August 18, 2008

Patricia W. Silvey
Director, Office of Standards, Regulations & Variances
U.S. Department of Labor
Mine Safety and Health Administration
1100 Wilson Boulevard
Arlington, VA 22209-3939

Re: Comments of the National Mining Association on MSHA's Proposed Rules Refuge Alternatives for Underground Coal Mines (73 Fed. Reg. 34,140; RIN 1219-AB58)

Dear Ms. Silvey:

Set forth below and in the attachment to this letter are the comments of the National Mining Association (NMA) on the Mine Safety and Health Administrations (MSHA) Notice of Proposed Rulemaking (NPR) amending 30 C.F.R. Parts 7 and 75, published in the Federal Register for June 16, 2008.

Introduction

At the outset let us express our appreciation for having the opportunity to comment on this important rulemaking intended to "improve … preparedness for mine emergencies and require refuge alternatives underground to protect persons trapped when a life-threatening event occurs that makes escape impossible."

73 Fed. Reg. 34,141

All who work in or around the coal industry support efforts to enhance miner safety and to enhance the likelihood of survival in the event that miners cannot escape in an emergency situation. Escape remains the basic tenet and while we strive to provide the tools and training required to make it successful, we likewise recognize that one of the basic underpinnings of the Mine Improvements and New Emergency Response (MINER) Act of 2006, which NMA supported, was to enhance the likelihood that miners would survive while awaiting rescue.

During the course of the public hearings comments have been offered regarding the expedited timeframes imposed by the MINER Act for MSHA to complete the rulemaking mandated by the act and whether, in this instance, adequate time was

provided to ensure that pre-fabricated refuge facilities would perform as expected during emergency conditions. We share these concerns. Never before has the industry been required to implement potentially life-saving technology of this magnitude without it first having been subjected to rigorous testing, including testing underground to ensure that it will be available for miners in the event of an emergency. While we respect the hard work that has been performed by the industry, working with researchers at the National Institute for Occupational Safety and Health (NIOSH), state regulatory authorities and chamber manufacturers within these severely compressed timeframes, one simple fact remains – no chamber has ever been deployed underground to test its functional capacity and life saving capability. Miners deserve better. They deserve to know that the safety tools they might have to rely upon to sustain them while awaiting rescue have undergone the full range of testing necessary to validate that they will perform as expected. Unfortunately such is not the case here.

However unpalatable and politically difficult this might be, we urge the agency to defer final action on this NPR until these units have been thoroughly tested, including human-subject testing, in the underground environment.

While this recommendation will be untenable to some, we encourage the agency to recall the decision-making process employed following enactment of the Federal Coal Mine Safety and Health Act of 1969.[1] Faced with a deadline to require underground coal mine operators to purchase and deploy self-contained self-rescuers (SCSR), the agency delayed implementation to resolve outstanding technical questions regarding the safety and functional utility of the devices. While the agency was confident that SCSR's were "reliable and safe to use and store in underground mines"[2] it also believed additional field testing was required to determine how miners would be affected by the use of these devices in actual underground emergency applications.[3] The delay, which afforded time for in-mine testing, culminated in the total redesign of at least one unit. We believe that outstanding questions regarding the operational readiness and functional capacity of pre-fabricated rescue chambers obligates the agency to follow a similar course of action and to forego issuance of a final rule unit these critical, life-saving issues are examined and resolved.

The knowledge that will be gained by pursuing this approach will provide essential information to guide the agency as the final rule is developed. Our concern, shared by many, is that failure to follow this approach creates the possibility that miners

[1] The 1969 act required coal mine operators to give all underground coal miners self-rescue devices that would protect them from poisonous gases for at least one hour. The initial regulatory requirements implementing this were superseded by new final regulations on Nov. 21, 1978 whose effective date was delayed 6-months beyond the regulatory implementation deadline.

[2] 42 Fed. Reg. 54,243 (Nov. 16, 1977)

[3] The agency's decision to delay implementation was upheld by the Court. See *Council of Southern Mountains v. Secretary of Labor,* (653 F. 2d 573 (D.C. Cir. 1981)

will go without this valuable protection for an indeterminate period of time and, more importantly, that these facilities might fail to provide the life support capabilities required during an emergency. We cannot tolerate even the remotest likelihood of such an outcome and the failure to conduct underground testing before finalizing this rulemaking creates the possibility that this might occur. Importantly, it should be noted that adoption of our deferral/testing recommendation does not mean that miners will go without protection. Program Information Bulletin P07-03 (PIB)[4] which the agency issued on Feb. 8, 2007 remains in effect today and ensures that miners are provided with a 96-hour supply of breathable air.

Should the agency not choose to follow the approach recommended above, we urge the agency to recognize as was reflected in the report to accompany the MINER Act that:

> … good safety practice is often an evolving concept based upon experience and technological development.[and that] … each underground coal environment is unique and that what works effectively in one setting may not be optimal in the next.

