2008 AUG 18 P 3:09

State of West Virginia
Joe Manchin III, Governor

WV Office of Miners' Health, Safety & Training
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August 15, 2008

Mine Safety and Health Administration (MSHA)
1100 Wilson Boulevard, Room 2350
Arlington, Virginia 22209-3939

RE: **"RIN 1219-AB58"**
Comments: Refuge Alternatives for Underground Coal Mines; Proposed Rule

Attn: Office of Standards, Regulations, and Variances:

The West Virginia Office of Miner's Health, Safety, and Training respectfully submits the following comments with regard to the above referenced proposed regulation.

You will recall that as Director of this agency I provided testimony at the July 31, 2008 public hearing held in Charleston, West Virginia. You will also recall that West Virginia Mine Safety Technology Task Force, Co-Chairman, and former Acting Director of the Office of Miner's Health, Safety and Training, Jim Dean, also testified and submitted extensive written comments as did Mr. Randall Harris, who has served as consultant to the agency and the Task Force since early 2006. I will synopsize my comments while referring only to my main areas of concern and defer to the more extensive written comments (in lieu thereof attached and adopted here by reference) submitted by Mr. Dean and Mr. Harris to avoid redundancy.

Comment #1 concerning the statement:
Section 75.1506, Paragraph (a) (1) would require at least 15 square feet of usable floor space and at least 60 cubic feet of usable volume per person.

While pre-fabricated self-contained units approved for use in West Virginia will effectively be "grandfathered" for ten (10) years, such a requirement will de-rate those "shelters". It should be remembered that emergency shelters are the last resort in the event of an emergency. This requirement would necessitate self-contained units that would be too large to effectively manage in lower seam heights. We urge that this requirement be stricken as unnecessary. Additionally, this requirement while perhaps applicable to 1950s and 60s "Fall-out shelters", should not be applicable to underground shelters, which may have to be relocated as frequently as every thirty-six (36) hours.

Comment #2 concerning the statement:
Section 75.1506, Paragraph (b) (1) would require that refuge alternatives be located between 1,000 feet and 2,000 feet from the working face.

Existing regulations in West Virginia developed by the state's Mine Safety Technology Task Force require pre-fabricated self-contained shelters to be located no farther than 1,000 feet from the working face. MSHA has ignored existing requirements and findings from West Virginia and Illinois. Should shelters located within 1,000 feet of the working face sustain damage from an explosion that would render them ineffective it is a veritable certainty that miners located on that section would also not survive. We urge that this requirement be changed to require shelters no farther than 1,000 feet from the working face.

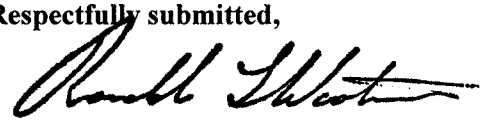
Comment #3 concerning the statement:
Section 75.1507 Paragraph (a) (11) (i) would require pre-fabricated self-contained shelters to be located only in cross cuts.

Such a requirement would almost certainly result in more damage to such shelters due to the difficulty of moving them into and out of cross cuts during moves. Due to roof control issues in some coal seams in West Virginia, mining entries and crosscuts wider that sixteen foot (16') may present significant roof control problems. These narrow entries and crosscuts will likely result in damage to shelters, which are relocated from one crosscut to another either inby and outby. Again, should shelters located within 1,000 feet from the working face in open entries sustain damage from and explosion that would render them ineffective it is a veritable certainty that miners located on that section will also not survive. We urge that this requirement be changed to allow pre-fabricated self-contained shelters to be placed in open entries as opposed to cross cuts.

Comment #4 concerning the statement:
Section 75.1507 Paragraph (c) (1-5) requires a method to assure that a refuge alternative is constructed and functional within 10 minutes after a person arrives at the pre-positioned materials. Purging of the refuge alternative once constructed would also be necessary.

We have serious doubts that such a structure could be completed within 10 minutes to begin with under such circumstances. We also consider it unlikely that miners would choose such an option. Assuming such a structure can be constructed we suspect that it may well be impossible to purge it of contaminated air which will most assuredly remain within. We consider this requirement to be wholly unrealistic and urge that it be stricken.

Respectfully submitted,



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Jim Dean
Former Director, WV Office of Miners Health Safety and Training 2/06 – 9/06
Co-Chair WV Mine Safety Technology Task Force
Dated 7/31/08
RIN 1219–AB58 Comments

Thank you Ms. Silvey and members of the panel, my name is Jim Dean. The purpose of my providing comments is that I believe that MSHA has missed the point in proposing rules on refuge alternatives especially in regard to emergency shelters and is either unaware or has chosen to ignore the process at which rules were developed in West Virginia. I would like to state that my comments here today represent my own views and opinions having served as the Acting Director of the West Virginia Office of Miners Health Safety and Training and original chairman of the West Virginia Mine Safety Technology Task Force with the WV Office of Miners Health Safety and Training, which I currently co-chair with Director Ron Wooten. If the panel has any questions they may be forwarded to me in writing. Other Task Force members include three individuals representing labor nominated by the United Mine Workers of America and three individuals representing industry nominated by the West Virginia Coal Association, with all members being appointed by Governor Joe Manchin and confirmed by the West Virginia Senate. Some of those members are here with me today, they are representing labor: Ted Hapney, Gary Trout, and Steve Webber and representing industry; Dale Birchfield, Terry Hudson, and Todd Moore.

As a matter of background, I served as the Interim Director of the West Virginia Office of Miners Health Safety and Training from February 14, 2006 until September 21, 2006. As the Director, I also served as the Chairman of the WV Mine Safety Technology Task Force and the Board of Coal Mine Health and Safety. As you know, The West Virginia Legislature approved WV Senate Bill 247 January 23, 2006 following the tragic accidents with 14 fatalities occurring at Sago, and Aracoma, with Governor Joe Manchin approving this legislation the following day. Senate Bill 247 required the Director of the Office of Miners Health Safety and Training to promulgate rules to define and implement the provisions of Senate Bill 247.

This action began a series of public policy reforms of mine safety in an effort to create effective solutions to issues surrounding better response following a disaster. It also placed West Virginia in a leadership position for change in mine safety reform in the absence of national standards on many areas of technology that were not widely understood by all individuals working in the mining industry.

The original Emergency Legislative Rule filed by the West Virginia Office of Miners Health Safety and Training was on February 1, 2006 which addressed storage caches of Self Contained Self Rescuers (SCSRs), Strobe lights and lifelines, wireless communication devices, and wireless tracking devices which almost all required purchase orders or plans within 30 days of notification of approval by the Director. Of key importance and relevance was the requirement in this version of emergency rules for 16 SCSRs per person in a section cache of scsrs in addition to additional scsrs contained

outby for breathable air, which I have included as Attachment 1 (http://www.wvminesafety.org/PDFs/56-04er.pdf). For a section with 10 workers, this would have required a total of 160 SCSRs to be present in a section cache.

For the Ocenco EBA 6.5 at 8.0 lbs (donned weight) per unit would represent 1,280 pounds total or 128 pounds of scsrs per person. For the CSE SR100 at 5.7 lbs (carried weight) per unit would be somewhat better at 912 pounds total or 91.2 pounds per person. This existing requirement and the need for a better alternative for providing a breathable atmosphere for trapped miners became the impetus for requiring shelters in West Virginia.

During this time, many concerned individuals from labor, industry and technology vendors were working and providing input to better refine these emergency rules. Several of these individuals, and others, began working with me as the Acting Director and eventually were named as WV Mine Safety Technology Task Force members. There was also a great deal of discussion regarding mine shelters after the successful rescue of 72 potash miners on January 30, 2006 at the Esterhazy potash mine in Saskatchewan, Canada. During these discussions, a representative of industry, Chris Hamilton from the West Virginia Coal Association suggested that emergency shelters be considered as an alternate means of providing the sustaining air that would be provided by the sixteen SCSRs per person in the section cache. Individuals from both labor and industry agreed that based on manufacturers initial input that this seemed to be a means that could successfully provide the atmosphere that could sustain life for a trapped miner and that further definition and creation of standards needed to be developed.

The revised version of these emergency rules §56-4-4 dated February 27, 2006 (http://www.wvminesafety.org/PDFs/56-04era.pdf) provided for the use of emergency shelters/chambers in lieu of 16 scsrs per person on the section, which is Attachment 2. This version of emergency rules also required the Director to establish the Mine Safety Technology Task Force within 7 days of the effective date of these rules with three representatives from labor, three representatives from industry and chaired by the Director. This rule required all actions of the Task Force to be unanimous and directed the Task Force to commence a study, working with the Director, to determine the commercial availability and functional and operational capability of scsrs, emergency chambers/shelters, wireless communication devices and wireless tracking devices. These rules also required the Task Force to provide the Director with a written report summarizing its findings on these items and related safety measures. The report was also to include the task force's findings and recommendations regarding implementation, compliance and enforcement of these requirements.

As the Acting Director, I announced the names of the members of the Task Force on March 9, 2006 and appointed Randall Harris as technical advisor and facilitator. The group held its first meeting on March 13th. The group met a total of 36 full days between March 13 and May 25, 2006. The Task Force met in open public forum with experts from industry, labor, MSHA, NIOSH regulators, and academia at five different locations throughout the state, to facilitate participation in the open public meetings, in addition,

representatives of the Task Force visited various vendors, research institutions, and underground mines. I can definitely say that the State of West Virginia, through this Task Force's efforts, reached out to MSHA, NIOSH, various manufacturers, and other countries for assistance, information and advice before setting standards for shelters and the other areas in the report. This also included inviting employees from MSHA and NIOSH to observe and participate in various meetings sponsored by the agency. This also included approval group meetings for various shelter manufacturers following the finalization of WV's shelter rules. A list of organizations consulted and/or whose material was reviewed during Task Force deliberations and writing of the report may be found on pp 112-113 of the final report.

The resultant final rules approved by the WV Legislature may be found on the West Virginia Office of Miners Health Safety and Training's website which is Attachment 3 (http://www.wvminesafety.org/PDFs/56-04final.pdf). This document outlines the requirements for emergency shelters as was primarily defined in the amended emergency rule filed June 9, 2006 with the West Virginia Secretary of State's Office following a public hearing. This document also went through the Legislative Rule making committee and was authorized by the State Legislature. This authorization was cited in Section 64-10-1(a) of House Bill 2670 which was passed March 10, 2007 and later approved by Governor Manchin on March 28, 2007. The Technical advisor and facilitator, as previously mentioned, was Randall Harris. The Task Force report which was issued May 29, 2006 may also be found on the WV Office of Miners Health Safety and Training's website which is Attachment 4 (http://www.wvminesafety.org/PDFs/MSTTF%20Report%20Final.pdf). Pages 44 to 61 are relevant to discussing the background, thought process and requirements on Emergency Shelters.

It is of importance to note that the WV Board of Coal Mine Health and Safety endorsed the Task Force report and its recommendations unanimously in a letter dated May 30, 2006 (Attachment 5). This Board is also composed of equal representatives from Labor and Industry and is statutorily charged with the review of all serious and fatal accidents and devotes its time toward promulgating rules to prevent fatal accidents and injuries.

Many believed that the Task Force would not be able to agree on its recommendations. Through the process developed, the support of upper management of the entities being represented, both the United Mine Workers of America and Industry and the character of those involved, all recommendations of the Task Force were unanimous and formed the basis for the final rules referenced above. It is my opinion, that this approach of including representatives of the groups most affected, who are closest to the issue, in the initial development of public policy, can provide the most effective solutions to the problems being addressed.

We concluded that the first and preferred option for miners in an emergency is to escape without delay. However, it was found that options existed to provide the primary function of an Emergency Shelter/Chamber which is designed to potentially sustain life after a major underground event such as an explosion and where escape is cut off. We

developed recommended minimum requirements for the emergency shelter/chamber and its use. In developing recommendations we reviewed summaries of mine accidents that resulted in barricading of miners and developed a scenario. The scenario used is of an accident in which miners within 1,000 feet of the working face have survived a methane explosion. Our scenario does not include secondary explosions or on-going fires in the immediate area.

The scenario did not address these issues because there was complete agreement at that time that nothing would be capable of surviving these events in close proximity. The miners will have made every attempt to exit and found all escapeways impassable. As a last resort, they have been forced to return to the shelter/chamber to await rescue. In our scenario, miners approaching the emergency shelter/chamber may have consumed much of their SCSR time, be exhausted from escape attempts, with some injured and all under great stress. In this condition, the miners will need to be protected by the shelter/chamber within minutes of reaching it and for a period of at least 48 hours.

(Note: Under WV rules, the section cache of scsrs contains two scsrs per person in addition to the one being worn (three in the case of M20s being worn.))

It is also important to note that during our deliberations and prior to setting standards for shelters, we believed that there is little chance of an explosion or fire occurring at the face that would: 1) prevent escape for surviving miners and 2) have surviving miners to benefit from an emergency shelter if an explosion were to occur greater than 15 psi. After reviewing the proposed MSHA regulation, I believe that MSHA has missed this important point in crafting the regulation and appears to be more interested in protecting the shelter, rather than looking realistically and solely at protecting the miner.

Given the background process that I have just described, I am concerned about areas that significantly deviate and conflict with West Virginia's program on emergency shelters. As you know, West Virginia is the leading underground coal producing state in the nation. This program has been in place since June 9, 2006, and is viewed by some as the model program in the industry, with many states accepting it, including MSHA for breathable air. This program is nearing complete implementation and will probably be completed by the end of MSHA's rulemaking on refuge alternatives – end of 2008/ early 2009. We have discussed many times that if we have overlooked some aspect or applied some incorrect logic that might endanger a surviving miner, every single member would agree to work to change that standard. We also agree that changing standards just to be different is unnecessary. This would delay the implementation process and deployment of shelters underground. I am also very concerned about the apparent lack of MSHA's communication with our state in the initial drafting of these proposed rules.

In reading the proposed rule by MSHA there appears to be conflicting statements on the use of the refuge alternative or shelter. On page 34142, Section §7.501 it states that "*under the proposal refuge alternatives could also be used to facilitate escape by sustaining trapped miners until they receive communications regarding escape options...*". The concern is that this statement seems to encourage that the refuge

alternative be the first place to go until someone either contacts them or arrives to rescue them. While in several other locations the proposed rule states that refuge alternatives are a last resort. I personally know of no US coal miner that is in favor of a refuge alternative being the first place to go and discuss an escape strategy. They should already know their strategy. I believe that if the unit was deployed and systems activated and then an escape attempt made with miners eventually returning to the refuge, it would shorten the designed service time. I strongly encourage MSHA to consistently refer to refuge alternatives and their use as a last resort option in instances that previously called for barricading.

I am pleased to see that the proposed rule appears to grandfather state approved units to meet the requirements of the proposed rule. I would ask MSHA to consider if there needs to be any difference from WV's program. I can understand why there may need to be specifications to accommodate for regional ambient temperatures, but ask that you consider this program as a model for the nation.

If there are significant regional differences and this is not possible, it is imperative that the final rule clearly and unconditionally accept current state approved units, as meeting ***all*** requirements of MSHA's rule on refuge alternatives, and extends for the life of the units, with a ten year maximum. We have previously discussed the service life with manufacturers and generally concur with the estimated service life of pre-fabricated or portable shelters of approximately 10 years with 5 years for most of the components (some may be longer or shorter). I would also strongly encourage MSHA to allow for current state approved replacement units to be acceptable ***anytime*** during the 10 year period if a unit was damaged during normal handling or during a roof fall. Some mines are discussing ordering spare units that could be utilized in such a case to quickly provide the needed protection in case of damage. In my opinion, these should meet the requirement for the full ten year period.

A phase in time for units meeting the final rule should be addressed that when new replacement units meeting MSHA's final rule are *readily available for delivery, units ordered after that time would be required to meet the final rule requirements. Readily available could be defined as a 1 week delivery time from order and could be confirmed by contacting the manufacturer.* This change would allow for this protection to be available for miners if a unit were damaged and allow for the development of the next generation of this technology that will be required by the proposed rule.

I believe that it is important to note that there are mainly two primary types of portable shelters approved in West Virginia, inflatable and steel. There are advantages and disadvantages to each in the areas of transportability, simplicity of use in a wide variety of seam characteristics and reported functionality. MSHA should be as flexible as possible in allowing mines and miners to select an option and not be swayed as vendors try to sell their product by criticizing their competitors. It is also my opinion that in no way should MSHA force the purchase of one shelter over another, just because it is available.

In our original deliberations, we discussed applying minimum area per person requirements and decided to allow other factors (mainly temperature and storage of necessary components) to drive the size of emergency shelters. In my opinion this performance based standard is the right approach rather than specifying a value for comfort or something arrived at by taking information out of context such as square footage and volume for radiation fallout shelters for families.

We conducted an extensive review of past incidents where barricading may have been implemented. In the final report it cites: *From 1940 to 1980 US Bureau of Mines reported that 127 miners survived behind barricades while 40 died. Each accident was unique and the reporting was not consistent making it difficult to draw statistical conclusions. However, of those that discussed duration, the maximum was 54 hours at the Belva No. 1 mine in 1954 and the least was 4 hours at the Pocahontas 31 mine in 1957. The majority were in the 20-30 hour range. Based on its findings, the Task Force set a minimum duration of 48 hours.*

Table 4 on pg 22 of the 2007 Foster Miller Phase II Chapter 3 study (Attachment 6), which I believe was commissioned by NIOSH under the MINER ACT, in which they examined a total of twelve past mining disasters where refuge stations would have had a positive impact, i.e. saved lives. Table 4 indicates that in all but one of the twelve cases that rescuers would have made contact with trapped miners within 48 hours or less. I point this out only to indicate that there is a substantial safety factor in the present 96 hours and that as time increases, so does the complexity of sustaining trapped miners.

I believe that there have been substantial changes in the number of mine rescue teams since 2006 which will reduce the time for response. There has been a substantial increase in the number of SCSRs and their distribution along escapeways. There has been substantial improvement in training so that miners better understand their escape options and many other improvements, which collectively will substantially reduce the miners need to barricade as well as reduce mine rescue response time.

I also believe it is also important to note that prior to 2006 as regulatory agencies, we essentially required a few basic tools, boards and brattice cloth for constructing barricades as illustrated in 30 C.F.R. §75.1100-2 (i)(1), Quantity and location of firefighting equipment - Emergency materials: which requires mine operators to have emergency materials readily available not exceeding 2 miles from each working section. ***These emergency materials include boards, brattice cloth, nails, tools, etc. for mine emergency situations. In an emergency, these materials would be used for providing emergency barricades and for controlling/restoring ventilation controls.*** This was the standard since the passage of the 1969 Mine Act (approximately 39 years). Since 2006 we have been focused on providing a breathable atmosphere for trapped miners and I believe that everyone should not lose sight of that goal. We, collectively, have made significant progress.

The Foster Miller Chapter 3 study previously introduced as Attachment 6 on page 18 states: *Explosions occurring right at working faces killed all or some of the affected section miners instantly in most cases, while face area miners were not killed instantly in most cases of explosions occurring away from the face. In cases of particularly violent outby explosions (Scotia, Jim Walters and Finley, for example), face area miners still died instantly from the explosions.* While the original Task Force report recommended that shelters be placed in crosscuts, we deliberated that this may not be valid due to the view that most incidents that would prevent escape, would occur in outby locations and therefore, it was not included in the final WV rules. We have since discussed the probability of damage occurring through handling trying to place them in crosscuts being much greater than the probability of a miner being capable of surviving an event that would damage a shelter designed to withstand a 15 psi event. We communicated this to Mr. Kohler at NIOSH in writing which I have included as Attachment 7.

I would like to request that MSHA explain why they have deviated from their stated requirements for breathable air to date of requiring 3 times purge air to the proposed requirement in 7.505(3)(i) on page 34168 of the proposed rules, which states: " The airlock shall be designed for multiple uses to accommodate the structures maximum occupancy." This is vague and should not be. If it is a refuge alternative rated for 30 people does it mean that it should be capable of being purged 30 times? If that is the intended meaning, it is unreasonable. I am also interested in any physical tests or computer modeling that MSHA is aware of that indicate the effectiveness of purging on various size spaces, especially those greater than 50 square feet in area.

On page 34156 and other locations within the proposed rules I am concerned that MSHA envisions allowing the construction of a refuge alternative. As I understand the proposed rule, MSHA is discussing using inflatable stoppings. I have not seen deployment in low visibility conditions and believe that this product would serve a better function as a temporary stopping in a mine rescue scenario.

On page 34157 of the proposed rule MSHA states that "*The Agency would require that this training expose the miners to the expected heat and humidity conditions in the refuge alternative.*" I believe that miners should certainly be informed that conditions within the refuge alternative or shelter may be uncomfortable but certainly not life threatening, and do not believe that exposing thousands of miners to some high unknown temperature and humidity is necessary or advisable. How does MSHA know what the expected conditions within the refuge alternative will be? Based on my understanding a range of temperatures of X with a range of relative humidity readings of Y would result in an apparent temperature of 95 degrees F. Miners certainly can relate and understand this through their personal exposure to conditions such as this and even higher on hot humid days. I have personally heard many "considered opinions" about the use of the apparent temperature versus other means. It is important that miners be protected from heat stress and in West Virginia apparent temperature is used.

I do not believe that the proposed rule should discuss the use of seismic location devices unless the Agency is willing to significantly upgrade its seismic capabilities. I am

personally unaware of any significant update of such technology that would have restored the miners' confidence in MSHA that they would bring, let alone detect trapped miners with seismic equipment. I strongly encourage the agency to invest in the necessary upgrades and more timely delivery of its seismic technology and discuss the current limitations of seismic detection in order for working miners to better understand these limitations. I believe that it should not be present in the final rule unless MSHA is willing to obtain the significant upgrades, test them and the testing results widely disseminated.

It is disturbing to me that members of both NIOSH and MSHA since 2006 have been involved in numerous meetings with representatives from the state, and actually sat in meetings for determining whether manufacturers products would be approved (as observers) and failed to point out issues or concerns and more importantly bring solutions to the table and are now proposing significantly different standards. Again, I would ask MSHA to consider if there needs to be any difference from WV's program. I can understand why there may need to be specifications to accommodate for regional ambient temperatures, but ask that you again consider this program as a model for the nation.

Given the past history of MSHA's Rule development, if that same historical process would have been followed in these rules, it would appear that MSHA would have been developing these rules at the time WV was implementing its rules. It is also important to note that the NIOSH evaluation studies were being finalized after shelters were being placed in West Virginia's mines. If this is factual, MSHA certainly should have communicated with the WV Office of Miners Health Safety and Training regarding potential conflicts and impacts of its proposed rules.

Amid rumors that MSHA is planning on de-rating the occupancy of WV approved shelters, it is imperative that the final rule clearly and unconditionally accept current state approved units, as meeting ***all*** requirements of MSHA's rule on refuge alternatives, and extend for the life of the units, with a ten year maximum with some statement for allowing use of spare units for their full life and making sure that units meeting newly promulgated rules be readily commercially available as previously discussed.

If MSHA is planning on de-rating these units and will not change the location requirement to language similar to: ***within 2,000 feet of the nearest working face***, I personally do not agree with the statement on page 34167 of the proposed rule which reads: *MSHA acknowledges that West Virginia and Illinois have laws and/or regulations on refuge alternatives and has drafted the proposed rule to minimize conflict with these laws and regulations.* You have essentially wrecked the progress made by our state since 2006. If this is your intention, I would ask Governor Manchin, every member of the state legislature, and every member of the West Virginia federal delegation to ensure that does not happen by whatever means necessary. A great deal of effort, time, and financial resources have been expended by dedicated safety professionals at all levels within our State to get this far.

I hope that the information I presented and the attachments make it clear that our program dealing with emergency shelters is not: Jim Dean's program, Ron Wooten's program, Miners Health Safety and Training's program, Labor's program, Industry's program, the Legislature's program or even the Governor's program, but rather the entire state of West Virginia's program. I believe that our process was comprehensive, practical, and well founded that greatly improved mine safety in the area of post-event survival from where it was in 2005 and it should not be delayed by conflicting federal guidelines.

I appreciate the opportunity to share my concerns, observations and suggestions with you today. In closing, I feel it is important to state again for the record that the Task Force recommendations and resulting rules in Attachments 3 and 4 had unanimous support of both industry and Labor and their upper management. I would encourage MSHA to not cast this aside and review in detail the rationale used in West Virginia. In my opinion, it appears you have not done this review. We also kept MSHA and NIOSH informed and provided opportunity for input early in our process, but were not provided the same opportunity by MSHA. I also question the timeframe in which MSHA developed these rules.

I would appreciate MSHA reviewing the information and comments presented today and respond to requests made in a timely manner so that I might submit additional written comments prior to the closing date. I am very concerned about the lack of clear communication from MSHA regarding the impact of the proposed rules on our progress to improving our miners' safety, but am willing to work with MSHA in looking at ways technology can improve miner safety. Thank you.

Oral Comments on 30 CFR Parts 7 and 75
Refuge Alternatives for Underground Coal Mines; Proposed Rule as published in the Federal Register / Vol. 73, No. 116 / Monday, June 16, 2008 / Proposed Rules

July 31, 2008

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Thank you Ms. Silvey. My name is Randall Harris. My comments here today are based upon my background as a health physicist, engineer, and safety professional and upon my personal experience as a consultant with the State of West Virginia. During that time, I was the primary technical advisor to the West Virginia Mine Safety Technology Task Force and subsequently supported the implementation of those recommendations by the Director of the WV Office of Miners Health Safety and Training.

Director Wooten and Mr. Dean have already articulated the background of the West Virginia law and the means by which recommendations were arrived at and promulgated into rules. I will not revisit those. Rather, I will predominately focus on the processes followed during the implementation of the law and highlight some aspects of the many technical issues facing those charged with drafting the MSHA proposed rules. I will supplement my remarks with a detailed written section-by-section comment on the proposed rule following this testimony.

Here and in my written comments, I will discuss relevant observations from my extensive participation during the implementation phase of the West Virginia mine safety rules. This include reviewing SCSR storage plans, lifeline implementation plans, defining testing and approval processes for communication and tracking systems along with individual mine implementation plans and defining the testing and approval processes for underground emergency shelters. I have lead each of the peer reviews that preceded the manufacturer's approval by the Director and assisted West Virginia mine inspectors in reviewing and approving individual mine implementations plans for each of the items required by West Virginia law.

Before my implementation observations, I would like to expand upon Director Wooten's and Mr. Dean's comments with observations from my time advising the Taskforce and the West Virginia rulemaking processes that are relevant to your comparison of the West Virginia process to the proposed Federal rules.

My first observation is that the taskforce process worked because everyone involved was focused on the same goal, identifying the best solutions for increasing the chances of miners to escape and if that were impossible that they could be isolated from a hazardous atmosphere until conditions allowed escape or rescue could arrive. During the deliberations, the individuals were not subjected to undue influence by the ideological or political agenda of the communities they represented

and approached the issue as the mine safety professionals they are. The elevation of this subject to the national stage has heightened the interjection into the process of these external influences. It has been detrimental to professional and timely decision making of the body. Moreover, it limits its ability to reproduce the progress of that first effort. Despite obvious pressures, the MSHA career professionals need to guard against the same.

My second observation is that the Taskforce was focused on the mining conditions in West Virginia. We did not attempt to develop solutions that were universally applicable. Many vendors and experts from outside the U.S. presented forceful positions concerning, for instance, the inability of a shelter to maintain internal temperatures without mechanical cooling, which while valid in many mining environments were not applicable to the conditions in West Virginia. Since the issuance of the taskforce report, the promulgation of rules, and their implementation many have mistakenly assumed that the West Virginia recommendations and rules could be simply copied to their mining conditions. We do not believe this to be the case and is a misapplication of our work. Mining conditions vary widely across the country and the world depending upon local geology, topography and mining practices. Steadfast focus of performance based standards and prudent flexibility in application is essential.

My third observation is that comfort was not and should not be the concern when setting performance standards for emergency shelters. The concept of shelters was approached with one objective; isolate the miner from a toxic atmosphere if and only if escape is not an option. I along with those that worked through this viewed the shelter as a big SCSR a miner could crawl into. I have done dozens of briefings on the totality of the aids to escape that were put into place by the West Virginia law. More than once, I was greeted with someone stating, "You'll find me dead in an entry before I'll get into one of those boxes." While I have yet to have anyone hold that position at the end of the briefings the best response came from a miner in McDowell County who afterwards told me that "With the all this added equipment, if it is so bad that I am faced with having to get into a shelter it will not be a hard decision. It will be getting in the shelter now or be put in a body bag." Many of the comments relating to the amount of space and amenities in shelters are missing the point completely.

My fourth observation is that we did indeed recognize the necessity to ensure that miners occupying a shelter are not subjected to the buildup of life threatening temperatures due to the heat generate by their own bodies. However, in solving one problem we did not want to create the unintended consequence of adding an explosion hazard with the large battery packs necessary to operate air conditioning once the power is off. We collected temperature data in West Virginia mines and

asked manufactures to develop solutions for these conditions that did not require power. Once challenged, they found a simple solution by increasing the surface area of the shelter in relation to the number of occupants. This inevitably increased the viability of those options that could provide the largest surface area. Under West Virginia mine conditions inflatable shelters generally can provide a larger surface area per occupant for a larger numbers of occupants than hard-sided solutions. Their smaller size prior to occupancy increases maneuverability during normal operations, which has made them popular in the lower height mines that predominate in West Virginia. While some still argue that hard-sided shelters provide greater protection against secondary explosions the analysis of accidents done by West Virginia and others have indicated the in the few instances where secondary explosion occurred those affected were more often rescuers rushing to their co-workers aid than those that survived the initial event. Shelters along with their communication requirements provide a degree of reassurance to rescuers that should avert unnecessarily heroic advances, reducing this risk. Additionally the concern expressed by some about added protection from the heat of ongoing fires, while it may seem obvious to non-miners, betrays our industry's lack of options for fighting an ongoing mine fire. If the coal in which the shelter is located is indeed on fire we currently are limited to cutting off the oxygen long enough to

extinguish the fire or inundating the mine with water. Either option is beyond the ability of any shelter to offer survival.

Transitioning to comments on the proposed rule, I would like to highlight a few areas of particular concern and as stated, I will supplement these with some 90 pages of detailed written comments.

My first comment is there seems to be a misunderstanding in the proposed rule regarding the objective of an emergency shelter. In Section §7.501 the proposed rule states that "*under the proposal refuge alternatives could also be used to facilitate escape by sustaining trapped miners until they receive communications regarding escape options…*". It is indeed the practice in other parts of the world that shelters are gathering places prior to escape, however this is not the case in the U.S. Everything done to enhance safety by West Virginia and Congress since 2006 point to escape as the primary objective of miners and policy makers, implying another objective is inconsistent with miners' common sense and legislative intent. Shelters provide a last resort to isolate the miner from toxic carbon monoxide, which is the killer of those that survive the effects of the initial event.

Consistent with this objective of a shelter West Virginia performance based standards reflect an analysis of accident reports from over 40 years in which the survivors of the initial event attempted to barricade. This review of West Virginia, Bureau of Mines, NIOSH, and MSHA documents revealed that in only one instance did miners survive

beyond 48 hours in barricades. The logic behind MSHA PIB 07-03's extension of this to 96 hours was never provided. To avoid conflict and despite the belief that it was excessive and introduced complexity that increased the likelihood of malfunction, we asked manufacturers with whom we were then working through the approval process what it would take to increase their durations. Their engineers revised their designs but as expected it increased the complexity of the systems however, they could do it. As a result, even through the West Virginia rules states "at least 48 hours" all the approvals have been for at least 96 hours. It is requested that MSHA provide the logic for this increase in duration and if that logic does not support a safety benefit that outweighs the risk induced by the added complexity it is requested that the final rule state "at least 48 hours."

In a NIOSH report referenced in the proposed rule on the evaluation of shelters, NIOSH's comments were not included. These comments offered explanation as to why some of the key values exceeded the levels anticipated. Having been personally involved with NIOSH's development of the evaluation protocol leading up to and the discussions after the evaluations I must point out that the comments accompanying the spreadsheet, while brief are critical to understanding the results. However, even those brief notes do not reflect the testing difficulty that was more often the root of the failure than the product evaluated. All those involved in this exercise went into it knowing it

was as much an exercise to learn how to test, as it was a test of the shelters. Also not included in the MSHA description were the follow up email from NIOSH noting that each of the issues raised in the original report were resolved and the shelter were able to meet all the requirements set by West Virginia. While from an implementation basis, West Virginia considered this testing informative, we did not then, nor do we now consider them representative of the performance of the shelters involved. We request that MSHA's reference to this document in this rule or future documents be omitted or references to the intent of the evaluations, the resolution of all the issues raised and the limitations of their significance are included.

The West Virginia approval process included interaction with the applicants early and often. Applicants provided design drafts, invited me into brainstorming sessions on problems as they arose, allowed me to share common issues with other applicants, and were open to hard questions. Of the over, three dozen companies that contacted West Virginia about approval only six made it through the approval processes to the last step and to date only four have been issued approvals. The last step involved a multi-hour grilling patterned on a PhD thesis defense panel in which they defended their assertions of their shelter's ability to meet the West Virginia and MSHA PIB 07-03 standards. The panel consisted of several university professors with relevant expertise and me.

Early in the evolution of the West Virginia approval process it was decided that human subject testing would not be necessary nor was it the best proof of viability. During the study of the joint NIOSH/MSHA approval process for SCSR's we concluded that manufacturers spent significantly more time debating with the agencies which human subject would be used in the approval testing than preparing their product for the test. The result was that the human subject was often the one that best fit the capabilities of the devices instead of the one that was most representative of the mining population that would use the device. When discussing how a human shelter test might be conducted the conversation inevitably came back to who should be in the shelter and who would make that decision. In addition, we struggled with how we would know that the participant's metabolic characteristics would be representative of those miners that might actually use the shelter in an emergency. However, mostly we struggled with how we could get participants to duplicate the mental and physiological conditions of those that would have just survived an explosion, unsuccessfully tried to escape and are now facing death.

Similar challenges face any physical test of shelters ability to survive an explosion as the size and configuration of the only testing facility, NIOSH's Lake Lynn, did not match those of the typical West Virginia coal mine and was not available much of time. It was therefore; decided in conversations with the Director that the only

practical approach was to require the manufacturers to demonstrate using computational methods that the shelter could meet the standards set forth in West Virginia law and PIB 07-03.

In accomplishing this, the applicants employed engineering firms and universities with software and experience in computer simulation. During the final panel, these experts presented their results, the processes they used, and the assumptions they made during the analysis. In meeting this requirement applicants told us that their final products were improved as they could make design modifications and understand the impact on performance in almost real-time.

Two months ago, I participated in demonstration in Huntington Utah with the Modern Mine Supply Company. With the assistance of observers from the University of Utah mining department, 26 volunteers occupied a West Virginia approved shelter. Simulating the ambient mine temperatures used in the West Virginia approval process the interior temperature stabilized at an apparent 84 degrees Fahrenheit within 90 minutes. We continued the test for an additional 90 minutes to ensure that temperatures would not change. During that time, a paramedic checked the 26 occupants hourly. The only change noted was a decrease in pulse and blood pressure. At no time did the carbon dioxide increase above the required threshold. The oxygen concentration did increase and the flow rate had to be lowered because the occupants were not consuming at the rate anticipated in MSHA PIB

07-03. We did find an increase in carbon monoxide which was finally tracked to the cross-sensitivity of the carbon monoxide monitoring instruments to certain forms of alcohol that are present in personal hygiene products. While, debate is valid concerning if the volunteers were representative of the mining population and was their metabolic rates representative of miners who had tired to escape, the fact is that the results tracked exactly with the computational values developed during the West Virginia approval process. MSHA and NIOSH were invited to the test but the staff were told by management they could not attend because it involved human subject testing.

MSHA and NIOSH representative were also invited to each of the West Virginia approval panel sessions. We were told that their management only allowed their participation on the condition that they were not officially there, they could not offer opinions, or make judgments upon the validity of our recommendations. Never in off-the-record discussions following the panels or in multiple subsequent conversations where the differences that are currently evidenced between the West Virginia standards and those represented in this proposed rules pointed out. The West Virginia approval process was comprehensive and professionally conducted.

This brings me to a subject that is covered in the preamble but not in the proposed rules. West Virginia moved first. West Virginia reached out to MSHA through out the process. West Virginia conducted

a comprehensive approval process. West Virginia was never notified by MSHA formally or informally that neither the standards nor the approval processes it followed were flawed. The shelters approved and which will be installed in all West Virginia mines prior to the finalization of this rule should be formally accepted as meeting the requirements and should have to be modified only following their manufacturer's stated lifecycle. Shelters that are damaged as the result of normal operations during this period should be allowed to be replaced by similar units if models meeting any variations in the finalized version of the MSHA rule are not readily available. The alternative to this approach would be either closing a section of a mine for an extended period of time or depriving miners of a valuable survival tool. It is requested that the MSHA final rule specifically include provisions to this effect without qualification.

On multiple occasions, I along with others have expressed concern to MSHA and NIOSH officials regarding the underlying assumption behind PIB 07-3 that now have been carried forward into this proposed rule. The assumption that a barricade can be erected in a toxic atmosphere and purged with the use of pre-positioned compressed air bottles is not valid. Concentrations of carbon monoxide are likely to be present at levels significantly higher than that supporting human life. Tests conducted by several manufactures and even preliminary evaluations conducted in a simulated crosscut by MSHA itself

demonstrated the difficulty of purging a significant concentration of a gas from such a space using the conditions in this PIB. West Virginia commissioned a computational fluid dynamics model of the conditions laid out in PIB 07-03 and found it not possible to purge a space of toxic levels of carbon monoxide following the suggestions in this document. Using the computational model, we were able to simulate indefinitely full compressed air bottles. Even when we did that and allowed air to enter for 50 minutes, over three times the duration possible by the requested air supply, there were still large areas within the space with toxic levels of carbon monoxide. Yet having reported these results to MSHA this option remains in the proposed rule. In the strongest terms possible, I urge that this option be omitted in the final rule.

My final comment is that MSHA states its desire to use performance based standards several times in the preamble and in subsequent explanations. Yet, many parts of the proposed rule are very prescriptive. More than once, I have been told by MSHA officials that once something is issued as part of the CFR it very difficult to modify even if knowledge or technology advances make it moot or incorrect. MSHA has at its disposal tools, which are better suited to addressing these types of changes in understanding or interpretation. These include the established vehicles such as the PIB. It is requested that MSHA avail itself of this flexibility and include in the rule only those elements

necessary to establish performance standards and utilize its other tools to communicate the details it feels necessary to accomplishing them.

In closing, I want to say that I make these comments under no illusions that they represent the only or best conclusions to the issues I raise. As one who has been intimately involved in the processes leading to this point I know that no one has all the answers and that the best solutions are those resulting from the most open and inclusive evaluation possible. While the timing imposed by the 2006 MINER Act may have abbreviated the typical MSHA rule writing process, the subject had long been known to the agency. The Federal Coal Mine Health and Safety Act of 1969 and the Federal Mine Safety and Health Act of 1977 had also required MSHA to review the subject of shelters and promulgate appropriate rules. In addition, the abbreviated timing should not have precluded those staff working on the rules from reaching out to those states with co-enforcement authority for lesson-learned. Safety is an ever-evolving process with wisdom diffused across the whole of mining community. Continuous interaction and exchange of knowledge at all levels is essential not just during the rule making process.

Thank you.

Detailed Comments on 30 CFR Parts 7 and 75
Refuge Alternatives for Underground Coal Mines; Proposed Rule as published in the Federal Register / Vol. 73, No. 116 / Monday, June 16, 2008 / Proposed Rules

July 31, 2008

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My comments are based upon my background as a health physicist, engineer and safety professional and upon my personal experience as a consultant from February 2006 with the West Virginia Office of Miners Health Safety and Training. During that time, I was the primary technical advisor to the West Virginia Mine Safety Technology Task Force, participated in the Sago investigation, and subsequently supported the implementation of those recommendations by the Director of the WV Office of Miners Health Safety and Training.

These comments follow the order of the subject's occurrence in the published proposal. The term shelter is used throughout these comments interchangeably with refuge. The published text is provide in *Times Roman Italics Font* for reference with comments in **Arial Font**

Comment 1 concerning the statement:

I Introduction ...MSHA has reviewed NIOSH's report and determined that refuge alternatives are practical and will increase the chance for survival for persons trapped in underground coal mines, when integrated into the mine's comprehensive escape and rescue plans.

The conclusion that shelters are only one party of a comprehensive escape and rescue plan is critical. The primary objective of the comprehensive plan should be that all miners escape in the event of an emergency and ONLY IF escape is blocked should a shelter be utilized. In keeping with that finding, it is critical that all personnel involved miners, operators, inspectors, and trainers understand and apply that concept in all things associated with refuge. It is requested that MSHA modify those portions of the comprehensive escape and rescue plan rules and guidance documents to emphasize this point.

Comment 2 concerning the statement:

B. Discussion of the Hazard MSHA reviewed a number of underground coal mine accident reports in the development of this proposed rule. The Agency discusses the following accidents, which reflect typical emergency conditions, hazards, and issues in underground coal mines.

The accidents chosen for discussion should have been expanded to at least the 12 accidents from 1970 that were covered as party of the NIOSH report, available in the NIOSH Docket 125 collection. That report did a comprehensive analysis of the each addressing questions related to the usefulness of a shelter and its respective distance from the miners. In reading these analysis the potential for reducing fatalities of a shelter located within 1,000 feet of the working face is effectively demonstrated. It is

requested that the final rule be modified so as not preclude the current West Virginia rule of not to exceed 1,000 feet.

Comment 3 concerning the statement:

II. Section-By-Section Analysis, A. Part 7 Approval

Under the proposal, manufacturers could apply for approval of a prefabricated self-contained refuge alternative or for approval of a refuge alternative component. MSHA is proposing the approval requirements in party 7 to allow refuge alternatives or components to be tested by applicants or third-parties. MSHA has a 20-year history of administering this program, which has reduced product-testing costs and improved approval efficiency. Under the proposal, the applicant, usually the manufacturer would have to provide the required information and demonstrate that the refuge alternative or component meets the technical requirements and test criteria. Based upon an evaluation of this information, MSHA would issue an approval.

The proposal to use Part 7 third-party approval is commended. This places the timeline for the longest part of the process in the hands of the applicant and reduces the pressure on the already over taxed MSHA Approval and Certification staff. However, it will require an acceleration of accreditation of third-party laboratories. The issue of the use of testing done at facilities outside the U.S. and where protocols, while as rigorous as the MSHA procedures, are not identical needs to be resolved as well. Mining is an international business as is mine safety. There is growing need for MSHA to resolve differences in acceptance procedure across international boundaries to ensure that innovations reach U.S. miners as quickly as possible. It is requested that MSHA take the necessary steps to ensure that more third-party testing facilities are approved and that efforts to accept approvals by foreign mine safety agencies be accelerated.

Additionally, it has been our experience that minor modifications will be required to each shelter based upon the operation capabilities of a mine to transport the shelter during normal operations. It is requested that the approval must accommodate these minor variations and avoid the manufacturers having to file for modifications to their approvals for things that do not affect performance.

Comment 4 concerning the statement:

Section 7.501 Purpose and Scope....Refuge alternatives that states have approved and those that MSHA has accepted in approved ERPs would meet the requirements of this proposed rule. When mine operators replace these refuge alternatives or components, the new refuge alternatives or components must meet the requirements of the proposed rule. Based on preliminary discussions with manufacturers, MSHA used the estimated service life of the pre-fabricated self-contained refuge alternative. This would allow refuge alternatives to be used until replaced or 10 years maximum.

The acceptance of those shelters approved by state mine health and safety agencies is welcomed. However, if as in the sentence at the beginning of this section...

Section 7.501 Purpose and Scope....Refuge alternatives that states have approved and those that MSHA has accepted in approved ERPs would meet the requirements of this proposed rule.

...these units are deemed to have met the requirement there is no need for a duration condition. It is requested that those shelters approved by West Virginia be accepted as meeting these requirements without qualification.

Additionally, it is requested that allowing manufacturers to submit the testing data used in those accepted state approvals as equivalent third-party testing under Part 7 be included as well. Those manufacturers who participated in these approval processes incurred significant costs in doing so. Since MSHA's acceptance of those approvals effectively acknowledges the validity of those approvals, accepting the data and testing results under Part 7 follows. It is requested that the final rule allow for the acceptance of those shelters approved by West Virginia as equivalent to MSHA approval throughout their manufacturer's anticipated life expectancy without qualification.

Comment 5 concerning the statement:

Section 7.501 Purpose and Scope...Refuge alternatives that states have approved and those that MSHA has accepted in approved ERPs would meet the requirements of this proposed rule. When mine operators replace these refuge alternatives or components, the new refuge alternatives or components must meet the requirements of the proposed rule. Based on preliminary discussions with manufacturers, MSHA used the estimated service life of the pre-fabricated self-contained refuge alternative. This would allow refuge alternatives to be used until replaced or 10 years maximum. This would allow refuge components to be used until replaced or 5 years maximum.

West Virginia moved first. West Virginia reached out to MSHA through out the process. West Virginia conducted a comprehensive approval process. West Virginia never was notified by MSHA formally or informally that either the standards or the approval processes it followed were flawed. The shelters approved and which will be installed in all West Virginia mines prior to the finalization of this rule should be formally accepted as meeting the requirements and should have to replaced by one approved under existing rules at the time of manufacturer's anticipated lifecycle. Shelters that are damaged as the result of normal operations during this period should be allowed to be replaced by similar units if models meeting any variations in the finalized version of the MSHA rule are not readily available, The alternative to this approach would be either closing a section of a mine for an extended period of time or depriving miners of a valuable survival tool. It is requested that the MSHA final rule specifically include provisions to this effect.

Comment 6 concerning the statement:

This would allow refuge components to be used until replaced or 5 years maximum.

