Application of the RACAL Airstream Helmet in Four Underground Coal Mines

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The Mine Safety and Health Administration (MSHA) conducted field studies on the RACAL Airstream Helmet to determine its suitability as an interim personal protective device in underground coal mines where technology is inadequate to control dust. The studies of the RACAL Airstream Helmet were conducted in four underground longwall mining sections to evaluate user acceptance and the helmet's applicability to the coal mine environment and to determine the life expectancy of its final filter.

User acceptance and applicability to the coal mine environment were assessed using responses to a questionnaire by miners participating in the studies who wore the helmet in the mines and by actual use of the helmet by personnel conducting the survey. In general, the miners who participated in the study felt that the helmet afforded them personal protection against dust. However, use of the helmet on a continuing basis did present specific problems that would make its universal acceptance questionable. The life of the final filters was determined by monitoring daily the decrease in air quantity through the helmet. The data obtained showed a correlation to previous work conducted in the laboratory in which there was determined to be a relationship between life of the final filter and total airborne dust exposure.

This article summarizes the survey procedure used, outlines specific problems associated with the helmet, and consolidates the results obtained from the four underground evaluations conducted. **Parobeck, P.S.; Francart, W.J.; Ondrey, R.S.; Stoltz, R.T.; Atchison, D.J.; Gerbec, E.J.: Application of the RACAL Airstream Helmet in Four Underground Coal Mines. Appl. Ind. Hyg. 4:126–133; 1989.**

Introduction

Longwall mining was introduced in the United States in 1960. In this method of mining, multiple (usually three to five) entries are driven on each side of the area (called a panel) to be mined as shown on the schematic in Figure 1 for a typical longwall, multiple-entry retreating system. The entries, usually in excess of 600 m (2000 ft) are connected by a set of bleeder entries to facilitate the bleeding of methane from the mined area (gob). Panel widths range from 90 to 200 m (300–650 ft). Coal is removed by either a plowing or shearing technique. Coal is continuously conveyed from the face by an armored flight conveyor to a belt which transports coal from the panel. Self-advancing hydraulic roof supports temporarily support the roof during coal extraction.

Since 1960, the number of longwalls in operation has steadily increased each year until 1981, after which the number of longwalls in operation has remained constant at approximately 90. Although the longwall mining method has many distinct advantages, such as increased productivity and safety, it has a disadvantage in that the levels of respirable dust generated by the coal-cutting operation are often difficult to keep within the limits of the allowable U.S. respirable coal mine dust standard of 2.0 mg/m^3 as stipulated in the Code of Federal Regulations, Title 30, Part 70. In fact, for some of these operations, technology available to keep dust within the applicable standard is not very effective. In these instances, the Federal Mine Safety and Health Act of 1977 requires that respiratory equipment be made available to personnel. However, the use of respiratory equipment does not preclude the use of environmental control measures. It only provides personal protection for employees until environmental controls are instituted.

Approximately eight years ago, an airstream helmet manufactured by RACAL, (shown in Figure 2) was introduced on the market. This helmet provides respiratory protection in dust-laden environments by maintaining a continuous stream of filtered air across the wearer's face. The helmet is powered by a 5-volt rechargeable battery pack that is worn on the belt. Air is induced into an opening in the rear of the helmet by a small motor/fan assembly, filtered, and passed over the wearer's face. A diagram of the helmet is shown on Figure 3. As shown, the helmet contains two filters: a coarse filter to remove large particulates before they enter the helmet and a final fine filter to remove finer particulate

Reference to specific brands, equipment, or trade names is made to facilitate understanding and does not constitute endorsement by the Mine Safety and Health Administration.