U.S. Senate Report No. 109-365, pg. 3

The final rule, if it is to achieve the objectives outlined in the MINER Act must recognize and reflect these principles, namely, that safety is enhanced through experience and technologic development and that each mine is unique. The NPR recognizes this by providing several means by which a mine operator can provide a facility for miners can seek refuge in the event of an emergency. Given the great diversity of operations in the underground coal sector, the varying geologic conditions that exist and the particular needs of each workforce, we encourage the agency to maintain the full suite options proposed.

Specific Comments

Service Life

Unfortunately, the NPR contains, in certain instances, prescriptive requirements that will undermine the individualized approach envisioned by the Congress. For example, the preamble language contained in § 7.501 Purpose and Scope discusses, without explanation, fixed service-life limits for pre-fabricated self-contained units and components. Neither the preamble nor the supplemental materials in the rulemaking docket contain justification for this one-size-fits-all approach. Similarly, the industry's limited in-mine experience with these units provides little, if any, information to support this determination. We believe the

[4] Program Information Bulletin No. P07-03, Implementation of Section 2 of the MINER Act of 2006: Options for Providing Post-Accident Breathable Air to Underground Coal Miners. (Feb. 8, 2007). The PIB required operators to provide "Each miner [with] a 96-hour supply of breathable air located within 2000 feet of the working section."

preamble, consistent with Congressional intent, should be revised to reflect MSHA acceptance, upon submission of necessary documentation, of the manufacturer's recommended service-life limits, rather than apply an arbitrary deadline to all units. In the event that a manufacturer chose to not seek a different service-life, the 10 year structure and 5-year component timeframes in the NPA could be retained as the default service-life limits.

Grandfathering of Purchased and/or Delivered Pre-Fabricated Refuge Units

As was discussed by numerous witnesses during the public hearing, operators have placed purchase order and begun taking delivery of refuge chambers believing they would be accepted for purposes of compliance with the agency's final rule, once promulgated. This certainty, while implied in the preamble to the NPR (pg. 34,142), has been called into question causing grave uncertainties about the compliance status of these units and, more problematically, raising the prospect of operators deciding to defer delivery of additional units until promulgation of the final rule. We were encouraged by the comments offered by Patricia Silvey, Director, Office of Standards, Variances and Regulation, MSHA who stated in response to a question posed during the first public hearing conducted on the NPR that:

> …a refuge alternative that was approved by the state or in an operator's approved ERP … would be accepted for the maximum – for the estimated service life or a maximum of 10 years.

Hearing transcript, July 29, 2008 at 23

It is imperative that the agency unconditionally accept state approved units as meeting all requirements of the final rule. Moreover, to avoid the possibility that deliveries will be deferred or delayed due to remaining uncertainty, we call upon the agency to provide clarity and finality to this question as soon as practical, even in advance of publication of the final rule.

Just as has occurred with other safety technology introduced into underground mines, improvements to the current generation of units can and will be made as the industry and manufacturers gain experience with the operation and durability of these units underground. It is crucial that miners have confidence that these units, which historically have been viewed with extreme skepticism, will provide the life sustaining capabilities that have been advertised. As such, we believe that MSHA should require modifications to existing units only if it is determined that the units design and functional capabilities will not, if properly maintain and operated, sustain life for the required period of time.

Pre-Fabricated Refuge Facilities – Structural Design

Central to our concerns are the requirements in § 75.1506(a)(1) which would require pre-fabricated rescue facilities to provide at least 15 square feet of floor space and at least 60 cubic feet of volume per anticipated occupant. The agency has received, both during the hearings and in written testimony, extensive comments questioning the foundation for this requirement and its historic basis. We agree with others that these requirements cannot, and should not, be considered life sustaining. Rather, the limited information considered by NIOSH and reflected as a recommendation in their report[5], upon which the agency's NPR is based, were designed to provide comfort for persons who might be confined for prolonged (2 week) duration. Even if one were to accept the need to consider these criteria, the NPR design standards are in conflict with and far exceed the refuge facility specific standard developed and implemented in Directive D5 to implement the South African Mine Health and Safety Act of 1996 -- $0.6m^2$ minimum per person floor area.[6]

Attached to these comments is a report prepared for NMA by Dr. Joel Haight, an associate professor of energy and mineral engineering at Penn State University. As reflected on his curriculum vitae, Dr. Haight specializes in human factors engineering and has conducted research in work physiology and occupational biomechanics, all of which are applicable to this issue. Dr. Haight's analysis, which was limited to an evaluation of the proposed floor space and volume requirements in proposed § 75.1506(a)(1), recommends as values reasonable to sustain life:

- $7.5\ ft^2$/person unrestricted floor space for seated refuge and $9.4ft^2$/person for supine refuge; and as reasonable to sustain life
- $30ft^3$/person unrestricted volume

