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RECOMMENDED GUIDELINES FOR OXYGEN SELF-RESCUERS — VOLUME IV — UNDERGROUND NON-COAL MINING

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The Bureau of Mines initiated a contract for the development of guidelines for the storage and use of self-contained self-rescuers (SCSR) in underground noncoal mines. An SCSR is a device capable of supplying, in an emergency, 1 h of self-contained oxygen (no breathing of mine air). The information and recommendations in this report were developed primarily from three sources: discussions with mine representatives (including management, labor, and government), site visits in underground mines, and a detailed analysis of every reported noncoal accident that produced hazardous atmosphere during the 5-year period 1976-80, plus 10 other major incidents from prior years.

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DISCLAIMER

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies or recommendations of the Interior Department's Bureau of Mines or of the U.S. Government.

FOREWORD

This report was prepared by Foster-Miller, Inc., Waltham, MA, under USBM Contract No. J0199118. The contract was initiated under the Minerals Health and Safety Technology Program. It was administered under the technical direction of Pittsburgh Research Center with Jerry Stengel acting as Technical Project Officer. Sylvia Brown was the contract administrator for the Bureau of Mines. This report is a summary of the work recently completed as a part of this contract during the period December 1980 to December 1982. This report was submitted by the authors in June 1983.

The technical effort was performed by the Mining Division of the Engineering Systems Group, with Randolph Berry as Program Manager and Donald Mitchell as Senior Engineer.

The authors would like to extend their special appreciation and acknowledgement to the literally hundreds of mining industry representatives who supplied fact and opinion which contributed to this report: owners, operators, management and labor of underground United States mines and representatives from state and federal mining agencies.

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1. INTRODUCTION

1.1 Regulations

Section 57.15-30, 30 CFR 57, requires that a 1-hr self-rescue device must be made available by mine operators to all personnel in underground metal and nonmetal mines (including stone). These devices are jointly approved by the Mine Safety and Health Administration (MSHA) and by the National Institute for Occupational Safety and Health (NIOSH). Most, if not all, of the devices used are Filter Self-Rescuers (FSRs) approved under Subpart I of Part 11, 30 CFR.

Coal miners also must have 1-hr self-rescue devices (30 CFR 75.1714). Theirs, however, must be Self-Contained Self-Rescuers (SCSRs), also called oxygen self-rescuers, approved under Subpart H of Part 11. SCSRs provide a closed-circuit source of oxygen rather than filter carbon monoxide (CO) from the air in the mine. Thus, they protect coal miners from an oxygen-deficient atmosphere and from toxic products in addition to CO.

Guidelines for implementation of Section 75.1714 are given in two Memoranda of MSHA, in Appendix C of this report.

1.2 Status of SCSR Technology

This study and the findings therefrom are based in part on SCSR technology, knowledge and experience as it existed in the Spring of 1982.

Five models of approved 1-hr SCSRs are commercially available. Two use a chemical, potassium superoxide (KO_2), to produce oxygen and reduce CO_2 concentrations. The other three provide oxygen from a bottle and have a CO_2 scrubber. Four of the five units are similar in outward appearance: They have a size, configuration and weight not too unlike a 1-gal bottle of milk. Two belt-worn, 10-min models have been approved but are not commercially available. More details on all models of SCSRs are given in Appendix D.

Several studies of SCSRs have already been conducted, as described in the following paragraphs:

Recommended Guidelines for Oxygen Self-Rescuers - Volume I, Underground Coal Mining (1) provide recommendations to assist coal miners, operators and MSHA in interpreting and implementing the regulations which require SCSRs in coal mines. The primary emphasis was on the planning and implementation of storage plans.

Recommended Guidelines for Oxygen Self-Rescuers - Volume II, Appendices (2) contained technical data and documentation to supplement the recommendations in Volume I. Among the topics were reports of interviews with coal mining representatives, analysis of post-1972 coal mine fires and explosions, and analyses of SCSR maintenance and training.

Recommended Guidelines for Oxygen Self-Rescuers - Volume III, Coal Mine Escape Speed Studies (3) reported on how fast a miner could escape from underground coal workings. Data were also obtained on the oxygen consumption of miners and the life of chemical SCSRs used in escaping.

Evaluation of the Safety of One-Hour Chemical Self-Rescuers (4) reported on an investigation into the fire hazards associated with the use of chemical oxygen self-rescuers. It was found that the chance of a fire being caused by a chemical oxygen self-rescuer was finite but exceedingly small and that this risk did not outweigh the benefits of having chemical SCSRs available to the coal mining population.

Laboratory Testing of Chemical Oxygen Self-Rescuers for Ruggedness and Reliability (5) contained the results of chemical-oxygen SCSR laboratory testing designed to simulate underground environmental conditions. Chemical-oxygen SCSRs subjected to the testing were found to have no significant degradation in performance in either the man test or breathing machine tests.

Evaluation of Self-Contained Self-Rescuer (6) contained several major conclusions:

a. Although coal miners *could* comply with the requirement to wear, carry or be within 25 ft of a SCSR, storage plans should and will be the rule in order to minimize the nuisance and mobility restrictions caused by the size and weight of the present SCSR.

b. Coal miners prefer the additional protection afforded by a SCSR.

c. Chemical SCSRs are safe and reliable (compressed oxygen units had not been tested at this time)

d. Future effort should be directed towards improving the wearability, decreasing size and weight, and a continuing USBM/MSHA/NIOSH long-term program to evaluate SCSRs already placed in service.

1.3 Basis of Findings

The findings given in Section 2 are based on the information, experience and judgment gained from the following sources in addition to that derived from the studies previously cited:

a. Discussions with managers and key personnel in the six MSHA Metal and Nonmetal Safety and Health Districts. These are included in Appendix B.

b. Detailed discussions with almost 200 miners and persons representing metal and nonmetal miners and mine operators. These are included in Appendix B.

c. Examination of how SCSRs might be used in 17 operating mines. These are also included in Appendix B.

d. Analysis of the 102 reported accidents involving potentially irrespirable atmospheres in metal and nonmetal mines during the years 1976 through 1980, plus ten major accidents from prior years. These are detailed in Appendix A.

2. FINDINGS

2.1 Need for SCSRs

The need for SCSRs in coal mines, and the best methods for satisfying that need, have been well documented in the references cited in the previous section. Our study of the need for SCSRs in noncoal mines resulted in finding of some key differences between coal and noncoal, both in terms of the need for SCSRs and how that need should be satisfied:

Greatest need for SCSRs

Coal: The accident history in coal shows many instances in which FSRs were inadequate, either because of low O_2 or high CO. SCSRs were therefore required.

Noncoal: In general, SCSRs show a clear advantage over FSRs in accidents involving poorly ventilated workings. In these instances, however, SCSRs would have to be immediately available.

Implementation Methods

Coal: Where SCSRs would be required in an accident, there is usually sufficient time for a miner to travel to a storage location where an SCSR can be picked up and donned. In Volume I of this report, "Sufficient time" was defined as 5 min.

Noncoal: In accidents where SCSRs might have saved lives, SCSRs would have to be donned at the first sign of danger, perhaps even before the miner's awareness that danger exists. This requires wearing or carrying an SCSR.

Fires

Coal: Coal mine fires have often produced atmospheres with low O_2 or high CO which render FSRs inadequate.

Noncoal: Fires in noncoal mines have been found to produce atmospheres in which FSRs would be sufficient protection for escape, provided that escape procedures are implemented promptly.

Implementation Methods

Coal: Discussed previously. Most desirable storage location for section workers is the mouth of the intake escapeway.

Noncoal: There are often instances in which a fire may be suspected but not yet discovered. Those miners searching for a fire - or any other source of an irrespirable atmosphere - might improve their level of protection by carrying an SCSR in the event that escape becomes necessary.

Adequacy of SCSR

The 1-hr duration of SCSRs might be much more or considerably less than needed in noncoal mines. Miners are or should be within 30 min of safety. If access to a safe area is prevented, they often will need many hours of oxygen. Observations in all of the deep-shaft, multi-level mines visited in this and in prior studies indicated miners should have little difficulty using FSRs in reaching shaft stations in fewer than 30 min. In room-and-pillar operations and drifts they could walk to fresh air in fewer than 30 min, often 10 to 15 min. Section 57.11-50, 30 CFR 57, requires among other things, "In addition to separate escapeways, a method of refuge shall be provided for every employee who cannot reach the surface from his working place... within...one hour... . These refuges shall be positioned so that the employee can reach one of them within 30 min from the time he leaves his working place."

2.2 Recommendations

Recommendation No. 1

Where SCSRs may be required, every effort should be made to utilize storage plans rather than wear and carry. The sole exception to this recommendation is in Recommendation No. 2.

Recommendation No. 2

Where SCSRs may be required for protection from atmospheres in poorly ventilated workings, SCSRs should be worn, carried, or kept within 25 ft. Storage plans should not be allowed.

Recommendation No. 3

Where SCSRs may be required for protection from atmospheres in fires, storage plans should be allowed. FSRs should continue to be worn.

Recommendation No. 4

Shaft stations (provided that doors are installed), communication stations, and refuge chambers are good storage locations. Pumps stations, shops, electrical installations, and powered equipment are bad locations.

Recommendation No. 5

Some metal and nonmetal miners have a greater need for access to SCSRs. This category includes the following:

a. Mantrip operators and cagers

b. Supervisors

c. Miners attempting to locate a fire

d. Miners working downwind of a potentially irrespirable atmosphere

e. Miners who may be exposed to salt dust-filled air.

Recommendation No. 6

Some metal and nonmetal mines require daily mantrips involving changes in elevations of up to 6000 ft and temperature differentials of up to 150°F. Underground storage should be preferred to daily transportation of SCSRs on such mantrips. Storage should be provided in locations where temperatures are above 23°F and below 100°F.

Recommendation No. 7

A rigorous training program should accompany any introduction of SCSRs. The traditional emphasis on how to operate the unit should be maintained, but increased emphasis must be placed on recognizing danger signals and deciding *when* to don a SCSR.

2.3 Discussion

Recommendation No. 1

The experience in coal mining has been that SCSR usage would, should, and has primarily been implemented through storage plans rather than wear or carry. This is documented in Volume I and II of this report (1, 2) and in an MSHA evaluation (6). Metal and nonmetal mining will often involve even more restricted spaces and difficulty in traveling - such as up raises, ladderways, and through 24 in. × 24 in. openings in platforms. Thus, storage plans might be even more necessary in noncoal than in coal mines.

Although storage plans might be the rule, the only hazards in which SCSRs might have saved lives in the past would have required immediate use of an SCSR, as discussed in the next paragraph.

Recommendation No. 2

The accident history analyzed and discussed in Appendix A taught that the one application in which SCSRs offered a clear advantage over FSRs was in hazardous atmospheres caused by poorly ventilated workings, or the unplanned rapid release of gases (subsections A.3 and A.4). In these instances, however, the SCSR would have had to be immediately available, perhaps even before the miner was aware of the need. This requirement for immediate availability was confirmed by many of the miners and mining industry representatives interviewed during this program (subsection B.3, Appendix B).

Recommendation No. 3

Our analysis of previous fires in metal and nonmetal mines and calculations of the products of combustion in actual and hypothetical fire situations (subsection A.6, Appendix A) show that miners should have sufficient time to reach a stored SCSR were it required. Furthermore, the belt-worn FSR should provide adequate protection prior to reaching an SCSR, even if the miner must travel through products of combustion. (The bigger problem is training the miners to don FSRs - see subsection 2.4).

Recommendation No. 4

The majority of the fires which were analyzed occurred on or around mobile or electrical equipment. Typically, the fire extinguisher on the equipment could not be used, being inaccessible because it was in the fire area. It is reasonable to assume that machine-stored SCSRs would be equally inaccessible in the event of fire.

On the other hand, a communications station is an excellent storage location because a miner can report a fire or suspicion of fire and obtain a SCSR at the same time.

Recommendation No. 5

After the Sunshine disaster, an 8-hr supply of air or oxygen for hoistmen was made mandatory. Several mine safety departments which we interviewed expressed interest in supplying their hoistmen with a 1-hr portable supply so that they could exit the mine after the last man was hoisted. The major requirement was that the hoistman should be able to "unplug" his hose from the fixed 8-hr supply and plug into a portable supply. Although currently available SCSRs would not provide this "plug in" capability, they would at least provide the hoistman with a self-contained air source to permit leaving the mine.

Accident history shows that there are several categories of workers other than hoistmen who may be among the last to leave a mine in the event of fire. Included in this grouping would be cagers and supervisors.

Another category of worker who may be exposed to greater than normal risk are those persons responsible for locating a fire. Although persons in those two groups may not encounter oxygen-deficient air, they might be exposed to dangerous levels of CO (high concentrations and/or prolonged exposure) and the use of an SCSR should increase their confidence.

SCSRs also could be considered for persons working downwind of a potentially irrespirable hazard. Subsection A.6 of Appendix A describes procedures to calculate the oxygen and CO percentages in the air from a fire. These procedures could be used to determine the possible need for SCSRs downwind of a diesel fuel storage, a wood-lined drift, and a raise, to mention some examples.

A final category in which SCSRs might be considered is in mines where there is a potential for accidents involving salt dust-filled air. As explained in subsection A.4.1, prior experience has shown that salt dust concentrations can be enough to actually clog filter-type respirators similar to FSRs.

Recommendation No. 6

In general, carrying SCSRs on mantrips should not be encouraged, for the same reasons which were discussed for coal mining in Volumes I and II of this report. In addition, metal and nonmetal mines mantrips tend to be more crowded and exposed than do coal mantrips, making storage or carrying more difficult. In addition, some metal and nonmetal mantrips involve extreme changes in elevation and temperature which in the past have been detrimental to FSRs (subsection B.2, Appendix B).

Recommendation No. 7

As discussed further in Section 3, the accident analysis of Appendix A shows an astonishing number of miners who did not don their belt-worn FSRs when faced with the danger of a hazardous atmosphere. There is no reason to believe that this trend would be improved when a bigger, more complicated, more expensive self-rescuer is introduced. Thus, there will be an extreme need to train miners not just in *how* to use a SCSR, but *when*.

2.4 Other Factors

Some practices in metal and nonmetal mines have the potential for increasing the chance of exposing miners to irrespirable atmospheres. Many miners believe the risk for such atmospheres is low in metal and nonmetal mines as compared to coal. They cite the noncombustibility of most metal and nonmetal mine strata; and, the fact that almost all coal mines liberate methane and coals are generally capable of igniting, propagating flame and liberating toxic and volatile products. Also cited are the more than 500 major disasters recorded in coal mines as compared to 104 in metal and nonmetal mines since the 1860's.

It is difficult to use past data to evaluate risks; accidents in metal and nonmetal mines prior to 1966 were not required to be reported. Data for the period 1976 through 1980, given in Table 1, indicate a higher incidence of fires and explosions in metal and nonmetal mines than in coal. There has been a major reduction in

TABLE 1. - Fires and explosions in underground mines, from 1976 to 1980

	Fires			Explosions			Million man-hours	Average number of mines*
		Injuries			Injuries			
	Accidents	Fatal	Non-fatal	Accidents	Fatal	Non-fatal		
Coal	41	1	65	4	32	3	1071	2289
Metal/nonmetal	66	0	28	2	5	6	281	745

*The number of operating mines varies from year to year. This figure represents the average number of mines operating on *any given day* during the 5-year survey period.

Source: References A89 to A120, Appendix A.

coal mine fires, an average of 8 per year from 1976 through 1980 as compared to typically more than 50 a year prior to 1970. Major explosion frequency in coal mines has not changed much, 4 in the 5-year period 1976 to 1980 as compared to 22 in the preceding 25 years. The decrease in coal-mine fires is attributed, by the Subcommittee on Underground Coal Mining of the National Fire Protection Association's Committee on Mining Facilities, to the technical, operational and legal changes, particularly in electrical systems, that have occurred since 1969.

One deficiency that could have serious repercussions is the failure of metal/nonmetal miners to use FSRs during evacuation. During the period 1976 through 1980, only 19 of more than 400 miners escaping through smoke put on FSRs; none of the many thousands of other miners evacuating put on FSRs. This is not necessarily typical; in the Lakeshore Mine fire (1973) all of the miners except the two who were trapped donned FSRs, were hoisted in the smoke-filled exhaust air, and came through without injury. That is a classic example of FSR adequacy and effectiveness when miners are properly trained and use their FSRs.

Another serious deficiency was delay in evacuating miners following awareness of smoke. In 22 of the 48 fires synopsized in Appendix A, orders for evacuation were delayed for 20 to 120 min after smoke or fire was encountered. Causes for delay included:

a. Waiting for permission from senior officials who were either on the surface or away from the mine

b. Miners and supervisors searching for the source of the smoke

c. Fighting the fire, before reporting it.

The latter cause could have an adverse impact on successful escape should miners depend on SCSRs. In general, miners will stay and attempt to extinguish a fire rather than escape. Sometimes they will be successful and sometimes not. This attitude of combativeness in the face of adversity is a characteristic of miners. A danger could exist in this trait should the miner be given an oxygen source and told it will protect him against all atmospheres. This could increase his likelihood to stay and fight a fire, regardless of its magnitude, rather than escape. While his exertions deplete his oxygen source, the fire-produced atmosphere is extending farther and farther. Should the miner then be forced to flee, he may not have sufficient oxygen.

Some other deficiencies observed in mines and in reports of accidents that need attention were:

a. Uncontrolled airflows through abandoned workings containing large quantities of wood and/or sulfide-bearing waste

b. Ventilation systems either being inadequately designed or maintained for rapid evacuation and positive escape

c. Communications not being readily accessible. In one mine, stope miners, motormen, mechanics, electricians, geologists, engineers, hoistmen, and supervisors had pagers that worked; mine management considered these to be cost-effective for production as well as safety.

3. REFERENCES

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4. Watson, Doyak and Furno, "Evaluation of the Safety of One-Hour Chemical Self-Rescuers," USBM Open File Report No. 123-80, 1980.

5. Stengel, Kyriazi and Benz, "Laboratory Testing of Chemical Oxygen Self-Rescuers for Ruggedness and Reliability," USBM Report of Investigations No. 8657, 1982.

6. Peluso, R.G., D.H. Huntley and E. Teaster, "Evaluation of Self-Contained Self-Rescuers," MSHA, June 1981, pp. 21.

APPENDIX A

THE POTENTIAL FOR UNSAFE AIR IN UNDERGROUND METAL AND NONMETAL MINES

This Appendix contains an analysis and evaluation of accidents which created unsafe air in underground metal and nonmetal mines during the 5-year period 1976 through 1980. Ten prior-occurring accidents were also studied because of their special relevance to the subject of mine evacuation and the potential use of SCSRs.

This Appendix is divided into the following subsections:

A.1 Summary and Conclusions

A.2 Background

A.3 Hazards Due to Poorly Ventilated Workings

A.4 Hazards Due to Unplanned Rapid Release of Gases

A.5 Hazards Due to Ignitions and Explosions

A.6 Hazards Due to Fires

A.7 Reports on Individual Mine Accidents

A.8 References

A.9 Index of Mine Accidents.

A.1 Summary and Conclusions

Table A-1 presents injury statistics which are relevant to unsafe air for the 5 year period 1976 through 1980. A study of the accident reports from that 5 year period produced in part the following facts:

a. There were 102 reported accidents involving more than 8000 miners. Of those, 80 were injured, eight fatally.

b. The Incidence Rate for those 102 accidents was less than 0.06.*

c. Fires were the most frequent cause for exposure to air that could become unsafe to breathe. The chance was greater for fire to occur in a metal or nonmetal mine than in a coal mine.

*Incidence Rate is a term defined in 30 CFR 50.1 See Table A-1.

TABLE A-1. - Injuries from fire, explosion, ignition and breathing other unsafe air in underground metal/nonmetal mines, 1976-1980

Calendar year:	1976	1977	1978	1979	1980	Total
Mines	739	733	673	679	899	
Miners	28,214	28,516	27,661	29,000	38,430	
Million manhours	52	53	52	55	68	280
Total injuries	3,079	4,023	4,631	5,163	4,868	21,764[a]
Number of accidents						
Fire (F)	7	18	20	11	10	66
Explosion/Ignition (EI)	1	1	2	3	0	7
Other Unsafe Air (O)	4	10	2	9	4	29
Total F, EI, O	12	29	24	23	14	102
Number of injuries						
Fire (F)	0	16	2	1	9	28
Explosion/Ignitions (EI)	2	4	0	11	0	17[b]
Other Unsafe Air (O)	5	14	0	9	7	35[c]
Total F, EI, O	7	34	2	21	16	80
Incidence rate[d]						
All injuries	11.8	15.2	17.8	18.8	14.3	15.6
F, EI, O	0.03	0.13	0.01	0.08	0.05	0.06
Use of filter self-rescuers						
Properly used	4	2	0	0	4	10
Improperly used	0	8	1	0	0	9
Failed to protect	0	0	0	0	0	0

a - Includes 159 fatalities

b - Includes 5 fatalities

c - Includes 3 fatalities

d - Incidence rate = (total injuries) × 200,000/hr of employee exposure

SOURCE: References A89-A120.

d. Refuge chambers were used by 27 miners in one accident, a fire.

e. FSRs were used by 19 miners in 6 accidents.

f. At least 400 miners left their FSRs on their belts while escaping through smoke.

g. The chance for an explosion occurring in an underground metal or nonmetal mine was similar to that in an underground coal mine.

The following conclusions were drawn from a study of these 102 accidents:

a. Of the eight fatalities, 5 died in an explosion and would not have been saved with SCSRs. The three other fatalities, caused by poorly ventilated workings, would have been saved with SCSRs and possibly with FSRs.

b. To save the three lives mentioned in (a), the self-rescue devices, whether they be FSRs or SCSRs, would have to be activated and used from the miner's first awareness of the need to escape. This would have required that the miners have immediate awareness of danger and be able to don and activate a self-rescuer before being overcome, which could be a matter of seconds.

c. Proper use of FSRs would prevent as many injuries as proper use of SCSRs.

To gain further information on possible applications for SCSRs, 10 major accidents from years before 1976 were also studied. The following conclusions are based on our study of the aforementioned 102 reported accidents plus the 10 accidents from prior years:

a. The "typical" fire in a metal/nonmetal mine produces CO and O_2 levels such that a filter self-rescuer affords the miner adequate protection.*

b. If SCSRs were required for escape from a fire, there would be adequate time to acquire them from storage locations.

*This discovery was surprising because it differed from our analysis of coal mine accidents, in which there were several instances in which fires produced atmospheres with CO so high or O_2 so low that FSRs might have proved inadequate.

c. Because most fires involve equipment, SCSRs should not be stored on or near mining machinery and equipment.

d. The one application where SCSRs offer greater protection than FSRs is in hazardous atmospheres due to poorly ventilated workings.

e. To offer protection greater than an FSR in a poorly ventilated area, an SCSR would have to be worn or carried and donned at the beginning of danger.

Other factors were also discovered in the 112 accidents - factors, other than SCSRs, which can have a major impact on the protection of miner's in accidents involving unsafe air:

a. Had conditions worsened, up to 850 miners might have needed some auxiliary source of oxygen. If this source were SCSRs, 700 miners would have needed them immediately for periods from 10 min to many hours.

b. Causes for worsening of conditions did exist including such factors as delays in evacuation, uncontrolled ventilation, and firefighting by inadequately trained persons.

c. Escape must begin soon after danger develops. Each minute of delay allows heat and flame to attack more fuel, produce more CO and smoke, and consume more oxygen.

d. Escape plans should be designed to work in all foreseeable emergencies.

e. A readily accessible communications system is an absolute necessity both to initiate evacuation, and to alert miners of danger quickly.

f. Monitoring and testing the atmosphere in and from abandoned areas is an important safety measure.

g. The potential for development of an irrespirable atmosphere in the event of fire can be predetermined.

A.2 Background

Miners in metal and nonmetal mines have FSRs available. FSRs, however, cannot protect them from atmospheres containing hydrogen sulfide (0.04 percent), sulfur dioxide (0.03 percent), carbon monoxide (1.5 percent), carbon dioxide (3.5 percent), or low oxygen (less than 13 percent). Therefore, mine accidents producing unsafe air were studied to investigate factors such as the following:

a. Lives which could have been saved, and injuries which could have been prevented, by proper use of self-rescuers - both filter self-rescuers (FSRs) and self-contained self-rescuers (SCSRs).

b. Occasions when miners have needed an auxiliary source of oxygen, whether that source had to be immediately available or could be some distance away, and how long a miner might need to depend on that source.

c. Other factors, besides self-rescuers, which either added to, or subtracted from, the miners' level of protection in accidents involving unsafe air.

The period of study was the most recent 5 years for which data was available, 1976 through 1980. During most of those years, mines should have been in compliance with regulations promulgated in accordance with P.L. 91-173 as amended by P.L. 95-164 (Federal Mine Safety and Health Act of 1977). During this 5 year period a total of 102 accidents were reported to MSHA. We define "accident" as follows:

a. One or more miners either were or conceivably could have been exposed to an atmosphere that might have been unsafe to breathe normally.

b. That atmosphere was from a fire, ignition, explosion or other cause.

c. Other causes include atmospheres in or from old workings and unplanned release of gases. They *do not* include mine-air contamination resulting from: use of explosives; malfunctioning of internal combustion engines; welding and cutting-torch fumes; and, planned drilling into pockets of gas to relieve pressure on the back (roof, top, ceiling). Nor do they include injuries resulting from an in-rush of water, drowning or being drawn into or covered by loose material. Protection from each of these accident categories does not include dependence on escaping with an auxiliary source of oxygen.

Fifty-one of these 102 accidents are described individually in subsection A.7 of this Appendix. The other 51 were not investigated by MSHA.

In addition to the above-mentioned accidents, Table A-2 lists 10 accidents which were also studied and included in subsection A.7 because they contained information and lessons important to this study.

Specific attention is called to the fire of 2 May 1972 in the Sunshine Mine. That fire frequency referred to when self-rescue devices are discussed; therefore, its synopsis in subsection A.7 includes pertinent statements from depositions and other sworn testimony of 59 of the 82 survivors.

Unsafe air can consist of different components and be caused by different factors. We found that the major lessons learned from study of the accident reports could be conveniently classified into four areas:

a. Hazards due to poorly ventilated workings

b. Hazards due to unplanned rapid release of gases

c. Hazards due to ignitions and explosions

d. Hazards due to fires.

TABLE A-2. - Ten significant accidents occurring prior to 1976

Mine	Date	Killed	Injured	Probable cause
Homestake	5/9/75	0	0	Fire in abandoned area
Magma No. 9	3/22/73	0	0	Fire in shaft
Sunshine	5/2/72	91	40	Fire in abandoned area
Star	1/20/71	2	0	Fire in active workings
Dead Horse	5/20/71	0	2	Methane ignition
Belle Isle	3/5/68	21	0	Fire at shaft bottom
Climax	7/8/64	1	4	Fire and explosion
Cane Creek	8/27/63	18	2	Gas explosion
Cane Creek	7/31/63	0	4	Gas explosion
No. 1 Incline	11/5/53	8	0	Dust explosion

The next four subsections, A.3 to A.6, discuss each of these four areas individually and include a list of relevant accidents, all of which are individually discussed in subsection A.7.

A.3 Poorly Ventilated Workings, (A-1, A-2)*

Poorly ventilated areas of mines can become reservoirs for toxic and flammable atmospheres. Such atmospheres could entrap persons who enter or mine into them. They also could endanger persons in adjoining active workings should gases flow out through fissures, passageways and other uncontrolled ventilation paths.

Old workings are potential bad-air reservoirs when they offer natural shelters from air flow yet contain sufficient oxygen to support other activities including:

a. Chemical and bacterial breakdown of timber, consuming O_2 and generating heat and oxides of carbon (CO and CO_2)

b. Chemical reactions between carbonate rocks and water, producing the CO_2 that depletes O_2

c. Chemical reactions between sulfides, air, and moisture, consuming O_2 and generating heat, CO and SO_2

d. Leaching of sulfides, forming H_2S and sometimes SO_2; these highly soluble gases could originate on the surface where rain, snow and coursing streams leach outcrops and waste piles; should the gas-bearing water seep into abandoned areas, stagnant pools, if disturbed, can release these highly toxic gases

e. Formation of flammable gas-air bodies, hydrogen and hydrocarbons may have evolved from carbonaceous and organic matter in the area or may have flowed considerable distances through fractures, faults and fissures opened by the redistribution of stresses.

In addition to these hazards, fires can often begin and propagate undetected in poorly ventilated workings. This problem is considered separately in subsection A.6.

*Underscored numbers in parentheses refer to the references listed in subsection A.8.

A.3.1 Potential Impact of Self-Rescuers

Table A-3 lists three accidents which involved hazardous atmospheres caused by poorly ventilated workings:

The following conclusions can be drawn from Table A-3:

a. Proper use of FSR could have saved one life and possibly two other lives, and also could have prevented one injury.

b. Proper use of SCSRs could have saved three lives and three injuries.

c. In cases of asphyxiation and suffocation, self-rescue devices, whether they be FSRs or SCSRs, must be activated and used from the miner's first awareness of the need to escape - in some instances, this may even be too late.

d. In cases of asphyxiation and suffocation, the self-rescuer would have to be worn or carried to be useful.

TABLE A-3. - Accidents involving poorly ventilated workings

Report No.	Accident	Injuries		Potential impact of self-rescuers
		Fatal	Nonfatal	
A.7.1	Cross Mine Asphyxiation 9/19/80	1	1	1 life, 1 injury saved* with FSRs or SCSRs
A.7.2	Knight Mine Asphyxiation 5/6/77	0	2	2 injuries saved* only with SCSRs
A.7.3	Nevada Mine Suffocation 8/10/80	2	0	2 lives saved* with SCSRs, possibly saved* with FSRs

*Items with an asterik are speculative. In these cases, for the life to be saved or injury to be prevented, the self-rescuer would have to be donned from the time of first exposure to the hazard (implying self-rescuer would have to be worn or carried). Note that the victim might not have been aware of the hazard until he exhibited symptoms such as dizziness or collapse.

A.3.2 Other Factors

The accidents listed above taught the importance of monitoring and testing the atmosphere in and from abandoned areas on a regularly scheduled basis and/or before persons attempt to enter unoccupied areas.

A.4 Unplanned Rapid Release of Gases

A sudden outflow of gas can overwhelm the mine ventilation. On two separate occasions, millions of cubic feet of methane, with unknown quantities of other gases, erupted into a Louisiana salt mine (A-14, A-15). To dilute that outflow to a safe level would require more than 100 million cubic feet of air per minute, an obvious impossibility. In a Russian mine, gas from a pocket was "flamed" to keep the atmosphere "safe"; this method was proven deficient when it led to a major explosion (A-2). Purportedly a similar means has been used in a salt mine in Louisiana (not the mine mentioned above) (A-14).

This problem is generally associated with isolated, randomly-occurring pockets. Examples of such are found in three of the four remaining operations in Louisiana salt domes, in a uranium mine in Utah, and in the Permian basin potash deposits of the southwestern United States, among others. Frequently, N_2 or CO_2 is the principal gas. A pocket, however, might be filled with flammable gases, as in the Louisiana salt mine mentioned above. The types of gases cannot be predicted.

Fortunately, pressures in these pockets are often only inches of water. In the Belle Isle Mine, however, pressures exceeding 80 atmospheres were measured on a number of occasions (A-14, A-15). In the Cane Creek Mine, (A-16) pressures purportedly pushed a 3000-lb drilling machine 20 ft out of the hole being drilled. In the Carlsbad, New Mexico area, pressures up to 4 atmospheres have been measured (A-17). Gas can flow unexpectedly from pockets along faults and slips, particularly those opened by redistribution of the stresses that follow normal mining operations. Blasting overbreak and pillar extraction can cause more rapid flows.

A.4.1 Potential Impact of SCSRs

Table A-4 lists two accidents which involved hazardous atmospheres caused by unplanned rapid release of gases without subsequent ignition or explosion:

TABLE A-4. - Accidents involving unplanned rapid release of gases

Report No.	Accident	Fatal	Nonfatal	Potential impact of self-rescuers
A.7.4	Lisbon Mine Gas outbursts 3/29, 4/6, 5/17/79	0	0	-
A.7.5	Nash Draw Mine asphyxiation 3/29/76	1	0	1 life saved with SCSR

Rapid release of gases led to one death from 1976 through 1980. Three outbursts occurred within 2 months in the Lisbon Mine; no one was injured. As many as 20 outbursts occur each year in mines in Louisiana salt domes. Except for the outburst leading to the Belle Isle Mine explosion in 1979, no injuries have ever been reported. (It should be noted that although the Belle Isle Mine Explosion (6-8-79) is classified as an explosion, it resulted from a methane gas outburst).

SCSRs were needed by the two miners involved in the Nash Draw Mine accident. Either SCSRs or FSRs might have been important to persons in the Lisbon Mine.

To have been useful for protection against outbursts, SCSRs would have had to be worn or carried by almost all of the persons involved. Equally important to many was the need to know they had to don and activate SCSRs. Among the important lessons of Nash Draw, as well as many other accidents included in this report, were the need for miners to have immediate awareness of danger and to be able to don and activate a self rescuer before being overcome, which could be a matter of seconds, if that long.

Had miners been exposed to gases expelled in other outbursts in salt mines, and exposure was possible, SCSRs would have been needed. Prior difficulties have been experienced with Universal gas masks in salt dust-filled air because the salt dust tended to clod the filter. Similar problems might occur with a filter self-rescuer.

A.4.2 Other Factors

Analysis of gas outburst accidents teaches that a number of precautionary steps can be taken:

a. Drill exploratory holes

b. Before blasting, test for flammable gases and lock out all power except that needed for ventilation and blasting

c. Simultaneously blast rounds from the surface while persons are neither underground nor near shafts and portals

d. After blasting and before restoring power, test for flammable gases and examine areas around the blast sites.

e. Immediately evacuate areas of gas outburst and test for gas before re-entering.

A.5 Ignitions and Explosions (A-20, A-21, A-22, A-23, A-24, A-25, A-26)

An explosion in a metal or nonmetal mine is such a rarity that its potential has led to misconceptions, such as "explosions are not a problem for hard rock miners, but for coal miners." This is not necessarily true, as Table A-5 makes clear.

TABLE A-5. - Five-year history of explosions and ignitions in underground mines, 1976-1980

	Reported cases	Injuries		Million man-hours	Average number of mines*
		Fatal	Nonfatal		
Coal explosions	4	32	3	1071	2289
Metal/nonmetal				281	745
Explosions	2	5	6		
Ignitions	5	0	6		

*The number of operating mines varies from year to year. The figure represents the average number of mines operating on *any given day* during the 5-year survey period.

Source: References A89 to A120.