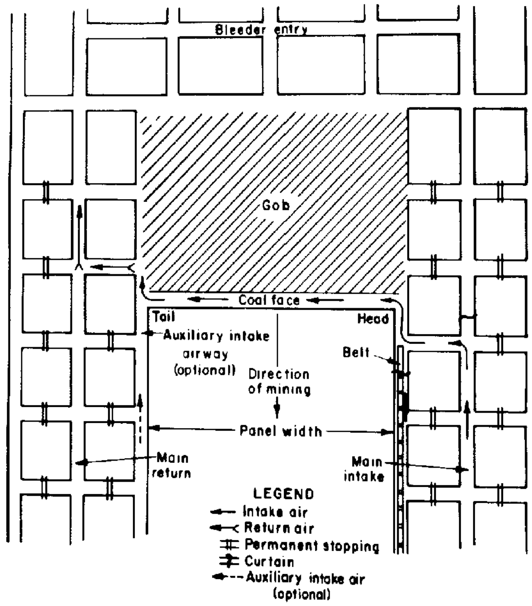

FIGURE 1. Schematic of a multiple entry retreating longwall mining system.

material before the air passes across the wearer's face. This final filter is rated by the manufacturer as being better than 99.5 percent effective against dusts of 0.5 µm or larger in size.

In order to determine the suitability of this helmet as an interim personal protective device in underground coal mines, studies were conducted on four longwall sections at mines using the helmet. The helmet's efficiency for dust removal was not evaluated during these studies since it has been determined previously. In one laboratory study,[1] the efficiency of the helmet for removing particulates from −200 mesh coal and −325 mesh silica dust aerosols was 100 and 99 percent, respectively. A field study[2] demonstrated that the unit reduced respirable dust with an efficiency of 84 percent when working on a longwall mining section having a face velocity under 2 m/s (400 fpm). This study pointed out that the efficiency was significantly reduced when face velocities were as high as 6 m/s (1200 fpm).

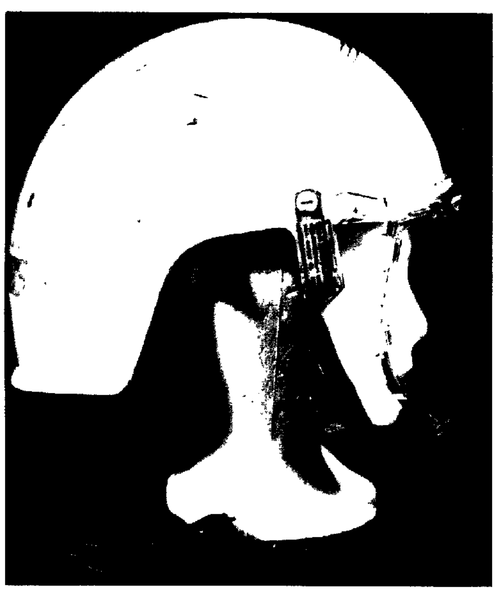

FIGURE 2. RACAL Airstream Helmet.

Table I lists descriptive information on each of the four mines studied. It should be noted that three of the operations employed double-drum ranging-arm shearers for fracturing the coal from the longwall face while one employed a plow. Table II lists parameters characterizing the dust control and ventilation systems employed on each section surveyed. In general, the shearer or headgate operators and shield setters wore the airstream helmets. The number of workers at each mine participating in the survey ranged from four to eight.

The purpose of the studies was to evaluate user acceptance of

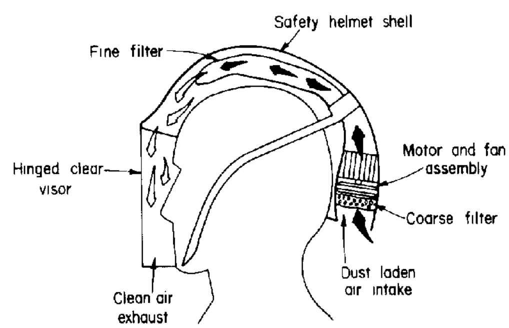

FIGURE 3. Schematic of RACAL Airstream Helmet.