The significance of this issue cannot be understated. As noted earlier, deliveries of pre-fabricated refuge facilities have begun and are occurring on an almost daily basis. The existing units have been designed and engineered to provide occupants with, at minimum, 96-hours of life sustaining support and to maintain an apparent temperature below 95 degrees Fahrenheit. Additionally, the units are designed to conform to mine specific considerations, including space limitations. We have been advised that the criteria of the NPR if unchanged, has the potential to reduce (de-rate) projected occupancy by as much 60 percent. It is important to recognize that mine operators, in order to comply with the requirements of PIB No. P07-03 which many viewed as premature given the on-going NIOSH study and the pendency of MSHA rulemaking, committed tens of millions of dollars to purchase these potentially life saving devices. To now impose requirements that effectively render these units non-compliant is unwarranted unless the agency can document that the

[5] Research Report on Refuge Alternatives for Underground Coal Mines, Office of Mine Safety and Health, National Institute for Occupational Safety and Health, Dec. 2007.

[6] Review of Best Practices Regarding the Use of Refuge Chambers in South Africa, Bluhm Burton Engineering (PTY) Ltd. BBE Report No. 5207 (Sept. 2007).

units will not, if properly maintain and operated, sustain life for the required period of time.

Shelter Location and Positioning

Section 75.1506 and 1507 contain, among other things, requirements related to the location and positioning of shelters in proximity to the working section or where mechanized mining equipment is being installed or removed. Additionally, the preamble explanation of this section identifies considerations, not specified in the regulatory text, to be considered in making these determinations.

While the requirements in this section are in large part tailored after the recommendations contained in the NIOSH report[7] portions have been ignored that should be considered prior to promulgation of the final rule. For example, the NIOSH report discusses whether "the presence of escape shafts or other means of exiting the mine could effectively eliminate the need" for outby refuge alternatives.

NIOSH's recognition that outby refuge alternatives could, in certain instances, be unnecessary is premised upon a detailed study performed for the institute by Foster-Miller.[8] Among other things Foster-Miller conducted a detailed analysis of 12 past mining disasters to determine if refuge facilities would have had a positive impact on the outcome. The report's conclusion, illustrated in Table 4, page 22, is that in no instance would outby refuge facilities have been beneficial to the outcome of the tragedy. Based upon this finding, we encourage the agency to include in the final rule authority for district managers to, on a upon site-specific case-by-case basis, approve plans not containing provisions for outby refuge facilities.

Section 75.1506 (b)(1) requires refuge facilities to be located "Between 1,000 feet and 2,000 feet from the working face…" This provision, derived from the NIOSH report is in conflict with the placement standard which operators must meet to comply with the West Virginia statutory requirement that chambers be located "within 1,000 feet". We join with the West Virginia Coal Association and urge that the final rule be revised to require the place of refuge facilities "within 2,000 feet of the working face and from locations where mechanized mining equipment is being installed or removed."

Section 75.1506(e)(1) would prohibit persons, other than those referred to in section 104(c) of the Mine Act from working in an area where a refuge alternative has been removed from service. We recommend that this section be amended to permit persons to continue to work, if the operator provides, in such instance barricade materials on the section and the additional SCSR's along with instructions

[7] Id at 5.

[8] Foster-Miller Phase II Report under contract to the National Institute for Occupational Safety and Health, Refuge Alternatives in Underground Coal Mines, Report No: NSM-080020-1839 (Dec. 2007).

to the crew that an alternative plan is in place and the specifics of the plan. MSHA has recognized other situations in the mining process where this occurs and rather than require withdrawal from the area, the operator is permitted to continue working while precautions are approved by the agency. For example, when the tailgate or headgate of a longwall is blocked and only one escapeway exists the agency permits mining to continue once the operator has submitted a plan to the district manager for review and approval. Similarly, operators are permitted to continue operating where the CO monitoring on a beltline fails. In such instances the mine continues to operate provided the operator physically examine the beltline for hazards until corrected. We believe protective measures can be implemented to permit the section to continue operating while ensuring miners are protected in the event of an emergency and urge the agency to recognize this, as it has done in other circumstances.

More problematic than the distance requirement, is the requirement in § 75. 1507(a)(11)(i) and (ii) which impose significant limitations on where a refuge facility can be placed in proximity to the working face and other designed locations or designated pieces of equipment. While we are cognizant of the need, as identified in the preamble to accompany this section, to protect refuge facilities from "potential damage from a working face explosion and … the potential of a fire a certain areas or equipment" (Fed. Reg. 34,161) we believe these provisions are misdirected and create the potential for introducing unnecessary risks. Review of the Foster-Miller report and our collective experience leads us to conclude that the risk of damaging a pre-fabricated refuge facility during movement and placement, and more importantly, the safety risk to miners as they maneuver these to comply with the placement requirements far outweigh the potential that these will be damaged by an event at the locations designated in the proposed rule. Should the agency not agree to delete these provisions, we would encourage that the final rule include authority for the district manager to approve an alternate location in the Emergency Response Plan.