A worldwide increase in flammable gases in metal and nonmetal mines has been noted over the past 30 years. The increase is believed to result from mining at greater depths, using more powerful explosives, and extracting ores from larger areas at greater rates. In addition to the pockets previously discussed, gases, often methane, might be occluded in strata over an extensive area. Examples of this can be found in zinc deposits in upstate New York, copper mines in northern Michigan and Tennessee, gold mines in the Cripple Creek, CO, and San Benito CA, districts, limestone and salt mines in Pennsylvania, New York, Ohio and Kansas, and trona and potash mines in Wyoming, New Mexico and Utah, among others. Mining operations cause fractures, joints and other paths to open between the mine and the gas-bearing rock. Gas flows into a mine depend on gas pressures, water table locations and the rate of barometric pressure depressions.

Some investigators believe that metal and nonmetal mine gases could present a greater explosion hazard than methane does in coal mines. Flammable gases associated with ore deposits often contain comparatively high percentages of hydrogen and heavy hydrocarbons, making the gas more readily ignitable and capable of producing higher pressure. Other investigators believe that N_2 and CO_2 are highly effective inerting agents and frequently are the principal gases associated with ores, particularly those with pockets of gas.

To aid evaluation of the hazard, some basic information is here presented. Ignition and explosions involve burning. Burning in confined space, such as a mine, produces pressure. With ignition, the pressure developed is barely perceptible.*

An explosion, however, develops sufficient pressure and violence to destroy as well as disrupt ventilation. For example, experimental explosions involving methane and oil shale dust have developed up to 18 psig and wind velocities of 75 to 650 mi/hr (A-27). Pressures and impact velocities developed during an explosion could tear away brattice cloth, rupture eardrums and wetwall block stoppings, collapse lungs and fracture bones, and even cause death (A-23, A-28, A-29).

*"Perceptible" means pressure in excess of 0.2 psig (5 in. water gauge). That definition is based on United States Bureau of Mines research in the Experimental Coal Mine in which instrumentation does not respond accurately to lower ignition-explosion developed pressures.

Burning consumes oxygen and produces carbon monoxide among other gases. The atmosphere following ignitions and explosions can, for worst case conditions, contain 10 percent CO and 0.5 percent O_2 (A-21, A-23, A-24).

When flammable gas is the principal fuel, flame seldom affects persons at distances greater than five times the length of the original gas-air mixture even though forces destroyed stoppings and caused other damage over a wide area. Assume, for example, a flammable body of gas fills the entire face, but extends only 1 ft into the drift or down the raise. Persons within 5 ft might receive burns, whereas persons farther away probably will be unharmed. For a flammable methane-air mixture to lead to a major explosion in a mine passageway, the body of gas must extend at least 10 ft (A-23, A-24).

This is why ventilation is the principal safeguard against explosion. Good ventilation limits the extent of a flammable gas-air mixture as well as the concentration of the gas. This in turn limits the area affected.

Ignitions generally involve flammable gas only. In an explosion, combustible dust may be the dominant fuel. The combination of gas and dust lowers the individual minimum explosive limits; thus, in some mines a seemingly safe flammable gas concentration could be dangerous. For example, minimum explosive limits are 5 percent for methane and 0.2 oz/ft^3 for gilsonite dust. The explosion produced by ignition of 2-1/2 percent methane and 0.01 oz/ft^3 gilsonite dust can be more violent than that caused by either alone.

Explosion hazards of numerous dusts have been evaluated by the United States Bureau of Mines since the 1920s. Detailed lists and data are given in the references cited (A-27, A-30, A-31).

A.5.1 Potential Impact of SCSRs

Table A-6 lists eight accidents which involved hazardous atmospheres caused by ignitions and explosions.

TABLE A-6. - Accidents involving ignitions and explosions

Report No.	Accidents	Injuries		Potential impact of self-rescuers
		Fatal	Nonfatal	
A.7.6	Belle Isle Mine explosion 6/8/79	5	6	-
A.7.7	USBM No. 1 Shaft ignition 11/1/78	0	0	-
A.7.8	Alchem Trona ignition 6/3/77	0	4	-
A.7.9	Belle Mine ignition 10/27/76	0	2	-
A.7.10	Cane Creek ignition 7/31/63	0	4	-
A.7.11	Cane Creek explosion 8/27/63	18	0	3 lives saved with SCSRs, possibly saved with FSRs
A.7.12	Dead Horse ignition 5/20/70	0	2	-
A.7.13	No. 1 Incline explosion 11/5/53	8	0	-

Ignitions and explosions in the years 1976 through 1980 caused 5 fatal and 12 nonfatal injuries. In the years 1953 to 1976, they caused 29 fatal and at least 12 nonfatal injuries.

In the accidents cited above, the following were true:

a. FSRs were not used.

b. Had FSRs been used in the Belle Isle Mine explosion, breathing through them might have been difficult if not impossible.

c. Either FSRs or SCSRs, had they been available, might have aided in saving the lives of three miners in the 1963 Cane Creek Mine Explosion.

d. SCSRs would have been of no use to the other 24 miners who died in these accidents nor to at least 19 of the nonfatally injured miners.

e. In cases of ignition and explosion, SCSRs would have had to be worn or carried by almost all of the persons directly affected in order to be useful.

A.6 Fire

Metal/nonmetal mines contain all the ingredients needed for fire, namely:

a. Oxygen in the mine ventilation, compressed airlines and welding-cutting equipment.

b. Heat from spontaneous combustion, welding-cutting slag and sparks, electrical short circuits, smoking, and other open flame.

c. Fuel in the form of diesel oil, lubricants, conveyor belting, urethane foam and wood.

This study, which was concerned with the question of the need for oxygen during escape, did not include fires causing only burns to persons as a result of cutting, welding, electrical short circuits, and ignition of fuel (diesel, propane and gasoline), by smoking or other deliberately-applied open flame. The relatively high incidence of those types of injuries suggests the need to explore the potential for increased injury severity should an SCSR case catch on fire or be penetrated by flame from an oxygen-acetylene torch or by the arc from an electrical short circuit.

During the period 1976 through 1980, 28 miners suffered smoke inhalation in 66 fires. Forty-three of these fires are included in this report. Study of those and of fires in previous years indicates wood has been the principal fuel in metal and nonmetal mine fires. Wood also has been associated with almost all fires that exposed more than a few persons to danger. Other fuels are relatively limited in quantity.

Study of those fires also inferred that the potential for development of an irrespirable atmosphere and for escape could be predetermined. The following example shows how this might be done.

A.6.1 Wood Fire Example

The example wood fire has the following assumed conditions:

a. Drift 8 ft high and 10 ft wide

b. Supported by square sets on 5 ft centers

c. Each set consists of eight 12 by 12 in. timbers

d. Two inch thick lagging boards on the top, bottom and both sides of the timbers

e. The timber and lagging have a density of 40 lb/ft^3

f. 50,000 cfm of air are flowing through the drift

g. Heat and flame penetrate 1/40 in./min into the timbers and lagging*

h. Spread 3/4 fpm down the drift**

i. CO from the fire is the maximum likely to be produced in a ventilated mine passageway, 1.3 ft^3/lb of wood burned (A-42, A-43)

j. Miners can use FSRs to escape in the return air from a fire provided the O_2 is greater than 13 percent and CO less than 1.5 percent.

Question: Can miners escape, and if so, how much time do they have using FSRs in the return air from a worst-case fire in the above-described drift assuming no dilution of the fire-contaminated air?

*The rule of thumb used by many fire control engineers is wood chars at a rate of 1/40 in./min. In actuality the char rate is proportional to the magnitude of the radiation intensity to which the wood is exposed. For the radiation intensity likely to occur in a severe fire in a mine, the penetration rate given should represent a worst-case condition (A-11).

**A flame spread rate of 3/4 fpm represented the worst-case condition in the 51 fires synopsized in this report and is consistent with findings in United States Bureau of Mines and Forest Products Laboratory full-scale research (A-11, A-37, A-38, A-39, A-40, A-41).

Solution:

1. Calculate the pounds of wood burning per minute that could cause the O_2 concentration to be reduced to 13 percent. This can be approximated using the formula (A-11)

$$F = kQ(O_2 \text{ intake} - O_2 \text{ return})$$

where

F = the quantity of fuel burning in lb/min

k = a constant which for wood, oil and similar fuels approximates 0.08

Q = the quantity of air flowing over the fire in cfm

O_2 intake = the oxygen concentration in the air flowing to the fire generally is 0.209 ($\sim$21 percent)

O_2 return = the oxygen concentration in the air flowing from the fire assuming no dilution by other air flows.

For the example fire where Q = 50,000 cfm and the minimum desired O_2 return is 13 percent, then F = (0.08) (50,000) (0.209 - 0.13) = 316 lb of wood burning per minute.

2. Determine the maximum CO concentration likely to be produced by burning 316 lb of wood per minute. For this example: (316) (1.3 ft^3 of CO/lb of wood burning) = 411 cfm of CO. And (411 cfm of CO)/(50,000 cfm of air + 411 of CO) = 0.82 percent CO. That is less than the maximum allowable 1.5 percent CO concentration, indicating FSRs should provide protection for escape. Had it exceeded 1.5 percent the need for refuge chambers, SCSRs, auxiliary sources of oxygen, or combinations of these would be indicated.

3. Estimate the length of drift on fire which would consume 316 lb/min of wood. The density of the wood was assumed to be 40 lb/ft^3; therefore, 316/40 = 7.9 ft^3 of wood per minute need to be burning.

With flame and heat penetrating 1/40 in./min into the wood a 12- by 12-in. timber would be consumed in 240 min and a 2-in. thick lagging board in 80 min.

Each 5-ft length of assumed drift contains 56 and 30 ft^3 of timber and lagging respectively; therefore (56/240) + (30/80) = 0.6 cfm of timber and lagging consumed in a 5-ft length of drift, or 0.12 cfm/ft of drift.

To consume 7.9 ft^3/min of wood, therefore, requires flames throughout 7.9/0.12 = 65.8 ft of drift.

4. Estimate the time needed for flames to extend 65.8 ft; this is the time from the beginning of the fire miners have to escape using FSRs assuming worst-case conditions. If the flame spreads down the drift at a rate as high as 3/4 fpm, the air returning from the fire would contain more than 13 percent O_2 and less than 0.82 percent of CO for more than 85 min (65.8/0.75 = 87.7).

A.6.2 Actual Wood Fires

The methods for calculating the Wood Fire Example were used to estimate worst-case conditions during 11 actual fires (Table A-7). Those fires were selected because their investigation reports contained sufficient albeit limited data on duration of the fire and length or quantity of wood burned.

In those 11 accidents, actual airflows across the fire or subsequently admixed with the fire products exceeded the "Safe Airflow" values given above. Thus, there was sufficient oxygen and low enough CO for escape. None of the almost 3000 miners involved reported being injured by smoke and fumes in these fires. One miner, in the Miller Mine, put on an FSR.

A.6.3 Potential Impact of SCSRs

Table A-8 lists 48 accidents which involved hazardous atmospheres caused by fires.

These fires can be categorized according to the *location* of the fire:

a. Fires in old workings (A.7.14 to A.7.23)

b. Fires in shafts (A.7.24 to A.7.34)

c. Fires in other areas (A.7.35 to A.7.61).

TABLE A-7. - Accidents involving wood fires

Fire	Average flame spread (ft/min)	Maximum CO-potential (cfm)	Minimum safe airflow* (cfm)
Belle Isle (1/9/79)	0.500	4.1	500
Climax (8/8/78)	0.050	0.4	50
Grace (6/22/76)	0.300	36.4	4,410
Homestake (4/1/76)	0.003	45.4	4,550
Kelley Shaft (6/27/77)	0.800	1,650.0	200,000
Lucky Friday (12/17/80)	0.008	0.3	40
Miller (8/8/80)	0.030	520.0	63,000
Pleasant Gap (8/26/77)	0.200	60.0	7,270
Reserve (4/5/76)	0.020	0.1	15
San Manual (5/23/80)	0.700	4.9	600
Sunshine (11/30/77)	0.030	0.2	25

*Quantity of air required to have more than 13 percent O_2 and less than 1.5 percent CO in the return air from the fire. That quantity should support escape using FSRs; multiply by 100 for escape without a self-rescue device.

Fires in old workings can present the same kind of danger as hazards due to poorly ventilated areas, discussed in subsection A.3. Fires may start and go undetected for an extended period of time, allowing a buildup of toxic gases and/or deficient O_2 atmospheres. The following conclusions were drawn from the analysis of 10 reports on fires in old workings:

a. Sunshine Mine Fire of 2 May 1972 was the glaring example in the category. In our opinion all 91 lives, and 40 injuries, could have been saved by *proper* use of FSRs or SCSRs.

b. Fires in old workings may be difficult to find. Personal searching for a fire are exposed to the risk of stumbling into a bad atmosphere.

TABLE A-8. Accidents involving fires

Report No.	Accidents	Fatal	Nonfatal	Potential Impact of Self-Rescuers
A.7.14	Sunshine Mine Fire (5-2-72)	91	40	91 lives and 40 injuries saved with FSRs or SCSRs
A.7.15	Homestake Mine Fire (5-9-75)	0	0	
A.7.16	Magma Mine Fire (5-2-80)	0	0	
A.7.17	Beyer Mine Fire (1-22-78)	0	0	
A.7.18	Crescent Mine Fire (3-25-79)	0	0	
A.7.19	Eagle Mine Fire (10-3-77)	0	0	
A.7.20	Kelley Mine Fire (4-7-77)	0	0	
A.7.21	Kelley Mine Shaft Fire (6-27-77)	0	0	
A.7.22	New York Mine Fire (7-20-77)	0	0	
A.7.23	Silver Dollar Mine Fire (8-27-76)	0	0	
A.7.24	Belle Isle Mine Fire (3-5-68)	21	2	
A.7.25	Belle Isle Mine Fire (2-2-79)	0	0	
A.7.26	Bunker Hill Mine Fire (6-28-78)	0	0	
A.7.27	Climax Mine Fire and Explosion (7-8-64)	1	1	
A.7.28	Lucky Friday Mine Fire (12-17-80)	0	0	
A.7.29	Magma No. 9 Shaft Fire (3-22-73)	0	0	
A.7.30	Miller Mine Fire (8-8-80)	0	0	
A.7.31	Reserve Mine Fire (4-5-76)	0	0	
A.7.32	Star Mine Fire (1-20-71)	2	0	
A.7.33	USBM No. 1 Shaft Fire (12-6-78)	0	0	
A.7.34	Water Lilly Mine Shaft Fire (1-19-79)	0	0	
A.7.35	Bellefonte Mine Fire (6-8-76)	0	2	
A.7.36	Belle Isle Mine Fire (1-9-79)	0	0	
A.7.37	Bunker Hill Mine Fire (11-15-79)	0	0	
A.7.38	Cabin Creek Mine Fire (4-16-77)	0	9	9 injuries saved with proper use of FSRs or SCSRs
A.7.39	Cayuga Mine Fire (3-28-78)	0	0	
A.7.40	Cherokee Mine Fire (1-6-78)	0	0	
A.7.41	Climax Mine Fire (9-3-77)	0	0	
A.7.42	Climax Mine Fire (8-8-78)	0	0	
A.7.43	Climax Mine Fire (10-11-78)	0	0	
A.7.44	Fletcher Mine Fire (7-7-80)	0	0	
A.7.45	Georgia Marble No. 5 Fire (1-31-78)	0	0	
A.7.46	Gordonsville Project Fire (4-19-78)	0	0	
A.7.47	Grace Mine Fire (6-22-76)	0	0	
A.7.48	Homestake Mine Fire (4-1-76)	0	0	
A.7.49	Logan Wash Fire (9-12-78)	0	0	
A.7.50	Montevallo Mine Fire (9-20-77)	0	0	
A.7.51	Ozark Mine Fire (12-16-78)	0	0	
A.7.52	Pleasant Gap Mine Fire (8-26-77)	0	0	
A.7.53	Retsoff Mine Fire (12-8-77)	0	0	
A.7.54	San Manuel Mine Fire (10-18-76)	0	0	
A.7.55	San Manuel Mine Fire (5-23-80)	0	0	
A.7.56	Sherman Mine Fire (3-20-80)	0	0	
A.7.57	Sunshine Mine Fire (11-23-77)	0	0	
A.7.58	Sunshine Mine Fire (11-30-77)	0	0	
A.7.59	Sunshine Mine Fire (2-22-78)	0	0	
A.7.60	Weeks Island Storage Complex Fire (12-1-78)	0	0	
A.7.61	Young Mine Fire (10-16-78)	0	0	

Fires in shafts present a tremendous danger because the exit may be blocked. If the shaft is on intake air, all or a large part of a mine may become contaminated. The hazard is greatest in mines or areas of a mine where a single shaft is the only exit.

The following conclusions were drawn from the analysis of 11 reports on fires in shafts or dead-end headings:

- FSRs were rarely used.
- In all three fatal accidents, FSRs or SCSRs would not have saved lives or injuries. In two cases (Belle Isle and Star) egress was prevented by the fire. In the third case, an explosion caused the death and injury.
- In many of the 11 accidents, there was the potential for air contamination throughout the mine, which would have required many miners to use FSRs or SCSRs. Based on the analysis in subsections A.6.1 and A.6.2, we can theorize that filter self-rescuers would be adequate.

Fires in other areas refers generally to drifts and stopes. Virtually all of them involved either rubber-tired equipment or permanent electrical installations. The following conclusions were drawn from the analysis of 27 reports on fires in other areas:

- FSRs were rarely used.
- Although FSRs were used in the only accident resulting in injuries, they were used improperly and not soon enough. Proper and timely use of FSRs would have prevented 9 nonfatal injuries.
- Self-rescuers should not be stored on mining equipment because the operator invariably evacuates the machine immediately if it catches on fire.

In summary for all types of fires, filter self-rescuers, properly used, would have provided adequate protection (with the possible exception of one incident). Oxygen self-rescuers, properly used, would have provided adequate protection - either stored or carried. However, SCSRs stored on mining equipment would not have been available when the equipment caught on fire.

A.6.4 Other Factors

Analysis of mine fire accidents provided the following lessons:

a. Atmospheres in and from abandoned areas should be monitored and tested on a regular basis and before persons attempt to enter.

b. Escape plans must be designed to work in all foreseeable emergencies.

c. A readily accessible communications system is vital; this includes not only communications to initiate evacuation, but also means for miners to become aware of fire quickly.

d. Self-rescue devices, whether they be FSRs or SCSRs, should be activated and used from the miner's first awareness of the need to escape.

e. There should be no delay in evacuation. This means escape must begin soon after the fire develops; each minute of delay allows heat and flame to attack more fuel, produce more CO and smoke, and consume more oxygen.

f. If miners search for a suspected fire before notifying management, the searching miners are also exposing the rest of the personnel underground to some risk.

Many reasons are given for delaying evacuation. The authors of this report have had long experience in mining and particularly with mine rescue and recovery following fires. They do, therefore, understand those reasons; they do not agree with them. In many of the fires cited, miners stayed to fight the blaze. Sometimes they were successful, sometimes not. This combativeness is a characteristic of miners. It is a trait, however, that could expose the miner to even greater danger should he be given a portable oxygen source. This could increase the likelihood of miners staying and fighting fires rather than fleeing. While the oxygen source is being depleted, the potentially irrespirable atmosphere is growing larger and extending beyond the miner. His chances for escape diminish; not only will he have less oxygen, he may have to seek safety through denser smoke. As many a mine rescue person knows, the range of vision on the return air side of a small fire drops to a few yards in a very short time; and, the route of travel can barely be seen, if found.

A.7 Reports on Individual Mine Accidents

This subsection contains reports on the 61 accidents referenced in the previous subsections. Index tables of these accidents, organized by report number, alphabetically, and chronologically, are in subsection A.9.

A.7.1 Cross Mine Asphyxiation, September 19, 1980 (A-3)

Background

Cross Mine is near Nederland, CO. The ore, containing silver, gold, copper and lead, is mined by drifts following the veins. The mine has developed on four levels off a 190-ft-deep shaft. The two lower levels are being mined; the other two have been abandoned. A decline from the surface intersects the top level. A 10 hp fan in the portal forces 12,000 cfm into the mine.

The accident occurred on the bottom level. This is 200-ft-long, 5- to 6-ft-wide, and 7-ft-high. Little to no air was reaching this level; the ventilation door on the second level had fallen down, short-circuiting the air back to the shaft rather than to the lower levels.

The Accident

Two miners proceeded to the fourth level to muck out ore. This was 8 hr after a series of slab shots had broken the ore.

The one survivor later reported the air was clear, with no smoke, dust or smell of fumes. They began to clean up the area. In 10 to 15 min the survivor began to feel dizzy and sat down. He then noticed his partner had an oxygen cutting torch in his mouth. Neither attempted to turn on the compressed air hose.

After a while the two forced their way to the skip where they collapsed, as shown in Figure A-1.

Two hours later a mine official found them. One hour later they were brought to the surface. One was dead; the other was hospitalized for 5 days.

The MSHA investigation report stated death resulted from CO poisoning. This accident was included in this study because blasting might not have been the source for the CO:

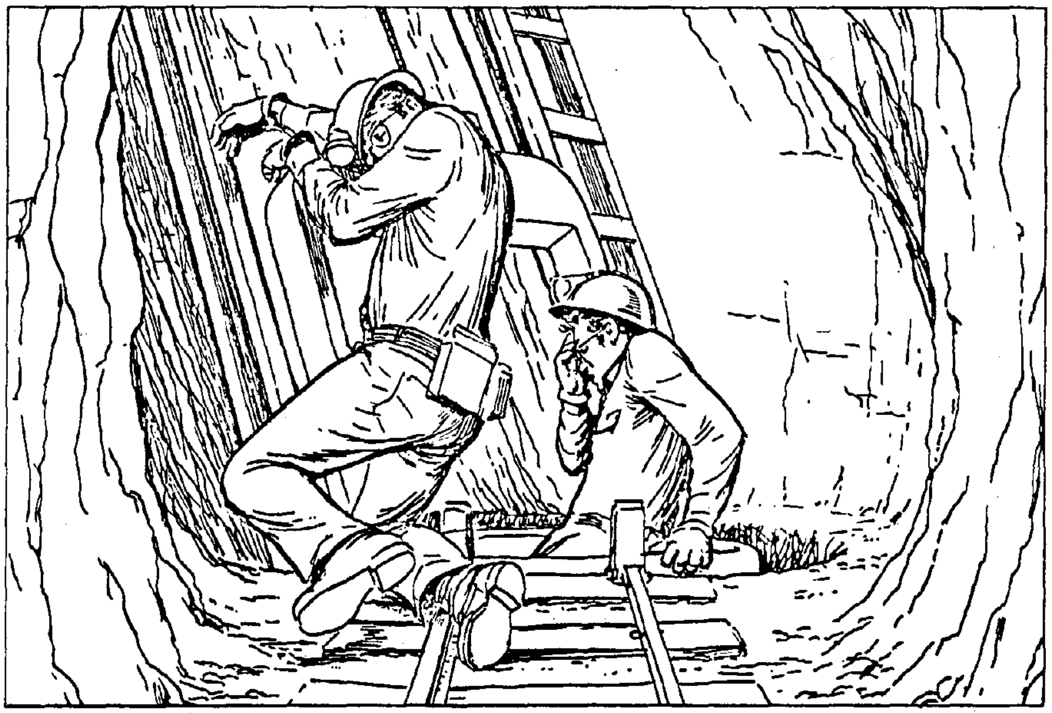


FIGURE A-1. - MSHA illustration of Cross Mine asphyxiation.

a. The CO concentration at the shaft station averaged 550 ppm 16 hr after blasting.

b. For CO to cause young, healthy persons such as these two miners to become dizzy after 10 to 15 min of work requires at least 1500 ppm.

c. The average CO concentration in the drift, therefore, was at least 1025 ppm.

d. For CO to cause death within 2 hr requires at least 1200 ppm.

e. The open volume of the fourth level approximated 7700 ft^3. To have 1200 ppm, therefore, requires at least 9 ft^3 of CO.

f. For blasting to produce 9 ft^3 of CO requires more than 30 lb (60 sticks) of 40 percent dynamite.

g. A greater quantity would be needed to compensate for dilution during the 8 to 10 hr that elapsed between blasting and death.

h. Slab shots in the accident area would not likely require 30 or more pounds of explosives.

Potential Impact of SCSRs

The one survivor stated he never thought of using his FSR. There was no smoke or dust in the air and they entered the place 8 hr after the shots had been fired. The miners generally returned an hour after blasting.

The miners had, but did not use, a readily accessible source of oxygen, compressed air. The deceased miner did put the oxygen cutting torch in his mouth.

Although there was little to no air flow in the accident area, there was sufficient oxygen to support life as evidenced by the facts that they were in the drift for more than 2 hr and MSHA and mine officials were in the accident area for several hours before ventilation was restored. Thus, FSRs should have protected these two miners. SCSRs worn or stored in the drift also could have been used.

A.7.2 Knight Mine Asphyxiation, May 6, 1977 (A-5)

Background

Knight Mine, a fluorspar operation, is near Rosiclare, IL.

The Accident

Two miners were removing a pump from a sump in an abandoned area. The duct normally used to direct air to the sump had been removed. The two collapsed into unconsciousness.

Fortunately, the mine foreman came to the work site. He immediately installed the ventilation duct. Some other miners came and helped remove the two unconscious men.

The two regained consciousness when brought to fresh air. They were sent to the hospital.

They had been overcome by hydrogen sulfide (H_2S) gas. H_2S is frequently found in fluorspar mines in Illinois. H_2S is also found in gypsum mines, in sulfide ore mines and in some mines in which methane is liberated or oil seeps. Because it is heavy (specific gravity is 1.2) and highly soluble, it should be expected in low-lying pools of water. Disturbance of the pool will release the gas. Its TLV is 0.002 percent; a concentration of 0.05 percent can cause death.

Potential Impact of SCSRs

FSRs were not used. FSRs offer little or no protection against H_2S. SCSRs would be protective; however, they had to be donned and activated within seconds of awareness, assuming the miners could become aware of their danger.

Other Factors

Ventilation and testing for gas could have prevented this accident.

A.7.3 Nevada Mine Suffocation, August 10, 1980 (A-7)

Background

Two miners in the Nevada Mine, near Bonanza, CO, mined silver from a shrinkage stope. This type of 2-man operation is not uncommon in the west.

The Accident

The accident site was the 43-ft-deep shaft, the only access into the mine. Needing to pump water from the shaft the two miners, the only persons on the property, set an electric pump on a landing above the water. Obviously the pump didn't work, so they set up a gasoline-powered pump alongside of it. Later that day their bodies were found on the pump platform. The two had died from CO poisoning. The accident is shown in Figure A-2.

Potential Impact of SCSRs

SCSRs had they been activated, probably would have saved the lives of these two miners. But, why would they have activated SCSRs? FSRs possibly would have saved their lives; but the two miners did not have FSRs.

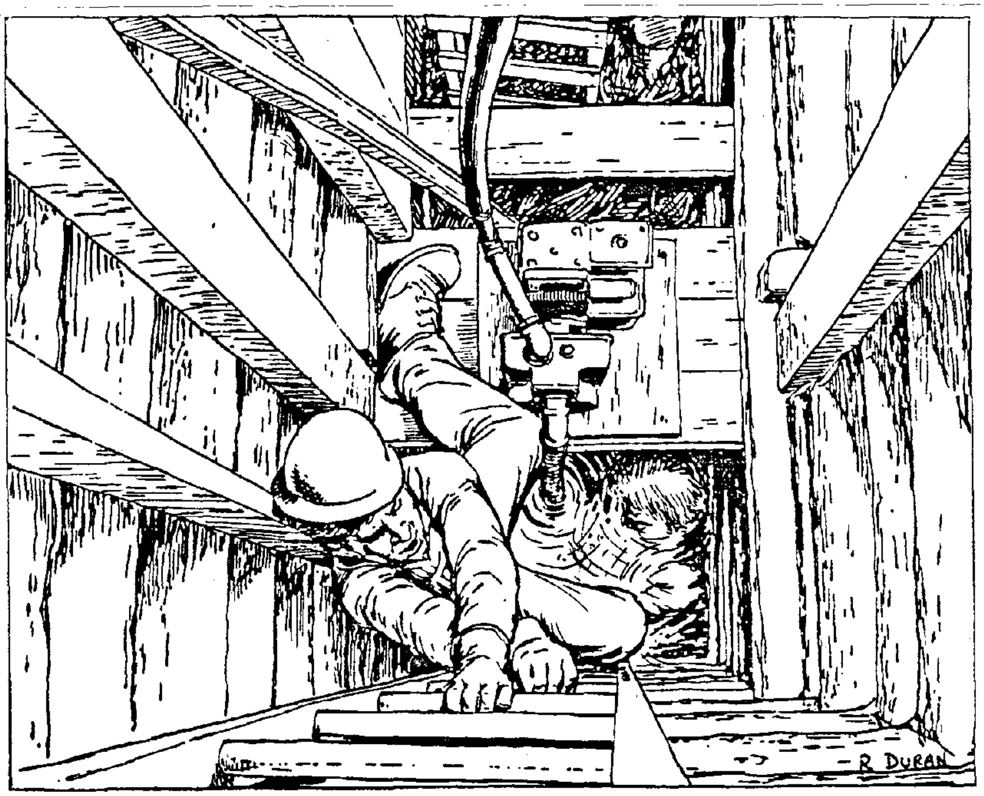


FIGURE A-2. - MSHA illustration of Nevada Mine suffocation.

A.7.4 Lisbon Mine Gas Outbursts, March 29, April 6 and May 17, 1979 (A-18)

Background

In the Lisbon Mine, near Moab, UT, uranium ores are mined from rooms and pillars. A sublevel haulage is used to transport ore from the working areas to the shaft skip pocket. The mine is 2917 ft below the surface. In 1973 it was classified "gassy".

The Accidents

On March 29, immediately following blasting at the face, rock from the just-exposed rib blew out. The 10-ft-wide drifts were filled 6-1/2- to 7-1/2-ft-deep for 160 ft. An estimated 250 tons of rock had been expelled. Shortly after, 3.5 percent methane was detected. Miners were underground at the time, but several hundred feet from the outburst. No one was injured. Ventilation controls in the area, however, were destroyed.

Although the company began an extensive drilling program, outbursts occurred on April 6 and May 17. The quantity of rock expelled was about 40 tons each time.

Subsequent investigations indicated the outbursts were associated with pockets of methane and carbon dioxide; and, the atmosphere following an outburst could be expected to contain sufficient oxygen to support life as well as combustion.

Potential Impact of SCSRs

FSRs were not used in any of these outbursts. Had ignitions or explosions occurred, FSRs should have provided adequate protection. Our calculations indicate the maximum probable irrespirable atmosphere would extend 10 to 150 ft in length for the outbursts that occurred. Because miners would be farther than that from the face while blasting, they probably could escape if they were not seriously injured.

A.7.5 Nash Draw Mine Asphyxiation, March 29, 1976 (A-19)

Background

Nash Draw Mine is near Carlsbad, NM. Potash is mined by the room-and-pillar method; pillars generally are not mined. Two shafts connected to one level; two declines went to a lower level. This mine, as well as most mines in the area, had a history of pockets of gas in the polyhalite strata 15 to 25 ft above the potash. Samples have been taken from holes drilled into the polyhalites since the 1930's; typically, the gas pockets contain more than 90 percent N_2. Because the pressure in some pockets can cause falls of roof, particularly in intersections, holes are often drilled into the polyhalite at intersections. Gas pressures up to 4 atmospheres have been recorded.

The Accident

Prior to the accident, a fall of roof covered an undercutter. The fall was 48-ft-long, 32-ft-wide and 5-ft-thick. A 10-ft-long crack was in the roof above the fall.

Figure A-3 shows the scene of this accident.

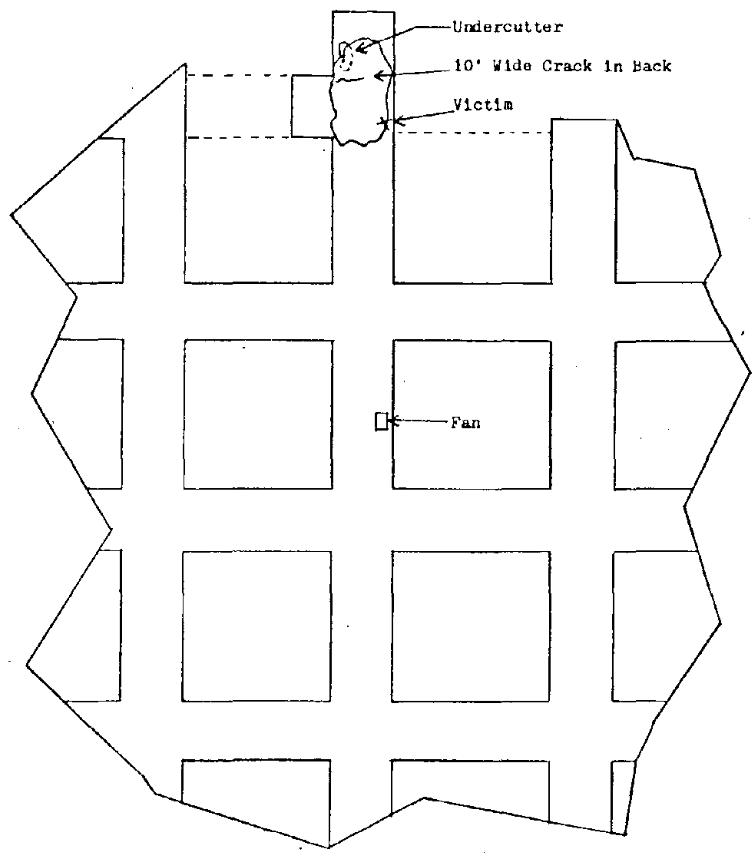


FIGURE A-3. Location of Nash Draw Mine asphyxiation.

The victim (the mine foreman) was notified of the fall and was told no one had been injured. He and a mechanic travelled by jeep to the fall. Their mission was to determine how to recover the machine. The victim, about 15 ft ahead of the mechanic, walked around the right side of the fall.

The mechanic, when he reached the edge of the fall, began to feel weak and nauseous. He turned to go back. Turning again he noticed the victim was down and his light immobile. He tried to reach the victim, but becoming dizzy and disoriented, he couldn't. Then, he put on his FSR. He reached the victim, but was too weak to move him. He returned to the jeep and drove for help.

Two and a half hours later, rescue team personnel wearing oxygen breathing apparatus recovered the body of the foreman. The cause of death was suffocation.

Potential Impact of SCSRs

SCSRs, had they been activated, would have saved the victim and, but for chance, might have been needed by the mechanic. However, it is reasonable to assume that an SCSR would have been used in the same manner that the FSR was used. Thus, the mechanic would have donned an SCSR and might have been able to save the foreman. There is no reason to believe that the foreman would have used an SCSR any more than an FSR.

The mechanic had told the victim before they went in that the air smelled damp and musty. The foreman purportedly replied the smell was of "virgin air".

The "successful" use of an FSR raises questions and complicates this accident report. That is, FSRs provide no protection against an oxygen deficiency. Its use, however, does indicate that SCSRs might have been beneficial. Obviously, had the two used SCSRs to enter the area they would have been protected. In the absence of that, the mechanic using an SCSR instead of an FSR would have been able to bring oxygen to the foreman.