TABLE I. Descriptive Information of Mines Studied

Mine	Seam	Seam Height	Type of Miner	Type of Roof Supports	Length of Face	Panel Depth	Type of Cut
A	Pittsburgh	1.8 m (72 in.)	Sagem DTS 300 Double-Drum Ranging Arm Shearer	Westfalia Chocks	150 m (500 ft)	1650 m (5400 ft)	Unidirectional against air
B	Pocahontas #3	1.3 m (50 in.)	Westfalia Plow	Hemscheidt Shields	140 m (450 ft)	1100 m (3600 ft)	Half-face bidirectional
C	Tiller	1.4 m (54 in.)	Sagem Sirus 400 Double-Drum Ranging Arm Shearer	Westfalia Shields	60 m (195 ft)	825 m (2700 ft)	Bidirectional
D	Lower Kittanning	2.1 m (84 in.)	Anderson Mavor-Double-Drum Ranging Arm Shearer	Thyssin Shields	140 m (450 ft)	1435 m (4700 ft)	Bidirectional

the helmet, to assess its applicability to coal mine environments, and to determine the life expectancy of the helmet's final filter when used under field conditions. User acceptance and applicability to the coal mine environment were assessed using voluntary responses to a questionnaire completed by the miners participating in the study who wore the helmets in the mines. In addition, comments were obtained from the MSHA personnel who also wore the helmets during the conduct of the surveys. The life of the final filters was determined by monitoring daily the decrease in air velocity through the helmet. This article summarizes the procedures used and results obtained from the four studies conducted.

Survey Procedures

Respirable dust samples were collected at fixed-point locations along the longwall face to determine dust levels and were collected on face workmen (personal samples) to determine employees' exposures to respirable dust. In addition, total airborne dust samples were collected at the return end of the face. The total airborne dust samples were collected for the purpose of obtaining information about the size distribution of the aerosol generated by the mining process.

The personal respirable coal dust samples were collected during a full eight-hour shift on various face personnel and on the two MSHA employees conducting the studies. The fixed-point respirable dust samples were collected at the head, midpoint, and the tail of the longwall face and in the main intake airway. The total dust samples were collected at the tail of the longwall face. Fixed-point samplers were operated only during the time they were on section.

Respirable dust samples were collected using approved MSA personal respirable coal mine dust samplers operated at a flow rate of 2.0 L/min. The total dust samples were collected using the same equipment operated at the same flow rate but without the 10-mm cyclone precollector.

All filter cassettes were pre- and postweighed on an analytical balance to a hundredth of a milligram then truncated to a tenth of a milligram. Respirable dust concentrations were converted to MRE equivalent concentrations by multiplying by the constant factor 1.38.[3]

At the start of each study, new final filters were installed in the helmets. At the end of each shift, the quantity of air supplied by each airstream helmet was measured. This was done by attaching a 122-cm (48-in.) section of 10-cm (4-in.) diameter metal tubing (Figure 4) to the helmet's air inlet and measuring the velocity of air in the tubing with an Alnor Model 8500 hot-wire anemometer. Prior to the study, the anemometer was calibrated to an accuracy of ± 1 percent on the 0.05 to 1.5 m/s scale (10 to 300 fpm) using a standardized calibration procedure traceable to the National Bureau of Standards.[4] The precision of subsequent measurements with the anemometer was taken as that specified by the manufacturer (± 3% of reading). Therefore, measurements ob-

TABLE II. Dust Control Parameters in Mines Studied

Mine	Average Intake		Average Water Pressure	Location Where Measured	No. of Sprays	Spray Location	Wetting Agent
	Velocity	Quantity					
A	3.0 m/s (590 fpm)	17.0 m³/s (36,000 cfm)	860 kPa (125 psig)	External spray manifold	98	18-Top of shearer 80-In drums	Wen-Don
B[A]	1.8 m/s (350 fpm)	11.8 m³/s (25,000 cfm)	860 kPa (125 psig)	Venturi spray along panline	62	22-Along panline 40-On shield canopies	Wen-Don
C	0.6 m/s (110 fpm)	6.9 m³/s (14,600 cfm)	600 kPa (87 psig)	Cutting drum	63	7-Top of shearer 4-Bottom of shearer 51-In drums	None used
D[B]	1.0 m/s (200 fpm)	7.6 m³/s (16,000 cfm)	770 kPa (112 psig)	External spray manifold	109	25-Top of shearer 84-In drums	Wen-Don

[A]Plow
[B]Shearer Clearer System (New Technology)

