

SAES Pure Gas, Inc.  
Underground Breathing and Life Support System

**Date:** March 20, 2006

**To:** U.S. Department of Labor  
Mine Safety and Health Administration (MSHA)

**From:** SAES Pure Gas, Inc.

**Subject:** Regulatory Information Number (RIN) 1219-AB44

SAES Pure Gas, Inc. (SPG) reviewed your Agency's request RIN 1219-AB44. The research was conducted by our following Managers: Operations Manager, Research and Development Manager, Product Manager, and Environmental Health & Safety Manager. Collectively, this team has 23 U.S. Patents and over 60 years of experience in the Research, Development, Marketing, and Safely Manufacturing advanced gas purification technologies. These systems provide purification for Ultra-High Purity (UHP) bulk gases and specialty gases, as well as in-situ purification for Semiconductor processing tools. SPG is a member company of the SAES Getters Group, who offer a wide variety of industrial products, such as gas analyzers, and gettering materials which provide vacuum for television screen, cell phones, incandescent lights, linear accelerator and flat panel displays. Please see our web page at [www.saesgetters.com](http://www.saesgetters.com).

Please accept the responses to your questions in sections A-J in the following two Attachments:

- Attachment **A**; SPG response to sections B, C, D, and H.
- Attachment **B**; SPG's EH&S Managers response to sections E, F, I, and J.

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ATTACHMENT A

**B. Breathing Apparatus:**

1. Please see the comments on Attachment B for this question.
2. Utilizing a combination of two technologies, a re-breather system and Supplied Air Respirator, we think a new portable system needs to be developed. This dual cascade air cart system would be capable of delivering breathable air manifold with 6 outlets. Each outlet would have 100' of hose line and a buddy breather valve with 25' of piggy back hose. This would give a rescue team the ability to supply 12 miners of breathable air for an undetermined amount of time by continually swapping out the exhauster re-breathers.
3. We believe the technology for re-breathers is pretty good. However, we are researching different types of media for chemical absorption. When completed, they should be readily available. However, they will need to have U.S. approval and certification.
4. Once we completed our testing, we will be able to better answer this question. The time-line for our R&D data could be a matter of weeks, the cost to gather this data should be less than \$5,000.<sup>00</sup>. The cost to bring this technology to market is yet to be determined.

**C. Self-Contained Self-Rescuers:**

1. Yes, we believe that there are few new technologies that will deliver breathable air. One method uses a combination of HEPA filtration and a chemical cartridge that absorbs CO<sub>2</sub> better than those of current chemical absorbents. The second method enhances the previously mentioned system, but it blends in oxygen when the ambient atmosphere is below 19.5%.
2. Yes, the SCSR should be capable of providing breathable air for no less than 120 minutes. Each miner underground, should be required to have one on their person at all times. Depending on the length of the mine shaft, caches of the same SCSRs should be stored in a ready for use condition. *For the portion of this question regarding a SCSR that provides for a longer duration of breathable air, please refer to (section D Rescue Chamber).*
3. We feel that a miner needs to have immediate access to breathable air. Further more, the miner needs to have the capacity to replenish that breathing support system, such would be the case of a trapped miner who is still in harms way. *For a better explanation, please refer to (section D Rescue Chamber).*
4. The miner needs to be responsible to conduct a daily cursory check of all their equipment. A more detailed inspection needs to be done at the beginning of every week, or inspected as prescribed by the manufacturer, which ever is more frequent.
5. We think the service life of the SCSR needs to base on recommendations of the manufacturer, which will be driven by the conditions of the mining operation itself. e.g. atmospheric conditions including concentrations of gases, dust, humidity, temperatures, how the device is intended to be used, stored, etc. Then based on totality of the circumstances, the end of service can either be conditionally extended or reduced as approved by MSHA and NIOSH.