Conclusion

In their written submittal, the West Virginia Coal Association remarked:

> …I'll observe there has been unprecedented criticism levied towards MSHA over the past two years than ever before in the history of the agency. That is a fact – plainly and simply. Some of it deserved, perhaps, some not.

This comment succinctly captures the industries frustration with the myopic approach the agency has employed in implementing the MINER Act. Rather than pursue a holistic approach the agency via its numerous regulations, policy statements, guidance documents, etc. has created a patchwork regulatory scheme lacking consistency or proper reasoning. To understand this one need look no

further than the self-contained self-rescuer (SCSR) provisions contained in the final Emergency Mine Evacuation Rule. [9]

In § 75.1714-4 the rule specifies locations where SCSR's are to be stored. Subsection (d) (1) provides authority to place SCSR's in hardened rooms "designed and constructed to the same explosion force criteria as seals", i.e. locations with seals capable of withstanding an explosive force of at least 50 psi. Contrast this to the requirement of the proposed rule that a refuge facility constructed in place must be capable of withstanding a 15 psi overpressure wave. Simply out, these conflicting requirements prohibit operators from storing SCSR's in in-place refuge facilities. We have yet to understand the logic behind these inconsistent approaches.

In closing let us reiterate our recommendation that the agency defer issuance of a final rule until additional testing, including in-mine human subject testing is completed. Miners and operators alike must have confidence that the technology we are introducing into the mines, especially technologies that may be called upon to provide vital life-sustaining services in the event of an emergency, have undergone and passed rigorous, comprehensive testing. Such is not the case today.

Sincerely,

Bruce Watzman
Vice President
Safety, Health & Human Resources

[9] Emergency Mine Evacuation, Final Rule, (71 Fed. Reg. 71,429)(Dec. 8, 2006)

Opinion Report – Unrestricted Floor Space and Volume in Underground Mine Refuge Chambers

For

National Mining Association
Washington, DC

August, 2008

By

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Abstract

Regulations have been proposed by the Mine Safety and Health Administration (73 Fed. Eg. 34140) that will require mining companies to provide temporary safe haven, i.e., a refuge chamber, for miners trapped in an underground mine while they await rescue. This regulation proposes values for unrestricted floor space and volume for each miner in such a refuge chamber of 15 ft^2/person of floor space and 60 ft^3/person volume. The agency has acknowledged other proposals, namely the National Institute for Occupational Safety and Health (NIOSH) recommended 15 ft^2 floor area and 85 ft^3 volume and have asked for comments (NIOSH, 2007). It has been suggested that occupancy in this chamber should be designed for at least 96 hours – a rescue time goal. Four days of occupancy and the need for food, acceptable quantity and quality of breathing air, temperature control, appropriate humidity, light, communications capability, etc, would suggest that the space and volume requirements for each individual be maximized.

There are available recommended continuous-occupancy limits and evacuation and convergence cluster limits from the National Fire Protection Association and the Society of Fire Protection Engineers (NFPA, 2008; SFPE, 2002) for use in comparison. These limits define the maximum and minimum floor space requirements needed by humans for long term and very short term occupancies and they were used to define the boundary conditions for this evaluation. 96 hours, depending upon the perspective, could be considered a mid-term occupancy, thus the floor area and volume should be something between the minimum space required for evacuation and the maximum space required for continuous occupancy. The boundary conditions for evacuation (7ft^2/person, which is where congestion and restricted movement begin) and continuous occupancy in a general industrial to high-hazard occupancy of 100 ft^2/person can set the acceptability limits (NFPA Fire Protection Handbook, 2008). For a midrange occupancy period, one may be tempted to establish a value in the middle of that range – which would be 53.5 ft^2/person. However, given the nature of the underground mining

environment where space is at a premium, especially in an emergency case, other factors must be considered. Therefore, one would expect that this midrange number would have to be much lower. While, in this type of a situation, one would suggest as much space as possible due to respiratory needs and the potential length of stay, it is understood again that space is at a premium. Therefore, for these reasons, it is suggested that for seated positions, 7.5 ft^2/person be considered. For height limited chambers where a supine position is required, it is suggested that 9.4 ft^2/person be considered (6'3" person 18" wide). It is suggested, however, that the MSHA and NIOSH limit of 15 ft^2/person unrestricted floor space be evaluated for feasibility and where space constraints allow it, to account for potential onset of claustrophobia that may result from 96 hours in confined quarters.