A.7.6 Belle Isle Mine Explosion, June 8, 1979 (A-15)

Background

Belle Isle Mine produces salt from a dome near Morgan City, LA. Portions of the mine affected by the explosion and events are shown in Figure A-4.

The mine has two levels. Rooms and headings were developed 63 ft wide and 22 ft high on the upper level. When the planned extent of a room was reached, the bottom was benched, leaving 82 ft high openings. Intake air was drawn into the 1225 ft deep No. 2 Shaft by an underground fan. Air coursed through the mine and exhausted up the No. 1 Shaft.

The Accident

Two shot firers blasted precharged holes in three faces. About 10 min after shooting the third face a "blowout" of flammable gases and salt erupted from 8 Main Entry East. The gas ignited, and heat and winds exceeding 300 miles per hour spread throughout the mine.

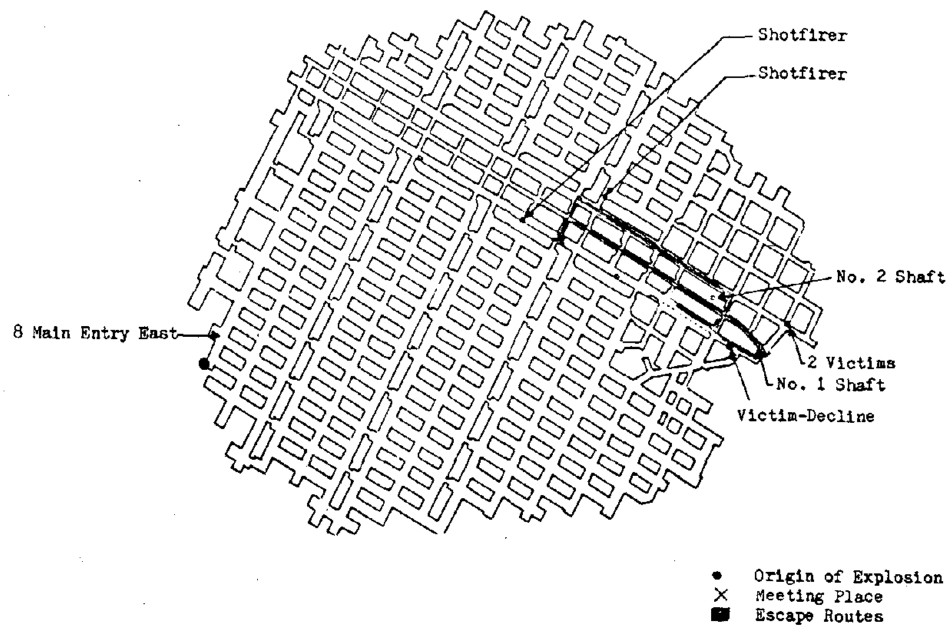


FIGURE A-4. - Area map of Belle Isle Mine explosion.

Twenty-two persons were in the mine at the time of the explosion. Five were killed by explosion forces rupturing their lungs. Two of the deceased were the shot firers; they purportedly had walked more than a half mile in the 10 min between shooting the last face and the explosion.

Twelve miners were attending a meeting 3500 ft from the origin of the explosion. A strong concussion bowled them over; hurricane-like winds filled the air with dirt; visibility was zero. One miner, who got separated from the others, tried to go to the No. 2 Shaft which he had been taught was the primary escapeway. Heat and winds (one blast of wind blew him bodily 30 ft) forced him to crawl back and try for No. 1 Shaft. This route too had zero visibility, but heat and winds were less. He became disoriented and confused, fell down, stumbled, weaved from side to side and thought he was lost until he heard screaming sounds. Moving towards the sounds, he met two miners. These three found Peggy Blaney, badly injured, and screaming; they helped her crawl to No. 1 Shaft. There they met nine other miners. All but Ms. Blaney and another miner joined hands and began to try to get to No. 2 Shaft. They moved slowly; even these many minutes after the initial explosion they were being buffeted by hurricane-like, dirt-filled winds.

Although they had difficulty breathing, dust caused choking and coughing, no one put on an FSR. Arriving at the No. 2 Shaft bottom, they found the mine phone and signal lines blown out. They succeeded in contacting persons on the surface by shouting and using cap lamps 1-1/2 hr after the explosion. They were hoisted to the surface 2 hr later.

Three miners sitting in a vehicle near No. 1 Shaft station were blown 300 ft by the explosion forces. Two died. The third was Ms. Blaney (see preceding paragraph).

Two miners driving a jeep towards No. 1 Shaft were blown off the roadway. The rear half of the jeep hung over the edge of the conveyor decline. When the driver got out, he fell 20+ ft onto the conveyor. His rescue is mentioned below. The passenger fell 30 ft to the floor. His death was not caused by the fall, but by explosion forces which ruptured alveoli in his lungs as was the case with the other victims.

Two other miners were riding a small tractor-type conveyance. One was blown off the vehicle, but neither was seriously hurt. They found the driver of the jeep and helped him to the No. 1 Shaft. The tunnel conveyor operator also reached the No. 1 Shaft. These four, Ms. Blaney and another miner (see discussion above) were hoisted to the surface 1/2-hr after the explosion. The first rescue teams entered the mine 6 hr later.

Potential Impact of SCSRs

No one used an FSR though all had them on their belts and many reported the air caused choking and coughing. Six survivors were hoisted to the surface via the No. 1 Shaft 1/2-hr to reach No. 2 Shaft; there they waited more than 2 hr.

The 17 survivors were fortunate indeed. Thirty-four hours after the explosion the atmosphere near No. 1 Shaft contained 700 ppm of CO.* At that concentration, the following effects can be expected:

*The actual CO concentration might have been greater. During recovery of this mine following a major fire in 1968 it was learned that colorimetric and length-of-stain CO detectors gave less than actual concentrations. The error was believed to result from these detectors being affected by products of volatilization of salt particles in the air.

After 15 min walking, or 45 min resting	Throbbing headache
After 40 min walking, or 70 min resting	Dizziness to collapse
After 90 min walking, or 180 min resting	Death

High concentrations had to be in the mine in the first several hours after the explosion. That 17 miners survived and explosion forces were the cause of the five deaths infers that self-rescue devices were not critical to safety. Had they been, SCSRs would have been more effective than FSRs. During recovery operations following the 1968 fire in this mine, salt in the mine air accelerated the build-up of resistance to breathing through Universal gas masks. Thus, the heavy concentrations of dust in the air for the several hours after this explosion possibly could have made breathing difficult to impossible through FSRs.

The usefulness of SCSRs for the 11 survivors who reached the surface 3-1/2 hr after the explosion is suspect. Their travel to No. 2 Shaft was difficult and might have consumed more oxygen than SCSRs could provide for travel and the hours awaiting rescue.

A.7.7 USBM No. 1 Shaft Ignition, November 1, 1978 (A-36)

Background

USBM No. 1 Shaft, an experimental oil shale mine near Rio Blanco, CO, is shown in Figure A-5.

The first 2352 ft of shaft are lined with steel and concrete leaving an 8-ft internal diameter; the bottom 26 ft are unlined and 10 ft in diameter. Automatic methane monitors set to alarm at 1 percent methane were at the 2080 level and the shaft collar. Crews carried methane detectors.

The Accident

A crew in the shaft was trying to enlarge a cut out in the steel liner at Level 5. Holes had been drilled into the oil shale to reduce any potential for methane buildup. Hole were being drilled in the steel liner; 14 holes had been enlarged by use of an oxygen-acetylene torch. While enlarging the 15th hole, flames burst out.

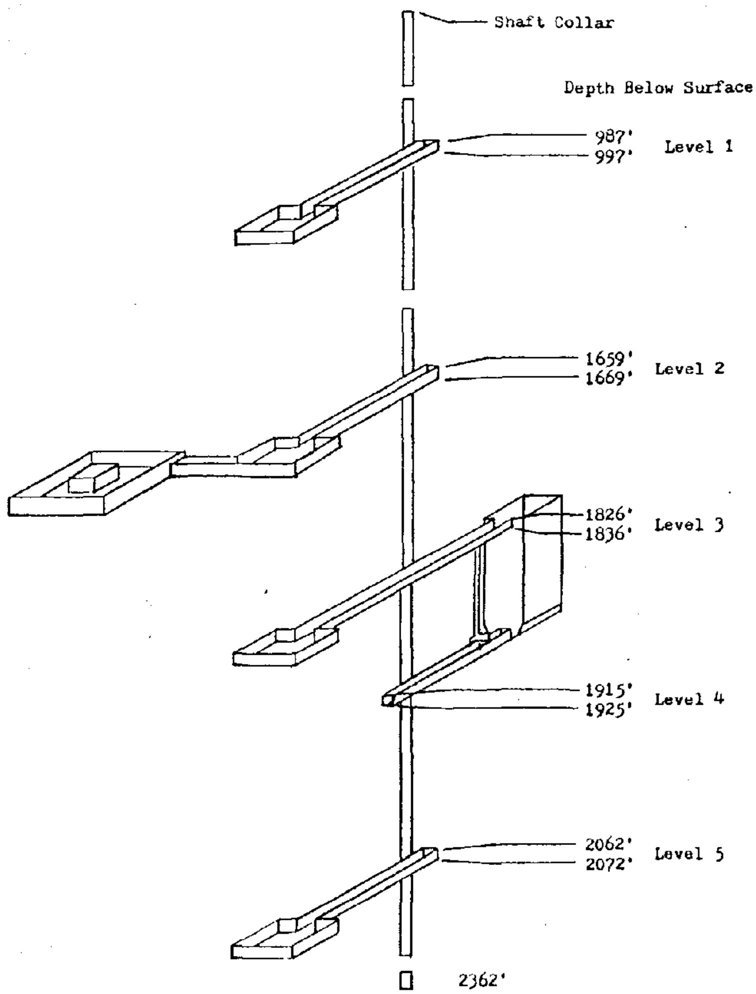


FIGURE A-5. - Illustration of USBM No. 1 shaft.

Subsequent investigation indicated from 0.2 to 3.4 percent methane at the collar of the 15th hole and zero methane a few inches away.

Potential Impact of SCSRs

FSRs were not used. Had it been necessary to use SCSRs, they should have been immediately available. In the initial rush to leave, the miners might forget to stop for SCSRs.

A.7.8 Alchem Trona Ignition, June 3, 1977 (A-23)

Background

Alchem Trona Mine is near Green River, WY. The mine is classified "gassy" by MSHA. Oil shales, containing methane, form the roof and underly the trona. A full-retreat room-and-pillar system is used. The area in which this accident occurred was a seven entry panel on retreat, as shown in Figure A-6. The three center entries were on intake air with two returns on either side. The projected flow of air across the pillar line should have been 40,000 to 45,000 cfm. Roof falls, the absence of line curtains, and removed check curtains resulted in a flow of 15,000 cfm. The panel contained two sections, one mining pillars in the four entries to the left (north) and the other in the three to the right (south section).

The Accident

The four miners who were to work the south section were instructed not to turn on any electrical equipment. The foreman then took the north section crew to its work area and tested for

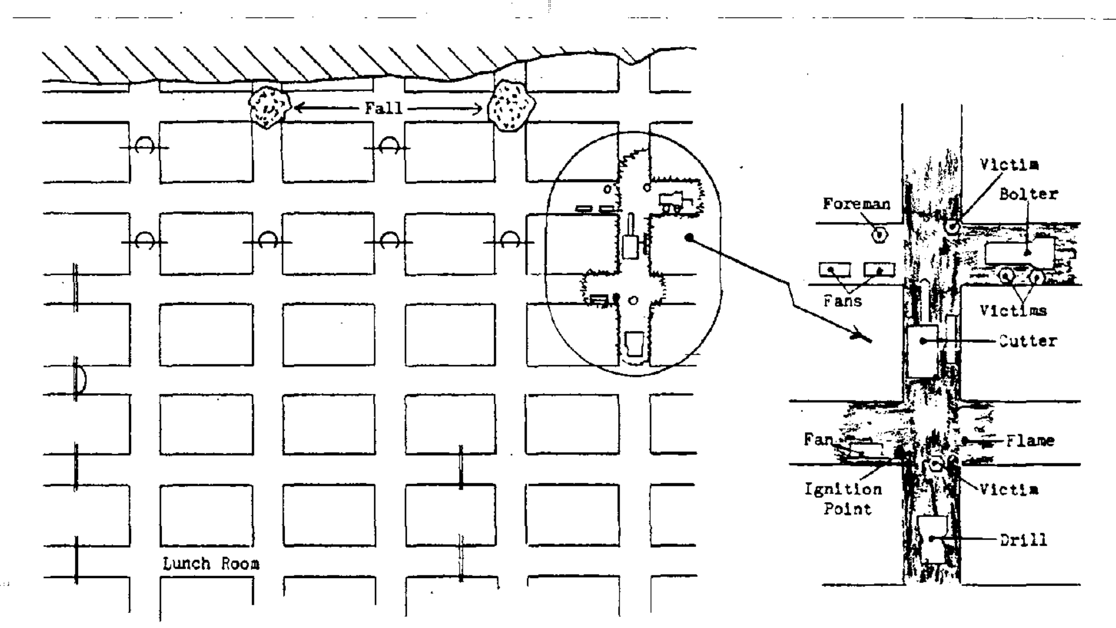


FIGURE A-6. - Location of Alchem Trona ignition.

methane. The foreman then proceeded towards the south section. He heard the roof bolter operating and called to the operator to stop. This was done and immediately afterward an ignition occurred.

Flames filled the area as indicated on the drawing. The clothing on the four miners caught on fire. The foreman extinguished the burning clothes and took the four burned men to the surface.

Subsequent investigations indicated that prior to the ignition, 3 to 4 percent methane had been detected in the south section. The ignition was caused by a faulty splice in the power cable to the fan.

Flames filled a volume of at least 53,000 ft^3, extending 100 ft from the point of ignition. The original methane-air body, therefore, had a length of 20 to 25 ft and a volume less than 5000 ft^3. Assuming worst-case conditions, the ignition might produce as much as 480 ft^3 of CO. The initial average CO concentration, therefore, was less than 1 percent. The 15,000 cfm air flow would dilute the CO to a safe concentration (below 800 ppm) within 30 sec.

The four miners received second and third degree burns to the skin. None showed indications of smoke or toxic product inhalation.

Potential Impact of SCSRs

FSRs were not used and were not needed. Had they been needed the probability is the four miners would have been more concerned with extinguishing their burning clothes than with putting on FSRs.

SCSRs would have been of no use either. If they were carried, the probability is that they would have been dropped while the miners fought the flames. If they were worn, the probability is, as it was the FSRs, that extinguishing burning clothes would take priority. Stored SCSRs would have been accessible only to the foreman; however, he probably would still rush in, depending if need be on his belt-worn FSR.

A.7.9 Belle Mine Ignition, October 27, 1976 (A-33)

Background

Belle Mine is in Bellefonte, PA. Limestone is mined from sublevel stopes.

The Accident

Two miners were to drive a 6- by 6-ft raise. It has reached a height of 125 ft. The miners traveled up 90 ft when they smelled "boiled cabbage". They opened an air hose and continued up the raise, blowing air ahead of them. When they reached the top, one leaned over. Purportedly his cigarette lighter fell out of his pocket; he accidently struck the lighter when he picked it up.

The forces of the resulting ignition knocked the men to the floor of the raise climber. When they realized what happened, they began slapping at each other to extinguish flames in their hair and clothes. They quickly lowered the raise climber, reached the drift, and ran for help.

They were hospitalized and treated for first and second degree burns.

Potential Impact of SCSRs

FSRs were not used and not needed. If needed, they probably would not have been used until after the miners reached the drift. Air in the drift was fresh.

SCSRs were not needed. Had they been, they would have had to be immediately available.

A.7.10 Cane Creek Ignition, July 31, 1963 (A-16)

Background

Cane Creek Mine was about 20 miles southwest of Moab, UT. At the time of this accident, the mine was being developed by two descending drifts driven from a single 2189-ft-deep shaft. The drifts were in salt, oil shales, polyhalites, and other clastic strata overlying potash, the goal of the operations. The drifts, 18-ft-wide and 6- to 8-ft-high, extended about

2000 to 3000 ft from the shaft station. The mine workings are shown in the drawing included in the synopsis of the explosion on August 27, 1963.

The shaft was the sole means of ingress and egress. A dividing partition wall had not been installed. In-line fans forced air down the shaft and into the drifts through metal tubing. The air returned through the mine openings and up the shaft. Fan tubing installations such as this are common cause for recirculation. Return air measurements made after this accident indicated 12,500 to 16,000 cfm in the two drifts, air temperatures of from 100 to 105°F, and flammable gases of from 0.1 to 6.7 percent.

The Accident

About 11:00 p.m. on July 31, 1963 four miners were burned when combustible gas was ignited in 3U drift. The information which follows is not substantiated. Neither this ignition nor prior encounters with gases and oils had been reported to MSHA (then the Health and Safety activity of the Bureau of Mines). They were known by a mine inspector for the Industrial Commission of Utah. The U.S. Geological Survey previously made suggestions on how to relieve the high gas pressures being encountered. On at least one occasion, when drilling blast holes, gas pressures pushed the drill and its operator back 20 ft.

Purportedly, gas coming from a rock bolt hole was ignited when a miner attempted to light a cigarette. Flame flashed over a large area. Flame continued to burn in crevices and the muck pile for 6 hr.

Potential Impact of SCSRs

Burns were the only injuries suffered; therefore, SCSRs had they been available, would have not prevented injury.

Other Factors

Subsequent events, discussed later in Cane Creek Mine Explosion (August 27, 1963), indicated that for conditions existing, the 25 to 50 persons underground needed protection. Either SCSRs or FSRs would have been a positive supplement to critically essential safety requirements, such as:

a. Operating the mine as a gassy mine

b. Providing two separate openings or having adequately supplied refuge chambers at critical places.

A.7.11 Cane Creek Explosion, August 27, 1963 (A-16)

Background

This mine and its conditions are described in the report of a gas ignition. Figure A-7 illustrates areas involved in both accidents.

The Accident

The explosion occurred at about 4:40 p.m. Of the 25 miners underground at the time:

a. Eighteen died:

1. Twelve from the forces of the explosion

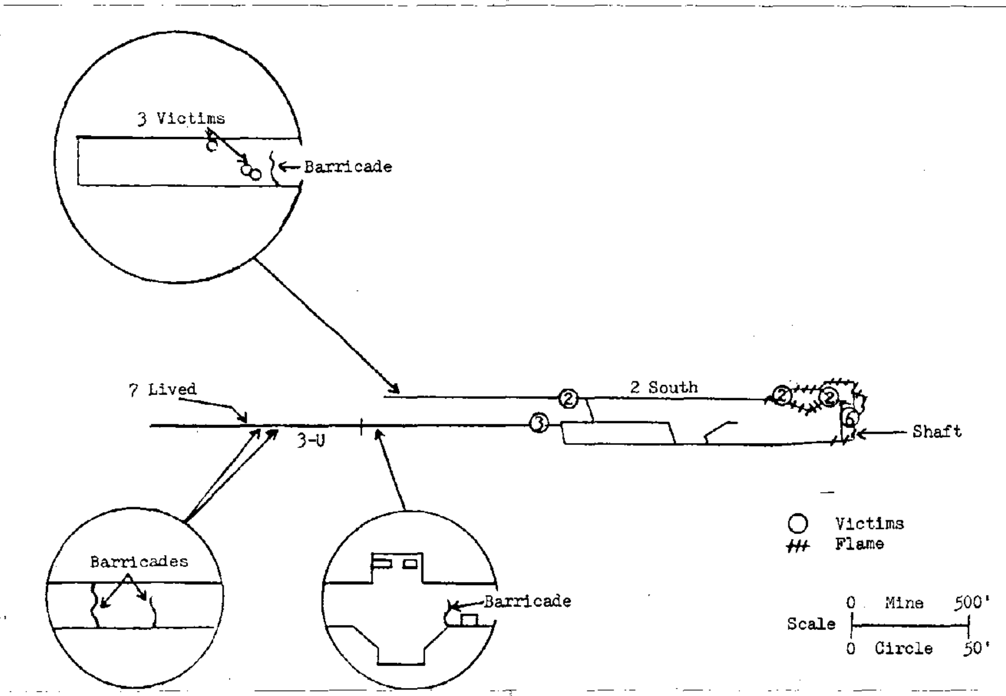


FIGURE A-7. - Location of Cane Creek explosion.

2. Three from irrespirable atmosphere in 3U drift

3. Three from irrespirable atmosphere behind a poorly constructed barricade in 2 South drift.

b. Seven barricaded in 3U drift and lived. Two of the seven left the barricade after the explosion and were met by a rescue crew 19 hr later at the shaft station. Rescue teams reached the other five and brought them to safety 50 hr after the explosion.

The probable (p) and the known (k) events during this disaster were:

3:10 p.m.	Mine foreman entered mine and checked shop area (k)
3:30	Miners entered mine (k)
3:30-4:00	Miners bolted 3U face area; mine foreman tested for methane at 3U face (k)
3:30-4:10	Miners charged 43 holes in face of 2 South (p)
4:20	2 South face blasted (k)
4:40	2 South crew returned to face (p)
4:40	Explosion initiated in shop area (k).

Note:

Air flow measurements purportedly made 2 weeks before the explosion indicated 14,500 cfm returning from 2 South. The cross sectional area of 2 South averaged 160 ft^2. The shop area was 1800 ft from the face of 2 South. Therefore, gases and blasting fumes from 2 South would reach the shop area in about 20 min. Force directions and other evidence left little doubt the explosion initiated in the shop area.

Post 4:40 in 3U - Seven miners and the mine foreman in 3U knew something out of the ordinary had happened. Two of them had been knocked down by a strong wind. They got into a shuttle car and began to ride to the shaft. They met two miners in the 3U drift. Thus, the group now consisted of 10 people. As they traveled they heard a voice cry out, "I can't see." Smoke became so dense they decided to abandon efforts to reach the shaft; they began to walk back to a better atmosphere.

Seven made it back to the 3U face. After two unsuccessful attempts they built a barricade of cut-up pieces of flexible vent tubing. One miner who went back into the smoke to get the compressed air line found the other three miners lying on the floor with their heads near the end of a metal ventilation duct. He told them to move back to the barricade. They didn't or couldn't and died.

After several hours two miners left the barricade to try to repair the compressed air line in case compressor air was restored. Although they were in heavy smoke, their flame safety lamp indicated sufficient oxygen.

These same two miners left the barricade again 15 hr later, again using the flame safety lamp, in an attempt to repair the compressed air line. They reached the shaft and banged with a steel bar on a pipe in the shaft. This was not heard by the growing number of people on the surface. Fortunately, a rescue team sent underground at 11:30, the morning after the explosion, found them. Fifty hours after the explosion, rescue teams reached the five miners behind the 3U barricade.

Post 4:40 in 2 South - We know little of what the 5-man, 2 South crew did after they blasted the round at 4:20. Two bodies were found 725 ft from the face; it appeared they died near there when caught by the forces of the explosion.

Footprints of a third miner indicated he might have been near those two at the time of the explosion and then walked perhaps 400 ft into a blind drift and then 1200 ft back to the barricade in 2 South drift.

The barricade probably was built by the other two miners. They and the miner who had walked so far died behind the barricade. The barricade only blocked part of the opening. They had a flame safety lamp.

Potential Impact of SCSRs

The seven who barricaded in 3U did not need filter or oxygen self rescuers. Had they not been so wise as to construct a good barricade (remember they made three), SCSRs would not have saved them (some SCSRs might provide up to 4 or 5 hr of oxygen, not the 18 to 50 hr needed).

If the three who died in 3U drift had worn or carried SCSRs, or if at least 10 SCSRs had been in the shuttle car, it is reasonable to assume these three also might have reached the safety of the 3U barricade.

FSRs might have also saved these three lives. Although the CO and O_2 concentrations are unknown, the ability of other miners to return to the compressed airline - and the flame safety lamp - indicate that FSRs would have supplied adequate protection.

If the three who died behind the 2 South barricade had SCSRs.

a. They would have died if they had remained there.

b. They might have lived had they gone to another location or had built a good barricade. However, they did not need SCSR's to find another location to build a good barricade; they had a flame safety lamp and good materials for barricading were ample. Remember, the one who screamed, "I can't see," walked at least 1600 ft.

Thus, SCSRs might have saved three lives in this disaster.

Other Factors

Little had been learned from the gas ignition just 27 days before:

a. Despite NO SMOKING orders and signs, some miners smoked while underground.

b. A well-equipped mine-rescue station was maintained at the mine. No team had been assembled.

c. Few persons knew how to test for gas and seldom did.

d. When gas was found (on one occasion 4 percent methane was detected in 3U drift) operations continued as usual.

e. No positive steps had been taken to ventilate the workings properly.

f. Refuge chambers did not exist.

g. Equipment and blasting practices capable of igniting methane were in standard use.

A.7.12 Dead Horse Ignition, May 20, 1970 (A-34)

Background

Dead Horse Mine was a mercury operation in Idria, CA. Information on this accident may be incomplete; MSHA was notified 24 hr after the ignition; and, the mine was closed shortly afterwards. The accident site is shown in Figure A-8.

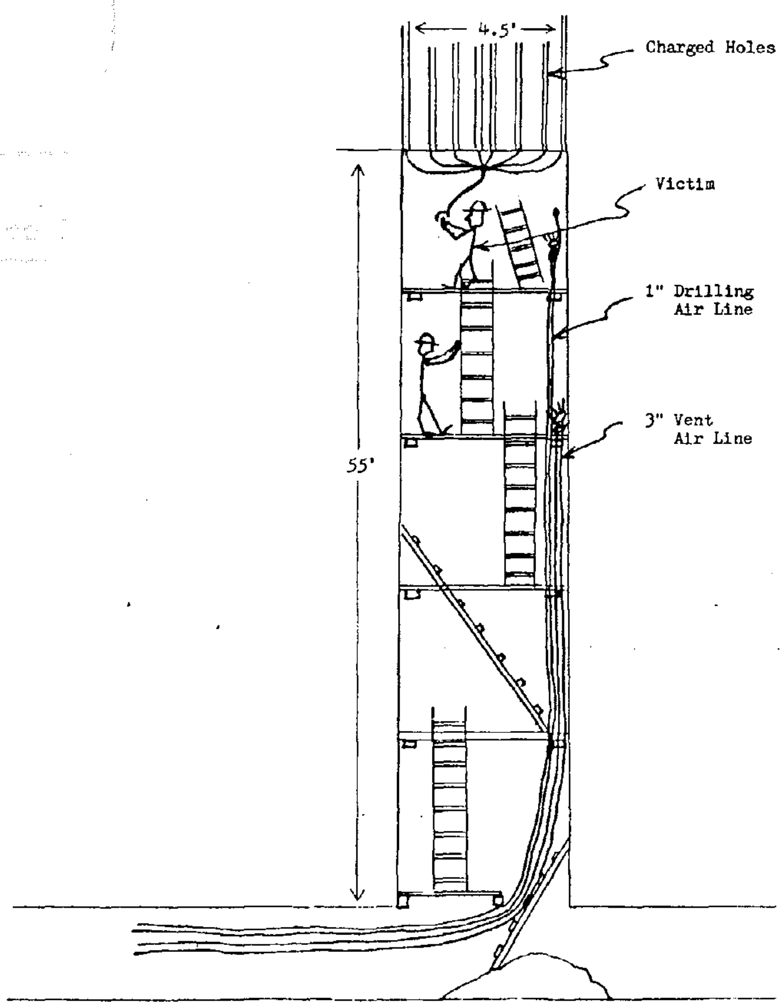


FIGURE A-8. - Accident site of Dead Horse Mine Ignition.

Dead Horse Mine was an exploration mine consisting of a 3150 ft long adit with two branching drifts. One drift, 1200 ft long, connected to the New Idria Mine, and had one raise. The other drift, 1000 ft long, had two raises; one was idle; the other was the site of the accident.

A fan at the portal and in-line fans blew 4300 cfm through 16-in. tubing. Air flows reversed when doors in the New Idria Mine connection were opened. The raises were ventilated by 3-in. hose from compressed air lines and by the 1-in. drill air lines.

Ground control, where required, was 3-piece timber sets on 5-ft-centers with lagging. Dynamite, safety fuse and igniter cord was used for blasting. Four miners were underground when the ignition occurred.

The Accident

This ignition occurred at the face of the 4-stage-high raise. One miner was waiting on the third stage for the other miner to light the igniter cord. When the match was struck, flames engulfed the entire area. The miner who struck the match fell down the raise. The other miner climbed down and helped his partner to the main adit where the other two miners assisted both men out of the mine.

The miner who struck the match and fell 45 ft down the raise received extensive first, second and third degree burns. The other miner received spotty first and second degree burns.

Potential Impact of SCSRs

Neither FSRs nor SCSRs were needed to protect miners in this accident. They might have been needed had a larger body of gas been involved.

Other Factors

More positive approaches to safety would have been to test for gas before and after blasting and to provide positive and adequate ventilation.

A.7.13 No. 1 Incline Explosion, November 5, 1953 (A-34)

Background

The No. 1 Incline Mine produced gilsonite from 10- to 14-ft-wide veins near Bonanza, UT. Gilsonite is one of the most combustible materials mined; its ignition and explosion hazard is far greater than that of any known coal dust. Mining in prior years had a history of explosions from use of permissible explosives and Cardox.

Gilsonite was mined by open-cut stoping. The mine was naturally ventilated. Stulls on 25-ft centers were used to keep the stopes open and when planked formed levels. Ore was mined on 40 to 45° slopes by drilling and blasting with compressed air shells. The broken ore slid down the slope to ore chutes where it was loaded into a skip and hoisted to the surface. The ore was dumped into a bin at the head house.

Figure A-9 shows general stoping practices at the time of the accident; since then important changes have been made. Also shown are the surface facilities, place where the explosion initiated, and the locations of the eight victims.

The Accident

Shortly after 8:00 in the morning, the shift boss was riding up the slope on a skip loaded with ore. Within minutes he arrived on the surface, walked 100 to 120 yards, when he heard what he described as a high-powered rifle shot; the explosion followed immediately.

The hoistman reported he dumped the skip the shift boss rode out; he returned the skip to the ore chute in the mine, hoisted it and dumped it; a 5-min task. Immediately thereafter he saw a flame between the head frame and the hoist house. He quickly left and had travelled less than 100 ft when flame, timber and mine debris began to fall around him. Later it was learned that all of the timber in the mine, more than a million linear feet, had blown out several thousand feet.

Efforts to reach the eight men known to be in the mine proved futile because of the heat and flame. After 15 hr, two miners wearing oxygen breathing apparatus were lowered in a bucket into an open portion of a stope. Because of what they saw, the absence of timber, a new shaft was sunk. The five victims in the west slope area were found on November 20.

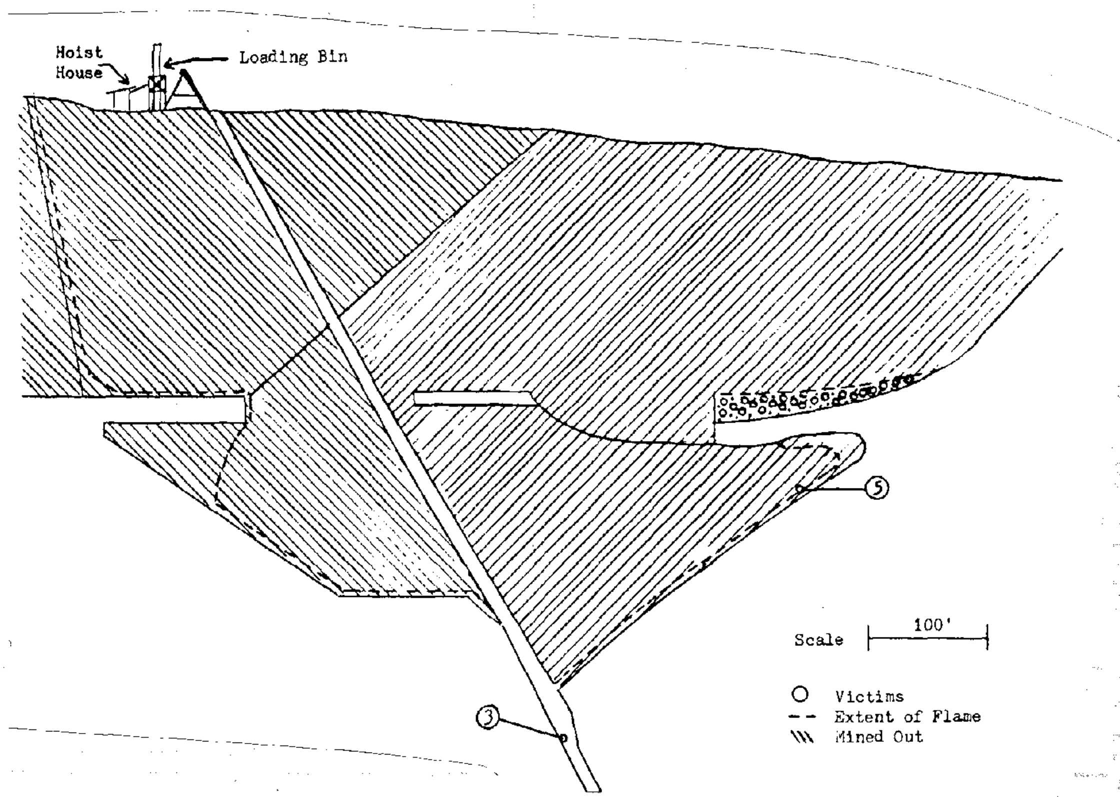


FIGURE A-9. - Location of No. 1 Incline explosion.

The other three were recovered March 12. These three may have died from CO, oxygen deficiency, shock, flying debris or combinations thereof.

Potential Impact of SCSRs

Auxiliary sources of oxygen would have been to no avail to these miners. Eight were in the mine at the time of the explosion. Had any lived there would have been no chance for finding, let alone reaching, them for weeks to months. None of the bodies indicated much time elapsed between the explosion and death, though no autopsies had been performed.