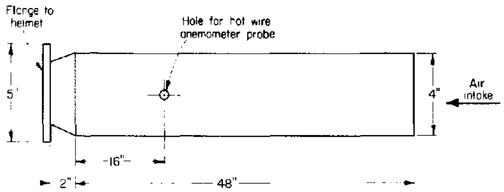

FIGURE 4. **RACAL Airstream Helmet tubing adaptor for making velocity measurements. (Drawing not to scale.)**

tained to quantitate the volume of air passing through the filter were considered to be within ± 5 L/min. If the velocity measured by the hot-wire anemometer fell below approximately 0.4 m/s (75 fpm) (corresponding to the manufacturer's recommended minimum flow rate of 170 L/min) with a battery used on section, the final filter was changed. This check was also repeated with a fully charged battery. In all cases, there was agreement with the results determined from the use of a battery which had been used on section.

Air flow through the helmet was also checked using a standard air flow indicator disc (RACAL Part AS144) supplied with the helmet. Basically, this procedure involves inserting the plastic disc over the air inlet of the helmet. If the disc is retained on the inlet, air flow through the helmet is considered adequate, which implies a good final filter. In addition, during the study at the second mine, air flow through the helmet was also checked using an AS145 air flow indicator disc. This disc was provided by a RACAL technical representative who visited the test site during this study. The 145 disc has a larger opening and is slightly thicker than the 144 disc. Therefore, a larger air flow is required for the 145 disc to be retained on the air inlet of the helmet. The results obtained with the air flow indicator discs were compared to the velocity measurements obtained with the hot-wire anemometer to determine the validity of using the disc to judge helmet performance.

The life of each final filter, when used in the field, was compared to predicted life expectancy obtained from laboratory data. This was done to determine if laboratory data are applicable for predicting life expectancy of the filters. The total dust concentration to which final filters were exposed was estimated by multiplying the respirable dust exposure of the person who wore the helmet by the average of the daily ratio of the total and respirable dust measurements obtained at the tail of the longwall face in each study.

In addition, a questionnaire (Appendix A) was distributed to participating miners at the beginning of each study. The questionnaire, whose completion was voluntary on the part of the miners, contained 16 questions relating to potential problems associated with wearing the helmet. All completed questionnaires were collected at the end of each study and the results tabulated.

Discussion

The personal and fixed-point measurements obtained during the respective studies are given in Tables III and IV, respectively. The results show that the average exposure of the designated occupation in all of the studies was above the applicable 2.0 mg/m³ respirable dust standard. The designated occupation is that occupation on a unit of mining equipment which was determined previously to have the greatest respirable dust concentration.

During these four studies, the adequacy of the quantity of air supplied by the helmet as the filter loaded was evaluated 163 times using the hot-wire anemometer velocity measurements and the RACAL AS144 Airflow Indicator Disc. A comparison of results obtained using these two methods showed that there was disagreement between the two methods 15 percent of the time (24 instances). In 20 of the instances of disagreement, the velocity measurements showed that a sufficient quantity of air was passing through the final filter, while the disc indicated the final filter needed to be replaced. The precision of the air quantity measurement was taken into consideration when making a determination on what was considered a sufficient quantity of air; i.e., a sufficient quantity of air was considered to be delivered through the filter if the flow rate had not dropped below 165 L/min.

However, in four of the cases of disagreement, the disc would have allowed the helmet to be used with inadequate air flow because of an overloaded final filter. Therefore, although the air flow indicator disc check disagreed with the velocity measurement 15 percent of the time, there was only a 2 percent disagreement which would have allowed for prolonged use of the final filter when, in fact, it should have been changed.