Breathing air is of concern in a mine collapse incident, and respiration rates are likely to be higher than resting respiration rates due to the potential for panic and metabolic increases related to reaching the chamber and any other necessary duties performed upon arrival. Under optimum conditions, the NIOSH recommended 85 ft^2/person unrestricted volume in the chamber should be considered, however, since breathing air is going to be manufactured and exhaled air filtered, 30 ft^3/person volume is sufficient for life to be sustained for 96 hours. (Åstrand and Rodahl, 1986) While military standards indicate that short term tasks can be safely performed in spaces as small as 24 ft^3/person, the expectation is that their standards are for short term occupancy (MIL-HDBK-759C, 1995). In an environment in which breathing air will be manufactured, volume may be less of an concern, so it is possible that a volume credit may be considered. However, filtration and conditioning efficiency and effectiveness may be improved if the volume is higher due to lower contaminant loading.

1.0 Introduction

The idea of protect-in-place or defend-in-place is not new. It has long been a concept considered by engineers, architects and fire protection engineers. It has also been the recommendation of fire fighters to provide areas along the evacuation route to keep the risk of exposure to fire and/or smoke low through keeping people in place in a ventilated, compartment-protected enclosure until they can be rescued. (Institute for Research in Construction, 2002) In a surface emergency, an individual may have three choices as to how to respond to that emergency. He/she can evacuate, hopefully, through a number of exits, he/she can make an effort to stop or control the emergency or he/she can go to a place of refuge and wait to be rescued. (Schroll, 2002) In an underground mine, the exit option may not be available and in a collapse case, controlling the emergency may not be an option either. In response to a number of recent mine collapse cases, the Mine Safety and Health Administration has proposed a regulation that would require the installation or placement of refuge chambers in the mine. One form of refuge chamber that can be deployed in a mine emergency is a pre-fabricated compartment structure that provides a place of safe refuge into which miners can secure themselves in the event of an emergency. These units are designed to provide safe breathing air for various, but extended periods of time. (www.strataproducts.com, accessed 4 August 2008) It is the "waiting for help" part of the taking refuge option that Schroll (2002) referred to that creates difficulty for the underground case. While waiting for help in a surface fire, fire fighters may be able to respond within an hour to rescue those in an area of safe refuge. In the underground mine collapse case; the rescue may not be so rapid and may range from a few hours to several days.

The expected occupancy duration in the proposed regulations for the design of these chambers is 96 hours. Given this potentially extended rescue time, appropriate consideration has to be given to life sustaining factors associated with refuge chamber

capabilities. Available literature on emergency response, including refuge chambers, suggests consideration for food, acceptable quantity and quality of breathing air, temperature control, appropriate humidity control, light, communications capability, ventilation of expended breathing air, propensity for claustrophobic response, etc. (NFPA, 2008; SPFE, 2002; Åstrand and Rodahl, 1986; ASSE, Brown, 2008; NIOSH, 2007, MIL-HNBK-759C, 1995). Many of these considerations would suggest that the unrestricted space and volume requirements be maximized; however, underground space is not plentiful, especially in low coal situations. In an emergency situation, it cannot be expected that human comforts would be maximized. In contrast though, by comparison to the do-nothing option (being left in a dark, air restricted, cold, wet mine for an extended period of time), a refuge chamber, represents a significant improvement, especially considering its capacity to remove the miner from an environment containing potentially toxic air, t even if the refuge area and volume were less than the proposed amounts.

From the perspective of a trapped miner, the amount of time being discussed (96 hours) that may be required in a mine rescue situation is characteristically long and therefore, an effort should be made to design as much space and volume as is feasible.

The idea of claustrophobia comes to mind in an underground setting, however, it is not extensively addressed here as it is assumed that an underground miner, by virtue of his/her chosen profession is not affected by this condition. . However, working in a mine where movement into and out of the mine is not restricted and being trapped in the mine for 96 hours are two different situations. Since there is little in the literature about claustrophobia in a refuge chamber, it is none-the-less treated here at least, briefly. Optimally, it is this phenomenon that would lead to a recommendation for consideration for a feasibility and special constraint evaluation for as much as 15 ft^2/person in floor space, conditions permitting. While a miner may not be affected while working underground in normal conditions, it is not fully known how he/she will react when

trapped. It is disconcerting to think about being confined to $15ft^2$ for four days, however when considering the environmental limitations that may be present, the recommended alternative values contained in this opinion are sufficient to maintain miners safety and to a lesser degree, comfort, while awaiting rescue.

2.0 Purpose, Scope and Objectives

2.1 Purpose

The purpose of this evaluation is to provide an opinion on the proposed space and volume requirements of a proposed mining regulation noted in the Federal Register/ Vol. 73, No. 116 (section 75.1506) from the Mine Safety and Health Administration (MSHA). . This evaluation is intended for use in the development of comments by the National Mining Association concerning this proposed regulation.

2.2 Scope

The scope of this evaluation is limited to evaluation and comment on the adequacy the proposed floor space and volume in the refuge chambers proposed in MSHA's regulation in section 75.1506 paragraph (a) (1).