A.7.14 Sunshine Mine Fire, May 2, 1972 (A-8)

Background

Sunshine Mine produces silver, copper and antimony at Big Creek Canyon, ID. Figure A-10 shows the general outline of the

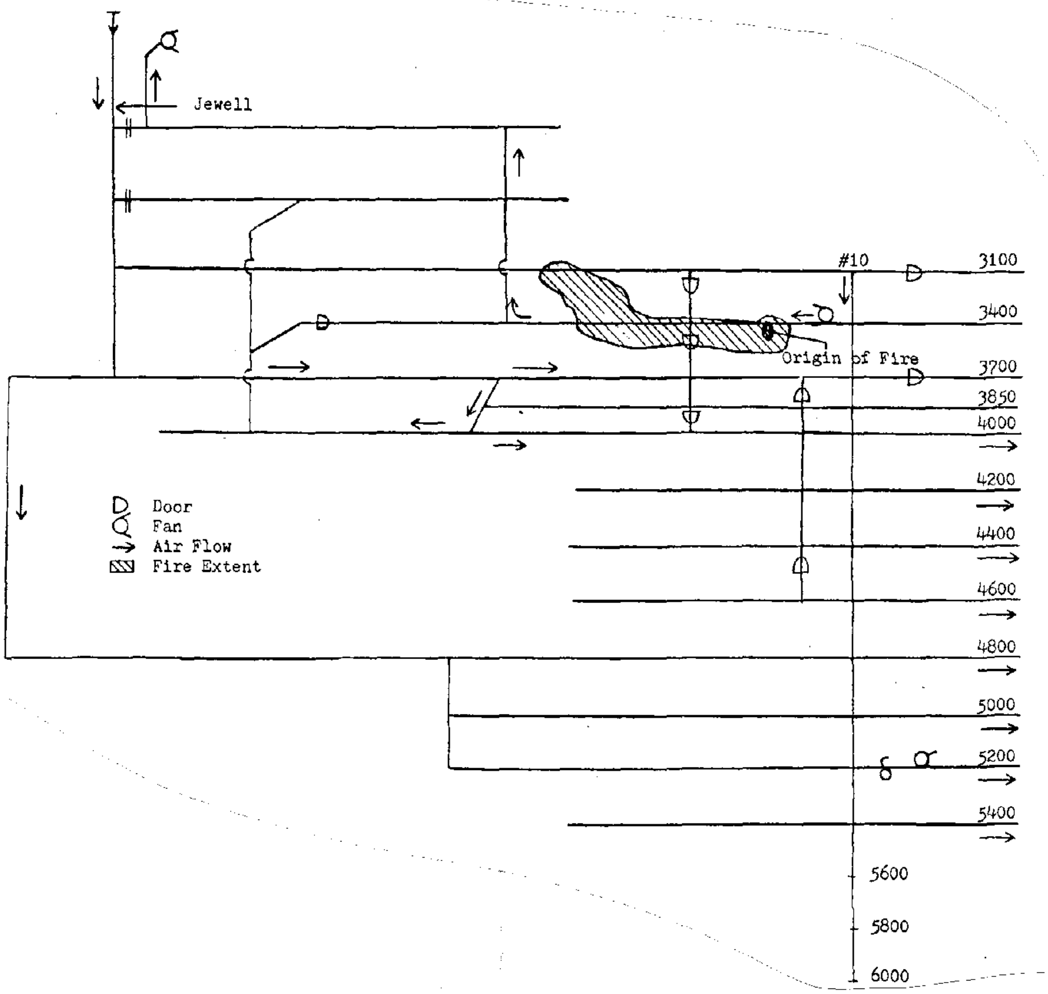


FIGURE A-10. - General outline of Sunshine Mine.

mine. Main access is through a 200 ft long adit to the Jewell Shaft; down that shaft to the 3100 and 3700 levels; then along a 5000 ft drift to the No. 10 Shaft. The No. 10 Shaft collared at the 3100 level, and was the sole means to the working levels.

Above the 3700 level the stopes were square-set and cut-and-filled with waste and rock. Lower level stopes were mined by horizontal cuts with sand fill. Ventilation prior to and during the fire was detailed in the referenced reports. (A-9, A-10, A-11, A-12).

The Accident

Sometime between 11:30 and 11:40 a.m. smoke was seen flowing out of a number of places on the 3700 level. Numerous people began searching for the source. The air flow carried the smoke to No. 10 Shaft and then down to the lower levels. The chippy hoist, which could transport 48 miners at a time in No. 10 Shaft, had to be abandoned; smoke was so dense in the hoist room the operator had trouble breathing and could not see the control dials.

After fruitless search for the source of the smoke the senior official in the mine ordered evacuation. Stench was released into the compressed air line at 12:03; shifters and motormen went to the working areas to call the miners out; and, the No. 10 Shaft double-drum hoistman was ordered to stop hoisting ore and to begin hoisting miners -- the first of nine trips began at 12:10.

The double-drum was used to hoist ore and waste. Single-deck, 9-man capacity man cages were suspended below the skip in each of the two compartments. Because of problems encountered in using the double-drum, one side was clutched out and 7 of the 9 evacuation trips were made with one cage.

The regular hoist operator became ill and turned the controls over to his "partner". This second hoistman collapsed at 1:02; the evacuation stopped; 60 miners remained on the lower levels. In summary:

a. Eighty miners were evacuated

b. Thirty-six had used FSRs

c. Two miners were rescued 7 days later

d. Ninety-one miners died.

The fire began as spontaneous combustion of timber in a manway between the 3550 and 3400 levels. This caused a section of the 3400 drift to collapse. The 3400 level was the main return; the collapse occurred downwind of the 3400-level booster fans. This caused the return air to split, part of it now went into old workings between the 3700 and 3400 levels, driving smoke and fumes that had collected in those workings into the main intake air flow on the 3700 level. The high-pressure air from 3400 level accelerated flaming which then spread through those workings and up into the 3100 level, the other main intake for the mine. The rapid flows of old and new fire products made every minute's delay critical.

None of the survivors saw flame or felt abnormal heat. None smelled the stench. The large toll of death could be attributed to one or more of the following:

a. The 20-min delay in beginning evacuation

b. Abandonment of the chippy hoist

c. Not stopping the 3400-level booster fans

d. The illness of the first and collapse of the second No. 10 hoistmen

e. Miners not barricading.

The movements of some miners can be traced from information in Table A-9.

TABLE A-9. - Movement of some miners in Sunshine Mine

Level	Miners on level prior to fire	Cage trips to level	Miners who died on the level
Jewell Adit	1	-	0
3100	3	-	31
3400	2	1	4
3700	52	4	16
4000	1	1	0
4200	4	1	3
4400	8	1	7
4600	20	3	0
4800	18*	1	7
5000	25	4	2
5200	21	0	21
5400	8	1	0
5600	10	1	0
5800		1	0

*Two miners on the 4800 level were rescued 7 days later.

Use of Self-Rescuers

The Sunshine Mine fire is often referred to in discussions of FSRs particularly their inadequacies. The following information is from detailed records made during the intensive investigations that followed this disaster. Information on the use of FSRs by 59 of the survivors in presented in Table A-10. In summary:

a. Thirty-six of the 80 miners who were evacuated on May 2 used FSRs; information given by 23 of those 36 is included in Table A-10.

b. Those 23 used FSRs for 5 to more than 90 min; some used up to three FSRs during that time.

c. Those 23 were in smoke without FSRs for 10 to more than 80 min, during which time some stood next to miners who died.

d. Many miners, including some who died, shared FSRs or obtained FSRs that had been previously used.

e. Four miners reported FSRs became uncomfortably hot.

f. Wet T-shirts and rags were "successfully used" in lieu of FSRs by at least nine survivors.

Potential Impact of SCSRs

FSRs or SCSRs could have saved the lives of all 91 miners had they been properly used. SCSRs would have been available had they been stored at shaft stations. Because some FSRs were available and were used at Sunshine, these are some valuable lessons to be learned, some of which might also be applied to the use of SCSRs.

It should be noted that most of the FSRs used were a 30-min type approved as BM-1447. That type did not have a heat exchanger which, in the presence of CO, would cause breathed air to be 20° to 50°F hotter than with presently-used FSRs.

TABLE A-10. - Survivors of Sunshine Mine Fire, May 2, 1972 (A-13)

Person	Escape route to Jewell	Estimated Minutes in smoke		Remarks
		Without FSR	With FSR	
Anderson, D.	5000-3100	30-45	15-25	FSR got warm as cup of stale coffee
Bailee, E.	5000-3100	> 60	0	Didn't use FSR because he wore dentures. At least 30 minutes in stope; may not have been in heavy smoke for the 60 minutes indicated.
Becker, G.	3700-3100	50	0	Couldn't inhale through FSR; he could exhale. He and many others left FSR's on cage when it got to 3100; big pile of FSR's in cage.
Bennett, P.	3700-3700	10-20	0	Held breath; took first cage in Jewell Shaft at 12:45
Bennett, W.	3700-3100	45	0	Used wet T-shirt for protection. Lungs hurt.
Benson, H.	3700-3100	50	0	Used O_2 bottles. Couldn't get air through FSR.
Bourgard, L.	5000-3100	30-40	25	FSR did not get hot.
Breazeal, R.	4400-3100	20-30	0	Used O_2 bottle.
Bruhn, C.	5000-3100	20	60	FSR got hot.
Bush, J.	2700-	50	0	Was in heavy smoke much of the time. Collapsed.
Clapp, D.	4600-3100	> 55	0	FSR wouldn't work
Davis, E.	3700-3700	10	0	
Dionne, H.	3700-3700	> 80	0	Severe headaches, dizzy, near collapse.
Dunlop, L.	3700-3700	0	0	Pulled 4 skips of muck after he learned of fire.
Fenner, J.	5000-3100	50	45	Used 2 FSR's. Smoke nil to light on 5000.
Findley, R.	4500-3100	> 80	5	Next to last person out. Used wet rag.
Flory, R.	4800-4800	15	> 30	Barricaded.
Follette, R.	5000-3100	40	45	
Fowler, H.	3700-3700	15	30	Took dentures out. FSR got hot.
Gardner, J.	4600-3100	45	25	FSR got hot.
Hansen, L.	4000-3700	10	0	Used wet rag.
Harris, W.	4400-3100	50	0	
Hawkins, L.	3700-3700	15	0	Wore OBA (oxygen breathing apparatus)
Henry, J.	5000-3100	55	0	part of time.
Jerome, T.	4600-3100	45	15	Used wet T-shirt.
Kienholtz, E.	4600-3100	40	20	FSR got hot.
Lamphere, J.	3700-3100	40	0	
				Used wet rag, O_2 bottle. Was ill for a week.

Table A-10 continued

TABLE A-10. - Survivors of Sunshine Mine Fire, May 2, 1972
(continued)

Person	Escape route to Jewell	Estimated Minutes in smoke		Remarks
		Without FSR	With FSR	
Launhardt, R.	Jewell-3100	0	0	OBA (oxygen breathing apparatus).
Markve, H.	5000-3100	30	30	Took FSR off frequently to talk.
McCoy, R.	5000-3100	50	0	Used compressed air. Passed out.
McGillverry, C.	5000-3100	50	0	Used compressed air. Passed out.
McKeen, W.	3700-3700	<5	0	
Mendy, H.	4600-3100	>50	0	Couldn't activate FSR.
Mendy, R.	4600-3100	>50	0	Couldn't activate FSR.
Mitchell, W.	4400-3100	>30	0	Used compressed air.
Morris, R.	4600-3100	>50	0	Wet T-shirt. Couldn't activate FSR.
Mossbaugh, L.	3700-3100	45	0	
Napier, C.	3700-3100	>40	0	Wet rag; O_2 bottle; air hose.
Nickelby, R.	3700-3700	25	0	Used shirt. Two miners with him died. Strenuous activity.
Norris, F.	4600-3100	40	15	
Olson, H.	2300-2300	0	0	
Oman, B.	Jewell	0	0	
Osterberg, G.	4600-3100	40	20	
Ostoj, R.	4600-3100	40	20	
Pederson, E.	2300-2300	0	0	
Peterson, C.	Jewell	4	0	
Peterson, G.	4400-3100	60	0	Used compressed air.
Rihtarshik, L.	5000-3100	50	10	Used wet rag and laid on ground for other protection. FSR got warm, no trouble breathing through FSR. Greg Dionne activated FSR for him.
Sabala, T.	3700-3100	35	10	Vomiting, took FSR out of mouth 4 or 5 times, laid on floor.
Schulz, B.	10 Shaft	<10	>90	Used 3 FSR's: a new and a used BM 1447, and a used W-65. Removed FSR frequently to talk.
Seagraves, J.	4000-3700	10	0	
Sliger, I.	3100-	30	10	First No. 10 hoistman. Used FSR after leaving hoist.
Smith, A.	3100-	50	0	
Stevenson, I.	5000-	60	10	
Tucker, K.	3700-3700	45	0	
Ulrich, N.	3700-3700	40	15	
Watts, T.	5000-3100	30	20	FSR uncomfortable.
Wilburn, K.	3700-3700	40	10	
Zingler, J.	Jewell-3100	0	0	

Besides the BM 1447, a number of W-65 model FSR's were used. Having two models caused problems; miners were observed beating W-65's with wrenches and rocks trying to "activate them". A W-65, however, does not have the "button" used to activate the BM 1447.

The major problem with FSRs was keeping them in the mouth. This problem affected three groups.

a. Miners who needed, but did not have their dentures.

b. Miners who had to vomit.

c. Miners who had to talk. Communications are critical in an emergency. Most of the miners reaching 3100 level had never been there before. They had to ask directions; others had to give directions. One miner, Greg Dionne, is known to have given verbal instructions to at least 20 miners in the use of FSRs; also, he took at least six FSRs out of his mouth and gave them to other miners.

A.7.15 Homestake Mine Fire, May 9, 1975 (A-4)

Background

Homestake Mine, In Lead, SD, produces 6500 tons of gold-bearing ore on two shifts a day. The ore bodies are mined by horizontal cut-and-fill stoping. Square-set stopes with backfill-ins are used in some areas; the fill often contains sulfides. Many drifts above the 3500 level are heavily timbered; rock bolts are the principal support in lower levels.

Three shifts, Yates, Ross and Number 5, were used to intake air from the surface into the mine. Yates and Ross shafts also were used for hoisting miners, supplies and ore. Two main surface fans exhausted air from the Ellison and Oro Hondo shafts. These shafts and the great extent of this mine are shown in Figure A-11.

A number of problems had developed in the mine that had important effects on this accident.

a. The Ellison Shaft caved. The caving crushed out most of the shaft timber support, and broken timber, rock, pipe and electrical cable filled the shaft from the 3200 to 2600 levels.

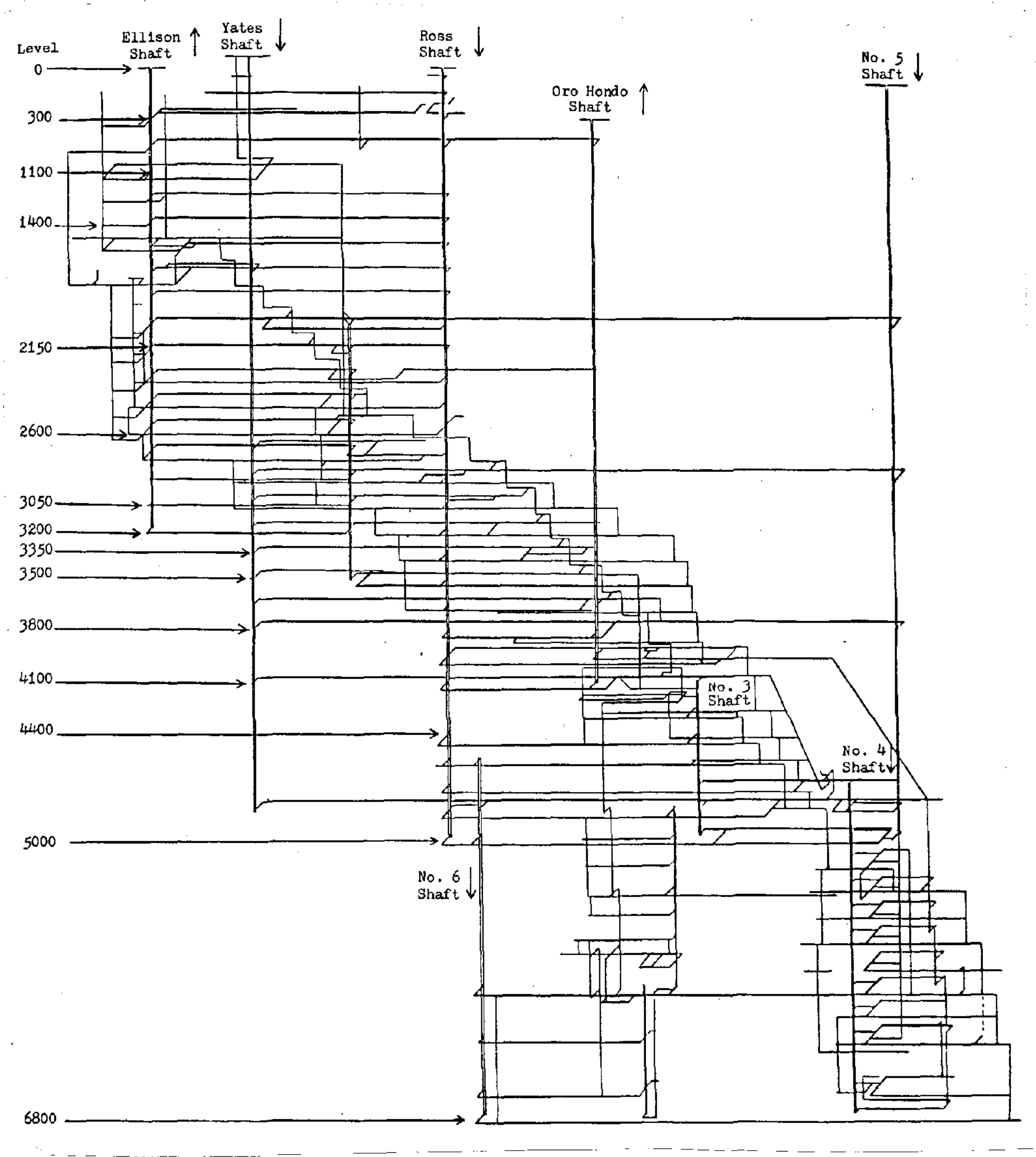


FIGURE A-11. - Homestake Mine.

b. The caving damaged the fan at the top of Ellison Shaft. This was one of the two main exhaust fans for the mine.

c. With the Ellison fan not operating, air flow on the 3050 level, the site of the fire, was reduced from the normal 19,500 to less than 2000 cfm.

d. This reduction allowed booster fans to induce a positive pressure across all doors separating the Ellison exhaust system and the Ross and Yates intake shafts. Consequently, leakage and products of combustion on the exhaust-air side could contaminate intake air flows between the 3350 level and the surface.

The Accident

At 9:30 a.m. two mine officials, while walking on the 3050 level drift, saw sparks falling from the back of the timbered drift. After spending 15 futile minutes trying to obtain water they donned their FSR's. The fire was beginning to spread rapidly across the drift and had propagated 10 ft along the drift. Very little smoke was being produced.

They ran through the fire, went down to the 3200 level, and then to the phone at Ross Shaft from which they called the mine superintendent. This was at 10:07, a 1/2-hr after they first sighted the fire.

The mine evacuation plan was put into effect at 10:16. Stench was released into the intake shafts, Yates and Ross. At 10:30 stench was released into the No. 5 Shaft and into the compressed air line. Meanwhile, the booster fans on the 3500 and 3800 levels which were forcing smoke and fumes from the fire into the main intake were shut down.

Smoke blocked the designated escape routes to Ross Shaft of miners in the No. 3 Shaft area on 4100 level and on the 2150 level. Fortunately, this possibility had been considered when evacuation plans were analyzed. So, when the trapped miners called the Safety Department monitoring unit they were advised of alternate routes which brought both groups to safety out Yates Shaft.

The first cage load of miners reached the surface at 10:40, a little more than 1 hr after the fire was first discovered and 1/2-hr after evacuation was begun. The last cage load reached the surface at 11:45 a.m.

The employee count showed 608 miners had reached the surface. Two miners were missing. Those two had been assigned to a stope off the 4400 level.

Mine rescue teams wearing oxygen breathing apparatus were directed to retrace the two probable escape routes that could be taken by the two missing men. The teams followed those routes and came to their common meeting point without finding the two. The teams then proceeded to the assigned work place. There were the two still working. The teams took them out; and, at 1:45 p.m. all 610 miners were out of the mine. No smoke was encountered by the mine rescue teams during their recovery efforts.

Figure A-12 illustrates the extent of the fire. The fire area was sealed; and, conditions indicated the fire had been isolated - not extinguished - the evening of May 16, 7-1/2 days after flames were first observed.

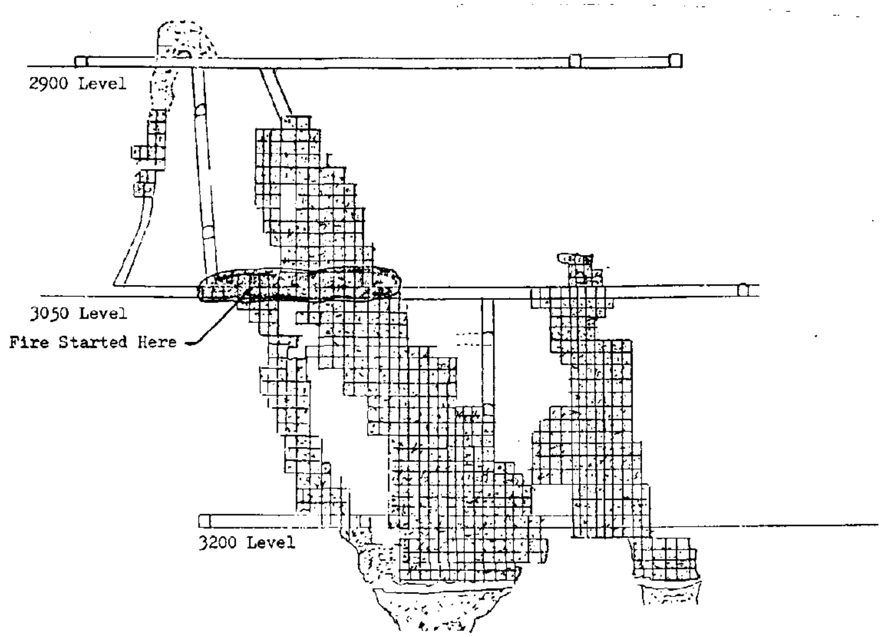


FIGURE A-12. - Extent of fire at Homestake Mine.

Potential Impact of SCSRs

Only two of the 610 miners used their FSRs. These were the two officials who first found the fire. They said they put on FSRs, not because they were needed, but as a precaution. Even the miners whose escape routes were blocked by smoke did not use FSRs.

During the first several hours after miners began evacuation, the maximum CO detected was 30 ppm in the 3050 drift. It was not until 4:00 p.m. that as much as 700 ppm of CO was detected. The oxygen concentration always was enough to sustain a flame safety lamp. Vacuum samples collected that afternoon and evening while the fire obviously worsened indicated from 16.7 to 20.9 percent O_2 in the immediate return from the fire. This contaminated air had to enter the main exhaust system before it could go to other parts of the mine. This would dilute the fire products with several tens of thousands of cubic feet of air per minute.

FSRs, therefore, would have protected miners for the conditions that existed. FSRs could be expected to have protected the miners even if the fire was as intense as it was later that day.

Other Factors

One-half hour before the two officials found the fire, another miner, a maintenance man, had passed through the fire area and had observed nothing out of the ordinary. Thus, the outbreak of fire was fortuitously witnessed almost at its inception.

The order to evacuate, though delayed by a half hour, had been given as soon as the discoverers reached a station where the information could be relayed to the surface. All subsequent actions were prompt and positive.

A.7.16 Magma Mine Fire, May 2, 1980 (A-6)

Background

Magma Mine is near Superior, AZ. Copper ore is mined from cut and fill stopes. The mine is developed to the 4100-ft level; stopes between the 3300 and 3200 levels were inaccessible.

The fire was in an abandoned stope off the 3320 Sublevel as shown in Figure A-13. This area had been mined using undercuts with square-set supports followed by partial sand filling.

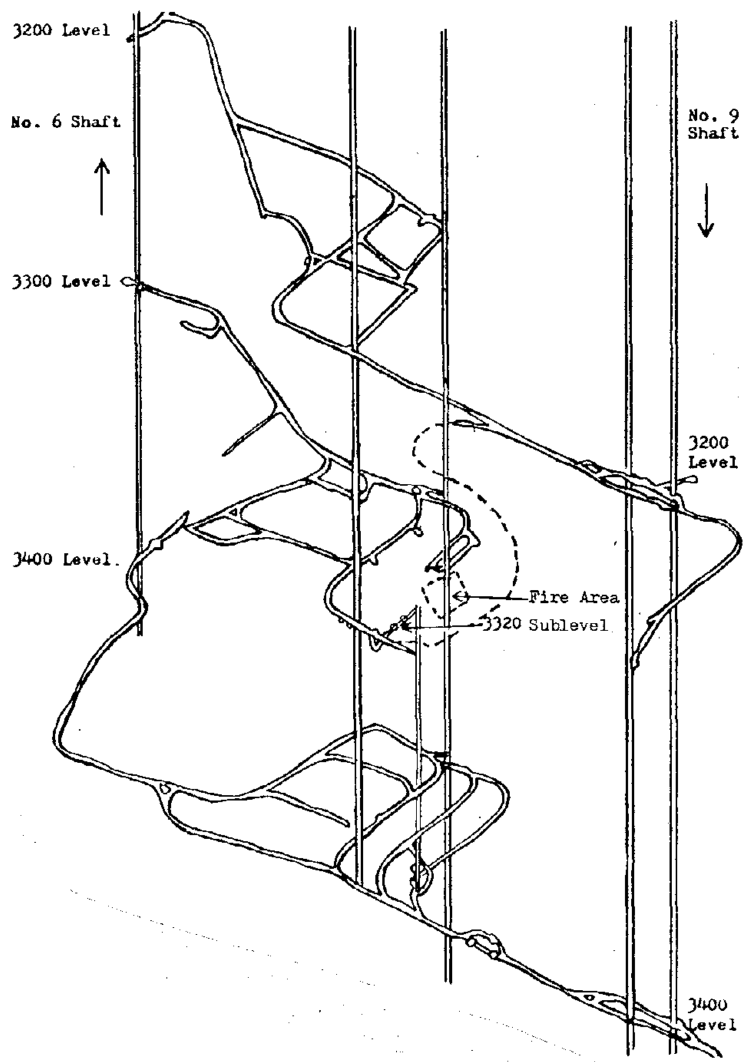


FIGURE A-13. - Magma Mine fire area.

The Accident

During the afternoon of May 2, smoke in the form of a haze was observed flowing along the roof of the 3320 Sublevel. No sign of fire could be found. CO-detector tube readings were below 50 ppm; and, instruments, placed in the immediate return from this area by FMC Corporation under contract with the U.S. Bureau of Mines, indicated no fire gases. Mine management, therefore, believed the smoke was from recirculation of blasting fumes.

Monitoring continued throughout the week. At 9:10 a.m., May 7, mine management notified MSHA the mine was being evacuated because of the increasing concentrations of smoke and CO on the 3320 Sublevel and adjacent working areas.

Bulkheads and seals were built and the entire area was refilled with sand. By May 11, the open areas of the mine were free of CO; samples taken within the sealed area indicated CO had decreased to 3-0 ppm. The fire probably was initiated by spontaneous combustion of exposed timber, the sulfides in the orebody, or both.

Potential Impact of SCSRs

FSRs were not used. Discussions indicate they were not needed at any time.

Other Factors

Bulkheads and seals were constructed by mine rescue teams. Although, initially believed not to be from fire, the smoke and haze were closely monitored. When it became evident that a potential problem existed there was no delay in evacuating all persons. The evacuation plan for this mine considered many, if not all, possible emergencies. Abandoned areas were regularly monitored by competent persons.

A.7.17 Beyer Mine Fire, January 22, 1978 (A-48)

Background

Beyer Mine produces limestone near Kansas City, MO. Rooms and pillars in the mine extend over 400 acres, much of which are abandoned. Access into the mine is through drifts.

The fire was not reported to MSHA. MSHA learned about it from a reference in a newspaper. No one was underground when the fire started.

The Accident

Smoke was observed issuing from several drifts. Local firemen wearing Scott Air Pac's and MSA 30-min OBA's extinguished burning after 6 hr of effort.

Potential Impact of SCSRs

None.

A.7.18 Crescent Mine Fire, March 25, 1979 (A-58)

Background

Crescent Mine, in Big Creek Canyon, ID, produces silver ore. This mine is typical of those in the Coeur d'Alene silver belt; mining is by the horizontal cut and fill on multiple levels; considerable quantities of timber are present in upper levels and shafts. The 12 level, where the accident occurred, was abandoned except for electrical circuits up to 2300 volts.

The Accident

Two mechanics on the Hooper level smelled and saw smoke rising up No. 1 Shaft. They immediately left the mine, arriving within 5 min of the surface. No one else had been underground. Mine management was notified.

Persons in the adjoining Bunker Hill Mine were immediately evacuated to the top station of Bunker Hill No. 1 Shaft. Bunker Hill Mine was checked and found clear of smoke and CO to the connecting drift which served as the main intake to Crescent.

All persons, other than mine rescue teams with oxygen breathing apparatus, were kept out of the Crescent and Bunker Hill mines, until the fire was extinguished late that day.

The fire is believed to have been caused by a combination of high humidity, a rockburst and collapse of a timber to which an electrical conductor was stapled. Two sets of timber burned.

Potential Impact of SCSRs

FSRs were not used. Prompt, positive response to the problem removed persons from any chance of danger. The fire was on the return end of the ventilating network and thus was unlikely, even had it been worse, to expose miners to danger provided evacuation was prompt. SCSRs, therefore, would have not been of use.

A.7.19 Eagle Mine Fire, October 3, 1977 (A-59)

Background

Eagle Mine, in Gilman, CO, has been in continuous operation since 1879. Zinc is the principal product, but lead, copper and silver also are recovered from the sulfide ore body. The veins mined range from 50- to 200-ft-thick.

Main access into the mine is through the No. 1 Shaft. This upcast shaft is 500 ft deep. It extends to the 16th level. A decline is used to gain access to the 20th level. The four levels below 20 were mined out and flooded. The distance between levels is 90 ft. Four declines from the surface, dipping 12 to 17 degrees, are the intake airways. They contain no means for transport other than walking.

Normally, the mine operates two shifts with 50 miners per shift. Ore is mined by square-set stopes using gob caved from the hanging wall for fill. Extracting pillars also requires a large amount of timber.

The sulfide ore, sulfides in the hanging wall and gob fill, and large quantities of timber present a major fire hazard. Some abandoned stopes are bulkheaded off by wood sealed with tar paper. Pipes through some seals allow sampling stopes for oxygen and carbon monoxide. All mine officials carry CO detectors. A number of old stopes are not sealed but are left open in hopes the air flow will be enough to prevent spontaneous combustion.

The Accident

A motorman on the 19th level detected smoke at 9:00 a.m. He immediately reported it to his foreman. The mine manager was notified at 9:10. Shortly thereafter, the foreman was instructed to activate the stench warning systems.

During those activities two miners from the 69-64N stope came down to the 19th complaining they were sick.

All employees went to their level stations at No. 1 Shaft which was on the exhaust air side. By 10:15, more than an hour after smoke was first detected, the 50 miners were out of the mine.

Some miners then returned to the fire area, staying on the fresh air side. The fire was in the 69-64N stope. The only access to this relatively new stope in a virgin area of the mine was off the 19th level. It had no connections to other levels; therefore, it was relatively easy to seal and isolate.

While seals were being built, mining was resumed in some stopes on the 19th and 20th levels, the fresh air side of the fire. Also, two drift miners were working above the 14th level in return air containing 40 to 60 ppm of CO.

Potential Impact of SCSRs

FSRs were not used. This fire scenario, however, had 50 miners exposed to potentially irrespirable atmospheres. With the constant fire hazard in this mine and primary escape through return air, SCSRs or other protection such as refuge chambers might be needed.

A.7.20 Kelley Mine Fire, April 7, 1977 (A-65)

Background

Kelley Mine is described in the following section, A.7.21. This fire involved the "Moose Shaft", a wood-lined, three-compartment shaft used as an exhaust for the Badger State and Mountain Con mines.

The Accident

The headframe was observed burning at 9:30 in the evening. Local fire units as well as company personnel fought the fire for 3-1/2 days. The fire had been brought under control in the headframe, but not in the shaft. It took another three days to remove the smoldering portions of the shaft lining.

Potential Impact of SCSRs

FSRs were not used. In as much as this was part of the exhaust system, miners in adjoining mines were able to evacuate without need for protection.

A.7.21 Kelley Mine Shaft Fire, June 27, 1977 (A-66)

Background

The Kelley Mine in Butte, MT, was a major producer of copper and silver ore from the mid-1800's until 1975. Since then, the mine has been maintained for the future.

The site of this accident was a vertical three-compartment, wood-lined shaft used for intake ventilation. Levels from this shaft extended into the adjoining Steward Mine.

The Accident

Smoke was observed at approximately 1:30 p.m. at the shaft collar by a machinist working nearby. He attempted to extinguish the fire with an extinguisher without success. He then called the Butte City Fire Department.

Smoke was observed by four miners on the 3800 level of the Steward Mine. They traced the smoke to the water drainage tunnel leading to the Kelley Mine. They called the mine clerk and then took a cage to the surface.

At 2:15 p.m. stench was activated. Within 30 min all persons had evacuated the Steward Mine; no one was in the Kelley. The fire was extinguished by 5:30 p.m. During those 4 hr 15 sets of shaft timber, about 200 ft of shaft, had been burned or charred.

Potential Impact of SCSRs

Miners in the Steward Mine did not use self-rescue devices. Although they had ready access to several intake air shafts, they were fortunate that the fire was discovered before it became fully developed. For example, burning timbers in a 200-ft length of the three-compartment, wood-lined shaft could produce 1650 cfm of CO. To dilute that to below 1.5 percent CO, a safe concentration for use of FSRs, requires 110,000 cfm of air.

Other Factors

Fire in a downcast, wood-lined shaft presents possibly the greatest fire hazard to miners. It contaminates the intake air with products of combustion and eliminates the shaft as a safe means for escape.

Should there be no fire doors and no other accessible intake air shafts, the sole means for escape would be in air that contains fire gases. Escape using FSRs depends on the CO and O_2 concentrations, which cannot be pre-determined. Escape using SCSRs depends on how long oxygen is needed and on how much oxygen was consumed during that time. These can be estimated for some, but not all miners.

Means other than reliance on self-rescue devices are indicated. Among those means are:

a. Fire doors activated by CO-sensing systems.

b. More than one intake air shaft or properly equipped refuge chambers.

A.7.22 New York Mine Fire, July 20, 1977 (A-72)

Background

New York Mine, an underground, crushed marble operation, was near Marble Hill, GA. The mine was opened by a slope. A raise from the mine went up into the abandoned Mountain Mine; that mine and breakthroughs into adjacent, abandoned quarries provided means for ventilation. The mine was developed by rooms and pillars with subsequent benching.

The Accident

Two MSHA inspectors and the mine manager were making an inspection of the mine. While testing the air in the escapeway, the MSHA inspectors detected 5 ppm of CO. They left the mine.

All of the miners (24) were on the surface in the lunch room; therefore, evacuation was not necessary.

A search found fire in a refuse dump in one of the adjacent, abandoned quarries. The only access to the fire was through the first level of the mine and across a sump filled with water. Fire extinguishers and a water hose were transported to the fire on a life raft.

Potential Impact of SCSRs

FSRs were not needed. The maximum CO concentration was 5 ppm; the TLV for CO is 50 ppm.