This sentence, which immediately follows the one included in the comment above, is confusing. Does this relate to the components inside a state approved shelter? Some of those components do indeed have five-year shelf or service life while other do not. Additionally the ambiguous use of the term component throughout this document makes it unclear as to its meaning. It is requested that the final rule clearing define component and acknowledge the approved lifecycle of any of those "components" currently included in a West Virginia approved shelter.

Additionally, mines using a West Virginia approved shelter now should be allowed to replace it with another of the same type if a delay in obtaining a unit modified to meet any

requirements differing from those in the original approval would result in the closing of the section or the denial of this tool to miners. It is requested that MSHA clarify the point and adopt the position proposed in Comment 4.

Comment 7 concerning the statement:

Section 7.502 Definitions...Apparent temperature. MSHA proposes to define apparent temperature as the combined effects of air movement, heat, and humidity on the human body. When no air movement is present, the apparent temperature equals the heat index. As heat and humidity increase, the amount of evaporation of sweat from the body decreases. The international scientific community generally recognizes a maximum safe apparent temperature of 95° Fahrenheit (F) in confined survival environments,[1] such as a refuge alternative. Body heat is the primary heat source in a refuge alternative and the humidity will likely be high in such a sealed environment. The carbon dioxide absorption process also generates heat and humidity.

This definition should stipulate the method to be used in determining apparent temperature. There are several recognized techniques some of which were designed for conditions not consistent with those in an enclosed space. The adoption by inclusion in the footnote of the Steadman Table (Steadman, R.G., 1979: The assessment of sultriness. Party I: A temperature-humidity index based on human physiology and clothing science. J. Appl. Meteor., 18, 861-873) is felt to be appropriate. The OSHA Technical Manual, Section III, Chapter 4, recommends for indoor applications using the web bulb procedure and the formula WBGT = 0.7NWB + 0.3GT where WBGT=Wet Bulb Globe Temperature, NWB = Natural Wet-Bulb Temperature and GT=Globe Thermometer Temperature. The results in an enclosed shelter will be nearly identical. Several have made an argument that MSHA should adopt the ISO formula to be consistent. However, the Steadman Tables are easier to understand when conducting training and while tend to over estimate the apparent temperature in relation to the ISO formula it provides an additional margin of safety.

While the standard is adequate for protection of occupants, those shelters approved by West Virginia were done so based upon typical ambient conditions in West Virginia mines. These conditions are not universal. It is requested that MSHA have its inspectors collect similar temperature information within 1,000 feet of working faces this summer. That this information be used to define several appropriate ranges of temperatures. Additionally, it is requested that these ranges be provided to manufacturers whom should be required to demonstrate what internal apparent temperatures would be reached in each range. This will provide valuable information to operators and inspectors on which shelter is best for a particular mine.

Comment 8 concerning the statement:

Section 7.502 Definitions...There is currently no permissible air conditioning equipment, which will overcome this problem in underground coal mines.

While this is currently true, there is at least one electrical air conditioner nearing approval by MSHA and there are several non-electrical options that are being tested by manufacturers. For those mines where the ambient temperature preclude cooling by natural transfer to the surrounding mine atmosphere these technologies will be critical.

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[1] R.G. Steadman (1979).

It is requested that MSHA provide a plan to work with NIOSH and manufacturers to expand methods for cooling on an expedited schedule.

Comment 9 concerning the statement:

Section 7.502 Definitions...Breathable oxygen. MSHA proposes to define breathable oxygen as oxygen that is at least 99 percent pure with no harmful contaminants. Acceptable breathable oxygen is frequently supplied from a compressed gas cylinder as U.S. Pharmacopoeia medical oxygen or as aviator breathing oxygen. This definition is consistent with the attachment to MSHA's PIB P07–03: ''Methods for Providing Breathable Air.'' MSHA solicits comments on the proposed definition. Comments should be specific, including alternatives, rationale, and supporting data.

The reference to PIB P07-03 should be expanded to make sure that it is understood that providing clean air that contains the proper percentage of oxygen is allowed so as to not preclude innovation. There are methods of separating oxygen from air and chemical generation of oxygen that have not yet been explored by shelter providers. Some of these may be better solutions, however, if the rules are written too prescriptively it will thwart that innovation. It is requested that each section the final rule be reviewed to ensure that in attempting to define the desired performance objective that it does not preclude innovation.

Comment 10 concerning the statement:

Section 7.502 Definitions...Flash fire. MSHA proposes to define flash fire as a fire that rapidly spreads through a diffuse fuel, such as airborne coal dust or methane, without producing damaging pressure.

It is requested that the definition be expanded to ensure the reader understand that it does not include an ongoing fire. There is confusion in the public about the ability or desirability of shelters to withstand ongoing mine fires. The public does not understand that technologies for fighting ongoing coal mine fires is limited and that most would involve techniques that would preclude successful rescue through the fire even within the 96 hours proposed in this rule.

Comment 11 concerning the statement:

Section 7.502 Definitions...Noncombustible material. MSHA proposes to define noncombustible material as material that will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

It is assumed that this reference is directed predominately at the inflatable options. If so, it is requested that the definition be modified to include some permeability requirement as that is more important since in an inflatable, the tent is stored inside a steel box until deployed. The noncombustible requirement needs to be limited to those materials exposed to the mine atmosphere prior to an event to allow innovation on the construction of internal support elements.

Comment 12 concerning the statement:

Section 7.502 Definitions...Overpressure. MSHA proposes to define overpressure as the pressure above the background atmospheric pressure. For example, air pressure in a car tire is measured with a pressure gauge as 30 psi, which is an overpressure. The absolute pressure of the air inside the tire is 44.7

psi which is 14.7 psi or one atmosphere higher. Explosion pressures are normally expressed as an overpressure beyond standard atmospheric pressure.

While it is discussed later in these comments, I would like to mention that the duration of the overpressure event is requested to mentioned here as well. The period listed elsewhere in the proposed rule is 0.2 seconds (200 milliseconds). This is effectively a static load and provides multiple means of testing. While there has been discussion among those working on this subject of using a period in the few millisecond range, the seminal study on the subject of human effects of blast waves, "The Biodynamics of Airblast" by Clayton S. White, et al sponsored by the Defense Nuclear Agency in 1971, indicates that in a closed environment such as a building or mines that wave reflection and wave stacking result in not only higher effective overpressures but prolonged durations. An overpressure event of 15 psi in mine entry could easily produce an effective duration exceeding 0.5 seconds (500 milliseconds). Additionally the internal amplification of the overpressure due to wave stacking in the body found that an external pressure of 20 psi resulted in an in-lung pressure of 60 psi (see page 77 of the above report).

In the October 2005 presentation "Survey of Blast Trauma from Evolving Tactics of Terrorism" by Catherine Y. Lee, MPH of the New York Medical College reported that blast lung injury (BLI) is the primary cause of fatalities in the aftermath of explosion. BLI a direct consequence of the blast wave from explosion upon the body causing a pulmonary contusion. BLI is a not only the major cause of mortality for blast victims but also among initial survivors. It was reported that the blast wave's impact upon the lung results in tearing, hemorrhage, contusion, and edema with resultant ventilation-perfusion mismatch from massive pulmonary hemorrhage that causes hypoxemia. The later fatalities occur due to pulmonary contusions that cause parts of the lung to consolidate, alveoli to collapse, and atelectasis (partial or total lung collapse). Consolidation occurs when the parts of the lung that are normally filled with air, fill with material from the pathological condition, such as blood. Over a period of hours after the injury, the alveoli in the injured area thicken and may become consolidated. BLI may occur without obvious external injury to the chest.

These results are validated by studies on the design of thermobaric (air vapor) weapons whose purpose is to create overpressure fatalities in enclosed spaces such as caves or bunkers. They found a factor of three to nine increases in fatalities for a given overpressure in enclosed space over that in open air. A 1988 study done on the effects of vapor cloud explosions in the chemical industry by ICI Engineering and included in NIOSH Docket 125, reports a probability of fatality of 100% at 10 psi over pressure in a building.

While there are no requested changes based upon this information it is critical that those finalizing these rule recognize that there is an overpressure threshold above which there are not likely to be survivors and protection of a shelter beyond these levels would not be useful.

Comment 13 concerning the statement:

Section 7.502 Definitions...Refuge alternative. MSHA proposes to define refuge alternative as a protected, secure space with an isolated atmosphere and integrated components that create a life sustaining environment for persons trapped in an underground coal mine. The proposed rule addresses refuge

alternatives that consist of a protective structure, an airlock, an interior space, and components that provide for breathable air, air monitoring, and harmful gas removal. The refuge alternative would also include provisions for sanitation, lighting, communications, food and water, and first aid.

It is requested that the definition emphasize the importance of ensuring the inability of toxic gases entering the space prior to occupancy or the ability to adequately purge the space to levels determined safe through air exchanges or active or passive toxic compound removal. If the space cannot be pre-established or re-established to protect the occupants from carbon monoxide without their SCSR's it is of little value. This definition as currently written excludes the option of individual breathable air supply discussed in other portions of the proposed rule. It is request that definition be modified to include all options contained in the final rule.

Comment 14 concerning the statement:

Section 7.503 Application Requirements, Proposed paragraph (a) would require that an application include information to assure that MSHA can determine if a refuge alternative or component meets the technical requirements for approval, functions as intended, and is safe for use in an underground coal mine.

The language needs to include the provisions in Section 7.501 Purpose and Scope concerning units approved by States prior to the effective date of this regulation. Additionally, it is recommend that a definition of "component" be included as any of the shelters are composed of hundreds of subsystems could be called components which according this text could result in unacceptably long approval cycles.

Comment 15 concerning the statement:

Paragraph (a)(3) would require the application to specify the capacity and duration (the number of persons it is designed to maintain and for how long) of the refuge alternative or component on a per-person per-day basis. For example, the application would need to include the specific number of persons and a specific length of time that the refuge alternative or component could support. The application also would need to contain this same information for food, water, lighting, sanitation, and any other materials that must be provided to assure proper use of the refuge alternative or component. This information is necessary so that MSHA can appropriately evaluate the performance of the refuge alternative or component and determine if it meets the requirement that it sustain persons for 96 hours.

The concept of using the shift change to determine the maximum number of occupants of a shelter was established by the West Virginia rules. It was recognized as not only practical but it provided an almost 100% safety margin for those most likely to be using a shelter. In a three-shift mine, the maximum number of people would be at the section once each shift. The "hot seat" changeover takes between 15 and 30 minutes then the shift relieved makes it way to the surface. That means between 45 and 90 minutes of each day there are the full number of miners for which the shelter was designed near the shelter. Since there are 1,440 minutes in day that means that between 96.8% and 93.7% of the time there are only half the number of miners that the shelter can support in the area. This makes a huge difference in the survivability of those that must use them.

An additional comment we would like to make here deals not so much with the intent of (a)(3) as with the 96 hour duration imposed under the PIB P07–03. Since PIB P07-03 was not subject to public comment this is the first opportunity to discuss the subject. A

review of the 12 accidents presented in the NIOSH Docket 125 discussed above and a review of MSHA historical records on accidents does not support 96 hours as the most likely duration. The State of West Virginia conducted such a review and concluded that the most likely maximum time to rescue was 41 hours. It therefore set the minimum duration at 48 hours. Prior to PIB P07-03, the shelter manufacturers were already extending the duration of their units as a function of competitive pressure. Without consultation with those working on state standards or inquiring into the ability of manufacturers to comply, the PIB doubled the value. To avoid a show down between Federal and State regulators manufactures redesigned their units expending time and expense to accommodate the additional supplies and complexity. While, the additional duration provides a significant margin of safety, there has never been an explanation of its derivation or validity. It is requested that MSHA explain the basis for doubling the duration and that if an adequate logic can not be demonstrated that it be reduced to 48 hours minimum.

Comment 16 concerning the statement:

Paragraph (b)(1) would require the application to describe the breathable air component, including drawings, air supply sources, piping, regulators, and controls. This information is necessary for the applicant to demonstrate that all systems are included and in their proper location, to assure proper functioning of this component.

The phrase "in their proper location" implies that there are defined locations for specific items within a shelter. Since the stated object of this regulation is to provide performance-based standards that encourage innovation, dictating location of specific devices seems inappropriate. It is requested that it be deleted from the final rule.

Comment 17 concerning the statement:

Paragraph (b)(2) would require the application to specify the maximum volume of the refuge alternative, excluding the airlock; the dimensions of usable space provided for each person; and the interior dimensions of the airlock. This information is necessary to demonstrate that there is adequate usable space when all systems and components are shown in their respective place.

The phrase "in their respective place" implies that there are defined locations for specific items. Since the stated object of this regulations was to provide performance based standards that encouraged innovation dictating location of specific devices seems inappropriate. It is requested that it be deleted from the final rule.

Comment 18 concerning the statement:

Paragraph (b)(3) would require the application to specify the maximum allowable positive pressures of the refuge alternative and airlock and describe the means used to limit or control the positive pressure in the refuge alternative and airlock. Information on the refuge alternative and airlock is essential for MSHA to determine whether the atmospheric pressure in the refuge alternative will maintain good air as miners enter and pass through the airlock. The information will be used to demonstrate that the pressure will be adequate for the intended purpose but not excessive, which could create adverse physiological effects for the miners.

The term "maximum" should likely be "minimum." It is the minimum positive pressure that affects the ability to exclude intrusion of toxic outside air and protects the miners.

The Department of Defense requires a minimum of 25 Pascal's (0.0036 psi or 0.10 inches of water) for shelters to prevent infiltration of chemical and biological agents. The concept of maximum pressure is also important but more so in that it affects the partial pressure of oxygen and carbon dioxide. There are actually several positive benefits from hyperbaric conditions. According to a study published in the American Journal of Physiology-Heart and Circulation Physiology hyperbaric oxygen increases by eight-fold the number of stem cells circulating in a patient's body (Journal of the American Medical Association, April 25, 1990 v263 n16 p2216(5)). While this is requested the Department of Defense values be adopted, discussion of maximum pressures is not of such a critical issue that it warrants codification.

Comment 19 concerning the statement:

Paragraph (b)(4) would require that the application specify the maximum allowable apparent temperature of the interior space of the refuge alternative and airlock and describe the means used to control the apparent temperature in the refuge alternative and airlock. This information provides a basis to determine whether the refuge alternative will protect miners from heat stress. Data show that apparent temperatures greater than 80 °F are generally associated with some discomfort. Medical evidence reveals that values approaching or exceeding 105 °F would be life-threatening, resulting in severe heat exhaustion or possible heatstroke if exposure is prolonged or physical activity high. The degree of heat stress would vary with age, health, and body characteristics.

It is requested that the language associated with this requirement be modified to be consistent with definition and the recommendation in comment 7 above.

Comment 20 concerning the statement:

Paragraph (b)(5) would require that each application include drawings that show the features of each component and contain sufficient information to document that each component meets the technical requirements of this subpart. Drawings of each component would illustrate the internal configuration of the refuge alternative. Under the proposal, this information would include the dimensions and layout of the refuge alternative components, controls, and materials necessary for proper operation. This information is necessary for the applicant or third party to make an appropriate and informed evaluation and of the unit to provide a basis for MSHA approval of the refuge alternative or component.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 21 concerning the statement:

Paragraph (b)(6) would require that the application include essential information or instructions, such as a training manual that contains sufficient detail to train personnel to transport, operate, and maintain the refuge alternative or component. MSHA recognizes that, as a general practice, manufacturers provide users with information necessary for safe and effective use of their products. Under the proposal, the applicant would be required to develop a training manual for each refuge alternative or component.

In keeping with the understanding that shelters are simply one component of a comprehensive mine escape and rescue system it is requested that these documents be required to be written in a manner that results in individual mines incorporating their

mine specific information regarding SCSR caches, communication and tracking, life lines, etc.

Comment 22 concerning the statement:

Paragraph (b)(7) would require a summary of the procedures for constructing and activating refuge alternatives. MSHA recognizes that, as a general practice, manufacturers provide users with information necessary for safe and effective use of their products. This summary information would include all of the steps and procedures to construct and activate a refuge alternative. This information would be used in evaluating the approval and for instruction in the construction and activation of refuge alternatives.

It is not clear what is meant by "constructing" as used in this description. All the discussion this far has focused upon manufactured systems. This harkens back to building barricades, a practice that this rule is intended to obsolete. In PIB P07-03, the document allowed for the erecting of barricades after an event that had created a hazardous atmosphere. The assumption in the PIB is that after erecting such a barricade the air behind it could be "purged" by releasing stored air. This has not been able to be demonstrated as practical either computationally or in practice. Does the wording leave open the option of simply providing brattice cloth and bottles of air in place of designed shelters? If so, it is likely that miners will unwittingly expose themselves to toxic air if they remove their SCSR's behind such a structure. It is requested that all references to post event barricade equivalent alternatives be deleted from the final rule.

Comment 23 concerning the statement:

Paragraph (b)(8) would require a summary of the procedures related to using refuge alternatives. This summary information would include steps and procedures for using the refuge alternative during a substantial period of time. This information would be used in evaluating the approval and for instruction in using the refuge alternatives.

It is requested that MSHA clarify what is meant by "substantial period of time." Does this relate to the 96 hour occupancy or the life expectancy of a shelter that has not been deployed? It is requested that the final rules reference the "rated duration" of the shelter. This encourage competition among those manufacturers that wish to compete on extended duration.

Comment 24 concerning the statement:

Paragraph (b)(9) would require that the application contain the results of inspections, evaluations, calculations, and tests conducted under this subpart. MSHA would use this information to evaluate the effectiveness and compatibility of refuge alternative components. For example, the application would contain the calculation of the rate oxygen is delivered on a per person basis and the results of tests, including calculations, of the carbon dioxide removal (scrubbing) to demonstrate that the refuge alternative will maintain a safe atmosphere for 96 hours.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 25 concerning the statement:

Paragraph (c) would require that the application for the air-monitoring component include additional information. This information is necessary for the applicant or third party to make an effective evaluation of the component to provide a basis for MSHA approval of the air-monitoring component.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 26 concerning the statement:

Paragraph (c)(1) would require that the application specify the types of sensors, their operating ranges, the gases measured, and any environmental limitations including the cross sensitivity of each detector or device to other gases. This information on the air-monitoring component is essential for MSHA to determine that persons inside the refuge alternative will be aware of the concentrations of carbon dioxide, carbon monoxide, and methane, inside and outside the refuge alternative, including the airlock. In addition, this will assure that oxygen concentrations can be monitored simultaneously.

The need to monitor carbon dioxide outside the shelter does not make sense. It is requested that it not be included as an outside requirement. It is also requested that the final rule specifically include oxygen sensors.

However the issues raised regarding cross sensitivity, which becomes more problematic in the closed environment of the shelter, may be a better subject for a PIB than to be written into the CFR.

A PIB could in detail inform the community of the issues such as that found in the Utah tests in which meters have cross sensitivity between alcohol and carbon monoxide and may falsely indicate carbon monoxide in response to many personal hygiene products. There is also a cross sensitivity issue in many meters between methane and cabon monoxide.

The PIB could explain to trainers that several studies examining the production of methane as the result of colonic fermentation in humans could result in increasing low levels of methane in long shelter occupancy. In an article in the medical journal Lancet, "Abnormal colonic fermentation in irritable bowel syndrome," T. S. King, et al report their control group of normal subjects generated 22 mL/hr. This would result in the addition of 2.1 liters of methane per occupant over 96 hours. Depending on the internal volume of the shelter, this may result in measurable although not explosive methane levels toward the end of occupancy. This needs to become part of the training so as not to cause undue panic among occupants.

Also, as with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 27 concerning the statement:

Paragraph (c)(2) would require that the application include the method for operation of each device so that it functions as necessary to test gas concentrations over a 96 hour period. This information will assist MSHA's evaluation of whether the air-monitoring component can sustain persons for 96 hours. The Agency recognizes that different types and combinations of instruments from several manufacturers may be used in an air-monitoring component. MSHA needs to assure that the different components are available and will provide reliable monitoring of breathable air as necessary over the 96- hour period. MSHA believes that a properly designed system would control gas concentrations inside the refuge alternative. The intent of this provision is that detectors would be used to periodically check gas concentrations in the refuge alternative and provide miners with this information.

This text addresses two critical features – metering oxygen and removing carbon dioxide along with the instruments used. The monitoring instrument issue is addressed below in Comment 28. The metering of oxygen is a critical issue and must be described in detail along with the methodology used to not on verify that there is sufficient oxygen provided but that it's flow rate can be adjusted with a degree of precision necessary to maintain the 18.5% level. Carbon dioxide removal is also a critical issue. The levels used in PIB P07-03 assume a level of activity that appears high. It is likely that in designing to these higher values the shelters will over achieve on carbon dioxide removal at the lower more likely activity levels. While carbon dioxide is a concern, hypercarbia is not as serious a problem as hypoxia. Hypercarbia actually stimulates ventilation the most likely effect will be to increase the oxygen intake. However, there appear to be no pronounced physiological effects associated with exposures up to 5% carbon dioxide according to studies published by Vercuryssen and Karmon in the Journal of the International society of Respiratory Protection 1984; 2: 63-89. If detected, deployment of additional carbon dioxide scrubbing materials would easily reduce this to acceptable levels prior to any effect of the occupants.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 28 concerning the statement:

Paragraph (c)(3) would require that the application include procedures for monitoring and maintaining breathable air in the airlock, before and after purging. Under the proposal, breathable air must be provided in the airlock at all times. However, when miners enter the airlock following an emergency, it will be necessary to monitor and purge the air to remove any contaminants and minimize contamination inside the refuge alternative as miners pass through the airlock into the interior space.

The purging of the airlock is critical element of the operation of the shelter. It is requested that the text address the need for manufactures to demonstrate they have procedures for bringing in injured miners through the airlock, as this will likely be different. It should also provide an estimate of the number of times the airlock can be purged. Barring a violation of the structural integrity of the shelters exterior there should be no need to purge the entire space.

It is not requested that a number be set in regulation, it has been found that manufacturers are using the number of airlock entries as a competitive feature and the

number will increase over time. It is requested that the final rule require the manufacturer to demonstrate the ability but not to dictate the method.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 29 concerning the statement:

Paragraph (c)(4) would require that the application include instructions for determining the quality of the atmosphere in the airlock and interior of the refuge alternative and a means to maintain breathable air in the airlock. The quality of air inside the refuge alternative is vital to sustain trapped miners. The procedures for using the air-monitoring component are essential for MSHA to determine whether the component provides adequate means for trapped miners to verify the quality of the air inside and outside the refuge alternative.

Since few if any monitors exist that will operate for 96 hours continuously, provisions must be made for an intestinally safe means of either recharging or changing batteries in these devices. It is requested that MSHA work with instrument manufacturers approved and these applying to provide options for extending the operational life of their devices in a potentially explosive atmosphere. It is also requested that MSHA ensure that training materials provided with the shelters describe options such as turning off the devices between readings to conserve battery life.

A concern that is not often emphasized is the possibility of over oxygenating the shelter. Oxygen rates have been set based upon average consumption using the PIB 07-03 activity rates, if occupants consume at lower rate oxygen percentages will increase over time. While the possibility of hyperoixia is minimal at the slightly above atmospheric pressures at which these shelter operate it wastes oxygen that could extend the effective duration. It is requested that training materials provide instructions for adjusting oxygen flow in these instances.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 30 concerning the statement:

Paragraph (d) would require that the application specify the volume of breathable air available for removing harmful gas, both at start-up and while persons enter or exit through the airlock; and the maximum volume of each gas that the component is designed to remove on a per-miner per-day basis. Information on harmful gas removal is essential for MSHA to determine the ability of the refuge alternative to sustain occupants for 96 hours. The purpose of this component is primarily to remove carbon dioxide exhaled by the occupants. MSHA also intends that this component be capable of removing toxic and irritant gases, fumes, mists, and dusts that may enter the refuge alternative through the airlock.

This seems redundant with that Paragraph (c)(3). Additionally, the area that must be purged is the airlock, this text could be read to imply the entire space, which would interject unnecessary complexity into the units. It is requested that be rewritten to

specify the airlock and it is requested that MSHA identify paragraphs that address similar subjects and consolidate them for ease of understanding and compliance.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 31 concerning the statement:

Paragraph (e) would require that the applicant certify that each component is constructed of suitable materials, is of good quality workmanship, is based on sound engineering principles, is safe for its intended use, and is designed to be compatible with other components in the refuge alternative, within the limitations specified in the approval. This information is needed to assure that the application, test results, and construction quality are complete and accurate.

While this is a worthwhile goal, it seems this statement leaves itself open to a broad range of interpretations that will result in considerable confusion on the part of applicants and reviewers. It is requested that this be reworded to stipulate what these phrases exactly mean or to include references to applicable ASTM standards or be omitted from the final rule.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 32 concerning the statement:

Section 7.504 Paragraph (a)(1) would require refuge alternatives and components to be intrinsically safe for use in an underground coal mine and designed with fire and explosion-proof features for use with an oxygen supply component. This requirement would assure that the refuge alternative or component does not contribute to a secondary fire or explosion.

Agree.

Comment 33 concerning the statement:

Section 7.504 Paragraph (a)(2) would require that a refuge alternative or component not produce noise levels in excess of 85 dBA in the structure's interior. Noise above this level can be irritating and interferes with communication. Exposure to noise at or above the 85 dBA level could adversely affect hearing. Based on MSHA's knowledge, noise controls such as dampening material are available to control noise levels.

The only sources of noise would be the components of the shelter itself since in the event of use all activities in the mine would have ceased except venation. An 85 dBA sound level is equivalent to a food processor on high or a gas-powered lawn mower idling. As point of reference the Department of Defense Human Design Handbooks stipulates at 5.8.3.3.1 that 75 dBA is the maximum sound level in an active machine shop. While this may be applicable to operating machines is not likely to be a problem in shelter during occupancy. It is requested that MSHA provide the logic for the inclusion

in the rule and if not necessary it is recommend that it be omitted from the final rule as unnecessary.

Comment 34 concerning the statement:

Section 7.504 Paragraph (a)(3) would require that the refuge alternative or component not liberate harmful or irritating gases or particulates into the structure's interior or airlock. Some materials off-gas when heated. Vapors, aerosols or particulates should not be released into the refuge alternative. The proposed rule would require that materials used in a refuge alternative or component be tested and evaluated to determine that nonmetallic materials do not release irritating odors or toxic gases when subjected to a flash fire test. The application would have to include the results of the tests and evaluation.

We agree that off-gassing could be an issue but not from overheating. More likely it will be from the toilet facilities. In a later comment, I will address this in detail, but MSHA should review the MSDS for all materials placed in the shelter and require that those be provided to trainers as they include discussion of any vapors and their effects.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 35 concerning the statements:

Section 7.504 Paragraph (a)(4) would require that the refuge alternative or component be designed to be moved safely with devices such as tow bars. MSHA recognizes that refuge alternatives could be a hazard to miners during transport if not properly designed and if miners are not adequately trained. Based on MSHA's experience, inadequate rigging and towing devices could cause accidents to miners. The refuge alternative should be designed with proper connections and devices to eliminate or reduce the use of chains, ropes, and slings. In addition, miners would need training on how to move a refuge alternative to avoid injury.

Section 7.504 Paragraph (a)(5) would require that the refuge alternative and components be designed to withstand damage during transport and handling. The proposed rule would require that designs incorporate bumpers, guarding, skids, packing and securing devices, and rigging components. Additionally the components and supplies must be configured, arranged, and stored to minimize shifting, movement, or damage during handling and routine transport. Training would incorporate precautions to prevent damage to the refuge alternatives and components while storing, handling, and transporting the equipment.

Agree. It should be noted that so far many mines have required special attachments or bumpers etc based upon how their mine operates. It is requested that MSHA address these minor modifications in a manner that does not require the manufacturers to return for a modification each time.

Comment 36 concerning the statement:

Section 7.504 Paragraph (b) would require that the apparent inside temperature be controlled to prevent heat stroke. The miners will produce heat within the confined space of the refuge alternative. The chemicals used to remove carbon dioxide also generate heat. Over time, the heat build-up could produce heat stroke. NIOSH stated that—Apparent temperature is a measure of heat stress, but other indices or

standards could be used, such as the wet bulb globe temperature. Regardless of the index selected, the numerical value must be assigned to prevent heat stroke.

As discussed in Comment 7 it is requested that this text stipulate the method to be used in determining apparent temperature. There are several recognized techniques some of which were designed for use in condition not consistent with those in an enclosed space. The adoption by inclusion in the footnote of the Steadman Table (Steadman, R.G., 1979: The assessment of sultriness. Party I: A temperature-humidity index based on human physiology and clothing science. J. Appl. Meteor., 18, 861-873) is felt to be appropriate. The OSHA Technical Manual, Section III, Chapter 4, recommends for indoor applications using the web bulb procedure and the formula WBGT = 0.7NWB + 0.3GT where WBGT=Wet Bulb Globe Temperature, NWB = Natural Wet-Bulb Temperature and GT=Globe Thermometer Temperature. The results in an enclosed shelter will be nearly identical. However, the Steadman Tables are easier to understand when conducting training and tend to over estimate the apparent temperature. This provides an additional margin of safety.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 37 concerning the statements:

Section 7.504 Paragraph (b)(1) would require that, when used in accordance with the manufacturer's instructions and defined limitations, the apparent temperature in the fully occupied refuge alternative not exceed 95° Fahrenheit. The apparent temperature is a measure of relative discomfort due to the combined effect of heat and humidity. The concept of apparent temperature was developed by R.G. Steadman (1979) and is based on physiological studies of evaporative skin cooling for various combinations of ambient temperature and humidity. At higher dew-points, the apparent temperature exceeds the actual temperature and measures the increased physiological heat stress and discomfort associated with higher than comfortable humidity. The likelihood of adverse effects from heat may vary with a person's age, health, and body characteristics; however, apparent temperatures greater than 80 °F are generally associated with some discomfort. Temperatures in excess of 105 °F are considered life threatening, with severe heat exhaustion or heatstroke possible after prolonged exposure or significant physical activity. There is a general consensus among researchers that the apparent temperature within a confined space occupied by humans should not exceed 95 °F.[2] MSHA recognizes that body heat and heat generated by chemical reactions (i.e., CO2 scrubbing chemicals) are inherent heat-producing sources within a refuge alternative. Ambient temperature in a refuge alternative also is affected by the mine temperature compounded by high humidity in the sealed environment. High humidity reduces a body's ability to regulate temperature by sweating, which could result in a dangerously elevated internal body temperature.

Section 7.504 Paragraph (b)(2) would require that calculations or tests be conducted to determine the maximum apparent temperature in the refuge alternative when used at maximum occupancy and in conjunction with required components calculations or test results. In addition, the proposed rule would

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[2] U.S. Department of Defense, National Aviation and Space Administration, Canadian, Australian, and the United Kingdom.

require that an application include test results and calculations to demonstrate that the apparent temperature within the refuge alternative would not exceed 95 °F when used in conjunction with required components and fully occupied. MSHA requests specific comments on the apparent temperature and mitigation of heat stress and heat stroke. Comments should address the generation of heat and the methods for measuring heat stress on persons occupying the refuge alternative. Comments should be specific including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and supporting data.

Again, it is requested that this is a sufficiently important subject that MSHA should stipulate a method. The Steadman method is as good as any. However, without stipulating a method MSHA leaves itself open for confusion between the applicants and the reviewers and could lead to unnecessary litigation if an application were denied based upon apparent temperature. The other more pressing issue for the reviewers and the applicants is what are the conditions outside the shelter? This makes a huge difference in determining the ability of a design to maintain the design temperatures without a mechanical or electrical cooling system. As noted elsewhere in the MSHA introduction heat transfer is function of surface area. Nevertheless, it is also a function of the temperature gradient across the membrane separating the miners from the outside and the conductivity of that membrane.

Additionally, there are a number of assumptions that must be included in this discussion including the heat generated by the occupants that have been omitted from this section. Without these, there will be considerable confusion among the applicant and regulatory communities. It is requested that MSHA stipulate the use of 400 Btu per hour per person and stipulate the relationship within that between latent and sensible heat.

In addition, it must be recognized that the ability of the water vapor represented by the humidity to condense on the interior of the shelter walls accounts for a significant portion of the heat transfer to the outside. The latent heat released by changing from water vapor to liquid is on the order 966 Btu per pound and since water weights 8.34 pounds for gallon that is over 8,000 Btu per gallon of water condensed. As noted in the MSHA text the dew point will change based upon the humidity and the temperature of the surface it is in contact with. There are several mechanisms that work in concert to define the equilibrium temperature in a shelter, in addition to the heat transferred by conduction through the membrane due to the difference in air temperatures on either side of the membrane and the loss of heat on the outside of the membrane to the mine air by convection these mechanism allow for the natural equilibrium of temperature and humidity in the shelter. However, all these are dependent upon the ambient conditions in the mine. The ambient conditions used in West Virginia apply to West Virginia. We made no attempt to set conditions for anywhere else. We have tested them on small scale, computationally and at full scale, they work for us. They may not work in Alabama. It is requested that MSHA determine a set of ranges that represent the conditions across the nation that would allow manufacturers and operators to determine what is the best solution for their mine.

It is requested that MSHA have its inspectors collect temperature and humidity information within 1,000 feet of the face in mines during their inspections over the summer. This information should be used to establish realistic ambient temperature ranges that can be used by manufactures to demonstrate the resultant internal temperature.

It is requested that MSHA require manufactures to submit testing or simulation results within these specific ranges of ambient temperatures and humidity that represent the typical ranges of underground coalmines around the nation. This will allow the Districts and States to determine if the right shelter has been chosen for their mine. It will likely require in some mines that active cooling be required due to elevated ambient temperatures. If so, it is important that it be recognized prior to the selection of a shelter option.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 38 concerning the statement:

Section 7.504 Paragraphs (c)(1)(i) and (ii) would require that refuge alternative accommodate a telephone or an equivalent two-way communication facility that can be used from inside the refuge alternative, or a two-way wireless system when it is approved in the operator's Emergency Response Plan (ERP). Manufacturers would need to provide suitable ports, connections, jacks, and fittings for communication equipment, and ports and connections would need to be designed for electrical permissibility and maintaining air quality (gas tight cable entries) within the refuge alternative.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 39 concerning the statement:

MSHA requests comments on including a requirement that refuge alternatives be designed with a means to signal rescuers on the surface. This would assure that rescuers on the surface could be contacted if the communications systems become inoperable. This signal would be similar to what miners had done in the past by hammering on the roof, ribs, or floor to create sounds that can be detected by seismic devices located on the surface. A signaling device would need to be configured to produce a sound on the roof, ribs, or floor while maintaining the isolated atmosphere. Comments should be specific, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and supporting data. MSHA requests comments on including a requirement that the manufacturer design refuge alternatives with a means to signal underground rescuers with a homing device. This would assure that rescuers could detect the trapped miners within the mine. Comments should be specific, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and supporting data.

The use of seismic listening for use in conjunction with underground shelters is valid only because we know where the shelters are. Previous efforts to use seismic listening for location have not been fruitful for many reasons not the least of which is the complexity of the technology in relations to the varying surface topography and the need to halt all extraneous noise. Even in the case of known shelters locations it will prove difficult but as last ditch effort, it could prove useful. It will be critical that both those underground and those above ground understand when and how this is to be done. Since the current practice of miners waiting for surface blasts to signal when to pound have proven to ignored by those trapped it is best to select a specific time such as at the

top of each hour and that a simple – very simple – code be developed to communicate conditions and number of survivors. This will need to be trained and prominently displayed inside the shelter. In addition, local mine inspectors will need quick access to portable listening equipment and quality GPS equipment. This information is need by the mine rescue teams as the plan their attack. Therefore, the first responding inspectors should ideally be brining this with them. Waiting for it comes from afar is too late. It is requested that if this is to be included as part of the final rule that MSHA must make a commitment to ensure that it and/or states have the necessary equipment and training to implement the technology. Baring that it is requested that it be omitted from the final rule; there is no value in providing false hope to miners.

Comment 40 concerning the statement:

Section 7.504 Paragraph (c)(2) would require that refuge alternatives include lighting sufficient to perform tasks. Lighting that generates significant heat, or requires continual manual power for light generation, would be unacceptable. Light is essential to allow persons to read instructions, warnings, and gauges; operate gas-monitoring detectors; and perform other activities related to the operation of the refuge alternatives. MSHA recommends a minimum of 1-foot candle of lighting be provided per miner per day.[3] The manufacturer or approval holder would have to measure the number of foot-candles provided per miner per day and report this information in the refuge alternative's manual. MSHA requests comments on the types, sources, and magnitude of lighting needed for the proper functioning of a refuge alternative and the needs of the occupants. Comments should be specific, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and supporting data.

The reference listed is in the Defense Department's Human Engineering Handbook actually discusses "Bomb shelters and mobile shelters, when used for rest and relief." While there are physiological benefits to providing some ambient low level lighting, miners unlike military personnel come with their own lights and are accustomed to working the dark. The 1-foot candle is the equal to the Average Parking Lot at night. If we have 16 miners in a shelter that is 40 inches high, we would have 16 times the amount of light in the average parking lot. Do we need that much light when it comes with the added risk of an electrical hazard? Since each miner has a lamp it all but one were turned off until it died then another and so forth would that not be enough light without adding the extra risk and complexity? As a backup chemical lights could be provided that when flexed produce a soft green light that if held next to a meter would allow it to be read. It is requested that this provision presents more potential problems than it solves and be omitted from the final rule.

Comment 41 concerning the statement:

Section 7.504 Paragraph (c)(3) would require that refuge alternatives include a means to effectively contain human waste and minimize objectionable odors. Information regarding the sanitation would assure that the manufacturer or approval holder has included an adequate means for containing waste. The proposed provisions on sanitation would encompass containment and disposal of waste. This provision would also require a means for operation and use, and a means, such as a plastic bag and closed receptacle, to contain the waste to prevent objectionable odors from being detected within the interior space. Provisions should include individually packaged sanitation supplies, including toilet paper

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[3] MIL–STD–1472F, Lighting for bomb shelters, NOTICE 1,05 December 2003.

and hand sanitizer. The manufacturer or approval holder would have to measure the length, width, and height of the container housing the sanitation component and report this information, together with operating instructions, in the refuge alternative's manual.

The use of self-contained chemical toilets presents an unnecessary problem. There are products on the market that use single use plastic bags which contain a solid that when combined with the liquids in the excrement form gel that can then be sealed and placed through a trap door for collection outside the shelter. I would propose that scoping up a pile of bags of human waste into a trash bag in the aftermath of an accident such that required use of the emergency shelter is of little consequence in the big picture. This eliminates a problem. It is requested that the final rule state that a means of disposing of human waste outside the shelter be provided.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 42 concerning the statement:

Section 7.504 Paragraph (c)(4) would require that refuge alternatives include first aid supplies to treat injuries. The provision would assure that a sufficient quantity of first aid supplies are available for injured miners.

The experience of those working with manufacturers is that stating "first aid supplies" will produce a wide array of contents. It is requested that MSHA link the requirement to that associated with other requirements for the content of first aid keeping in mind that there may be trauma victim in the shelter and that it is likely there will not be a trained paramedic. First aid kits should contain instruction for treating at least blunt force trauma, lacerations, burns, shock, and similar insults that could be anticipated in the aftermath of an accident that would require use of shelter.

The final rule should also the address the position MSHA wishes to take concerning the recommendation by some manufacturers that anxiety and or sleep inducing drugs be included. It is requested that while these may be useful the potential medical issues of their use by untrained miners outweigh their value.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 43 concerning the statement:

Section 7.504 Paragraph (c)(5) would require that refuge alternatives be stocked with materials, parts, and tools for repairs of components. This requirement would assure that refuge alternative manufacturers provide a repair kit with necessary materials and appropriate tools to perform repairs. This should include adequate tools, metal repair materials, fiber material, adhesives, sealants, tapes, and general hardware (i.e., screws, bolts, rivets, wire, zippers and clips). Powered tools must be intrinsically safe and permissible.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 44 concerning the statement:

Section 7.504 Paragraph (d) would require that containers used for storage of refuge alternative components be airtight, waterproof, and rodent-proof; easy to open and close without the use of tools; and conspicuously marked with an expiration date and instructions for use of the component. This requirement would assure that the containers' contents are useable when needed. Some contents should be individually packaged and stored in containers. For example, food and water should be provided in individual, disposable packages and stored in a container.

Agree, however, again the use of the components is not specific. It is requested that if MSHA means food and water that it state such to avoid confusion.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 45 concerning the statement:

Section 7.505 Paragraph (a)(1) would require that refuge alternatives provide a minimum of 15 square feet of usable floor space and a minimum of 60 cubic feet of usable volume per person. MSHA believes that these proposed minimums are necessary to provide adequate room for miners using the refuge alternative. Usable space or volume means space or volume without stored items. The space and volume requirements are exclusive of the airlock space and volume. NIOSH design parameters requested 15 square feet and 85 cubic feet per miner. NIOSH stated that these recommendations were not to be considered absolute. Under this proposed provision, a space of 6 feet of length and 2.5 feet of width would amount to 15 square feet. If the same area has a height of 4 feet, the miner would be provided with 60 cubic feet of space. For mines with lower heights, the 60 cubic feet of space may need to be attained by increasing the length or floor area. MSHA solicits comments on these minimum space and volume requirements. Comments should be specific, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and supporting data. The area cannot be determined solely by the number of miners that would be using the refuge alternative. Miners would need some free space to operate components, drink, eat, and use the sanitation facilities—and tend to injuries. Additional space may be needed for suspended curtains, as party of a passive system CO2 removal system. Also larger volumes seem to be more effective at dissipating heat.

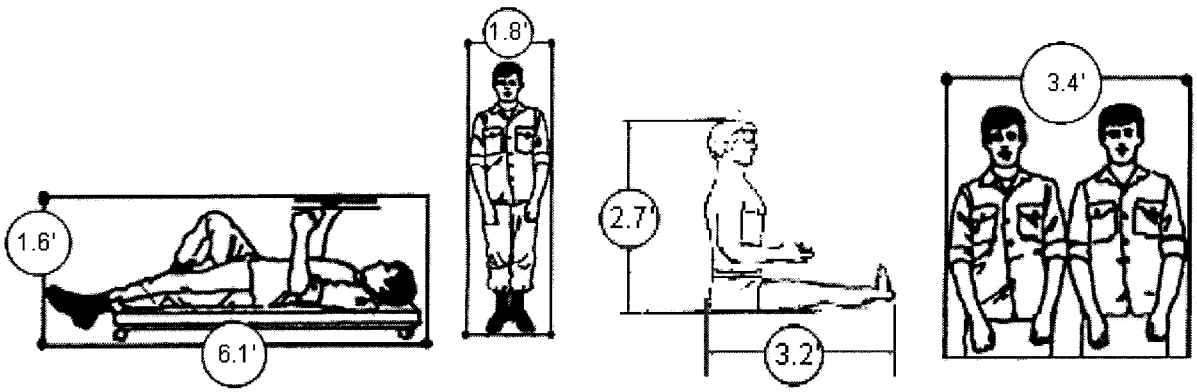
This requirement is based upon a statement in the NIOSH report that was taken from a footnote in a 1986 report that referenced a 1958 Civil Defense publication (TB-5-3, May 1958). That document was researched by the NIOSH contract authors. If they had would have found it providing guidance for family fall out shelters that requested 80 cubic feet per person. It has no relevance to this application, a fact that has been confirmed to me by the NIOSH staff. If the MSHA staff would have called them they would have been told the same.

Fallout shelters were designed for occupancy by untrained civilians for periods of at least two weeks. Underground emergency shelters are designed for the survival of trained miners for a period of not more than 96 hours but most likely less than 48 hours.

The net effect of this provision would be to reduce the effective occupancy of currently approved shelters by up to 50% and more than double their number of units required underground. This increases the potential for injuries resulting from handling these units during normal operations. It increases the number of locations to which mine rescue team may have to reach to find all the miners. Alternatively, it would require such extensive redesigns of the air quality systems as to make the unit impractical. It would also effectively eliminate all options for low coal seams.

There appears to no basis for the MSHA 60 cubic foot value other than it is less than the Civil Defense value. If one were to look for a realistic volume and floor space value, the best source is the military.

The US Department of Defense Human Engineering Manual (MIL-HDBK-759C) indicates that a supine man should have a space of 1.6 feet high by 6.1 feet long. It defines the space required for a man sitting to be 2.7 feet high by 3.2 feet long. If we assume that these are the two extreme positions in a shelter, we get a maximum volume of 29.6 cubic feet and a floor space of 10.9 square feet. (This value is arrived at by using the height of the sitting man, the length of the supine man and the design shoulder width.) As a point of reference, the South African regulation is 6.4 square feet of floor space with no volume value (Chief Inspector of Mines Directive B5, 14 Feb. 1994).



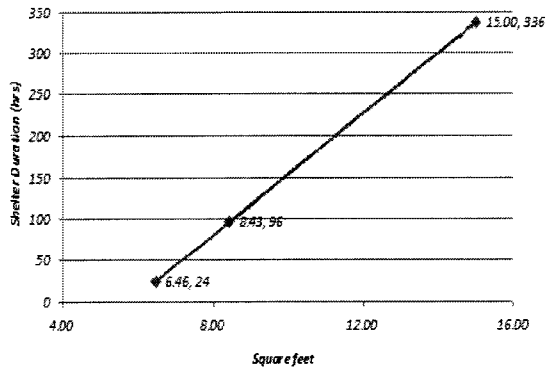
Images taken from the US Department of Defense Human Engineering Manual (MIL-HDBK-759C) and modified to indicate English units verse Metric units.

Since low-coal mines can result in interior shelter heights of 2 feet, the sitting position would not be applicable. In those situations, the volume would be limited to that of the supine position with a volume requirement of 17.6 cubic feet.

Additionally, the Department of Defense document identifies as 3.4 feet the space required for two men, which provides some guidance for the number of miners in given shelter length.