In the second mine, there was disagreement between the results obtained with the 145 disc and the velocity measurements

TABLE III. **Personal Respirable Dust Exposures of Face Workers (mg/m³ MRE equivalent)**

	Mine A						Mine B						Mine C							Mine D				
Shift No.	**1**	**2**	**3**	**4**	**5**	**Avg.**	**1**	**2**	**3**	**4**	**5**	**Avg.**	**1**	**2**	**3**	**4**	**5**	**6**	**Avg.**	**1**	**2**	**3**	**4**	**Avg.**
Shearer Operator													4.0	5.3	2.7	2.6	2.4	2.6	3.2*					
Head Shearer Operator	8.6	18.3	—	9.5	6.7	10.7														4.4	2.9	3.1	4.2	3.7
Tail Shearer Operator	8.6	9.6	9.5	9.3	6.9	8.7*														4.0	5.9	3.7	5.1	4.7*
Chocksetter	0.8	1.6	0.9	0.8	1.7	1.1	0.9	7.1	1.7	1.9	1.3	2.5	1.2	1.3	0.9	0.6	1.1	0.4	0.9	2.0	1.5	2.0	5.7	2.8
Chocksetter	2.2	3.5	2.0	0.6	4.4	2.5	2.0	1.3	1.9	2.0	3.5	2.1	1.9	2.3	0.9	0.8	—	0.9	1.3	2.6	2.6	3.4	2.2	2.7
Chocksetter	5.5	7.7	8.0	7.8	3.1	6.2	1.3	6.0	1.6	2.7	2.3	2.7	—	2.6	0.9	1.1	1.2	1.3	1.4					
Chocksetter													4.4	3.0	1.1	1.7	2.3	2.0	2.4					
Headgate Operator							1.3	2.8	0.4	0.8	1.3	1.3												
Tailgate Operator							2.0	2.0	2.6	3.5	2.6	2.5*												
Snaker																				3.4	2.6	—	—	3.0

*Designated occupation

TABLE IV. Fixed-point Respirable Dust Concentrations (mg/m³ MRE equivalent)

	Mine A							Mine B						
Shift No.	**1**	**2**	**3**	**4**	**5**	**6**	**Avg.**	**1**	**2**	**3**	**4**	**5**	**6**	**Avg.**
Intake	0.4	0.1	0.1	0.2	0.4	0.1	0.2	2.0	0.5	0.4	0.1	0.4	0.5	0.6
Headgate	0.9	1.2	0.8	0.6	0.8	0.9	0.8	1.2	2.3	1.6	1.9	3.1	4.0	2.3
Midface	3.0	4.8	4.0	2.3	3.5	5.3	3.8	1.3	5.7	2.4	3.4	3.0	—	3.1
Tailgate	5.9	10.2	12.4	8.2	5.2	10.4	8.7	4.2	12.2	—	4.2	5.3	3.8	5.9
Tailgate total airborne	50.0	89.4	87.2	65.3	46.7	87.2	70.9	14.6	—	23.6	33.7	29.5	48.8	30.0
Tonnage	2400	2688	2904	2040	1584		2323	1040	1620	750	1250	1143	—	1160

	Mine C								Mine D								
Shift No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Avg.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Avg.**
Intake	0.6	0.8	0.9	0.6	0.6	0.8	0.9	0.7	0.2	0.4	0.4	0.6	0.2	—	0.1	0.1	0.2
Headgate	1.1	1.2	2.0	0.8	1.1	0.9	1.5	1.2	1.5	1.9	1.5	1.5	1.5	2.0	1.3	1.2	1.5
Midface	1.6	2.8	2.0	1.6	1.1	1.7	1.2	1.7	2.3	2.2	1.7	3.7	3.8	5.5	3.0	2.3	3.0
Tailgate	1.9	1.3	1.2	1.6	1.5	2.2	2.4	1.7	3.4	12.5	2.8	8.0	2.3	10.4	7.4	6.4	6.6
Tailgate total airborne	—	10.2	5.8	18.2	6.1	16.7	—	11.4	16.8	24.0	14.5	37.0	21.4	21.1	44.5	27.8	25.8
Tonnage	390	700	350	540	290	440	530	462	2450	2100	1925	2275	1400	2450	2100	1400	2012

9 out of 26 times. In all nine cases of disagreement, the velocity measurements indicated the final filter was good, while the disc indicated the filter needed to be replaced. Therefore, when the 145 disc check disagreed with the velocity measurement, disagreement would have resulted in the installation of a new final filter. Although use of the 145 disc always resulted in providing adequate air flow through the helmet, its physical design (weight and larger opening) can lead to premature changing of filters.