A.7.23 Silver Dollar Mine Fire, August 27, 1976 (A-80)

Background

Silver Dollar Mine is in the Coeur d'Alene region near Osburn, ID. This mine produces lead and silver on an intermittent basis. It must be maintained because it serves as an exhaust airway and secondary escapeway for the Sunshine, Coeur and Consolidated Silver mines. The hoisting conveyances, sump pumps, ventilation system and escapeways were purportedly inspected every 3 months by company personnel. The mine had not been inspected by MSHA. Figure A-14 shows the portion of the mine involved in this accident.

The Accident

Smoke was seen coming from the Silver Dollar Tunnel. Miners were withdrawn from the Sunshine and Coeur mines. The Director of Safety from Sunshine and an aide tested the atmosphere from

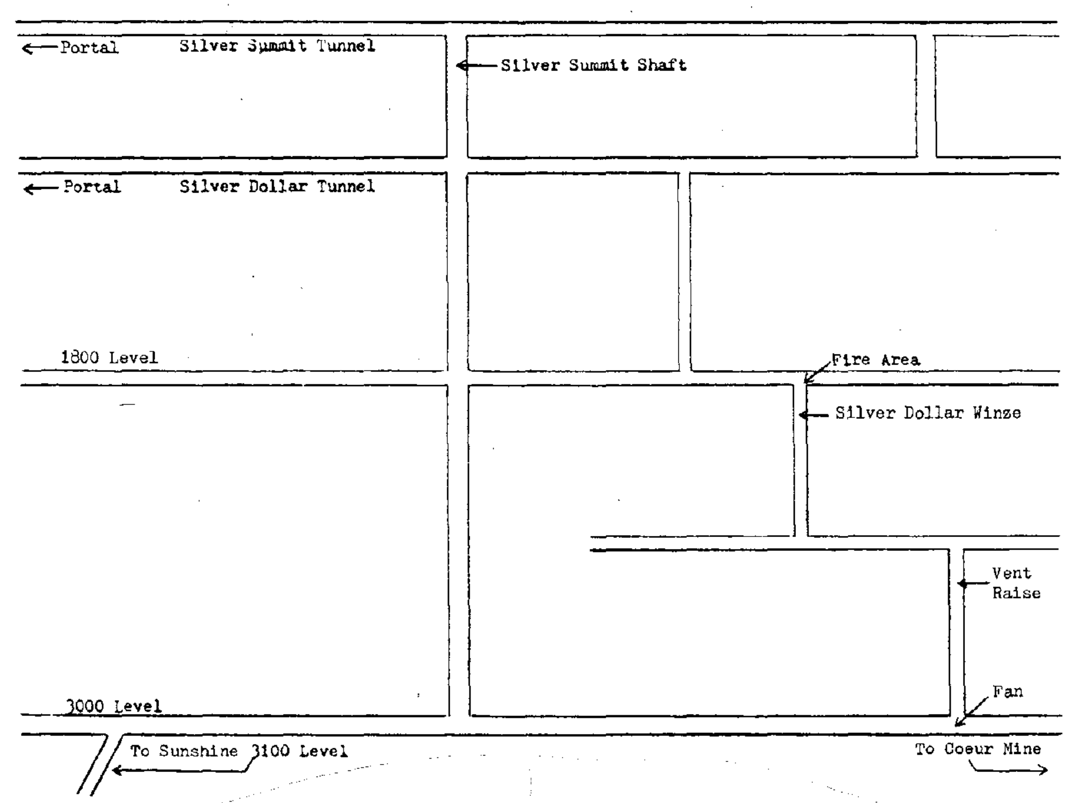


FIGURE A-14. - Silver Dollar Mine fire area.

the Sunshine 3100 level hoist room to the bottom of the Silver Dollar Vent Raise and fan. At the same time, a crew, carrying oxygen breathing apparatus, sealed the air doors in the drift connecting the Coeur and Silver Dollar mines.

For almost 5 hr teams wearing oxygen breathing apparatus explored the mine. They encountered smoke which limited visibility to 25 ft, but only 40 ppm of CO. The exhaust from the Silver Dollar Tunnel, however, contained 125 ppm of CO.

The electrical power was de-energized. Shortly afterwards the CO concentrations decreased steadily. The first MSHA inspector arrived. Explorations continued. Twenty hours after smoke was first sighted, the fire was found in timber ground supports around the Silver Dollar Winze hoist. Thirty hours after smoke was first sighted the fire was extinguished.

The probable cause for the fire was either radiant heat from a lamp igniting wood or an electrical short circuit igniting wood.

Potential Impact of SCSRs

FSRs were not needed, thus SCSRs would not have been needed.

Other Factors

The immediate evacuation of all miners from connecting mines was a positive demonstration of rapid and correct response to a potential fire. This fire was quite typical of many fires involving wetness and wood. That is:

a. Fires frequently are initiated by moisture of water causing electrical short circuits.

b. Heat or flames from a short circuit can ignite even wet wood.

c. Burning wet wood produces considerable smoke, but low concentrations of oxides of carbon.

d. Small fires in multi-level mines can be difficult to locate and extinguish.

A.7.24 Belle Isle Mine Fire, March 5, 1968 (A-45)

Background

Belle Isle Mine produces salt from a dome near Morgan City, LA. The mine has two levels. Rooms and headings are developed 63 ft wide and 22 ft high on the upper level. When the planned extent of a room is reached, the bottom was benched leaving 82 ft high openings.

A single shaft, 1250 ft deep, contained two timbered compartments. The upcast compartment provided two skipways and electric power service. The downcast compartment had a self-service auxiliary cage for personnel. Figure A-15 shows the mine and some of the important events in this accident.

The Accident

A fire occurred at about 11:30 p.m. in the lower part of the shaft. None of the 21 miners underground at the time survived:

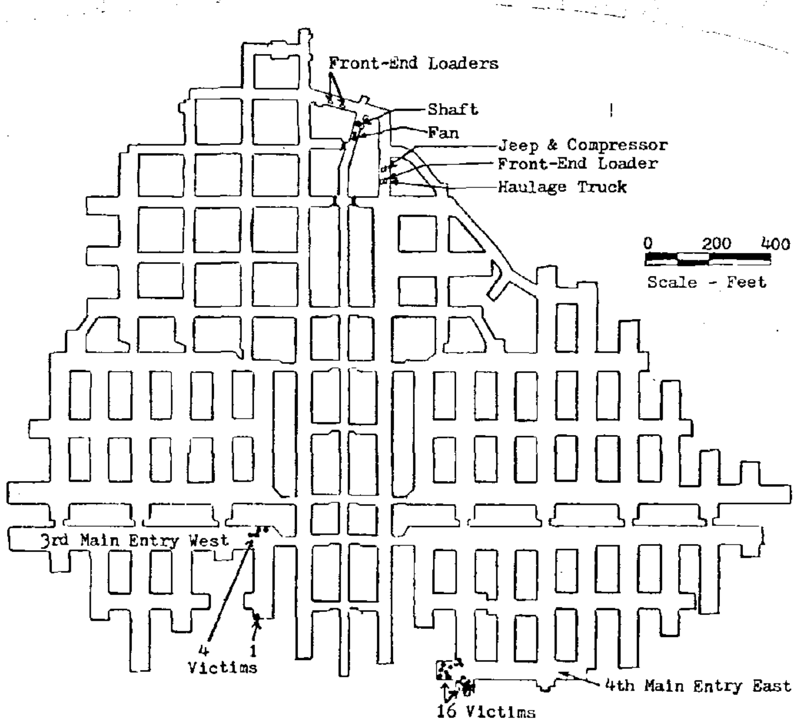


FIGURE A-15. - Belle Isle Mine.

a. Sixteen died together, 3000 ft southeast of the mine shaft. They were found 61 hr after the fire.

b. Four died together 2300 ft southwest of the mine shaft; 300 ft farther in was the fifth victim. These five were found 63 hr after the fire.

The maintenance crew on this shift was lubricating the skips, skip-loader and making needed repairs. At 11:25, the hoistman received a telephone call warning him that the shaft was on fire; the skip was lowered, but the crew could not get on because it was on fire.

Last communication with those underground was the directive to "Pour some water down the shaft." Underground power was cut off just before midnight. Pumping water continued until the next afternoon when it seemed the fire was extinguished. The first mine rescue squad went down in the morning of March 7, 31 hr after the fire began.

No footprints could be seen on the soot-covered floor. However, the miners obviously had made a major effort to fight the fire because they brought front-end loaders and trucks from the mine workings to dump salt into the shaft.

Recovery proceeded slowly because of the mine temperature (92 to 100°F), high humidity and the effect of the salt-laden air on the breathing resistance of the Universal gas masks used by the rescue teams. Salty moisture also fouled walkie-talkies and gas detection instruments; for example, actual CO concentrations were greater than 3000 ppm, whereas colorimetric and length-of-stain detectors indicated less than 1000 ppm of CO.

Potential Impact of SCSRs

All but one miner died from CO poisoning 6 to 7 hr after the fire; the 21st victim died from a skull fracture.

SCSRs, had they been available, would not have saved lives. Rescue took more than 60 hr. For the conditions existing, it would not have been possible for rescue teams to enter the mine within a few hours after the fire started.

FSRs were not used. The fact that miners lived for at least 6 hr indicates the probable CO concentration was 550 to

650 ppm. The chance for an oxygen deficiency was low; flame safety lamps carried by mine rescue teams stayed lit. Thus, FSRs should have provided adequate protection if the miners had a way out or a place of refuge.

A.7.25 Belle Isle Mine Fire, February 2, 1979 (A-47)

Background

Belle Isle Mine was described and illustrated in subsection A.7.6 and A.7.24.

The Accident

The fire was at the bottom of No. 1 Shaft. That shaft is upcast, 1163-ft-deep, and concrete lined. The diesel fuel line comes down this shaft; and, the diesel fuel storage tank is at the 1163 shaft station. The two hoisting compartments in the shaft fill approximately two-thirds of the cross section. Two skip-loading bins are 20 ft beneath the 1163-ft-level. Salt is transported from the "reclaim area" by a conveyor (see the drawing in the January 9, 1979 synopsis). The fire began at the head pulley and burned 13 ft back against the ventilation.

The fire was first noticed at 7:30 p.m. Evacuation was begun immediately and completed within 40 min. The fire crew extinguished the fire by 1:00 a.m.

Potential Impact of SCSRs

FSRs were not used. The fire was in the upcast shaft. It posed a hazard to persons underground only if the main mine fan stopped. The fan, then on the 1221 level near the No. 2 downcast Shaft, could not be affected by this fire. The fan is now on the surface; therefore, SCSRs would have not added to safety in this accident.

A.7.26 Bunker Hill Mine Fire, June 28, 1978 (A-49)

Background

Bunker Hill is an underground silver mine near Kellogg, ID. Ore is mined from overcut and fill and square-set stopes developed along the strike of the veins. The No. 3 Shaft, the site of the fire, is vertical and wood-lined. Information on this fire is incomplete, and limits analysis to broad generalities.

The Accident

Rail in the No. 3 Shaft was being cut. Molten pieces of metal dropped down into the shaft. Timber below the 1300 level ignited. All employees were evacuated from this and the connecting Crescent Mine. A rescue team wearing oxygen breathing apparatus extinguished the fire. The team purportedly did not detect toxic gases.

Potential Impact of SCSRs

Self-rescuers were not required. SCSR, had they been needed, could have been obtained from storage caches.

Other Factors

Fire in a downcast, wood-lined shaft, such as No. 3 presents possibly the greatest fire hazard to miners. It contaminates the intake air with products of combustion and eliminates the shaft as a safe means for escape. The prompt, positive reactions of miners to this fire diminished that potential.

Should there be no fire doors and no other accessible intake air shafts, the sole means for escape would be in air that contains fire cases. Escape using FSRs depends on the CO and O_2 concentrations, which cannot be predetermined. Escape using SCSRs depends on how long oxygen is needed and on how much oxygen was consumed during that time. These can be estimated for some, but not all miners.

Means other than reliance on self-rescue devices are indicated. Among those means are:

a. Fire doors activated by CO-sensing systems.

b. More than one intake air shaft or properly equipped refuge chambers.

A.7.27 Climax Mine Fire and Explosion, July 8, 1964 (A-54)

Background

Climax Mine near Leadville, CO, produces molybdenum mainly by the block caving method. This mine has been involved in more than 40 years of cooperative research described in numerous USBM publications.

Figure A-16 illustrates important features in the affected area.

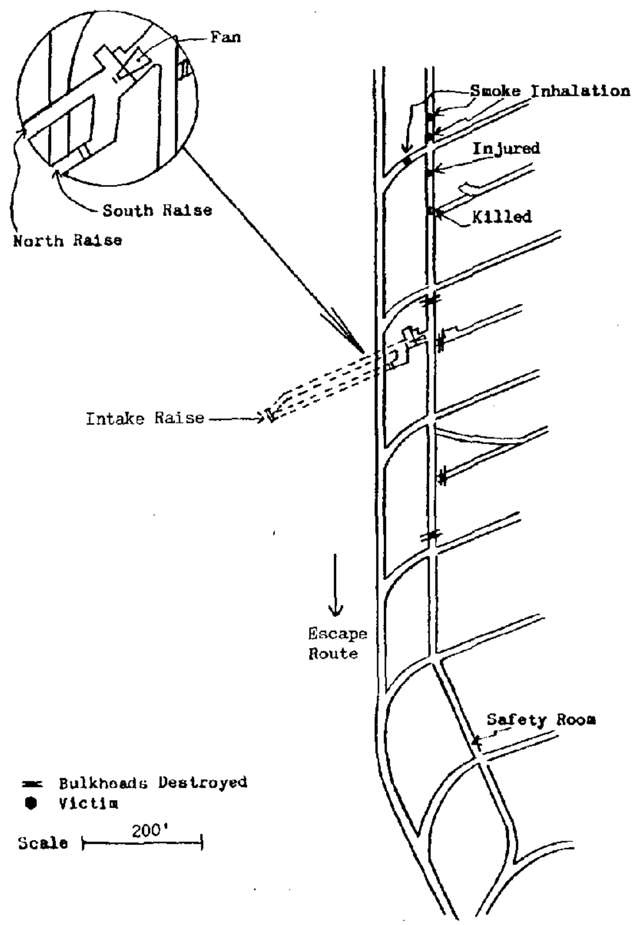


FIGURE A-16. - Climax Mine fire area.

A single vertical shaft from the surface to a depth of 65 ft delivered 240,000 cfm of air into two parallel raises, called the North and South chippy raises, which form the main intake. Each raise, about 500 ft long, had manway and muckway compartments and were timbered by square sets and cribs. These raises came together at the fan station on the Storke level.

The South chippy raise also contained the following:

a. Coaxial cable and single lines.

b. Telephone line in conduit.

c. Two 440-volt feeders each consisting of three single conductors in conduit.

d. Two 13,800-volt armored cables.

e. A 12-in. compressed air line.

f. A 3-in. water line.

At the time of this accident 263 miners were on the Storke level and a large number were on the Phillipson level and in other areas.

The Accident

A 2-man crew, welding and cutting above shaft (a), observed flames being sucked down the shaft. They gave alarm at 9:55 a.m. and got fire extinguishers. At 9:55 a.m. the compressed air line in the South chippy raise ruptured. A clock on the Storke level stopped at 10:08.

Some miners on the Storke level detected smoke sometime between 9:30 to 9:45 a.m. While three of those miners were looking for the fire, an explosion occurred. Flying debris killed one and seriously injured another. Four bulkheads and the Safety Room were destroyed.

Other miners came onto the scene, removed the dead and injured men. All miners were out by noon, 2 hr after the fire alarm was given. At 10:45 p.m. rescue teams from another mine arrived with oxygen breathing apparatus; only 2 of the 2054 employees at Climax knew how to use breathing apparatus. The apparatus teams built four seals.

From later studies, it was determined fire was in the South chippy raise, but none in the North. Limited evidence based on forces indicated the explosion may have originated in one of the chippy raises or near the fan. The cause for the explosion had never been determined. Strata-produced flammable gas or combustible dust are not likely fuels because of the ventilation scheme, shallow cover and distance to active and abandoned areas.

It could be assumed, without fact, the explosion might have originated in the South chippy raise if air flows through that raise were reduced markedly, allowing subsequent rapid thermal expansion or ignition of an explosive-concentration of CO evolved from wood, or a combination thereof.

Potential Impact of SCSRs

Neither FSRs or SCSRs were needed.

Other Factors

A chance change in events could have caused much of the area to be engulfed by a potentially irrespirable atmosphere and endangered many of the several hundred persons underground. Among the chance changes would be:

a. Fire in the North instead of or in addition to the fire in the South chippy raise.

b. The four bulkheads not being destroyed.

c. Blasting agents in the damaged magazine exploding.

d. The fan being restarted.

A.7.28 Lucky Friday Mine Fire, December 17, 1980 (A-68)

Background

The Lucky Friday Mine is in the Coeur d'Alene region near Mullan, ID. Silver and lead are mined from overcut and fill stopes. The fire was in the No. 2 Shaft, a downcast, three-compartment vertical shaft used for hoisting to the surface and for services. The shaft is supported by timber sets and lacing throughout its length.

The Accident

Day shift mechanics using an oxygen-acetylene torch cut six bolts off the south compartment skip shoes in No. 2 Shaft. The relationship of that work to this accident is not conclusive.

At approximately 10:30 p.m., the evening shift mine supervisor smelled smoke at the 3050-level station. Unable to find the source, he went to the surface to discuss this with the foreman. He, the foreman and shaft repairman examined the shaft to the 3200 level, but could not find fire though they could smell smoke. During that examination the foreman instructed the shifters to assemble their crews at the shaft stations and await further instructions. Ventilation doors on the 3050 level were opened to exhaust smoke out of the area.

The stench system was not activated because the foreman did not want to panic personnel underground and location and extent of fire had not been determined. One mine rescue team was ordered to stand by on the surface.

After further, fruitless search other than smelling smoke coming up the shaft against the ventilation, the foreman ordered the 100 miners to be hoisted out of the mine and the shaft sprinklers to be activated.

Evacuation started at 10:50, 20 min after smoke was first detected. The first level to be evacuated was the lowest, the 4600 level. Hoisting was stopped when sparks were seen falling down the shaft. After checking the shaft and finding neither sparks falling nor their source, hoisting was resumed. All miners were evacuated by 11:55, almost 90 min after smoke was first detected.

The foreman and shaft repairman put a work deck on the north compartment conveyance and, with two 10-lb extinguishers, proceeded to check out the shaft. The fire was located within 200 ft of the shaft collar. After consuming the contents of the two extinguishers, then a third, they removed some charred wood, hosed down the wood in the immediate area, and removed all visually charred wood:

a. One 8 in. x 8 in. x 5 ft timber

b. One 3 in. x 8 in. scab

c. Six pieces of lacing, 2 in. x 10 in. x 5 in

d. One 10 in. x 10 in. wall plate

e. One 8 in. x 10 in. divider.

Assuming the wood was subjected to flame or sufficient heat to cause charring for 12 hr, 235 ft^3 of CO could be produced

(0.3 ft^3/min). That quantity can be diluted to below the TLV (50 ppm) by 6500 cfm of air. Because wood was partially consumed only and the quantity of air was considerably greater, the CO from this fire could not have presented a hazard.

Potential Impact of SCSRs

FSRs were not needed.

Other Factors

Fire in a downcast, timbered shaft, however, is the most dangerous type of fire likely to occur in a mine. It is reasonable to assume a more severe fire failed to develop because most of the wood was exposed to a large flow of air which, by removing heat, maintained thermal forces and radiation intensities at low levels.

Were radiation intensity typical of mine fires, the 8 in. x 8 in. 5 ft timber would have been consumed rather than charred in fewer than 6 hr and the other pieces in much less time.

A.7.29 Magma No. 9 Shaft Fire, March 22, 1973 (A-69)

Background

Magma No. 9 Shaft was being sunk to be the main production and service shaft fo the Magma Mine. The mine, near Superior, Arizona, is described in subsection A.7.16 and is outlined in Figure A-17. No. 9 Shaft is downcast, 22 ft in diameter and lined with concrete.

The Accident

At 1:20 a.m. 161 persons were in the Magma Mine and 7 in the No. 9 Shaft. Two acetylene and four oxygen bottles were on the work cage 4750 ft below the collar of No. 9 Shaft. One acetylene bottle caught on fire. Failing to extinguish the fire and turn off the bottles, the seven miners climbed up shaft ladders to the 4100 station, 50 ft above the cage.

This station was not connected into the mine; no air flowed below the 3600 level. Waiting for help, the miners used compressed air for breathing. Shortly afterwards there was a series of explosions followed by hotter air. A bucket was lowered and the seven reached the surface at 2:10 a.m., 50 min after the fire started.

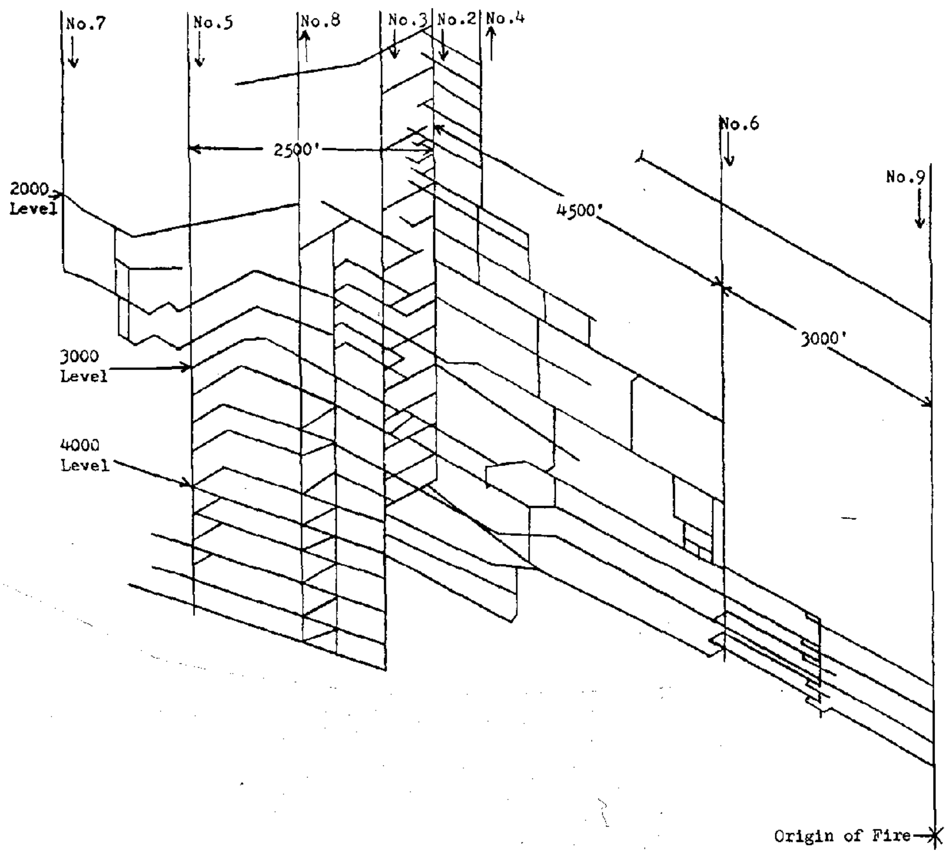


FIGURE A-17. - Magma Mine.

At 2:30 stench was released into the Magma Mine compressed air lines. All 161 miners in the mine were at the No. 2 and 3 intake air shafts by 3 a.m.

Miners were sent back to their working places at 4:30 a.m. The fire was extinguished at about that time.

Potential Impact of SCSRs

FSRs were not used. They might have been needed by the seven miners in No. 9 Shaft. An oxygen deficient atmosphere was not likely in the shaft and mine; available fuel was too small in quantity and the available air flow was too great, at least to the 3600 level.

The need for an auxiliary source of oxygen is not indicated. Had such been needed, the seven miners in the shaft would have had to have the source immediately available.

A.7.30 Miller Mine Fire, August 8, 1980 (A-70)

Background

Miller Mine, in Altaville, California, is an exploration operation. It consists of a decline tunnel, 1229 ft long, driven in sand and gravel. The main fan, pushing 40,000 cfm, is in-line with 42-in. vent tubing; two other in-line fans are used to direct the air to the face.

The ground was incompetent and had been supported by timer and steel. The ground, 480 ft to 570 ft from the portal, collapsed. The void was filled with bales of straw on top of the mine timbers. Creosoted timber cribs were built above the straw to help support the back of the case. The fan duct, air and water lines were disconnected outby the cave.

The Accident

About 10 hr after the cave void was filled, sparks from a cutting torch caught a bale of straw on fire. The fire was extinguished three times with dry chemical extinguishers. When it burst into flames the fourth time it got too smokey to see and hard to breathe.

The 15 miners purportedly left for the surface. When two got about 100 ft from the fire they connected a hose to the water line and returned to the fire. When the water was turned on they discovered there was no pressure. The two miners went to the surface and found the water line broken at the water truck. The truck was backed down the decline to supply water. Because of the dense smoke they couldn't get to the fire. All miners then evacuated.

The mine was sealed. Many different techniques were used until November 24 when it was determined the fire was either extinguished or isolated.

Potential Impact of SCSRs

One of the 15 miners used an FSR. Despite the dense smoke and the fact that all post-fire activities were in the return air from the fire, no one was injured. This, however, was fortunate rather than to-be-expected. Most of the products from burning straw and creosoted timber probably stayed in the void or escaped to the surface through cracks and fractures above the void.

Had much of the fire products entered the tunnel, FSRs might not have protected the miners. The CO-production and O_2 depletion capability of the great quantity of straw and timber could create a CO concentration exceeding 1 percent and an oxygen concentration below 10 percent. That would have required use of SCSRs or other auxiliary sources of oxygen. For the actions of these 15 miners the oxygen source would have to have been close at hand, if not worn, to be of use.

A.7.31 Reserve Mine Fire, April 5, 1976 (A-75)

Background

Reserve Mine, near Jeffrey City, Wyoming, is part of an interconnected complex of uranium operations which include the Golden Goose No. 1, Seismic, Congo Incline, and the Sheep Mountain-Highland mines. This multi-level operation is mined by open stopes and random pillars. The complex is ventilated by air entering shafts and exhausting through boreholes. Boreholes range from 18 to 72 in. in diameter and 300- to 1225 ft deep.

The Accident

A miner, approaching the Reserve Shaft on the No. 2 level from the Golden Goose No. 1 Mine, detected smoke. He found the smoke coming from a fire in the shaft skip pocket and manway. He was unsuccessful in extinguishing the fire with a dry chemical extinguisher.

He telephoned to the surface and was told to evacuate the mine. Crews for the Reserve and Golden Goose No. 1 mines were still on the surface; the Seismic Mine crew was underground. Stench was dumped into the compressed air line. The Seismic Mine crew was out of the mine in 22 min.

The fire was believed to have been ignited by hot welding slag the preceding day. The exterior faces of timber in the manway had burned for a distance of 24 ft.

Potential Impact of SCSRs

FSRs were not used or required.

Other Factors

FSR's or SCSR's might have been needed had the fire been more intense and the response less fast. The Reserve Shaft was downcast, which would force products of combustion into some of the workings in this complex of mines.

A.7.32 Star Mine Fire, January 20, 1971 (A-81)

Background

Star Mine, at Burke, Idaho, is a Coeur d'Alene lead, zinc and silver operation. The fire occurred on the 6900 ft level. The stopes to this level had been mined; and, the untimbered drift was being prepared for sand filling. For this, two miners were building a wooden retaining dam 1000 ft from the shaft; two others were cutting pipe hangers 250 ft from the shaft; and, a motorman hauled pipe joints and rail to the shaft. Ventilation was provided by air blown through a 20-in. diameter duct made of fiberglass and polylite polyester resin. The affected area is shown in Figure A-18.

The Accident

Hangers from the 2- and 3-in. pipes were being cut with an oxygen-acetylene torch. The ventilation duct, above the pipe, burst into flames. The two miners attempted to knock the duct down; failing that, they tried to extinguish the fire with rags wetted in the drainage ditch. They did not use the fire extinguisher on the welding cart which was right there.

Unable to control the fire, one miner started to warn the two miners building the dam, 750 ft downwind of the fire. After going perhaps 50 ft he had to retreat because of excessive heat and smoke. Mine officials were telephoned at 1:30 p.m., 1/2 hr after the fire began.

A mine rescue team with oxygen breathing apparatus began fighting the fire after 3:15 p.m. The fire was extinguished quickly; 400 ft of duct had burned.

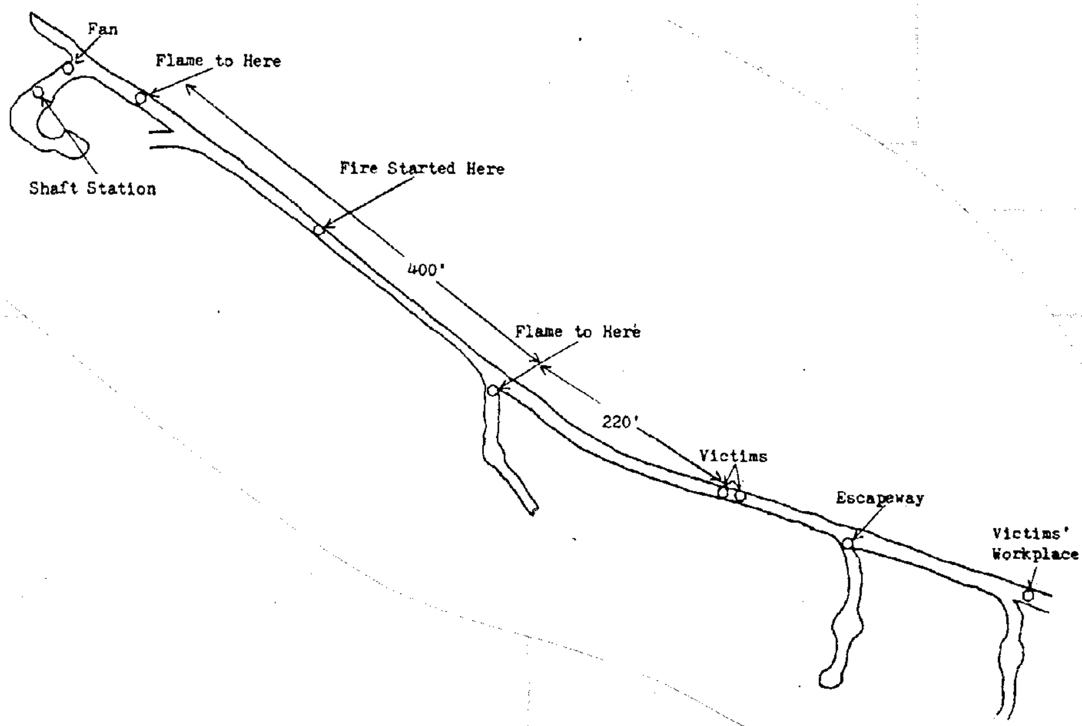


FIGURE A-18. - 6900 ft level of Star Mine.

The two miners building the dam obviously were aware of the fire. They were in the direct flow oath of the products of combustion and heat. There were no parallel entries for them to get around the fire. Their bodies were found 400 ft from the dam, just inby the end of the fire. Autopsies indicated both suffered from the effects of heat in the lungs, throats and mouths. The cause of deaths were reported to be suffocation due to exposure to conflagration. The rapid onset of rigor mortis indicated CO or oxygen levels were not likely important causes.

Potential Impact of SCSRs

It is not possible to say these two lives would have been saved had the miners donned and activated SCSRs.

a. It is reasonable to assume they were aware of the fire within minutes of its start.

b. Their only route to safety was through the "excessive heat" that forced one miner to stop his effort to reach them.

c. We do not know if SCSRs can be used in - let alone withstand - "excessive heat."

d. If SCSRs could be used they had to be immediately available.

Other Factors

For this fire, a more positive approach to safety than SCSRs would have been:

a. Use of ventilation tubing that met the requirements of 75.302, 30 CFR.

b. Miners being well aware of and trained in firefighting procedures appropriate to their work assignment.

A.7.33 USBM No. 1 Shaft Fire, December 6, 1978 (A-35)

Background

This shaft was described and illustrated in subsection A.7.7. The site of this fire was the face of the development drift off Level 5. The 10 by 10-ft drift had been advanced 80 ft from the shaft level.

The Accident

The midnight shift crew primed and charged 38 drill holes with permissible explosives. Eleven of the holes were wired into the blasting circuit. The miners went to the surface where blasts were initiated. After 30 minutes, two miners returned to the drift. The air smelled odd and the upper half of the drift was filled with smoke. They noticed a fire in the face area.

Efforts to extinguish the fire by stamping on it were futile. The miners left the compressed air line blowing and returned to the surface. Management ordered no one to enter the mine.

Samples taken at the shaft collar indicated 30 ppm of CO. The following afternoon CO readings indicated the fire was worsening; therefore, the shaft was flooded.

Potential Impact of SCSRs

FSRs were not used or required.

Other Factors

Conditions prevailed that could have led to a more serious fire while miners were underground, if not to an ignition as well as fire. Had conditions worsened, SCSRs might have been needed. Then, they would have to have been immediately available.

A.7.34 Water Lilly Mine Shaft Fire, January 19, 1979 (A-36)

Background

Water Lilly Mine is near Dividend, Utah. It was opened in the 1920's; no ore was produced and the mine was abandoned. It consisted of a vertical, wood-lined, 3-compartment shaft to a depth of 1450 ft with a 1000-ft long drift off the shaft bottom. Through the years the shaft timber rotted and the sides caved. In 1976, shaft rehabilitation was begun. For this, a 24-in. diameter ventilation duct was extended down the shaft as it was reclaimed.

The Accident

Two miners were loading muck at a depth of 850 ft into a bucket. They had to use an acetylene cutting torch to cut a pipe. Shortly afterwards they noticed a small fire.

The miners went to the surface and gathered all fire extinguishers available. They returned to the bottom and attempted to extinguish the fire, but without success. They returned to the surface. Water was pumped through the existing water and compressed air lines. After 10 hr the CO exceeded 700 ppm. After three days of pumping water (more than 100,000 gallons) and high-expansion foam (280 gallons of foam concentrate and 11,200 gallons of water) the fire was extinguished.

Potential Impact of SCSRs

FSRs were not used.

Other Factors

SCSRs would have had to be immediately available, probably worn, if the atmosphere became dangerous while the miners attempted direct attack of the fire. SCSRs, however, are intended for escape only; they should not be used by non-mine rescue trained persons for fighting fire.

A.7.35 Bellefonte Mine Fire, June 8, 1976 (A-44)

Background

Bellefonte Mine produces limestone from large open stopes near Bellefonte, PA. Fans ventilating the mine had stopped at 5:00 p.m. because of a failure at the power generating plant. At 8:00 p.m., the two miners involved in this accident were drilling blast holes in a stope undercut.

The Accident

The power failure caused a short circuit in a slusher motor causing the motor to burn. The fan outage was compounded by a reversal of air in the stope, and perhaps elsewhere. Three hours after the fan stopped the two miners stopped drilling in the stope undercut because of increasing throat and lung irritation. The foreman sent them to the surface. One of them, at 11:00 p.m., went to the hospital; X-rays indicated no problems.

Potential Impact of SCSRs

SCSRs would have not prevented this injury. The injured miner was unaware of the need for protection.