Another approach that has been suggested by some could be to extrapolate between the values utilized in South Africa mine shelters since the 1990's of and those of the U.S.

Navy for 100 men in fallout shelters for 14 days. This would result in a value of 8.4 square feet.



However, it is important to remember that emergency shelters are the last resort in the event of an accident to ensure survival not to ensure comfort. As one miner told me after a training session on all the things we have done to improve their chances for escape, "With all these extra escape additions if I have to, the decision to get into a shelter or not boils down to the shelter or a body bag...it's not that a hard a choice." Comfort is not the main consideration...survival is the ONLY consideration.

Additionally the concept of using the shift change to determine the maximum number of occupants of a shelter was adopted by West Virginia. It was recognized as not only practical but provided an almost 100% safety margin for those most likely to be using a shelter. In a three-shift mine, the maximum number of people would be at the section once each shift. The "hot seat" process takes between 15 and 30 minutes then the shift relived makes it way to the exit. That means between 45 and 90 minutes of each day there are the full number of miners near the shelter. Since there are 1440 minutes in day that means that between 96.8% and 93.7% of the time there are only half the number of men in the area that the shelter can support. This makes a huge difference in the survivability of any that must use them.

It is highly requested that this requirement be stricken as unnecessary.

Comment 44 concerning the statement:

Section 7.505 Paragraph (a)(2) would require that refuge alternatives include storage space for securing and protecting the components during transport and that permits ready access to components for inspection, maintenance, and activation. The proposed rule is intended to provide adequate storage space in addition to the usable space required for persons occupying the unit. The storage space is required for the supplies in containers. The containers need to be secured to prevent movement during transport. The supplies should be located to provide usable space for miners and to be accessible for inspection while the refuge alternative is stored. The components should be positioned to allow for visual checks for availability, readiness and shelf life dates.

Agree with the concept, however, because of the number of components and the fact that you have not defined what a component is; MSHA is setting up a situation where the shelter may have to actually be entered for each inspection. This will allow unnecessary contamination and damage that may affect the unit's performance in an emergency.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 45 concerning the statement:

Section 7.505 Paragraph (a)(3) would require that refuge alternatives include an airlock that creates a barrier to isolate the interior space from the mine atmosphere, except for a refuge alternative capable of maintaining adequate positive pressure. The intent of this provision is to provide breathable air to miners entering the refuge alternative if the mine atmosphere is contaminated. The miners would need to go into the refuge alternative through an airlock supplied with breathable air. The airlock would minimize the amount of contaminated mine air that could enter the interior space of the refuge alternative. The airlock would need to have positive pressure to prevent the contaminated atmosphere from entering the airlock when the outside door is opened. Conversely when the inside door of the airlock is opened, the air inside the airlock should not readily enter the interior space of the refuge alternative. Pressures need to be different between the interior space, airlock space and mine atmosphere. Pressures need to be incrementally higher in the interior space as compared to the airlock and the airlock pressure needs to be higher than the mine atmosphere. Miners will pass through the airlock via airtight doors into the interior space.

The proposed rule includes an exception for an airlock if the refuge alternative is capable of maintaining adequate positive pressure. The positive pressure would prevent outside air from contaminating the refuge alternative, therefore an airlock would not be necessary.

Section 7.505 Paragraph (a)(3)(i) would require that the airlock be designed to be used multiple times to accommodate the structure's maximum occupancy. This provision would assure access for the number of persons for which the refuge alternative is designed.

While we strongly agree on the value of an airlock, the first sentence includes, *"except for a refuge alternative capable of maintaining adequate positive pressure."* Since previous sections of the regulation require all shelter to have positive pressure this seems a contradiction. If the authors intend to imply that there is some level of "adequate positive pressure" below which an airlock is not required that should be specified. However, it is our view that it will hard to demonstrate such a system is technically feasible except by providing individual open-circuit breathing options. It is requested that a more definitive definition of an airlock be provided and the situations where they are not required be specified.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 46 concerning the statement:

Section 7.505 Paragraph (a)(3)(ii) would require that the airlock be configured to accommodate a stretcher without compromising the airlock's function. Following a mine accident, miners that would use the refuge alternative may be injured and transported on a stretcher. The airlock would need to be an adequate length to accommodate the stretcher (with injured miner) in the airlock with the outside door closed (to allow the interior door to be opened for access to the interior space).

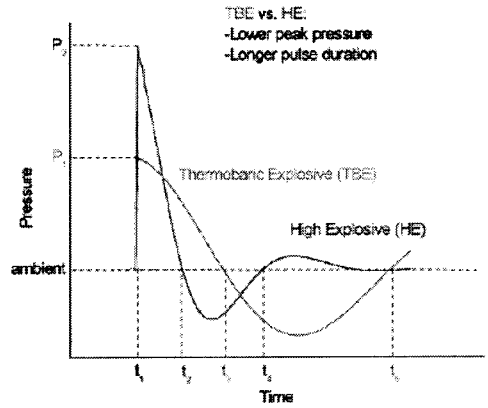
Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 47 concerning the statement:

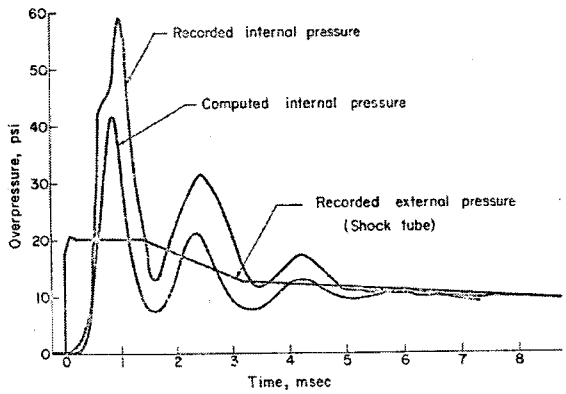
Section 7.505 Paragraph (a)(4) would require that refuge alternatives be designed and constructed to withstand 15 pounds per square inch (psi) overpressure for 0.2 seconds prior to activation.

Agree. As discussed in the Comment 11 the period listed in the text is 0.2 seconds. This is effectively a static load and provides multiple means of testing. While there has been discussion of using a period in the few millisecond range, the seminal study on the subject of human effects of blast waves, "The Biodynamics of Airblast" by Clayton S. White, et al sponsored by the Defense Nuclear Agency in 1971, indicates that in closed environment such as building or mines that wave reflection and wave stacking result in not only higher effective overpressures but prolonged durations. An overpressure event of 15 psi in mine entry could easily produce an effective duration exceeding 0.5 seconds that would not affect the design criteria for a shelter but would increase the trauma of anyone in the blast zone.

1: Pressure history of high explosive (HE) and thermobaric explosive (TBE) detonations



Additionally the internal amplification of the overpressure due to wave stacking within the body found was found in these studies. An external pressure of 20 psi resulted in an in-lung pressure of 60 psi (see page 77 of the above report). The cause of fatality in animal studies has shown to be damage to the lungs.

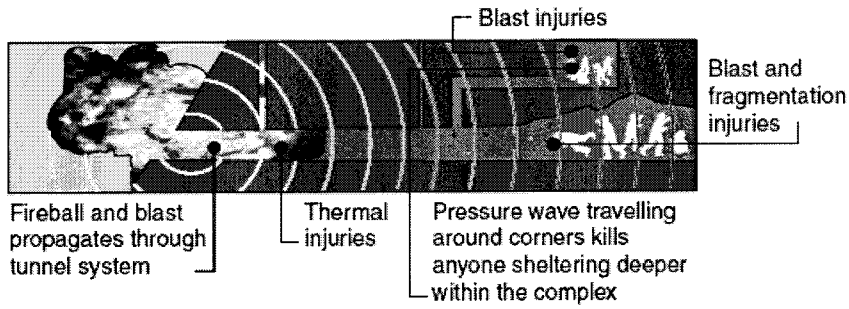


These results have more recently been replicated in studies of thermobaric (air vapor) weapons whose purpose is to create overpressure fatalities in enclosed spaces such as caves or bunkers. They find that there is over a factor three to nine increase in fatalities for a given overpressure in enclosed space over that in open air. A 1988 study done on the effects of vapor cloud explosions in the chemical industry by ICI Engineering and included in NIOSH Docket 125 reports a probability of fatality of 100% at 10 psi over pressure in a building.

Studies conducted in recent times by the military have resulted in a new class of weapons based upon these effects. Thermobaric weapons create a vapor cloud, which when ignited produce blast waves with the characteristics of vapor air explosions. These studies have resulted in data in which while the initial explosive force may not be as great as that from high explosives produces a longer duration of over pressure. As noted above this longer duration causes greater trauma to those in its path.

The US and UK military have deployed thermobaric weapons in the cave complexes in Afghanistan. They have reported from a military standpoint that they are effective.

A recent article on their application included the image here. Similar articles on these weapons places severity of the trauma inflected in a closed space such as mine tunnel at three times those experienced in open air. Current design criteria call for a design overpressure of at least 13 psi for these devices. Based upon these and the above values the 15 psi value for survivability of the shelter is sufficient as levels higher than that would not likely result in survivors.



All of this in relevant to an explosion in a mine in that it decreases the likelihood of survivors of an over pressure greater than the threshold values discussed above.

Comment 48 concerning the statement:

Section 7.505 Proposed paragraph (a)(5) would require that refuge alternatives be designed and constructed to withstand exposure to a flash fire of 300 °Fahrenheit for 3 seconds prior to activation.

Agree. Based upon the flame front patterns of a methane explosion the temperatures and duration are sufficiently conservative to ensure survivability. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 49 concerning the statement:

Section 7.505 Paragraph (a)(6) would require that refuge alternatives be constructed with materials that are noncombustible or MSHA-approved flame-resistant. MSHA tests for flame resistance of brattice cloth under 30 CFR 7.27 could be used to determine the flame resistance of noncombustible materials in refuge alternatives. Materials under this provision could include, but would not be limited to inflatable stoppings, inflatable shelters, and any materials providing a barrier used to protect the inside atmosphere from the hazardous outside atmosphere. Materials are generally tested for noncombustibility under ASTM E 136 ''Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C'' (2004), although a similar ISO test, ''ISO 1182:2002'' also exists.

Agree provided the final rule applies only to all materials exposed at the time of the initial event. Items that would be stored inside an undeployed shelter that itself has passed the noncombustibility test should not be subject to this requirement. The language should be clarified to avoid confusion on the party of applicant and reviewers.

However, the mention of inflatable stoppings here again begs the question regarding if MSHA proposes that post accident barricades can be erected and purged of hazardous air. This has not been demonstrated computationally or in practice and if that is MSHA intent then we must strongly object. Lacking a demonstrated methodology of purging a

space that has been contaminated to levels safe, enough to allow the removal of SCSRs this seems foolhardy.

With regard to those manufacturers who have successfully completed an approval by a state mine health and safety agency that those approvals and those supporting documents be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 50 concerning the statement:

Section 7.505 Paragraph (a)(7) would require that refuge alternatives be constructed from reinforced material that has sufficient durability to withstand routine handling and resist puncture and tearing during activation and use. Refuge alternatives need to be capable of withstanding the harsh mining environment and require materials to withstand abrasion, tears and punctures during handling and activation. This especially applies to inflatable-type stoppings and tent refuge alternatives. These materials must be made to isolate areas without compromising the interior atmosphere of the refuge alternative.

Agree. Again, there is confusion regarding the inclusion of stoppings in this text that must be resolved. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 51 concerning the statement:

Section 7.505 Paragraph (a)(8) would require that refuge alternatives be guarded or reinforced to prevent damage that would hinder activation, entry, or use. This paragraph would assure the refuge alternative design incorporates protective features to protect the integrity of the barrier and operation of doors, inflatable extensions of the refuge alternative, or any other functions necessary to use the refuge alternative.

Agree. It is again requested the final rule allow for sufficient flexibility such that manufacturers are not required to seek modification because a particular mine wants different or additional protection of hitching mechanisms. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 51 concerning the statement:

Section 7.505 Paragraph (a)(9) would require that refuge alternatives be designed to permit measurement of outside gas concentrations without exiting the structure or allowing entry of the outside atmosphere. Miners would need to conduct gas monitoring of the atmosphere outside of the isolated interior space to monitor harmful gas levels outside the refuge alternative when there is a lack of communication with rescuers and the occupants are considering whether evacuation is a viable option. To assure the safety of the miners, the design should incorporate methods or equipment that can monitor outside of the interior space without contamination.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 52 concerning the statement:

Section 7.505 Paragraph (b)(1) would require that tests be conducted to determine or demonstrate that the refuge alternative can be constructed, activated and used as intended. Under this provision, trained persons would need to be able to fully activate the structure, without the use of tools, within 10 minutes of reaching the refuge alternative. This provision would assure that miners can use the refuge alternative upon reaching it. Following an accident, the first actions of the miners are to attempt to evacuate wearing SCSRs. In a worst-case scenario, only one SCSR may be available to provide 60 minutes of breathable air. The first 30 minutes would enable the miner to attempt to evacuate and return to the refuge alternative if escape is impossible. If the miner cannot escape, and returns to a refuge alternative, the miner would have 10 minutes to establish a barrier between the interior and exterior atmospheres. The remaining 20 minutes of breathable air provided by the SCSR will allow refuge alternative purging to establish a breathable air atmosphere. It is expected that the testing under this paragraph would be conducted using simulated real-life situations and conditions, such as smoke, heat, humidity and darkness using SCSRs.

Again, there is concern about the use of the word "constructed" that implies the use of a post-event barricade which has not been demonstrated as effective. Additionally, the objective is to provide fresh air that is sufficiently safe to take off their SCSR. That is pre-established upon the opening of the shelter in the case of the hard-sided units or upon initial inflation on the part of the soft-sided units or in the case of the open-circuit units described in later section of this rule, once the face masks are donned the miners are safe. At that point, they will complete the deployment of various scrubbing subsystems etc. that will make the unit fully activated, but are in safe air while doing so. It is not believed possible that a post event atmosphere can be established using inflatable stoppings and purge air as described throughout this proposed rule. It is requested that the final rule simply state 30 minutes as the maximum time to establish safe air.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 53 concerning the statement:

Paragraph (b)(2) would test that an overpressure of 15 psi applied to the pre-activated refuge alternative structure for 0.2 seconds would not allow gases to pass through the barrier separating the interior and exterior atmospheres.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 54 concerning the statement:

Paragraph (b)(3) would test that a flash fire of 300° Fahrenheit for 3 seconds would not allow gases to pass from the outside to the inside of the structure.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 53 concerning the statement:

Section 7.505 Paragraphs (b)(2) and (b)(3) would assure that the refuge alternative is tested to verify that it will withstand an initial explosion and fire. It would also assure the structure and components are intact following a fire or explosion. The testing should demonstrate that the integrity of the barrier and operation of doors is maintained. MSHA tests for flame resistance of brattice cloth at 30 CFR 7.27 could be used to determine the flame resistance of noncombustible materials in refuge alternatives. Materials under this provision could include, but would not be limited to inflatable stoppings, inflatable shelters, and any materials providing a barrier used to protect the inside atmosphere from the hazardous outside atmosphere. Materials are generally tested for noncombustibility using ASTM E 136 ''Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C'' (2004), although a similar ISO test, ''ISO 1182:2002'' also exists.

Besides the recurring use of the term inflatable stoppings, isn't the flame issue not already covered under Section 7.505 Paragraph (a)(6)? It is requested that the final rule undergo a technical edit to identify redundant requirements and consolidate them for ease of understanding and enforcement.

Comment 54 concerning the statement:

Section 7.505 Paragraph (b)(4) would test that the expected overpressure forces do not prevent the stored components from operating.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 55 concerning the statement:

Section 7.505 Paragraph (b)(5) would test that a flash fire does not prevent the stored components from operating.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 56 concerning the statement:

Section 7.505 Paragraphs (b)(4) and (b)(5) would assure that refuge alternatives are tested to demonstrate that they will withstand an initial explosion and fire. Additionally, the test should assure that an isolated atmosphere is provided for the miners and the components are not damaged and are able to function as intended.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 57 concerning the statement:

Section 7.505 Paragraph (b)(6) would require testing to demonstrate that each structure resists puncture and tearing when tested in accordance with ASTM D2582–07 ''Standard Test Method for Puncture-Propagation Tear Resistance of Plastic Film and Thin Sheeting.'' This provision will test the capability of material used to construct the refuge alternative. The material must withstand the harsh mining environment and abrasion, tears, and punctures during handling, transportation and activation. This especially applies to inflatable-type stoppings and tent refuge alternatives. These materials must be made to maintain barriers without compromising the atmosphere established on the interior of the refuge alternative.

Request that the term stopping be omitted.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 58 concerning the statement:

Section 7.505 Paragraph (b)(7) would require that each reasonably anticipated repair can be completed within 10 minutes of opening the storage space for repair materials and tools. The inflatable-type refuge alternative has the potential to be ripped, torn or develop a leak. The refuge alternative must maintain an isolated atmosphere at all times. If a leak or tear occurs, the miners should be able to repair it with little delay or their safety could be jeopardized. The test would demonstrate that a miner would be able to make a repair, such as mending a tear or resealing the fabric, within 10 minutes of opening the storage space.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 59 concerning the statement:

Section 7.505 Paragraph (b)(8) would require that nonmetallic materials used to construct the refuge alternative, not release harmful gases or noticeable odors before or after the flash fire test. The test would determine the identity and concentrations of gases released. This provision would require a test of the material used to construct the refuge alternative to assure that the materials do not emit noticeable

odors that may sicken the miners occupying the refuge alternative. The testing should include provisions and instruments for detecting any released gases. Materials (i.e., paints, plastics, fiber, etc.) used in the manufacturing of the refuge alternative should not release harmful fumes, vapors, or gases.

Request the final rule be modified to indicate, as above, that this applies only to those materials that are exposed at the time of the event.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 60 concerning the statements:

Proposed § 7.505(c) addresses refuge alternatives that use pressurized air to activate the structure or maintain its shape.

Section 7.505 Paragraph (c)(1) would require a pressure regulator or other means to prevent over-pressurization of structures that use pressurized air to activate the structure or maintain its shape. Overpressurization of the interior space or airlock space would be detrimental to the safety of the miners. The regulator should be designed to assure that proper relief of overpressure can be accomplished.

Paragraph (c)(2) would require inclusion of a means to repair and repressurize the structure in case of failure of the structure or loss of air pressure. If the inflatable-type structure is damaged or leaks, it will need repair and additional compressed air to establish the pressure and volume of air that was lost.

Proposed § 7.505(d)(1) would require that refuge alternatives be designed such that pre-shift examination of the components critical for activation can be conducted without entering the structure.

Section 7.505 Paragraph (d)(2) would require that a refuge alternative be designed to provide a means to indicate unauthorized entry or tampering.

Section 7.505 Paragraphs (d)(1) and (d)(2) would assure that the refuge alternative is designed to allow for all necessary inspections. The gauges and controls for critical components, such as compressed air and oxygen, should be easy to observe to determine the readiness of those components.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 61 concerning the statement:

Section 7.506 Paragraph (a) would require that breathable air be supplied by compressed air cylinders, compressed breathable-oxygen cylinders, fans installed on the surface or compressors installed on the surface. Only uncontaminated breathable air is allowed to be supplied to the refuge alternative. Maintaining breathable air inside the refuge alternative is vital to sustain persons trapped underground. Currently MSHA will accept compressed air cylinders and compressed breathable oxygen cylinders as a means to supply breathable air in underground coal mines. MSHA will also accept fans or compressors installed on the surface as a means to supply breathable air in these mines. The proposed rule addresses MSHA's need to evaluate whether breathable air components will meet the requirement for sustaining

persons for 96 hours in a refuge alternative. Provisions regarding the proper use of approved breathable air components are important for MSHA to use in determining that a component will provide adequate air inside the refuge alternative. The Agency recognizes that different types and combinations of breathable air components from several manufacturers may be used to provide breathable air for refuge alternatives. MSHA needs to assure that these components and combination of components are reliable and ready to use for maintaining persons as necessary over the 96-hour period.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 62 concerning the statement:

Section 7.506 Paragraph (b) would require that mechanisms be provided and procedures be followed within the refuge alternative such that (1) breathable air sustain each person for 96 hours; (2) the oxygen concentration be maintained at levels between 18.5 and 23 percent; and (3) the average carbon dioxide concentration be maintained at 1.0 percent or less, with excursions not to exceed 2.5 percent.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 63 concerning the statement:

Section 7.506 Paragraph (b)(1) addresses MSHA's need to evaluate the effectiveness and compatibility of the breathable air components to assure that the supply of breathable air is sufficient to sustain persons occupying the refuge alternative for 96 hours. In MSHA's February 8, 2007, Program Information Bulletin No. P07–03, (PIB P07–03), MSHA addressed that the Agency considered 96 hours to be necessary. MSHA concluded that a 96-hour supply was warranted, and accordingly, the Agency is proposing 96 hours as a time that breathable air would need to be provided. MSHA solicits comments on the proposed 96- hour supply of breathable air. Comments should be specific, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and supporting data. In arriving at this 96-hour minimum, MSHA reviewed recent and historical data on entrapments. While it is clear that refuge alternatives can save the lives of trapped persons, it was not clear how long refuge alternatives should be capable of sustaining miners. The depth of the mine, the geology of the overburden, and the terrain above the mine significantly affects rescue activities.

Since PIB P07-03 was not subject to public comment this is the first opportunity to discuss the subject. A review of the 12 accidents presented in the NIOSH Docket 125 discussed above and a review of MSHA historical records on accidents does not support 96 hours as the most likely duration. The State of West Virginia conducted such a review and concluded that the most likely maximum time to rescue was 41 hours. It therefore set the minimum duration at 48 hours. Prior to PIB P07-03, the shelter industry was already extending the duration of their units as a function of natural competitive pressure. Without consultation of those working on the state standards or the inquiring into the ability of manufacturers to comply, the PIB doubled the value. To avoid a show down between Federal and State regulators manufactures expended time and expense and redesigned to accommodate the additional supplies increasing the complexity and cost of their devices. While, the additional duration provides a significant margin of safety,

there has never been an explanation of its derivation or validity. It is requested that MSHA provide the logic for the 96 hours and if can not be supported that the final rule stipulate at least 48 hours.

The last sentence in the above statement indicates that MSHA considered differences of geology and terrain's effects upon mine rescue times. However, the empirical evidence does not indicate that the wide range of geologies and terrains related the accident evaluated by NIOSH or in the review of the National Research Council or the summary of the 1983 Foster Miller study on shelters or a review of the durations prior to rescue or recovery indicate a duration beyond the 48 hours initially selected after reviewing all this data.

The only source for durations longer than 48 hours was a 1971 study by the Bureau of Mines done by the Westinghouse Corporation in which 5 days was chosen in the contract as a stipulation of the design of a shelter not because of the analysis. This value predates even the introduction of SCSR let alone all the other escape and rescue innovations of the last 40 years. The South African mine laws place the burden on the mines to determine the duration of occupancy. They utilize units ranging from large "bomb shelter" types spaces with unlimited duration due to ventilation and supply holes to the surface to 24-hour portable units. In Australia there, is likewise a range of solution deployed again based upon the assessment of the individual mines in coordination with the government.

While a margin of safety is desirable, there should be some basis for determining what that margin is. It is therefore requested that MSHA explain the basis for doubling the duration developed by the West Virginia mine office after considerable research. If logic does not exist for 96 hours, the final rule should state "at least 48 hours."

Comment 64 concerning the statement:

Section 7.506 Paragraph (b)(2) would require that mechanisms be provided and procedures be followed within the refuge alternative such that the oxygen concentration be maintained at levels between 18.5 and 23 percent. In this subpart, MSHA is defining breathable oxygen as oxygen that is at least 99 percent pure with no harmful contaminants. Acceptable breathable oxygen is frequently supplied from a compressed gas cylinder as U.S. Pharmacopoeia medical oxygen or as aviator breathing oxygen. In addition, consistent with NIOSH's recommendation, the Agency proposes that breathable air contain an oxygen concentration between 18.5 and 23 percent.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 65 concerning the statement:

Section 7.506 Paragraph (b)(3) would require that the average carbon dioxide concentration be maintained at 1.0 percent or less, with excursions not to exceed 2.5 percent. In this subpart, MSHA proposes that breathable air contain no harmful quantities of asphyxiant, irritant, or toxic gases, fumes, mists, or dusts. This is consistent with NIOSH's recommendation. The provision proposes that the carbon dioxide concentration not exceed a 1.0 percent time weighted average over the rated duration of the refuge alternative with excursions not to exceed 2.5 percent. MSHA is assuming that breathing rates for

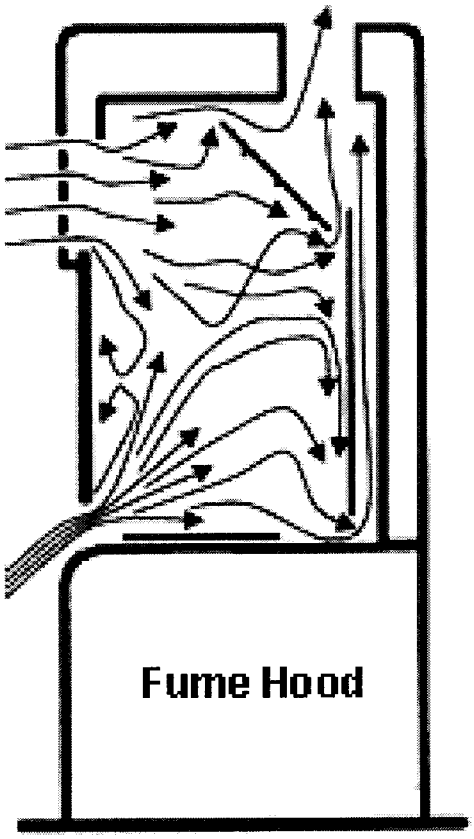
miners who have reached refuge alternatives would consist of activity levels of 4/5 at rest and 1/5 moderate activity. Therefore, using the respiratory quotient, which is the ratio of CO2 that expelled to O2 consumed, the average carbon dioxide generation is 1.08 cubic feet per hour per person. These breathing rates were based upon the U.S. Bureau of Mines Foster Miller Report of 1983, ''Development of Guidelines for Rescue Chambers,'' Volume I (Foster Miller report). The Agency recognizes that in an enclosed space, miners may die from the effects of CO2 rather than the effects of O2 deficiency. In PIB P07–03, MSHA demonstrated the rate at which a person would overexpose from carbon dioxide if carbon dioxide were not removed from the environment. MSHA used air supply calculations and activity levels based upon information provided in the Foster Miller report.

We agree with the carbon dioxide removal necessity; however, believe the activity levels are unrealistic considering the physical space within the shelter. The result has been the increase in the volume of oxygen and carbon dioxide scrubbing required. This likely provides an additional safety factor however, introduces the possibility of over oxygenating the space unless the occupant utilize their monitors to ensure that the level does not exceed the 23% target set out in this regulation. The basis for the 4/5 – 1/5 ratios has never been explained and it is requested that the basis for the determination along with references utilized in determining the activity levels be provided. If a logical explanation for the value cannot be determined, it is requested that it be deleted in the final rule.

Comment 66 concerning the statement:

Section 7.506 Paragraph (c) would require that breathable air supplied by compressed air from cylinders, fans, or compressors provide a minimum flow rate of 12.5 cubic feet per minute of breathable air for each miner. MSHA proposes to use 12.5 cubic feet per minute of breathable air as a required volume for each miner based on the amount of air needed for respiration and dilution of CO2 and other harmful gases. In addition, the 12.5 cubic feet per minute flow rate would assure positive pressure to prevent contamination from the mine atmosphere. A maximum positive relief valve would need to be located in the refuge alternative. MSHA requests comments regarding the flow rate. Comments should be specific including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and supporting data.

MSHA considered the enclosed space as similar to a loose-hood respirator using supplied air. Flair Corporation Bulletin 270 revision H (4–01) indicates that OSHA requires a supply air of 6 to 15 cfm (360 to 900 cfm) for supplied air hoods (continuous flow supplied air respirators) to purge accumulated carbon dioxide. The 12.5 cfm per person fell within this range. Engineering handbooks recommend ventilation rates in the range 10–15 cfm of fresh air per person for offices with 12.5 cfm per person being the midpoint of this range. MSHA believes that these quantities are conservative. However, they are design parameters for a life support system, which demands a more cautious approach. In addition, compressor wear reduces performance and the system will become less efficient with age. The Agency considers that the use of compressed air cylinders as the sole means of providing breathable air may be impractical and encourages mine operators to consider other options. As MSHA pointed out in PIB P07–03, a fan or equivalent method should be used to force fresh air into the hole with enough positive pressure to overcome total mine pressure to deliver sufficient quantities of breathable air. Compressor air intakes should be installed and maintained to assure that only clean, uncontaminated air enters the compressors. Mines should assure compressors have the capacity to deliver the required volume of air at the point of expected usage.

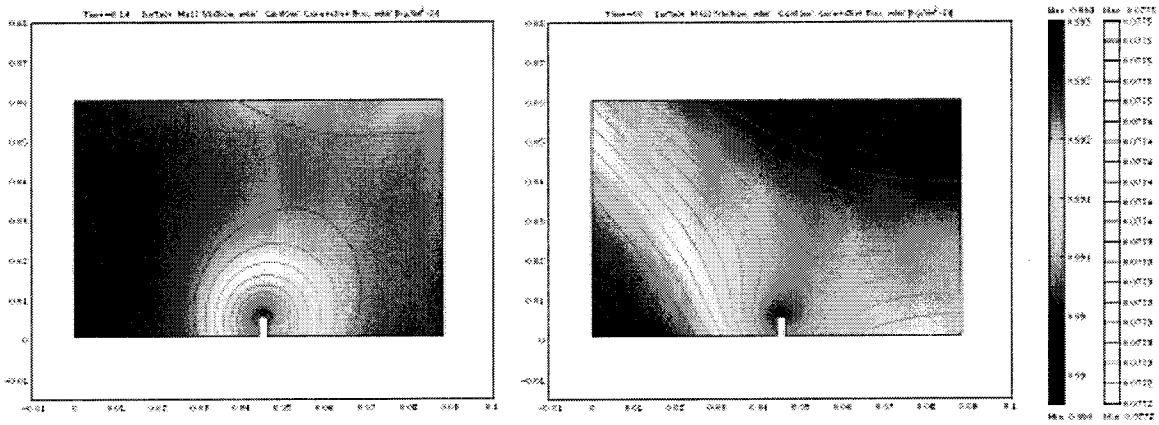


Open circuit respirators such as the one used in this analogy are designed with great care to ensure that the flow of air routes any contaminates in such a manner that they do not become trapped with the space. The document referenced could not be found however, the laboratory fume hood a more appropriate analogy. It is designed to ensure sufficient ventilation of large space such that hazardous gases are continuously removed from all corners of the space. The airflow and surfaces are designed to ensure sufficient turbulence of the high airflow (125 cfm) within the hood to ensure sufficient movement to carry any hazardous compounds from the space. This is a good analogy for what is needed to happen if an inflatable stopping were erected in a hazardous environment and the space needed to be purged.

Supplied air respirators such as the personal protection hood referenced in the MSHA text cover the head with an open flap along the shoulder and chest. Air is injected at the top rear of the head and works its way through the space toward to opening. The distance between the head and the inside of the hood is small and while the air flow is complicated, the possibility of leaving pockets of hazardous gases is low. However, the airflow patterns while still critical are simpler and the flow rates are much lower in the 24 cfm range.

Evaluations done by various manufactures and internally at MSHA have indicated the difficulty and complexity of purging a space once it is contaminated with carbon monoxide. These consideration have been taken into account by the manufacturers that have been through the West Virginia approval process. And those units can be successfully purged although the airlock should eliminate that need.

West Virginia University was asked to conduct a computational fluid dynamics model of PIB 07-03 with the assumption that the space is initially contaminated with toxic levels of carbon monoxide. The results could not demonstrate a means of purging the space using the MSHA standards.



For those looking at this in black and white, the dark red colors in the lower left of both images are above the fatal concentration of carbon monoxide and dark blue area in the upper right of the right image are carbon monoxide free.

The image to right shows the concentrations of carbon monoxide 30 seconds after the purge air tanks are opened. You will note that the lower left has the same initial levels of carbon monoxide. The area immediate to the point where the air is release is now blue. The image to the left is after 50 minutes of continuous tank discharge. Here the area in the lower left still has the initial carbon monoxide levels. The area to upper right near where the shelter air exits the barricade is now free of carbon monoxide; however, the area in middle still contains various levels of carbon monoxide. The amount of air used in the 50-minute model is over three times the actual ability of the tanks to supply purge air. It was an attempt to see if it could be done if enough air were available. Another point was because of funding we could only looked at this as a two-dimensional problem. It is expected that in a true three-dimensional model there would pockets of carbon monoxide at various points along the roof and floor that exceeded the safe thresholds as well.

The information provided by MSHA does not support their contention that a stopping can be erected after an event that creates hazardous gases without significant engineering that the air flow from a the single borehole they propose through an pressure relief valve in an inflatable stopping will be able to reduce toxic levels of contaminates in the space within the 10 minutes required in the previous section of this regulation. It may indeed not be able to reduce all pockets of hazardous gases in the space in any period.

<u>It is strongly requested that until MSHA is able to demonstrate that post event erected inflatable stoppings can be made safe that they not be allowed.</u>

Comment 67 concerning the statement:

Section 7.506 Paragraph (c)(1) would require that compressed air from cylinders, fans or compressors provide a minimum flow rate of 12.5 cubic feet per minute of breathable air for each miner. Fans or compressors would be required to (i) be equipped with a carbon monoxide detector located at the surface that automatically provides a visual and audible alarm if carbon monoxide in supplied air exceeds 10 ppm; (ii) provide in-line air-purifying sorbent beds and filters or other equivalent means to assure the breathing air quality and prevent condensation; (iii) include maintenance instructions that provide

specifications for periodic replacement or refurbishment of sorbent beds and filters or alternate means; (iv) provide an automatic means to assure that the maximum allowable positive pressure is not exceeded in the refuge alternative; (v) include warnings to assure that only uncontaminated breathable air is supplied to the refuge alternative; (vi) include air lines to supply breathable air from the fan or compressor to the refuge alternative; and (vii) assure that harmful or explosive gases, water, and other materials cannot enter the breathable air. In addition, the proposal would require that air lines be capable of preventing or removing water accumulation, and be designed and protected to prevent damage during normal mining operations, a flash fire of 300° F for 3 seconds, a pressure wave of 15 psi overpressure for 0.2 seconds, and ground failure. In PIB P07–03, MSHA provided a number of recommendations regarding hazards stemming from the use of compressors to provide breathable air underground. The Agency also acknowledges that these recommendations would apply to the use of fans used for the same purpose. As such, MSHA requested that compressor air intakes should be installed to assure that only clean, uncontaminated air enters the compressors. Care should be exercised when using compressors in the vicinity of other equipment having gas or diesel engines. Gas engines emit carbon monoxide (toxic fumes) and diesel engines emit sulfur dioxide (noxious fumes) and nitrogen oxides. Compressors requiring oil can generate carbon monoxide (CO) internally which can be supplied inadvertently to miners. Oil-type compressors could be used; however, the air quality must be sampled and/or controlled using CO filtration. Oil-less compressors do not generate carbon monoxide; thus, no CO filtering is required.

Again, it is highly requested that until such time as MSHA is able to demonstrate that this option is as safe as manufactured shelters whose deployment does not include trapping of hazardous air inside the shelter that the use of inflatable stoppings not be allowed as a class of solutions.

Comment 68 concerning the statements:

Section 7.506 Paragraph (c)(1)(i) would require carbon monoxide detectors for compressors or fans at the surface that automatically provide a visual and audible alarm if carbon monoxide in supplied air exceeds 10 ppm because compressors powered by gas engines emit carbon monoxide. Through the use of detectors at the surface, this provision is intended to assure that harmful levels of carbon monoxide would not be transferred into the refuge alternative from this equipment. MSHA is proposing to use the same early warning level for carbon monoxide in compressor supplied breathable air as established by OSHA, which will maintain uniformity in requirements for the use of such specialized equipment. MSHA believes warning operators when the CO level exceeds 10 ppm will help maintain safe breathable air in the refuge alternative. MSHA solicits comments on this provision including alternatives.

Section 7.506 Paragraph (c)(1)(ii) would require inline air-purifying sorbent beds and filters or other equivalent means to assure the breathing air quality and prevent condensation. Sorbent beds and filters would help assure that the air quality is maintained and condensation is prevented.

Section 7.506 Paragraph (c)(1)(iii) would require maintenance instructions that provide specifications for periodic replacement or refurbishment of sorbent beds and filters or alternate means. Proper maintenance and periodic replacement of sorbent beds and filters would help assure that the air quality is maintained and condensation is prevented.

Section 7.506 Paragraph (c)(1)(iv) would require that fans or compressors provide positive pressure and an automatic means to assure that the pressure is relieved in the refuge alternative at 0.25 psi above mine atmospheric pressure. MSHA believes that positive pressure to exceed total mine pressure will prevent contamination and allow sufficient quantities of breathable air. The pressure should be adequate for the intended purpose, but not excessive where it creates adverse physiological effects for the miners. An

automatic means, such as a relief valve set at 0.25 psi, should be provided to assure that the refuge alternative is not overpressurized if breathable air is being supplied through a borehole or other means. The Foster Miller report specifies a minimum of 5 inches of water gage overpressure in the refuge alternative that is equivalent to approximately 0.18 psi. Currently, most manufactured refuge alternatives have relief valves set at 0.25 psi. Having too much pressure differential would make opening doors difficult for miners entering the refuge alternative. MSHA requests comments on the proposed setting for pressure relief and whether a higher pressure relief should be required. Comments should be specific including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and supporting data.

Section 7.506 Paragraph (c)(1)(v) would require warnings to assure that only uncontaminated breathable air is supplied to the refuge alternative. This provision is intended to assure that only clean, uncontaminated air enters the compressors. Care should be exercised when using compressors or fans in the vicinity of other equipment having gas or diesel engines.

Section 7.506 Paragraph (c)(1)(vi) would require that fans or compressors supplying breathable air underground include air lines to supply the air to the refuge alternative, that (A) air lines be capable of preventing or removing water accumulation, and that (B) air lines be designed and protected to prevent damage during normal mining operations, a flash fire of 300 °F for 3 seconds, a pressure wave of 15 psi overpressure for 0.2 seconds, and ground failure.

Section 7.506 Proposed paragraph (c)(1)(vi)(A) is intended to prevent accumulation of water, which could affect the quantity and quality of breathable air provided underground. Moisture-laden air should not be pumped into the area where miners are trapped. If this moisture is not removed water could accumulate in the refuge alternative. All air supply systems must provide a means of preventing and removing the accumulation of water. MSHA anticipates air dryers with drain valves will be used. Air lines or pipes that are pre-installed must also be capped to prevent the entry of rain or moisture laden air. If horizontal runs of air lines or pipes are used, they must be provided with a means to automatically drain any water accumulation.

Section 7.506 Proposed paragraph (c)(1)(vi)(B) is intended to provide protection for lines that come from boreholes or air lines from the surface that are extended underground to a refuge alternative. This protection could consist of burying pipes by trenching deep enough to protect the pipes from mine traffic, explosions, ground movement or equipment damage.

Section 7.506 Paragraph (c)(1)(vii) would assure that harmful or explosive gases, water, and other materials cannot enter the breathable air. When connecting equipment to boreholes that enter the mine, precautions must be taken to prevent explosive or harmful gases from entering the equipment supplying the breathable air. Harmful gases could contaminate filters or other components or collect in the equipment and affect the quality of the air being supplied to the trapped miners.

Section 7.506 Paragraph (c)(2) would require redundant fans or compressors and power sources to permit prompt reactivation of equipment in the event of failure. It is crucial to maintain a continuous supply of breathable air to persons trapped underground and MSHA believes that redundant systems would assure that the supply is maintained in the event of failure of one of these systems.

Again, it is highly requested that until such time as MSHA is able to demonstrate that this option is as safe as manufactured shelters whose deployment does not include trapping of hazardous air inside the shelter that the use of inflatable stoppings not be allowed as a class of solutions.

Comment 69 concerning the statement:

Section 7.506 Paragraph (d) would require that compressed, breathable oxygen (1) include instructions for activation and operation; (2) provide oxygen at a minimum flow rate of 1.32 cubic feet per hour per miner; (3) include a means to readily regulate the pressure and volume of the compressed oxygen; (4) include an independent regulator as a backup in case of failure; and (5) be used only with regulators, piping, and other equipment that is certified and maintained to prevent ignition or combustion.

Agree if the flow rate for the oxygen is allowed to be variable such that occupants can adjust it depending on the actual consumption as indicated by the measured oxygen levels on their instruments. It is requested that the final rule not be such that manufacturers are prohibited from providing controls that would allow for flow rates below these.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 70 concerning the statement:

Section 7.506 Paragraph (d)(1) would require that compressed, breathable oxygen include instructions for activation and operation. This information will assure that mine operators have the proper information to correctly perform the tasks involving activating compressed oxygen cylinders. MSHA believes that failure to properly perform these tasks may imperil the lives of the miners within the refuge alternative. Instructions could include such items as checking for loose connections, leaking gas sounds, damage to hoses along their lengths or at their fittings, and broken gauges. The instructions would also help to assure that tanks are secured and pressure regulators are properly set and that wrenches and pliers will be in proper working order. Safe Use of Oxygen and Oxygen Systems: Guidelines for Oxygen System Design, Materials Selection, Operations, Storage, and Transportation, ASTM Stock No.: MNL 36.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 71 concerning the statement:

Section 7.506 Paragraph (d)(2) would require that compressed, breathable oxygen provides oxygen at a minimum flow rate of 1.32 cubic feet per hour per miner. MSHA is assuming that breathing rates for miners who are using a refuge alternative would reflect activity levels of 4/5 at rest and 1/5 moderate activity. Oxygen consumption at this assumed breathing rate would be 1.32 cubic feet per hour per person (0.022 cubic feet per minute per person). These oxygen consumption rates were based upon the U.S. Bureau of Mines Foster Miller Report of 1983, ''Development of Guidelines for Rescue Chambers,'' Volume I.

Agree while requesting that the basis for the 4/5 – 1/5 ratios be explained and if it can not justified that it be omitted from the final rule.

Comment 72 concerning the statement:

Section 7.506 Paragraph (d)(3) would require that compressed, breathable oxygen provide a means to readily regulate the pressure and volume of the compressed oxygen. Regulating is necessary to assure that oxygen levels remain within the requested values. In addition, all oxygen valves should be opened slowly to prevent the oxygen from heating.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 73 concerning the statement:

Section 7.506 Paragraph (d)(4) would require that compressed, breathable oxygen include an independent regulator as a backup in case of failure. It is crucial to maintain a continuous supply of breathable air to persons trapped underground. MSHA believes that redundant regulators would assure that the miners are maintained in the event of failure of one of these regulators. MSHA expects redundant oxygen control valves and regulators will be provided to assure continual availability of breathable oxygen. This provision is meant to assure that pre-connected valves and regulators are available. This will assure that miners will always have breathable air available in case of component failures.

This requirement would necessitate the installation of redundant piping, fittings, and regulators which would greatly increase the complexity and the probability of leakage. The devices referenced have been used throughout the mining and other industries for decades with only minimal failure. There appears to have been no risk analysis done on this requirement to justify the extra level of redundancy. It is suggested that the benefit does not exceed the added risk and requested that this section should be omitted from the final rule.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 74 concerning the statement:

Section 7.506 Paragraph (d)(5) would require that compressed, breathable oxygen be used only with regulators, piping, and other equipment that is certified and maintained to prevent ignition or combustion. Components such as piping, couplings, valves and regulators used to supply air to the refuge alternative must be maintained in operable condition and in accordance with manufacturer's recommendations. These components will likely be stored by the mine operator until needed for training or rescue operations. Improper storage of these components can lead to their corrosion or their contamination. Compressed oxygen components must not be used with previously used compressed air system components due to the fire and explosion hazards resulting from pure oxygen coming into contact with oil and grease that is inherent with used compressed air systems.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 75 concerning the statement:

Section 7.506 Paragraph (e) would require that carbon dioxide removal components (1) include instructions for activation and operation; (2) be used with breathable air cylinders or oxygen cylinders; (3) remove carbon dioxide at a rate of 1.08 cubic feet per hour per miner; (4) be contained to prevent contact with the chemicals and the release of airborne particles; (5) be provided and packaged with all necessary means to expedite use, such as hangers, racks, and clips; and (6) be stored in containers that are conspicuously marked with instructions for disposal of used chemicals.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 76 concerning the statement:

Section 7.506 Paragraph (e)(1) would require that carbon dioxide removal components include instruction for activation and operation. MSHA needs this information to assure that mine operators have the proper information to correctly perform tasks involving activating carbon dioxide removal components. Carbon dioxide is a natural asphyxiant produced through human respiration. To prevent the accumulation of harmful concentrations of carbon dioxide, scrubbing systems have been developed to chemically absorb the carbon dioxide. When entering a refuge alternative, miners would have to perform tasks to activate the carbon dioxide removal components. The miners would have to purge the atmosphere (in some cases), turn on the breathable air and maintain a viable atmosphere. Depending on the type of CO2 removal system, instructions could include activation scheduling and proper handling of these materials. MSHA believes that failure to properly perform these tasks may imperil the lives of the miners within the refuge alternative.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 77 concerning the statement:

Section 7.506 Paragraph (e)(2) would require that carbon dioxide removal components be used with breathable air cylinders or oxygen cylinders. MSHA needs to assure that carbon dioxide removal components are compatible with the overall system for providing breathable air.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 78 concerning the statement:

Section 7.506 Paragraph (e)(3) would require that carbon dioxide removal components remove carbon dioxide at a rate of 1.08 cubic feet per hour per miner. MSHA is assuming that breathing rates for miners who have reached refuge alternatives would reflect activity levels of 4/5 at rest and 1/5 moderate activity. Therefore, using the respiratory quotient, which is the ratio of CO2 expelled to O2 consumed, the average

carbon dioxide generation is 1.08 cubic feet per hour per person. These breathing rates were based upon the Foster Miller report.

