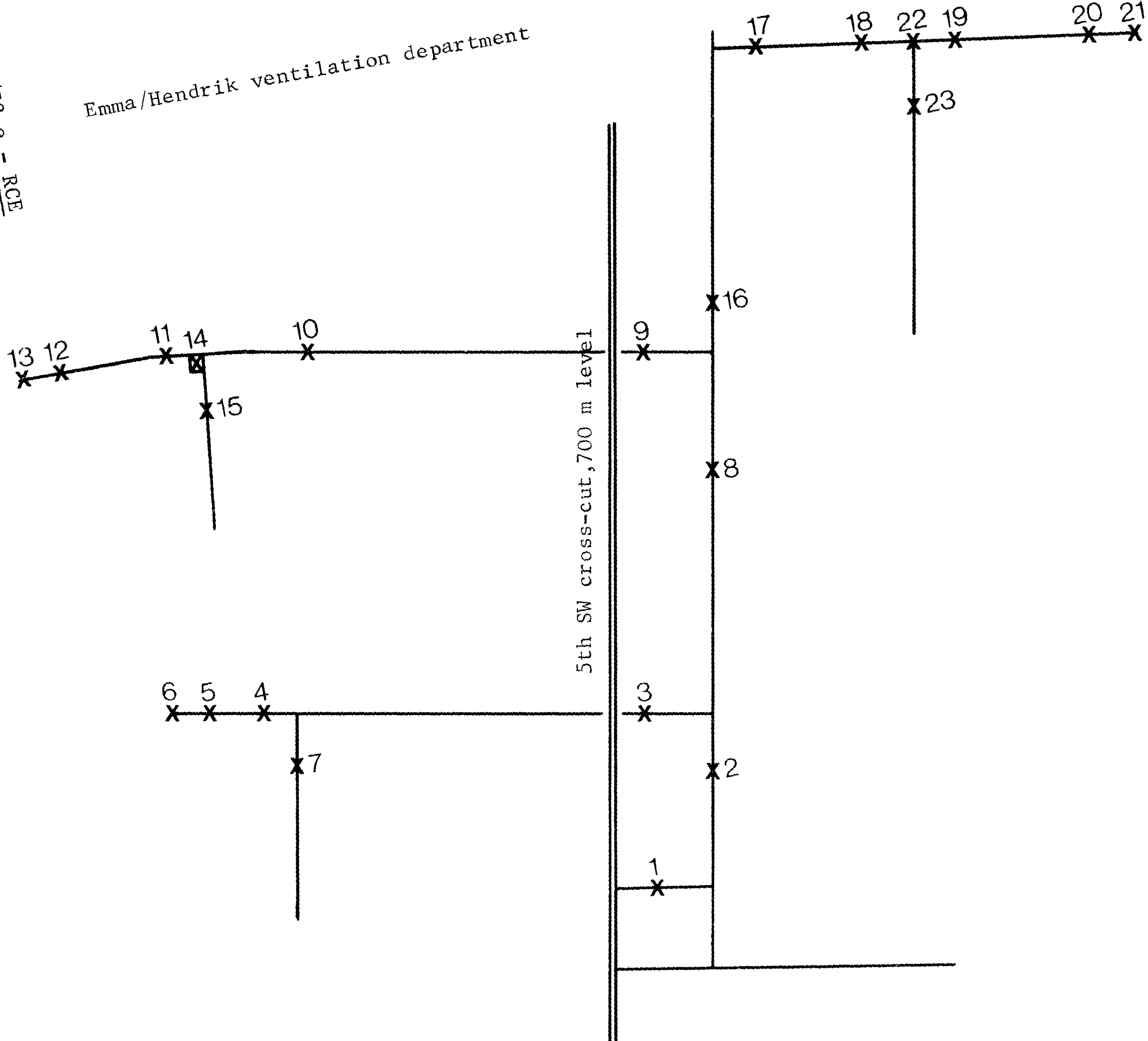
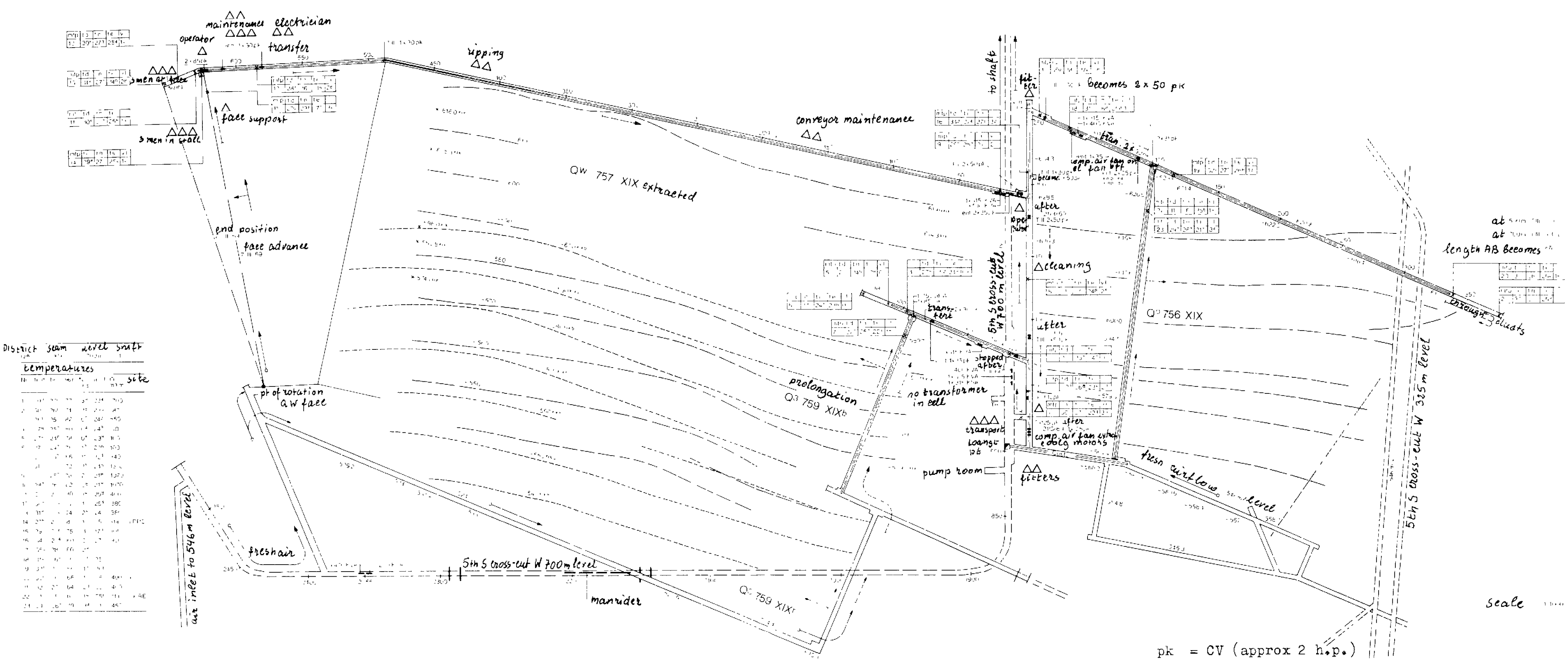
Emma/Hendrik ventilation department



District QW | Seam XIX | Level 700m | 757

TEMPERATURES

No	Td	Tw	% RH	air m/s	T eff.	Qtty m^3/m	Site
1	30^5	27^2	77	3^1	23^3	1650	
2	30^5	27^0	76	2^8	23^4	1810	
3	28^0	25^8	84	0^8	24^2	340	
4	27^5	25^4	84	0^8	24^8	120	
5	27^3	25^1	84	0^5	24^2	120	
6	27^6	25^0	80	1^2	22^8	110	
7	27^5	26^0	89	1^3	23^0	330	
8	31^9	27^8	73	2^5	25^5	1470	
9	29^0	27^4	88	2^6	23^0	1010	
10	28^2	25^3	79	2^4	21^4	1010	
11	30^0	28^0	86	1^4	25^8	420	
12	30^5	27^7	80	1^7	25^6	400	
13	31^0	27^7	78	3^8	23^4	400	
14	30^0	27^6	83	1^2	25^8	stal	1RRE
15	27^2	25^1	84	2^9	19^2	1000	
16	34^4	28^4	63	1^9	27^8	900	x
17	35^4	31^3	76	2^8	29^6	830	x
18	31^0	27^5	76	1^3	26^1	460	x
19	31^9	27^0	68	1^3	26^3	430	x
20	32^0	26^5	66	1^4	26^1	400	x
21	32^7	26^5	62	3^2	24^4	400	x 1RRE
22	31^2	27^4	74	1^4	26^1	stal	
23	29^7	27^0	80	3^1	22^4	450	