Other Factors

Given the same set of circumstances except for a larger fire, one of the following would have been required:

a. SCSRs or FSRs would have been needed by more miners

b. Miners should be withdrawn from the area in a mine or from a mine affected by failure of the ventilation system.

A.7.36 Belle Isle Mine Fire, January 9, 1979 (A-46)

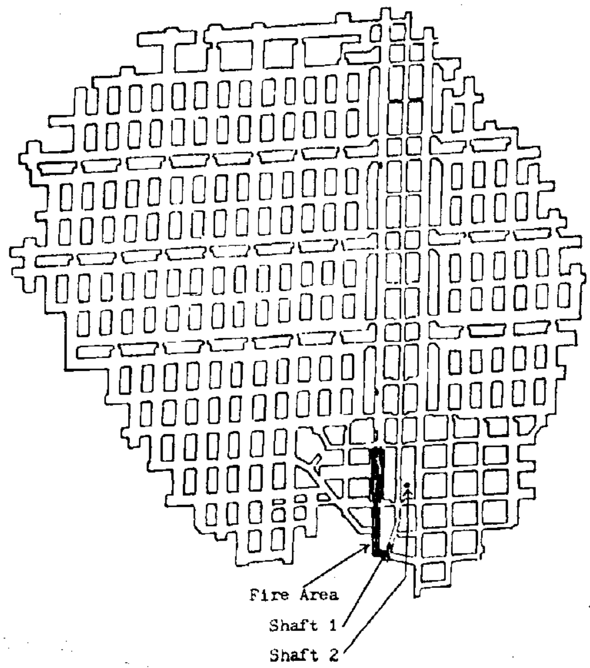
Background

The Belle Isle Mine was described in subsection A.7.6. Figure A-19 shows the mine and the site of this fire. The conveyors shown are four of five sections used to transport salt from the reclaim area to skip loading bins. In No. 1 Shaft all were 30 in. wide. The inclined belt to the left was MSHA-approved as fire resistant. All five were consumed by the fire. The conveyors were in timbered tunnels formed by cutting 12-ft wide by 12-ft deep channels in the floor of the 1221 level. The channels were covered by 3 × 8-in. tongue-and-groove lagging supported on 10 × 12-in. stringers and posts. Three Freecon high-expansion foam systems with heat sensors on 8-ft centers had been recently serviced by a fire specialty service firm.

The Accident

The oncoming day shift approaching the mine saw white smoke in the air exhausting from the No. 1 Shaft. No one was underground, though a midnight shift is often used.

Because no one was in the mine, the power was turned off. Power to the main mine fan, underground on the 1221 level, was



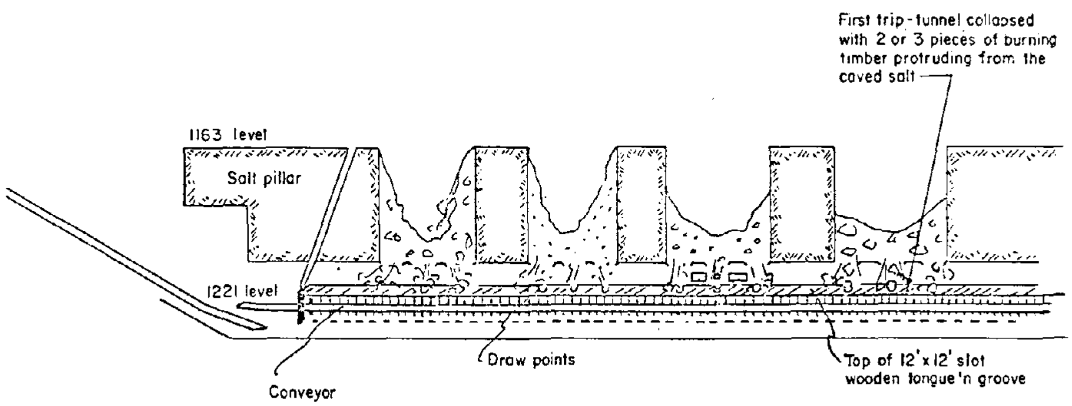


FIGURE A-19. - Belle Isle Mine.

disconnected. Power to the fan was restored two hours later. Mine rescue teams wearing oxygen breathing apparatus subsequently observed burning timbers in the reclaim area; the wood structure over the conveyors had collapsed.

Attempts to manually activate the high-expansion foam system were not successful. Partial seals were constructed. Portable extinguishers were consumed. By evening, heat and CO from the fire had increased considerably.

The diesel fuel line in No. 1 Shaft was changed to a water line. Rubber hose was extended from the fuel line. That, too, had no important effect.

By noon the next day, most of the conveyor belting had been consumed. The following days involved building salt seals, filling accessible voids with salt, and wetting down the area. Four days after it was first observed, the fire was brought under control and subsequently was extinguished.

Potential Impact of SCSRs

No need existed for an auxiliary source of oxygen for escape. Had persons been underground at the time of the fire they could have been evacuated without difficulty through the fresh air escapeway and No. 2 Shaft.

A.7.37 Bunker Hill Mine Fire, November 15, 1979 (A-50)

Background

The No. 2 Shaft, the site of this accident, is a 3-compartment shaft inclined at 45°, and is used primarily for man and supply hoisting. Shafts in this mine contain great quantities of timber.

The Accident

At 11:40 a.m. a mechanic on the 1700 level of the No. 2 Shaft smelled and saw smoke seeping through ventilation doors near No. 2 Shaft. The stench warning system was activated within minutes.

By 12:05 several rescue teams with oxygen breathing apparatus were ready to enter the mine. The 244 persons underground were evacuated by 1:25, 1 hr and 40 min after stench was released. A helmet crew quickly located the source of the fire, determined it and extinguished, and patrolled the air courses.

The fire was caused by a phase fault in the motor for a pump. Instantaneous trip breakers at the 900-level substation deenergized power to the pump. The pump was one of three in a concrete-lined room off the main 1700 drift; the room was 50 ft deep, 12 ft high, and 15 ft wide.

Potential Impact of SCSRs

FSRs were not used by miners during their evacuation. SCSRs, therefore, were not needed.

Other Factors

The fire was small and confined within a fireproofed area. Had, instead, the fire been in the shaft or a stope, for example, the 1 hr and 40 min taken for evacuation might have created the need by some miners for an auxiliary source of oxygen or other means for protection such as refuge chambers or safe-air compartmentalized areas on levels ventilated by a single split of air. SCSRs, had they been needed, could have been obtained from storage caches.

One possible, but not determinable reason for the long time taken to evacuate the mine was the time of the accident - 11:40 a.m. That is, some miners may have been eating lunch (lunch between 11:00 a.m. and noon is not uncommon) and therefore were not using compressed air at the time stench was dumped into the system. A possible important cause for the high toll of deaths in the neighboring Sunshine Mine, during the fire on May 2, 1972, was many miners were eating lunch at the time stench was allegedly dumped - not one individual testified that he learned of the fire through the stench warning system.

A.7.38 Cabin Creek Mine Fire, April 16, 1977 (A-51)

Background

Cabin Creek is an underground limestone mine near Plumville, Kentucky. Intake air was pulled into a 900-ft deep shaft, coursed through the rooms and pillars, and blown up an 18° inclined, 2823-ft long slope. The rooms and entries in the mine were generally 9 ft high by 15 ft wide. The part of the mine most affected by this fire is shown in Figure A-20.

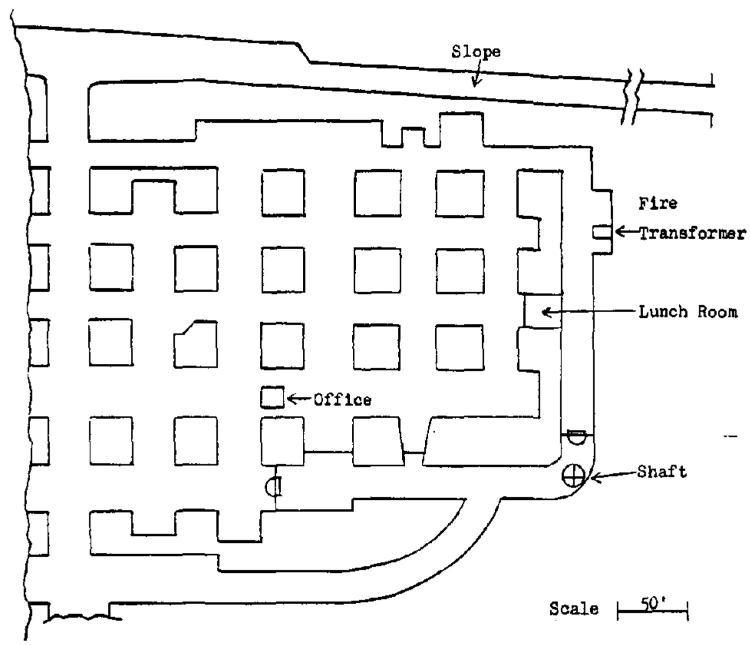


FIGURE A-20. - Cabin Creek Mine fire area.

The Accident

An electrical fault occurred on a 5000 KVA circuit at the bottom of the main power bore hole. The fault, initially phase-to-ground, escalated into phase-to-phase after both the main air break and oil circuit breakers failed to open. At 3:40 a.m., three attempts were made to close on the fault at the utility company generating plant.

Thirteen miners were in the underground lunchroom 30 ft outby the borehole. They heard three loud noises, probably from the three attempts to close on the fault. One miner looked out and saw flames filling the electrical switchgear area. The 13 then left, some traveling through smoke around the power borehole and others in generally clear intake air to the slope. There they were met by the 14th man, the foreman. After failing to contact the hoistman all 14 walked up the incline through smoke which "limited visibility to seeing a cap lamp six feet away."

Best estimates indicated the 14 miners were in smoke and electrical-fire products for 30 to 50 min. Two miners wore FSRs from the time they first became aware of the fire until they reached the surface. Neither had problems breathing through their FSRs; neither required medical attention other than a check-up.

Four miners left their FSRs in the lunchroom. These four required emergency oxygen when they reached the surface and were hospitalized for serious smoke inhalation and CO poisoning; they were released from the hospital 55 hr later.

Five miners put on FSRs while walking up the slope; however, they did not remove the bottom cannister. All five complained of the high resistance to and difficulty of breathing through the FSRs; they said they frequently "spit out" the mouthpiece, putting it back in their mouth "cause the smoke tasted so bad." These five needed emergency oxygen and hospitalization.

The other three, including the foreman, put on FSRs near the bottom of the slope. They removed the bottom cannisters, kept mouthpieces and noseclip on, but later complained of slight to some problems in breathing. No one determined whether those problems were caused by the FSRs, the miners' psychological states, or the fact they had been in smoke without protection until they reached the slope. Two were sent to the hospital for observation and released several hours later.

Potential Impact of SCSRs

Had SCSRs been available, it is reasonable to postulate as follows:

a. Persons who donned and activated SCSRs properly at their first awareness of the fire would have escaped successfully

b. Persons who did not use or know how to use SCSRs properly would have been injured by products of combustion.

c. SCSRs cached in the lunchroom, near the bottom of the shaft or near the bottom of the slope would have provided life support; however, the nearer the cache to miners when they first became aware of the fire, the less the chance of injury.

Other Factors

a. Smoke and fumes from this fire were probably as toxic and dense as those from any fire likely to occur in this mine.

b. Reasonable electrical maintenance and inspection procedures might have prevented this type of fire

c. Good training in the use of FSRs would be a positive approach to safety in this mine.

A.7.39 Cayuga Mine Fire, March 28, 1978 (A-52)

Background

Cayuga Mine, near South Lansing, New York, produces salt from two active levels. Access to the mine is through two vertical shafts. No. 1, the exhaust shaft, 1930 ft deep, extends to the 4 level. No. 3, the intake shaft, 2300 ft deep, intersects 6 level. At the time of this fire accident, one fan at the bottom of No. 3 Shaft induced 160,000 cfm of air into the mine. Two fans are generally used. Levels 4 and 6 are connected by two slopes. Salt is mined by the room-and-pillar method.

The Accident

At 2:15 a.m., the master mechanic observed smoke on Level 6. He immediately called the mine foreman, who was at the working faces, to evacuate the mine. He also called the hoistman to reverse the main fan.

The No. 3 Shaft became the exhaust and No. 1 the intake by 2:20, five minutes after smoke was first detected. The 23 miners assembled at the bottom of No. 1 Shaft were accounted for and evacuated. Evacuation was completed by 2:58 a.m.

By 10:00 that same morning, the fire was extinguished by mine rescue teams wearing oxygen breathing apparatus. The fire was in a diesel-powered air compressor rated at 160 cfm and 100 psig. The compressor was between the No. 3 Shaft bottom and the main fan.

Potential Impact of SCSRs

FSRs were not used. Because of the prompt, positive steps taken, they were not needed. Had the main fan not been reversed, the products of the fire would have contaminated all escape routes in the mine as well as the No. 3 Shaft station. Even in that case, FSRs would have provided adequate protection; there was no fuel other than in the compressor; and, the air flow was sufficient to maintain the CO concentration to below 100 ppm even if all of the fuel in the compressor ignited.

A.7.40 Cherokee Mine Fire, January 6, 1978 (A-53)

Background

Cherokee Mine is a copper, iron ore, and sulphuric acid producer near Ducktown, Tennessee. Three shafts and five boreholes, 2500 to 3000 ft deep, provides 500,000 cfm of air to the three levels being mined. Refuge chambers are maintained near each shaft station and borehole. The area on the middle level where this accident occurred is shown in Figure A-21.

The Accident

An Eimco 915H load-haul-dump (LHD) unit began to malfunction. The operator observed hydraulic oil leaking, so he began to maneuver the LHD out of the roadway. Flames flashed into the operator's compartment. The operator jumped from the loader, ran a short distance, and then returned to try to extinguish the fire. The fire extinguisher, however, was surrounded by flames. He then ran downwind to the loading ramp where he warned two miners. The three miners met two motormen and all five went to the repair shop. The mechanic there called the foreman on the surface and upper level.

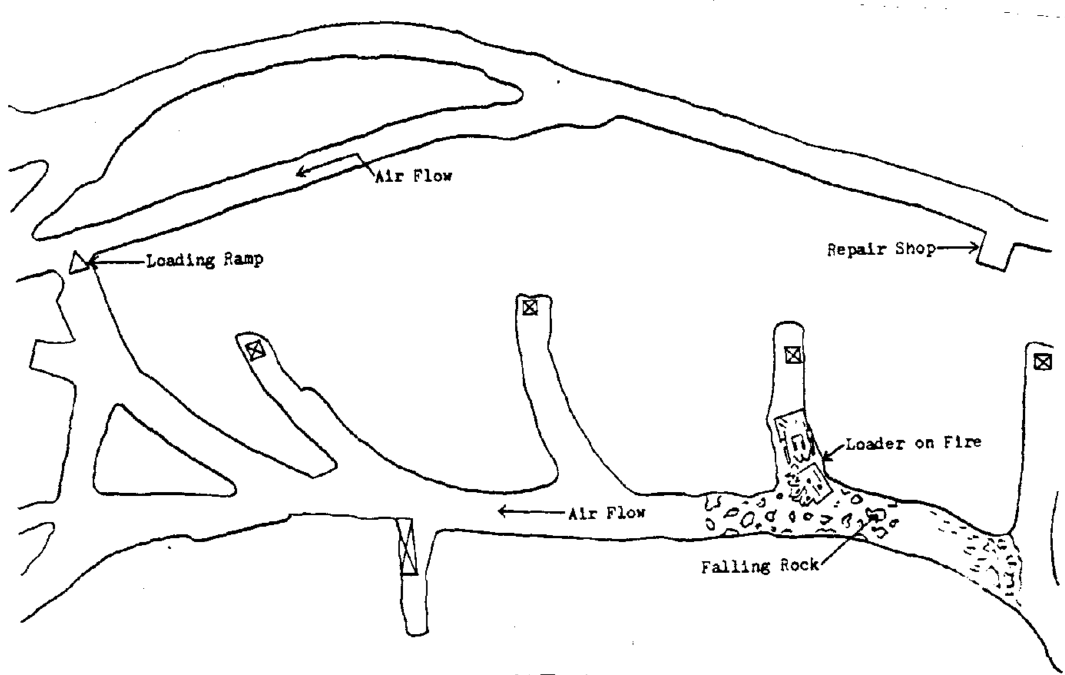


FIGURE A-21. - Middle level of Cherokee Mine.

Five miners took 20-pound fire extinguishers back towards the fire. Smoke was so dense they could get no closer than 125 ft from the burning LHD.

The foreman came from the surface. He met the five retreating. He decided it would be best to evacuate the mine. From the start of the fire until all 15 persons evacuated the mine was less than one-half hour; that included the estimated 10 min spent by the miners trying to put out the fire.

Rescue teams wearing oxygen breathing apparatus were at the fire 2-1/2 hr later. They extinguished the fire within 30 minutes. The teams during this time reported dense smoke and up to 10 ppm CO.

Smoke from the fire blackened roof for 100 ft upwind of the fire. That is, smoke backed up against a 110,000 cfm flow of air. Only the hydraulic hoses and oil and a portion of one tire burned. The steering case melted, but the fuel tanks and engine were unaffected.

Potential Impact of SCSRs

FSRs were not used. No one was injured. The ventilation scheme was such that miners could reach fresh air within two minutes.

Had SCSRs been needed they would have to have been worn or carried by each person. An SCSR stored on the LHD would have been unavailable.

A.7.41 Climax Mine Fire, September 30, 1977 (A-55)

The Accident

The Climax Mine was described in subsection A.7.27. At 2:30 a.m., fire was detected in a substation on the 600 level. Attempts to extinguish the flames failed and 81 miners on this level were evacuated. Others remained to fight the fire. An hour later smoke was detected on the Storke level above; the 120 miners on that level were evacuated within a half hour.

Continued burning caused a power shutdown. With this source for continued ignition gone, the fire was brought under control. It was extinguished by 5:00 a.m., 2-1/2 hr after it was detected; 185 pounds of dry chemicals from 13 extinguishers were used.

Potential Impact of SCSRs

FSRs were neither used nor required.

Other Factors

Fortunately, the fire was relatively small and contained. Ventilating air flows were great enough to prevent formation of an irrespirable atmosphere. SCSRs or other means for protection against an irrespirable atmosphere might have been required had conditions worsened.

A.7.42 Climax Mine Fire, August 8, 1978 (A-56)

The Accident

At 8:45 a.m. some miners on the Storke Level detected smoke in a lateral below a drift. Fifteen minutes later the fire was located. Wood lagging and cribbing had been ignited by an overheated trolley wire hanger insulator.

Stench was released at 10:07 after attempts to extinguish the fire with dry chemicals failed. Some miners de-activated the trolley wire and applied water. The fire was extinguished at 11:40. A mine rescue team arrived as the fire was extinguished.

Potential Impact of SCSRs

FSRs were not used. The long time required to extinguish this fire (almost 3 hr) and to initiate evacuation (more than 1 hr) might have led to the need for an auxiliary source of oxygen or other means to protect miners, particularly those who fought the fire. SCSRs, had they been needed, could have been obtained from storage caches.

A.7.43 Climax Mine Fire, October 11, 1978 (A-57)

The Accident

This accident occurred on the Storke level. At 6:30 p.m. the dispatcher observed glowing wires at the fan disconnect switch at the portal. Electricians were notified. Fifteen minutes later when smoke began to flow from the portal, the stench was released.

Employees were held at the 3130 assembly area. The source of the overheating and smoke was found, 750 ft of burning power cable. It was extinguished after the power was shut off.

Potential Impact of SCSRs

FSRs were not used. Miners were rapidly brought to a safe area. SCSRs, therefore, would have not contributed to safety. Had SCSRs been needed they could have been obtained from storage caches.

A.7.44 Fletcher Mine Fire, July 7, 1980 (A-60)

Background

Fletcher Mine produces lead ores near Bunker, Missouri. Access to the mine is through two circular 12-1/2-ft diameter concrete-lined shafts, 1033 ft in depth to the mine level. These shafts are upcast. The two downcast shafts are on the other end of the mine. The mine is developed on a single level with a lower elevation ventilation return drift. A room-and-pillar mining method is used. Rooms are generally 20 ft high by 30 to 40 ft wide. Two refuge chambers, one near the downcast shafts and one near the upcast shafts, are fully equipped.

The Accident

The load-haul-dump (LHD) involved in this accident was a Caterpillar 988-B. It contained about 320 gallons of oil (hydraulic, transmission and diesel fuel). One 10 lb fire extinguisher was mounted beside the operator's seat.

Shortly after the shift began, and after one truck was loaded, flame erupted from the engine compartment. The operator jumped from the loader, forgetting to turn it off. He returned in a futile effort to reach the fire extinguisher.

At this time a haul truck came by. The truck's fire extinguisher was applied with no success. The loader and truck operators drove off for help. Subsequently, the shift foreman and two miners arrived with two extinguishers which were applied with no success.

Numerous other mine personnel arrived. The fire was extinguished after 20 ten-pound dry chemical extinguishers were applied. During the fire fighting activities, considerable smoke had filled the area limiting visibility. The loader was repaired before MSHA investigated this accident; purportedly only a small quantity of hydraulic oil and grease on the engine was involved. Mine rescue trained teams arrived. Tests indicated 10 to 15 ppm of CO four hours after the fire was extinguished.

Potential Impact of SCSRs

Three miners donned FSRs while fighting the fire. Seven other miners complained of smoke inhalation; hospital doctors sent them home after their examinations. SCSRs were not required.

Other Factors

Had SCSRs been available they, too, may have been used by miners combatting the fire. For that use the SCSRs would have had to be at or brought to the fire area. MSHA may need to consider policy regarding the use of SCSRs while combatting fire by the general mine population.

A.7.45 Georgia Marble No. 5 Mine Fire, January 31, 1978 (A-61)

Background

No. 5 Mine, near Jasper, Georgia, produces crushed marble. Two drifts and a 10 deg decline provide access and ventilation. During initial mining, a room-and-pillar method was followed; subsequently, benching was used.

The Accident

A front-end, diesel-powered loader burst into flames. The operator, with hair and eyebrows singed, jumped from the loader. He and a miner nearby grabbed fire extinguishers, but the heat and flames kept them away.

The three miners, the only ones underground, immediately left the mine through an opening 150 ft from the loader. Because of the danger of the fuel tank exploding, the decision was to let the fire burn itself out. This took 24 hr.

Potential Impact of SCSRs

FSRs were not used. Escape was less than a minute. Protection, therefore, was not needed for the circumstances that existed.

A.7.46 Gordonsville Project Fire, April 19, 1978 (A-62)

Background

Gordonsville was a development for a potential zinc operation in Gordonsville, Tennessee. It consisted of a mile long, 18 percent decline 17 ft wide and 12 ft high. Drifts were being developed off the decline to the mining and haulage levels. A 30-in. belt conveyor transported ore and waste rock from a crusher at the bottom of the decline to the surface. Ventilation was provided by a fan on the surface blowing into a 4-ft diam rubberized duct. Compressed air from the surface went to the workings through a 4-in. steel pipe. Twenty-nine miners were underground when the fire occurred.

The Accident

The transmission of a Wagner Scooptram was heating up. Underground maintenance could not correct the problem, so the operator was told to drive it out to the surface shop. When about 3500 ft from the portal, the Scooptram caught on fire.

The operator turned the wheels into the rib and attempted to extinguish flames with a 10-lb and two 5-lb dry chemical extinguishers. He was assisted by two other miners, one of whom was the Shift Foreman (SF).

The SF went back down the decline and told the General Mine Foreman (GMF) and Mine Shift Boss (MSB). Meanwhile another miner went to the belt transfer, stopped the belts, and called the hoist operator on the surface.

The SF and the MSB went to the working areas to warn the miners while the GMF and several miners gathered available extinguishers and returned to the fire. Failing to control the fire all but two went to the REFUGE CHAMBERS.

Two miners, who were at the belt transfer point, went to the surface and informed mine officials. The ventilating fan was turned off to reduce oxygen to the fire.

Three mine rescue teams were assembled. The first team was underground about an hour after the fire began. The fire was brought under control. The quality of the air was tested to the refuge chambers and found safe for the 27 miners to leave.

Potential Impact of SCSRs

FSRs were not used. The miners had an auxiliary source of oxygen, the refuge chambers. With the exception of the two who went up the decline, all were in fresh air throughout the accident. The CO concentration, measured by the teams as below 10 ppm when the fan was off, was not unsafe and suitable for safe escape using FSRs.

A.7.47 Grace Mine Fire, June 22, 1976 (A-63)

Background

Grace Mine is near Morgantown, Pennsylvania. Magnetite ore is mined by the block-caving method. Load-haul-dump (LHD) units transport rock and ore from drawpoints to crushers. Most of the back and ribs in the drifts are supported by concrete and steel. The major quantity of combustibles in the mine is hydraulic and diesel fuel oil in the LHDs and storage tanks. The faces and edges of 2-in. planking, however, between steel sets also could be a major source of fuel in the event of fire.

The Accident

An LHD while tramming a load of ore burst into flame. The operator escaped from his compartment. He could not reach the unit's fire extinguisher. He went immediately to his shift foreman.

The shift foreman ordered the evacuation of persons on the return air side of the fire. He did not activate the stench warning system because he believed persons on the fresh air side were in no immediate danger, and, extinguishing the fire quickly would avert a major mine fire.

Thirteen miners, including two shift foremen, applied more than 400 lb of dry chemical fire extinguishing powder to no avail. Wood planking between steel sets on the back began to burn. The stench system was activated. An air line was converted to a water line; water was applied, and, the fire was extinguished 2 hr after it ignited.

Potential Impact of SCSRs

FSRs were not used. The rapid evacuation of miners from the return air side of the fire removed them from harm's way.

Other Factors

Calculations indicated this fire had the potential for evolving an average of 36 cfm of CO during the 2 hr it was fought. A person can undergo strenuous activity for 2 hr without serious harm provided the CO concentration is less than 150 ppm. To maintain 150 ppm from a fire evolving 36 cfm of CO requires an air flow of at least 240,000 cfm. That quantity of air was not available; therefore, the fire did not evolve as much CO as indicated and the velocity of the air was sufficient to remove the products from the area. If the latter was the case, then a fall of roof or other air flow disruption could have endangered the 13 firefighters.

Those 13 firefighters should have had protection against CO. That protection, however, should not be FSRs or SCSRs. Those devices are intended for escape, not for protection of persons fighting fire.

A.7.48 Homestake Mine Fire, April 1, 1976 (A-64)

Background

Homestake Mine, in Lead, Colorado, is one of the major gold mines in the world. Ore bodies are located in steeply dipping, highly folded "ledges." The mine, a portion of which is shown in Figure A-22, has been developed to a depth of 6800 ft below the surface.

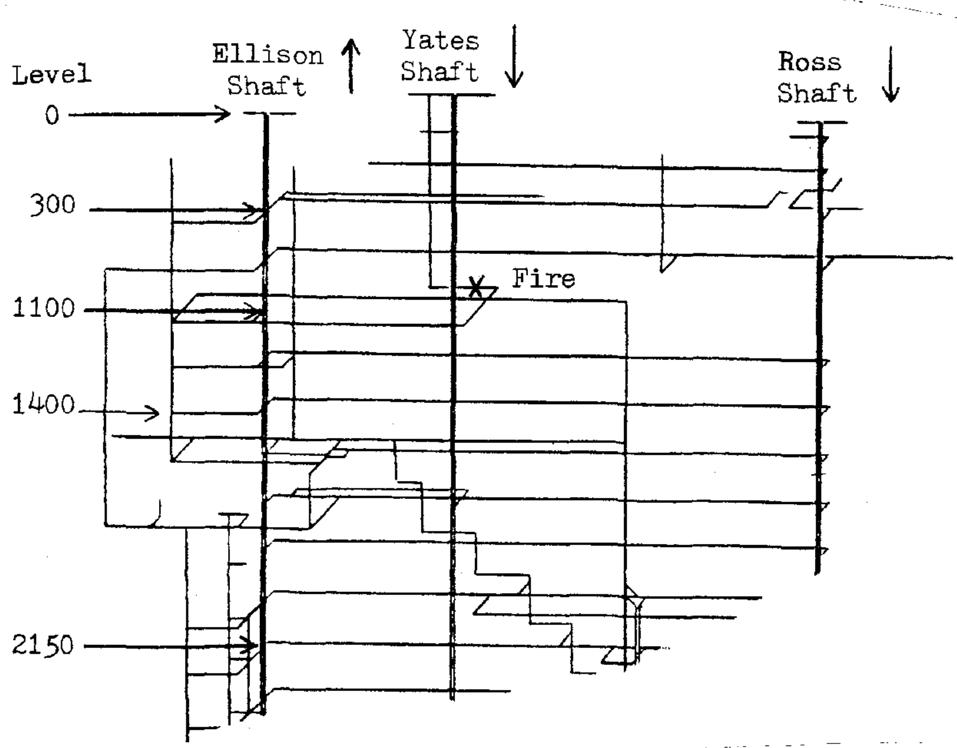


FIGURE A-22. - Fire area of Homestake Mine.

Most of present mining, below the 3500 level, uses the horizontal cut-and-fill method with rock bolts as the principal support. Much of the older workings were in square-set stopes, some of which were backfilled with mill tailings; haulage drifts generally were supported by wood sets.

The Accident

A miner, while ascending Yates Shaft, smelled smoke coming from the 1100 level. He reported it to a mine official. Three other officials, wearing gas masks, went to locate the fire.

Evacuation was begun within 10 min from the first observation of smoke. All 575 persons underground were out of the mine in less than an hour. Fifteen minutes later the first mine rescue team was in the mine. They extinguished the fire promptly.

The three officials had found the fire in a storage room on the 1100 level. It was of wooden structure, 10 ft long by 10 ft wide and 9 ft high. The wood that burned was up one side of the structure. The maximum CO concentration detected was 300 ppm at the fire area. The mine officials, before evacuating, adjusted the ventilation so that the products from the fire could go directly to the exhaust system rather than flow into Yates Shaft which was downcast.

Potential Impact of SCSRs

FSRs were not used.

Other Factors

The prompt, positive actions of all concerned made this a relatively minor fire. Had it not been detected and located so quickly and had its products not been diverted from Yates Shaft, then as much as 50 cfm of CO could have entered the workings through the Yates Shaft which was one of two main intake escapeways. With 142,000 cfm air flow the CO concentration carried into lower levels could have averaged 300 ppm for 2 hr. That concentration is not enough to be expected to cause death; however, it could cause nausea, weakness and even collapse. The above is based on calculations for the quantity of wood in the structure; the fact that it was the same concentration detected is coincidental and does lend support to the suggestion in the guidelines for determining the need for protection against products from a fire on the basis of calculations.

A.7.49 Logan Wash Fire, September 12, 1978 (A-67)

Background

Logan Wash is an oil shale mine at DeBeque, Colorado. It is being used to develop procedures for in-situ retorting to produce oil from shales.

The underground retorts, such as shown in Figure A-23, are developed through two main levels separated by 340 ft. The lower level is 30 ft below the ore horizon and the upper level is 50 ft above the ore.

The levels are connected by two raises. One, a manway raise, extends from the "product" level to the "air" level. The other, a ventilation raise, extends from the product level to the surface. Entries from the surface to the levels had been bulkheaded at the retort involved in this fire accident.

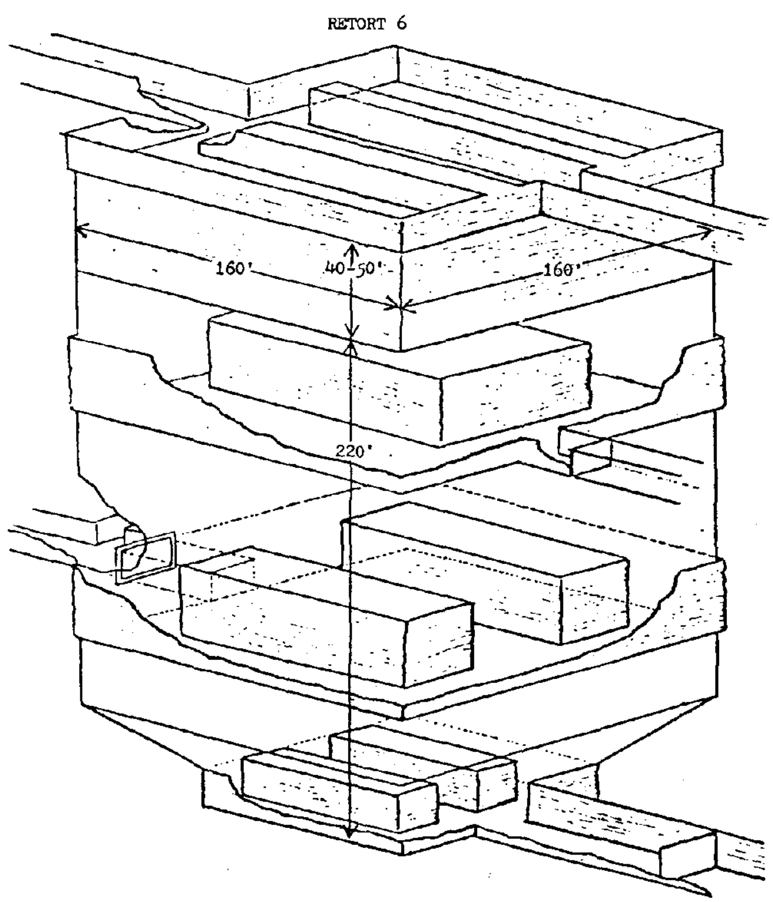


FIGURE A-23. - Logan Wash retort.

A sill pillar is above the retort. This pillar is 160 ft square and 40 to 50 ft thick. The gap between the bottom of this sill pillar and the rubblized oil shale in the retort ranges from an estimated 8 ft at the center to 35 ft in the corners. The sill is bolted on 10-ft centers with 30- to 40-ft long grounted bolts.

The Accident

Retort 6 was ignited as planned on August 28. A survey made September 5 indicated from 12 to 23 ft of the sill pillar had spalled. By September 12 the pillar had sagged more than 0.7 in. A horizontal crack was observed in the pillar; and, temperature data indicated the combustion front in the retort had propagated upward into the sill. A small hole developed which was sealed using grout. Several hours later a larger hole opened up.

Efforts began to cool the affected area. While seven officials and employees were standing on the sill assessing the situation, a 10-ft by 12-ft section of sill collapsed. All persons left the sill immediately, and without injury.

Failure of the sill forced fire gases from the retort up into the air level. Bulkheads were constructed. By September 25 the fire was contained, not extinguished.

Potential Impact of SCSRs

FSRs were not used. The ventilation system and mine layout assured, at least while fans were in operation, escape in intake air. Thus, for this accident, FSRs would have provided adequate protection for escape.

A.7.50 Montevallo Mine Fire, September 20, 1977 (A-71)

Background

Montevallo Mine, an underground limestone operation, is near Calera, Alabama. Access is through three openings from an open-pit quarry. Rooms are about 30 ft wide and 20 to 30 ft high. Drilling and blasting is done on the evening shift; mucking and hauling is done on the day shift. The accident occurred on the evening shift.