Agree provided that previous requests concerning the 4/5 – 1/5 activity levels are addressed.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 79 concerning the statement:

Section 7.506 Paragraph (e)(4) would require that carbon dioxide removal components be contained to prevent contact with the chemicals and the release of airborne particles. Commonly used CO2 removal systems include lithium hydroxide or soda lime curtains or soda lime cartridges. These systems will require proper handling and may involve using personal protective equipment. The NIOSH report stated that the scrubbing material must not become airborne or otherwise cause respiratory distress or other acute reaction.

Agree. As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 80 concerning the statement:

Section 7.506 Paragraph (e)(5) would require that carbon dioxide removal components be provided and packaged with all necessary means to expedite use. Depending on the type of CO2 removal component, items such as hangers, racks, and clips may be required to activate and use this component.

Section 7.506 Paragraph (e)(6) would require that carbon dioxide removal components be stored in containers that are conspicuously marked with instructions for disposal of used chemicals. Manufacturers would need to provide instructions for disposal of used chemicals.

This section has a lot redundant language with the same requirements in different subsections. It is requested that it be cleaned up to avoid confusion among applicants and reviewers.

Comment 81 concerning the statement:

Section 7.506 Paragraph (f) would require the carbon dioxide removal component be tested and evaluated to demonstrate that it can maintain average carbon dioxide concentration at 1.0 percent or less, with excursions not to exceed 2.5 percent under the following conditions:
(1) at 55 °F (±4 °F), 1 atmosphere (±0.5 percent), and 50 percent (±0.5 percent) relative humidity;
(2) at 55 °F (±4 °F), 1 atmosphere (±0.5 percent), and 100 percent (±0.5 percent) relative humidity;
(3) at 90° F (±4 °F), 1 atmosphere (±0.5 percent), and 50 percent (±0.5 percent) relative humidity;
(4) at 82 °F (±4 °F), 1 atmosphere (±0.5 percent), and 100 percent (±0.5 percent) relative humidity. The Agency is proposing testing and evaluating of the CO2 removal component to assure that the concentration not exceed a 1.0 percent time-weighted average over the rated duration of the refuge alternative with excursions not to exceed 2.5 percent.

The provisions in proposed paragraph (f) are consistent with NIOSH's recommendation. MSHA recognizes that some CO2 scrubbing components may not perform as well as others and that the most commonly used CO2 scrubbing chemicals performed their function within an acceptable range of the conditions found in underground mines. The testing procedure that would be required under proposed paragraphs (f)(1) through (4) are representative of extreme conditions that CO2 scrubbing components may be exposed to in different underground mines. The increased temperature and humidity ranges between these provisions reflect increases that would result from occupancy of a refuge alternative, although MSHA assumes that some body heat and moisture generation will be dissipated by contact with the refuge alternative or mine roof, ribs, and floor. Therefore, it is important to evaluate these CO2 scrubbing components and determine the differences in levels of effectiveness with currently available components. This will enable mine operators to make more informed choices in selecting scrubbing components to be used in their particular mining operation.

The intent is well founded, however the process is not well defined, and will likely result in confusion on everyone part. It is requested that a testing protocol defining an initial concentration of 2.5% of carbon dioxide be included in the final rule.

Comment 82 concerning the statements:

Section 7.506 Paragraph (g) would require that respirators or breathing apparatus used with a breathable air component (1) be NIOSH-approved with a means of flow and pressure regulation; (2) be equipped with fittings that connect only to a breathable air compressed line; (3) allow for communication, and the provision of food, and water while preventing the entry of any outside atmosphere; and (4) be capable of being worn for up to 96 hours. The proposed rule addresses the need to have provisions to assure the safe use of respirators or breathing apparatus.

Section 7.506 Paragraph (g)(1) would require that respirators or breathing apparatus used for a breathable air component have a NIOSH approval with a means of flow and pressure regulation.

Section 7.506 Paragraph (g)(2) would require that respirators or breathing apparatus be equipped with fittings that connect only to a breathable air compressed line. This provision would prevent respirators from being connected to piping that is not designed for breathing apparatus or to gas sources that are not capable of sustaining life. Compressed air regulating valves and supply hoses are generally shipped with quick-connect industrial interchange safety fittings/ couplings that prevent accidental separation of the hoses. The proposed rule would require that these fittings be incompatible with outlets for nonrespirable air or other gas systems so that asphyxiating substances are not introduced into breathing air lines. This provision is also comparable to the Occupational Safety and Health Administration respiratory protection standard 29 CFR 1910.134(i)(8), which states that— [t]he employer shall ensure that breathing air couplings are incompatible with outlets for nonrespirable worksite air or other gas systems. No asphyxiating substance shall be introduced into breathing air lines.

Section 7.506 Paragraph (g)(3) would require that respirators or breathing apparatus used with breathable air components allow for communication, and the provision of food and water while at the same time preventing the entry of any outside atmosphere. MSHA is proposing this requirement because communications with and between persons in refuge alternatives to convey and share information are vital to mine rescue efforts. The knowledge of where persons are in refuge alternatives, their condition and the conditions in the mine may make the difference between life and death in a post-accident crisis. In addition, being able to consume food and water is critical for the 96-hour confinement. MSHA believes that the proposed requirements could be met with full-faced respirators or breathing apparatus that have ports for the use of liquids, such as those used by commercial divers. Paragraph (g)(4) would require that

respirators or breathing apparatus used with breathable air components be capable of being worn for up to 96 hours. The refuge alternative standard would require that breathable air be provided in the refuge alternative at all times. Among the concerns addressed by this provision are that if respirators or apparatus are required to be worn for extended periods of time, the respirators or breathing apparatus would need to be of such a type or configuration that it would not become dislodged when sleeping or when activities are performed.

Section 7.506 Paragraph (h) would require that an applicant prepare and submit a risk analysis to assure that the breathable air component will not cause an ignition. The proposed provision requires that an analysis be conducted to evaluate the potential fire and ignition risks of the equipment and components.

Section 7.506 Paragraph (h)(1) would require that the risk analysis specifically address oxygen fire hazards and fire hazards from chemicals used for removal of carbon dioxide. This provision addresses MSHA's specific concern that the use of oxygen presents inherent potential fire hazards. The provision also focuses on assuring that fire hazards from chemicals used for removal of carbon dioxide are addressed by manufacturers of refuge alternative components.

Section 7.506 Paragraph (h)(2) would require that the risk analysis identify the means used to prevent any ignition source. This provision addresses the need to assure that refuge alternative manufacturers analyze inherent potential fire hazards and, if any potential exists, that the mitigation plan includes the means to prevent ignition of breathable air component equipment or materials.

Section 7.506 Paragraph (i) would require that the breathable air component shall include a fire extinguisher that (1) is compatible with the chemicals used for removal of carbon dioxide; and (2) uses a non-toxic extinguishing agent that does not produce a hazardous by-product when heated or activated. This paragraph addresses the need to assure that refuge alternative manufacturers analyze inherent potential fire hazards and develop means to prevent the ignition of breathable air component equipment or materials.

The proposed requirements in paragraphs (h)(1) and (2) would help assure that the fire extinguisher used in a refuge alternative or component does not contribute to a secondary fire or explosion. The provisions would assist MSHA in determining that materials used in the fire extinguisher are safe for use in an underground mine and do not give off harmful gases when exposed to heat.

It is not obvious what this provision addresses. None of the previous sections address the use of respirators or breathing devices. If it the intent of MSHA those behind inflatable stoppings be connected to an open-circuit breathing device, we could concur. While at least one manufacturer has proposed this, it does not currently meet the provisions of this rule as written. If it is the intent of MSHA to propose this as an option, we believe there are many in the mine safety community that would be willing to accept it, especially for low coal seams. However, as currently written it is not allowed. It is recommend that this be allowed but each section of the final rule be modified so as to not preclude its use.

Additionally, many of the subsections are redundant in that the regulation previously calls for intrinsic safety certification and only the use of NIOSH approved devices. Too many steps will bring this process to halt because there are not sufficient staff at the MSHA Approval and Certification center to handle the workload they currently have.

Again, this section raises the request in an earlier comment to simply require the MSDS sheets on every thing within a shelter. These sheets have all the information requested

in form familiar to users. Requiring a separate risk analysis for all these subsystems is redundant and undesirably time consuming. It is requested that this be omitted from the final rule.

In addition, as with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 83 concerning the statements:

Section 7.507 Air-Monitoring Components

Proposed § 7.507(a) would include requirements for an air-monitoring component that provides persons inside the refuge alternative with the ability to determine the concentrations of carbon dioxide, carbon monoxide, oxygen, and methane, inside and outside the structure, including the airlock. This proposal would assure that breathable air is properly monitored and that air monitoring equipment is properly inspected, tested, maintained, and stored so that it is fully charged and available for immediate use. The monitoring of these gases is critical to the survival of miners occupying a refuge alternative. The proposal includes the requested values provided in the NIOSH report for oxygen, carbon monoxide, and carbon dioxide. NIOSH requested values and gas concentration ranges that would assure that the quality of breathable air is maintained. The ability to monitor the atmosphere outside the refuge alternative would assist miners inside the refuge alternative in making crucial decisions in the event of a mine emergency. Additionally, methane would be monitored to negate the possibility of oxygen deficiency or the potential for explosion.

Section 7.507 Paragraph (b) would require that refuge alternatives designed for use in mines with a history of harmful gases, other than carbon monoxide, carbon dioxide, and methane be equipped to measure those harmful gas concentrations. Some mines have a history of liberating harmful gases such as hydrogen sulfide, volatile hydrocarbons, or sulfur dioxide. Miners would need to be prepared for potential liberating of these harmful gases and have appropriate monitoring equipment readily available.

Section 7.507 Paragraph (c) would require that the air-monitoring component be inspected or tested and the test results are included in the application. This provision will assure that all types of monitors or detectors that are included in the refuge alternative will be tested for the conditions for which they are intended. Performance testing will assure the components will operate for which the air monitoring is intended as well as meet the intrinsic safety requirements. Additionally, visual inspection, calibration, and performance test reports will need to be included in the application to verify performance.

Section 7.507 Paragraph (d) would require that all air-monitoring components be approved as permissible by MSHA and the MSHA approval number be specified in the application. MSHA will only accept MSHA approved permissible components to assure an explosion hazard does not exist in an explosive atmosphere and the components will serve the purpose for which they are intended. MSHA would allow third party testing of the components for air monitoring. Approval information will assure the components are performance tested for safe usage in the refuge alternative.

Section 7.507 Paragraph (e) would require that air monitoring components meet the following: (1) The total measurement error, including the cross-sensitivity to other gases, shall not exceed ±10 percent of the reading, except as specified in the approval, and (2) the measurement error limits not exceed after startup, after 8 hours of continuous operation, after 96 hours of storage, and after exposure to atmospheres with a carbon monoxide concentration of 999 ppm (full scale), a carbon dioxide concentration of 3 percent, and fullscale concentrations of other gases.

Section 7.507 Paragraph (e)(1) would assure that the instruments are tested to specific ranges. MSHA has referenced gas analyzer specifications from 30 CFR party 7 Diesel Engine approvals detailed in § 7.86(b)(10), which specifies that the gas analyzer error including cross sensitivity to other gases is 5%. MSHA recommends using gas analyzers that account for cross sensitivity, such as sensitivity to hydrogen or hydrocarbons which would result in false indication of actual carbon monoxide, and adjust readings accordingly. The ±5% error specification in § 7.86(b)(10) refers to the instrument error specification. The ±10% total measurement error specification above refers to the combined effects of environment and accessories on the measurement itself under normal conditions, and was arrived at through uncertainty evaluation of gas measurement instruments used at MSHA's Approval and Certification Center. Measurements taken when environmental conditions are not within the instruments' specified acceptable limits, or when the instrument is in need of calibration, can result in the measurement value falling outside the ±10% limit. Measurements that fall outside of the ±10% limit are not in compliance. The applicant needs to determine what environmental or calibration issues exist and resolve them to keep the combined instrument and measurement error within ±10%.

Section 7.507 Paragraph (e)(2) would require testing to demonstrate that the gas monitors or detectors will afford miners the capability to determine accurate gas concentrations throughout the duration of refuge occupancy and at different parameters such as startup, after 8 hours of continuous operation, during storage when continuously exposed to the maximum requested gas concentrations, and at other concentrations much higher than the requested maximum values. This requirement takes into account the effects high gas concentration levels may have on these measurements over extended periods of time. A consensus standard for instruments, ANSI/ISA– 92.02.01, Party I–1998 Performance Requirements for Carbon Monoxide Detection Instruments (50–1000 ppm full scale), specifies carbon monoxide instrument range limits of 1000 ppm, 2000 ppm overload, and the standard specifies these instruments be able to withstand a carbon monoxide shock loading of 4000 ppm.

Section 7.507 Paragraph (e)(3) would require that calibration gas values be traceable to the National Institute for Standards and Testing (NIST) ''Standard Reference Materials'' (SRMs). This procedure will assure proper calibration of the airmonitoring equipment. These standards are recognized and accepted by industry. This provision is based upon existing § 7.86(b)(16), which references NIST SRMs.

Section 7.507 Paragraph (e)(4) would require that the analytical accuracy of the calibration gas values be within 2.0 percent of NIST gas standards. This provision is based upon existing § 7.86(b)(16), which also references analytical accuracy of calibration gases within 2 percent of NIST gas standards.

Section 7.507 Paragraph (e)(5) would require that the analytical accuracy of the span gas values be within 2.0 percent of NIST gas standards. This provision is based upon existing § 7.86(b)(17) which also references analytical accuracy of span gases within 2 percent of NIST gas standards.

All these requirements are covered under other sections of the CFR. Why is it necessary to repeat them here? It only makes future updating of the CFR more difficult increasing the likelihood of conflicting rules. It is requested that it would be much simpler to state only MSHA approved intestinally safe gas detectors shall be used.

Comment 84 concerning the statement:

Section 7.507 Paragraph (e)(6) would require the detectors be capable of being kept fully charged and ready for immediate use. MSHA needs to assure that the detectors are reliable and ready to use for maintaining persons as necessary over the 96-hour period. Section 7.508 Harmful Gas Removal

Components This section addresses removing harmful gases to assure that breathable air is maintained for persons occupying refuge alternatives during the 96-hour period.

This was addressed in previous provisions and the request is the same. There must training provisions for extending the life of the detectors or the selection of detectors that allow for the replacement of batteries under intestinally safe conditions. Again, if it is include above, why is it repeated? It only adds to possible confusion. State it once then move on.

Comment 85 concerning the statement:

Section 7.508 Paragraph (a)(1) would require purging or other effective methods be provided for the airlock to dilute the carbon monoxide concentration to 25 ppm or less and the methane concentration to 1.5 percent or less as persons enter, within 20 minutes of miners activating the refuge alternative. The NIOSH requested value of maximum concentration of carbon monoxide is 25 ppm. This provision is intended to address evacuating contaminated air by forcing the contaminated air out of the refuge alternative environment. Airlocks are intended to speed up the process of ingress and egress, because this is a smaller volume as compared to the interior space to purge. MSHA believes that following the miners' attempt to escape and time required for constructing and activating the refuge alternative, the SCSRs would allow 20 minutes for purging the airlock to establish a breathable air atmosphere. In addition, purge air should be provided from compressed air cylinders. The allowable carbon monoxide contamination level is the NIOSH requested value contained in the NIOSH report. The methane concentration action level in 30 CFR 75.323(b)(2)(i) of less than 1.5 percent is the limit established for persons to be allowed to occupy an area.

Airlocks are discussed in the previous sections. This only adds carbon monoxide level information. It is requested that all the airlock information be included in one place. The addition of it here also allowed for inclusion of information that should have been consolidated above. Here the text discusses 20 minutes as the maximum purge time. If that is an issue, it should have been included in the previous discussion as well.

In addition, as with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 86 concerning the statement:

Section 7.508 Paragraph (a)(2) would require that chemical scrubbing or other effective methods be provided to maintain the average carbon dioxide concentration in the occupied structure at 1.0 percent or less with excursions not to exceed 2.5 percent. The provision addresses the harmful effects of carbon dioxide, a natural asphyxiant produced through human respiration. To prevent the accumulation of harmful concentrations of carbon dioxide, scrubbing systems have been developed to chemically absorb the carbon dioxide. Carbon dioxide scrubbing systems are described as active or passive. Passive systems rely solely on natural air currents for the air to react with the chemical bed. Passive systems chemicals are usually packaged in curtains that are suspended in the refuge chamber environment. Active systems were designed to increase efficiency of CO2 scrubbing systems. This is accomplished by forcing the air through the chemical bed by fans or compressed air. The requested average carbon dioxide concentration came from the NIOSH report.

Agreed.

Comment 87 concerning the statement:

Section 7.508 Paragraph (b)(1) would require that chemicals used in harmful gas removal be contained such that when stored or used they cannot come in contact with persons. Because these harmful gas removal chemicals are caustic, they would need to be contained. One way of packaging these chemicals is in curtains or cartridges that are isolated so that contact with or exposure to the chemicals is prevented. MSHA does not condone the use of uncontained materials because of the caustic nature of these materials. Chemicals must be activated without compromising the packaging materials and exposing miners to chemical hazards.

This is already required in 7.506 it is requested that MSHA explain why is it repeated. If not the redundancy is unwarranted it is requested that it be omitted from the final rule.

As with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 88 concerning the statement:

Section 7.508 Paragraph (b)(2) would require that each chemical used for removal of harmful gas be provided together with all materials, parts, or equipment necessary for its use. This requirement is proposed to expedite activation of the scrubbing system to reduce start-up time and make the system easy to use for the miner. The intent is to make the system as uncomplicated as possible, and to reduce harmful gases as soon as possible while ensuring everything necessary is provided. The harmful gas removal system should be designed on a perminer incremental basis to make the system easily understood by miners.

Section 7.508 Paragraph (b)(3) would require that each chemical used for removal of harmful gas be stored in an approved container that is conspicuously marked with the manufacturer's instructions for disposal of used chemicals. The intent of this provision is to provide for appropriate containment during shipping and pre-activation storage. Approved containers would be considered those appropriate for preactivation transport and storage in the mine environment as determined by generally accepted chemical industry practice. Disposal instructions are also to be provided to assure miners are not exposed or otherwise injured while handling chemicals. Activation instructions should also be provided on the container.

Section 7.508 Paragraph (c) would require that each harmful gas removal component be inspected or tested to determine its ability to remove harmful gases. The functionality and efficiency of the gas removal components need to be verified.

Again, this material is covered in multiple places throughout this regulation. It is requested that an attempt be made to consolidate material on each subject to improve the usefulness and reduce confusion.

Comment 89 concerning the statement:

Section 7.508 Paragraph (c)(1) would require that the component be tested in a refuge alternative structure that is representative of the configuration and maximum volume from which the component is designed to remove harmful gases. The intent is to obtain data that is directly representative of how the components will perform in actual use. Data from small-scale tests or prototype testing would require

interpretation along with making assumptions which introduces the potential for the measured performance not being representative of full-scale performance.

This entire proposed regulation is fraught with assumptions based upon paper studies and 50-year-old bench top testing. To say that extrapolation is not acceptable seem to undermine the foundation of these proposed regulations. While whenever possible testing at scale is preferred, it should not be required. Does placing a small section of brattice cloth in flame provide proof that full size sheet engulfed flame to the same extent would behave the same? What should be required is rigorous defense of any extrapolated data or of any assumptions, even those of regulators. It is requested that this section be modified to allow appropriate testing or that it be omitted from the final rule.

In addition, as with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 90 concerning the statements:

Section 7.508 Paragraph (c)(1)(i) would require that the test include three sampling points located vertically along the centerlines of the length and width of the structure and equally spaced over the horizontal centerline of the height of the structure. There are to be a total of three sampling points equally spaced along the center length of the structure on the longitudinal (horizontal) centerline and located so as to provide an accurate representation of the gas concentration found in the middle of the structure as opposed to the ends, corners, top, sides, or bottom.

Section 7.508 Paragraph (c)(1)(ii) would require that the structure be sealed airtight. The structure is to be airtight to prevent unintended atmosphere contaminants from entering into the structure and altering/interfering with the internal test atmosphere.

Section 7.508 Paragraph (c)(1)(iii) would require that the operating gas sampling instruments be placed inside the structure and continuously exposed to the test atmosphere.

Section 7.508 Paragraph (c)(1)(iv) would require that the sampling instruments simultaneously measure the gas concentrations at the three sampling points. Gas sampling instruments must operate continuously at the three sampling points while measuring the gaseous concentration inside of the structure. The intent of simultaneously sampling is to determine the interior atmosphere at different locations at a given point in time, to eliminate any sampling variability introduced by sequential sampling, and to determine if a homogenous atmosphere is maintained throughout the refuge alternative.

While this is good start at the description of the testing protocol, it does not contain everything necessary. Is it the intent of MSHA to lock testing protocol into regulation where they cannot be changed or is it as stated in the intro to develop performance based standards? This and other sections of similar levels of detail do neither. It is requested a simpler method be included in the final rule that describes the atmospheric conditions MSHA requires for each miner and based upon the configuration of the shelter design the applicant submits a testing protocol to demonstrate compliance. That way as monitoring technology changes there will not be the need to change the CFR. I am told by MSHA staff is almost impossible to do even where it is obviously wrong.

Comment 91 concerning the statements:

Section 7.508 Paragraph (c)(2) would require when testing the component's ability to remove carbon monoxide, the structure be filled with a test gas of either purified synthetic air or purified nitrogen that contains 400 ppm carbon monoxide. Refuge alternatives should be configured to ensure the air contained therein is normally isolated from the mine atmosphere that would negate the need to purge a refuge after an event. However, the concept of an airlock to provide a transition area into a breathable air zone, by its very nature, would possibly become contaminated after an event. In recognizing this, airlocks need the capability to remove contaminants or otherwise operated to ensure that contaminated mine atmosphere is prevented from migrating through the airlock into the breathable air refuge. The 400 ppm was selected based on safety considerations (ACGIH 400 ppm CO STEL limit) while also being able to determine multiple gas concentration level reductions of the gas purification/de-contamination system for the entire ingress/egress process at maximum occupancy.

Section 7.508 Paragraph (c)(2)(i) would require that after a stable concentration of 400 ppm, ±5 percent, carbon monoxide has been obtained for 5 minutes at all three sampling points, a timer be started and the structure shall be purged or CO otherwise removed. A uniform homogeneous atmosphere inside of the chamber containing a concentration of 400 ppm must be consistent for 5 minutes. After this is achieved, a timer will be started and the structure purged or CO otherwise removed to an acceptable concentration.

Section 7.508 Paragraph (c)(2)(ii) would require that carbon monoxide concentration readings from each of the three sampling devices be recorded every 2 minutes. The intent is to have enough data points to have a valid test.

Section 7.508 Paragraph (c)(2)(iii) would require that the time from the start of harmful gas removal until the readings of the three sampling instruments all indicate a carbon monoxide concentration of 25 ppm or less shall be recorded. The purpose for recording the time is to assure the time to remove the toxic gas and activate the refuge alternative is less than the time to deplete the life of the SCSR. All of the rated number of occupants need to be located safely inside the refuge alternative prior to depleting their SCSR air capacity.

It is hard to believe that the proposed regulation calls for the deployment of lethal levels of carbon monoxide in a test. I doubt that NIOSH or MSHA health and safety officers would allow such a test to be conducted on government property. How could MSHA in good faith propose it for someone else? We request that this section be struck and the use of a non-toxic alternative gas as proposed in the next section be used.

Comment 92 concerning the statements:

Section 7.508 Paragraph (d) would allow that alternate performance tests may be conducted if the tests provide the same level of assurance of the harmful gas removal component's capability as the tests specified in paragraph (c) of this section. Alternate tests shall be specified in the approval application. The intent of this statement is as a general protection clause. The applicant can perform other tests to assure the ability of these systems to remove harmful gases if the applicant can demonstrate that the same degree of protection is provided as the refuge alternative requirements. Alternate tests may be used if they are submitted to MSHA for approval and there is assurance that the capacity to remove harmful gas is adequate.

The rule should propose some acceptable gases so no applicant has to play bring MSHA a rock. Additionally how is it proposed this be done in the afore mentioned inflatable stopping cross sections, which because according to the rules because they are positive

pressure they do not require air locks per the positive pressure exclusion in section 7.505? It is requested that MSHA explain this discrepancy and modify the final rule accordingly.

Comment 93 concerning the statements:

Section 7.509 Approval Markings

Section 7.509 Paragraph (a) would require that each approved refuge alternative or component be identified by a legible, permanent approval marking that is securely and conspicuously attached to the component or its container. This requirement is necessary to assure that only approved materials and components are used in the refuge alternatives. The marking would be placed such that the marking will not be subject to damage or removal.

Section 7.509 Paragraph (b) would require that each approval marking include the refuge alternative's and component's MSHA approval number and expiration date. This requirement is necessary to assure that only approved materials and components are used in the refuge alternatives.

Section 7.509 Paragraph (c) would require that each refuge alternative structure provide a conspicuous means for indicating an out-of-service status, including the reason it is out of service. This requirement would assure the materials are able to be inspected and removed and replaced when needed.

Section 7.509 Paragraph (d) would require that each airlock be conspicuously marked with the requested maximum number of persons that can use it at one time. This requirement would assure the airlock is used as intended to allow safe passage of persons through the airlock and to prevent the contamination of the interior space atmosphere. container that is conspicuously marked with the manufacturer's instructions for disposal of used chemicals. The intent of this provision is to provide for appropriate containment during shipping and pre-activation storage. Approved containers would be considered those appropriate for preactivation transport and storage in the mine environment as determined by generally accepted chemical industry practice. Disposal instructions are also to be provided to assure miners are not exposed or otherwise injured while handling chemicals. Activation instructions should also be provided on the container.

Agree. In addition, as with comment 4 it is requested that those manufacturers who have successfully completed an approval by a state mine health and safety agency be allowed to submit those materials in support of this requirement and that the results be treated as those from an approved third-party testing laboratory.

Comment 94 concerning the statement:

Existing § 75.1502(c)(7) would be redesignated as paragraph (c)(8) and would require that the program of instruction include the locations of refuge alternatives. The locations of refuge alternatives may be critical for miners who are involved in mine emergencies.

Agree.

Comment 95 concerning the statement:

Paragraph § 75.1502(c)(10) would be new and require a summary of the procedures related to constructing and activating refuge alternatives. This summary information would be necessary for miners

during training. The summary would assure that all critical steps of constructing and activating the refuge alternative are reviewed in training.

Paragraph § 75.1502(c)(11) would be new and require a summary of the procedures related to refuge alternative use. This summary information would be necessary for the miners to review during training. The summary would assure that all critical steps of using the refuge alternative are reviewed in training.

Agree.

Comment 96 concerning the statements:

Section 75.1504 Mine Emergency Evacuation Training and Drills The best refuge technology, equipment and emergency supplies are of little benefit if they are misused or not used at all. In its report, NIOSH stated that— The potential of refuge alternatives to save lives will only be realized to the extent that mine operators develop comprehensive escape and rescue plans, which incorporate refuge alternatives. Emergencies can result in miner disorientation and panic. Using sound judgment in a given emergency can be critical for survival. MSHA and NIOSH have found that training is necessary to instill the discipline, confidence, and skills necessary to survive a mine emergency. This proposal would improve miner training and help assure that underground coal miners know when to use a refuge alternative and know how to use the various components to sustain life until rescued. During each quarterly drill, miners would be required to locate the refuge alternatives and review the activation and use of the refuge alternative for the area where the miners normally work and travel during each quarterly drill. Refuge alternatives expectations training would emphasize that miners first try to evacuate the mine and that refuge alternatives are a haven of last resort when escape is impossible. MSHA has identified problems related to skill degradation in emergency evacuations of mines. In a series of studies from 1990 through 1993, the U.S. Bureau of Mines, University of Kentucky, and MSHA researchers measured skills degradation. In one study, the proficiency rates dropped about 80 percent in follow-up evaluations conducted about 90 days after training. MSHA recognizes that with any non-routine task, such as constructing, activating, and using a refuge alternative, knowledge and skill diminish rapidly. In another study 4 researchers concluded that ''companies should adopt a hands-on training protocol.'' The proposed rule reflects MSHA's conviction that frequent and effective refuge alternative training would be necessary to assure miner proficiency.

Proposed § 75.1504(b)(3)(ii) and (4)(ii) would require that in quarterly training and drills, miners locate refuge alternatives. This knowledge would be critical to miners in a mine emergency.

Agree. However, request that shelter training be included as part of an overall emergency response system that includes escapeways, lifelines, SCSRs and caches, communication and tracking and lastly shelters, it should not be segregated.

Comment 97 concerning the statements:

Paragraph § 75.1504(b)(6) would require a review of the checklist for constructing and activating the refuge alternatives and components. MSHA proposes that quarterly training and drills includes this training as recognition that with any non-routine task, such as activating and using a refuge alternative, knowledge and skill diminish rapidly. Miners need to be aware of how to construct and activate a refuge alternative safely. The information in the proposed checklist would be used in the training and should include all of the step-by-step procedures easily understood by the miners to perform these tasks. For easy availability, mine operators should consider laminated cards or other equally durable forms of the checklist for use by miners.

Paragraph § 75.1504(b)(7) would require a review of the procedures related to use of refuge alternatives and components. Miners need to be aware of how to use a refuge alternative safely in the event of an emergency. MSHA recognizes that manufacturers generally provide information on the safe use of their products. This information would be used in training and should include the step-by-step procedures necessary to use refuge alternatives and should be easily understood by the miners. This information will be critical for miners who need to spend a sustained period in a refuge alternative. MSHA's Office of Educational Policy and Development will assist mine operators with job task analysis and training materials such as videos to improve the quality and effectiveness of programs of instruction. NIOSH is developing a refuge alternative training program that is expected to be available by the end of 2008. MSHA plans to include a delayed effective date in the final rule to allow mine operators to develop Emergency Response Plans and training plans and submit them to MSHA.

Proposed § 75.1504(c)(3) would require annual expectations training in construction, where applicable, activation, and use of refuge alternatives and components. Under the existing standard, each miner must participate in expectations training over the course of each year. This training includes donning and transferring self-contained self-rescuers (SCSRs) in smoke, simulated smoke, or an equivalent environment. The training also requires breathing through a realistic SCSR training unit that provides the sensation of SCSR airflow resistance and heat. Under the proposal, miners would have to be trained in construction, where applicable, activation, and use of refuge alternatives similar to those in use at the mine, including activation and operation of component systems; and instruction on when to use refuge alternatives during a mine emergency. Refuge alternatives expectations training would emphasize that miners first try to evacuate the mine and that refuge alternatives are a haven of last resort when escape is impossible. The proposed expectations training would require an annual realistic experience of constructing where applicable, activating, and using a refuge alternative in a simulated emergency situation. The proposed refuge alternative expectations training could be combined with the existing expectations training. Expectations training will be essential to reduce the level of panic and anxiety associated with the use of refuge alternatives. NIOSH supports expectations training to reduce the level of panic and anxiety associated with the use of refuge alternatives.5 Properly constructing and activating a refuge alternative can be a relatively complex procedure that must be done correctly to establish a breathable air environment in a smoke-filled mine. The operation of most refuge alternatives requires periodic monitoring and adjustments to the gases to assure a breathable atmosphere. Failure to correctly perform these tasks may imperil the lives of miners within the refuge alternative. MSHA envisions the use of a modified version of the refuge alternative in the mine for this training purpose. The miners would have to construct the refuge alternative, if applicable, activate the refuge alternative, purge the atmosphere, and turn on the breathable air and maintain a viable atmosphere. Although MSHA does not specify a minimum time for this annual training exercise, the duration should be sufficient to allow miners to perform all of the necessary tasks and give them a realistic experience of using the refuge alternative. The Agency would require that this training expose the miners to the expected heat and humidity conditions in the refuge alternative. MSHA does not expect that this training would include the actual use of oxygen and harmful gas removal components; these actions may be performed with compressed air and simulated removal components. The training must also emphasize that, in the event of an emergency, miners should first try to evacuate the mine and that refuge alternatives are the option of last resort when escape is impossible. MSHA solicits comment from the public on the Agency's proposed approach to expectations training. The Agency is interested in comment on its proposed strategy and the proposed elements of training. Please be specific in your response, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and data to support your comment.

Proposed § 75.1504(c)(4), redesignated from existing § 75.1504(c)(3), would require that a miner participate in expectations training within one quarter of being employed at the mine. MSHA would expect that any new miner would be given the expectations training within this timeframe. This could be accomplished during new miner or newly employed miner training.

While in agreement with the intent of the training focus of this proposed section, the inclusion of the phrase "for constructing" is again troubling. Throughout this proposed rule there are sprinkling of terms relating to the dated practice of building barricades after an event. The killer is carbon monoxide and there has not been shown to be a means for successfully purging a crosscut used as a barricade. The only sure way of ensuring that miners who have to take shelter is that the air quality is established prior to them entering. Lacking that it will require an engineered and tested system for purging to avoid pockets of hazardous gas within the space. If it is MSHA's intent to allow this option there needs to be considerable more testing done and specific directions provided the industry on how to duplicate the process once discovered. Lacking that it is strongly requested that all references to this technique be purged for this rule making process.

Comment 98 on the statements:

Section 75.1505 Escapeway Maps

Proposed § 75.1505(a)(3) would require that the escapeway map be posted or readily accessible at each refuge alternative. The location of refuge alternatives relative to the escapeway may be vital to the survival of miners during mine emergencies. Escapeway maps form the basis for decisions made during mine evacuation. Having escapeway maps on hand for miners would facilitate important decisionmaking.

Proposed § 75.1505(b) would require that escapeway maps include the locations of refuge alternatives, and that any change be shown on the map. Escapeway maps form the basis for mine rescue efforts. Locations of refuge alternatives are critical to decisions made during rescue efforts and must be kept current on the escapeway map.

Section 75.1506 Refuge Alternatives This section would require that mine operators provide refuge alternatives to accommodate all persons working underground and specify criteria for the use and maintenance of refuge alternatives. MSHA believes that refuge alternatives will provide a refuge of last resort for miners unable to evacuate the mine during an emergency. By providing the essential elements of survival (breathable air, water, food, communications, etc.) the likelihood of miners surviving an inhospitable postemergency environment would be increased. MSHA realizes that a flexible approach to providing refuge alternatives is necessary due to the wide range of mining conditions (seam height, pitch, mining method, and mine layout) that exist in underground coal mines. To address these widely-varying conditions, MSHA has taken a performance-based approach to refuge alternatives. For example, the refuge alternative has to provide for essential needs of occupants, but the proposal does not require specific methods, equipment, or devices.

Section 75.1506 Paragraph (a) would require each operator to provide refuge alternatives with sufficient capacity to accommodate all persons working underground. MSHA believes that escape to the surface is more protective than using a refuge alternative. However, when escape is impossible, a refuge alternative must be available for all persons underground. MSHA recognizes that the highest concentration of miners is near a working section. Toward this end, refuge alternatives would need to be located to accommodate the miners at or near a working section. Refuge alternatives would also be required for miners working in outby locations. The proposed rule would not require refuge alternatives for miners who can reach a surface escape facility within 30 minutes. Under the proposal, mines in which all miners would be within 30 minutes of the surface or a surface escape facility would not have to have a refuge alternative.

Agree, with the exception of the outby shelters component. The analysis done by NIOSH as well as those done by the Bureau of Mines and even other MSHA documents suggest that the greatest risk is for those near the working sections. The placement of extra SCSR caches lifelines and communication and tracking requirements make it very unlikely that an event on or near the working section would block someone outby from escape. The inclusion of the outby shelter areas is not warranted by the present data. MSHA is requested to document the necessity of these outby shelters and to what extent in the past accident they would have made a difference in reducing fatalities. If the documentation does not demonstrate the necessity of these refuge areas, it is requested that they not be included in the final rule.

Comment 99 concerning the statement:

Section 75.1506 Paragraph (a)(1) would require at least 15 square feet of usable floor space and at least 60 cubic feet of usable volume per person. This proposed requirement of interior floor space and volume is necessary to provide adequate room for miners during any period of time confined in the refuge alternative. MSHA is interested in practical floor space and volume requirements for mining operations. The proposed requirements are intended to mean that the miner would have this space available to them without being affected by any other factors, e.g., stored items. MSHA intends that space requirements would not include airlock space. The NIOSH report requested key design values of 15 square feet of floor space and 85 cubic feet volume per miner. However, in its report, NIOSH stated that these recommendations were not to be considered absolute. MSHA recognizes that achieving the volume per miner in refuge alternatives for low coal mines could be problematic. To lie down, miners would require a certain length and width. For example, 15 square feet would be provided by a space 6 feet long and 2.5 feet wide. This space would have to be 4 feet high, which would give each miner 60 cubic feet of volume. These dimensions would serve as a minimum for the miner during the periods of confinement. In lower mining heights, the 60 cubic feet of volume may need to be gained by increasing the floor space. For example, 60 cubic feet of volume in a refuge alternative 2.5 feet high would require 24 square feet of floor space, which could be provided by a space 6 feet long and 4 feet wide. MSHA solicits comment from the public on these proposed values for floor space and volume, particularly in low mining heights. Please be specific in your response, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and data to support your comment. Miners would need to have additional space to perform duties such as attending to the harmful gas removal components, performing gas tests or attending to basic needs—drinking, eating, and using the sanitation facilities—and providing for injured miners. Curtains suspended as party of a passive system to remove carbon dioxide should be considered when determining volume. Another important factor in the volume design is the need to control the apparent temperature in the interior space of the refuge alternative. Larger volumes are more effective at dissipating heat because of increased surface area.

This issue was addressed to great extent above. It is repeated here so as not be missed.

This requirement is based upon a statement in the NIOSH report that was taken from a 1958 Civil Defense publication (TB-5-3, May 1958) providing guidance for family fall out shelters that requested 80 cubic feet per person. It has no relevance to this application.

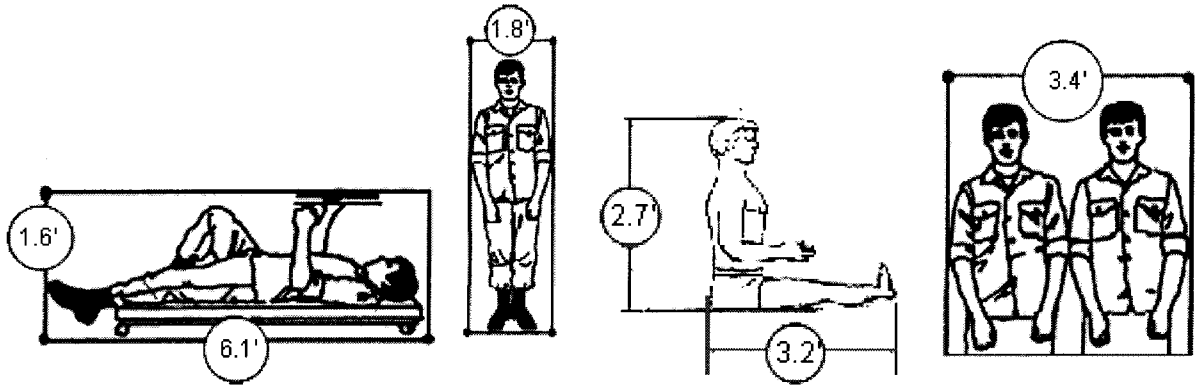
Fallout shelters were designed for occupancy by untrained civilians for periods of at least two weeks. Underground emergency shelters are designed for the survival of trained miners for a period of not more than 96 hours but most likely less than 48 hours.

The net effect of this provision would be reduce the effective occupancy of current shelters by up to 50% and more than double their number underground. This increases

the potential for injuries resulting from handling these units during normal operations. It increases the number of locations to which mine rescue team may have to reach to find all the miners. Alternatively, it would require such extensive redesigns of the air quality systems as to make the unit impractical. It would also effectively eliminate options for low coal seam.

There appears to no basis for the MSHA 60 cubic foot value other than it is less than the Civil Defense value. If one were to look for a realistic volume and floor space value, the best source is the military.

The US Department of Defense Human Engineering Manual (MIL-HDBK-759C) indicates that a supine man should have a space of 1.6 feet high by 6.1 feet long. It defines the space required for a man sitting to be 2.7 feet high by 3.2 feet long. If we assume that these are the two extreme positions in a shelter, we get a maximum volume of 29.6 cubic feet and a floor space of 10.9 square feet. (This value is arrived at by using the height of the sitting man, the length of the supine man and the design shoulder width.) As a point of reference, the South African regulation is 6.4 square feet of floor space with no volume value (Chief Inspector of Mines Directive B5, 14 Feb. 1994).



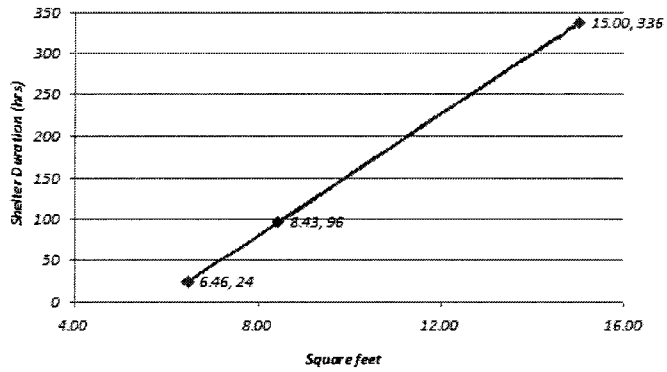
Images taken from the US Department of Defense Human Engineering Manual (MIL-HDBK-759C) and modified to indicate English units verse Metric units.

Since low-coal mines can result in interior shelter heights of 2 feet, the sitting position would not be applicable. In those situations, the volume would be limited to that of the supine position with a volume requirement of 17.6 cubic feet.

Additionally, the Department of Defense document identifies as 3.4 feet the space required for two men, which provides some guidance for the number of miners in given shelter length.

Another approach that has been requested by some could be to extrapolate between the values utilized in South Africa mine shelters since the 1990's of and those of the U.S. Navy for 100 men in fallout shelters for 14 days. Using the approach in graph on below this would result in a value of 6 square feet.

However, it is important to remember that emergency shelters are the last resort in the event of an accident to ensure survival not to ensure comfort. As one miner told me after a training session on all the things we have done to improve their chances for escape, "With all these extra escape additions if I have to, the decision to get into a shelter or not boils down to the shelter or a body bag...it's not that a hard a choice." Comfort is not the main consideration...survival is the ONLY consideration.



Additionally the concept of using the shift change to determine the maximum number of occupants of a shelter was adopted by West Virginia. It was recognized as not only practical but provided an almost 100% safety margin for those most likely to be using a shelter. In a three-shift mine, the maximum number of people would be at the section once each shift. The "hot seat" process takes between 15 and 30 minutes then the shift relived makes it way to the exit. That means between 45 and 90 minutes of each day there are the full number of miners near the shelter. Since there are 1440 minutes in day that means that between 96.8% and 93.7% of the time there are only half the number of men that the shelter can support in the area. This makes a huge difference in the survivability of any that must use them.

It is strongly requested that this requirement be stricken as unnecessary.

Comment 100 concerning the statement:

Section 75.1506 Paragraph (a)(2) would require that refuge alternatives for working sections accommodate the maximum number of persons that can be expected on or near the section at any time. The refuge alternatives for the working sections would need to include space to accommodate all persons working near the section. It should accommodate all miners that join those working at the section during a shift change. For example if a mine has a practice of ''hot refuge alternative in the mine for this training purpose. The miners would have to construct the refuge alternative, if applicable, activate the refuge alternative, purge the atmosphere, and turn on the breathable air and maintain a viable atmosphere. Although MSHA does not specify a minimum time for this annual training exercise, the duration should be sufficient to allow miners to perform all of the necessary tasks and give them a realistic experience of using the refuge alternative. The Agency would require that this training expose the miners to the expected heat and humidity conditions in the refuge alternative. MSHA does not expect that this training would include the actual use of oxygen and harmful gas removal components; these actions may be performed with compressed air and simulated removal components. The training must also emphasize that, in the event of an emergency, miners should first try to evacuate the mine and that refuge alternatives are the option of last resort when escape is impossible. MSHA solicits comment from the public on the Agency's proposed approach to expectations training. The Agency is interested in comment on its proposed strategy and the proposed elements of training. Please be specific in your response, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and data to support your comment.

While experiential training is important, requiring two shifts to drill at once in the mine could create safety problems of its own. Getting 16 to 36 men plus trainers to coordinate an underground exercise such that everyone gets some training value out of it will be difficult if not impossible. MSHA should provide flexibility for mines and trainers to develop training processes that work best for that mine, the type of emergency equipment they have installed and the number of people that need to be involved. Thirty plus people stumbling around in the dark does not make a good training exercise. It is requested that this be modified to allow training that is most practical and effective.

Comment 101 concerning the statement:

Section 75.1506 Paragraph (a)(3) would require that refuge alternatives for outby areas accommodate persons assigned to work in the outby area. The proposed rule would not require that outby refuge alternatives be able to accommodate all persons working inby its location. Refuge alternatives are used to shelter in-place only when evacuation is not feasible. Under the proposal, outby refuge alternatives would have to accommodate supply persons, locomotive operators, examiners, state and Federal inspectors, pumpers, maintenance persons, belt persons, and other persons who may be working in the outby areas. A refuge alternative must be sufficient to maintain the miners who can reasonably be expected to use it. MSHA solicits comment from the public on the Agency's proposed approach to refuge alternative capacity. Please be specific in your response, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and data to support your comment.