Velocity measurements led to 24 filter changes during these studies. However, after two of the final filters were changed, it was determined that their failure was due to bad motor housing assemblies and not to dust loading.

It was not possible from these studies to establish a life expectancy for the helmet's final filter. The life of filters that were changed varied from one to eight shifts. The variation in filter life is attributed to varying dust levels present at the work site and to the manner in which the individual miner was exposed to the dust on the longwall face (tending to be upstream of the shearer or vice versa).

The estimated loading of filters that were changed was compared to laboratory data established for estimating the life expectancy of the filters.[1] This comparison is shown in Figure 5. Thirteen of 20 data points are in close agreement with the established laboratory data. Although the actual reasons for four of the filters lasting longer than expected and three not lasting as long as expected are unknown, it should be noted that the variation in the concentration and particle size distribution of dust underground can be considerably different than that generated in the laboratory. Additionally, in the laboratory study, the helmet was operated continuously until the final filter was loaded with dust; during the field study the helmets were often turned off when the longwall was not operating and also during travel time. One reason the field and laboratory data differ could be that field data points plotted in Figure 5 represent full-shift time (8 hours), while in reality actual helmet operating time was unknown.

A total of 26 questionnaires were completed by employees who regularly wore the airstream helmets. The responses are summarized on the questionnaire shown in Appendix A. All of the employees except one thought that wearing the helmet would protect them from dust. Most of the employees had been wearing the helmet for approximately one year, and it had taken them a week or more to get used to wearing it. One employee claimed he never got used to wearing it. Most employees felt the helmet impaired vision; the visor had a history of fogging, but in the mines under study, antifogging agents had been applied to the visor.

Helmet noise does not appear to interfere with job performance. Most agreed that the air flowing across the face did not cause discomfort and would not prevent them from wanting to wear the helmet. Two-thirds of the respondents did not believe

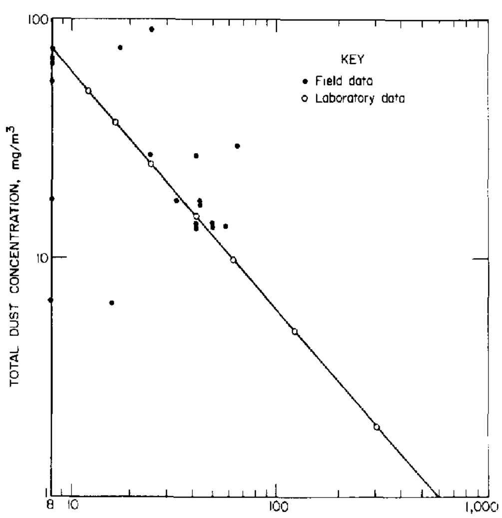

FIGURE 5. Filter life versus total airborne dust exposure.

that wearing the helmet caused any unsafe working conditions and indicated that they would be willing to wear the helmet regularly.

Specific problems with the helmet (enumerated in the questionnaire and observed by MSHA personnel conducting the studies) include the following:

1. The helmet is uncomfortable, bulky, and inconvenient to wear. The helmet is top heavy and tends to fall off when the head is tilted sideways (the use of the chin straps available from RACAL helps solve this problem). Also, the cap lamp cord occasionally snags on an object, causing the cap lamp or the helmet to be pulled off.
2. There is no "head" clearance when wearing the helmet under low top and under low shields. When moving in these conditions, vision is obstructed because the rear of the helmet, which extends towards the base of the neck, makes it difficult for the wearer to raise his head when crawling or stooping. In addition, the base of the helmet digs into the back of the neck when a low obstruction is struck by the helmet.
3. The helmet visor causes difficulty in seeing clearly at both close and distant ranges. The difficulty in seeing at distant ranges is due to excessive glare from the fluorescent lighting, a problem which can also be aggravated if the face shield is scratched. The difficulty in seeing at close range (such as on one's own person) is due to the visor's restriction in allowing the head to tilt forward.
4. The visor always fogs when doing vigorous manual labor such as shoveling. This restricts vision completely.
5. Peripheral vision is impaired due to the translucent visor support and the temple seals.
6. The temple seals interfere with the wearing of eyeglasses. Also, one eyeglass wearer complained of the air blowing across his face.
7. In some instances, the face visor will not stay up after a few months' wear.
8. The cap lamp points up when the visor is raised, making it difficult to see if there are no other light sources nearby.
9. The belt clip on the battery is too short (battery would pop off the miner's belt).
10. The plug on the end of the motor cord is easily pulled out of the battery because the fit is too loose.
11. A permanent cap lamp cord holder is needed.
12. Final filters are hard to change.
13. Batteries do not last a full shift.