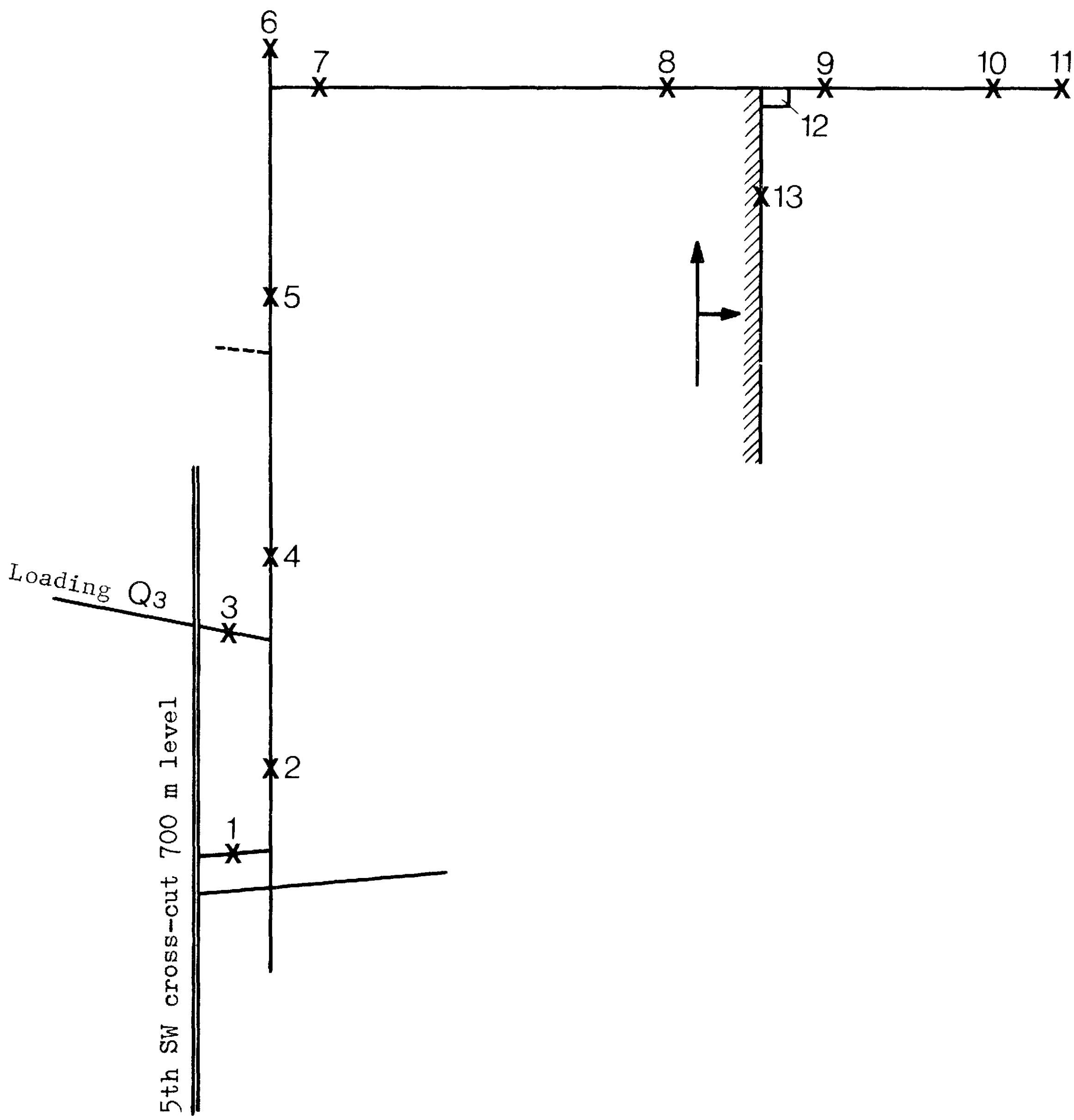


pk = CV (approx 2 h.p.)
mtp = measuring point
td = dry-bulb temperature
tn = wet-bulb temperature
vl = air velocity

Annex 3

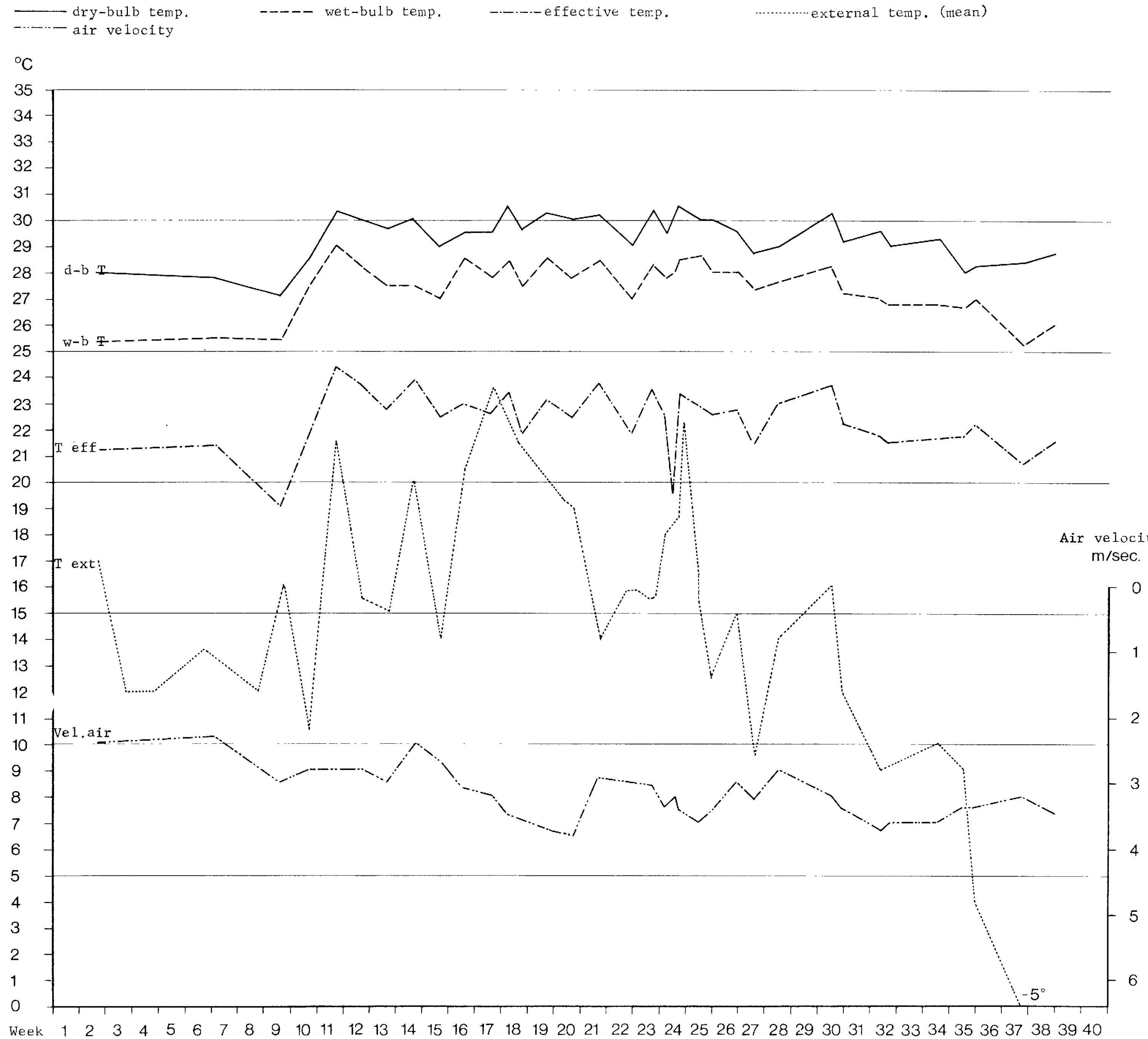
Annex 3 : Sketch of a section of underground workings in Emma/Hendrik mine with airways, technical equipment and working points

Emma/Hendrik mine.. District Q East, seam XIX, panel 756



Annex 4a : Situation plan with numbered measuring points corresponding to temperatures measured from 1st to 9th month

Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 1



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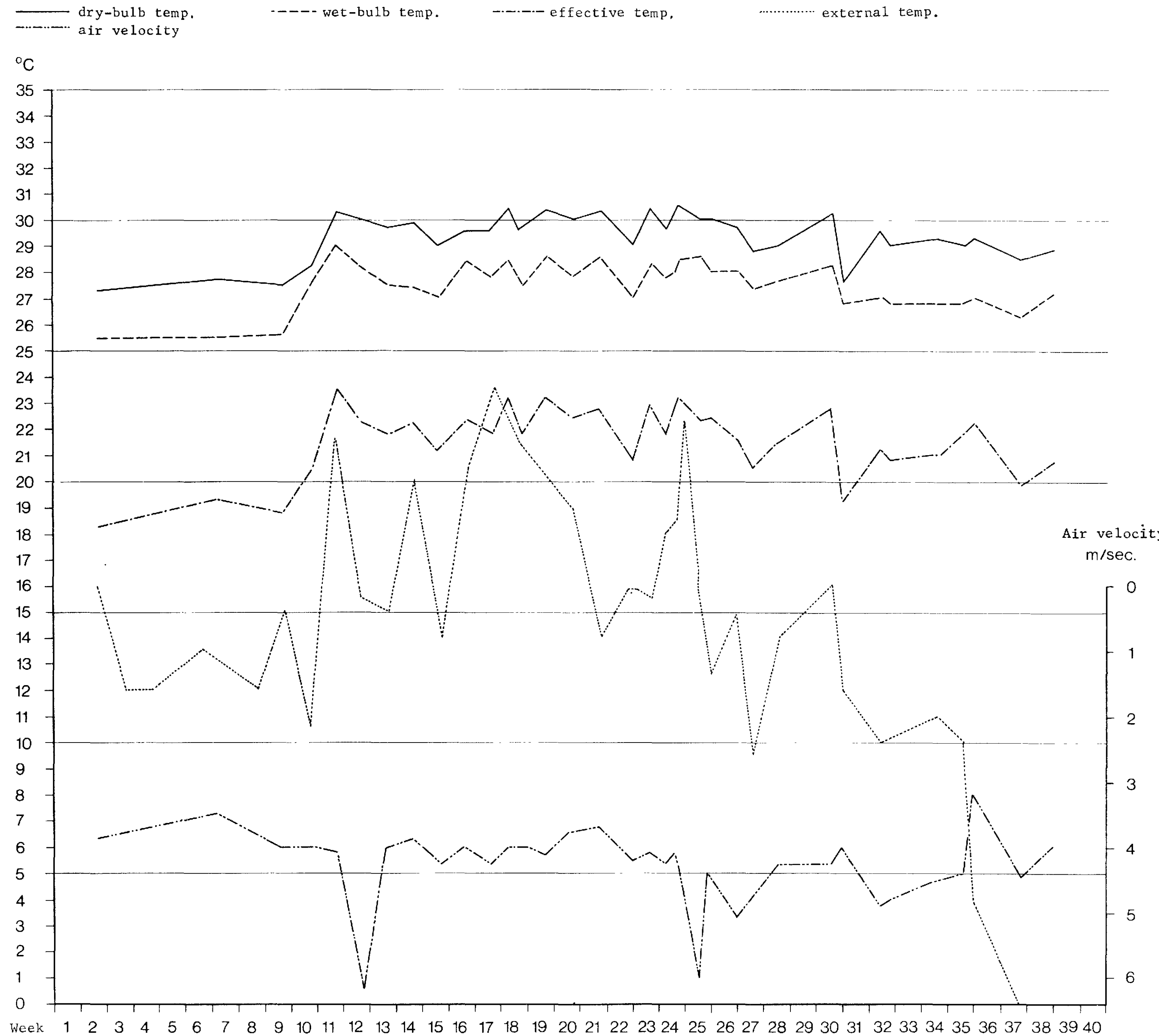
ANNEX 4b

Graph of results of measurement. Annexes 4b - 4n.

Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 2



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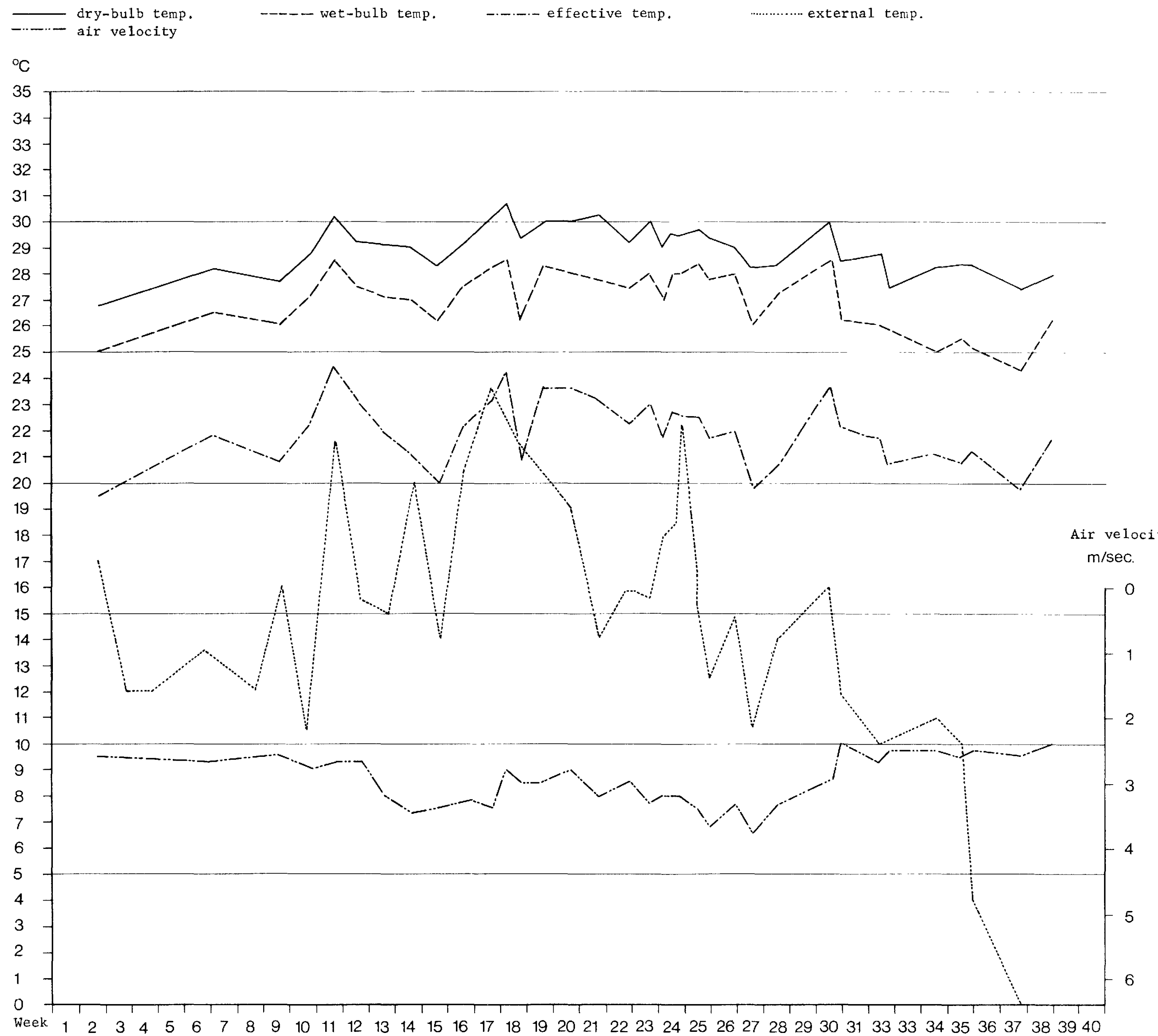
ANNEX 4c

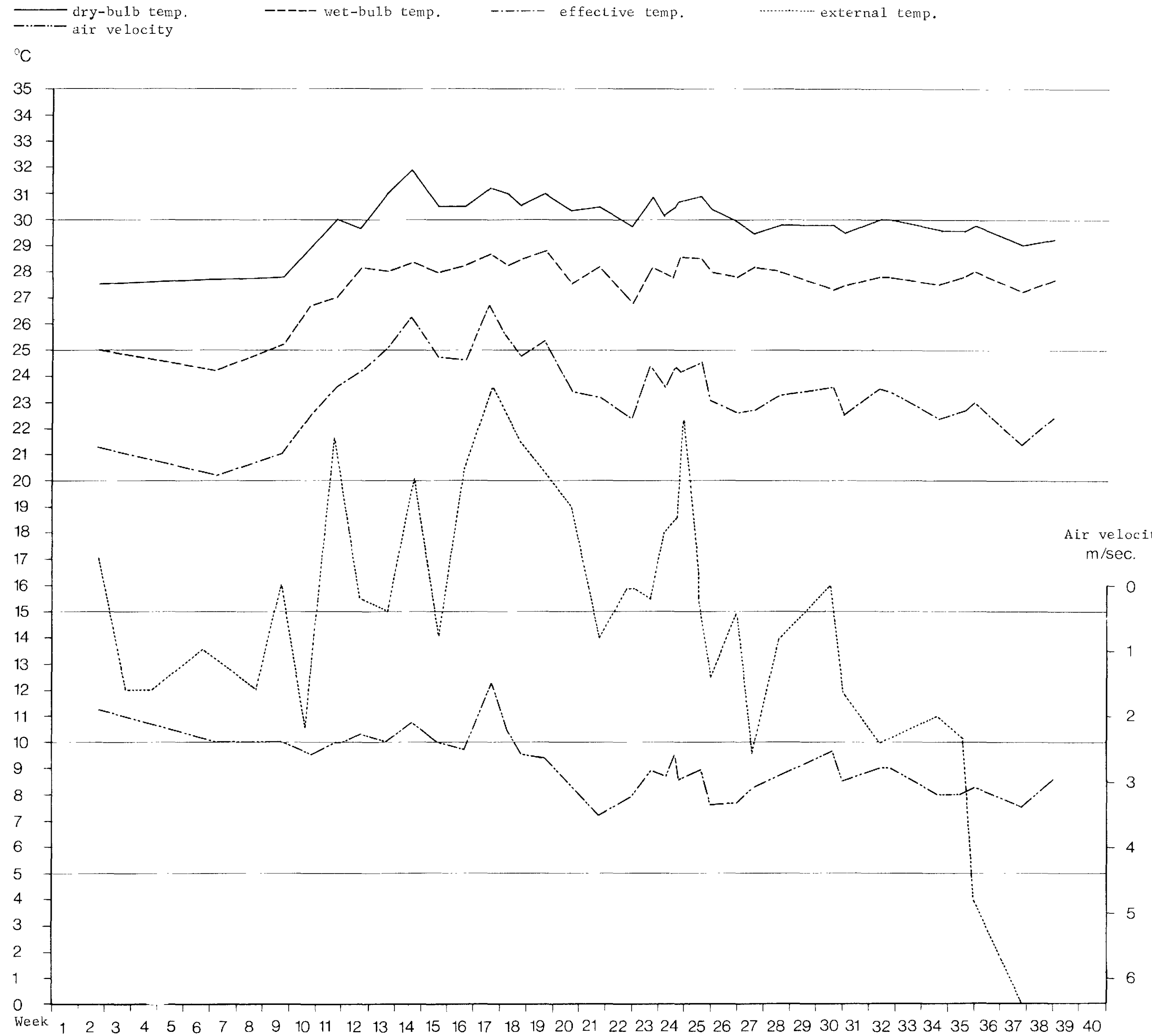
Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 3