The Accident

A drill jumbo, a truck-mounted compressor, and truck-mounted water tank were drilling a round. A large segment of rib and roof (later estimated at 500 tons) fell on the compressor and water tank. Flames erupted immediately from the compressor.

The compressor contained 50 gal of oil and had a 200 gal fuel tank. The compressor truck had a 100-gal fuel tank. The drill and water tank trucks each had 100-gal fuel tanks.

The two miners left the jumbo and hurried past the fire. They found the other two men in the mine and all four left. The distance from the fire to the portal was 550 ft. The two drillers said they thought of using their FSRs; however, because of the falling ground they individually decided haste best served the needs of safety. Once beyond the fire they were in good air and had no reason to dawdle.

The fire was allowed to burn itself out. The heading was then barricaded and posted against entry.

Potential Impact of SCSRs

FSRs were not needed. They not only were not used, but would not have been used; time taken to don them could have exposed the miners to growing flames, increasing temperatures, and falling ground. SCSRs, therefore, would have not been helpful to these miners.

A.7.51 Ozark Mine Fire, December 16, 1978 (A-73)

Background

Ozark Mine produces lead ore near Reynolds, Missouri. Access to the mine is by five shafts ranging from 1400 to 1500 ft deep. Ore is mined from random-sized rooms. Twenty-five miners were underground when this accident occurred.

The Accident

At 4:00 a.m., a miner detected smoke. He notified the mine foreman, and together they tried to locate the fire; however, the denseness of the smoke prevented this.

At 4:40, stench was dumped into the mine ventilation and compressed air systems. Evacuation was completed by 6:00 a.m.; all miners traveled in fresh air to the No. 1 main intake shaft.

Three officials subsequently located the fire. A drill was burning. Water was applied for at least a half hour; the fire was extinguished.

The exhaust air was tested. The maximum CO concentration found was 50 ppm.

Potential Impact of SCSRs

FSRs were not used.

Other Factors

The delay and then the time taken for evacuation and the subsequent exposure to fire products could have made this a dangerous situation. Fortunately, the fire was small, involving mainly rubber rather than the 200 gal of hydraulic oil and diesel fuel contained in the drill. Had those been involved, the 25 miners and later the three officials might have needed self-rescuers or other means of protection.

A.7.52 Pleasant Gap Mine Fire, August 26, 1977 (A-74)

Background

Pleasant Gap Mine is a limestone operation near Pleasant Gap, Pennsylvania. The mine has three adits driven into a quarry highwall. Rooms are 45 ft wide and 35 to 55 ft high. An incline with two 10-ft diam fans directs 229,000 cfm of intake air to the workings.

The Accident

The electrician's shop was a 10- by 14-ft wooden structure underground. It caught on fire. Miners activated the alarm system and then tried to extinguish the blaze with dry chemical extinguishers. This failed. All 19 miners evacuated the mine within 20 min after the alarm was given. Some evacuation routes were through return air. Later that day, 25 ppm of CO and 90 ppm CO_2 were measured at the exhaust drifts.

Potential Impact of SCSRs

FSRs were not used. Rough calculations indicate the burning shop could evolve 60 cfm of CO for 1 hr. Assuming equal flows of air to each adit and the shop, the CO concentrations might have been 0.08 percent. Calculations indicate, for the above assumptions, the oxygen in the air from the fire would be at least 20 percent. Miners, therefore, could escape without SCSRs; however, with 0.08 percent CO concentrations, the following effects might be expected:

After 15 min, throbbing headaches

After 30 min, collapse

After 60 min, death

The 19 miners evacuated within 20 min; therefore, the only threat was a possible headache.

Other Factors

Only small changes in the fire scenario could have been deadly. Such changes include the following:

a. Less air flow through the fire into the escape route

b. More rapid burning of the shop

c. Delay in giving the alarm or in evacuation.

Miners should wear FSRs whenever they are in smoke generated by a fire.

A.7.53 Retsof Mine Fire, December 8, 1977 (A-76)

Background

Retsof Mine, in Retsof, New York, produces rock salt. The main access to the mine is through the upcast Fuller Shaft, 1100 ft deep, with three compartments. Three miles away is the Sterling Shaft which also is upcast from abandoned workings. Retsof No. 2 Shaft, 4000 ft from Fuller, serves as the intake and the third escapeway. The air flow through the mine is 203,000 cfm. Salt is mined from 65 ft wide rooms, 8 to 12 ft high. Pillars are 70 ft square.

The Accident

The undercutter involved in this fire was electrically powered, rubber tired, and had a 12-ft bar. After undercutting 165 ft of salt, flame burst from the undercutter. The operator directed his helper to alert the driller in the next room and to clear the area. The operator then went to inform the shift foreman.

The foreman, after viewing the fire and smoke, decided proper equipment and trained personnel were needed. He directed all miners in the area to the lunch room; then, he asked the superintendent to activate the fire alarm. All miners evacuated. Mine rescue teams with oxygen breathing apparatus and water hoses extinguished the fire and secured the mine.

Potential Impact of SCSRs

FSRs were not used. Prompt, positive actions and reactions kept miners from being exposed to danger.

A.7.54 San Manuel Mine Fire, October 18, 1976 (A-77)

Background

The San Manuel Mine, owned and operated by Magma Copper Company, is in Pinal County, Arizona. The mine produces copper by the block-caving system of mining. More than 1 million cfm of air flows down the No. 1, No. 4 and No. 5 shafts and exhausts up the No. 3-A, No. 3-B, No. 3-C and No. 3-D production shafts. This positive pressure system has the main fans located on each level in a fan drift adjacent to a main crosscut with air lock doors. The air was directed to the panels and other working areas through ventilation raises and boreholes.

The Accident

At about 1:10 a.m., a miner on the mancage in No. 5 Shaft smelled smoke near the 2950 level. He put on his FSR and rode up to the 2650 level and went to the pump station 20 ft from the shaft. The site of this fire, the pump station on the 2675 level of No. 5 Shaft, is shown in Figure A-24.

Two pumpmen, both wearing FSRs, were in the pump station. They had discovered the fire and had turned off the pumps.

The fire was reported. Stench was introduced into the compressed air lines and ventilation system. All 187 persons underground were evacuated in 35 min, before 2:00 a.m.

Subsequent tests showed a short circuit in one pump motor. The inrush of current, 25,000 to 30,000A, flowing during the short circuit condition produced flames and sparks that ignited timber 3 ft away. Positive reactions by the pumpmen and mine supervisors prevented a serious fire and danger to the miners.

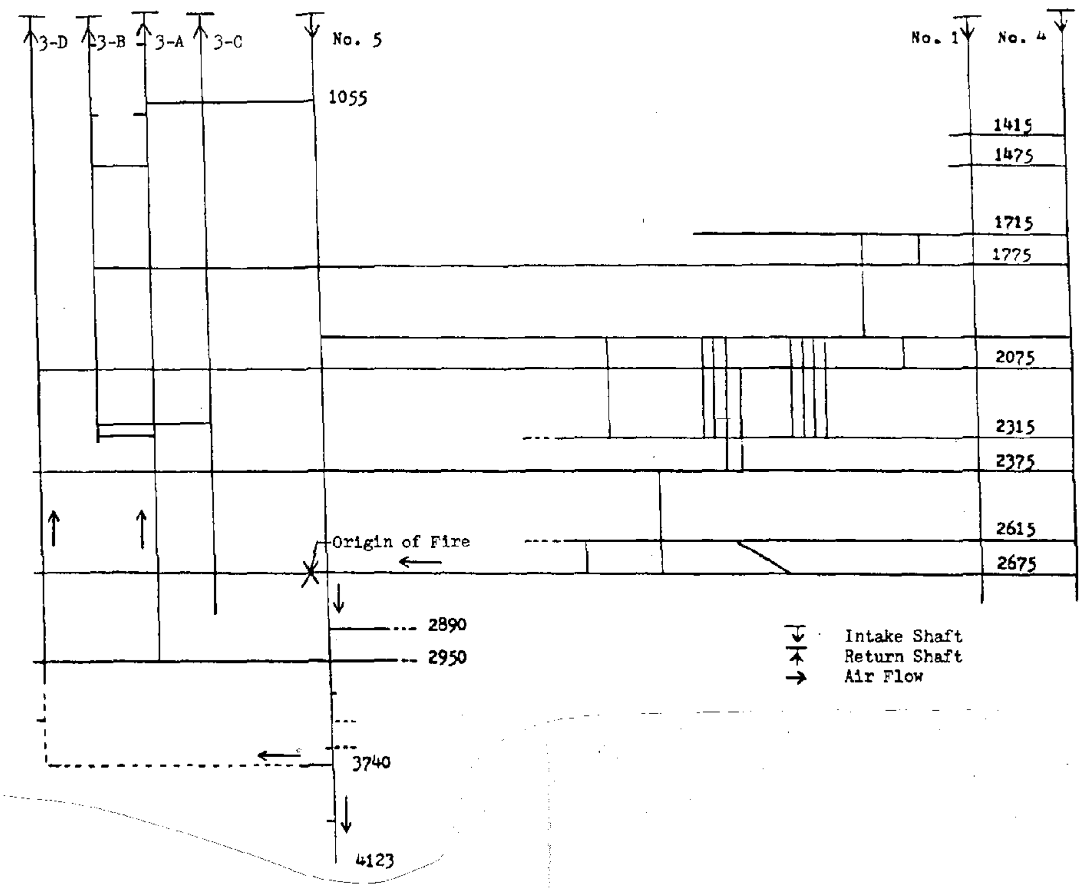


FIGURE A-24. - San Manuel Mine schematic.

Potential Impact of SCSRs

FSRs were used by 3 of 167 miners. SCSRs would not have been required.

Other Factors

The fire could have been much more intense involving timber. The proximity of the fire to the downcast No. 5 Shaft could have caused toxic fumes to the seven levels below 2675. Most of the miners were on those seven levels and their only egress was up the No. 5 Shaft or in returns; air, the air in those routes had the fire been serious, could have been irrespirable. Then SCSRs or refuge chambers might have been needed.

A.7.55 San Manuel Mine Fire, May 23, 1980 (A-78

Background

The San Manuel Mine is synopsized in subsection A.7.54. At the time of this accident 1137 persons were underground.

The Accident

Three electricians were salvaging electrical circuits on the 1775 level. The wire was put on two reels on a flat car. That was the lead car of two being pushed by a motor. As the trip was being trammed towards the shaft, one reel slid and struck a 10-in. compressed air line. The line broke, and air at 80 and 90 psi roared out. A nearby valve was closed, but it did not stop the flow. Another valve was found, and while all three men were turning it, one said he smelled smoke. The air was filled with dust which became so unbearable the miners went to the 3-A Shaft and out of the mine. There they notified the pipe fitters of the broken pipe, and then went via the No. 1 Shaft back to the 1775 level. They discovered fire. They telephoned the foreman.

Immediately following the call (2:45 p.m.) the stench alarm system was activated; ethyl mercaptan was injected into the compressed air lines, into the 3-A and No. 4 Shafts and into the ventilating air flow into the No. 4 and 5 Shafts. All 1137 miners were out and accounted for by 3:45 p.m. FSRs were not used.

On June 8, the fire was considered to be contained; it was not extinguished. This fire is believed to have been ignited by high-pressure, high-velocity, rust-laden air impinging on extremely dry timber. Once sufficient heat was generated, the fire spread rapidly - by 5 p.m., after 1-1/2 hr of fire fighting by mine rescue teams, 60 ft of drift timber were burning. Subsequent fire fighting activities were hampered by the 20°F differential between early morning and noon temperatures. That differential caused a pressure differential of one-half inch water gauge making pressure balancing and air flow control a difficult task.

Potential Impact of SCSRs

FSRs were not used by any of the 1137 persons underground. Discussions with some persons involved indicated no one expressed the need for an FSR or for oxygen. As soon as stench was smelled, and sooner for those who had received prior warning, all persons went to previously assigned evacuation-assembly areas. There, the area supervisors checked each person out, thus ensuring a complete evacuation. The miners then boarded mantrip cars to the nearest intake air shaft.

The positive and obviously well-disciplined responses of 1137 persons negated the need for auxiliary sources of oxygen. Only the three electricians were exposed to a potentially dangerous atmosphere when they traveled in the return from the fire to the 3-A Shaft. They, however, were not affected. Had they needed SCSRs they would have had to wear or carry them, at least until they reached a shaft station. The most probable storage locations for SCSRs on the 1775 level, other than on the locomotive, were at the 3-A and No. 1 Shaft stations, 1600 and 400 ft, respectively, from the origin of the fire.

A.7.56 Sherman Mine Fire, March 20, 1980 (A-79)

Background

Sherman Mine, a silver and lead operation, is near Leadville, Colorado. The ore is broken from large open stopes by drilling and blasting; load-haul-dump (LHD) units transport the broken ore to transfer pockets.

The Accident

A Wagner ST-2B LHD lost its brakes on a decline, ran against a rib, and the engine compartment became engulfed in flames. The operator jumped from the loader and ran to a phone.

Within 5 min of the start of the fire, the stench system was activated. Meanwhile, five miners contained the fire with several dry chemical fire extinguishers. The crew had the fire out within 15 min of its inception. Shortly afterwards that crew smelled the stench.

A half-hour later, the miners underground telephoned to the surface notifying them the fire was out, and all employees were safe, accounted for and in fresh air. The mine superintendent ordered those miners out and sent in a mine rescue team. The team found the fire to be out and the air to be safe.

Potential Impact of SCSRs

FSRs were not used. SCSRs, had they been necessary, would have to have been immediately available to persons fighting the fire; however, SCSRs are designed for escape only, not for protection of persons fighting a fire.

A.7.57 Sunshine Mine Fire, November 23, 1977 (A-82)

Background

This mine is described in subsection A.7.14. A drawing taken from the November 30, 1977 fire report shows a general schematic of the mine (subsection A.7.58). No. 10 Shaft, the site of this accident, is a downcast shaft through which intake air is forced to levels below 3700.

The Accident

The shift boss observed a warning light on the signal board in the 3700 level underground supervisor's office (the Blue Room). The light indicated a problem in the sump pump system. The sump was on the 5600 level of No. 10 Shaft. He went down to investigate. Twenty minutes later, the cager while in the 4800-level pocket smelled smoke. A few minutes later the shift boss called from the 5400 level reporting smoke coming up the shaft.

Within 5 min, the stench warning system was activated. Evacuation was completed in 35 min.

An hour later, the mine rescue team, wearing oxygen breathing apparatus entered. They quickly located the source of the smoke - insulation on wires in the pump motor starter housing. The overload relays had already de-energized the circuit.

Potential Impact of SCSRs

Miners did not need FSRs or SCSRs.

Other Factors

The No. 10 Shaft is critical to rapid, safe evacuation from the Sunshine Mine. Although smoke was rising from near the bottom of the shaft, miners were not made aware of the potential danger for at least a half hour. Fortunately, the cause for smoke was of minor import.

Had there been a major fire in No. 10 Shaft, successful escape with SCSRs cannot be assured. Some miners would have to climb raises, possibly through smoke, requiring higher than normal oxygen consumption for more than 60 min. Means other than SCSRs alone for protection against an irrespirable atmosphere are indicated; such might include:

a. Rapid, positive warning of smoke in No. 10 Shaft, Jewell Shaft and Silver Summit escapeway

b. Refuge chambers in or compartmentalized ventilation of levels below the 3700.

A.7.58 Sunshine Mine Fire, November 30, 1977 (A-83)

Background

This mine is described in subsection A.7.14.

The Accident

This accident is described in approximate time sequence because most actions taken exemplify good practice.

7:25 p.m. Two miners in a stope on the 5200 level heard a loud pop. Electrical power was lost to the slusher. The miners left the stope and reported the loss of power to the shift boss. The miners returned to their stope. Ventilation in this stope was upcast, exhausting on the 5000 level.

8:00 p.m. Two miners in a stope on the 5000 level smelled and saw smoke coming up their raise. They climbed up to the 4800 level, went to the No. 10 Shaft station and reported the fire.

8:11 p.m. The stench warning system was activated. Miners left their working places, went to the No. 10 Shaft; and hoisting was begun to take them to the 3100 and 3700 levels. Figure A-25 shows the stope area in which this fire developed with respect to the mine layout.

8:30 p.m. Electrical power to the 5000 level was locked out.

8:35 p.m. The last main train left No. 10 Shaft for the Jewell Shaft.

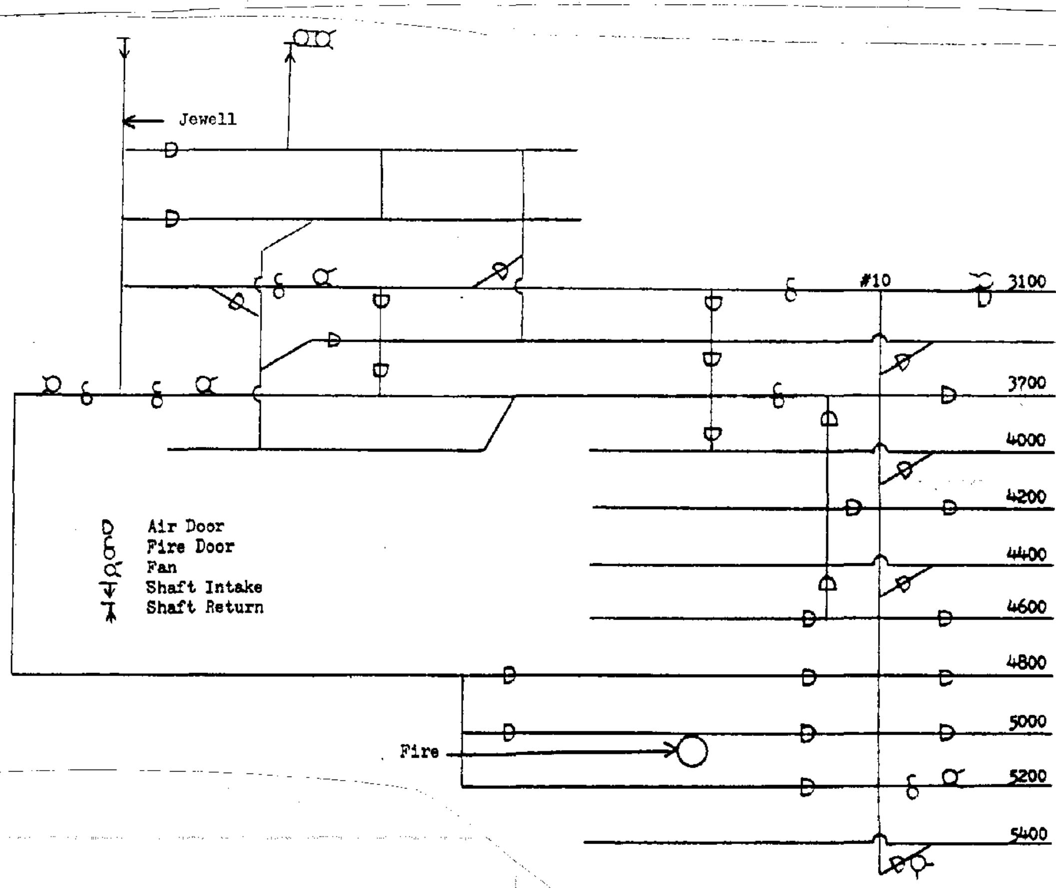


FIGURE A-25. - Sunshine Mine schematic.

9:10 p.m.	Evacuation completed.
9:40 p.m.	A mine rescue team entered the mine; a back-up team was on the surface. Light smoke and 10 ppm CO was detected on the 5000 level; none on the 5200 level.
12:41 a.m.	Fire located and extinguished. The fire was confined to several pieces of lagging, a girt, and a wall plate. The fire was caused by a short circuit in the power cord going down a raise between the 5000 and 5200 levels, the raise in the stope mentioned at 7:25 p.m.

Potential Impact of SCSRs

FSRs were neither used nor needed. The prompt, positive actions taken while this fire was in its incipient stage negated the need for SCSRs.

Other Factors

Even had the fire been more intense, FSRs probably would have been adequate for the ventilation, fire location and time from detection to evacuation. This fire is typical of many fires in ore mines. Unless the igniting source is powerful, ore-mine fires typically burn slowly for hours to days until the heat generated exceeds the capacity of the ventilating air to remove heat. The principal, critical exceptions to that are fires in heavily timbered shafts, stopes, raises and drifts.

A.7.59 Sunshine Mine Fire, February 22, 1978 (A-84)

Background

This mine is described in subsection A.7.14. The drawing in subsection A.7.58 shows a general schematic of the mine.

The Accident

About 6:45 a.m. smoke was smelled at the No. 10 Shaft station on the 4800 level. The crew, after failing to contact the underground supervisor, called the shift boss on the surface. An MSHA inspector at the mine learned of the fire at 7:00 a.m.

Five supervisors and a miner, three of whom had experienced the May 2, 1972 fire, entered the mine. The stench warning system was not activated; and, the six investigators had no rescue apparatus. As they descended the No. 10 Shaft they monitored the air and notified crews to evacuate to the 3700 level. By 8:00 a.m. the 21 miners on the work shift had assembled at the 3700 level, No. 10 Shaft station.

At 8:34 a.m. two other supervisors, one of whom had a major role in the May 2, 1972 fire, located the fire in the 4800 level battery charging station; a motor generator armature had shorted. The fire was extinguished; and the miners returned to work at 8:48 a.m. No one was injured.

Potential Impact of SCSRs

Neither FSRs nor SCSRs were needed.

Other Factors

For 2 hr the crew of 21 miners and 8 "fire searchers" were underground and away from rapid exit to the surface or to the safety of the Jewell Shaft. Until the fire was located, the potential for exposure to an irrespirable atmosphere existed. They did have FSRs which, for the ventilation scheme and fire location, probably would have protected them. Response to this fire was slower than that described in subsections A.7.57 and A.7.58. The reasons for this have not been discovered, and the supports belief for the need for Coeur d'Alene miners, among others, having some combination of the following items:

a. An auxiliary source of oxygen

b. A positive, rapid response to potential fire

c. Refuge chambers or compartmentalized ventilation systems on levels.

A.7.60 Weeks Island Storage Complex Fire, December 13, 1978 (A-87)

Background

The United States Department of Energys Weeks Island Storage Complex was a salt mine being converted for underground storage of oil. The mine was near New Iberia, Louisiana.

The Accident

Airflow control stoppings were being coated with polyurethane foam. The foam on one stopping ignited spontaneously. The fire was discovered 3 hr after the application. It could not be extinquished with a portable fire extinguisher. Evacuation was then begun and was completed within a half hour. The fire was extinguished 5 hr later by a rescue team wearing oxygen breathing apparatus.

Potential Impact of SCSRs

FSRs were not used. Stored SCSRs would have met the needs of miners for escape.

A.7.61 Young Mine Fire, October 16, 1978 (A-88)

Background

Young Mine, near Strawberry Plains, Tennessee, is a zinc producer. Access was by a 3-compartment, vertical, 936-ft deep shaft. Four other shafts were used for ventilation. Mining was on four levels in which ore was mined from large horizontal stopes. The ore was drilled and blasted. Diesel-powered, load-haul-dump (LHD) units were used for mucking and hauling the ore. Figure A-26 illustrates the area of the mine involved in this accident.

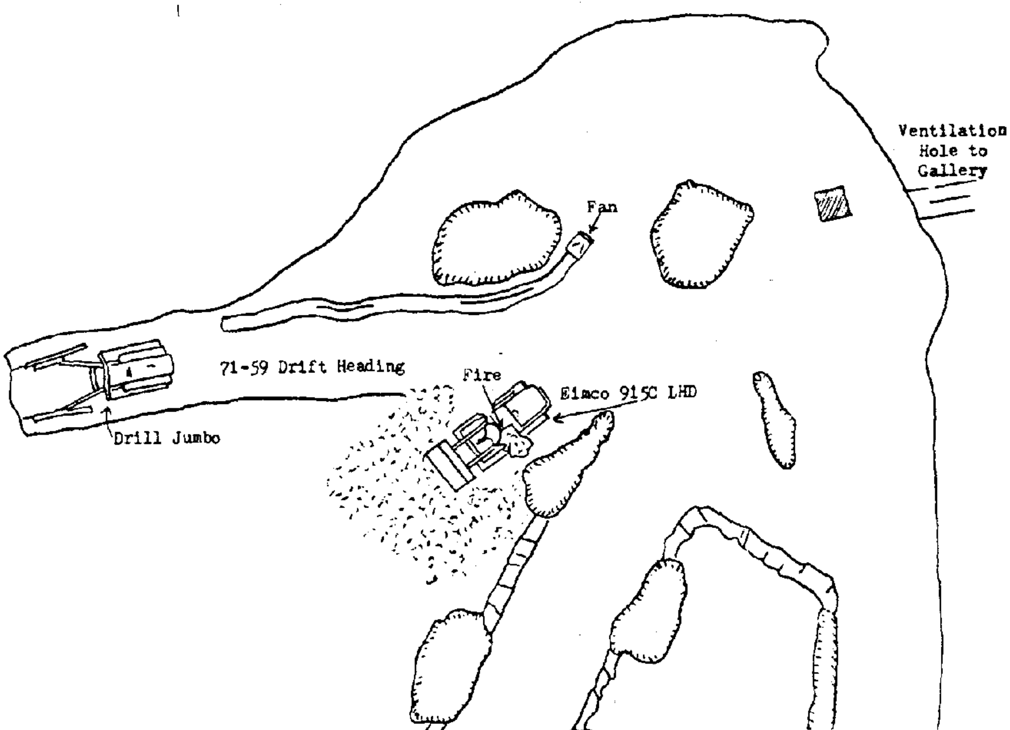


FIGURE A-26. - Young Mine fire area.

The Accident

A just-repaired LHD was parked at a muck pile. The driver went to the drill jumbo to help his partner. They smelled smoke. When they went to see where the smoke was coming from, they saw the LHD on fire. They tried to get to the fire extinguisher on the LHD, but the heat and smoke were too intense.

One of the miners tried to use his FSR; however, he could not get the nose clip on. He dashed through the fire reached fresh air. There, he found his partner had not come with him. Holding his nose with his fingers, he went back and found his partner going the wrong way. He led him to fresh air.

They then searched for and found the foreman. The foreman informed all the men in the immediate area and brought them to what should be a safe environment.

During this time, fifty blasting caps in a box on the LHD engine compartment detonated. The 150 to 250 lb of dynamite in the LHD bucket did not explode. There were 70 to 80 persons underground; they were evacuated about 2 hr after the fire began.

Potential Impact of SCSRs

One miner used an FSR; however, he could not use the nose clip because of the difference in design of his nose and of the FSR nose clips. The same problem would exist with an SCSR.

Other Factors

Had the dynamite exploded, those miners that survived would have needed FSRs, SCSRs or other means for escape from the toxic blasting fumes.

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A-97. 1979 UG M/NM Stone Fire 81-1116. Metal/Nonmetal Accident and Injury Abstract, HSAC-MSHA:AB060LA, May 20, 1981, 7 pp.

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A.9 Index of Mine Accidents

Table A-11 lists the mine accident reports in order of our report number.

Table A-12 lists the mine accidents in alphabetical order by mine name.

Table A-13 lists the mine accidents chronologically according to date of accident.

TABLE A-11. - Mine accident reports in order of our report number

Report No.	Mine name - type of accident	Date
A.7.1	Cross Mine - Asphyxiation	9/19/80
A.7.2	Knight Mine - Asphyxiation	5/6/77
A.7.3	Nevada Mine - Suffocation	8/10/80
A.7.4	Lisbon Mine - Gas Outbursts	3/29,4/6,5/17/80
A.7.5	Nash Draw Mine - Asphyxiation	3/29/76
A.7.6	Belle Isle Mine - Explosion	6/8/79
A.7.7	USBM No. 1 Shaft - Ignition	11/1/78
A.7.8	Alchem - Trona Ignition	6/3/77
A.7.9	Belle Mine - Ignition	10/27/76
A.7.10	Cane Creek - Ignition	7/31/63
A.7.11	Cane Creek - Explosion	8/27/63
A.7.12	Dead Horse - Ignition	5/20/70
A.7.13	No. 1 Incline - Explosion	11/5/53
A.7.14	Sunshine Mine - Fire	5/2/72
A.7.15	Homestake Mine - Fire	5/9/75
A.7.16	Magma Mine - Fire	5/2/80
A.7.17	Beyer Mine - Fire	1/22/78
A.7.18	Crescent Mine - Fire	3/25/79
A.7.19	Eagle Mine - Fire	10/3/77
A.7.20	Kelley Mine - Fire	4/7/77
A.7.21	Kelley Mine Shaft - Fire	6/27/77
A.7.22	New York Mine - Fire	7/20/77
A.7.23	Silver Dollar Mine - Fire	8/27/76
A.7.24	Belle Isle Mine - Fire	3/5/68
A.7.25	Belle Isle Mine - Fire	2/2/79
A.7.26	Bunker Hill Mine - Fire	6/28/78
A.7.27	Climax Mine - Fire & Explosion	7/8/64
A.7.28	Lucky Friday Mine - Fire	12/17/80
A.7.29	Magma No. 9 Shaft - Fire	3/22/73
A.7.30	Miller Mine - Fire	8/8/80
A.7.31	Reserve Mine - Fire	4/5/76
A.7.32	Star Mine - Fire	1/20/71
A.7.33	USBM No. 1 Shaft - Fire	12/6/78
A.7.34	Water Lilly Mine - Fire	1/19/79
A.7.35	Bellefonte Mine - Fire	6/8/76
A.7.36	Belle Isle Mine - Fire	1/9/79
A.7.37	Bunker Hill Mine - Fire	11/15/79
A.7.38	Cabin Creek Mine - Fire	4/16/77
A.7.39	Cayuga Mine - Fire	3/28/78
A.7.40	Cherokee Mine - Fire	1/6/78

TABLE A-11. - Mine accident reports in order of our report number (continued).