The analysis done by NIOSH as well as those done by the Bureau of Mines and even other MSHA documents suggest that the greatest risk is for those near the working sections. The placement of extra SCSR caches lifelines and communication and tracking requirements make it very unlikely that an event on the working section would block someone outby for escape. The inclusion of the outby shelter areas is not warranted by the present data. MSHA is requested to document the necessity of these outby shelters and to what extent in the past accident they would have made a difference in reducing fatalities. If the documentation does not support the refuges it is, recommend this be deleted from the final rule.

Comment 102 concerning the statement:

Section 75.1506 Paragraph (b) addresses proposed locations for placement of refuge alternatives. Refuge alternatives would have to be near locations where miners are typically stationed. MSHA's experience shows that the highest concentration of miners underground will be at the working section, therefore, a refuge alternative capable of accommodating these miners must be positioned close to the working section.

Section 75.1506 Paragraph (b)(1) would require that refuge alternatives be located between 1,000 feet and 2,000 feet from the working face and from areas where mechanized mining equipment is being installed or removed. MSHA is proposing these distances to accommodate the periodic advancement of the working section, to recognize the potential for damage from an explosion, and to limit travel time from the working section to the refuge alternative. In its report, NIOSH requested that the refuge alternative be located no further from the working face than the distance a miner could reasonably travel in 30 to 60 minutes under expected travel conditions. NIOSH also requested that the refuge alternative be located at least 1,000 feet from the working face to limit damage from explosions at the working face. In its report, NIOSH recognized that establishing the exact location is problematic and indicated it would appear advantageous to place the refuge alternative as close to the face as possible to minimize the time and effort required for miners to reach it. NIOSH added that locating the refuge alternative closer to a

*possible explosion source will increase the chance it is damaged by overpressure or flying debris from the initial explosion. NIOSH analyzed past disasters as well as various probable scenarios. NIOSH further noted that lower seam heights, difficult bottom conditions, and the presence of smoke, among other factors, would affect travel times. NIOSH went on to say that, [n]onetheless, the experience of studying mine explosions at NIOSH's Lake Lynn experimental mine suggests that refuge chambers should normally be located a minimum of 1000 feet from the working face and could be as far as 2000 feet * * *.*

This NIOSH reasoning is consistent with MSHA's rationale for at least 1,000 feet, which is based on explosion pressure. West Virginia requires ''An emergency shelter/chamber shall be maintained within one thousand (1,000) feet of the nearest working face in each working section.'' Illinois requires that ''Rescue chambers must be provided and located within 3,000 feet of each working section of a mine, in accordance with a plan submitted by an operator and approved by the Mining Board.'' The proposal would require that refuge alternatives be located between 1000 feet and 2000 feet from the working face and from locations where mechanized mining equipment is being installed or removed. As an alternative to the proposed requirement that refuge alternatives be located between 1,000 feet and 2,000 feet from the working face and from areas where mechanized mining equipment is being installed or removed, MSHA is considering including the following alternative in the final rule. As an alternative to the specific requirements in the proposal for locating refuge alternatives in inby areas, MSHA is proposing to allow, depending on mine specific conditions, refuge alternatives with boreholes to be located up to 4,000 feet from the working face. MSHA solicits comments on this proposed alternative to locating refuge alternatives in inby areas. MSHA also solicits comments on the proposed requirement that refuge alternatives be located between 1,000 feet and 2,000 feet from the working face and from areas where mechanized mining equipment is being installed or removed. Please be specific in your response, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and data to support your comments.

The NIOSH evaluation of the location of shelters indicated the 1000 to 2000 feet were the optimum location for shelters. Page 18 of the report concluded that explosions occurring right at the face killed all or some of the miners instantly, while face workers were not killed when the explosion occurred away from the face. Of the 11 accidents where enough information was available to determine the likelihood that a shelter at 1000 feet would have saved lives the answer was yes in all cases. When answering which location would be favored they answered five would have favored 1000 feet while one would have favored 2000 feet. In one case, either would have worked, in two cases neither would have worked and in two cases, there was not enough information to make a recommendation. This analysis mirrors that done by the West Virginia Task Force. The 1000-foot selection was made on a reasoned analysis of the facts. The text in the proposed rule not only misstates the conclusions of the NIOSH study the 4000-foot value proposed by MSHA is not supported by any logic. It is incumbent upon MSHA to explain why they have chosen to ignore the finding of other professionals who have looked at this same subject and reached similar conclusions. It also requested that MSHA think through the concept that Illinois and West Virginia came to different conclusions because mining practices differ in the two regions. It is requested that MSHA provide a performance metric for distance from the face and let the mines, Districts and States determine which is best for their mines in general and each mine in particular.

Comment 103 concerning the statement:

Section 75.1506 Paragraph (b)(2) would require that refuge alternatives be spaced within one-hour travel distances in outby areas where persons work such that persons in outby areas are never more than a 30- minute travel distance from a refuge alternative or safe exit. Proposed paragraph (b)(2) further

provides that the operator may request and the District Manager may approve a different location in the Emergency Response Plan (ERP). The operator's request would have to be based on an assessment of the risk to persons in outby areas, considering the following factors: Proximity to stoppings; proximity to potential fire or ignition sources; conditions in the outby areas; location of stored SCSRs; and proximity to the most direct, safe, and practical route to an intake escapeway. This approach is generally consistent with NIOSH's recommendations. Persons who work in outby areas may need to travel more than 30 minutes to reach a refuge alternative. They should be provided with additional SCSRs to assure that they can reach a refuge alternative from outby areas.

In 2006, MSHA examined how far miners could travel during 30 minutes for the Emergency Mine Evacuation final rule (71 FR 71430, December 8, 2006). Existing § 75.1714–4(c)(2) provides two methods for determining the 30-minute spacing of SCSR storage locations in escapeways. The first method, in existing § 75.1714–4(c)(2)(i), requires the mine operator to calculate the spacing based on a sample of typical miners walking a selected length of each escapeway. A sample of typical miners is a cross-section of the population of all miners who would have to evacuate the mine and use the SCSRs stored in the escapeways. In general, operators using this option must use a sample that includes miners of various ages, weights, levels of physical fitness, and smoking habits; and a selected portion of the escapeway that reflects entry height, slope, and underfoot conditions representative of the entire escapeway. The second method, in existing § 75.1714–4(c)(2)(ii), requires a mine operator to use a table that specifies maximum SCSR storage location spacing based on average entry height. This table is based on statistical data collected from the 1997 MSHA–NIOSH study.6 The mine operator may use the SCSR storage location spacing specified in the following table, except for escapeways with uphill grades over 5 percent. Average entry height Maximum distance between SCSR storage locations (in feet)

<40 in. (Crawl)	*2,200*
>40–<50 in. (Duck Walk)	*3,300*
>50–<65 in. (Walk Head Bent)	*4,400*
>65 in. (Walk Erect)	*5,700*

For spacing refuge alternatives in outby areas, the mine operator may choose either of the above methods. MSHA solicits comment from the public on the Agency's proposed approach to locating refuge alternatives in outby areas, including the minimum and maximum distances. Please be specific in your response, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and data to support your comment.

The analysis done by NIOSH as well as those done by the Bureau of Mines and even other MSHA documents suggest that the greatest risk is for those near the working sections. The placement of extra SCSR caches lifelines and communication and tracking requirements make it very unlikely that an event on the working section would block someone outby for escape. The inclusion of the outby shelter areas is not warranted by the present data. MSHA is requested to document the necessity of these outby shelters and to what extent in the past accident they would have made a difference in reducing fatalities. If the documentation does not support the refuges it is, recommend this be deleted from the final rule.

Comment 104 concerning the statement:

Section 75.1506 Paragraph (c) would require that roof and rib support for the refuge alternative locations be specified in the mine's roof control plan. The proposed provision addresses hazards from falling material, which may compromise the integrity of the refuge alternative. MSHA understands that no currently available refuge alternatives can withstand significant roof and rib falls. Humidity resulting from fires, vibrations, shock, and thermal effects are often associated with catastrophic events that may

require the use of additional roof support for areas housing refuge alternatives. Due to the vital need for refuge alternatives to serve their intended purpose, mine operators must assure that they are adequately protected from roof and rib falls. MSHA encourages mine operators to plan and prepare locations for refuge alternatives in advance. The necessary steps to protect refuge alternatives from roof and rib falls must be described in the roof control plan. MSHA anticipates that in a significant number of instances, operators will need to provide supplemental roof and rib support to protect the refuge alternative.

Agree.

Comment 105 concerning the statement:

Section 75.1506 Paragraph (d) would require that the operator protect the refuge alternative and contents from damage during transportation and storage. The proposed provision is intended to assure that care will be taken to avoid damage to the refuge alternative at all times. Mine operators need to assure that miners follow all safe procedures when transporting a refuge alternative from one location to another. Attention needs to be paid to procedures such as the use of proper connections for transportation and devices such as tow bars, clevises and hitches. Refuge alternatives that have materials and components stored on transportable equipment, such as a skid, would require care to assure that they are not damaged while in storage.

Agree.

Comment 106 concerning the statement:

Section 75.1506 Paragraph (e) would require that a refuge alternative be removed from service if examination reveals damage or tampering that could interfere with the functioning of the refuge alternative or any component. Refuge alternatives may be damaged by persons, mining equipment or the mine environment. The proposed rule would require that damage must be evaluated and any indication that it interferes with the functioning of the refuge alternative or its components would require that the refuge alternative be immediately removed from service. For example, if examination reveals a leak in a compressed gas storage system, the refuge alternative would have to be removed from service since it would be unable to provide breathable air in an emergency.

Section 75.1506 Paragraph (e)(1) would require the operator to withdraw all persons from the area serviced by the refuge alternative if the refuge alternative is removed from service, except those persons referred to in § 104(c) of the Mine Act. Under the proposal, if an inoperable or damaged refuge alternative would not provide the protection intended, all persons would have to be withdrawn from the area serviced by the refuge alternative. This would not include persons performing the repairs, who should be provided with additional SCSRs to assure that they can reach another refuge alternative.

Section 75.1506 Paragraph (e)(2) would require that refuge alternative components removed from service be replaced or be repaired in accordance with manufacturer's specifications. This proposed provision would require mine operators to maintain the refuge alternative in its approved condition by using approved components and repairing it in accordance with the manufacturer's specifications. Miners would be provided the protection afforded by approved refuge alternatives at all times.

Section 75.1506 Paragraph (f) would require that, at all times, the site and area around the refuge alternative be kept clear of machinery, materials, and obstructions that could interfere with the activation or use of the refuge alternative. Under the proposal, refuge alternative locations would be easily accessible in that the areas around them would be maintained without obstructions to hinder access to the refuge alternative or to allow the refuge alternative to expand or be constructed to create the secure

space. The proposal is necessary to assure the availability and survivability of the refuge alternative and its occupants.

Agree.

Comment 107 concerning the statements:

Section 75.1506 Paragraph (g) would require that each refuge alternative be conspicuously identified with a sign or marker. The proposal would provide a quick way for persons not using the lifeline system to easily locate the refuge alternative in an emergency.

Section 75.1506 Paragraph (g)(1) would require that a sign or marker made of reflective material with the word "Refuge" be posted conspicuously at each refuge alternative. Reflective material greatly increases the visibility of these signs. This requirement is the same as the existing § 75.1714–4(f), which requires reflective signs on SCSR storage locations.

Section 75.1506 Paragraph (g)(2) would require that a directional sign, made of reflective material, be posted leading to each refuge alternative location. Miners may not be located in escapeways when an emergency occurs. For these miners, a clear system of signs may be critical during an emergency. Persons traveling in adjacent entries would have signs directing them to the refuge alternative.

Agree. However, it is requested that the final rule include the requirement that the location be surveyed in after each move. This will greatly assist in the location of the shelter if drilling is required or if seismic listen is used.

Comment 108 concerning the statement:

Section 75.1507 Emergency Response Plan; Refuge Alternatives Proposed § 75.1507 would require mine operators to include refuge alternative provisions in their Emergency Response Plan (ERP). Section 2 of the MINER Act requires each underground coal mine operator to develop and adopt an emergency response plan.

Section 75.1507 Paragraph (a)(1) would require that the mine operator specify the types of refuge alternatives and components used in the mine. There are three types of refuge alternatives envisioned in the proposed rule. The proposed rule would provide flexibility in the type of refuge alternatives that will meet the requirements. The type of alternative is not specific to the seam heights. One type is a pre-fabricated self contained unit. The unit is portable and may be used in outby applications as well as near the working section. This unit has all the components built-in. A second type is constructed in place. Typically, the components of this unit are placed in a cross-cut or dead-end entry and stoppings are built to create a secure area with an isolated atmosphere. The components, including breathable air, removal of harmful gases, and air monitoring should be approved components and placed such that they are ready to be activated when miners reach the secure area. The stoppings and doors would have to be designed to resist a 15 psi overpressure. This refuge alternative would typically be used outby. If used near the working section, the stoppings could be removed to allow the components to be moved periodically to the next location and new stoppings would have to be built. A method and materials, if needed, would be necessary to provide breathable air for the miners while this type is being moved. A third type uses materials prepositioned for miners to construct a secure area with an isolated atmosphere. The materials and components are portable and used to construct a secure area following an accident. The components, including breathable air, removal of harmful gases, and air monitoring should be approved components and placed such that they are ready to be activated when miners reach the secure area. MSHA envisions that mine operators using this type would have all materials and components in a protected self-

contained unit ready to be activated. The proposed rule would allow for the refuge alternative materials and components to be placed at locations such that, following an accident, a secure space could be constructed with the materials and the breathable air component would be readily activated within the secure space to create an isolated atmosphere. This provision would require the operator to provide details of this refuge alternative in the ERP. This alternative would require the operator to have the materials situated in a safe location and to move them as necessary to be located near the working section as required. The provisions are necessary to assure the availability and survivability of the structure and the occupants. As appropriate, MSHA would approve the refuge alternatives and components. The pre-fabricated self-contained unit would need to be approved under Party 7, including structural, breathable air, air monitoring, and harmful gas removal components of the unit. The structural components of units constructed in place and with materials pre-positioned would be approved by the District Manager and as appropriate, would be inspected during the enforcement process. The breathable air, air monitoring, and harmful gas removal components of these units would be approved under Party 7.

This section introduces a new type of shelter, a built in place shelter with an airlock, that is not mentioned previously and whose structure thus has no regulatory definitions. If that is intended to be an option, the regulation should provide details and requirements. The option for the after the event stopping is again mentioned here. The objections raised above still apply. The dated practice of building barricades after an event should not be encouraged or included in the CFR. The killer of those that survive an explosion or fire is carbon monoxide and there has not been shown to be a means for successfully purging a crosscut used as a barricade. The only sure way of ensuring that miners who have to take shelter is that the air quality is established prior to them entering. Lacking that it will require an engineered and tested system for purging to avoid pockets of hazardous gas within the space. If it is MSHA's intent to allow this option there needs to be considerable more testing done and specific directions provided the industry on how to duplicate the process once discovered. Lacking that it is strongly requested that all references to this technique be purged for this rule making process.

Also in those cases where an operator selects an MSHA approved model why is the operator required to again document all the requirements that the manufacturer has had certified by MSHA. It is requested that an operator stating the approval number of the model selected be sufficient,

Comment 109 concerning the statement:

Section 75.1507 Paragraph (a)(2) would require that the ERP include procedures for maintaining the approved refuge alternatives and components. This proposal would assure that miners are able to maintain or correct any problems that may develop during storage or use of the refuge alternatives. Procedures should include maintenance checks and replacement schedules for components.

Agree.

Comment 110 concerning the statement:

Section 75.1507 Paragraph (a)(3) would require that the rated capacity of each refuge alternative, the number of persons expected to use each refuge alternative, and the duration of breathable air provided per person by the approved breathable air component of each refuge alternative be defined in the ERP. The ERP would need to state specifically that the refuge alternatives can support a specified number of persons for a designated length of time. This information assists MSHA in evaluating whether the refuge

alternative or component meets the requirements for sustaining persons for 96 hours. MSHA solicits comments from the public on the 96-hour duration. Please be specific in your response, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and data to support your comment.

Agree. Providing that requests concerning outby shelter are addressed and requesting that by selecting an MSHA approved model the operator should not be required to again document all the requirements that the manufacturer has had certified by MSHA.

Comment 111 concerning the statement:

Section 75.1507 Paragraph (a)(4) would require that the ERP include the method for providing breathable air and removing carbon dioxide with sufficient detail of the component's capability to provide breathable air over the duration stated in the approval. For example, the Agency recognizes that different types and combinations of equipment and methods from several manufacturers may be used to provide for breathable air and for the removal of carbon dioxide. This information assists MSHA in evaluating whether the breathable air meets the requirements for sustaining persons for 96 hours.

Agree, noting the previous request for documentation on the derivation of the 96 hour value and that lacking that the final rule state a minimum of 48 hours. Additionally, it is requested that by selecting an MSHA approved model the operator should not be required to again document all the requirements that the manufacturer has had certified by MSHA.

Comment 112 concerning the statement:

Section 75.1507 Paragraph (a)(5) would require that the ERP include methods to provide ready backup oxygen controls and regulators. The term ''ready'' is meant to be pre-connected valves and regulators. Redundant oxygen control valves and regulators are necessary to assure that miners will always have breathable air available in case of component failures.

Agree, but it is requested that by selecting an MSHA approved model the operator should not be required to again document all the requirements that the manufacturer has had certified by MSHA.

Comment 113 concerning the statement:

Section 75.1507 Paragraph (a)(6) would require that the ERP include the methods for providing an airlock and methods for providing breathable air in the airlock. Refuge alternatives that require an airlock would be required to provide breathable air in the airlock at all times. However, when miners enter the airlock, it is necessary to monitor and provide purge air to remove any contaminants and minimize contamination inside the refuge alternative. Sufficient purge air is necessary to clear the airlock of contaminants.

Agree, but note that previous provision of these regulation require all alternatives to have an air lock. It is requested that the phrase "that require an airlock" should be struck.

Comment 114 concerning the statement:

Section 75.1507 Paragraph (a)(6) would require that the ERP specify that the airlock is capable of maintaining breathable air, except where adequate positive pressure is maintained. The ERP should provide specific information regarding how the airlock will provide and maintain breathable air. Purging or other effective methods would be necessary, within 20 minutes of miners activating the refuge alternative, for the airlock to dilute the carbon monoxide concentration to 25 ppm or less and the methane concentration to 1.5 percent or less as persons enter. The proposed rule includes an exception for an airlock if the refuge alternative is capable of maintaining adequate positive pressure. The positive pressure would prevent outside air from contaminating the refuge alternative. The proposal would assist MSHA in evaluating whether the airlock would function effectively.

Agree. But note it is requested that by selecting an MSHA approved model the operator should not be required to again document all the requirements that the manufacturer has had certified by MSHA.

Comment 115 concerning the statement:

Section 75.1507 Paragraph (a)(7) would require that the ERP include methods for providing sanitation facilities. The ERP should contain information on containing waste and eliminating objectionable odors. The ERP should also include information that the sanitation facilities are adequate for the specified number of persons and where it is to be located. The proposal would assist MSHA in determining that the refuge alternative includes an adequate means for containing waste.

Agree. But note it is requested that by selecting an MSHA approved model the operator should not be required to again document all the requirements that the manufacturer has had certified by MSHA.

Comment 116 concerning the statement:

Section 75.1507 Paragraph (a)(8) would require that the ERP include the methods for harmful gas removal. Sufficient purge air is necessary to clear the refuge alternative of smoke and carbon monoxide unless the design of the refuge alternative prevents the infiltration of these combustion products. Information on harmful gas removal is essential for MSHA to determine the ability of the refuge alternative to sustain occupants for 96 hours. The purpose of this component is primarily to remove carbon dioxide exhaled by the occupants. MSHA also intends that this component be capable of removing toxic and irritant gases, fumes, mists, and dusts that may enter the refuge alternative through the airlock.

Agree. But note it is requested that by selecting an MSHA approved model the operator should not be required to again document all the requirements that the manufacturer has had certified by MSHA.

Comment 117 concerning the statement:

Section 75.1507 Paragraph (a)(9) would require that the ERP include methods for monitoring gas concentrations, and charging and calibrating equipment. This information is essential for MSHA to determine that persons inside the refuge alternative will be aware of the concentrations of carbon dioxide, carbon monoxide, methane, and oxygen inside and outside the structure, including the airlock. This information assists MSHA in evaluating whether the air-monitoring component meets the requirements for sustaining persons for 96 hours. Different types and combinations of instruments may be used to comprise an air-monitoring component. The proposal allows MSHA to determine that discrete

components are appropriate, available, and functional for monitoring breathable air. MSHA believes that a properly designed system would control gas concentrations inside the refuge alternative. The intent of this provision is that detectors would be used to periodically check and provide a means of increasing the miner's awareness of gas concentrations. Instruments that require fresh air for initial startup would not be appropriate to be stored for use in refuge alternatives. If the battery life of the instruments is not sufficient for 96 hours of monitoring then multiple detectors would be required.

Agree. But note previous recommendation concerning the 96-hour value and the fact that selecting MSHA approved instruments should suffice for descriptions. Also I again note it is requested that by selecting an MSHA approved model the operator should not be required to again document all the requirements that the manufacturer has had certified by MSHA.

Comment 118 concerning the statement:

Section 75.1507 Paragraph (a)(10) would require that the ERP include the method to provide lighting sufficient to perform tasks. Sufficient light is essential to allow persons to read instructions and warnings, as well as reading gages, operating gas monitoring detectors, and other activities related to the operation of the refuge alternatives and the needs of the occupants. Lighting that generates significant heat, or requires continual manual power for light generation, would be unacceptable for use in a refuge alternative.

The previous recommendations on the value of additional lighting verse the risk of additional power sources remains and should be addressed. Also, note previous recommendation concerning the 96-hour value and the fact that selecting MSHA approved instruments should suffice for descriptions. Also I again note it is requested that by selecting an MSHA approved model the operator should not be required to again document all the requirements that the manufacturer has had certified by MSHA.

Comment 115 concerning the statement:

Section 75.1507 Paragraph (a)(11) would require mine operators to affirmatively state in the ERP that the locations are suitable for refuge alternatives. The proposed rule would require that refuge alternatives be protected from known hazards in the coal mine. Refuge alternatives would also need to be located so that they are easily accessible. The proposed rule would require that refuge alternatives be placed at locations that do not have obstructions to future physical dimensions of the refuge alternative. The provisions are necessary to assure the availability and survivability of the structure and the occupants.

Agree.

Comment 116 concerning the statement:

Section 75.1507 Paragraph (a)(11)(i) and (ii) would require that the ERP specify that refuge alternatives are not within direct line of sight of the working face and, where feasible, not in areas directly across from, nor closer than 500 feet radially from, belt drives, take-ups, transfer points, air compressors, explosive magazines, stoppings, entrances to abandoned areas, and fuel, oil, or other flammable or combustible material storage. The proposed rule addresses the potential damage from a working face explosion and, additionally, the potential of a fire at certain areas or equipment. Locating refuge alternatives away from these areas would minimize the heat or explosive forces that could occur and affect the safety of persons in the refuge alternative. NIOSH requested that refuge alternatives be positioned in crosscuts rather than entries, or located in deadend cuts to decrease the possibility of damage from overpressure or flying

debris from an explosion. NIOSH also requested that refuge alternatives be located away from potential sources of fires, such as belt drives. NIOSH further requested that, whenever practical, the refuge alternative should not be located in nor off of track entries nor within approximately 1,000 feet of any mine seal. This proposal includes locations for refuge alternatives that are consistent with NIOSH's recommendations. The Agency would consider exceptions to this requirement when it is not feasible to locate the refuge alternative according to this provision.

This section again adds a new requirement to a previously discussed subject in the proposed rule, this time that the shelter cannot be in an entry. While not stating it directly, "not with line of sight" effectively means in a crosscut. It also adds the 500 foot rule that further limits its placement. In a six entry section with 20 foot entries and 75 foot pillars and with a belt in one of the center entries there may not be a place within 1000 or even 2000 feet of the face that meet all these requirements. While it is agreed that these are valid consideration they should have been discussed in previous section on locations. We believe a location adjacent to the primary or secondary escape way that avoids to the extent possible the issues raised makes the most sense. If you think through the scenario in which it will be used, something has happened, escape has been tried – though one of the escape ways – and it was unsuccessful. The miners will be returning up the escapeways. If MSHA feels that a location to this degree must be prescribed then it is requested that a scenario approach be used as a performance based standard of a miner that tried to escape and could not.

Comment 117 concerning the statement:

Section 75.1507 Proposed paragraph (b) contains provisions for ERPs for refuge alternatives constructed in place. The proposal would require that the ERP specify that stoppings and doors are designed to resist 15 psi overpressure.

Section 75.1507 Paragraph (b)(1) would require that the ERP include information on breathable air components approved by MSHA. Breathable air is intended to protect miners from injury or death from a contaminated atmosphere. MSHA is proposing that breathable air contain an oxygen concentration between 18.5 and 23 percent and a carbon dioxide concentration not exceeding a 1.0 percent time-weighted average and that at no time exceeds 2.5 percent for any 24-hour period. These concentrations are consistent with NIOSH's recommendation. Breathable air delivered from fans or compressors through pipes or air lines would need to meet the requirements of Party 7.

Section 75.1507 Paragraph (b)(2) would require that the ERP specify that the refuge alternative is capable of withstanding exposure to a flash fire of 300 °F for 3 seconds and a pressure wave of 15 psi overpressure for 0.2 seconds. Because the stoppings must protect the components of the refuge alternative and persons inside, the stoppings must be able to withstand both flash fires and explosive overpressures.

The use of built in place shelters must address the issue of roof, rib and floor control, off-gassing of methane and oxygen absorption of oxygen of the coal, sealing of air pathways through the natural surfaces or the maintenance of positive pressure at all times prior to the occupancy to prevent infiltration of gases. In addition, it will require the airlock and other provision of maintaining the integrity of the internal atmosphere as miner enter along with all the inspection requirements of purchased units. If the MSHA Approval and Acceptance Center is not to have role in the evaluation of these then an approval manual will need to be developed for use by the District staff. It is strongly

requested that all these elements be addressed in the final rule, as they are not in this proposed rule.

Comment 118 concerning the statement:

Section 75.1507 Proposed paragraph (c) contains provisions for ERPs for refuge alternatives consisting of materials prepositioned for miners to construct a secure space with an isolated atmosphere.

Section 75.1507 Paragraph (c)(1) would require that the ERP specify the means to store and protect materials from being damaged when moved. The operator would be required to provide details of how the components are placed on a transportation device to provide security, transportation readiness and component integration to assure this alternative will be available when needed and readily constructed and activated. The materials should be arranged together and protected from potential damage when moved.

Section 75.1507 Paragraph (c)(2) would require that the ERP specify that the refuge alternative can withstand exposure to a flash fire of 300 °F for 3 seconds and a pressure wave of 15 psi overpressure for 0.2 seconds prior to construction and activation. Because this type of refuge alternative is constructed following an accident, materials and components would be stored in a crosscut or deadend entry until needed. The materials and components must be stored in a container that will withstand a flash fire of 300 °F for 3 seconds and a pressure wave of 15 psi overpressure for 0.2 seconds so that the components would operate as intended and would be available and functional when needed.

Section 75.1507 Paragraph (c)(3) would require that the ERP specify the method for assuring that the refuge alternative could be constructed and functional in 10 minutes. Under the location requirements for refuge alternatives, miners would never be more than 30 minutes from either the portal or a refuge alternative. In the event of an accident, a miner with only one SCSR would have 30 minutes to reach the portal or a refuge alternative. The proposal would allot 10 minutes to establish a barrier between the interior and exterior atmospheres. The remaining 20 minutes of breathable air provided by the SCSR would allow time for purging the refuge alternative to establish a breathable atmosphere.

Section 75.1507 Paragraph (c)(4) would require that the ERP specify the method for having all components ready to be activated and used. Components include breathable air, harmful gas removal, air monitoring, communication, first aid, food and water, and sanitation. The proposal would assist MSHA in determining that components comprise a complete functional refuge alternative.

Section 75.1507 Paragraph (c)(5) would require that the ERP specify the means to assure that the initial air quality is breathable once the refuge alternative is constructed. This refuge alternative is built following an accident, which could produce smoke and contaminated air in the area where the refuge alternative is constructed. Therefore, the atmosphere may be contaminated and would need purging or other effective methods as necessary, within 20 minutes of miners activating the refuge alternative, for the airlock to dilute the carbon monoxide concentration to 25 ppm or less and the methane concentration to 1.5 percent or less as persons enter. An operator would need to provide sufficient compressed air to purge the refuge alternative to establish a breathable atmosphere. Paragraph (d) contains provisions for ERPs if the refuge alternative would only sustain persons for 48 hours. It would require that the ERP specify that advance arrangements have been made to assure that persons who cannot be rescued within 48 hours will receive additional supplies to sustain them until rescue. The basis for the proposal is MSHA's existing PIB on breathable air.

This has been addressed multiple times through out these comments. MSHA has not demonstrated that a space the size they are intending to allow be created here can be

purged by any amount of air at all let alone in 20 minutes. Despite multiple discussions with technical support staff along with District and HQ staff on this subject MSHA have not been able to validate the efficacy of this approach, yet it continues to be proposed. It is the least expensive approach, which we hope is not the reason for its longevity. <u>It is again strongly requested that this be deleted in the final rule.</u>

Comment 119 concerning the statement:

Section 75.1507 Paragraph (d)(1) would require that the advance arrangements specified in the ERP include pre-surveyed areas for refuge alternatives with closure errors of less than 20,000:1. The proposed provision is intended to assure that the survey that is done on the surface and the one performed underground are closed. The surface survey could be done with global positioning satellite equipment. When a survey connects back to itself, it is called a loop. The loop in this provision would begin with the surface survey of the location above the location of the refuge alternative and along a route to the underground location of the refuge alternative and back to the beginning survey location on the surface. If a loop is surveyed perfectly, the survey should come back to the exact point at which it started. If the loop does not come back to the exact starting point, it is called a closure error. Closure errors indicate that some or all of the survey measurements within a loop have errors. This provision assures accuracy in getting the borehole to the correct location underground.

Agree, but it is requested that it also include provisions for the maintenance of survey monuments and the demonstration by the mine of a contract with surveyor for immediate response to locate the surface points of the shelters. In difficult topography, the early arrival of these resources is critical.

Comment 120 concerning the statement:

Section 75.1507 Paragraph (d)(2) would require that the advance arrangements specified in the ERP include an analysis to indicate that the surface terrain, the strata, the capabilities of the drill rig, and all other factors that could affect drilling are such that a hole sufficient to provide required supplies and materials reliably can be promptly drilled within 48 hours of an accident at a mine. This provision is intended to assure that conditions that could interfere with or delay drilling are discovered and prepared for well in advance. The drill rig capabilities should be examined to assure the appropriate drill model is selected. This allows planning so that correct equipment and supplies are available when needed.

Agree, but recommend that it also include provisions for the demonstration by the mine of a contract with drilling contractor and access to earth moving equipment for immediate response to cut roads and pads for the rapid erecting of the drilling rig at the sites surveyed under the previous requirement. In difficult topography, the early arrival of these resources is critical.

Comment 121 concerning the statement:

Section 75.1507 Paragraph (d)(3) would require that the advance arrangements specified in the ERP include permissions to cross properties, build roads, and construct drill sites. This provision is intended to assure that the arrangement to drill a borehole is done in advance so that normal delays that would occur during a mine emergency are eliminated and the drilling can proceed immediately upon arrival of the drill rig.

Agree, however it is requested that it go one step further and emergency power should be given to MSHA to force access if necessary in an emergency.

Comment 122 concerning the statement:

Section 75.1507 Paragraph (d)(4) would require that the advance arrangements specified in the ERP include an arrangement with a drilling contractor or other supplier of drilling services to provide a suitable drilling rig, personnel, and support so that a hole can be completed to the refuge alternative within 48 hours. MSHA expects that the arrangements that are finalized with the drilling contractor and other suppliers are such that all details including, but not limited to, mobilization, availability, ancillary services, back-up plans, drillhole specifications, completion schedules, and spare parts are considered and included.

Agree, but as in the comment 119 above it is requested that it include provisions for the demonstration by the mine of a contract with drilling contractor and earth moving equipment for immediate response to cut roads and pads for the rapid erecting of the drilling rig at the sites surveyed under the previous requirement. In difficult topography, the early arrival of these resources is critical.

Comment 123 concerning the statement:

Section 75.1507 Paragraph (d)(5) would require that the advance arrangements specified in the ERP include the capability to promptly transport a drill rig to a presurveyed location such that a drilled hole would be completed and located near a refuge alternative structure within 48 hours of an accident at a mine. MSHA intends that this provision would assure the prompt delivery of the drill to the site. If the site is not easily accessible, the operator should have advance arrangements to have the appropriate equipment to transport, deliver, or carry the drill rig to the site. The operator should consider and prepare for potential delays. These procedures should be adequately evaluated to assure that 48 hours are more than reasonable. MSHA expects that the borehole would be drilled near the location of the refuge alternative. A method for supplying breathable air from the surface through the borehole would need to have the capability to provide a sufficient quantity of air to dilute any harmful gases in and around the refuge alternative. MSHA requests comments on whether the rule should contain a provision that the advance arrangements specified in the ERP include a method for assuring that there will be a suitable means to connect the drilled hole to the refuge alternative and that the connection be made within 10 minutes. Under this provision, MSHA would expect the operator to have detailed plans for making connections from the drill hole casing to the refuge alternative. These plans would have to address the conditions that the miners will encounter during this planned work, including smoke, contaminated atmosphere, lack of adequate lighting, etc. The means to connect the drill hole casing should include all necessary clamps, fittings, connections, proper and sufficient hosing, mechanical supports, and tools. The connection to the refuge alternative should also be planned. The number of steps to accomplish this task of making the connections should be minimized and simplified. Under this provision, MSHA would also expect that advance arrangements specified in the ERP include the capability to provide full-face breathing apparatus to persons exiting the refuge alternative to make necessary connections from the borehole. The breathing apparatus would be necessary to protect the miner from any gases or toxic products of combustion generated by a fire or explosion. The apparatus would need to have adequate capacity to allow sufficient time to complete the connection. The operator would also need to provide several breathing apparatus to enable occupants to come to the aid of an injured miner. Other devices, such as tag lines or tethers, would need to be available to assist miners in returning to the refuge alternative. Comments should be specific, including alternatives, rationale, safety benefits to miners, technological and economic feasibility and supporting data.

Section 75.1507 Paragraph (d)(6) would require that the advance arrangements specified in the ERP include a list of the pipes, air lines, approved fan, and approved compressor that will be used. This information decreases the possibility that an inappropriate or inadequate source of breathable air would

be connected to the borehole. Paragraph (d)(7) would require that the advance arrangements specified in the ERP include a method for assuring that the breathable air system, including compressors and fans, is designed for the planned conditions. The design should include consideration of pipe resistance, volumes and velocities needed, connections required on the surface, power needs, supplies required and necessary redundant or back-up requirements. The system should be on hand and ready to provide breathable air after the borehole is completed.

Section 75.1507 Paragraph (d)(8) would require that the advance arrangements specified in the ERP include a method for assuring the immediate availability of a backup source for supplying breathable air and a backup power source for surface installations. This information assists MSHA in evaluating the continued availability of breathable air.

With shelters such as those described in this proposed rule are in place the urgency of supplying additional air is greatly reduced. If the hole is punched and the air samples come back acceptable, the miners can be instructed to escape. It the air is bad and the progress of rescue teams is slowed, then the hole can act as a pilot for a larger hole to allow for a capsule. MSHA should have contracts in place with firms having rigs large enough to drill capsule size holes, that MSHA require in these contracts that the firms stop what they are doing and relocate to the site immediately. These contracts should be such that more than one firm is located near each District. It is likely that those states with mine offices would participate with MSHA in this program, if asked. The pre-positioning of air compressors is admirable but it is recommend that considering all the other options on now available the large bore drill rigs may be more practical and provide a greater degree of safety.

Additionally the concept of adding full-face breathing apparatus to be stored inside a shelter produces considerable added training and logistical problems. The likelihood of needing to extend the air supply beyond the 96 hours currently in the rule is very low. In those few cases it is better to have the drilling rigs in place to provide escape cages than the approach described. It is requested that this be omitted from the final rule.

Comment 124 concerning the statement:

Section 75.1507 Paragraph (e) would require the ERP to specify that the refuge alternative is stocked with essential supplies. Paragraph (e)(1) would require that the ERP specify a minimum of 2,000 calories of food and 2.25 quarts of potable water per person per day to sustain the maximum number of persons reasonably expected to use the refuge alternative at one time. These requirements would provide adequate amounts of food and water and are consistent with NIOSH recommendations. These components should be replaced prior to their expiration.

Section 75.1507 Paragraph (e)(2) would require that the ERP specify that manuals and instructions for operation, training, and maintenance for the refuge alternative and components are provided. The proposal requires operators to obtain information necessary for the safe and effective use of the refuge alternative and its components.

Agree.

Comment 125 concerning the statement:

Section 75.1507 Paragraphs (e)(3) and (e)(4) would require that the ERP specify that the refuge alternative is stocked with sufficient quantities of materials and tools to do repairs and first aid supplies.

MSHA proposed rules have provided flexibility in the type of refuge alternatives that will meet the requirements. The type of alternative is not specific to the seam heights. MSHA recognizes that the 60 cubic feet requirement may be of concern in mines with low seam heights.

Agree, with the last sentence especially. As noted in detail above there is no basis for the 60 cubic foot value and it is of concern not only to those in low coal but also to all manufacturers of portable units. It imposes unnecessary burden without an improvement in safety. It actually may reduce safety if MSHA allows the use of the low cost low safety inflatable stopping option. As some operators will go that way based solely on cost. It is requested that all references to cubic feet per miner be omitted form the final rule.

Comment 126 concerning the statement:

Section 75.1507 Section 75.1508 Training and Records for Examination, Maintenance, Transportation, and Repair of Refuge Alternatives and Components

Section 75.1507 Paragraph (a) would require that persons be trained on examining, maintaining, transporting, and repairing refuge alternatives and components. A refuge alternative includes a number of functional components that are vital to the survival of persons using it. This proposal addresses training for routine examination, maintenance, transportation, and repair of refuge alternatives and components in addition to the training and drills provided all underground miners.

Section 75.1507 Paragraph (a)(1) would require the operator to assure that all persons assigned to examine, maintain, transport, and repair refuge alternatives and components are trained prior to performing the task. This training assures that these critical facilities and components are available and usable when needed. All facilities and components should be maintained using the manufacturer's specifications and procedures. The examiner should be trained in the aspects critical to the activation and use of the refuge alternative. In addition, paragraph (a)(1) would require training in proper transportation of the refuge alternative or component. Miners need to be aware of the safe procedures necessary to transport a refuge alternative or component from one location to another. Training in these procedures would include knowledge of all connections necessary for transportation, such as tow bars, clevises, and hitches. MSHA requests comments on these training requirements and whether it would be more appropriate to include training on examining, maintaining, transporting, and repairing refuge alternatives under the training provisions of Party 48. Comments should be specific, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and supporting data.

Section 75.1507 Paragraph (a)(2) would require the operator to certify, by signature and date, the training of persons who examine, maintain, transport, and repair refuge alternatives and components. The training certifications help MSHA and the operator assure that the appropriate personnel have received the required training. Maintenance and repair work on refuge alternatives and components will not occur at regular intervals. To facilitate these maintenance tasks a justin- time approach to training is required. The required training can vary given the scope of the tasks and the interval since the last training in that same task.

Section 75.1507 Paragraph (b) would require the person conducting the maintenance or repair to make a record of all corrective action taken at the completion of each repair required by this paragraph. Records of training help assure that persons are periodically re-trained to prevent skills degradation.

Section 75.1507 Paragraph (c) would require that the mine operator keep the training certifications and repair records at the mine for one year. Certification and repair records are necessary to help MSHA and the operator identify any systemic defects or problems with the refuge alternative are identified and corrected.

Agree with this section but requested that MSHA recognize that there is great deal of training required of MSHA and state staff that also must take place and MSHA should take the lead in cooperating with state inspectors in obtaining that training.

Comment 127 concerning the statement:

Section 75.1600–3 Communications Facilities; Refuge Alternatives

Section 75.1600 Paragraph (a) would require that refuge alternatives be provided with a two-way communication system and an additional communication system when approved in the mine operator's Emergency Response Plan. Communications with the persons in refuge alternatives are vital to mine rescue efforts. The knowledge of where miners are in refuge alternatives, their condition, and the conditions in the mine may make the difference between life-and-death in a post-accident crisis.

Section 75.1600 Paragraph (a)(1) would require a two-way communication facility that is a party of the mine communication system, which can be used from inside the refuge alternative. The communications device must be usable without further exposing persons to smoke and toxic gases. MSHA solicits comments on the proposed two-way communication facility. Please be specific in your response, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and data to support your comments.

Section 75.1600 Paragraph (a)(2) would require an additional communication system when approved in the operator's Emergency Response Plan (ERP).

Agree with this section but requested that MSHA recognize that there is great deal of training required of MSHA and state staff that also must take place and MSHA should take the lead in cooperating with state inspectors in obtaining that training.

No comment on the following sections:

III. Executive Order 12866 Executive Order (E.O.) 12866 requires that regulatory agencies assess both the costs and benefits of regulations. To comply with E.O. 12866, MSHA has prepared a Preliminary Regulatory Economic Analysis (PREA) for this proposed rule. The PREA contains supporting data and explanation for the summary materials presented in this preamble, including the covered mining industry, costs and benefits, feasibility, small business impacts, and paperwork. The PREA can be found at MSHA's Web site at http://www.msha.gov/ REGSINFO.HTM.

A copy of the PREA can be obtained from MSHA's Office of Standards, Regulations and Variances at the address in the ADDRESSES section of this preamble. MSHA requests comments on all the estimates of costs and benefits presented in this preamble and in the PREA, and on the data and assumptions the Agency used to develop estimates.

Under E.O. 12866, a significant regulatory action is one meeting any of a number of specified conditions, including the following: Having an annual effect on the economy of $100 million or more, creating a serious inconsistency or interfering with an action of another agency, materially altering the budgetary impact of entitlements or the rights of entitlement recipients, or raising novel legal or policy issues. Based

on the PREA, MSHA has determined that this proposed rule would have an annual effect of $100 million or more on the economy and that, therefore, it is an economically significant regulatory action. Congressional Review Act The costs in the PREA represent what MSHA believes to be the upper bound of the range of estimated compliance costs: $102.6 million first year and $43.3 million yearly. MSHA has presented these upper-bound estimates as a conservative approach to estimating compliance costs. However, based upon a review of literature and discussions with manufacturers of refuge alternatives, MSHA believes that a more realistic assumption of the types of refuge alternatives required under the proposal provides a lower-bound estimate of costs: $84.1 million first year and $38.7 million yearly. MSHA has revised the PREA to include these lower-bound estimates of costs. If costs are more in line with the lower-bound estimates, the Congressional Review Act (CRA) would not apply. If costs are more in line with MSHA's upper-bound estimates, then the rule would be classified as a major rule and MSHA would comply with the CRA. Under the CRA, major rules generally cannot take effect until 60 days after the rule is published.

A. Population at Risk The proposal would apply to all underground coal mines in the United States. Based on the most recent MSHA data, there were 624 underground coal mines, employing approximately 42,200 miners, in the United States in 2007, of which 613 mines employ miners working underground. These 613 mines employ approximately 37,800 miners and 5,100 miners working underground, for a total of approximately 42,900 workers underground.

B. Benefits

1. Introduction One of the goals of the MINER Act is to improve emergency response capability in underground coal mines. MSHA has published a number of standards in the last several years and has stated in them that, in the event of a mine emergency in an underground coal mine, the miner should be trained to evacuate the mine. Over the years, MSHA has promulgated a number of rules that address the safety of miners in the event of explosions, fires, or inundations in underground coal mines. These rules include requirements which address escape from a mine, such as: Two separate and distinct escapeways for each working section, maps in an underground mine that delineate escape routes out of the mine, miner participation in practice drills to escape the mine in an emergency situation, and life-saving devices such as lifelines and self-contained self-rescue (SCSR) devices to facilitate escape. This proposed rule would require refuge alternatives in the event that escape is delayed or not possible. This proposal would improve mine operators' preparedness for mine emergencies and increase miners' safety by requiring refuge alternatives underground to protect and sustain miners trapped when a life-threatening event occurs that prevents escape. The refuge alternatives proposed in the rule may also assist miners in escaping from the mine.

2. Evaluation of Accident and Injury Data MSHA has evaluated its accident and injury data from 1900 through 2006. During that period, 264 miners who were alive after a mine accident died later during rescue or escape. Because forty-three lives have previously been attributed to other recent MSHA regulatory actions, a total of 221 lives could have been saved over the 107 year period for purposes of estimating benefits for this proposal. If refuge alternatives had been available, MSHA estimates that the range of lives saved would be between a low of 25 percent and a high of 75 percent. MSHA estimates that 55 lives could have been saved under the lower estimate, and that 166 lives could have been saved under the higher estimate. Using these estimates, the proposal would result in approximately one-half life saved per year under the lower estimate or one and one-half lives saved per year under the higher estimate.

3. Conclusion The proposed rule would implement the MINER Act. It would require that mine operators install refuge alternatives and would include requirements for use, transport, maintenance, and inspection of refuge alternatives. These provisions would be essential for effective operation of the refuge alternatives during an emergency. The proposed rule would also include requirements for training of

miners on how to use refuge alternatives during an emergency. To facilitate mine emergency preparedness, refuge alternative training would be integrated into existing escapeway drill training—quarterly mine evacuation training and annual expectations training. The proposed rule would include requirements for installing necessary roof support in areas where refuge alternatives are placed to assure that they will not be damaged. It would also require that the locations of refuge alternatives be noted on the mine maps so that miners can easily locate the refuge alternatives in an emergency. The proposal would also require that miners be trained to maintain and repair refuge alternatives. In addition, the proposal would require that refuge alternatives (and their components) be inspected before each shift to assure that they are always functioning properly and will be effective in the event of any emergency. The proposal would also include requirements for the location of refuge alternatives to assure that they are readily accessible to all miners underground when an emergency occurs.