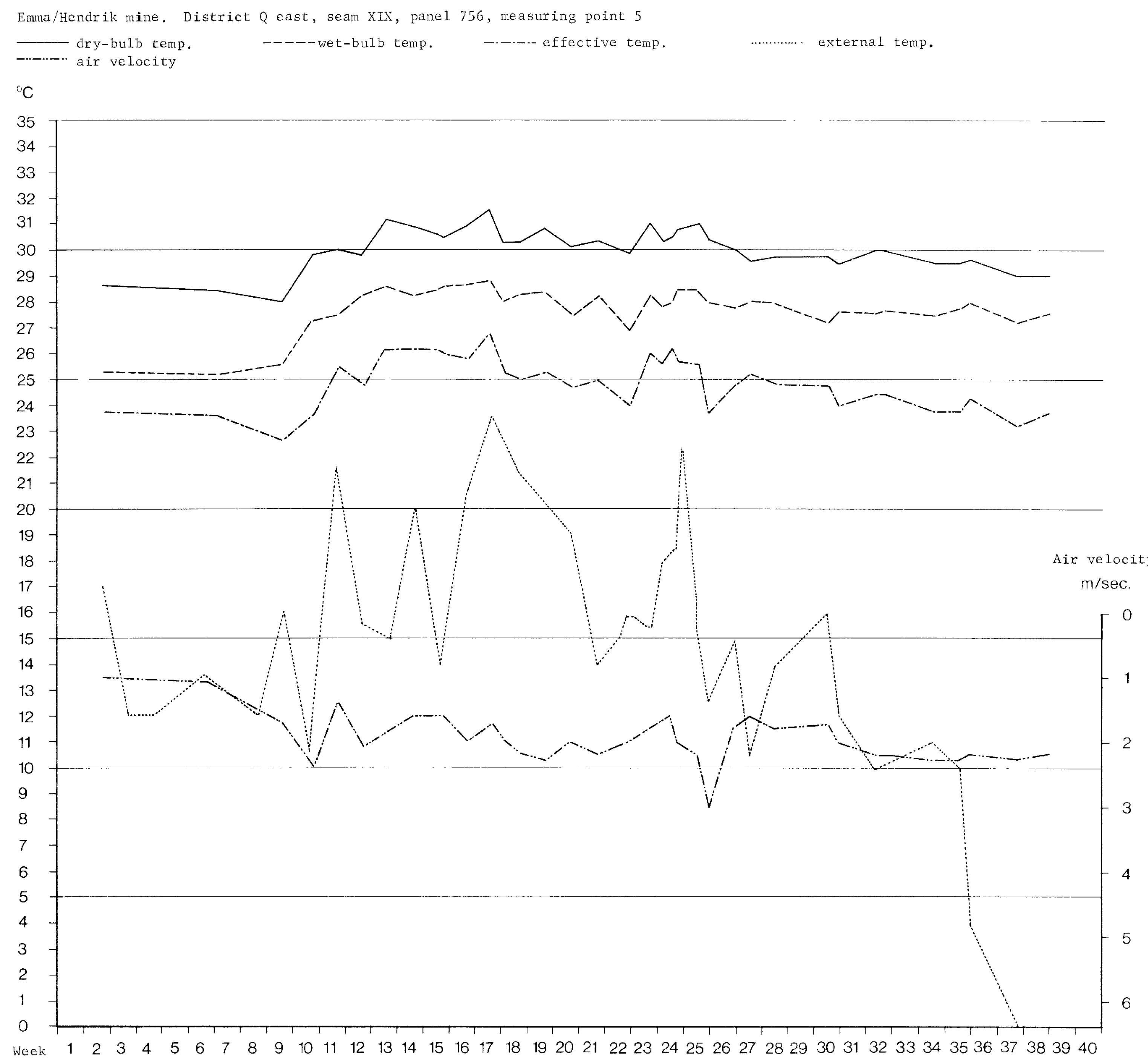


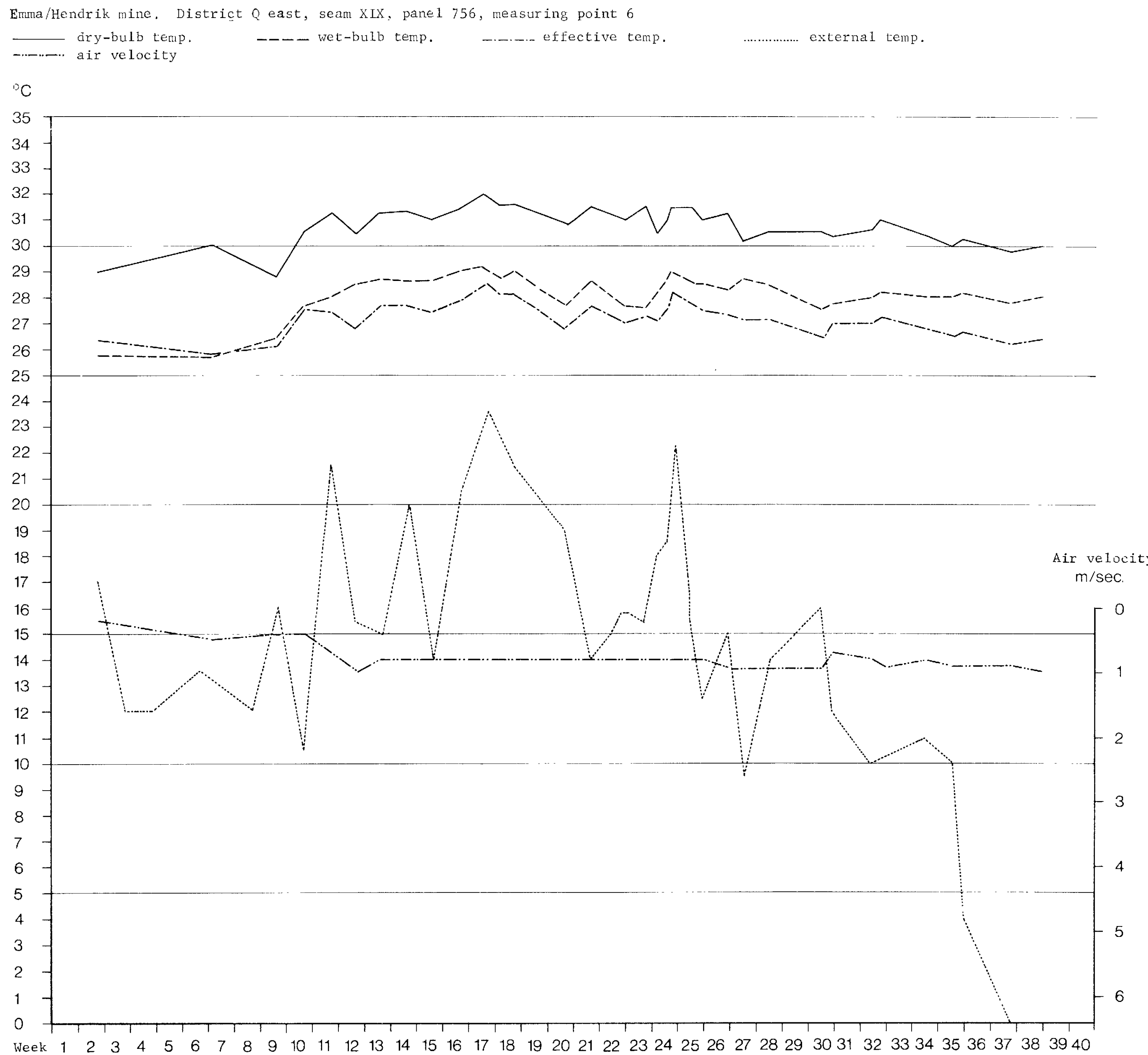
528/72 e - RCE
ANNEX 4d

Annex 4d

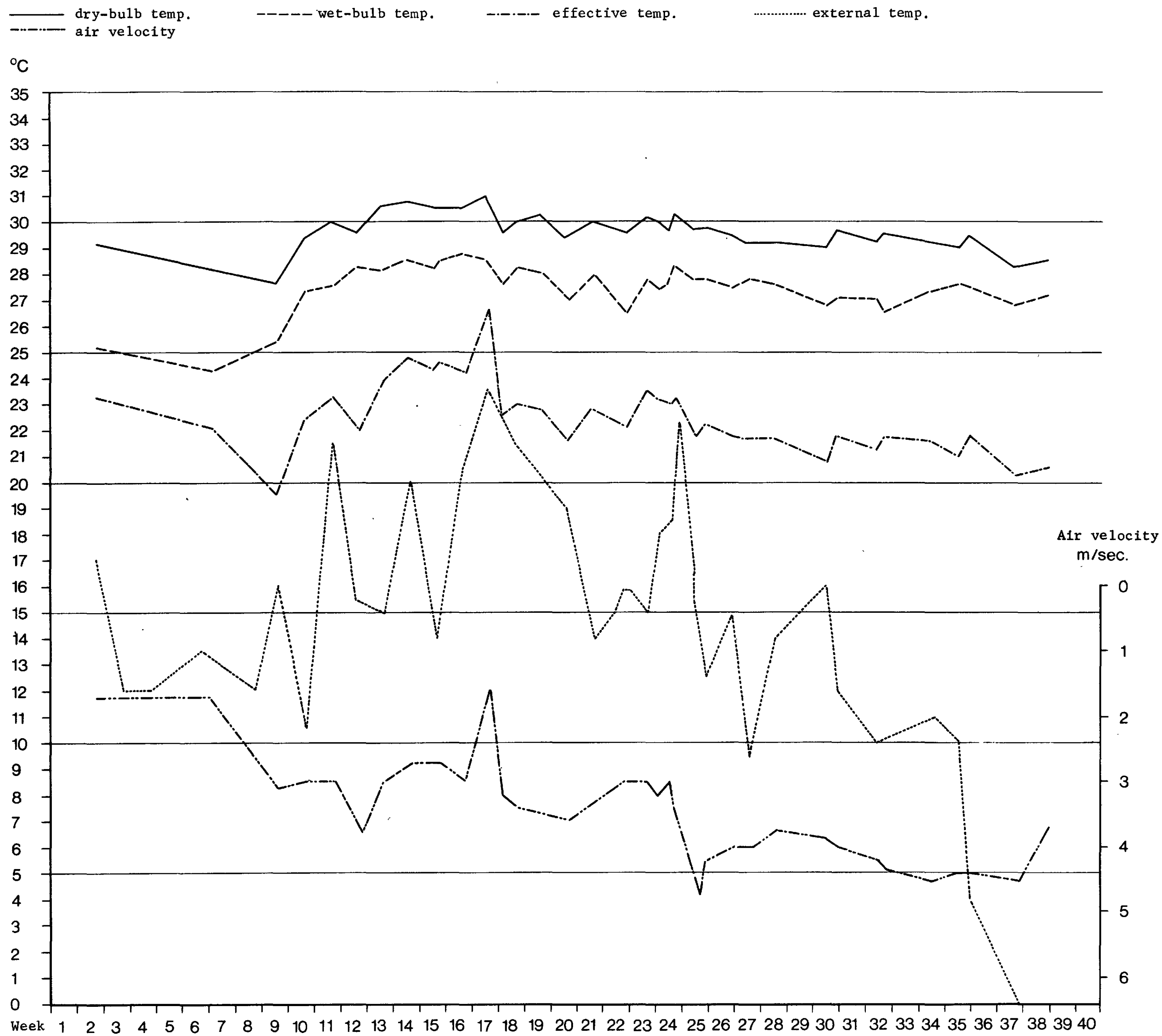
Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 4



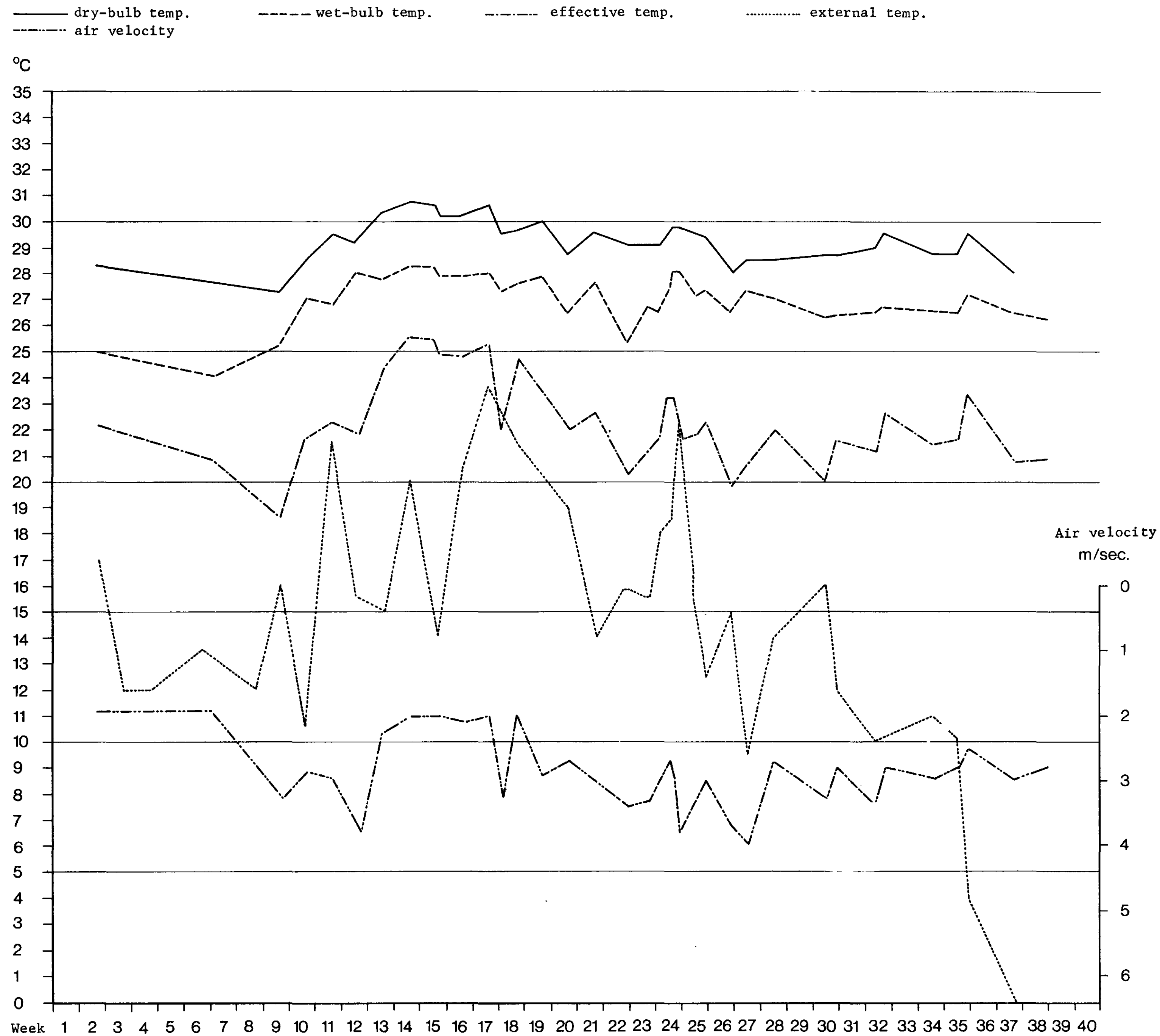

Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 5
dry-bulb temp.
wet-bulb temp.
effective temp.
external temp.
air velocity
°C
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Air velocity
m/sec.
0
1
2
3
4
5
6
Week
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40


Emma/Hendrik mine, District Q east, seam XIX, panel 756, measuring point 6
dry-bulb temp.
wet-bulb temp.
effective temp.
external temp.
air velocity
°C
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Week 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Air velocity
m/sec.
0
1
2
3
4
5
6

Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 7



Emma/Hendrik mine District Q east, seam XIX, panel 756, measuring point 8



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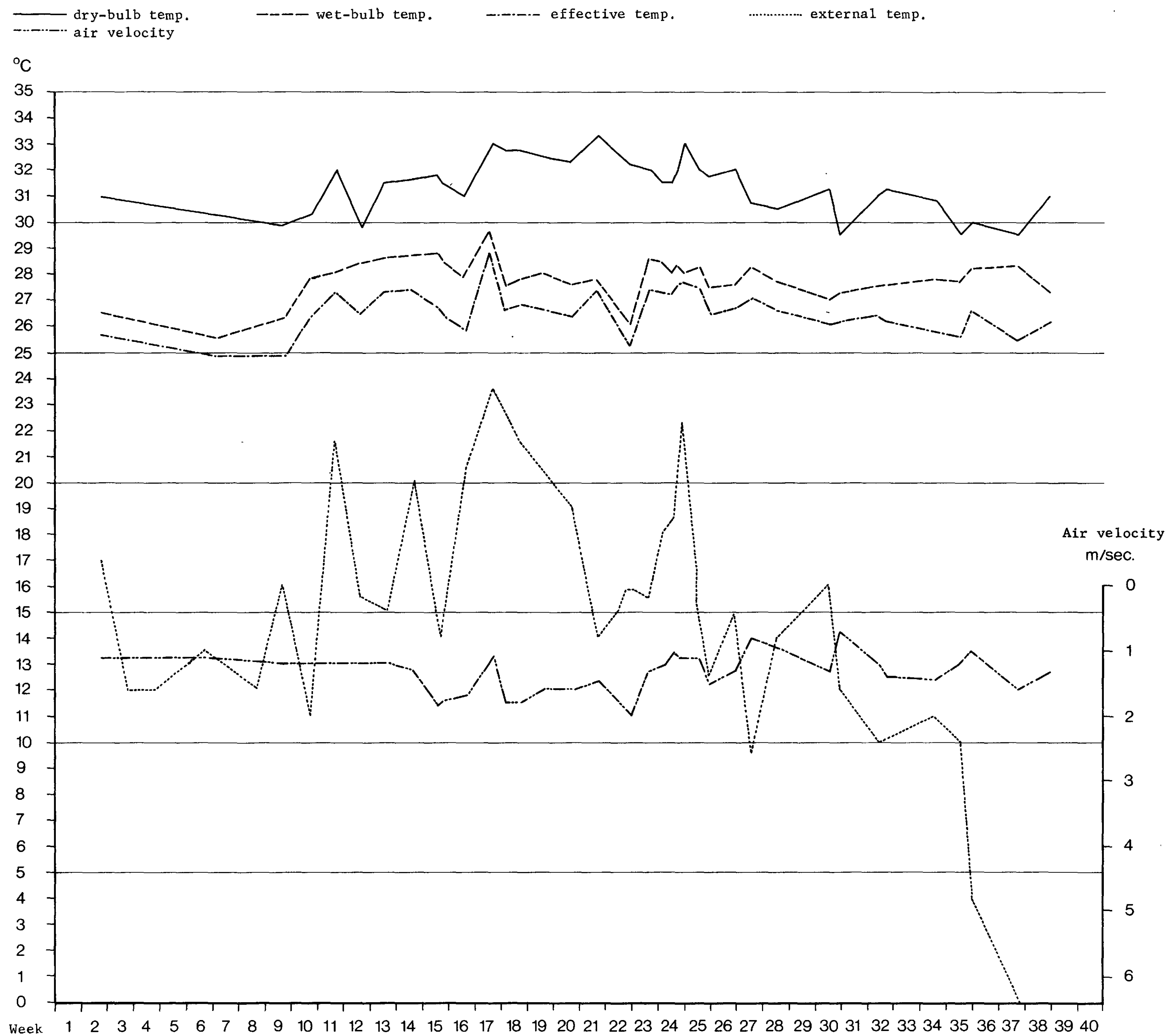
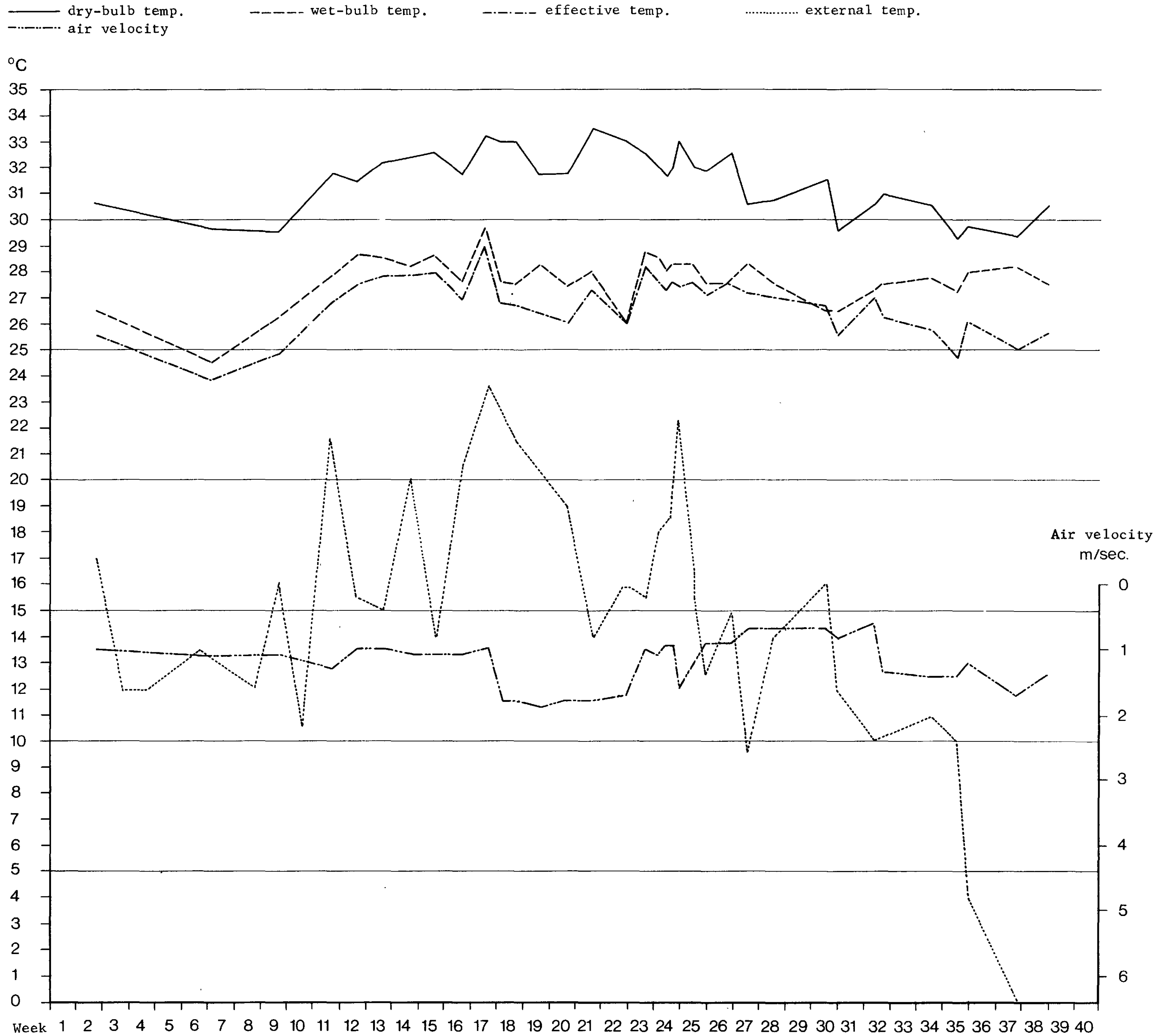
ANNEX 4i

Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 9



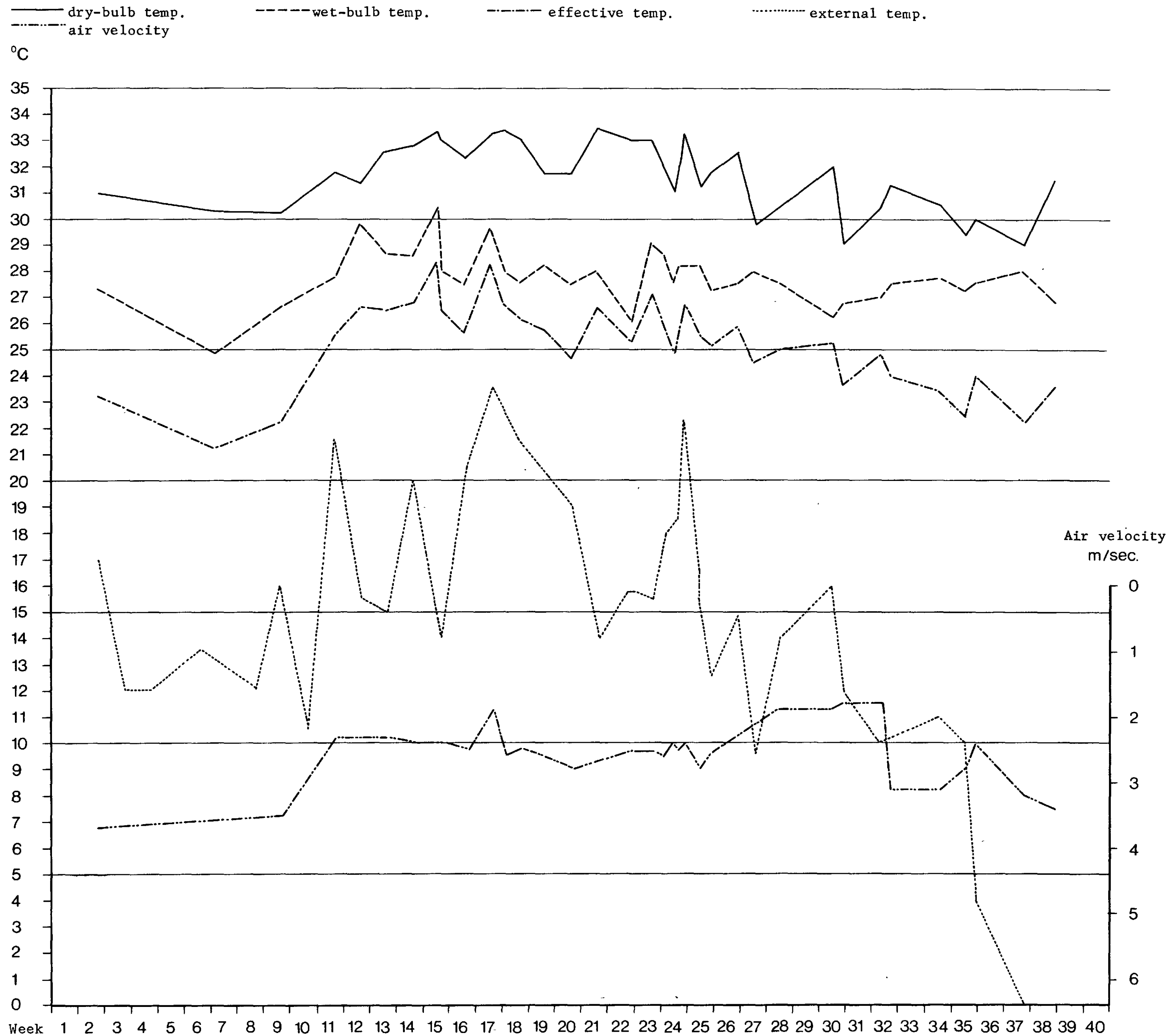
528/72 e - RCE
ANNEX 4j

Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 10



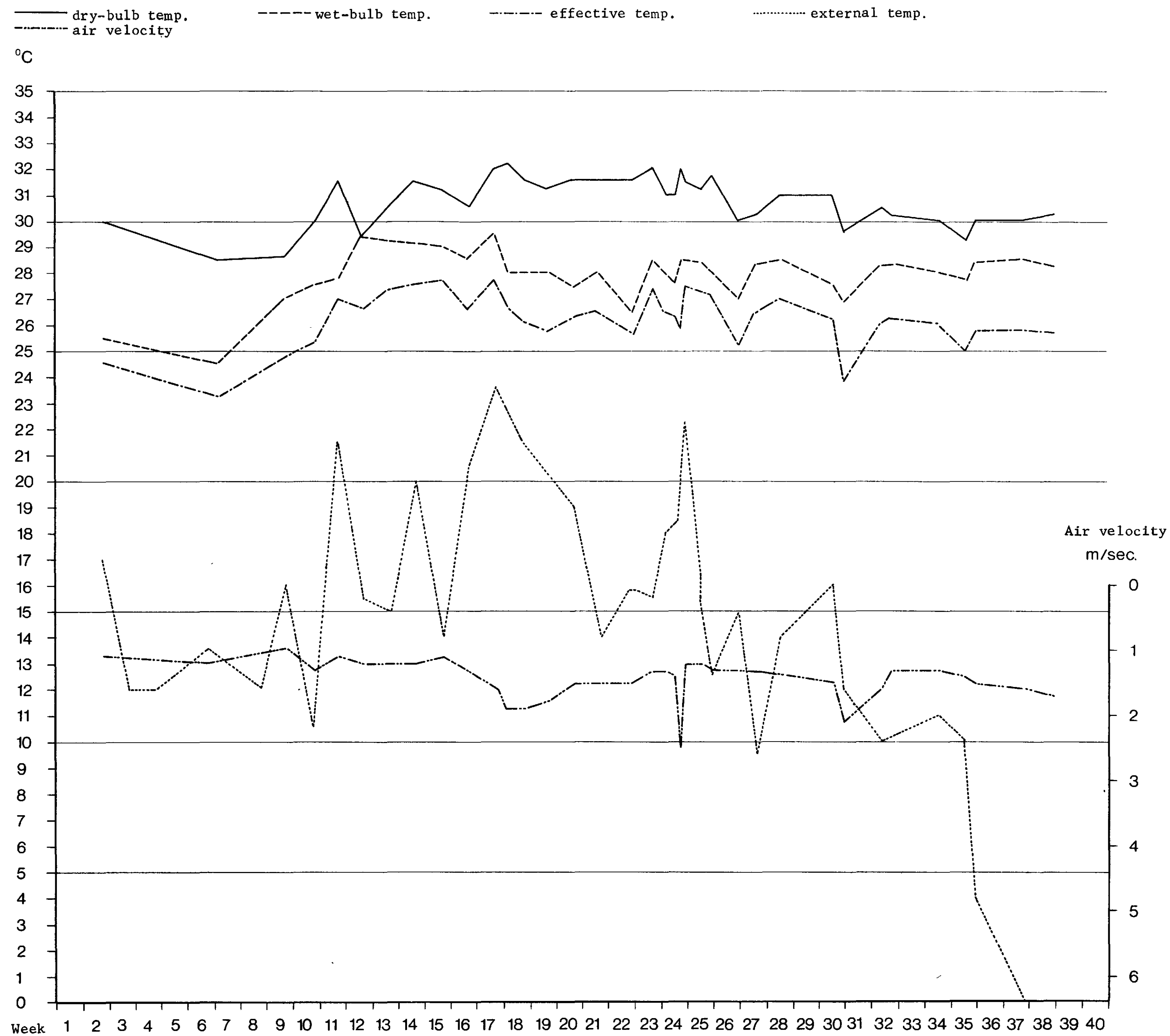
528/72 e - RCE
ANNEX 4k

Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 11



528/72 e - RCE
ANNEX 41

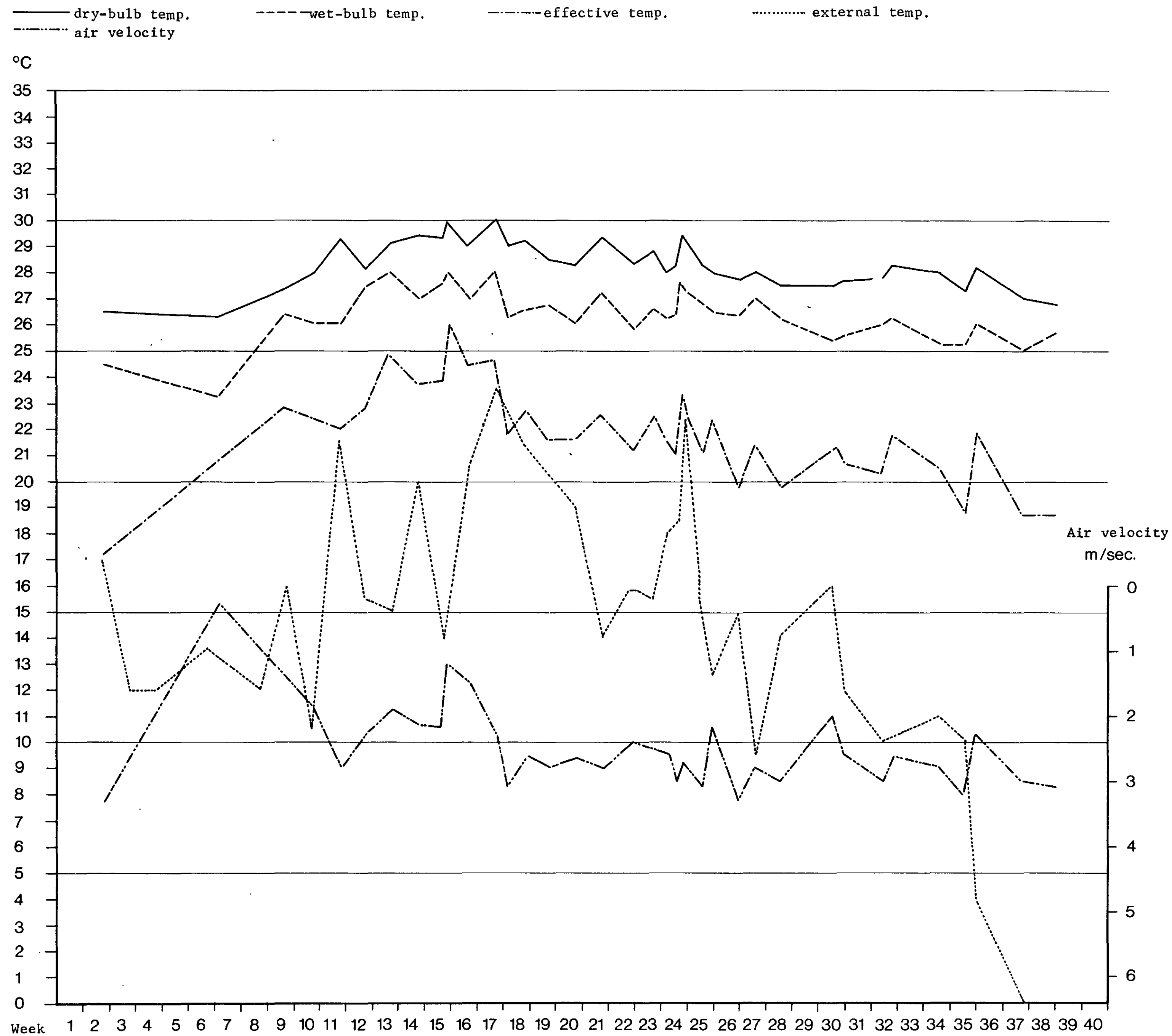
Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 12