Report No.	Mine name - type of accident	Date
A.7.41	Climax Mine - Fire	9/30/77
A.7.42	Climax Mine - Fire	8/8/78
A.7.43	Climax Mine - Fire	10/11/78
A.7.44	Fletcher Mine - Fire	7/7/80
A.7.45	Georgia Marble No. 5 Mine - Fire	1/31/78
A.7.46	Gordonsville Project - Fire	4/19/78
A.7.47	Grace Mine - Fire	6/22/76
A.7.48	Homestake Mine - Fire	4/1/76
A.7.49	Logan Wash - Fire	9/12/78
A.7.50	Montevallo Mine - Fire	9/20/77
A.7.51	Ozark Mine - Fire	12/16/78
A.7.52	Pleasant Gap Mine - Fire	8/26/77
A.7.53	Retsof Mine - Fire	12/8/77
A.7.54	San Manuel Mine - Fire	10/18/76
A.7.55	San Manuel Mine - Fire	5/23/80
A.7.56	Sherman Mine - Fire	3/20/80
A.7.57	Sunshine Mine - Fire	11/23/77
A.7.58	Sunshine Mine - Fire	11/30/77
A.7.59	Sunshine Mine - Fire	2/22/78
A.7.60	Weeks Island Storage Complex - Fire	12/1/78
A.7.61	Young Mine - Fire	10/16/78

TABLE A-12. - Mine accidents in alphabetical order by mine name

Mine name	Type of accident	Date	Report No.
Alchem	Trona Ignition	6/5/77	A.7.8
Bellefonte Mine	Fire	6/8/76	A.7.35
Belle Isle Mine	Fire	3/5/68	A.7.24
Belle Isle Mine	Fire	1/9/79	A.7.36
Belle Isle Mine	Fire	2/2/79	A.7.25
Belle Isle Mine	Explosion	6/8/79	A.7.6
Belle Mine	Ignition	10/27/76	A.7.9
Beyer Mine	Fire	1/22/78	A.7.17
Bunker Hill Mine	Fire	6/28/78	A.7.26
Bunker Hill Mine	Fire	11/15/79	A.7.37
Cabin Creek Mine	Fire	4/16/77	A.7.38
Cane Creek Mine	Ignition	7/31/63	A.7.10
Cane Creek Mine	Explosion	8/27/63	A.7.11
Cayuga Mine	Fire	3/28/78	A.7.39
Cherokee Mine	Fire	1/6/78	A.7.40
Climax Mine	Fire	7/8/64	A.7.27
Climax Mine	Fire	9/30/77	A.7.41
Climax Mine	Fire	8/8/78	A.7.42
Climax Mine	Fire	10/11/78	A.7.43
Crescent Mine	Fire	3/25/79	A.7.18
Cross Mine	Asphyxiation	9/19/80	A.7.1
Dead Horse Mine	Ignition	5/20/70	A.7.12
Eagle Mine	Fire	10/3/77	A.7.19
Fletcher Mine	Fire	7/7/80	A.7.44
Georgia Marble No. 5	Fire	1/31/78	A.7.45
Gordonsville Project	Fire	4/19/78	A.7.46
Grace Mine	Fire	6/22/76	A.7.47
Homestake Mine	Fire	5/9/75	A.7.15
Homestake Mine	Fire	4/1/76	A.7.48
Kelley Mine	Fire	4/7/77	A.7.20
Kelley Mine	Fire	6/27/77	A.7.21
Knight Mine	Asphyxiation	5/6/77	A.7.2
Lisbon Mine	Gas Outbursts	3/29/80	
Lisbon Mine	Gas Outbursts	4/6/80	A.7.4
Lisbon Mine	Gas Outbursts	5/17/80	
Logan Wash	Fire	9/12/78	A.7.49
Lucky Friday Mine	Fire	12/17/80	A.7.28
Magma Mine	Fire	5/2/80	A.7.16
Magma No. 9 Shaft	Fire	3/22/73	A.7.29
Miller Mine	Fire	8/8/80	A.7.30

TABLE A-12. - Mine accidents in alphabetical order by mine name (continued)

Mine name	Type of accident	Date	Report No.
Montevallo Mine	Fire	9/20/77	A.7.50
Nash Draw Mine	Asphyxiation	3/29/76	A.7.5
Nevada Mine	Suffocation	8/10/80	A.7.3
New York Mine	Fire	7/20/77	A.7.22
No. 1 Incline	Explosion	11/5/53	A.7.13
Ozark Mine	Fire	12/16/78	A.7.51
Pleasant Gap Mine	Fire	8/26/77	A.7.52
Reserve Mine	Fire	4/5/76	A.7.31
Retsoff Mine	Fire	12/8/77	A.7.53
San Manuel Mine	Fire	10/18/76	A.7.54
San Manuel Mine	Fire	5/23/80	A.7.55
Sherman Mine	Fire	3/20/80	A.7.56
Silver Dollar Mine	Fire	8/27/76	A.7.23
Star Mine	Fire	1/20/71	A.7.32
Sunshine Mine	Fire	5/2/72	A.7.14
Sunshine Mine	Fire	11/23/77	A.7.57
Sunshine Mine	Fire	11/30/77	A.7.58
Sunshine Mine	Fire	2/22/78	A.7.59
USBM No. 1 Shaft	Fire	12/6/78	A.7.33
USBM No. 1 Shaft	Ignition	11/1/78	A.7.7
Water Lilly Mine	Shaft Fire	1/19/79	A.7.34
Weeks Island Storage Complex	Fire	12/1/78	A.7.60
Young Mine	Fire	10/16/78	A.7.61

TABLE A-13. - Mine accidents chronologically according to date of accidents

Date	Mine Name	Type of accident	Report No.
11/5/53	No. 1 Incline	Explosion	A.7.13
7/31/63	Cane Creek Mine	Ignition	A.7.10
8/27/63	Cane Creek Mine	Explosion	A.7.11
7/8/64	Climax Mine	Fire & Explosion	A.7.27
3/5/68	Belle Isle Mine	Fire	A.7.24
5/20/70	Dead Horse Mine	Ignition	A.7.12
1/20/71	Star Mine	Fire	A.7.32
5/2/72	Sunshine Mine	Fire	A.7.14
3/22/73	Magma No. 9 Shaft	Fire	A.7.29
5/9/75	Homestake Mine	Fire	A.7.15
3/29/76	Nash Draw Mine	Asphyxiation	A.7.5
4/1/76	Homestake Mine	Fire	A.7.48
4/5/76	Reserve Mine	Fire	A.7.31
6/8/76	Bellefonte Mine	Fire	A.7.35
6/22/76	Grace Mine	Fire	A.7.47
8/27/76	Silver Dollar Mine	Fire	A.7.23
10/18/76	San Manuel	Fire	A.7.54
10/27/76	Belle Mine	Ignition	A.7.9
4/7/77	Kelley Mine	Fire	A.7.20
4/16/77	Cabin Creek Mine	Fire	A.7.38
5/6/77	Knight Mine	Asphyxiation	A.7.2
6/5/77	Alchem	Trona Ignition	A.7.8
6/27/77	Kelley Mine	Shaft Fire	A.7.21
7/20/77	New York Mine	Fire	A.7.22
8/26/77	Pleasant Gap Mine	Fire	A.7.52
9/20/77	Montevallo Mine	Fire	A.7.50
9/30/77	Climax Mine	Fire	A.7.41
10/3/77	Eagle Mine	Fire	A.7.19
11/23/77	Sunshine Mine	Fire	A.7.57
11/30/77	Sunshine Mine	Fire	A.7.58
12/8/77	Retsoff Mine	Fire	A.7.53
1/6/78	Cherokee Mine	Fire	A.7.40
1/22/78	Beyer Mine	Fire	A.7.17
1/31/78	Georgia Marble No. 5	Fire	A.7.45
2/22/78	Sunshine Mine	Fire	A.7.59
3/28/78	Cayuga Mine	Fire	A.7.39
4/19/78	Gordonsville Project	Fire	A.7.46
6/28/78	Bunker Hill Mine	Fire	A.7.26
8/8/78	Climax Mine	Fire	A.7.42

TABLE A-13. - Mine accidents chronologically according to date of accident (continued)

Date	Mine name	Type of accident	Report No.
9/12/78	Logan Wash	Fire	A.7.49
10/11/78	Climax Mine	Fire	A.7.43
10/16/78	Young Mine	Fire	A.7.61
11/1/78	USBM No. 1 Shaft	Ignition	A.7.7
12/1/78	Weeks Island Storage Complex	Fire	A.7.60
12/6/78	USBM No. 1 Shaft	Fire	A.7.33
12/16/78	Ozark Mine	Fire	A.7.51
1/9/79	Belle Isle Mine	Fire	A.7.36
1/19/79	Water Lilly Mine	Shaft Fire	A.7.34
2/2/79	Belle Isle Mine	Fire	A.7.25
3/25/79	Crescent Mine	Fire	A.7.18
6/8/79	Belle Isle Mine	Explosion	A.7.6
11/15/79	Bunker Hill Mine	Fire	A.7.37
3/20/80	Sherman Mine	Fire	A.7.56
3/29/80	Lisbon Mine	Gas Outburst	A.7.4
4/6/80	Lisbon Mine	Gas Outburst	
5/2/80	Magma Mine	Fire	A.7.16
5/17/80	Lisbon Mine	Gas Outburst	A.7.4
5/23/80	San Manuel Mine	Fire	A.7.55
7/7/80	Fletcher Mine	Fire	A.7.44
8/8/80	Miller Mine	Fire	A.7.30
8/10/80	Nevada Mine	Suffocation	A.7.3
9/19/80	Cross Mine	Asphyxiation	A.7.1
12/17/80	Lucky Friday Mine	Fire	A.7.28

APPENDIX B

DISCUSSIONS WITH REPRESENTATIVES OF UNDERGROUND MINERS

B.1 Introduction

Suggested guidelines for SCSRs on underground metal and nonmetal mines are based in part on mine visits and discussions with mining groups. Underground observations were made in the folloiwng mines:

a. Avery Island Mine, Avery Island, LA

b. Belle Isle Mine, Morgan City, LA

c. Bulldog Mountain Mine, Creede, CO

d. Cashin Mine, Paradox, CO

e. City Service's Calloway and Cherokee Mines, Copper Hill, TN

f. Fire Fly and Grey Down Mines, San Juan County, UT

g. Friedensville, Center Valley, PA

h. LaSal Mine, LaSal, UT

i. Lucky Friday Mine, Mullan, ID

j. Potash Company of America Mine, Carlsbad, NM

k. Probe Mine, Green River, UT

l. Schwartzwalder Mine, Golden, CO

m. Section 35 Mine, Ambrosia Lake, NM

n. Sunshine Mine, Big Creek, ID.

Individuals and organizations with whom discussions were held are listed in subsection C.6 and may be summarized as follows:

a. Miners in the stopes and drifts visited

b. MSHA Metal and Nonmetal Health and Safety District Offices

c. Representatives of operators of underground metal and nonmetal mines

d. United Steel Workers of America, Locals 18, 5089, and 7854.

This appendix summarizes those observations and discussions. In many of the mines visited we wore or carried SCSRs. Some of the miners we met took this opportunity to get a feel for working and traveling while wearing an SCSR. This we believe gave both them and us better albeit limited knowledge and experience. In our summary of discussions, we have attempted to refrain from editorializing or otherwise changing the tone of opinions expressed; thus, the reader should understand that the contents of those discussions do not necessarily reflect our opinions.

B.2 SCSR Design

Without exception, metal and nonmetal miners perceived inadequacies in the design of SCSRs for their needs. These are discussed below individually; however, the concerns expressed considered them mutually.

Duration

"The one-hour capacity of SCSRs has little applicability." Many miners are within a 10- to 30-min walk to the surface. Should they be unable to travel directly to the surface because of fire, for example, escape by alternate routes could require considerable effort over many hours.

In some mines, particularly multi-level operation, it takes more than an hour to travel from the surface to many work sites, and this involves a man train part of the way. In Bunker Hill Mine, for example, it takes more than 1-1/2 hr to travel to working areas in "J Country". Representatives of the 2000 miners in the Coeur d'Alene Valley stated that if in-mine hoists were inaccessible they would need 4 to 6 hours of oxygen for escape in the best of conditions. The extensiveness and complex travel routes through mines in the Coeur d'Alene and elsewhere can be appreciated in some schematics of mine layouts in Appendix A. Those representatives also questioned whether a one-hour SCSR would provide oxygen for one hour to miners climbing several hundreds of feet of ladders in air that normally is 100°F or more and 95 percent RH or more; they suggested escape-time studies would be important to their understanding of the adequacy of SCSRs.

Our in-mine observations found the above comments to be appropriate. In one mine, for example, the travel time from the face to the surface was 5 minutes by the normal route and 2 hr by the only other alternate. In a group of five medium-sized mines the escape times determined in evacuation drills ranged from 15 to 36 min; escape routes included travel up wood-lined shafts. Should fire prevent escape through a shaft, miners would have to barricade at the bottom of an escape borehole and wait at least an hour before a 2-person capsule could be made available. This, however, might not be feasible; none of the miners we spoke with were aware of their need to build barricades near the bottom of an escape borehole; barricading materials were not observed. Typically those boreholes have a fan on top blowing air into the mine; should a borehole be needed for escape the fan would have to be removed which, if barricades were not constructed, could result in fire-produced gases flowing to the borehole.

Our observations in other mines indicated few miners knew their secondary escape routes; fewer still had actually travelled them. This was an important contributor to death in the May 2, 1972 fire in Sunshine Mine.

We also observed numerous stopes where, should dense smoke enter the raise, it would be safer for miners to retreat to a dead-end, preferably taking the compressed air hose if they could locate one, and barricade. There they would wait for a mine rescue team to retrieve them, which could be many hours later. These were stopes where the one way in was the only way out.

Climatic Conditions

Sealing of SCSR cases was a matter of great concern. Previous experiences with FSRs were cited. One of two models of FSRs are vacuum sealed. In some mines all vacuum-sealed FSRs had to be replaced; many exceeded the weight specification in fewer than 90 days; the internal parts of many others "rotted" within two years. The manufacturer redesigned this model; 25 redesigned units were tried by the same mines and failed in three months.

Two mine operators suspected the above described problem was caused not by abuse but by the FSRs being subjected to twice daily changes in elevation of up to 6,000 ft and/or temperature differentials of up to 150°F. They were concerned that we had no information regarding this for SCSRs, particularly because MSHA, NIOSH, U.S. Bureau of Mines and FSR manufacturers were well-aware of the problem.

The low temperature limitations of SCSRs, 10 to 23°F, were expected to cause problems. For miners working near shafts and in the many small drift mines, temperatures below 10°F are common for months. Frequently electrical power for heaters is not available. Many thought that to maintain the immediate availability of SCSRs by using heaters, powered by batteries or generators, would result in a diminution of safety.

Size

Miners were unanimous in their expressions on the size of SCSRs. They were shown only two types, MSA's model 464213 and Draeger's OSY-SR-60B. Their sizes and shapes were considered excessive and hazardous not only for normal wear and carry, but for escape, particularly if vision was limited.

Many stated it was so difficult to carry lunch pails that they generally left them elsewhere or did not bother with lunch. Some claimed to have problems with FSRs and cap lamp batteries, particularly while climbing in raises or operating a mucker or jack leg in a timbered drift. Numerous persons pointed out the criticality of freedom of movement on ladders; reduced freedom purportedly has caused miners to lose their grip and fall.

Subsection 11-37 of Part 57, 30CFR, requires ladderways constructed after November 15, 1979 to have a minimum unobstructed cross-sectional opening of 24 in. × 24 in. measured from the face of the ladder. Variances are being requested for mines in steeply dipping narrow vein deposits where following the ore and attempting to minimize dilution often requires smaller cross-sections. particularly in areas prone to rock bursts. Many ladderways established prior to that regulation have smaller cross-sections Thus, stope and raise miners (who typically weigh 200 to 225 lb and are 19 to 20 in. across the shoulders) could be correct in wondering whether a larger opening would be necessary to accommodate carrying an SCSR. They believed the problem could be greater in an emergency, expressing much concern with the exposed breathing bag and its potential for being torn by splinters, nails and wires along the ladders.

In one mine, we made a cursory test of carrying and of escape with an SCSR in a raise similar to that depicted in Figure B-1. It should be noted that the person was slighter in build than the typical raise miner, weighing 145 lb and having a shoulder-to-shoulder measurement of 17 in. Also, the ladderway, 30 in. × 30 in. with a steel ladder, was of superior quality. No problems were encountered going down into the stope; because the upper half of the body was farthest from the ladder there was sufficient space for the breathing bag which was at chest level. When climbing up, however, and particularly when opening landing guards and making the transition to the next ladder, the breathing bag caught on the ladder and some landing guards; once, part of the bag caught between rungs on the ladder. This experience indicated the possible importance of tests with SCSRs having breathing bags below chest level; such might interfere with climbing down as well as up.

B.3 Storage

Almost every person we met was firm in his belief that present SCSRs could not and would not be worn, carried or kept within 25 ft of most miners. Almost all metal and nonmetal miners said that to derive the maximum benefit, SCSRs must be readily available and storage was a probable impracticality.

Reasons given for the above contradiction, that SCSRs had to be immediately available to be of use yet it was unlikely that they could or would be, included the following:

a. "You can appreciate there will be problems with the storage concept. Again using an example, a miner's work will cause him to move in and out of several access drifts around the active stope. There is no way a cache of units will remain within 25 ft of the man or any other selected travel distance. Further, if completely engulfed in smoke, you can also envision how easy it would be (particularly considering the probability of panic) for the man to become disoriented in that maze and never make his way to the cache."

b. "...it seems appropriate to discuss the suggestion put forward to store the SCSRs and continue wearing the current self-rescuer. The miner would use it to get to the SCSR cache where he would switch units. We believe this will lead to increased fatalities because the idea has serious flaws. It is well established that a man is rendered unconscious in a few breaths in a 1 percent CO-laden atmosphere and succumbs shortly thereafter. One breath means the man's certain end. Now feature a man who is even mildly excited, thereby increasing his breathing rate, taking off his self-rescuer in a CO-laden atmosphere and putting on an SCSR. He is going to breathe during the exchange and this will be his finish. The scenario is so potentially dangerous it is hard for prudent men to conceive that it would be workable."

c. "If the storage concept is adopted how does an operator cover those employees who are transients in the mine? This category of people includes such people as visitors, foremen, and other supervisors, geologists, electricians, mechanics, monitoring technicians, etc. They must travel up raises and through the same places as miners. If the miner cannot wear the device and work, it is hard to see how these people can do otherwise. Some of these people such as electricians, technicians, and geologists are heavily burdened with tools, probes, and instruments. They are already weighed down more than any miner. They move through the mine and never return to a given area. How can they be expected to remain within some selected distance of a cache? These people present a particularly difficult situation."

d. "I am convinced personnel in our mine must have the units on their person or within easy reach at all times. A stope miner, for example, 100 ft from the bottom of the manway is also 100 ft from the top. If he left his SCSR at the top and then climbed to the bottom to work on a hung chute, for example, and met an emergency, he would be out of luck. Vertical movement in our type of mine is common and frequent and dictates strongly the need to wear the self-rescuer. One hundred percent of our personnel wear their units (filter SRs). They may take them off along with their lamp belt when they sit down to eat, but that is it. So I will say that consideration of SCSRs for our mine should be on the basis of wearing them. The only alternative would be to wear some other type unit and move toward a cache of SCSRs. If an alternate unit is adequate to reach a cache (one must remember the great distances that could be involved), it is adequate to reach a source of fresh air."

e. "Our miners work great distances from each other, so we would need more than one central location and we would need just about a location for every stope. Again they could use their old one (FSR) and walk to a fresh air source quicker than they could change rescuers."

f. "In a mechanized mine the proposed SCSRs would have to be carried into and out of the mine by each employee and would be stowed during the shift on the machine operated by that employee. This would subject the units to extreme handling abuse and could contribute to slips and falls during machine ingress/egress. These units would burden employees who are wearing cap lamps and batteries and carrying lunch buckets to the point that they would be treated much the same as infantrymen treated heavy, cumbersome, nonfunctional equipment during past wars. They would be conveniently misplaced, forgotten, destroyed or ignored. Thus, the effectiveness of the SCSR would be lost."

g. "As far as mounting the units, mining equipment has never been adaptable to mounting anything on and being able to keep it in working condition. Fire extinguishers were hard enough to solve."

h. "Storage of SCSRs on equipment such as front-end loaders and LHDs is impractical. Should the equipment catch on fire - and equipment fires are among the most common - the operator would not be able to try to obtain both the equipment-mounted fire extinguisher and SCSR. In the event of such fire which would you attempt to get?" (Note: This needs to be considered further; equipment fires described in Appendix A became serious because the first action of machine operators was to leave the compartment and subsequent efforts to reach fire extinguishers failed.)

i. "Storage on machines doesn't seem like a good idea, because in an emergency first you take a running fit, then you get your mind back. By then, you could be far from your self-rescuer stored on the machine."

j. "...the relationship of the ventilation system to a storage plan. This will be difficult if not impossible to establish. There are so many different stoping methods requiring different development layouts in metal mines which are "tight" in space and configuration that one can always rely on some ventilation reversal in a fire. This may occur through the whole mine or in various parts. Given the unpredictability, how can one be expected to know where to store SCSRs so they are accessible?"

k. "If a regulation is going to be written concerning areas for storage of rescue equipment, the areas should be specified pursuant to travel times by an average individual from their work place rather than specific locations in a mine such as shaft stations. In determining the time from the work place, any travel by mechanized means such as underground motors or a hoist should be excluded so that all times are determined by a person walking through a smokey atmosphere."

B.4 Inspection, Testing, and Training

Inspection and Testing

MSHA and operators of the larger mines inspect, test and maintain records of FSRs for many small mines. This practice, we are led to understand, is at no cost to the small mine operators and does not inconvenience the "inspector." Some "inspectors" expressed doubts whether this practice could continue for SCSRs mainly because of the greater space and testing time required.

Records in two mining districts indicated an annual loss through damage of 30 and 10 percent of FSRs for small and large mines, respectively. The relatively high rate of FSR loss for small mines was attributed to miners taking their mine belts with FSR and cap lamp battery from work to home, generally in the back of a pick-up truck. We believe this to be the probable cause because observations in small and large mines indicated conditions did not differ importantly as far as FSR wear-and-tear was concerned. SCSRs are not likely to survive storage in the back of a pick-up truck. Thus, SCSRs may fail to serve the needs of persons in small mines more quickly than persons in large mines.

The chance of needing an SCSR for escape from fire may be greater in small than in large mines, based on our observations in the Colorado plateau uranium and silver-copper regions. All mid- to large-size mines had two or more separate routes for egress and positive, well designed ventilation. Most small mines had one practical route for egress. Some had only one drift; others had several drifts of which only one was passable unless persons were to escape through areas with rotted timbers, loose ground, radon-daughter concentrations (5.3 WL in one mine visited), and recirculating air. At one small mine, the main fan was in the drift, 6 ft from the portal; at another, the fan was at the mouth of the drift. Scrap wood, drums of diesel fuel, gasoline-powered hoists, LHDs, and pick-up trucks were within 10 to 40 ft of the portals. At those two mines, fire near the portals would quickly fill the drift and active workings with toxic fumes; this is unlikely to impossible at the nearby larger operations. Fire in an LHD on the drift could prevent miners' escape through a one drift mine.

In the event of emergency in most mid- to large- size mines, both people and telephone and/or radio communications are available for rapid warning and evacuation of miners. At most of the small mines a miner's first awareness of the need to escape would probably be abnormal smoke, heat or flame; seldom are other miners or means for communication available.

Training

Representatives of metal miners expressed concerns about SCSR training. Their concerns were based on the claim that miners in some locals had never donned an FSR. They suggested regulations for SCSR training be specific, "not ambiguous generalities, like you have for coal miners."

Representatives of mine operators also expressed the need for specific training regulations. One pointed out his concern for our suggestion that training, inspection, maintenance and testing has been extensively researched during the development of SCSR guidelines for coal. He stated, "We would suggest that you do not rely too much on the data collected for coal mines and address the conditions which exist in metal/nonmetal mines. If the tests assume like conditions between metal/nonmetal and coal the data may reflect a bias."

B.5 Economic Impact

The economic impact of SCSRs was among the many points raised by representatives from government and labor as well as mine operators. Although this subject had no bearing in formulating these guidelines, their comments are given below for equity and interest.

The consensus of persons responsible for enforcing Mine Health and Safety regulations was that storage could be the dominant means for making SCSRs available. This would necessitate operators submitting plans specific to each mine. In turn, enforcement personnel would have to make detailed investigations of each plan. Based on present experiences with requests for variances on fire door regulations, one district estimates at least 5000 manhours of effort would be required for this. Some inspectors expressed concern that with the possible reductions in future staffing, SCSR-plan approval activities could take away from other health and safety efforts.

Some representatives of miners pointed out the initial cost of an SCSR was less than 3 days' pay for many miners. "Cost, therefore, should not be a considered factor." One person wrote us, in his discussion of compartmentalized ventilation systems for multi-level miners, "While I am not aware of the cost of boreholes, I am aware of the financial impact, for the loss of human lives in mines... It seems to me that regardless of how many millions of dollars the government spends on enforcement of safety guidelines and mandatory safety standards, the danger of a repeat of the Sunshine Mine fire will always exist until the ventilation systems in large underground mines properly reflect concern, both in design and in construction, for fires. As you know, it is the ventilation system which determines whether an underground fire is merely a nuisance or a disaster. It seems, therefore, more intelligent to require improved ventilation and obtain that by using the monies that would be spent on requiring oxygen self-rescuers instead of positive good air."

Representatives of uranium mine operators expressed great concern with potential costs for SCSRs. The concern they explained was the present and long-term forecasted depressed state of the industry. One presented data he believed would be typical of Colorado Plateau uranium mines: "In 1981, the mine had an operating loss of $0.92/lb of recovered uranium oxide (U_3O_8). Projections for fiscal 1982 indicate a loss of $0.64/lb recovered. We will, however, continue to operate this mine for an undetermined period to discover if certain economies will turn the loss into a profit. With the additional expense of the SCSR program if it were to be instituted during fiscal 1982, the operating loss would be an additional $0.15 or $0.79/lb - an amount we would find unsurmountable, forcing closure of the operation."

Another operator, with responsibility for 24 uranium mines and 96 miners, wrote, "To require that each miner be equipped with an SCSR means that a total of $56,700 would have to be expended. The economics of metal mining decry the application of a device which is about ten times as expensive as the current device and does not promise to significantly serve the need better."

An operator of a silver mine estimated the costs to provide miners with SCSRs would represent up to 20 percent of his yearly profit. The manager of mine safety for a major corporation anticipates an annual cost of from $600,000 to $750,000 to provide SCSRs for its 1000 underground employees; this was predicated on their belief that for conditions in his company's mines, SCSRs could not be stored resulting in at best a 1-year life expectancy.

B.6 SCSR Discussions

Persons and their affiliations with whom SCSRs were discussed are listed on the following pages. Not included, but of great importance to the knowledge gained in this study, are the more than 100 miners who took the time to discuss SCSRs, FSRs, and escape.

1. AMAX Chemical Corporation
   R.D. Brown, Vice President, Carlsbad Operations

2. American Gilsonite
   Paul Fessenden, Mine Superintendent
   Robert J. Ranes, Safety Engineer

3. The Anaconda Copper Company
   Hugh Graham, Safety Department

4. ASARCO
   David N. Lewis, Cover Unit Superintendent
   Terry W. Tew, Chief Engineer, Leadville Unit
   John Lomas, Safety Director, Northwestern Operations
   Kim Bradshaw, Safety Inspector, Galena Unit

5. Atlas Minerals
   Thomas L. Wilson, Manager of Mines
   Jack Erwin, District Mine Foreman
   D. Benham, Chief Engineer

6. Black Cloud Mine (ASARCO),
   Leadville, CO

7. Bovey Engineers (Spokane, ID)
   George Wallace

8. Bunker Hill Company
   Ed Holbert, Safety Engineer

9. Cashin Mine (Paradox, CO)
Thomas Crabbe, Contract Miner

10. Chevron Oil Company
Terry Tilley

11. Cities Service Company
B.W. Chastain, Safety Engineer

12. Cleveland-Cliffs
Alvin Langstaff, Mining Engineer

13. Climax Molybdenum Company
James Keith, Safety Director
Daniel Larkin, Safety Engineer
Joseph Rivera, Safety Inspector
Michael Nay, Regulations Coordinator

14. Cotter Corporation
Carl Urban, Jr., Safety Director, Schwartzwalder Mine
Darrell Pettyjohn
Jerry Powers
Steven Engelman

15. Alvin Dee Mining (Moab, UT)
Dwayne Johnston, Contractor

16. Duval Corporation
Jack Hunt, General Superintendent, Carlsbad Operation

17. Eagle Mine
Gilman, CO (see New Jersey Zinc, Item No. 35)

18. Energy Fuels, Nuclear Industries
Richard D. Husted, Mine Safety Engineer

19. Exxon Colony Operations
Roland Wilson, Safety Director, Exxon

20. Fire Fly Mines (Moab, UT)
Kent Gordon, Contractor
Vern Shumway, Director of Operations
Virgil Ellis, Director of Operations
Theodore Shannon, Director of Operations

21. Grey Dawn Mines
Ray Pene, Contractor

22. Hecla Mining Company
    Bert Fetter, Safety Department, Lucky Friday Operations
    Jon Langstaff, Senior Safety Engineer

23. Don Holmes Contractors (Vernal, UT)
    Michael Smith, Foreman-Miner

24. Homestake Mining Company
    Steven Smith, Safety Director, Bulldog Mountain Mine
    J. Fowler, Shift Boss, DO
    M. McClure, Shift Boss, DO
    John Magee, Mine Superintendent, DO
    M.M. Roeber, Chief Geologist, DO
    T.M. Robertson, Resident Manager, DO

25. Alan K. Hull, Attorney at Law, Boise, ID

26. International Minerals & Chemical Corporation
    R.W. Hougland, Vice President/General Manager,
    Carlsbad Operations

27. Kennecott Minerals Company
    W.G. Miles, Manager, Safety and Security

28. Kerr-McGee Corporation
    G.D. Milligan, Manager of Mine Safety
    Walter Case, Superintendent, Hobbs Potash Facility
    Mike Peralta, Company Safety Inspector, Grants Operations
    Calvin S. Edwards, Director of Safety, Grants Operations
    Arzell Hale, Director of Safety, Trona Operations

29. M-E Mining (Moab, UT)
    L. McNeely, Contractor

30. Mine Safety and Health Administration (MSHA)
    Thomas Shepick
    Aurel Goodwin
    Frank J. Delimba
    Michael P. Trainor, Northeastern District Manager
    Horst S. Gottschalk, Southeastern District Manager
    Monford P. Turner, Supervisor, Mining Engineer
    Wayne D. Kanack, South Central District Manager
    Harold Yount
    Henry Soto
    H.P. Richardson
    Marvin Nickels, Dallas Subdistrict Manager
    William McCullough
    William Gardner, Rocky Mountain District Manager
    Jack S. Petty, Denver Subdistrict Manager

Thomas J. Caster, Supervisor, Mine Inspector
H.G. Plimpton, Salt Lake City Subdistrict Manager
Jack Baker, Supervisor, Mine Inspector
Ronald Beason, Mine Inspector
Larry E. Nelson, Supervisor, Mine Inspector
Larry O. Weberg, Supervisor, Mine Inspector
Gary Fowler, Mine Inspector
Ralph Foster, Mining Engineer (ventilation)

31. Mississippi Chemical Corporation
J.H. Walls, General Manager, Carlsbad Operations

32. Mobil Oil Corporation
Michael Carlozzi

33. Multi Mineral Corporation
Daniel Koss

34. National Potash Corporation
R.B. Foster, General Manager, Carlsbad Operations

35. The New Jersey Zinc Company
Patrick J. Dougherty, Mine Engineer, Gilman Operations
Durbin McIlnay, Mine Superintendent, Gilman Operations
Kenneth Cox, Manager Friedensville Operations
Donald Habersberger, Chief Engineer, Friedensville Operations

36. Occidental Oil Shale, Inc.
Levi Brake, Manager, Safety/Health/Security
James Townsend, Ventilation Engineer
John Robson, Mining Engineer

37. Phillips Petroleum
Joseph Ingvalson

38. Potash Company of America
David Rice, Vice President, U.S. Operations
Donald Roberts, Mine Superintendent, Carlsbad Operations
Roy H. Blackman, Attorney at Law

39. Rio Algom Corporation
A. Christianson, Shift Boss
T.R. Sullivan, Mine Engineer
L.M. Key, Shift Boss
Joseph Vancil, Mine Superintendent

40. Rio Blanco Oil Shale Company
Paul Marshall, Superintendent

41. Sunshine Mining Corporation
Robert E. Launhardt, Safety Director
L. Wadsworth, Safety Engineer

42. Tosco Corporation
Michael D. McGuire, Senior Safety Supervisor

43. Union Carbide Corporation
Carl R. Thomas, Safety Engineer, Urevan Area
Gordon Sampson, Safety Engineer, LaSal Area
E.A. Piersall, Safety Director, Metals Division

APPENDIX C

Memorandum on Self-Contained Self-Rescuers,
from MSHA Coal Mine Administrator
to District Managers

U. S. Department of Labor

Mine Safety and Health Administration
4015 Wilson Boulevard
Arlington, Virginia 22203

RESB

DEC 31 1981

CMS&H Memo No. 82-3-A(5003)

MEMORANDUM FOR: DISTRICT MANAGERS
Coal Mine Safety and Health

FROM: JOSEPH A. LAMONICA
Administrator
for Coal Mine Safety and Health

SUBJECT: Guidelines for Permitting Storage of Self-Contained Self-Rescuers (75.1714-2(e))

Since issuance of the subject memorandum on June 8, 1981, comments have been received by this office from interested parties. After due deliberation of these comments, the subject memorandum is hereby reissued with the paragraphs changed from the June 8, 1981, memorandum identified with an asterisk (*). Minor clarifying changes have also been made.

The District Manager is required in Section 75.1714-2(e)(1) to consider eleven factors in deciding whether to permit an operator to place a self-contained self-rescuer (SCSR) more than 25 feet from a miner. In order to assist you when considering these factors, the following guidelines are provided and should be used to determine (1) whether to permit or prohibit storage, (2) storage distances, and (3) storage methods and procedures.

(i) Distance from affected sections to surface.

* If the deepest penetration of a working section is not farther from the surface than the travel distance listed in (iii) below, the District Manager may approve a plan for the operator to provide miners only with filter-type self-rescuers. However, when the deepest penetration of a working section is greater than the travel distance listed in (iii) below, operators shall be required to provide self-contained self-rescuers.

(ii) Pitch of seam in affected sections.

* In pitching seams, such as encountered in anthracite mines, self-contained self-rescuers should be stored on level travelways.

2

(iii) Height of coal seam in affected sections.

The height of the travelway affects the speed of travel and consequently the distance that miners may be away from stored self-contained self-rescuers.

Miners generally should not be farther from self-contained self-rescuers than a distance that they can travel at a normal pace in 5 minutes. However, the time and distance can be increased or decreased after considering all factors. Miners should never be farther from self-contained self-rescuers than a distance they can travel at a normal pace in 10 minutes.

To assist you in establishing the maximum storage distance, the following table is suggested; interpolation of the table for travel distances should be made for coal seam heights not specifically listed.

Height of Coal Seam (Inches)	5-Minute Travel Distance (Feet)
60 or more	1,000
36 - 46	700
30 or less	400

(iv) Location of escapeways.

* Where designated escapeways are not readily available, such as during travel in remote locations of bleeders and return airways, storage of SCSRs should be limited to not more than 5 minutes travel time.

(v) Proposed location of self-contained self-rescuers.

The preferred locations for storage of self-contained self-rescuers are in the intake escapeway and accessible from more than one entry.

The environment in the storage location should be in accordance with manufacturers' recommendations.

* Storage plans should include provisions for segregating visitors' SCSRs from those provided for employees at the mine.

Each miner must be trained to know the specific location of the SCSR that is available for him/her.

(vi) Type of work performed by affected miners.

* Different plans may be approved for various categories of miners, dependent primarily upon the amount of travel required to perform their work. Storage plans for section workers should rarely allow for travel times greater than 5 minutes. Storage plans for rovers may allow for travel time of up to 10 minutes.

(vii) Degree of risk to which affected miners are exposed.

* The amount of methane liberation and the size and type of power systems, i.e. battery, electrical (a.c. or d.c.) or diesel, are some of the factors that should be considered when evaluating the degree of risk. Another factor should be the history of violations that could lead to the cause and effect of fires, explosions and inundations.

(viii) Potential for breaking into oxygen deficient atmospheres.

When mining near abandoned areas as described in Section 75.1701, or into areas having a high potential for outbursts, storage of self-contained self-rescuers shall not be permitted.

(ix) Type of risks to which affected miners are exposed.

The types of risks that should be considered when evaluating storage plans are the risks associated with explosions, fires, and inundations.

(x) Accident history of mine.

The types of accidents which should be considered are those relating to explosions, fires, inundation of gases, and outbursts.

(xi) Other matters bearing upon the safety of miners.

* Storage plans should include a requirement for examination of SCSRs during the period of the preshift examination or at the beginning of the shift.

Plans should include a provison that would permit any miner to wear or carry a SCSR.

The tests required under the provisions of Section 75.1714-3(d) shall be made in accordance with the manufacturer's approved instructions.

The minimum number of SCSRs underground at each mine must be equal to or greater than the number of miners underground.

Also, you have received a copy of "Guidelines for Oxygen Self-Rescuers" Volumes I and II. This report has been distributed by the Bureau of Mines and will be used by many operators as a basis for developing storage plans. Many recommendations made in the report were included above and others will be helpful to the operator in preparing a storage plan, and to you in approving plans. However, the guidance provided in this memorandum for the eleven factors should be the primary source of guidance when giving permission for storage of self-contained self-rescuers.

U. S. Department of Labor

Mine Safety and Health Administration
4015 Wilson Boulevard
Arlington, Virginia 22203

DEC 31 1981

CMS&H Memo No. 82-2-A (5003)

MEMORANDUM FOR: DISTRICT MANAGERS
Coal Mine Safety and Health

FROM: JOSEPH A. LAMONICA
Administrator
for Coal Mine Safety and Health

SUBJECT: Interpretation of Section 75.1714, 30 CFR 75, and Section 75.1106, 30 CFR 75

Since issuance of the subject memorandum on June 8, 1981, comments have been received by this office from interested parties. After due deliberation of these comments, the subject memorandum is hereby reissued with the paragraph changed from the June 8, 1981, memorandum identified with an asterisk (*).

Self-contained self-rescuers must soon be made available to miners under the subject regulation. Experience with filter self-rescuers under the same regulation and studies at a number of mines indicate a need for the following interpretations of some provisions of this and other regulations to minimize compliance and enforcement problems:

Section 75.1714(a) - The term "visitor" includes insurance inspectors, equipment manufacturers' representatives, and others to whom the mine operator may deny entry, but does not include persons having the right to enter the mine.

Section 75.1714-1(b)(3) - Under this section, MSHA will consider for approval as a self-rescue device or devices, when used and maintained as prescribed by MSHA, a combination of separate 10-minute and 60-minute self-contained breathing apparatus approved under Subpart H of 30 CFR 11.

Section 75.1714-2(c) - The determination that wearing the self-contained self-rescuer is hazardous may be made by an individual miner or by the operator. The inspector should not issue a citation unless the person is more than 25 feet from their self-contained self-rescuer.

* Section 75.1714-2(e)(3) - This section prohibits the operator from obtaining permission from the District Manager to place the self-contained self-rescuers more than 25 feet away from the miners on mantrips into and out of the mine. For purposes of this section only, miners are not considered to be on mantrips while walking into or out of the mine, or while being transported in shafts or slopes. Therefore, permission may be granted for storage of self-contained self-rescuers for miners in these situations.

Section 75.1106-2 - Transportation, handling, and storage of any compressed oxygen cylinders associated with approved self-contained self-rescuers are not controlled by this standard because they are personal protective devices rather than mining equipment.