2.3 Objective

The objective of this evaluation is to compare the proposed floor space and volume requirements contained in the proposed regulation for refuge chambers used in underground coal mines to other similar criteria established for human occupancy in other similar standards, consensus guidelines, general emergency response literature, etc.

3.0 Methodology

The methodology used for this evaluation was an extensive literature review. No new inventions were discussed or considered. It was an effort to explore regulations, consensus standards, general, good engineering practice among other sources. An attempt was made to draw distinctions and connections between this proposed mining application and similar applications in other industries, occupancies, or surface type applications. A comparative analysis format was used; however, direct comparison was not possible as the published emergency response literature is focused on rescue within a much shorter time frame than what the mining application is based on.

A range of floor space options was considered using continuous occupancy, short duration tasks in temporary work spaces and evacuation capacity guidelines from the National Fire Protection Association, the Society of Fire Protection Engineers and military standards. (NFPA, 2008; SFPE, 2002, MIL-HNBK-759C, 1995) A mid-range within these boundary limits was determined and then adjusted downwards to give consideration to the limited space availability in an underground setting. The MSHA proposed volume limit was compared against the work physiology literature, military standards and the NIOSH recommendation. This analyst could find no stated unrestricted volume limits, so the basis for consideration was a resting and a working (or panicked) respiration rate. Since, with the current design of refuge chambers, breathing air would be manufactured within the chamber, this comparison does not yield a direct answer. However, it does provide a foundation for an opinion. Resting respiration rate is found in the literature to be about 6.0 liters/minute/person, but working respiration rates (one that would more closely simulate a panicked or fear-generated respiration rate), can be as high as 100 liters/minute per person. (Åstrand and Rodahl, 1986; NIOSH, 2007) This would suggest that to provide adequate, clean breathing air, the more volume available the better. This was evaluated to determine if it was possible to help assure a more efficient filtering of expended breathing air.

4.0 Results, Discussion and Conclusions

MSHA has proposed 15 ft^2 floor area and 60 ft^3 volume for the refuge chambers. While there is no requirement for nor adequate coverage of this temporary safe haven application in the research literature to help facilitate making a definitive recommendation, the NFPA Life Safety Code, MIL-HDBK-759C and the work physiology literature give us a basis for opinion and recommendation. With these boundary considerations and the special limitations of an underground mine, 7.5 ft^2/person floor area for seated refuge and 9.4 ft^2/person for supine positions is reasonable for unrestricted floor space. Although, 15 ft^2/person would be more desirable, these suggested limits are acceptable when considered in combination with appropriate controls on breathing air availability and quality. Volume limit has not been researched as much as the floor space limit, so it is difficult to determine an appropriate number because volume can be sacrificed as air supply and ventilation improves. Recognizing that some of the miners are likely to be operating at an elevated respiration rates (possibly as high as 100 liters/minute/person - some of this is attributable to the trek to arrive at the chamber from as much as 1000 feet away and some may be due to a heightened state of stress or even panic), in the opinion of this analyst, 30 ft^3/ is a more reasonable volume to suggest to sustain life. Although, with greater volumes and the subsequent air handling load increase, the contaminant load per m^3 of air handled in any filtration system may result in a longer useful life of the system.

Opinion:

- **7.5 ft^2/person unrestricted floor space for seated refuge and 9.4 ft^2/person for supine refuge – reasonable to sustain life**
- **30 ft^3/person unrestricted volume – reasonable to sustain life**

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Opinion Report – Unrestricted Floor Space and Volume in Underground Mine Refuge Chambers

BIOSKETCH – JOEL M. HAIGHT

Summary of Experience

Dr. Haight has more than 27 years of experience in health and safety engineering, as well as process design in the environmental and safety field. He is currently on the faculty in Penn State University's Energy and Minerals Engineering Department, where he does research in the areas of human performance optimization, intervention effectiveness of safety related interventions and human error (aging work force and automation driven human error). Dr. Haight teaches system safety engineering, fire protection engineering, mill and plant operations and engineering management for safety.

- **The Pennsylvania State University (2000 - present):** Associate Professor of Energy and Mineral Engineering
- **Primatech Inc., Mobile, AL (1999):** Senior Principal Engineer - Consulting
- **Chevron Overseas Petroleum, Inc., Republic of Kazakhstan (1993 - 1999):** Staff Engineer, Safety and Environmental Affairs
- **Chevron USA Inc., Pascagoula, MS (1990 - 1993):** Senior Engineer, Environmental, Safety and Health
- **Chevron USA Inc., Philadelphia, PA (1987 - 1990):** Supervisor of Safety Engineering Services
- **Chevron USA Inc. Richmond, CA (1985 - 1987):** Safety Engineer
- **Chevron Research Company, Salt Lake City UT (1984 - 1985):** Safety Engineer
- **Chevron USA Inc., Bakersfield, CA (1981 - 1984):** Safety Engineer
- **Chevron USA Inc., Perth Amboy, NJ (1981 - 1981):** Safety Engineering Intern