C. Compliance Costs MSHA estimates that the total yearly cost of the proposed rule would be approximately $43.3 million for underground coal mine operators and refuge alternative manufacturers. MSHA estimates that the proposed rule would result in a total yearly cost of $2.1 million for manufacturers and $41.2 million for underground coal mine operators. The first-year cost of the proposed rule is approximately $102.6 million. The costs in the PREA represent what MSHA believes to be the upper bound of the range of estimated compliance costs: $102.6 million first year and $43.3 million yearly. MSHA has presented these upper-bound estimates as a conservative approach to estimating compliance costs. However, based upon a review of literature and discussions with manufacturers of refuge alternatives, MSHA believes that a more realistic assumption of the types of refuge alternatives required under the proposal provides a lower-bound estimate of costs: $84.1 million first year and $38.7 million yearly. MSHA has revised the PREA to include these lower-bound estimates of costs. By mine size, the estimated yearly cost would be $3.1 million for operators with 1–19 employees; $33.1 million for operators with 20–500 employees; and $5 million for operators with 501+ employees. The approximate cost of the proposed rule by provision would be: $2.1 million for refuge alternative and component application and approval costs; $21.8 million for the costs to purchase, install, transport, and repair refuge alternatives; $6.6 million for the costs for pre-shift exams and revisions to plans and maps; and $12.8 million for training costs. Table 1 presents a summary of the yearly costs of the proposed rule by mine size and by cost category. MSHA solicits comments on the yearly costs of the proposed rule. Comments should be specific including alternatives, rationale, and supporting data.

Comment 128 concerning the statements:

IV. Feasibility

Although MSHA has concluded that the requirements of the proposed rule would be both technologically and economically feasible, MSHA recognizes that all refuge alternative applications may not be appropriate for all mining conditions.

A. Technological Feasibility MSHA believes that this proposed rule is feasible because refuge alternatives are currently being manufactured for use in underground coal mines in West Virginia and Illinois. MSHA recognizes that it may not be feasible to locate the refuge alternative according to this proposal. In addition, MSHA recognizes that using the refuge alternatives in low coal mines could be problematic. The Agency further recognizes that certain types of refuge alternatives may not be feasible in low coal mines. MSHA also recognizes that research on some requirements of refuge alternatives, for example, post accident communications, is on-going. MSHA will continue to work with NIOSH and the mining community as refuge alternative technology continues to be developed. MSHA solicits comment from the public on the location of refuge alternatives, the use of refuge alternatives in low coal mines, and the feasibility of requirements for refuge alternatives. Please be specific in your response, including alternatives, rationale, safety benefits to miners, technological and economic feasibility, and data to

support your comment. Also, MSHA may approve refuge alternatives or components that incorporate new technology, if the applicant demonstrates that the refuge alternative or components provide no less protection than those meeting the requirements of the proposed rule.

Agree with the analysis that current products and those underdevelopment can meet the requirements even in the low coal mines. The technology will improve and as these units are withdrawn for their period rebuilds, those improvements can be incorporated. The challenge for MSHA will be to maintain its stated objective of staying with performance based rules. They are more difficult to enforce, as they require more evaluation, skill, and application of common sense on the party of MSHA staff and state staff however, that is the price we must pay if we are not to lock technology at today's level.

Comment 129 concerning the statement:

B. Economic Feasibility MSHA estimated that the yearly compliance cost of the proposed rule is approximately $41.2 million for underground coal mine operators, which is 0.3 percent of annual revenue of $14.1 billion for all underground coal mines. MSHA concludes that the proposed rule would be economically feasible for these mines because the total yearly compliance cost is below one percent of the estimated annual revenue for all underground coal mines.

The industry has absorbed the costs in West Virginia, not without some complaining, but they have, because safety is good business. The coal mining industry is already one of the safest among major industrial sectors. The market for quality staff is tight, not only are firms paying above market wages they are touting their safety programs as recruitment tools. If we do not make progress with safety now it will never be done.

Comment 130 on the statements:

V. Regulatory Flexibility Act and Small Business Regulatory Enforcement Fairness Act Pursuant to the Regulatory Flexibility Act (RFA) of 1980, as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA), MSHA has analyzed the impact of the proposed rule on small entities. Based on that analysis, MSHA has notified the Chief Counsel for Advocacy, Small Business Administration (SBA), and made the certification under the RFA at 5 U.S.C. 605(b) that the proposed rule would not have a significant economic impact on a substantial number of small entities. The factual basis for this certification is presented in the PREA and summarized below.

A. Definition of a Small Mine Under the RFA, in analyzing the impact of the proposed rule on small entities, MSHA must use the SBA definition for a small entity, or after consultation with the SBA Office of Advocacy, establish an alternative definition for the mining industry by publishing that definition in the Federal Register for notice and comment. MSHA has not established an alternative definition and is required to use the SBA definition. The SBA defines a small entity in the mining industry as an establishment with 500 or fewer employees. MSHA has also examined the impact of this proposed rule on underground coal mines with fewer than 20 employees, which MSHA has traditionally referred to as ''small mines.'' These small mines differ from larger mines not only in the number of employees, but also in economies of scale in material produced, in the type and amount of production equipment, and in supply inventory. Therefore, the cost of complying with MSHA's proposed rule and the impact of the proposed rule on small mines will also be different. This analysis complies with the legal requirements of the RFA for an analysis of the impact on ''small entities'' while continuing MSHA's traditional concern for ''small mines.''

B. Factual Basis for Certification MSHA initially evaluates the impact on small entities by comparing the estimated compliance cost of a rule for small entities in the sector affected by the rule to the estimated revenue of the affected sector. When the estimated compliance cost is less than one percent of the estimated revenue, the Agency believes it is generally appropriate to conclude that the rule would not have a significant economic impact on a substantial number of small entities. When the estimated compliance cost exceeds one percent of revenue, MSHA investigates whether further analysis is required. Total underground coal production in 2007 was approximately 278 million tons for mines with 500 or fewer employees. Using the 2007 price of underground coal of $40.37 per ton, MSHA estimates that underground coal revenue was approximately $11.2 billion for mines with 500 or fewer employees. Under MSHA's upperbound estimate, the yearly cost of the proposed rule for mines with 500 or fewer employees is estimated to be approximately $36 million, or approximately $59 thousand per mine. This is equal to approximately 0.32 percent of annual revenue. Under MSHA's lower-bound estimate, the yearly cost of the proposed rule for mines with 500 or fewer employees is estimated to be approximately $32 million, or approximately $52 thousand per mine. This is equal to approximately 0.29 percent of annual revenue. Since, under both the upper and lower-bound estimates, the yearly cost of the proposed rule is less than one percent of annual revenue for small underground coal mines, as defined by SBA, MSHA has certified that the proposed rule would not have a significant impact on a substantial number of small mining entities, as defined by SBA. However, MSHA has provided, in the PREA accompanying this rule, a complete analysis of the cost impact on this category of mines. Total underground coal production in 2007 was approximately 7.7 million tons for mines with fewer than 20 employees. Using the 2007 price of underground coal of $40.37 per ton, MSHA estimates that underground coal revenue was approximately $310.2 million for mines with fewer than 20 employees. Under MSHA's upperbound estimate, the yearly cost of the proposed rule for mines with fewer than 20 employees is estimated to be approximately $3.15 million, or approximately $14,116 per mine. This is equal to approximately 1.02 percent of annual revenue. Under MSHA's lowerbound estimate, the yearly cost for mines with fewer than 20 employees is estimated to be approximately $2.8 million, or approximately $13 thousand per mine. This is equal to approximately 0.91 percent of annual revenue. In the Agency's PREA, MSHA estimates that some mines might experience costs somewhat higher than the average per mine in its size category while others might experience lower costs. Even though the analysis reflects a range of impacts for different mine sizes, from 0.32 to 1.02 percent of annual revenue under MSHA's upperbound estimate and from 0.29 to 0.91 percent of annual revenue under MSHA's lower-bound estimate, the Agency concludes that this is not a significant economic impact on a substantial number of small mines. MSHA has provided, in the PREA accompanying this rule, a complete analysis of the cost impact on this category of mines.

The number of small mines is diminishing not just because of the cost of safety but because the cost of mining small reserves is increasing. The seams are getting thinner and the equipment to mine it is getting more sophisticated and expensive. There is developing companies that specialize in conglomerating and managing groups of small mines by consolidating overhead and sharing expenses, these firms are continuing to operate the small mines. The mine safety regulations by states and MSHA have increased the opportunities for other small business to enter the mine equipment market. There are a growing number of small businesses that are not captured in the MSHA analysis because they outside the mining world that now have mining equipment divisions. And the number grows daily.

No Comment on the following statements:

VI. Paperwork Reduction Act

A. Summary This proposed rule contains information collection requirements that would affect requirements in existing paperwork packages with OMB Control Numbers 1219–0004, 1219–0054,

1219– 0066, 1219–0073, 1219–0088, and 1219– 0141. The new information collection requirements contained in the proposed rule are found in proposed §§ 7.503, 75.221, 75.360, 75.372, 75.1200, 75.1502, 75.1505, 75.1506, 75.1507, and 75.1508, which would establish new approval requirements for refuge alternatives. This proposed rule would result in 90,189 burden hours and related costs of approximately $6.8 million in the first year the rule is in effect. In the second year the rule is in effect, and every year thereafter, the proposed rule would result in 78,138 burden hours and related costs of approximately $6.6 million. For a detailed summary of the burden hours and related costs by provision, see the PREA accompanying this proposed rule. The PREA is posted on MSHA's Web site at http://www.msha.gov/ REGSINFO.HTM.

A copy of the PREA can be obtained from MSHA's Office of Standards, Regulations, and Variances at the address provided in the ADDRESSES section of this preamble.

B. Procedural Details The information collection package has been submitted to OMB for review under 44 U.S.C. 3504, paragraph (h) of the Paperwork Reduction Act of 1995, as amended. A copy of the information collection package can be obtained from the Department of Labor by electronic mail request to king.darrin@dol.gov or by phone request to 202–693–4129. MSHA requests comments to: • Evaluate whether the proposed collection of information is necessary for the proper performance of the functions of the agency, including whether the information will have practical utility; • Evaluate the accuracy of the Agency's estimate of the burden of the proposed collection of information, including the validity of the methodology and assumptions used; • Enhance the quality, utility, and clarity of the information to be collected; and • Minimize the burden of the collection of information on those who are to respond, including through the use of appropriate automated, electronic, mechanical, or other technological collection techniques or other forms of information technology, e.g., permitting electronic submission of responses. Comments on the information collection requirements should be sent to both OMB and MSHA. Addresses for both offices can be found in the ADDRESSES section of this preamble. The regulated community is not required to respond to any collection of information unless it displays a current, valid, OMB control number. MSHA displays OMB control numbers in 30 CFR party 3.

VII. Other Regulatory Analyses

A. The Unfunded Mandates Reform Act of 1995 MSHA has reviewed the proposed rule under the Unfunded Mandates Reform Act of 1995 (2 U.S.C. 1501 et seq.). MSHA has determined that the proposed rule would not include any Federal mandate that may result in increased expenditures by State, local, or tribal governments or significantly or uniquely affect small governments. MSHA estimates that the proposed rule would increase private sector expenditures by more than $100 million in the first year and has included an analysis of the costs of the requirements of the proposed rule in this PREA.

B. Treasury and General Government Appropriations Act of 1999: Assessment of Federal Regulations and Policies on Families The proposed rule would have no effect on family well-being or stability, marital commitment, parental rights or authority, or income or poverty of families and children. Accordingly, § 654 of the Treasury and General Government Appropriations Act of 1999 (5 U.S.C. 601 note) requires no further agency action, analysis, or assessment. C. Executive Order 12630: Government Actions and Interference With Constitutionally Protected Property Rights The proposed rule would not implement a policy with takings implications. Accordingly, Executive Order 12630 requires no further agency action or analysis. D. Executive Order 12988: Civil Justice Reform The proposed rule was written to provide a clear legal standard for affected conduct and was carefully reviewed to eliminate drafting errors and ambiguities, so as to minimize litigation and undue burden on the Federal court system. Accordingly, the proposed rule meets the applicable standards provided in § 3 of Executive Order 12988. E. Executive Order 13045: Protection of Children From Environmental Health Risks and Safety Risks The proposed rule would have no adverse impact on children. Accordingly, Executive Order 13045

*requires no further agency action or analysis. F. Executive Order 13132: Federalism The proposed rule would not have ''federalism implications'' because it would not ''have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.'' MSHA acknowledges that West Virginia and Illinois have laws and/or regulations on refuge alternatives and has drafted the proposed rule to minimize conflict with these laws and regulations. G. Executive Order 13175: Consultation and Coordination With Indian Tribal Governments The proposed rule would not have ''tribal implications'' because it would not ''have substantial direct effects on one or more Indian tribes, on the relationship between the Federal government and Indian tribes, or on the distribution of power and responsibilities between the Federal government and Indian tribes.'' Accordingly, Executive Order 13175 requires no further agency action or analysis. H. Executive Order 13211: Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use The proposed rule has been reviewed for its impact on the supply, distribution, and use of energy because it applies to the coal mining industry. Insofar as the proposed rule would result in yearly costs of approximately $41.2 million to the underground coal mining industry, relative to annual revenues of $14.1 billion in 2007, it is not a ''significant energy action'' because it is not ''likely to have a significant adverse effect on the supply, distribution, or use of energy * * * (including a shortfall in supply, price increases, and increased use of foreign supplies).'' Accordingly, Executive Order 13211 requires no further Agency action or analysis. I. Executive Order 13272: Proper Consideration of Small Entities in Agency Rulemaking MSHA has reviewed the proposed rule to assess and take appropriate account of its potential impact on small businesses, small governmental jurisdictions, and small organizations. MSHA has determined and certified that the proposed rule would not have a significant economic impact on a substantial number of small entities.*

List of Subjects 30 CFR Party 7 Coal mines, Mine safety and health, Reporting and recordkeeping requirements, Underground mining. 30 CFR Party 75 Coal mines, Mine safety and health, Reporting and recordkeeping requirements, Safety, Training programs, Underground mining.

Dated: June 11, 2008. Richard E. Stickler, Acting Assistant Secretary for Mine Safety and Health.

-----Original Message-----
From: RANDALL HARRIS [mailto:randall.j.harris@verizon.net]
Sent: Sunday, August 17, 2008 3:52 PM
To: zzMSHA-Standards - Comments to Fed Reg Group
Cc: 'RANDALL HARRIS'; 'Ron Wooten'
Subject: RIN 1219-AB58

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AB58-COMM-10-1

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August 17, 2008

Ms. Patricia Silvey
1100 Wilson Blvd.
Arlington, Virginia 22209-3939

Subject: RIN 1219-AB58

Ms Silvey:

Attached is a supplemental document to the comments provided at the July 31, 2008 hearing on proposed rules concerning "Refuge Alternatives for Underground Coal Mines".

This documents relates to the testing of an emergency shelter approved under the West Virginia Code of Sate Rules 56-4 concerning underground emergency shelters.

It is believed that this document provides valuable insights to several portion of the proposed rule upon which comments have already been provided by those associated with Office of Miners Health and Safety.

Sincerely,

Randall J Harris
Engineering Advisor to the Director
Office of Miners' Health and Safety

Assessment of the Performance of the Modern Mine Safety Supply, LLC 26-Person Emergency Shelter

Provided for
Ron Wooten, Director
West Virginia Office of
Miners Health Safety and Training
1615 Washington Ave
Charleston, WV 25301

Report Dated: July 16, 2008

Prepared by:
Randall J Harris
Health Physicist &
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Assessment of the Performance of the Modern Mine Safety Supply, LLC 26-Person Emergency Shelter

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Contents

Abstract

The objective of this analysis was to evaluate the performance of the Modern Mine Safety Supply, LLC (MMSS) 26-person emergency shelter against the West Virginia and U.S. Mine Safety and Health Administration standards; to compare human subject performance to that predicted by the computational models required under the West Virginia approval process, to compare human subject parameters to the standards used by West Virginia and MSHA; and to observe group and individual reactions to the shelter environment.

The methodology used was to place a production model MMSS 26-person emergency shelter in an environment that closely reflected that in an underground coalmine and have it occupied by 26-persons for a period sufficient to achieve stabilized internal atmospheric conditions and maintain those conditions for a period of at least sixty minutes.

The results demonstrated that MMSS 26-person emergency shelter performed as predicted in computational models and was able to establish and maintain a survivable atmosphere within the standards set by the State of West Virginia and MSHA.

Conclusions include that the projected values for oxygen consumption and carbon dioxide production set by the agencies may be conservative, that erroneous carbon monoxide readings may occur due to cross-sensitivity of multi-gas instruments, that the U.S. Mine Rescue Association's standard heat index chart for determining the apparent temperature is adequate and protective, that the West Virginia standard assuming a 55 degree Fahrenheit ambient temperature will result in adequate heat transfer to maintain safe internal temperatures, and that inclusion of materials such as books and cards may be valuable for morale.

A. Purpose and Scope

Background: In January 2006 an explosion occurred in the Sago Mine in West Virginia. Twelve miners who found escape blocked and opted to seek shelter in a hand-built barricade with eleven expiring due to carbon monoxide poisoning and one surviving with significant disabilities. The Sago disaster triggered February 2006 legislative action by officials in West Virginia requiring additional emergency technology including the ability to protect trapped miners from a hazardous atmosphere. In May of that same year the U.S. Congress also took action passing legislation modeled, in large part, on the West Virginia requirements. The federal MINER Act mandated emergency shelters in underground coalmines.

Lacking any specific Federal requirements or approval process the State of West Virginia formed a taskforce of mine safety experts to developed shelter performance standards and then initiated a shelter approval process within its Office of Miners Health Safety and Training (OMHS&T). The approval process utilized computational methods for validating the performance of shelter designs. This was due in large part to lack of access to testing facilities capable of duplicating the environments such shelters would encounter in an emergency but also because the variability among the miner community made it difficult to select appropriately representative candidates to participate in a human subject test.

The performance standards for emergency shelters were extrapolated from analogous existing Federal and State requirements for air quality and from published reports from the U.S. Bureau of Mines (BOM), the U.S. National Institutes of Occupational Safety and Health (NIOSH), U.S. Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA) concerning survival in enclosed spaces. In addition, interviews and correspondence were conducted with human physiologists, explosive experts, mine safety agencies, and other knowledgeable professionals around the world. The results were promulgated in West Virginia law as west Virginia Code of State Rules §56-4-8[1].

This report focuses upon those standards affecting the ability of internal shelter atmosphere to provide life support. The West Virginia standards required emergency shelters to be able to provide for rapidly establishing and maintaining for at least 48 hours an internal atmosphere of oxygen above 19.5 percent, carbon dioxide below 0.5 percent, carbon monoxide below 50 ppm[2], and an apparent-temperature of 95 degrees Fahrenheit. These were latter modified to incorporate standards stipulated by the U.S. Mine Safety and Health Administration (MSHA) under PIB 07-03[3] in mid 2007 which increased the duration to at least 96 hours of breathable air. The MSHA PIB also decreased the carbon monoxide to 25 ppm from 50 ppm; increased the oxygen low rate to 0.62297 L/min oxygen per miner from 0.5; increased the carbon dioxide scrubbing capacity to 0.5097 L/min carbon dioxide from 0.4 L/min and include a three fold chamber volume purge air requirement.

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[1] Can be found at: http://www.wvminesafety.org/PDFs/Shelters/56-4-8%20(2).pdf
[2] ppm = parts per million. 50 ppm is equal to 0.005 percent
[3] http://www.msha.gov/regs/complian/PIB/2007/pib07-03.asp

In late 2007 leadership from the NIOSH, National Personal Protection Laboratory in Pittsburgh, PA volunteered to conduct simulated human subject evaluations of emergency shelters approved under the West Virginia process at their Lake Lynn facility in rural West Virginia. Those tests involved the artificial introduction of heat, moisture, and carbon dioxide in quantities representative of the number of miner that could occupy the shelter. These evaluations provided valuable insights into how to test shelters and provided validation of the performance predicted by computational methods while identifying several areas in which the participating manufacturers could improve their designs. NIOSH provided its results in letter report to Congress which was widely misinterpreted as an approval testing report. This has lead to considerable confusion in the mining community. All the issues identified in the letter report were subsequently resolved to NIOSH's satisfaction through additional testing; however, while providing verbal and email responses of such to the State of West Virginia's OMHS&T and the manufacturers concerned, a supplementary report was not issued to Congress.

One manufacturer, Modern Mine Safety Supply, LLC (MMSS), submitted a unit for evaluation to NIOSH during that initial evaluation period that was unable to meet its designed performance due to a mechanical subsystem failure. MMSS took the necessary corrective actions and requested a re-evaluation. However, due to scheduling at the NIOSH the evaluation could not have occurred until after MMSS was to deliver their first units. MMSS contacted the University of Utah to coordinate a human subject version of the NIOSH evaluation. The time durations for the required procedural process of the human subject testing protocol approval at the university also pushed the projected testing beyond the delivery date of their first order. Therefore, MMSS requested that the State of West Virginia's OMHS&T coordinate and report on the testing.

Objectives: The results reported here relate to evaluation of the performance of the MMSS 26-person emergency shelter against the West Virginia and MSHA standards, the comparison of human subject performance to that predicted by computational models required under the West Virginia approval process, the comparison of human generated parameters to the standards used by West Virginia and MSHA, and the observation group and individual reactions to the shelter environment.

On April 8, 2008, the author participated in a full occupancy test of the 26-person MMSS emergency shelter as approved for underground coalmines under West Virginia 56 CSR 4 covering protective clothing and equipment. The assessment took place the MMSS facility in Huntington Utah.

The performance standards under West Virginia Rule 56 Section 4 part 8.4 provide for rapidly establishing and maintaining an internal shelter atmosphere of oxygen above 19.5%, carbon dioxide below 0.5%, carbon monoxide below 50 ppm, and an apparent-temperature of 95 degrees Fahrenheit[4].

[4] http://www.wvminesafety.org/PDFs/Shelters/56-4-8%20(2).pdf

In addition, shelters approved under this rule were reviewed against MSHA PIB 07-03 that sets standards using different assumptions than used for the West Virginia standards. The major differences are:

- 96 hours of breathable air
- 25 ppm instead of 50 ppm on the maximum CO;
- 4 gasses to be detected in the chamber (O_2, CO_2, CO, and CH_4);
- 0.62297 L/min oxygen per man, not 0.5;
- 0.5097 L/min CO_2 scrubbing capability, not 0.4;
- 3 fold chamber volume purge air requirement.

The scope of the study included monitoring gases, temperature, and humidity inside the shelter under full occupancy in an external atmosphere representative of that found in underground coalmines in the Western United States and West Virginia.

The monitoring protocol followed was that developed as part of the NIOSH evaluations of shelters in late 2007. Human subject testing protocol followed were those mandated by the University of Utah. Observers outside the shelter included members of the MMSS team, the Huntington Utah Emergency Services, and the University of Utah. Participants inside the shelter included a licensed emergency medical technician (EMT) from the Huntington Emergency Services, a reporter from the Emory County Progress and the author.

B. Literature Review

Prior to conducting the assessment all material collected during the drafting of the West Virginia Mines Safety Task Force Recommendation of May 2006[5] relating to shelters were reviewed along with subsequently identified relevant publications.

The additional material reviewed included those relating to the expected energy expenditure of miners occupying a shelter. It was found that the typical sitting miner's energy expenditure of 20 kcal/kg/min would likely only be increase by upper body movement which would add 0.02 kcal/kg/min or about 0.1% based upon work published by K Tsurumie, et al.[6] This is significant in that it is much less than in MSHA PIB 07-03 which assumes 4/5 of the time at rest and 1/5 doing light work which includes walking. Since occupants of an emergency shelter as defined in West Virginia rules will not have space for walking the most likely increased activity would be upper body movement. This in addition to discovered reports by Blackburn and Calloway[7], R

[5] http://www.wvminesafety.org/PDFs/MSTTF%20Report%20Final.pdf
[6] K. Tsurumi, et al, "Estimation of Energy Expenditure during sedentary Work with Upper Limb Movement", Journal of Occupational Health, 2002; 44: 408-413
[7] M. Blackburn and N Calloway, "Heart rate and energy expenditure", Am J Clin Nutr 42, 1161-1169 (1992)

Eston, et al[8], and W Saris[9] provided greater resolution to the work by M. Dauncey and W. James[10] upon which the energy expenditures used in setting the performance standards by both West Virginia and MSHA were based. The additional information indicated that for heart rates between 60 and 100 beats per minute, typical of at-rest rates, required the use of a different energy expenditure formula. The net result of these reports was the likelihood that oxygen consumption and carbon dioxide generation rates may have been over estimated by both agencies.

Regarding maximum internal apparent temperature, in addition to the literature reviewed and referenced during the West Virginia Task Force proceedings additional material was found relating to the prediction of hyperthermia[11], which added further insight into the selection of the methodology for determining the maximum apparent temperature described in the West Virginia rule. The most informative of these was "Thermal Comfort and the Heat Stress Indices."[12] In this document, the authors compared differing methods for recommending a method for use by the Israeli government in setting safety rules. Their analysis found some variations in the various approaches, but concluded the wet bulb method represented in the Steinman approach and adopted by West Virginia was the least confusing for a regulatory application. Additionally, it was found that the U.S. Army Research Institute of Environmental Medicine recommends its use for field exercises noting that although it may overestimate the apparent temperature by 1-2 degrees Fahrenheit for indoor situations, it is simpler to use.[13]

An anomalous reading during the MMSS testing of carbon monoxide when participants where present prompted significant additional post testing literature research. Bag samples of the air inside the shelter were taken with participants present during a time in which multi-gas instruments indicated the presence of carbon monoxide; however, subsequent laboratory testing of the sample found no carbon monoxide.

The literature research focused on secondary sources of carbon monoxide and the cross-sensitivity of electronic carbon monoxide monitoring instruments to other compounds. In summary it was found that most electronic carbon monoxide detection devices have cross-sensitivity levels for multiple compounds.

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[8] R Easton, et al, "Validity of heart rate, pedometery, and accelerometery in predicting energy cost", J App Physiol 84, 362-371 (1998)

[9] W Saris, "Habitual physical activity in children", Med Sci Sports Exerc 18, 253-263 (1986)

[10] M Dauncey and P James, "Assessment of the heart-rate method for determining energy expenditure in man"; J of the Nutrition Society, 0007-1145/79/3203-0210 (1979)

[11] Elevation of core body temperature above the normal diurnal range of 36°C to 37.5°C due to failure of thermoregulation

[12] Yoram Epstein and Daniel S. Moran, Thermal Comfort and the Heat Stress Indices , Heller Institute of Medical Research, Sheba Medical Center, Tel Hashomer and the Sackler Faculty of Medicine, Tel Aviv University, Israel, April 13, 2006

[13] http://www.usariem.army.mil/heatill/appendc.htm

According to the documents reviewed and conversations with manufacturer's technical staff it was determined that the carbon monoxide readings were likely due to one or more of the compounds for which such carbon monoxide sensors have shown documented cross-sensitivity. It was found that these compounds include; hydrogen sulfide, hydrogen, methane, carbon dioxide, sulfur dioxide, nitric oxide, nitrogen dioxide, ammonia, ethyl acetate, diethyl ether, chloroform, trichloroethylene, halothane, ammonia, methoxyflurane, enflurane, isoflurane, sevoflurane, desflurane, and isobutane. While the degree to which each type of carbon monoxide sensor is affected by these compounds varies the measurement of carbon monoxide when logically there should not be any can often be traced back to one or more of these.

During the literature review it was also discovered that several of the compounds which affect cross-sensitivity for carbon monoxide are generated by the human body as part of natural metabolic processes. These include methane, hydrogen, ammonia, and several of the alcohol variants. While not a problem in the open environment of a mine, in the closed environment of the shelter and over an extended period these could result in the erroneously increasing readings of carbon monoxide. In an article in the medical journal Lancet, T. S. King, et al[14] report their control group of normal subjects generated 22 mL/hr of methane. This would result in the addition of 2.1 liters of methane per occupant over 96 hours. Depending on the internal volume of the shelter, this may result in measurable although not explosive methane levels toward the end of occupancy. In the 670 cubic feet of the MMSS shelter tested this would result a methane reading of 0.01 percent after 96 hours[15]. While, none of these gases were detected in the MMSS testing, they could reach detectable ranges in an extended occupancy situation dependent on the metabolism of the occupants.

C. **Materials and Methods**

Shelter Description: The shelter used for the assessment was the 26-person MMSS emergency shelter designed for use in underground coal mines. The model used was designed according to the West Virginia approval process, although it was destined for a Wyoming coalmine. The interior volume of the shelter, less the airlock and stored materials, was approximately 670 cubic feet or approximately 26 cubic feet per person. The exterior surface was approximately 1,690 square feet or 65 square feet per person. The MMSS 26-person emergency shelter weights 22,000 pounds fully provisioned.

The shelter provides replacement medical grade oxygen from compressed bottles stored at the rear of the unit and removed carbon dioxide using a soda lime cartridge scrubbing system with an MSHA approved explosion-proof blower system. The oxygen supply rate is manually set by an occupant based upon the number of occupants as indicated on flow rate chart posted on the wall next to the flow meter. A precise medical grade flow meter designed to accomplish the task

[14] T. S. King, et al , "Abnormal colonic fermentation in irritable bowel syndrome," Lancet, 1998 Oct 10;352(9135):1187-9.
[15] 2.1 L = .07 ft^3 or .07ft^3/670ft^3 = .0001 or .01 percent methane after 96 hours with 26 occupants

is used. Prior to use, the soda lime is sealed in stainless steel containers that are packaged in dual heavy gauge plastic bags and placed in rack below the oxygen bottles as needed. Breathable grade compressed air for purging is provided from bottles stored inside the airlock compartment of the shelter.

The shelter is provided with sufficient water and food for 26 occupants for 96 hours along with a complete working section first aid kit. A PETT®[16] toilet was provided in the airlock section with single use chemically treated disposable plastic liners are then sealed in Ziploc® bags and placed in a disposal repository.

Seating is provided with 18-inch wide plastic seats bolted to a steel beam for 20 people with portable seating provided for an additional six. The floor has 1 inch thick perforated rubber mat to allow condensed water to accumulate without pooling around occupants feet.

Participants: With the exception of the EMT, one MMSS staff, a reporter, and the author all participants were randomly selected from a group of forty volunteers. Twenty-six participants entered the shelter and two remained outside as alternates in case any had to leave during the test.

Table 1: Participant Data

Subject	Age	Weight	Height	BMI[17]	Body Volume[18] Ft^3	Rest Pulse	Rest BP	Projected[19] VO_2 L/min	Projected VO_2 cfm
A	45	225	70	32.3	3.3	71	170/98	0.543	0.019
B	31	170	62	31.1	2.5	60	155/94	0.442	0.015
C	29	176	59	35.5	2.6	80	128/90	0.454	0.016
D	35	175	68	26.6	2.5	71	140/90	0.452	0.016
E	28	155	69	22.9	2.3	49	122/80	0.413	0.014
F	30	160	66	25.8	2.3	75	130/80	0.423	0.015
G	24	265	75	34.0	3.9	69	122/90	0.613	0.021
H	33	150	69	22.1	2.2	78	130/88	0.403	0.014
I	28	150	64	25.7	2.2	64	111/82	0.403	0.014
J	48	190	71	26.5	2.8	83	120/62	0.480	0.017

[16] www.thepett.com

[17] BMI = W / H^2 where W is the weight in kilograms and H is the height in meters. DuBois D, DuBois EF "Variations of Basal Metabolic Rate per unit of Surface Area", Arch Intern Medicine. July 1930, pp 607-617

[18] S. B. Heymsfield, et al, "Chemical determination of human body density in vivo: relevance to hydrodensitometry", Am-J-Clin-Nutr. Baltimore, Md.: American Society for Clinical Nutrition. Dec 1989. v. 50 (6) p. 1282-1289

[19] Computed by using a daily resting energy expenditure estimation by Wang of REE = 70.5 x $BM^{0.734}$ and applying an oxygen consumption rate of 4.80 kcal/L from McArdle then reducing to a per-minute rate in both liters and cubic feet. (Z. Wang, et al "Resting energy expenditure-fat-free mass relationship: new insights provided by body composition modeling", Am J Physiol Endocrinol Metab 279: E539-E545, 2000; 0193-1849/00, Vol. 279, Issue 3, E539-E545, September 2000) and (W. McArdle, et al "Exercise Physiology: Energy, Nutrition, and Human Performance", Lippincott Williams & Wilkins, 2006)

Subject	Age	Weight	Height	BMI[17]	Body Volume[18] Ft^3	Rest Pulse	Rest BP	Projected[19] VO_2 L/min	Projected VO_2 cfm
K	19	174	63	30.8	2.5	74	138/80	0.450	0.016
L	52	182	75	22.7	2.6	76	130/80	0.465	0.016
M	55	140	66	22.6	2.0	55	150/84	0.384	0.013
N	61	190	67	29.8	2.8	68	142/89	0.480	0.017
O	37	210	73	27.7	3.1	72	142/90	0.517	0.018
P	22	190	70	27.3	2.8	78	140/82	0.480	0.017
Q	21	170	70	24.4	2.5	62	150/90	0.442	0.015
R	29	240	74	30.8	3.5	84	130/84	0.570	0.020
S	29	160	70	23.0	2.3	74	128/88	0.423	0.015
T	37	225	79	25.3	3.3	72	130/84	0.543	0.019
U	21	190	69	28.1	2.8	75	128/88	0.480	0.017
V	52	170	73	22.4	2.5	74	152/90	0.442	0.015
W	56	218	72	29.6	3.2	60	149/94	0.531	0.019
X	21	230	70	33.0	3.3	81	132/92	0.552	0.019
Y	57	175	73	23.1	2.5	49	130/89	0.452	0.016
							Total	11.837	0.413
Alternates									
Z	20	210	76	25.6	3.1	71	160/91	0.517	0.018
AA	32	185	70	26.5	2.7	56	149/84	0.471	0.016

Six participants were in the normal weight range, fifteen were in the overweight range, and seven were in the obese range[20]. Their ages ranged from 19 to 61 years with a median of 31 years. All except the reporter were associated with coal mining with some actively working in the industry while others were retired or currently working in mining support fields. Six were welders at a mining equipment company that came straight from work to participate in the test.

Huntington Utah is a small mining community. As soon as word spread that a tests was going to be performed on emergency shelters everyone wanted to participate. Forty volunteers showed up at the test site for the pre-test briefing and exam. An EMT took vital signs and reviewed each volunteer's health questionnaire with them. Only those that reported no health conditions and whose vital signs were within normal ranges were included in the pool from which a random sample was drawn.

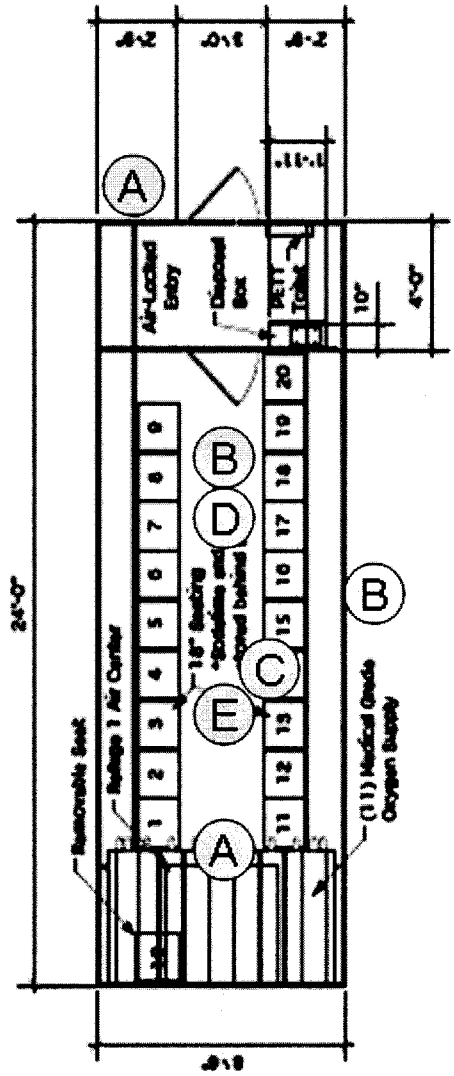
[20] BMI is calculated from the body area divided by the weight. Categories include ; Underweight less than 18.5, Normal weight 18.5-24.9, Overweight 25-29.9, Obese = 30 or greater

Prior to beginning the test those selected were provided a tour of a shelter and given the training that would be provided to miners. Following this the group was briefed on a scenario that they were asked to envision as the conditions they had faced prior to entering the shelter.

The scenario was an abbreviated version of what is believed the second-left crew at the Sago mine experienced before they chose to barricade. The participants where asked to keep that in their mind as they entered the shelter and as they evaluated their experiences during the test.

Monitoring Equipment:

An Industrial Scientific MX 6 iBird multi-gas meter[21] was used as the primary gas analysis tool. Two identical units were used each calibrated as documented in the manufacturers instruction manual. One was used to test the atmosphere inside and was operated in the handheld mode by an MMSS staff trained in its use. The second unit was connected through tubing to two locations within the shelter and one location in the direct air path of the soda lime scrubber. These measurements were taken from outside the shelter using the pump capability of the instrument. Both multi-gas instruments were later compared against another unit with all three reading the same values with test gases.



Temperatures were measured using electronic thermocouple devices inside and out, each calibrated against a mercury laboratory thermometer.

Humidity was measured using an Omega HHF 23 electronic relative humidity device that uses a capacitive relative humidity sensor calibrated to +/- 3%.

The EMT utilized a pressure cuff and stethoscope for collecting vital signs.

Monitoring locations used in the analysis are shown to the right.

[21] http://indsci.com/products/portable/mx6.aspx?id=106

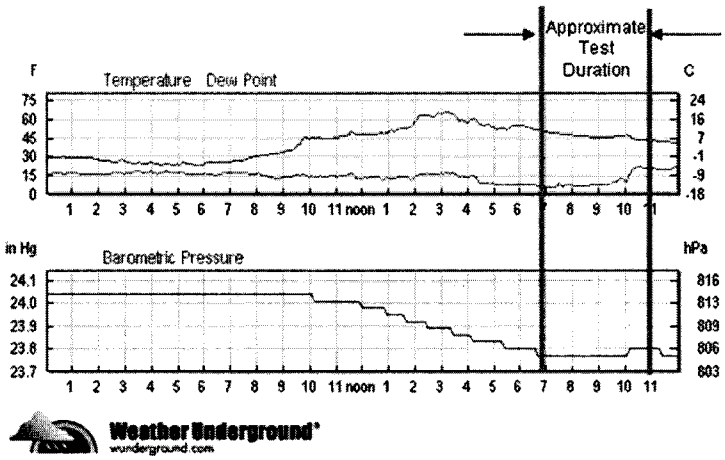
Methods and Conditions of Study: It had been determined that the testing would continue until the all environmental conditions had reached an equilibrium state and no variations were detected for at least one hour beyond that point.

Additionally, to validate the ability of the system to deliver the medical grade oxygen for the full period, the system would then be allowed to flow until it was unable to deliver the required flow rates.

Participants were told that if at anytime they wished to exist they would be allowed to, in addition if the EMT determined that any changes in a participant's vital signs were trending in a harmful direction they would be asked to leave. Any participant that exited the shelter during the test would be replaced by an alternate.

Ambient conditions in the test MMSS facility were carefully monitored to approximate those in the West Virginia standards as well as those of the Western US coalmines. Checking with the local weather it was determined that a starting time of approximately 6:30 pm Mountain Standard Time on April 8, 2008 would provide an ambient temperature averaging near 55 degree Fahrenheit during the test.

KUTCASTL2 Weather Graph for 4/8/2008



When the test began the ambient temperature inside the test MMSS facility was 56.6 Fahrenheit and was 55.8 Fahrenheit at the final reading with an average during the testing of 55.1 Fahrenheit. The temperature was controlled by opening and closing large overhead doors to ensure even temperature throughout the space.

On April 8, 2008 the humidity in Huntington averaged 39% except during a short rain around 4 pm Mountain Standard Time when it was 78%. In the test facility, the humidity ranged from 30.9 at the start of the test to 33.1 at its end. Data from the weather service is provided to above.

Instrumentation maintained outside was connected to the inside of the shelter through a threaded coupling that was sealed with putty once

all the cables and tubing were in place. Handheld devices were used inside the shelter.

A table was placed adjacent to the emergency shelter where data was collected from external instruments. Handheld instruments were used internally and UHF radios were used for communication between those outside and inside to report readings.

Data was recorded every five minutes externally and every fifteen minute internally. Once each hour the EMT checked vital signs of those inside the shelter. Each data entry was observed by at least two people.