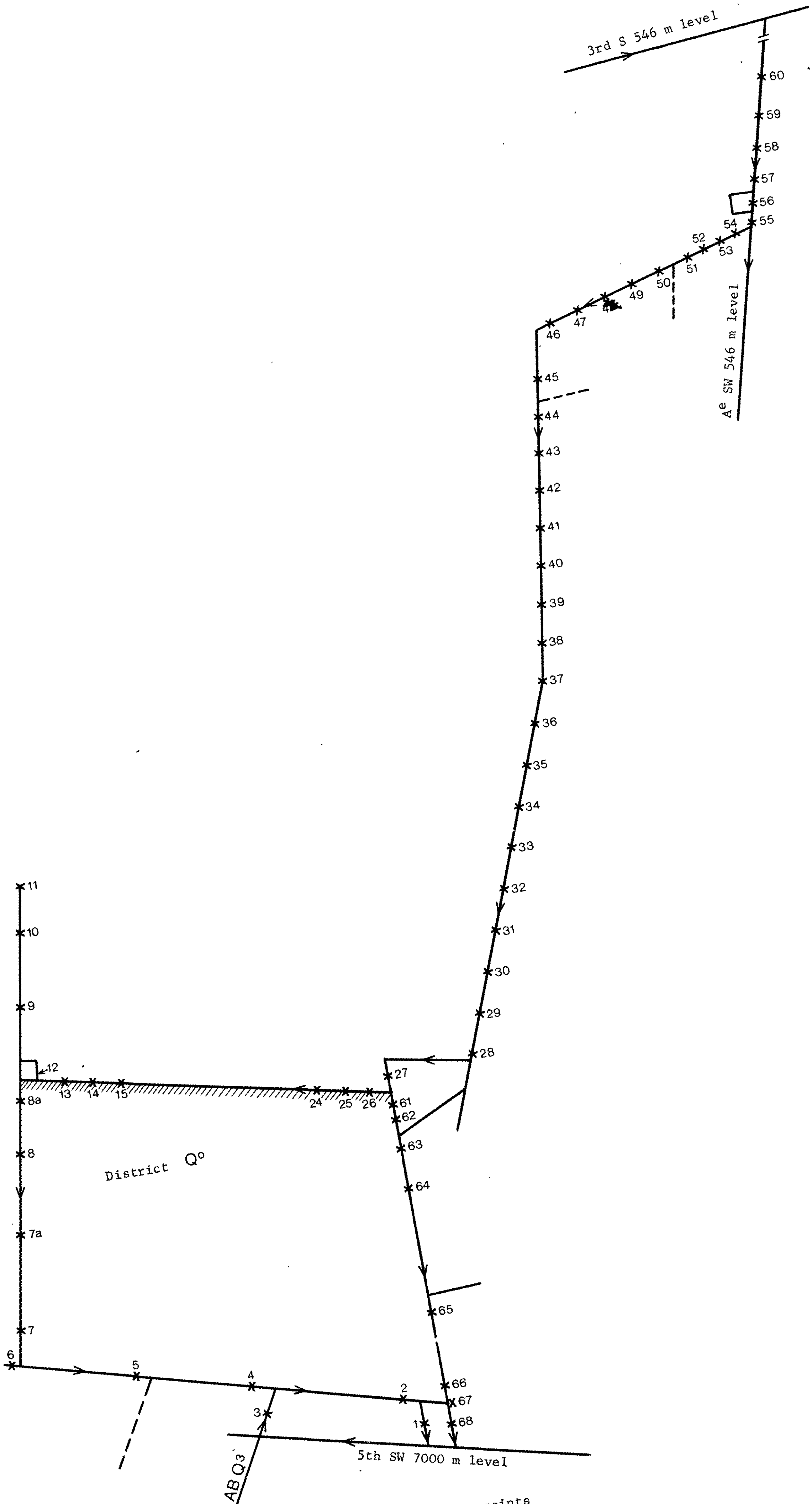


528/72 e - RCE
ANNEX 4m

Annex 4m

Emma/Hendrik mine. District Q east, seam XIX, panel 756, measuring point 13





Annex 5a : Plan of a district with temperature measuring points

528/72 e - RCE

Site description	No.	T dry bulb	T wet bulb	% R.H.	Air m/s	T eff.	m^3/min	Remarks
supply gate pt 520	34	25.5	23.0	79	2.9	16.2	800	
supply gate behind drive	35	25.5	23.0	79	2.8	16.4	800	Control belt conveyor
supply gate before drive	36	25.2	22.9	81	2.8	16.1	800	
supply gate pt 640	37	25.0	22.7	81	2.5	16.3	800	
supply gate pt 700	38	25.0	22.6	80	2.5	16.3	800	
supply gate pt 760	39	25.0	22.5	79	2.3	16.9	800	
supply gate pt 840	40	25.0	22.4	79	2.4	16.6	800	
supply gate pt 900	41	25.0	22.4	79	2.4	16.6	800	
supply gate behind drive	42	25.0	22.4	79	2.6	16.1	800	Control belt conveyor
supply gate before drive	43	25.0	22.2	77	2.5	16.2	800	
supply gate pt 1050	44	25.0	22.1	76	2.3	16.6	800	"Grunder" pump
supply gate before old face Q°	45	25.0	21.6	73	2.3	16.5	730	
supply gate, dipping, pt 20	46	25.0	21.6	73	2.2	16.7	730	
supply gate, dipping, pt 60	47	24.9	21.5	73	2.1	16.8	730	
supply gate, dipping, pt 120	48	24.8	21.4	73	2.3	16.3	730	
supply gate, dipping, pt 160	49	24.6	21.2	73	2.3	15.9	730	
behind old supply gate Q°	50	24.4	21.1	74	2.2	15.8	730	
before old supply gate Q°	51	24.3	21.0	74	2.7	14.8	790	
supply gate, dipping, pt 130	52	24.2	20.9	73	2.6	14.8	790	
supply gate, dipping, pt 90	53	24.1	20.8	73	2.6	14.7	790	
supply gate, dipping, pt 60	54	24.0	20.6	73	2.7	14.1	790	
dip towards A SE 546 m level	55	23.9	20.5	73	4.1	12.7	1920	in front of face area
A SE 546 m level	56	24.6	21.0	71	4.0	13.8	1920	
A SE 546 m level	57	23.9	20.5	73	3.9	12.7	1920	
A SE 546 m level	58	23.6	20.2	73	3.9	12.1	1920	
A SE 546 m level	59	23.6	20.0	71	3.9	12.0	1920	
A SE 546 m level	60	23.2	19.5	70	4.0	11.7	1920	
behind head of face	61	25.6	23.2	80	0.8	21.1	200	
behind head of face	62	25.6	23.4	82	0.8	21.1	200	
supply gate in dir. of load. pt	63	25.7	23.5	82				
supply gate in dir. of load. pt	64	26.9	24.1	79				
supply gate in dir. of load. pt	65	27.6	25.1	81	0.6	24.0	250	
supply gate before doors	66	27.5	24.9	80	0.6	23.8	250	
near return roller	67	28.0	25.5	81	0.5	24.7	250	
at feeder end	68	29.5	28.0	89				

Continuation of Annex 5b

Site description	No.	T dry bulb	T wet bulb	% R.H.	Air m/s	T eff.	m^3/min	Remarks
in cross-cut	1						2050	
42" belt pt 30	2	30.0	28.5	89	3.8	23.0	2150	
loader gate Q3	3						1150	
behind load. gate Q 3 42" belt	4	31.2	29.2	86	3.2	24.7	1000	
42" belt pt 105	5	31.2	29.2	86	2.0	26.5	1000	
return roller 42" belt	6	32.0	30.1	87	0.8	29.0	1000	
behind drive 2nd belt	7	31.0	29.5	90	3.3	24.6	1000	
2nd feeder belt pt 140	7a	31.0	29.0	86	3.3	24.3	1000	
in front of elec. equipment	8	30.0	28.8	91	30	23.8	1000	
foot of face	8a	29.8	28.5	90	3.0	23.3	1000	
betw. S.M. loader and face	9	32.5	30.9	89	1.4	29.2	320	
at S.M. loader	10	32.7	31.0	89	1.0	29.8	320	
inbye loader gate	11	33.0	30.8	85	2.4	28.4	320	
stall at foot of gate	12	31.4	30.2	92	2.0	27.4		
face cyl. 2	13	28.9	28.1	94	3.1	23.1	1000	
face cyl. 4	14	28.8	28.0	94	3.8	21.3	1000	
face cyl. 6	15	28.5	27.8	94	2.0	23.6	1000	
face cyl. 8	16	28.4	27.7	94	3.6	20.9	1000	
face cyl. 10	17	28.2	27.5	94	3.6	20.4	1000	
face cyl. 12	18	28.1	27.3	93	3.6	20.2	1000	
face cyl. 14	19	27.9	27.1	93	3.6	20.0	1000	
face cyl. 17	20	27.5	26.6	93	3.7	19.1	1000	
face cyl. 20	21	26.9	26.1	93	3.5	18.1	1000	
face cyl. 23	22	26.2	25.5	94	2.2	19.8	1000	
face cyl. 26	23	26.1	25.1	92	3.5	16.8	1000	
face cyl. 29	24	26.0	25.0	92	3.5	16.6	1000	
face cyl. 32	25	25.8	24.6	90	3.6	16.0	1000	
face cyl. 35	26	25.3	24.1	90	3.5	15.3	1000	
head of face	27	25.3	23.0	81	2.4	17.1	800	
head of face after extension	28	25.6	23.3	81	2.5	21.1	800	
supply gate pt 220	29	25.8	23.5	81	2.7	17.2	800	
supply gate pt 280	30	25.8	23.4	81	2.7	17.3	800	
supply gate pt 340	31	25.7	23.2	81	2.6	17.3	800	
supply gate pt 400	32	25.7	23.1	79	2.8	16.8	800	
supply gate pt 460	33	25.6	23.1	79	2.7	16.8	800	

Results of temperature measurements

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ANNEX 5b