Education, Licenses, Professional Memberships and Certifications

- Ph.D. and Masters degree in Industrial Engineering – Auburn University (1994 and 1999)
- Member – NIOSH Board of Scientific Counselors (2005-2009)
- Licensed Professional Engineer, State Of Alabama, #23372 (2000)
- Certified Industrial Hygienist, Comprehensive Practice, CIH #4905 (1990)
- Certified Safety Professional, Comprehensive Practice, CSP #8011 (1986)
- American Society of Safety Engineers, Professional Member and Past Administrator of Engineering Practice Specialty (National Office)
- American Industrial Hygiene Association, Full Member (past officer)
- Human Factors and Ergonomics Society, Voting Member

Service and Honors

- 2008 Editor-in-Chief- Safety Professional's Handbook – Published June 2008
- 2008 ASSE Meritorious Service Award – Council on Practices and Standards
- 2008 ASSE Safety Professional of the Year – Engineering Practice Specialty
- 2005 ASSE Safety Educator of the Year
- 2004 ASSE Professional Safety Paper Award – First place
- 2003 ASSE Safety Professional of the Year – Engineering Practice Specialty

Opinion Report – Unrestricted Floor Space and Volume in Underground Mine Refuge Chambers

A. Selected Refereed Publications

1. Haight, J.M., Managing Safety Engineering Work - chapter, *The Safety Professionals Handbook*, American Society of Safety Engineers, Editor: Joel M. Haight, **2008**.

2. Shim, D., Kim, J.Y., Hallbeck, M.S., Haight, J.M., Jung, M.C., Ergonomic Hand Tool and Desk and Chair Development Process, *The International Journal of Occupational Safety and Ergonomics,* Vol. 14, No. 2, **2008**, pp. 247-252

3. Jung, M.C., Haight, J.M., Hallbeck, M.S., Biomechanical and Physiological Analysis of a Luggage Pulling Task, *Journal of Industrial Health*, V. 45, N. 6, December **2007**, pp. 95-100

4. Agraz-Boenekar, R., Groves, W.A., Haight, J.M., An Examination of Observations and Incidence Rates for a Behavior Based Safety Program, *Journal of Safety, Health and Environmental Research*, V.4, N. 3, Fall **2007**

5. Wincek, J.C. and Haight, J.M., Realistic human error rates for process hazard analyses *Process Safety Progress Journal, American Institute of Chemical Engineers*, Vol. 26, No. 2, June **2007**; Published Online: 4 Jan **2007**, DOI: 10.1002/prs.10184

6. Haight, J.M., Do Automated Control Systems Reduce Human Error and Incidents? *Professional Safety - The Journal of the American Society of Safety Engineers*, Vol. 52, No. 5, May **2007**, pp 20 -27

7. Haight, J.M. and Caringi, R.G., Automation vs. Human Intervention What is the best mix for optimum system performance? A Case Study, International Journal of Risk Assessment and Management, Vol. 7, No. 5, May **2007**, pp 708-721

8. Haight, J.M. and Belwal, U., Can We and Do We Need to Design for an Aging Workforce?, *Professional Safety - The Journal of the American Society of Safety Engineers*, Vol. 51, No. 7, **2006**, pp. 20-33

9. Jung M.C., Haight J.M., Freivalds, A. Luggage-pulling task evaluation by kinematics and subjective ratings, *The Journal of Safety, Health and Environmental Research*, Vol. 3, No. 1, **2006**, pp. online journal (34 pages)

10. Haight, J.M. and Miles T.P., Experience Offsets and Accommodations for an Aging Workforce, *Annual Review of Gerontology and Geriatrics*, Springer Publishing, New York, V. 25, **2005**, pp. 147-164

11. Haight J.M. Loss Prevention in Chemical Processing. In Encyclopedia of Chemical Processing; Sunggyu Lee, Ed.; Taylor & Francis, Inc.: New York, **2005**; Vol. 3, pp. 1483-1492.

12. Iyer, P.S., Haight, J.M., del Castillo, E., Tink, B.W., Hawkins, P.W., A Research Model – Forecasting Incident Rates from Optimized Safety Program Intervention Strategies, *Journal of Safety Research,* V. 36, N. 4 **2005**, pp. 341-351

13. Kecojevic, V., Bise, C., Haight, J.M., Teaching and Learning – Professional Software in an Undergraduate Mining Engineering Curriculum – *Interactive Learning Environments*, V. 13, N. 1-2, **2005**, pp. 1-13

14. Haight, J.M. (1) and Kecojevic, V., Automation vs. Human Intervention – What is the Best Fit for the Optimal System Performance? *Process Safety Progress Journal, American Institute of Chemical Engineers*, V. 24, N. 1, **2005**, pp 45-51