Some problems which are associated with wearing the helmet or are mechanical in nature could be minimized or eliminated easily. For example, one complaint which could be easily addressed is the apparent short battery life which was traceable to improper charging. On two separate days an employee complained that his filter needed to be changed. In both instances, the battery was poorly charged. An adequately charged battery would have provided an adequate air supply. To assure proper charging, a voltmeter/ammeter should be used to check the battery charge before the battery is taken underground.

Regarding the problem of visors easily scratching, the RACAL technical representative who visited one test site indicated that a more scratch-resistant visor could be produced at an increased cost. However, the company is reluctant to do this unless there is an established market for these helmets. In addition, a stick-on visor shield is currently available for use.

In addition to the problems associated with wearing the helmet, there were problems with the use of the air flow indicator disc which prevented its use in some cases. One such problem developed because of a ridge around the motor housing assembly of some helmets. The motors of these helmets had been repaired and when the motor assemblies were inserted into the helmets, the circular seam, shown in Figure 6, between the helmet and the motor housing was sealed with a hot iron. This produced an irregular ridge which would occasionally cause the air flow indicator disc to "hang up" and remain on the helmet after the fan motor had been turned off. Therefore, care had to be taken to ensure the air flow indicator disc did not "hang up" on these ridges, giving a false indication of the status of the final filter.

Another problem which affected the use of the air flow indi-

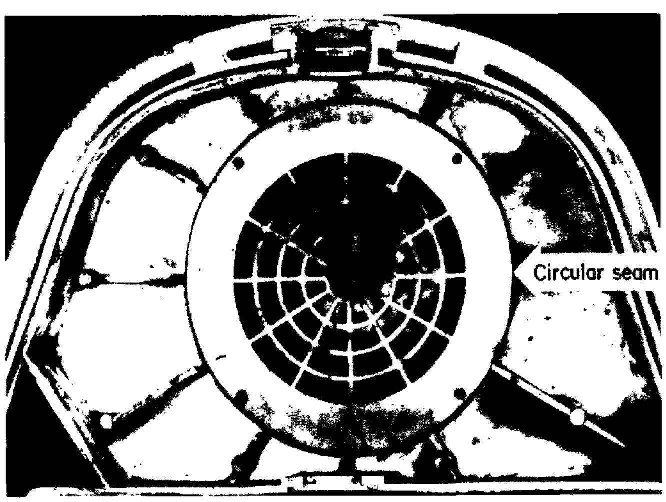

FIGURE 6. Motor housing assembly on RACAL Airstream Helmet.

cator disc was that some motor housing assemblies had convex rather than flat surfaces. This prevented the air flow indicator disc from seating properly (lying flat) on the motor housing assembly. Consequently, the air flow indicator disc would always fall off the motor housing assembly, even when testing a newly installed final filter.

Maintenance of the helmets varied among the four mines. One mine had a structured maintenance program with a single individual responsible for maintenance of all helmets. The other mines left the maintenance responsibilities to each individual miner. The structured maintenance program ensured that all helmets were regularly attended to on a daily basis. The only problem associated with this type of maintenance program was the interchanging of parts among various helmets, causing employee dissatisfaction. Overall, however, this was noted to be the better system of maintenance because of the daily cleaning and inspection of the helmets. The helmets' final filters for this mine were changed using the air flow indicator disc check. In the other mines, the helmets' final filters were changed at the discretion of the miners.

Cost data were obtained for two of the mines in which studies were conducted. Both of these mines used approximately the same number of helmets, yet the monthly maintenance cost varied considerably. In the mine where the final filters were changed at the discretion of the miner, the monthly maintenance cost was approximately $2,500. In the mine where the final filters were changed based on the air flow indicator disc check, the monthly maintenance cost was approximately $800.