D. Assessment Results

Table 2: Data Set - Part 1

TIME MNT pm	EXT RH percent	EXT Temp A °F	EXT Temp B °F	EXT Temp AVG °F	INT Avg Temp °F	INT Temp A °F	INT Temp B °F	INT RH B %	INT O_2 A %	INT O_2 B %
6:40							70.00			20.80
6:45	30.90				70.40	69.50	71.30	60.00		20.90
6:50	30.90	59.90	56.60	58.25	71.35	70.70	72.00	62.30		
6:55	31.00	59.90	57.20	58.55	72.05	71.50	72.60	64.60	30.80	
7:00	31.10	59.00	57.30	58.15	72.75	72.10	73.40	66.50	20.90	21.00
7:05	31.20	59.00	57.20	58.10	73.05	72.30	73.80	67.10	21.00	
7:10	31.30	59.00	57.30	58.15	73.70	73.00	74.40	68.60	21.00	
7:15	31.40	58.50	57.30	57.90	74.00	73.50	74.50	71.10	21.00	21.20
7:20	31.40	58.60	57.40	58.00	74.20	73.80	74.60	71.90	21.00	
7:25	31.60	58.60	57.50	58.05	74.40	74.10	74.70	73.20	21.00	
7:30	31.60	57.20	56.00	56.60	75.05	74.50	75.60	72.60	21.20	21.20
7:35	31.70	57.60	55.80	56.70	75.15	74.90	75.40	73.40	21.20	
7:40	31.80	57.60	55.10	56.35	75.60	75.30	75.90	74.50	21.30	
7:45	31.80	58.10	55.50	56.80	75.75	75.60	75.90	76.10	21.20	21.10
7:50	31.90	57.20	56.30	56.75	76.35	75.80	76.90	76.00	21.20	
7:55	32.00	58.10	56.90	57.50	76.85	76.00	77.70	73.80	21.20	
8:00	32.00	59.00	57.30	58.15	76.65	76.40	76.90	76.90	21.30	21.10
8:05	32.10	58.10	56.60	57.35	76.75	76.60	76.90	79.60	21.20	
8:10	32.10	58.10	56.90	57.50	76.95	76.70	77.20	78.00	21.20	
8:15	32.20	57.20	54.60	55.90	77.15	76.80	77.50	77.90	21.30	21.00
8:20	32.20	56.80	53.90	55.35	77.20	76.90	77.50	78.90	21.20	
8:25	32.20	57.20	54.00	55.60	77.00	76.90	77.10	79.20	21.20	
8:30	32.30	57.20	54.80	56.00	77.40	77.20	77.60	79.00	21.10	21.00
8:35	32.30	57.20	54.70	55.95	77.55	77.40	77.70	79.50	21.20	
8:40	32.30	55.40	53.30	54.35	77.85	77.70	78.00	80.40	21.20	
8:45	32.30	55.40	53.00	54.20	78.10	77.70	78.50	80.10	21.20	20.50
8:50	32.50	55.40	52.80	54.10	78.25	77.90	78.60	79.20	21.20	
8:55	32.50	55.40	52.50	53.95	78.25	78.00	78.50	80.00	21.10	
9:00	32.50	57.20	53.50	55.35	78.40	77.80	79.00	80.00	21.10	20.90
9:05	32.60	57.20	53.80	55.50	78.65	78.10	79.20	80.00	21.00	
9:10	32.60	56.30	53.60	54.95	78.60	78.20	79.00	80.10	21.00	
9:15	32.60	57.20	54.50	55.85	78.90	78.40	79.40	80.70	21.00	20.90

TIME MNT pm	EXT RH percent	EXT Temp A °F	EXT Temp B °F	EXT Temp AVG °F	INT Avg Temp °F	INT Temp A °F	INT Temp B °F	INT RH B %	INT O_2 A %	INT O_2 B %
9:20	32.60	57.20	54.40	55.80	79.05	78.50	79.60	79.80	21.00	
9:25	32.60	57.20	54.60	55.90	79.25	78.70	79.80	79.90	21.10	
9:30	32.60	57.60	56.00	56.80	79.55	78.70	80.40	77.00	21.10	20.80
9:35	32.70	59.00	56.30	57.65	79.45	78.70	80.20	79.50	21.00	
9:40	32.70	59.00	57.50	58.25	80.00	79.00	81.00	80.50	21.00	
9:45	32.80	58.10	56.10	57.10	80.30	79.30	81.30	80.80	21.00	20.80
9:50	32.80	58.10	54.00	56.05	80.00	79.30	80.70	80.80	21.00	
9:55	32.80	54.50	51.80	53.15	80.10	79.30	80.90	80.40	21.00	
10:00	32.90	55.40	52.80	54.10	79.95	79.20	80.70	82.00	20.90	20.80
10:05	33.00	54.50	52.50	53.50	79.85	79.30	80.40	83.00	20.80	
10:10	33.00	55.40	52.50	53.95	79.85	79.30	80.40	82.00	20.90	
10:15	32.90	56.30	54.60	55.45	79.95	79.10	80.80	79.10	20.80	20.70
10:20	32.90	55.40	53.30	54.35	79.20	78.60	79.80	81.30	20.80	
10:25	32.90	56.50	53.00	54.75	78.75	78.30	79.20	83.00	21.00	
10:30	32.90	57.20	53.80	55.50	78.50	78.10	78.90	82.50	21.00	20.80
10:35	33.00	57.20	55.00	56.10	78.60	77.80	79.40	83.40	21.00	
10:40	33.10	57.20	55.70	56.45	78.70	77.90	79.50	83.40	21.10	
10:45	33.10	57.20	56.10	56.65	78.70	77.80	79.60	84.40	21.00	20.90
10:50	33.10	57.20	54.80	56.00	78.80	78.20	79.40	83.10	21.00	

Derived values in Table 2

EXT Temp Avg = (EXT Temp A + EXT Temp B)/2

Table 3: Data Set – Part 2

TIME MNT Pm	INT CO_2 A %	INT CO_2 B %	INT CO_2 C %	INT CO_2 D %	INT CO_2 E %	INT CO_2 Avg %	INT CO_2 Resp ft^3	INT CO_2 Record ft^3	CO_2 Absorb ft^3/min	H_2O from CO_2 gal
6:40		0.40			0.06					
6:45	0.15	0.11	0.09	0.08	0.09	0.09		0.56		
6:50	0.00	0.13	0.11	0.11		0.12		0.70		
6:55	0.00	0.13	0.11			0.12		0.72		
7:00	0.00	0.11	0.13	0.12	0.06	0.11	148.31	0.63	29.54	0.17
7:05	0.00	0.09	0.13			0.11	100.64	0.66	20.00	0.12
7:10	0.00	0.13	0.15			0.14	101.12	0.84	20.06	0.12
7:15	0.00	0.11	0.15	0.08	0.12	0.12	101.12	0.69	20.09	0.12
7:20	0.00	0.13	0.13			0.13	101.12	0.78	20.07	0.12
7:25	0.00	0.11	0.11			0.11	101.12	0.66	20.09	0.12
7:30	0.00	0.13	0.15	0.08	0.13	0.12	101.12	0.74	20.08	0.12
7:35	0.00	0.13	0.17			0.15	102.08	0.90	20.24	0.12
7:40	0.00	0.15	0.10			0.13	102.08	0.75	20.27	0.12
7:45	0.00	0.13	0.13	0.10	0.09	0.11	102.56	0.68	20.38	0.12
7:50	0.00	0.15	0.13			0.14	102.08	0.84	20.25	0.12
7:55	0.00	0.15	0.11			0.13	102.08	0.78	20.26	0.12
8:00	0.00	0.17	0.15	0.09	0.12	0.13	102.08	0.80	20.26	0.12
8:05	0.00	0.15	0.19			0.17	102.56	1.02	20.31	0.12
8:10	0.00	0.11	0.19			0.15	102.08	0.90	20.24	0.12
8:15	0.00	0.11	0.19	0.09	0.12	0.13	102.08	0.77	20.26	0.12
8:20	0.00	0.11	0.17			0.14	102.56	0.84	20.34	0.12
8:25	0.00	0.11	0.17			0.14	102.08	0.84	20.25	0.12
8:30	0.00	0.11	0.19	0.09	0.16	0.14	102.08	0.83	20.25	0.12
8:35	0.00	0.09	0.15			0.12	101.60	0.72	20.18	0.12
8:40	0.00	0.11	0.13			0.12	102.08	0.72	20.27	0.12
8:45	0.00	0.09	0.17	0.10	0.13	0.12	102.08	0.74	20.27	0.12
8:50	0.00	0.11	0.19			0.15	102.08	0.90	20.24	0.12
8:55	0.00	0.13	0.11			0.12	102.08	0.72	20.27	0.12
9:00	0.00	0.15	0.17	0.12	0.09	0.13	101.60	0.80	20.16	0.12

TIME MNT Pm	INT CO_2 A %	INT CO_2 B %	INT CO_2 C %	INT CO_2 D %	INT CO_2 E %	INT CO_2 Avg %	INT CO_2 Resp ft^3	INT CO_2 Record ft^3	CO_2 Absorb ft^3/min	H_2O from CO_2 gal
9:05	0.00	0.15	0.15			0.15	101.60	0.90	20.14	0.12
9:10	0.00	0.13	0.15			0.14	101.12	0.84	20.06	0.12
9:15	0.00	0.11	0.13	0.18	0.12	0.14	101.12	0.81	20.06	0.12
9:20	0.00	0.11	0.13			0.12	101.12	0.72	20.08	0.12
9:25	0.00	0.11	0.13			0.12	101.12	0.72	20.08	0.12
9:30	0.00	0.11	0.15	0.10	0.12	0.12	101.60	0.72	20.18	0.12
9:35	0.00	0.11	0.17			0.14	101.60	0.84	20.15	0.12
9:40	0.00	0.11	0.17			0.14	101.12	0.84	20.06	0.12
9:45	0.00	0.11	0.15	0.12	0.16	0.14	101.12	0.81	20.06	0.12
9:50	0.00	0.11	0.15			0.13	101.12	0.78	20.07	0.12
9:55	0.00	0.11	0.15			0.13	101.12	0.78	20.07	0.12
10:00	0.00	0.15	0.21	0.16	0.12	0.16	101.12	0.96	20.03	0.12
10:05	0.00	0.13	0.15			0.14	100.64	0.84	19.96	0.12
10:10	0.00	0.13	0.17			0.15	100.16	0.90	19.85	0.12
10:15	0.00	0.15	0.19	0.12	0.14	0.15	100.64	0.90	19.95	0.12
10:20	0.00	0.13	0.17			0.15	100.16	0.90	19.85	0.12
10:25	0.00	0.09	0.15			0.12	100.16	0.72	19.89	0.12
10:30	0.00	0.15	0.11	0.08	0.09	0.11	101.12	0.65	20.09	0.12
10:35	0.00	0.09	0.09			0.09	101.12	0.54	20.12	0.12
10:40	0.00	0.09	0.13			0.11	101.12	0.66	20.09	0.12
10:45	0.00	0.09	0.07	0.08	0.08	0.08	101.60	0.48	20.22	0.12
10:50	0.00	0.11	0.09				101.12	0.09	20.21	0.12

Derived values in Table 2

- INT CO_2 Avg % = (INT CO_2 B + INT CO_2 C + INT CO_2 D + INT CO_2 E) / 4
- INT CO_2 Respired ft^3 = O_2 Volume table 4 * 0.8
- INT CO_2 Recorded ft^3 = 601.9 * (INT CO_2 Avg % / 100) [601.9 = internal volume less volume of people]
- CO_2 Absorbed ft3 / min = (INT CO_2 Respired ft^3 - INT CO_2 Recorded ft^3) / 5 [5 min between readings]
- H_2O from CO_2 Absorbed = (((CO_2 Absorbed ft3 / min / 0.79))*0.039)/8.34 [0.79 = ft3/mole, 0.039 lb/mole, 8.34 lb/gal]

Table 4: Data Set – Part 3

TIME MNT pm	INT CO A ppm	INT CO B ppm	O_2 Flow L/min	O_2 Added L	O_2 Volume ft^3	Delta P psi	INT Absolute Pressure psi
6:40	0		0.0				
6:45	0	0	0.0				
6:50			0.0				
6:55		4	16.1			0.0200	13.6200
7:00	9	5	16.1	80.5	185.4	0.0200	13.6200
7:05		8	16.1	80.5	125.8	0.0200	13.6200
7:10		10	16.1	80.5	126.4	0.0200	13.6200
7:15	17	12	16.1	80.5	126.4	0.0200	13.6200
7:20		14	16.1	80.5	126.4	0.0200	13.6200
7:25		15	16.1	80.5	126.4	0.0200	13.6200
7:30	22	16	13.0	80.5	126.4	0.0200	13.6200
7:35		17	13.0	65.0	127.6	0.0150	13.6150
7:40		19	13.0	65.0	127.6	0.0150	13.6150
7:45	28	20	13.0	65.0	128.2	0.0100	13.6100
7:50		21	13.0	65.0	127.6	0.0150	13.6150
7:55		21	13.0	65.0	127.6	0.0150	13.6150
8:00	33	22	13.0	65.0	127.6	0.0100	13.6100
8:05		24	13.0	65.0	128.2	0.0150	13.6150
8:10		25	13.0	65.0	127.6	0.0100	13.6100
8:15	38	27	13.0	65.0	127.6	0.0050	13.6050
8:20		28	13.0	65.0	128.2	0.0150	13.6150
8:25		28	13.0	65.0	127.6	0.0150	13.6150
8:30	43	29	13.0	65.0	127.6	0.0100	13.6100
8:35		31	13.0	65.0	127.0	0.0200	13.6200
8:40		32	13.0	65.0	127.6	0.0150	13.6150
8:45	47	33	13.0	65.0	127.6	0.0050	13.6050
8:50		34	13.0	65.0	127.6	0.0150	13.6150
8:55		36	13.0	65.0	127.6	0.0150	13.6150
9:00	53	36	13.0	65.0	127.0	0.0250	13.6250

TIME MNT pm	INT CO A ppm	INT CO B ppm	O_2 Flow L/min	O_2 Added L	O_2 Volume ft^3	Delta P psi	INT Absolute Pressure psi
9:05		38	13.0	65.0	127.0	0.0050	13.6050
9:10		39	13.0	65.0	126.4	0.0100	13.6100
9:15	56	38	13.0	65.0	126.4	0.0150	13.6150
9:20		42	13.0	65.0	126.4	0.0100	13.6100
9:25		42	13.0	65.0	126.4	0.0100	13.6100
9:30	55	41	13.0	65.0	127.0	0.0100	13.6100
9:35		38	13.0	65.0	127.0	0.0050	13.6050
9:40		40	13.0	65.0	126.4	0.0100	13.6100
9:45	58	40	13.0	65.0	126.4	0.0050	13.6050
9:50		41	13.0	65.0	126.4	0.0100	13.6100
9:55		42	13.0	65.0	126.4	0.0100	13.6100
10:00	61	41	13.0	65.0	126.4	0.0100	13.6100
10:05		43	13.0	65.0	125.8	0.0050	13.6050
10:10		43	13.0	65.0	125.2	0.0200	13.6200
10:15	57	41	13.0	65.0	125.8	0.0050	13.6050
10:20		41	13.0	65.0	125.2	0.0050	13.6050
10:25		42	13.0	65.0	125.2	0.0100	13.6100
10:30	63	43	13.0	65.0	126.4	0.0100	13.6100
10:35		45	13.0	65.0	126.4	0.0150	13.6150
10:40		45	13.0	65.0	126.4	0.0100	13.6100
10:45	65	45	13.0	65.0	127.0	0.0100	13.6100
10:50		47	13.0	65.0	126.4	0.0100	13.6100

Table 5: Data Set – Part 4

	AGE	SEX	HEIGHT	HEIGHT cm	WEIGHT lb	WEIGHT kg	BMI	VOLUME ft3	SURFACE m2
A	45	M	5 ft 10 in	177.8	225	102.3	32.3	3.3	2.2
B	31	M	5 ft 2 in	157.5	170	77.3	31.1	2.5	1.8
C	29	F	4 ft 11 in	149.9	176	80.0	35.5	2.6	1.7
D	29	F	5 ft 8 in	172.7	175	79.5	26.6	2.5	1.9
E	35	M	5 ft 9 in	190.5	155	70.5	22.9	2.3	2.0
F	28	M	5 ft 6 in	167.6	160	72.7	25.8	2.3	1.8
G	30	M	6 ft 3 in	190.5	265	120.5	34.0	3.9	2.5
H	24	M	5 ft 9 in	190.5	150	68.2	22.1	2.2	1.9
I	33	F	5 ft 4 in	162.6	150	68.2	25.7	2.2	1.7
J	26	M	5 ft 11 in	180.3	190	86.4	26.5	2.8	2.1
K	48	F	5 ft 3 in	160.0	174	79.1	30.8	2.5	1.8
L	19	M	6 ft 3 in	190.5	162	73.6	22.7	2.4	2.0
M	52	F	5 ft 6 in	167.6	140	63.6	22.6	2.0	1.7
N	55	F	5 ft 7 in	170.2	190	86.4	29.8	2.8	2.0
O	61	M	6 ft 1 in	185.4	210	95.5	27.7	3.1	2.2
P	37	M	5 ft 10 in	177.8	190	86.4	27.3	2.8	2.0
Q	22	M	5 ft 10 in	177.8	170	77.3	24.4	2.5	1.9
R	21	M	6 ft 2 in	188.0	240	109.1	30.8	3.5	2.4
S	29	M	5 ft 10 in	177.8	160	72.7	23.0	2.3	1.9
T	29	M	6 ft 7 in	200.7	225	102.3	25.3	3.3	2.4
U	37	M	5 ft 9 in	190.5	190	86.4	28.1	2.8	2.1
V	21	M	6 ft 1 in	185.4	170	77.3	22.4	2.5	2.0
W	52	M	6 ft 0 in	182.9	218	99.1	29.6	3.2	2.2
X	56	M	5 ft 10 in	177.8	250	113.6	33.0	3.6	2.3
Y	21	M	6 ft 1 in	185.4	175	79.5	23.1	2.5	2.0
Z	57	M	6 ft 4 in	193.0	210	95.5	25.6	3.1	2.3
AA	36	M	6 ft 1 in	178.9	188	85.5	26.5	2.7	2.0

Table 6: Data Set – Part 5

	Heat Rate Btu/min	Sensible Btu/min	Latent Btu/min	Vt L/breath	Exhaled H2O condensate L/hr	Initial BP	BP 7:30pm	BP 8:30pm	BP 9:30pm	BP 10:30pm
A	7.2	3.6	3.6	1.12	0.194	170/98	140/100	150/11	160/110	Removed
B	5.9	2.9	2.9	1.04	0.193	155/94	140/94	140/98	138/96	Removed 10:10pm
C	5.8	2.9	2.9	1.33	0.196	128/90	130/96	128/88	128/88	128/90
D	6.4	3.2	3.2	0.75	0.191	140/90	130/98	150/100	160/110	155/104
E	6.5	3.3	3.3	0.51	0.188	122/80	120/77	128/82	124/84	Removed 10:10pm
F	6.0	3.0	3.0	0.70	0.190	130/80	120/72	120/74	118/60	118/58
G	8.2	4.1	4.1	1.23	0.195	122/90	138/90	140/98	134/84	130/90
H	6.4	3.2	3.2	0.46	0.188	130/88	128/88	128/88	120/84	Removed 10:10pm
I	5.7	2.9	2.9	0.69	0.190	111/82	110/82	120/78	120/79	122/78
J	6.8	3.4	3.4	0.74	0.191	120/62	120/60	120/82	118/78	118/79
K	6.0	3.0	3.0	1.02	0.193	138/80	120/88	122/82	118/80	130/82
L	6.6	3.3	3.3	0.50	0.188	130/80	120/77	138/88	140/88	130/84
M	5.7	2.8	2.8	0.49	0.188	130/80	120/80	121/79	126/80	128/91
N	6.5	3.3	3.3	0.96	0.193	150/84	140/91	130/84	140/91	130/88
O	7.3	3.6	3.6	0.82	0.191	142/89	134/89	120/88	142/89	140/92
P	6.7	3.4	3.4	0.79	0.191	142/90	130/11	140/96	131/96	Removed 10:10pm
Q	6.4	3.2	3.2	0.61	0.189	140/82	130/86	140/86	150/96	144/100
R	7.8	3.9	3.9	1.02	0.193	150/90	140/89	132/92	128/91	Removed 10:10pm
S	6.3	3.1	3.1	0.52	0.188	130/84	128/88	130/84	128/86	132/88
T	7.9	4.0	4.0	0.66	0.190	128/88	120/72	132/74	132/88	132/91
U	7.1	3.5	3.5	0.85	0.192	130/84	134/89	130/84	120/88	130/84
V	6.6	3.3	3.3	0.48	0.188	128/88	130/84	140/78	140/86	118/74
W	7.3	3.7	3.7	0.94	0.192	152/90	150/90	145/88	140/89	141/90
X	7.6	3.8	3.8	1.17	0.195	149/94	130/79	144/80	140/84	140/84
Y	6.7	3.4	3.4	0.52	0.188	132/92	135/90	140/92	141/93	140/90
Z	7.5	3.7	3.7	0.68	0.190	132/92	130/89	134/84	140/84	142/86
AA	6.7	3.4	3.4	0.74	0.191					

In an attempt to determine if the welders were the source of the carbon monoxide they were removed at 10:10 once it was obvious the testing had accomplished the atmospheric stability objectives. The carbon monoxide did not stop rising. One person was replaced by the EMT with an alternate when his BP increased.

Values, Calculations, and Discussion:

Oxygen: Ambient oxygen concentrations were measured at 20.9 percent.

After entering the shelter an occupant activated the oxygen replacement system and set the flow rates for the number of occupants according to the instructions for 0.62 L/min per person or 16.1 L/min total flow. The internal oxygen rose to 30.0 percent. As occupants began consuming the oxygen it declined as expected but then slowly began to rise again.

At 7:27 pm, the author requested that the flow rate be lowered to 0.50 L/min or 13 L/min total to avoid over oxidation[22]. With that adjustment, the oxygen concentrations held steady around 21 percent. The level of activity among participants was likely somewhat higher than would be expected under normal occupancy, as the EMT in making his hourly vital sign checks required everyone to shift a seat in order to get adequate access for the pressure cuff.

The rate of oxygen consumption by the 26 participants in this analysis can be estimated from the flow rate of oxygen less the vented oxygen in the air released as a function of the overpressure relief value. Measurements of the pressure difference between the shelter and the outside were taken throughout the test. It is estimated that 3,163 L or 112 cubic feet of oxygen into to shelter. Since the pressure difference maintained was minimal it can assumed that an equal amount of mixed air was vented through the over pressure valves. At 21 percent oxygen that means 23.5 cubic feet of oxygen was also vented.

The oxygen used by the 26 participants was 88.5 cubic feet or 2,499 L of oxygen over 230 minutes for a rate of 0.418 L/min. This value correlates closely with the projected 0.413 L/min predicted using the method described in note 18 on page 9 of this report. The adjusted flow rate of 0.50 L/min appears to have been sufficient to replace consumed oxygen as well as that that vented.

Oxygen was measured at two locations in the shelter with a total of 64 measurements recorded. The average was 21.18 percent oxygen; the median was 21.00 with a standard deviation of 1.213 percent. After the testing was completed and the participants were removed and a purge conducted the flow rate was set back to the MSHA recommended 0.62 L/min rate and the bottles continued to supply oxygen for an addition 114 hours. Since the oxygen stabilized early and maintained throughout the test and the duration exceeded the 96-hour standard the MMSS 26-person shelter demonstrated its ability to meet West Virginia and MSHA requirements.

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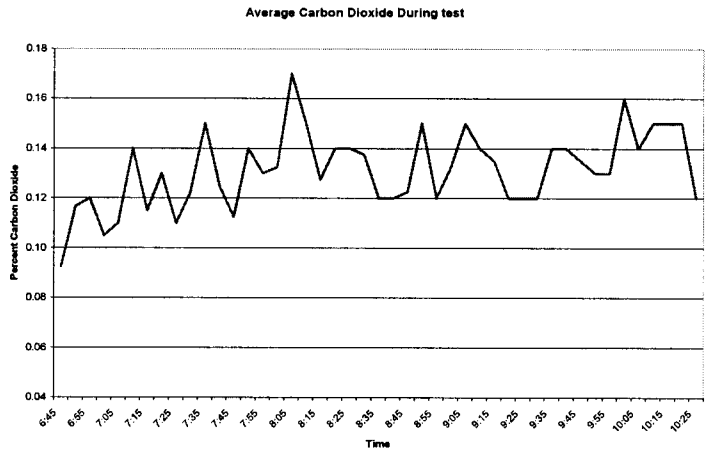
[22] Oxygen toxicity is not a factor until the partial pressure of oxygen exceeds 11 psi. At normal atmospheric conditions oxygen partial pressures will be below 3 psi. The concern was not toxicity rather that excess oxygen decreases the combustible range for a number of materials. Additionally, higher flow concentrations would not result in significant increases in the hemoglobin oxygen uptake thus have no metabolic value and wasted oxygen. C Lambertsen "Extension of oxygen tolerance in man", Experimental Lung Research, 14, pp1035-1058 (1988) and Cook, et al, "Combustibility of fabrics in oxygen-rich compressed air", Textile Research Journal, 33: 591-599 (1967)

Carbon Dioxide: Ambient carbon dioxide concentration was measured at 0.03% prior to entering the shelter.

Upon occupancy the soda lime cartridges were deployed and the explosion proof fan started.

Carbon dioxide was measured at two locations within the shelter and at the scrubber outlet. The high carbon dioxide level was 0.21 percent and the lowest 0.09 percent.



One-hundred-twenty-six measurements were recorded during the test with an average carbon dioxide concentration of 0.1279 percent, a median of 0.1300 percent with a standard deviation of 0.0305 percent[23].

The production of carbon dioxide is determined from the respiratory exchange ratio (RER) that is expressed as the rate of carbon dioxide production over the rate of oxygen consumption and is generally accepted as 0.8 for a person at rest[24].

During the 230 minutes of the test 3,163.5 liters of oxygen were added to the chamber. As noted above the oxygen consumption adjusted for vented air was 2,499 L or 88.5 cubic feet. This worked out to 0.418 L/min per participant.

The internal volume of the shelter accounting for stored supplies is 670 cubic feet. Using a value of 1.100 g/cc body density[25] or 68.7 pounds/cubic foot[26] the participants occupied 68.1 cubic feet leaving 601.9 cubic feet of air. Based upon measured carbon dioxide levels the amount of carbon dioxide absorbed by the soda lime scrubber can be inferred as approximately 2,000 L or 70 cubic feet.

Since the carbon dioxide stabilized and was able to be maintained within acceptable limits with the maximum number of occupants throughout the testing period the MMSS 26-person shelter was deemed to have meet West Virginia and MSHA requirements.

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[23] Carbon dioxide values at the outlet of scrubber were not used in developing averages as they were always zero
[24] J. G. McGeown. "Physiology: A Core Text of Human Physiology", Elsevier Health Sciences (2002)
[25] S. B. Heymsfield, et al, "Chemical determination of human body density in vivo: relevance to hydrodensitometry", Am-J-Clin-Nutr. Baltimore, Md.: American Society for Clinical Nutrition. Dec 1989. v. 50 (6) p. 1282-1289
[26] 0.00220462262 grams per pound / 0.00035314667 cubic centimeter per cubic foot

Internal Temperature Management: Understanding the volume of carbon dioxide absorbed is important for understanding the heat balance since the conversion of gaseous carbon dioxide to a solid through the 44 pounds of soda lime in the scrubber cartridges generates heat.

The primary constituents of soda lime are calcium hydroxide - $Ca(OH)_2$ (about 70-80%), water - H_2O (about 16 to 20%), and sodium hydroxide - NaOH (about 1-2%).

One hundred grams, 0.22 pounds, of soda lime can absorb about 26 liter of carbon dioxide, or 1.16 moles[27] carbon dioxide[28]. The 44 pounds of soda lime in the MMSS scrubber should be able to remove of carbon dioxide 232 moles of carbon monoxide.

$CO_2 + H_2O \leftrightarrow H_2CO_3$
$H_2CO_3 + 2\ NaOH\ (KOH) \leftrightarrow Na_2CO_3\ (K_2CO_3) + 2\ H_2O + 13.7$ kcal
$Na_2CO_3\ (KO_3) + Ca(OH)_2 \leftrightarrow CaCO_3 + 2\ NaOH\ (KOH)$

In the reactions, first, the gaseous carbon dioxide reacts with water to form carbonic acid - H_2CO_3. Then the NaOH reacts with the carbonic acid to produce Na_2Co_2 and H_2O. The Na_2Co_2 reacts with the $Ca(OH)_2$ that has been disassociated into calcium and hydroxide ions (Ca++ and OH-) to produce $CaCO_2$ (calcium carbonate, otherwise known as limestone). The carbon dioxide is now in a stable state.

Since the multi-gas instrument consistently registered 0.00 percent carbon dioxide at the scrubber outlet it is inferred that all carbon dioxide was reacted.

During this exothermic reaction, 1 mole[29] of water contained in soda lime is consumed and 2 moles of water[30] in addition to 13.7 kcal, or 53.5 Btu[31] generated. During the test, the participants consumed 2,499 L of oxygen and generated 2,000 L of carbon dioxide or 89.2 moles of carbon dioxide. To remove all the carbon dioxide would have generated 4,776 Btu of heat over the 3 hours and 50 minutes or 1,245 Btu/hr.

During the test, water was not seen to be dripping from the soda lime scrubber. This implies that an extra 180 moles of water was added to the interior of the shelter. Therefore, the 0.1 pounds of water per minute was either adsorbed onto soda lime, which can be up to16% water, about 7

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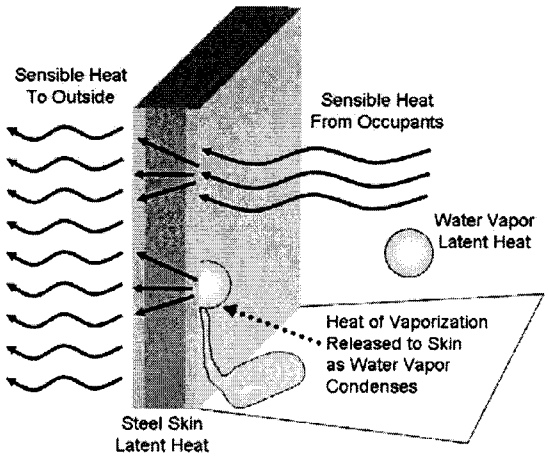
[27] G. Hirabayashi, et al. "Effects of temperature gradient correction of carbon dioxide absorbent on carbon dioxide absorption", British Journal of Anesthesia 2006 97(4):571-575; doi:10.1093/bja/ael21

[28] At STP 60 degrees Fahrenheit at 14.696 psi

[29] The basic International System unit of amount of a substance equal to the amount containing the same number of elementary units as the number of atoms in 12 grams of carbon-12. Example one liter of water contains 55.5 moles of H_2O

[30] G. Hirabayashi, et al. "Effects of temperature gradient correction of carbon dioxide absorbent on carbon dioxide absorption", British Journal of Anesthesia 2006 97(4):571-575; doi:10.1093/bja/ael210

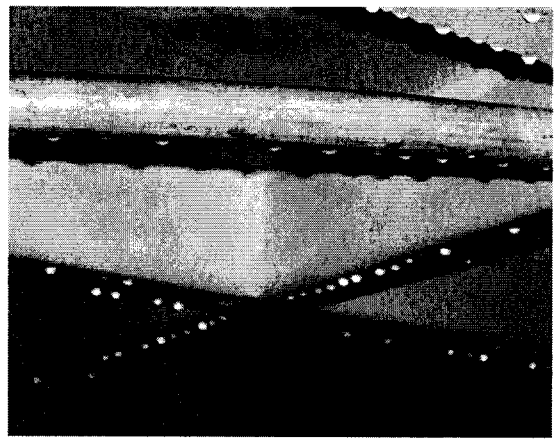
[31] 1 Btu = 252 cal therefore 1 kilocalorie = 3.9673727 Btu (1 Kilocalorie (Kcal) is the amount of heat needed to raise the temperature of one kilogram of water 1 degree Centigrade. 1 British Thermal Unit (Btu) is the amount of heat necessary to raise the temperature of one pound of water one degree Fahrenheit.)



pounds of water or it accompanied the scrubbed air as water vapor. Because it requires 1,077 Btu to transform one pound liquid water to a vapor[32] there was evidently an approximate 4 minute lag to add the approximate 107.7 Btu's to the 0.1 pounds of water to create the vapor. The result would have been an additional 0.1 pounds or 0.01 gallons of water vapor per minute added to the shelter's atmosphere as the result of the soda lime scrubber.

Appreciating the difference in types of heat is fundamental to understanding the results recorded in this analysis. Heat is added to shelter's interior by the soda lime and from the participants themselves, but not always in the same ways. Two forms of heat must be considered in understanding the temperature result of the analysis. Sensible heat is defined as when a substance is heated its temperature rises as the heat is added. Similarly, when heat is removed from an object and its temperature falls, the heat removed is also called sensible heat.

Latent heat is the additional heat required to produce the change in state of a substance, such as the water to vapor change discussed above. Latent heat however, does not affect the temperature of a substance - for example, water remains at 100°C while boiling.



Cooling occurs as sensible heat in the shelter's atmosphere is transmitted through the shelter's skin and radiated to the cooler atmosphere outside.

Cooling also occurs with the condensation of the water vapor on the inside of the shelter's skin that transforms the latent heat as the vapor changes state back to water in sensible heat that is transferred to the surface skin. The resultant sensible heat on the inside surface is transmitted through the shelter skin to the cooler atmosphere outside where it heats the cooler air molecules outside.

The key to achieving a stable temperature inside appears to be ensuring there is sufficient surface area on the shelter's skin to allow for condensation and the transfer of heat to the outside.

[32] Latent heat of vaporization of water is 2.5×10^6 joules per kilogram or 2369.5 Btu per 2.2 pounds or 1077 Btu per pound

In determining the allocation between sensible and latent heat from the participants, first the use of the resting human metabolic rate of 58 W_{th}/m^2 was applied to the individual body surface areas of the participants[33]. This resulted in an estimate of 167.4 Btu/min[34] or 10,044 Btu/hr for an average of 386.3 Btu/hr per participant. This was divided equally between sensible and latent based upon the approximate equal split between the two at the average relative humidity of 77.3 percent experienced during the test[35].

The latent heat is attributed to water vapor in exhaled breath and perspiration[36]. Using the assumption above that means 83.7 Btu/min were added to shelter's atmosphere in the form of water vapor. Since any heat above that required for maintenance of the water in the vapor phase would have been included in the sensible heat value, the 523.8 Btu/hr this number represents equates to 0.48 pounds of water vapor which when condensed would form 0.06 gallons of water per hour.

The participants added 1,245 Btu/hr in latent heat from removal of carbon dioxide by the soda lime, 5,022 Btu/hr from respiration and perspiration along with 5,022 Btu in sensible heat for at total of 11,298 Btu/hr or 434 Btu/hr per occupant.

The difference in the initial ambient humidity and the average humidity represents the point of equilibrium between the generation of water vapor and condensation of water vapor. The water vapor releases the heat of vaporization to the shelter's surface upon which it condenses and that heat is then transfer to the exterior through the skin material. The interior surface of the shelter's skin increases in temperature relative to the outside, which forces the heat to outside where it is transferred to cooler air molecules.

The heat is transferred to the outer surface with a rate that is a function of the thickness of the shelter's skin, its thermal conductivity, and the difference in temperature between the two surfaces. Since the temperature stabilized at a difference of 21.19 degrees Fahrenheit between the inside and outside of the shelter the effective thermal conductivity of the shelter as built with 1,690 square feet was 0.012 $Btu/hr \cdot ft^2 \cdot °F$.

While not considered in this analysis due to time constraints the ability of the 22,000 pound mass of the shelter to absorb heat from the occupants would be an interesting further evaluation.

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[33] BSA = $(W^{0.425} \times H^{0.725}) \times 0.007184$, where the weight is in kilograms and the height is in centimeters per D DuBois and EF DuBois, "A formula to estimate the approximate surface area if height and weight be known". Arch Intern Medicine. 1916; 17:863-71 and Y Wang, et al, "Predictors of body surface area", J Clin Anesth. 1992; 4(1):4-10.

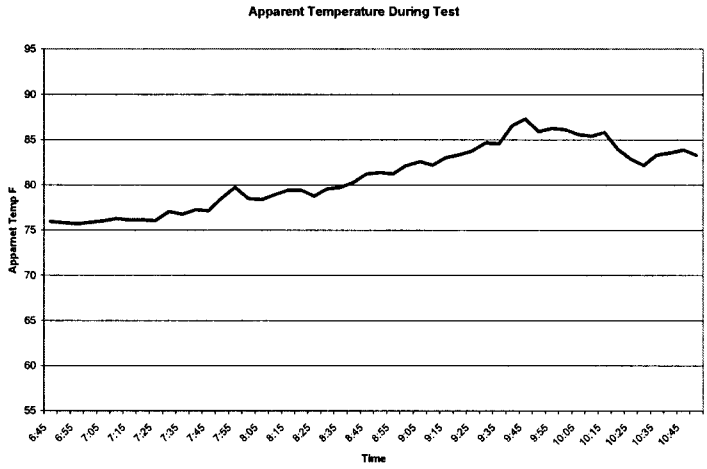
[34] British thermal unit per minute (Btu/min) to thermal watts (W_{th}) multiply by 17.57250

[35] R. R. Gonzalez, et al, "Heat strain models applicable for protective clothing systems: comparison of core temperature response", Journal of Applied Physiology Vol. 83, No. 3, pp. 1017-1032, September 1997 and T Tayton, "Textbook of Medical Physiology" (7th Ed), WB Saunders USA (1986).

[36] While beyond the time scope of this analysis it is believed that the majority of the perspiration is actually absorbed in the clothing of the participants is not converted to water vapor. It is also believed that effect on temperature management will be found to be de minimis.

Ambient Test Facility Temperature: The Ambient temperature outside the shelter was relatively stable during the test period. At the start of the test the ambient temperature inside the test MMSS facility was 56.6 Fahrenheit and was 55.8 Fahrenheit at the final reading with an average during the testing of 55.1 Fahrenheit. Temperature was controlled inside the facility by opening and closing large overhead doors to ensure even temperature throughout the space.

Apparent Temperature: The internal temperatures were collected at two locations with relative humidity collected at only one of those, for purposes of reporting apparent temperature only those readings from the co-located temperature and relative humidity will be used.



Apparent temperature[37] is an adjustment to the dry bulb temperature based on the level of humidity. It is based upon the work of R.G. Steadman. The version referenced in the 2006 West Virginia Task Force Recommendation was Steadman's 1984 simplified version[38]. In 1979 he published a more sophisticated version based upon liner regression techniques[39] and that is used here.

The nine step formula used in this report is $AT = -42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - 0.00683783T^2 - 0.05481717R^2 + 0.00122874T^2R + 0.00085282TR^2 - 0.00000199T^2R^2$ where T is ambient temperature dry bulb Fahrenheit and R is relative humidity.

The US Department of Defense notes that they have found the use of the Steadman formula over estimates the apparent temperature between 1-3 degrees Fahrenheit for person indoors since it assumes a person outdoors in the shade[40].

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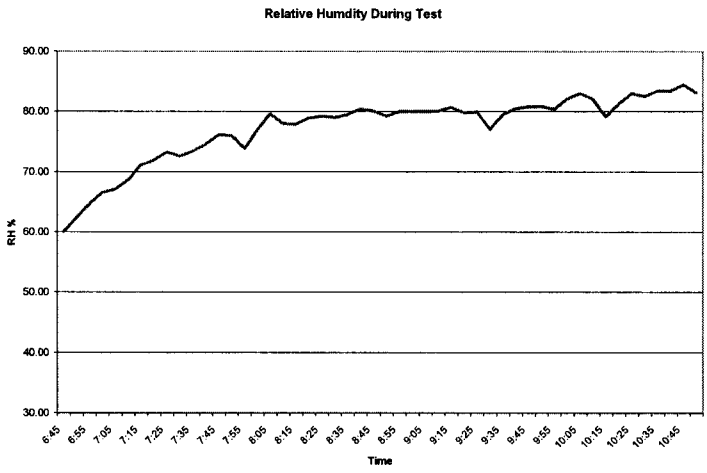
[37] Apparent temperature is defined as the temperature at the reference humidity level producing the same amount of discomfort under the current ambient temperature and humidity. It was invented in the 1970's as measure of thermal sensation in indoor conditions. The AT formula used in the West Virginia Task Force report was his 1984 version which was a simplified version of his 1977 liner regression techniques. The chart in the US Mine Rescue Association reflects this updated version and is used in this report. This is not the only means of computing apparent temperature but it is widely utilized including by the U.S. Mine Rescue Association to estimate health risk to mine rescue team members.

[38] R. G. Steadman, "A Universal Scale of Apparent Temperature", J. App. Met, 23, 12, pp1674

[39] R. G. Steadman, "The Assessment of Sultriness. Part I: A Temperature-Humidity Index Based on Human Physiology and Clothing Science", Journal of Applied Meteorology, July 1979, Vol 18 No7, pp861-873 and "The Assessment of Sultriness. Part II: Effects of Wind, Extra Radiation and Barometric Pressure on Apparent Temperature". Journal of Applied Meteorology, July 1979, Vol 18 No7, pp874-885.

[40] US Army, Heat Stress Control and Heat Casualty Management, TB MED 507/AFPAM 48-152(I), & March 2003

Relative humidity is an important component of the apparent temperature value. The relationship is rather complex but in general the higher the relative humidity the hotter it feels. The stabilization of the relative humidity in the shelter appears to have been predominately affected by the high condensation rate on the shelter's inner skin.



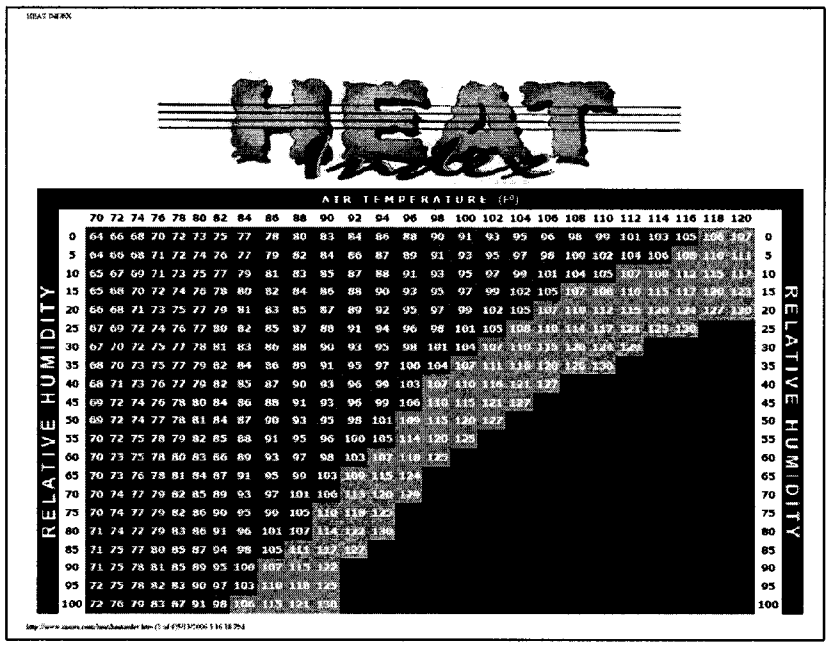
The values below were determined using the long version of the Steadman formula and compared to the US Mine Rescue Association Steadman chart.

Table 6: Calculated Apparent Temperature Data

Time pm	Temp °C	Temp °F	Relative Humidity %	Apparent Temp °F Chart[41]	Apparent Temp °F Calculated[18]	Apparent Temp °C Calculated[42]
6:45	21.1	71.3	60.0	73	75.9	24.4
6:50	22.2	72.0	62.3	73	75.8	24.3
6:55	22.5	72.6	64.6	73	75.7	24.2
7:00	23.0	73.4	66.5	76	75.8	24.3
7:05	23.2	73.8	67.1	76	76.0	24.4
7:10	23.5	74.4	68.6	77	76.3	24.6
7:15	23.6	74.5	71.1	77	76.1	24.5
7:20	23.6	74.6	71.9	77	76.1	24.5
7:25	23.7	74.7	73.2	78	76.0	24.4
7:30	24.2	75.6	72.6	79	77.0	25.0
7:35	24.1	75.4	73.4	79	76.7	24.8
7:40	24.3	75.9	74.5	79	77.2	25.1
7:45	24.3	75.9	76.1	79	77.1	25.0
7:50	24.9	76.9	76.0	80	78.5	25.8
7:55	25.3	77.7	73.8	81	79.6	26.4
8:00	24.9	76.9	76.9	81	78.5	25.8
8:05	24.9	76.9	79.6	81	78.4	25.7
8:10	25.1	77.2	78.0	81	78.9	26.0
8:15	25.2	77.5	77.9	81	79.4	26.3
8:20	25.2	77.5	78.9	81	79.4	26.3
8:25	25.0	77.1	79.2	81	78.7	25.9
8:30	25.3	77.6	79.0	81	79.5	26.43
8:35	25.3	77.7	79.5	82	79.7	26.5

[41] US Mine Rescue Association, Heat Index Chart available at www.usmra.com/heat/heatindex.htm
[42] $[°C] = ([°F] - 32) \times 5/9$

Time pm	Temp °C	Temp °F	Relative Humidity %	Apparent Temp °F Chart[41]	Apparent Temp °F Calculated[18]	Apparent Temp °C Calculated[42]
8:40	25.5	78.0	80.4	83	80.3	26.8
8:45	25.8	78.5	80.1	83	81.2	27.3
8:50	25.8	78.6	79.2	83	81.3	27.4
8:55	25.8	78.5	80.0	84	81.2	27.3
9:00	26.1	79.0	80.0	84	82.1	27.8
9:05	26.2	79.2	80.0	84	82.5	28.1
9:10	26.1	79.0	80.1	84	82.1	27.8
9:15	26.3	79.4	80.7	85	83.0	28.3
9:20	26.4	79.6	79.8	84	83.3	28.5
9:25	26.5	79.8	79.9	85	83.7	28.7
9:30	26.8	80.4	77.0	86	84.6	29.2
9:35	26.7	80.2	79.5	86	84.5	29.2
9:40	27.2	81.0	80.5	86	86.5	30.2
9:45	27.3	81.3	80.8	86	87.2	30.7
9:50	27.0	80.7	80.8	86	85.8	29.9
9:55	27.1	80.9	80.4	86	86.2	30.1
10:00	27.0	80.7	82.0	86	86.1	30.0
10:05	26.8	80.4	83.0	86	85.5	29.7
10:10	26.8	80.4	82.0	86	85.4	29.6
10:15	27.1	80.8	79.1	86	85.8	29.8
10:20	26.5	79.8	81.3	86	83.9	28.8
10:25	26.2	79.2	83.0	86	82.8	28.2
10:30	26.0	78.9	82.5	86	82.1	27.8
10:35	26.3	79.4	83.4	86	83.3	28.5
10:40	26.3	79.5	83.4	86	83.5	28.6
10:45	26.4	79.6	84.4	86	83.8	28.8
10:50	26.3	79.4	83.1	86	83.2	28.4



Because the long Steadman formula is difficult to follow, for ease of presentation the formula was broken into its nine steps in the table below.