15. Michael, J., Evans, D., Jansen, K., Haight, J.M. (3), Relationship Between Management Commitment to Safety and Employee Outcomes: An Exploratory Study With Wood Manufacturing Employees, *Journal of Safety Research*, V. 36, N. 2, **2005**, pp. 171-179

16. Jung, M.C., Haight, J.M. (2), Freivalds, A., Literature Review of Manual Wheeled Devices, *International Journal of Ergonomics,* V. 35, **2005**, pp 79-89, (online 8 October, **2004**)

17. Kim, J. Y., Jung, M. C. and Haight, J. M., *The Sensitivity of Autoregressive Model Coefficient in Quantification of Trunk Muscle Fatigue During a Sustained Isometric Contraction,* International Journal of Industrial Ergonomics, V. 35 (**2005**), 321-330, published on line 8 December, **2004**

18. Iyer, P., Haight, J.M., Del Castillo, E., Tink, B.W., Hawkins, P.W., *Intervention Effectiveness Research: Understanding and Optimizing Industrial Safety Programs Using Leading Indicators, Chemical Health and Safety* – American Chemical Society - Division of Chemical Health and Safety, V. 11, N. 2, pp. 9-19, **2004**

19. Haight, J.M., Occupational Health Risks in Crude Oil and Natural Gas Extraction, Encyclopedia of Energy, Elsevier Science, Academic Press, March **2004**

20. Haight, J.M., *Human Error and the Challenges of an Aging Work Force, Professional Safety* – Journal of the American Society of Safety Engineers, V. 48, N. 12, pp. 18-24, **2003**

21. Haight, J.M., Thomas, R.E., *Intervention Effectiveness Research – A Review of the Literature on "Leading Indicators",* Chemical Health and Safety – American Chemical Society - Division of Chemical Health and Safety, V. 10, N. 2, pp. 21-25, **2003**

22. Haight, J.M., R.E. Thomas, Leo A. Smith, R.L. Bulfin and B.L. Hopkins, Evaluating the Effectiveness of Loss Prevention Interventions: Developing the Mathematical Relationship Between Interventions and Incident Rates for the Design of a Loss Prevention System (Phase 1), *Professional Safety* - The Journal of the American Society of Safety Engineers, Vol. 46, No. 5, pp. 38-44, **2001**

23. Haight, J.M., R.E. Thomas, Leo A. Smith, R.L. Bulfin and B.L. Hopkins, An Analysis of the Effectiveness of Loss Prevention Interventions: Design, Optimization, and Verification of the Loss Prevention System and Analysis Model (Phase 2), *Professional Safety* - The Journal of the American Society of Safety Engineers, Vol. 46, No. 6, pp. 33-37, **2001**

B. Research
(Current)

1. Sponsor - Chevron Corporation – The goal is to further extend an Intervention Effectiveness Model for the safety and health program in the Nigerian Oil Industry, 1 October 2007 - 30 September 2009, Role - PI

2. Sponsor - System Improvements, Inc. – Goal - Incident Investigation Research – Determine Efficacy of Taproot Methodology, – 1 May 2007 – 31 March 2009, Role - PI

3. Sponsor – National Institute of Occupational Safety and Health – Goal - Review and Analysis of Existing Surface Mine Data to Determine Intervention Effectiveness Measures, Pittsburgh, PA, 15 March 2008 – 30 November 2008, Role - PI

4. Sponsor - Hydro One Network Services, Inc. – Goal - Intervention Effectiveness Research – Application of Existing Power Company Model to Construction Division – Toronto, Ontario, 15 March 2008 – 14 March 2010, Role - PI

(Completed)

5. Sponsor – Chevron Corporation – Goal - Creating a Research Focus in Safety, Health, and Operational Excellence Decision-Making, 1 October 2005 – 30 September 2007, Principal Investigator, Role - PI

6. Sponsor – National Institute of Occupational Safety and Health – Goal - Review and Analysis of Surface Mine Data to Determine Intervention Effectiveness Measurement Variables, Pittsburgh, PA, 1 July 2006 – 31 December 2006, Principal Investigator, Role - PI

7. Sponsor – National Institute of Occupational Safety and Health – Goal - Developing Intervention Effectiveness and Optimization Strategies Research for Safety and Health Programs in Mining, Pittsburgh, PA, 1 May 2005 – 30 September 2005, Principal Investigator, Role – PI

8. Sponsor – National Institute of Occupational Safety and Health – Goal - Developing Intervention Effectiveness and Optimization Strategies Research for Safety and Health Programs in Mining, Pittsburgh, PA, 1 September 2004 – 30 April 2005, Principal Investigator, Role – PI

9. Sponsor – Hydro One Network Services, Inc. – Goal - Intervention Effectiveness Research – Data Managing Website Development, Toronto, Ontario, April 2005 – June 2006, Role – PI

10. Sponsor - Hydro One Network Services Inc., Goal Intervention Effectiveness Research – Initial Model Development in Forestry Services Division, Toronto, Ontario 2002-2004, Role - PI