Another observation was whether the helmets were worn or carried into the mine. In only one mine were the helmets worn into the mine. When the helmets are worn into the mine, it is easier to keep them clean internally, thus causing less reluctance to wear them.

Summary

Studies were conducted on the RACAL Airstream Helmet in four mines to evaluate user acceptance, to determine the helmet's applicability to the coal mine environment, and to determine the life expectancy of its final filter. In general, the miners who participated in the study felt that the helmet afforded them personal protection against dust. However, use of the helmet on a continuing basis does present specific problems. For instance, miners refused to wear the helmet when doing heavy labor (e.g., timbering, shoveling, and pulling cables) because of visor fogging. The helmet was found to be difficult to wear when working in low coal situations. However, effectiveness was found to be increased when there was a structured helmet maintenance program at the mine.

Life expectancy of the final filter could not be directly determined from data obtained during this study. The data obtained show, however, that the field data correlate fairly well to laboratory data obtained for filter life versus total airborne dust exposure. Thus, the laboratory data can be used as an indicator for filter life. This study also shows that, with proper use, the RACAL indicator disc provides a generally reliable indicator for determining decreased air flow through the helmet and the resulting necessity for changing the helmet's final filter.

Conclusion

In conclusion, although a laboratory evaluation[1] has shown that the airstream helmet has the capability to provide adequate protection in mine environments where the total dust concentration ranges from 9.5 to 37.6 mg/m^3, this field study suggests that adequate protection is not absolutely ensured in underground coal mines because, among other things, face shields were not always maintained in a "closed" or down position, mine personnel had tendencies not to wear the helmet when it interfered with job performance, and power supply failures reduced the effectiveness of the helmet's performance. In addition, the helmet's filtration system was not always maintained. If the airstream helmet is used on longwall sections where miners are exposed to dust levels in excess of the 2.0 mg/m^3 respirable dust standard, procedures for their maintenance and use are necessary to ensure that adequate protection is provided.

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APPENDIX A

QUESTIONNAIRE
(User evaluation of the Airstream Helmet)

Date ______________

1. Name (optional) ______________
2. Occupation ______________
3. Your height ______________
4. Do you believe that wearing the helmet will protect you from dust?
   Yes [25] No [1]
5. How long have you been wearing the helmet?
   Less than 1 week [1] 1–2 weeks [3] 3–4 weeks [0] Month or longer [22]
   If longer than a month, how long? ______________

6. Is the headband comfortable?
Yes [12] No [14]
If no, what appears to be the problem? ______

7. How long did it take you to get use to wearing the helmet?
Immediately [2] 1 week [9] 2 weeks [4] Longer [8] Never [1]
8. Is the helmet comfortable now?
Yes [12] No [14]
If no, what appears to be the problem? ______

9. Have you had problems with the helmet?
Yes [16] No [10]
a. What was the problem? ______

b. Do you consider the problem
Severe [4] Moderate [10] Minor [9]
c. Do you have any suggestions to correct the problem? ______

10. Does helmet noise interfere with performance of your job?
Yes [6] No [20]
If yes, how does it interfere? ______

11. Does the visor ever fog?
Yes [22] No [4]
If yes, how often? ______
Under what conditions? ______
Was an anti-fogging agent applied to the visor?
Yes [5] No [19]
12. Does the helmet impact vision?
Yes [18] No [8]
If yes, how does it impact vision? ______

13. Is the air blowing across your face a discomfort?
Yes [2] No [24]
If yes, why? ______
Would this prevent you from wanting to wear the helmet?
Yes [1] No [9]
14. Do you believe that wearing the helmet causes any unsafe working conditions?
Yes [9] No [18]
If yes, what? ______

Could anything be done about it?
Yes [6] No [4]
If yes, what? ______

15. Any other comments about the helmet? ______

16. Would you be willing to wear the helmet regularly?
Yes [14] No [8]
If yes, when?
[8] all the time
[9] when I believe I need it.
[5] when directed to, based on the dust level.