$AT =$

Step 1 $- 42.379$

Step 2 $+ 2.04901523T$

Step 3 $+ 10.14333127R$

Step 4 $- 0.22475541TR$

Step 5 $- 0.00683783T^2$

Step 6 $- 0.05481717R^2$

Step 7 $+ 0.00122874T^2R$

Step 8 $+ 0.00085282TR^2$

Step 9 $- 0.00000199T^2R^2$

Table 7: Raw Calculation Data

Time	AT deg C	AT deg F	AT step 1	AT step 2	AT step 3	AT step 4	AT step 5	AT step 6	AT step 7	AT step 8	AT step 9
6:45	24.4350	75.9831	-42.3790	146.0948	608.5999	961.5036	34.7614	197.3418	374.7920	218.9018	36.4196
6:50	24.3494	75.8289	-42.3790	147.5291	631.9295	1008.1629	35.4473	212.7613	396.8378	238.3230	40.0400
6:55	24.2928	75.7271	-42.3790	148.7585	655.2592	1054.0939	36.0406	228.7608	418.3750	258.3801	43.7715
7:00	24.3743	75.8737	-42.3790	150.3977	674.5315	1097.0536	36.8392	242.4152	440.2240	276.8195	47.4120
7:05	24.4695	76.0451	-42.3790	151.2173	680.6175	1112.9843	37.2418	246.8094	449.0506	283.3732	48.7990
7:10	24.6144	76.3059	-42.3790	152.4467	695.8325	1147.1157	37.8499	257.9674	466.5842	298.5923	51.8379
7:15	24.5103	76.1186	-42.3790	152.6516	721.1909	1190.5182	37.9517	277.1123	484.8888	321.1832	55.8348
7:20	24.5106	76.1191	-42.3790	152.8565	729.3055	1205.5296	38.0536	283.3834	491.6619	328.8925	57.2517
7:25	24.4822	76.0680	-42.3790	153.0614	742.4918	1228.9716	38.1557	293.7236	501.8943	341.3502	59.4999
7:30	25.0349	77.0628	-42.3790	154.9056	736.4059	1233.5836	39.0807	288.9281	509.8474	339.8227	59.9473
7:35	24.8773	76.7791	-42.3790	154.4957	744.5205	1243.8774	38.8742	295.3308	512.7418	346.4343	60.9520
7:40	25.1520	77.2736	-42.3790	155.5203	755.6782	1270.8907	39.3914	304.2490	527.3511	359.2623	63.6281
7:45	25.0890	77.1603	-42.3790	155.5203	771.9075	1298.1850	39.3914	317.4577	538.6767	374.8595	66.3905
7:50	25.8495	78.5290	-42.3790	157.5693	770.8932	1313.5605	40.4363	316.6240	552.2380	378.8008	67.9725
7:55	26.4986	79.6974	-42.3790	159.2085	748.5778	1288.8060	41.2820	298.5584	547.4676	360.9035	65.4347
8:00	25.8357	78.5043	-42.3790	157.5693	780.0222	1329.1158	40.4363	324.1674	558.7776	387.8255	69.5919
8:05	25.7891	78.4203	-42.3790	157.5693	807.4092	1375.7818	40.4363	347.3304	578.3966	415.5371	74.5645
8:10	26.0771	78.9388	-42.3790	158.1840	791.1798	1353.3872	40.7524	333.5077	571.2013	400.5566	72.1567
8:15	26.3442	79.4196	-42.3790	158.7987	790.1655	1356.9046	41.0697	332.6531	574.9113	401.0828	72.5323
8:20	26.3436	79.4185	-42.3790	158.7987	800.3088	1374.3231	41.0697	341.2484	582.2914	411.4462	74.4064
8:25	25.9753	78.7555	-42.3790	157.9791	803.3518	1372.4285	40.6469	343.8484	578.4874	412.4413	74.2014
8:30	26.4371	79.5868	-42.3790	159.0036	801.3232	1377.8406	41.1758	342.1140	584.5350	413.0221	74.7878
8:35	26.5338	79.7609	-42.3790	159.2085	806.3948	1388.3479	41.2820	346.4582	589.7516	418.8058	75.9328
8:40	26.8385	80.3092	-42.3790	159.8232	815.5238	1409.4861	41.6014	354.3470	601.0426	429.9957	78.2626
8:45	27.3492	81.2286	-42.3790	160.8477	812.4808	1413.2283	42.1364	351.7075	606.5014	429.5286	78.6787
8:50	27.4268	81.3682	-42.3790	161.0526	803.3518	1399.1294	42.2438	343.8484	601.2156	420.4654	77.1167
8:55	27.3464	81.2235	-42.3790	160.8477	811.4665	1411.4640	42.1364	350.8299	605.7442	428.4568	78.4824
9:00	27.8814	82.1865	-42.3790	161.8722	811.4665	1420.4542	42.6749	350.8299	613.4853	431.1858	79.4854
9:05	28.1015	82.5826	-42.3790	162.2820	811.4665	1424.0503	42.8912	350.8299	616.5955	432.2774	79.8883

9:10	27.8857	82.1943	-42.3790	161.8722	812.4808	1422.2298	42.6749	351.7075	614.2522	432.2644	79.6842
9:15	28.3642	83.0556	-42.3790	162.6918	818.5668	1440.1383	43.1081	356.9963	625.1360	440.9861	81.7036
9:20	28.5398	83.3716	-42.3790	163.1016	809.4378	1427.6643	43.3256	349.0779	621.2824	432.2910	80.2944
9:25	28.7760	83.7967	-42.3790	163.5114	810.4522	1433.0450	43.5436	349.9534	625.1908	434.4640	80.9007
9:30	29.2375	84.6275	-42.3790	164.7408	781.0365	1391.4158	44.2008	325.0110	611.5934	406.5321	76.2687
9:35	29.2141	84.5853	-42.3790	164.3310	806.3948	1433.0180	43.9812	346.4582	628.3127	432.2809	80.8977
9:40	30.2936	86.5285	-42.3790	165.9702	816.5382	1465.5177	44.8630	355.2290	648.9719	447.6454	84.6087
9:45	30.7179	87.2922	-42.3790	166.5849	819.5812	1476.4273	45.1959	357.8816	656.2245	452.6585	85.8731
9:50	29.9420	85.8956	-42.3790	165.3555	819.5812	1465.5311	44.5313	357.8816	646.5743	449.3178	84.6102
9:55	30.1553	86.2795	-42.3790	165.7653	815.5238	1461.8901	44.7523	354.3470	646.5663	445.9827	84.1903
10:00	30.0606	86.1091	-42.3790	165.3555	831.7532	1487.2965	44.5313	368.5907	656.1769	462.7630	87.1421
10:05	29.7625	85.5726	-42.3790	164.7408	841.8965	1499.8378	44.2008	377.6355	659.2501	472.3562	88.6179
10:10	29.6726	85.4106	-42.3790	164.7408	831.7532	1481.7675	44.2008	368.5907	651.3073	461.0427	86.4954
10:15	29.8984	85.8170	-42.3790	165.5604	802.3375	1436.4748	44.6417	342.9806	634.5403	431.1434	81.2884
10:20	28.8721	83.9699	-42.3790	163.5114	824.6528	1458.1547	43.5436	362.3245	636.1453	449.8227	83.7606
10:25	28.2512	82.8522	-42.3790	162.2820	841.8965	1477.4522	42.8912	377.6355	639.7178	465.3061	85.9923
10:30	27.8735	82.1723	-42.3790	161.6673	836.8248	1462.9892	42.5669	373.0994	631.0561	457.9755	84.3170
10:35	28.5169	83.3304	-42.3790	162.6918	845.9538	1488.3213	43.1081	381.2841	646.0514	470.9881	87.2622
10:40	28.6410	83.5537	-42.3790	162.8967	845.9538	1490.1958	43.2168	381.2841	647.6797	471.5813	87.4821
10:45	28.8300	83.8940	-42.3790	163.1016	856.0972	1509.9608	43.3256	390.4824	657.0956	483.5655	89.8181
10:50	28.4998	83.2996	-42.3790	162.6918	842.9108	1482.9677	43.1081	378.5460	643.7274	467.6058	86.6355

Interior Pressure: Barometric pressure for April 8, 2008 was reported by the National Weather service to be 27.7 inches of mercury which converts to 13.6 psi adding the additional pressure maintained within the shelter provides an internal pressure which ranged from 13.620 psi to 13.605 psi.

While this has minimal impact on the occupants it impacts the actual number of oxygen molecules that are available. The number of oxygen molecules is determined by the percentage of oxygen times the pressure multiplied by the volume of the space then divvied by the number of oxygen molecules per unit of volume at that pressure. The number of oxygen molecules a volume can hold is also affected by the higher than normal percentage of the air that is occupied by water vapor in the humid environment of the sealed shelter.

Since the shelter's atmosphere contained significant quantities of water vapor its potential effects on the pressure and the resultant partial pressures of the various gases must be understood. As water vapor, measured by humidity, increases its partial pressure[43] contribution to the total air pressure increases thus lowering the partial pressure contribution of the other gases. Since the total air pressure in the shelter remained relatively constant due to the overpressure values, the presence of water vapor in the air dilutes or displaces the other air components as its

[43] According to Dalton law of gas mixtures the partial pressure is that pressure a gas would exert it alone occupied a space. It is determined by taking the mole fraction of the gas times the actual pressure of the mixed gas.

concentration increases. Since the levels of oxygen and carbon dioxide were closely monitored it must be inferred that the partial pressure of nitrogen and rare gases were disproportionally affected.

The partial pressure exerted by a relative humidity of near 80% is approximately 0.4 psi and represents approximately 1.5 pounds per cubic foot of water vapor in the air. Since the absolute pressure in the shelter was generally around the 13.6 psi ambient for the site that means approximately 3% of pressure was attributed to water vapor. While not significant issue for health it should be considered for those wishing to do a more precise analysis of the atmospheres in shelters.

The value of most concern is the difference between the partial pressure of oxygen in the shelter's air verse that in blood. It is that difference that provides the mechanism for moving oxygen into the blood. At all times during the test it was significantly high enough to ensure adequate transfer of oxygen into the blood through the lungs. The oxygen partial pressure averaged 2.85 psi during the testing period. The minimum oxygen partial pressure for inhaled air required for an adult is 1.95 psi in order to achieve a hemoglobin oxygen saturation of 1.35 ml/g.[44]

Carbon Monoxide: Ambient carbon monoxide was zero. Within 15 minutes the carbon monoxide levels according to multi-gas instruments began to rise with an initial reading of 4 ppm.

While this did not a surprise the author as other studies had reported that smokers 'degas' carbon monoxide when entering a clean environment the values being recorded by the multi-gas instruments continued to rise. Measurements were being taken at two locations with the inside handheld unit and from an identical external unit. This caused some concern as the internal unit began to register levels near 40 ppm approximately one hour into the test. After much discussion between the staff outside and those inside a hypothesis emerged that it was either a calibration error or a cross-sensitivity error. Since there were several welders in the chamber that had just come from work the handheld instrument was held next to their clothing and levels of 49 ppm were recorded. There was only one smoker among the participants so we did believe one could cause that much carbon monoxide. The assumption was that if the elevated readings were not an instrument error it was the residual carbon monoxide from the welders clothing.

As noted in the literature review section, considerable time was spent in post-test efforts trying to determine the cause for these readings. An air sample that had been pulled from the shelter and analyzed by a gas chromatograph found no carbon monoxide. After the participants had been removed at the end of the test period a purge was conducted according to manufacture's instructions and the carbon monoxide level returned to zero eliminating the shelter as the source.

[44] R. Schwartzstein and M Parker, "Respiratory Physiology", Lippincott Williams & Wilkins (2006)

The two multi-gas instruments were taken to a nearby lab and exposed to a known calibration gas along with a unit from the lab; all reading being the same eliminated a calibration error. A detailed inspection of operating procedures and gas sampling of the welding shop where the six welding participants worked found only one working in area were there was measurable carbon monoxide. This instance was due to an unvented space heater but measuring his clothing immediately after leaving the area did not result in carbon monoxide levels higher than 9 ppm.

Upon questioning each participant, it was discovered that several had gone home from work and showered prior to coming to the test site and others who had not had applied cologne. A review of the contents of personal hygiene products; deodorants, colognes, and some shampoos revealed that many contained compounds found on lists of chemicals to which carbon monoxide detectors have cross-sensitivities. While the specific source was not identified it is likely to an ingredient in one the products used by the participants since the duration of the test had been long enough for human generated methane, ammonia, or alcohols to have accumulated sufficiently to have result in cross-sensitivities resulting in the readings.

It appears the carbon monoxide issue was unrelated to the operation of the shelter; however, the purge system did operate as designed and thus demonstrated its ability to meet West Virginia and MSHA requirements.

Participant Behavior: Upon entering the shelter occupants tended to organize themselves by level of acquaintance; friends with friends, co-workers, relatives, etc. This was evidenced by their behavior and discussions during the test period. Talk tended to be about what had happened at work that day, latest gossip, hobbies, and the news.

No one complained about the lack of space. The author notes that on the trip to Utah he had been in center seat on a plane for a period longer than the test duration and had more freedom of movement in the shelter than on the plane.

Several of the participants discussed the scenario they had been given prior to entering and speculated on how the miners at Sago must have felt while in their barricade.

While it turned out not to be a problem, the rising carbon monoxide levels did evoke a sense of apprehension among the participants. While it would have been unethical to intentionally provoke such stress among the participants, it presented an opportunity to observe behavior when presented with an unexpected threat while in the confines of the shelter. There was no panic rather the group vocalized suggestions on the cause and possible remedies. While, this did not approach the level of stress that would be experienced in real accident, it did provide the opportunity observe individual and groups response. The same problem solving techniques and the emergence of leaders that was described by Vaught's NIOSH document on group behavior in underground mine fires[45] were observed. It may be because so many of the participants work

[45] C Vaught, et al, "Behavioral and Organizational Dimensions of Underground Mine Fires", NIOSH Informational Circular 9450, May 2000

closely with each other and all shared a common understanding of the mining environment or it may have been because they currently shared the common situation. In either case it bodes well for how groups might respond during an unexpected event while in an emergency shelter.

As the duration progressed and the humidity exceeded the dew point, water began to condense on all surfaces of the shelter. But even prior to that it because obvious that clothing and paper provided for notes was becoming saturated. One person who had begun reading a book noted that the pages were getting wet. While the condensation was noticeable it was not problematic during the time spent during this test. It is possible that for full durations by the maximum number of people that clothing and cardboard boxes will become saturated. Besides a comfort issue fully saturated skin tends to perspire less forcing more of the human body's temperature regulation into the exhaled moisture. This might further increase humidity.

When interviewed after the conclusion of the test all said it was a good experience and that if necessary they would not hesitate using a shelter if escape were not possible.

E. Conclusions and Recommendations

Based upon the results of the recorded data and the analysis the MMSS 26-person shelter performed as predicted by computational modeling in the West Virginia approval application. The MMSS 26-person shelter demonstrated its ability to meet all the performance requirements of West Virginia and those of MSHA PIB 07-03.

The projected values for oxygen consumption and carbon dioxide scrubbing set by the agencies standards may be conservative and occupants must be trained to depend upon their multi-gas instruments in adjusting oxygen supply and deploying scrubbing materials as needed.

The erroneous reading of carbon monoxide due to cross-sensitivity of electronic multi-gas instruments is not unique to the models used in this test. It is recommended that occupants be briefed on the possibly of erroneous readings and the inclusion of supplementary carbon monoxide specific sampling tubes be considered in case verification is required to avert undue apprehension.

The use of the U.S. Mine Rescue Association's standard heat index chart for determining the apparent temperature is adequate and protective. While other methods may produce greater precision this approach is already accepted and understood by the mining community.

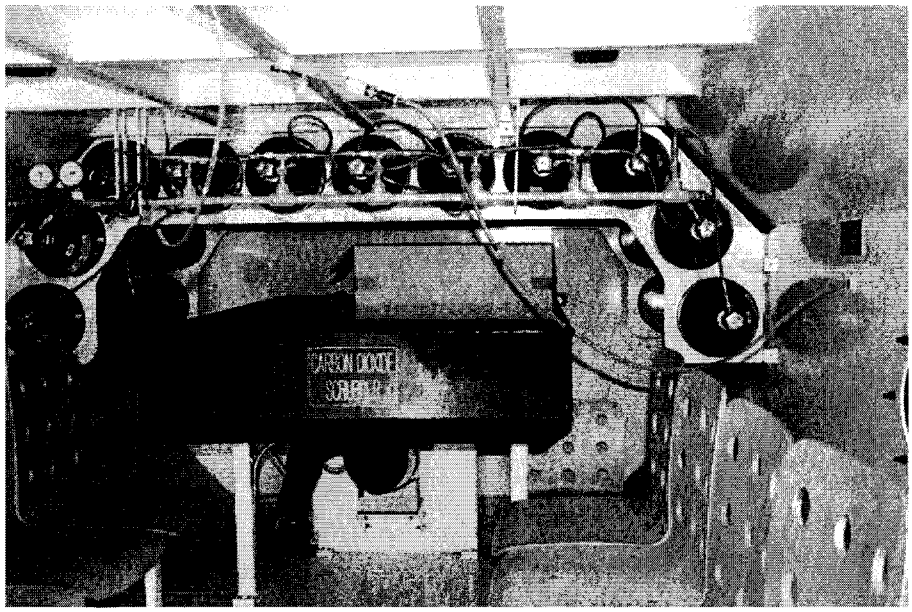
The West Virginia rule was set assuming a 55 degree Fahrenheit ambient temperature. This was an import consideration in setting the West Virginia rules. Since these units are sized based upon the maximum number of miners at shift change over 95% of the time the units would be over sized for the number of people most likely to occupy them. In those cases the internal heat generation would be greatly reduced. However, the temperature of 55 degrees Fahrenheit was

specific to West Virginia coalmines and is common in coalmines in the Western United States. MMSS assured the author that the mine for which this unit was intended had an ambient temperature of 55 degrees as well.

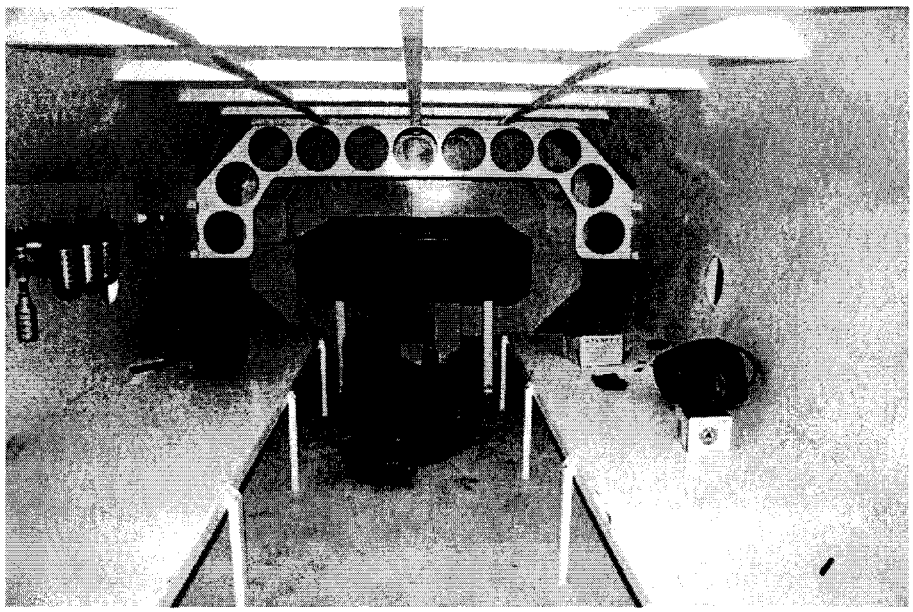
Based upon these results it was calculated that to maintain the internal thermal conditions demonstrated in this test if the external temperature were to raise to an average of 60 degrees Fahrenheit the surface area would have to be increased to 2,061 square feet or 79.2 square feet of surface per occupant. If the outside temperature increased to 70 degrees Fahrenheit the surface area would have to be expanded to 4,884 square feet or 187.8 square feet of surface area per occupant. As the outside temperature approaches the target inside temperature the likelihood of condensation decreases along with that of thermal conduction. While some of this can be overcome by increasing surface area there is point beyond which artificial cooling will be required.

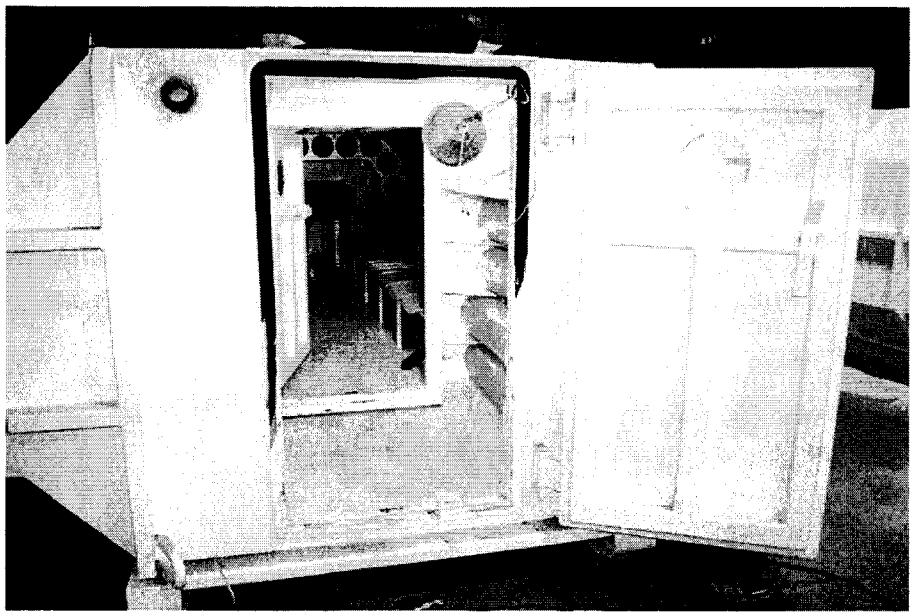
The inclusion of other than survival materials is likely a good idea. The West Virginia rule did not specifically address the issue. It was obvious from observing the participants that the several decks of playing cards provided were being used along with the books and paper, while becoming moist these appear to have been appreciated. It is recommended that care be taken in selecting such items that are moisture tolerant.

Appendix A. Photographs

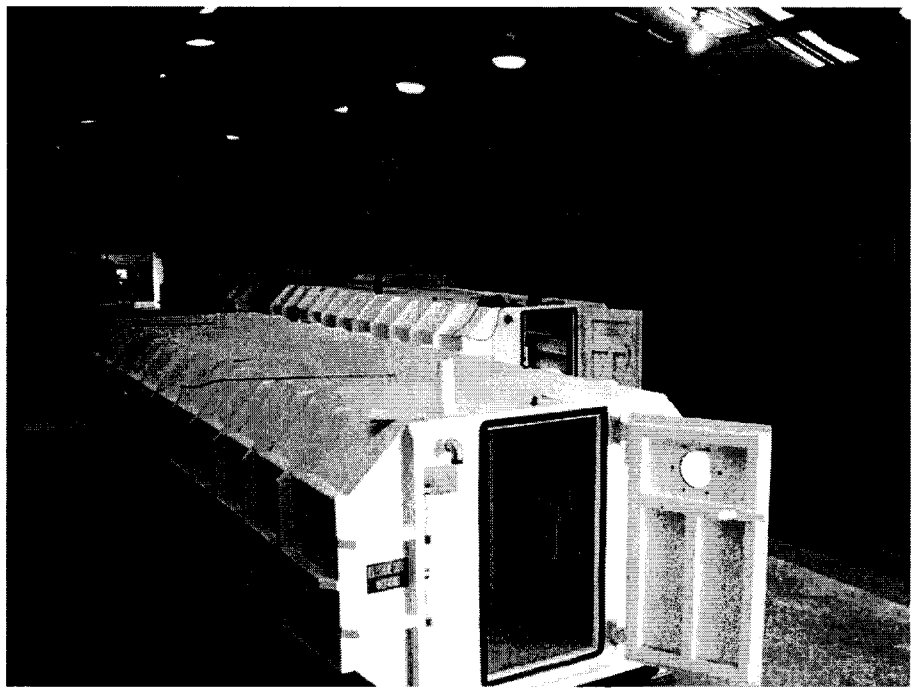


The image above is the view of rear of shelter showing seating, stored oxygen bottles and carbon dioxide scrubber. Note the seats on floor behind scrubber. For the 26 man unit there is one on either side along with four portable seats for use in the floor between the seats. The cardboard box on the scrubber contains one of soda lime canisters that are places in the scrubber during operation. The image below shows a unit during final assembly.



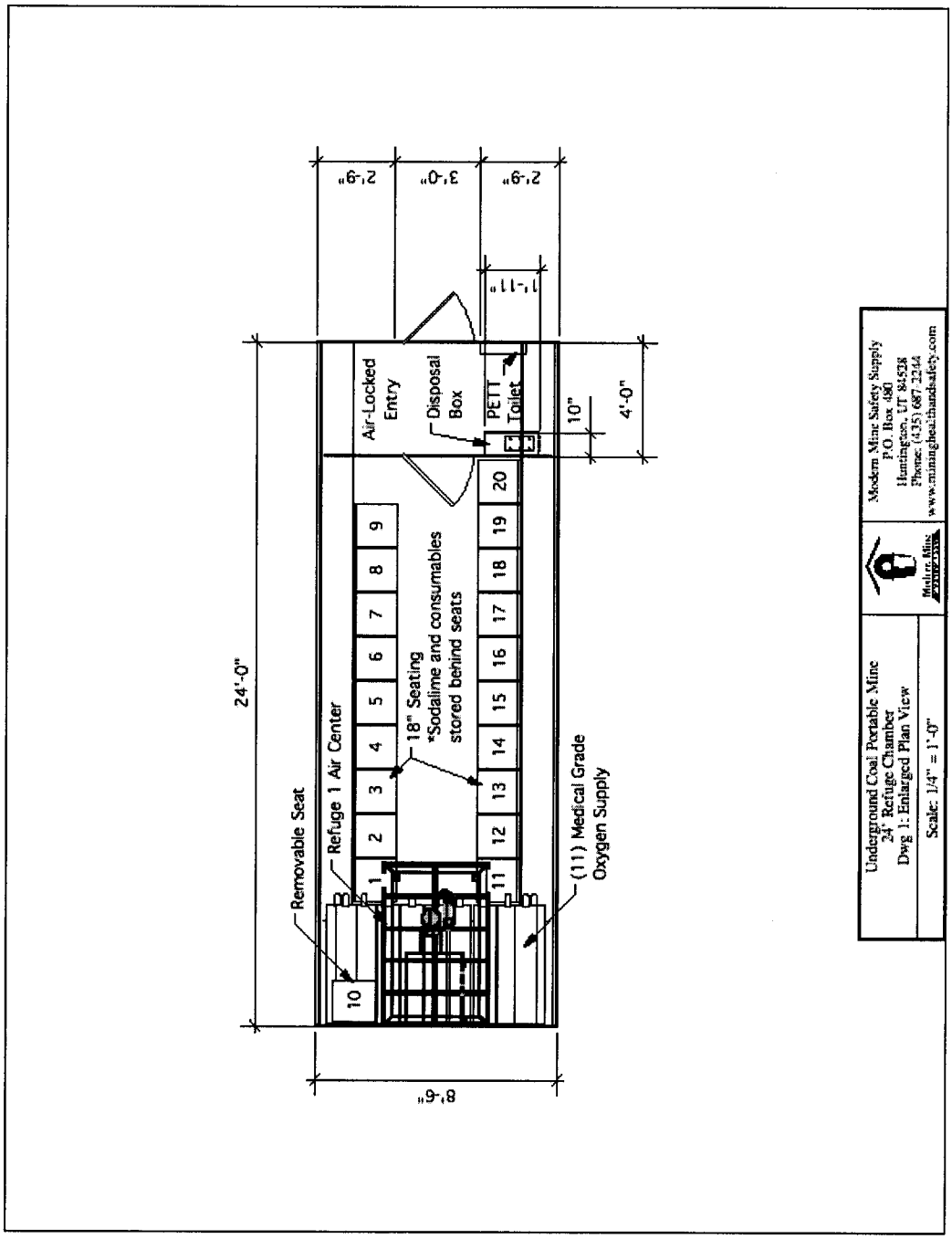


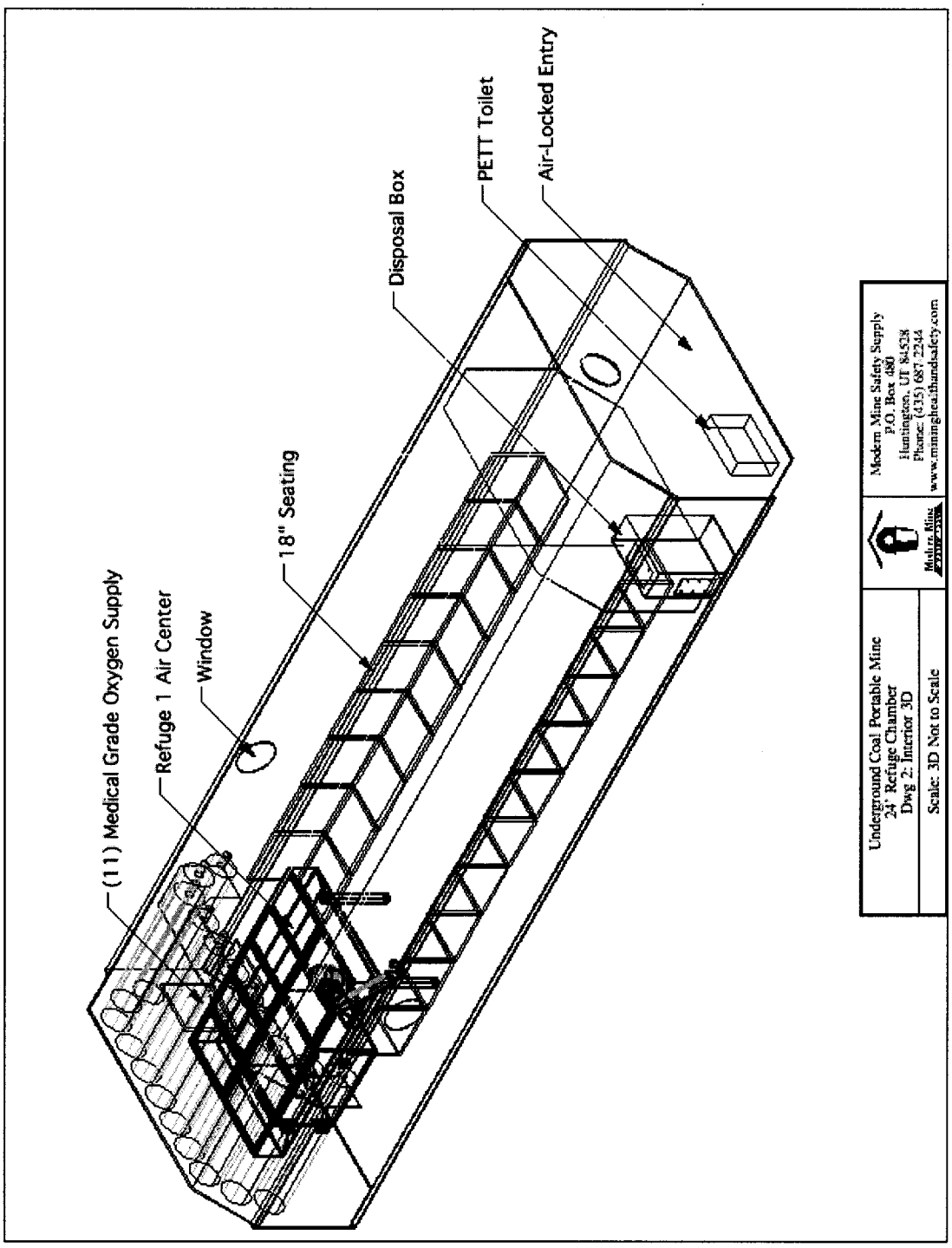
The image above shows the airlock and inner door open. Note the yellow purge air bottles located to the right of the door. The toilet is located to the left. The image below was taken during the test. While conditions were cramped it was not uncomfortable. Spirits remained high throughout the test duration.



Modern Mine Safety Supply, LLC Assembly Facility in Huntington, Utah
with units at various stages of final assembly

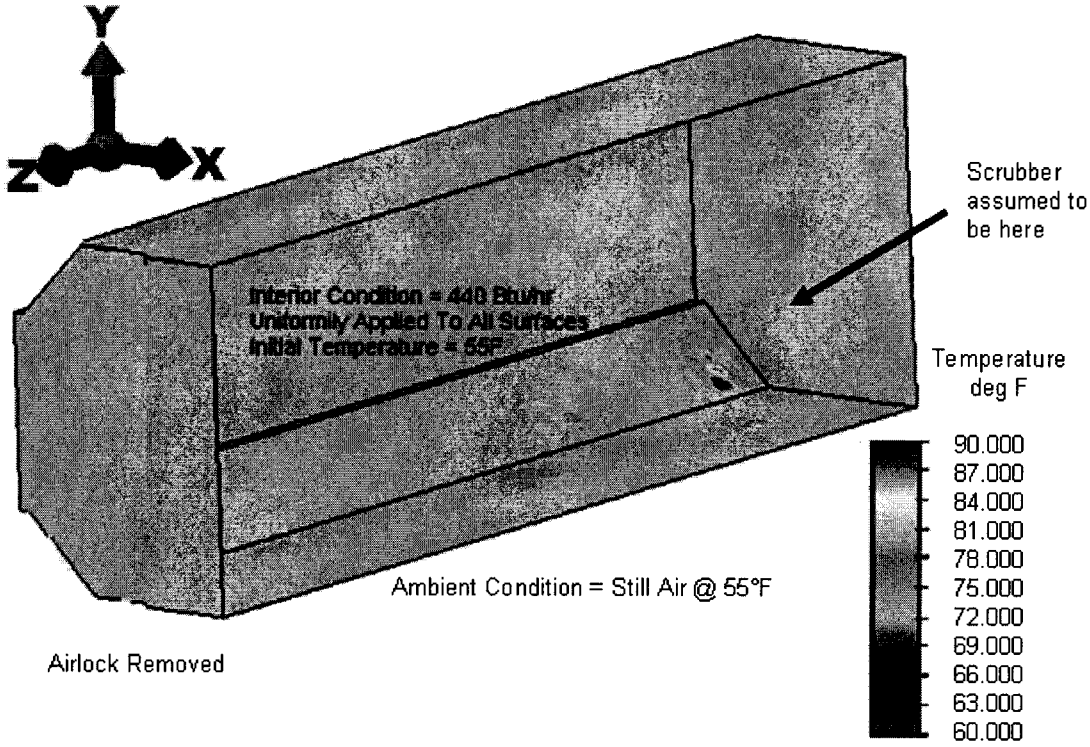
Appendix B. Schematic of Shelter




(11) Medical Grade Oxygen Supply
Refuge 1 Air Center
Window
18" Seating
Disposal Box
PETT Toilet
Air-Locked Entry
Underground Coal Portable Mine
24' Refuge Chamber
Dwg 2: Interior 3D
Scale: 3D Not to Scale
Modern Mine Safety Supply
P.O. Box 480
Huntington, UT 84528
Phone: (435) 687 2244
www.miningboat/thundasafety.com

Appendix C. Excerpts from West Virginia Application

Steve Dowdon, PE, of Peterson, Inc. performed a thermal analysis of the MMSS 16-person emergency shelter as part of the West Virginia OMHS&T approval process. The results below show the results of that analysis. The ambient outside air temperature was assumed to be 55 degrees Fahrenheit with no air movement beyond convection as the result of heating air at the outer surface of the shelter with the interior shelter having the same temperature upon occupancy. The occupants were assumed to produce 400 Btu per person with an additional 40 Btu per occupant being added by the soda lime scrubber. Using the worst case situation the humidity was assumed to be 100%. This meant the dry bulb temperature would have to have been maintained below 82 degrees Fahrenheit. The results of Dowdon's analysis indicated that the shelter would be able to meet this standard.



Appendix D. Participant Forms

MODERN MINE SAFETY SUPPLY, LLC
MINE REFUGE CHAMBER
TEST INVOLVING HUMAN SUBJECTS

The purpose of this study is to conduct a live test of the Modern Mine Safety Supply, LLC (MMSS) Mine Refuge Chamber with twenty-six (26) human test subjects inside. This test will evaluate the mine refuge chamber's systems capability to maintain the breathing air above 19.5% oxygen and below 0.50% carbon dioxide. We will also test the structure's capability to reject heat and maintain apparent temperature levels below 94° Fahrenheit.

I would like to ask you to complete the enclosed questionnaire and return it prior to the start of any testing. Participants will be completely enclosed in the Mine Refuge Chamber for up to 8 hours to fulfill the purposes of this study. The test process poses little or no danger because any or all participants can be immediately removed to the outside atmosphere at any time they desire, if breathable air quality or temperature presents a risk.

Records and data pertaining to the participants will be held strictly confidential. All information will be kept in a secure location, and will only be viewed by Randy Tatton for the purposes of collecting and interpreting the records and data for report generation.

If you have any questions, concerns, or complaints or if you feel you have been harmed by this research please contact Randy Tatton, Modern Mine Safety Supply at (801)673-1400.

It should take 30 minutes to complete the questionnaire. Participation in this study is voluntary. You can choose not to take part and you can also choose not to finish the questionnaire or omit any question you prefer not to answer without penalty or loss of benefits.

By returning this questionnaire, you are giving your consent to participate.

Thank you for your willingness to participate in this important study of the Modern Mine Safety Supply Mine Refuge Chamber.

Consent to Participate in Research

You are being asked to participate in a research study.

Before you agree, the investigator must tell you about:

(i) the purposes, procedures, and duration of the research;
(ii) any procedures which are experimental;
(iii) any reasonably foreseeable risks, discomforts, and benefits of the research;
(iv) any potentially beneficial alternative procedures or treatments; and
(v) how confidentiality will be maintained.

Where applicable, the investigator must also tell you about:

(i) any available compensation or medical treatment if injury occurs;
(ii) the possibility of unforeseeable risks;
(iii) circumstances when the investigator may halt your participation;
(iv) any added costs to you;
(v) what happens if you decide to stop participating;
(vi) when you will be told about new findings which may affect your willingness to participate; and
(vii) how many people will be in the study.

If you agree to participate, you must be given a signed copy of this document and a written summary of the research.

If you have questions, complaints or concerns about this study, you can contact Randy Tatton at (801) 673-1400. If you need to contact someone for an injury that resulted from being in this study, please call Randy Tatton at (801) 673-1400. Randy Tatton can be reached at this number from 8:00am – 6:00pm Monday through Friday.

Your participation in this research is voluntary, and you will not be penalized or lose benefits if you refuse to participate or decide to stop.

Signing this document means that the research study, including the above information, has been described to you orally, and that you voluntarily agree to participate.

Name of Participant	Signature of Participant	Date
Name of Witness	Signature of Witness	Date

HEALTH HISTORY QUESTIONNARE

All questions contained in this questionnaire are strictly confidential

Participant ID Number:	□ M □ F	**Age:**
Primary Care Physician:	**Phone Number:**	

PERSONAL HEALTH HISTORY

Do you currently have a cough, cold or other respiratory illness?	□ Yes	□ No
Do you currently have the flu, a fever or contagious illness?	□ Yes	□ No
Is stress a major problem for you?	□ Yes	□ No
Do you panic when stressed?	□ Yes	□ No
Do you have a problem with confined or small spaces?	□ Yes	□ No
Do you have a back problem that would be aggravated by prolonged sitting?	□ Yes	□ No

Check if you have, or have had, any symptoms in the following areas to a significant degree and briefly explain.

□ Ears	□ Chest/Heart
□ Nose	□ Back
□ Throat	□ Intestinal
□ Lungs	□ Circulation

List any medical problems that you have been diagnosed with

List your prescribed drugs and over-the-counter drugs, such as vitamins and inhalers

Name the Drug	Strength	Frequency Taken

Allergies to medications

Name the Drug	Reaction you had

Appendix E. Local news article

Emery County Progress

April 15, 2008

Mine refuge chamber test

By PATSY STODDARD
Editor

Huntington company leads the way in manufacture of refuge chambers

The human test subjects enter the mine refuge chamber for the initial human test of the chambers made by the Huntington company Modern Mine Safety Supply. Subjects: Cory Burgess, Bryan Christensen, Kade Stevenson, Gavin Anderson, Eric Behling, Scott Kerksiek, Bodie Marshall and Josh Hatch await being sealed in the chamber.

A sophisticated mine refuge chamber over the period of two years has been developed and fabricated through a joint effort of Modern Mine Safety Supply, LLC, a local Emery County business and Mining Health and Safety Solutions Inc. a South Jordan business owned by previous residents of Carbon and Emery counties.

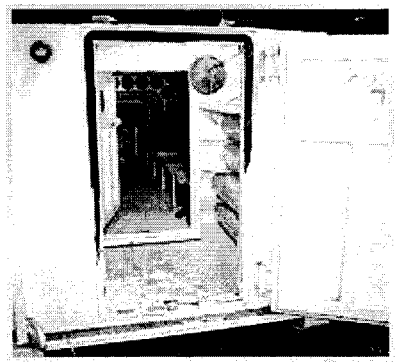
Two years of hard work on a prototype mine refuge chamber brought MMSS to the point that it was time to conduct a test that would involve human test subjects. The purpose of this test was to determine two major factors. Would the mine refuge chamber be able to maintain breathable air and remain cool enough inside to keep miners alive and safe?

Forty people showed up on site at the MMSS fabrication shop to participate in the test and 26 were finally chosen to actually do so. The participants were requested to complete a confidential detailed medical questionnaire and had their blood pressure and other vital signs checked by EMT Martin Wilson. Several of the prospective human test subjects were asked not to participate due to various health conditions or if they had a cold or other respiratory problems. The personal medical information was not associated directly with the individual and was kept strictly confidential.

The test subjects were briefed by Randy Tatton CMSP, President of MHSS. Tatton said, "We appreciate everyone coming. This is a very critical and special human subject test that has not been done before. I am confident that we are going to take care of the atmosphere inside and keep you safe." Tatton stressed that the miners first priority must be to evacuate to the surface in the event of an emergency, but when that's not possible, they may possibly be saved if they have a chamber of this type to get into until emergency response personnel can reach them.

Tatton explained that being in the mine refuge chamber is just like being closed in a trunk of a car or a freezer It's an air tight box. He said the critical difference is that the air inside the mine refuge chamber is maintained to be breathable. Medical grade oxygen is used to replenish the oxygen that is consumed by the respiratory process and the exhaled carbon dioxide is absorbed by the carbon dioxide scrubber.

Tatton stressed to participants that the entire atmosphere inside the mine refuge chamber when the doors are closed will be the same atmosphere that will be breathed for the duration of the test. The air will just be re-conditioned to ensure breathability and recirculated throughout the chamber. He said the systems that maintain the air breathability have been thoroughly tested and proven.



The mine refuge chambers at the Huntington plant.

Tatton said the most critical thing they are concerned about is if the occupants should become too hot and that the primary purpose of this test is to ensure the inside of the mine refuge chamber remained cool enough so as not to be dangerous to the occupants. Tatton showed a chart which outlined the temperature and humidity levels which they would use as a guideline to ensure the temperature inside the mine refuge chamber was safe for the occupants.

The human subjects were to remain in the chamber until the temperature stabilized. If the temperature rises above safe levels, the test subjects will be removed. If this is the case, air conditioning will be needed prior to the units being delivered to the mines that have purchased them.

Emery County Progress

April 15, 2008

Company info and refuge chamber facts

By PATSY STODDARD
Editor

EMT Martin Wilson checks the blood pressure on Jeri Proulx

Modern Mine Safety Supply, LLC is helping to move the safety of coal mining into the future. They are located on SR31 in Huntington. They manufacture mine refuge chambers. The chambers arrive at the fabrication shop in four pieces and are welded together. They cut all the tubing that goes around the chambers. This tubing adds support to the chamber and makes it capable of withstanding an explosion with pressures of 15 psi.

The chambers are equipped with seven purge bottles. When the chamber is entered the door into the air-locked area is closed creating just a small space between the occupation area and the outside door. Once inside this air-locked area with both doors closed, the possibly contaminated air is purged to the outside by breathable grade compressed air. Then when fresh air is introduced into the air-locked area the inside door to the chamber is opened and the men move into the occupation area of the chamber.

The chamber is equipped with chairs along each side with an aisle in the middle. The chamber has a first aid kit and a bathroom facility. MMSS is also working on an air conditioner for the unit. The chamber is equipped with meal kits and potable water. Each kit has 910,000 calories and includes water pouches that contain 14 quarts of water per miner.

Four of the chambers being constructed now are going to the Bridger underground mine in Wyoming. There are mine phones in the mine refuge chamber and if not damaged by the emergency event occupants will be able to communicate to the surface. When men enter the chamber they turn on a signal light which indicates someone is inside to alert possible rescuers.

Plant manager, Shawn Sitterud said the chambers they have constructed so far have all been sold. Energy West Mining has purchased eight units, Bridger underground mine has purchased four units and mines in Colorado have also ordered the chambers. A chamber has also been delivered to New York.

The chambers weigh approximately 22,000 pounds. Ten ton cranes are used to move them around as they are assembled. It takes 200 pounds of wire to weld everything together. The chambers are painted white so they will reflect light so they can be located in an emergency.

The chamber is custom built to the unique needs and conditions of individual mining operations. The chamber is built to survive the effects of an initial explosion and could potentially protect the occupants in the event of a secondary explosion. The company is committed to ensuring the highest level of safety and service by giving a second chance to those who may not otherwise have one.

The chambers going to Bridger are 24 feet long, 95 inches wide and 5 feet 7 inches tall. The chambers weigh 11 tons upon completion.

Sitterud said the chambers are used beyond coal mining. They are used in metal/non metal mines also.

Modern Mine Safety Supply, LLC announced that the U.S. Department of Labor, Mine Safety and Health Administration approved their explosion proof blower assembly June 26, 2007. After months of hard work and research this technology is now available to power carbon dioxide scrubbing units in refuge chambers, safe havens and other refuge areas.

The company capitalizes on decades of fabrication and mining safety expertise to make their high quality Mine Refuge Chamber and Turn Key Safe Haven. With the addition of the permissible explosion proof blower assembly it makes their carbon dioxide scrubbing unit even more efficient and effective. The mine refuge chamber is certified by the West Virginia Office of Miners' Health Safety and Training.

Mark Leffler works on the tubing for the oxygen.

Randall Harris who works with the Office of Miners Health, Safety and Training from West Virginia was on hand for the test. He said the state of West Virginia approved the mine refuge chamber and mines there are required to have one near each working section of the mine. By the end of the year, 300 of these chambers will be installed in West Virginia mines. He said the mine refuge chambers were considered as a means to provide breathable air following the Sago mine disaster where 11 miners died of asphyxiation only 1,000 feet away from fresh air. Harris said this product has been developed with no money from the federal government. Four small businesses across the country have done this voluntarily and should be commended.

The 26 participants climbed into their chamber at 6:35 p.m. The temperature of the chamber was 65 degrees at the onset. At

7:50 p.m. the temperature had climbed to 77 degrees and the oxygen level had elevated to 21.1 percent. At 8:30 p.m. the temperature was 78 degrees. An hour later the temperature inside the chamber was 79 degrees. When this temperature is applied in conjunction with the relative humidity which was 80 percent, the resulting apparent temperature is 84 degrees. This is a safe apparent temperature for the occupants. When apparent temperatures rise above 94 degrees it begins to become detrimental to human health.

The 26 occupants of the chamber passed the time in various ways. Some of them struck up a poker game; others read books and all talked. Wilson the EMT was kept busy taking the blood pressure readings. Jeri Proulx was kept busy taking readings and reporting them by radio to those on the outside monitoring the instruments from the outside. In a real emergency the atmosphere inside and outside will be monitored from within the chamber. The participants came out of the chamber no worse for the wear at approximately 10:50 p.m.

They all said they felt good and had suffered no adverse conditions from their experience within the chamber. In good sprits, one participant noted that what happens in the shelter stays in the shelter.

The occupants were: Jennie Tatton, JoDell Muller, Kyle Gundersen, Frank Hurst, Vince Christiansen, Anita Sitterud, Clerece Chidester, Joan Burgess, Cory Burgess, Bryan Christensen, Kade Stevenson, Gavin Anderson, Eric Behling, Ted Allen, Cory Sosa, Brad Sitterud, Randall Harris, Scott Kierksiek, Frank Gordon, Bodie Marshall, Josh Hatch, Cory Proulx, Jeri Proulx, Will Payne, Martin Wilson and Patsy Stoddard.