**D. Rescue Chamber:**

1. Yes, it is our belief that all underground mines should have a rescue chamber to be utilized as a safe refuge area.
2. Our basic concept of the Rescue Chamber is a system that we are calling the Underground Breathing and Life Support System (UBLSS). It is the *safe refuge area* for miners to utilize during underground emergencies. Designed of modular type steel construction, the UBLSS will

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serve as a complete Rescue Chamber placed underground in the mine. It will contain all the essential items necessary to support human life for daily emergencies to catastrophic events. The UBLSS will be capable of being moved from location to location as the mining operation is dynamic. It will have the ability to lower the concentration of airborne hazards to a level that will support life for a minimum of 48 hours. The air support system will utilize a combination of metal catalyst, formed molecular sieves, High Efficiency Particulate Air (HEPA) filtration, and an oxygen blending station. In addition to breathable air, it will include; water, Meals Ready to Eat (MREs), blankets, trauma kit for medical aid, Automatic External Defibrillator (AED), Oxygen therapy bag with selection of OPAs/NPAs, Stokes Basket, SKED, adjustable Cervical collars, ropes, pulleys and other related hardware to fabricate mechanical advantage systems to facilitate rescue operations, and a port-a-potty. Also included in the UBLSS is a communication link to the above ground Mine Rescue Command Center. The UBLSS will be strategically located in the last seam excavated and it is designed to support a team of 12 miners. Depending on the specific mining operation, there may be multiple UBLSSs located through-out the mine.

3. Our breathing system will be designed to keep breathable air for 12 miners going for 48 hours. However, we have some ideas that may increase the time line for breathing.
4. We believe that the Rescue Chamber needs to be designed for the size of the team working underground. We are basing our concept on a team of 12 miners.
5. Depending on the size of the mine and the distance between active seams, there may be a need to have a series of Rescue Chambers. The best scenario is to have one chamber per team, if they are separated by more than one previously excavated seam. But, if two teams were working on opposite sides of the same lateral, and no more than one seam apart, one Rescue Chamber may be sufficient, as long as there were 12 miners or less with the two teams. Or, based on our modular type construction, we add another section to facilitate the extra team of 12 miners (a total of 24 miners at one Rescue Chamber).

***Note: These are the Specifications we are designing our Rescue Chamber around:***

- Reduces atmospheric concentrations below the PEL for: CO, H<sub>2</sub>S, CH<sub>4</sub>, CO<sub>2</sub>, and particulate dust.
- Backup compressed O<sub>2</sub> system that blends existing air to  $\geq 19.5\%$  O<sub>2</sub>.
- The Rescue Chamber will need to be fire resistant.
- It will need to be water resistant and have the ability to eject water from within the structure.
- It will need to be battery operated.
- It will need to have the ability to re-charge the batteries while in operation.
- It will need to have that ability to accommodate modular type construction.
- Direct reading instrumentation that is internally located with directional probes for interior and exterior atmospheric monitoring.
- A system to link the direct reading instrumentation to the mine operator for daily use, and can be linked to the Mine Rescue Command Center during catastrophic events.
- The link will also have voice communications ability with a beacon back-up alarm system.
- Exterior and interior lighting system made up of non-energy consuming technology.
- A cache of either SCBAs rated at 4500 psig, 60 minute duration or re-breathers rated at 240 minutes. This will allow members of the underground team the ability to respond during catastrophic events to aid in removing a member of their team that may be trapped by fallen debris. Once that rescue mission is completed, the entire underground team would escape to the Rescue Chamber and wait for the mine rescue team to extract them.

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- Portable Supplied Air Respirator cart, complete with a 6 person manifold, 100' lines, buddy breathers with 25' pigtails, and full face masks. This will be taken to the fallen miner(s) as outlined in the above bullet.
- Solid steel wheel casters on each corner of the Rescue Chamber and eight attachment points. They would be located on each side (4) and one at the every corner (4), to be used for the purpose of positioning the chamber underground.

**H. Developing New Mine Rescue Equipment:**

1. We believe that *we have existing* technology that can be modified for mine rescue operations. So the problem that we have with modifying and developing this new equipment is the cost of bringing the product(s) to market.
2. We do not have any *other* specific problems (referring to question 1) with making and/or modifying any of the equipment that we have described in this document, as long as we know what the working parameters are. Prior to us embarking on a project like this, we plan to visit multiple underground mines and gather the data that we feel is necessary to develop and bring to market a system that will be successful in saving lives.
3. It would be a great benefit to have a list with the points of contacts for underground mines to arrange for visits (the list should include the Safety Officer, The Mine Operations Manager, and the local Miners Union Representative. This would provide us with three different points of view for an operation. We would also like to interview miners who survived mine accidents from various magnitudes, including the miners that rescued them. We think that gathering this data is a critical step in developing a rescue system that will be successful and welcomed by the mining industry because they fostered the design process. As you can imagine, the bottom line of this R&D process ultimately comes down to the cost associated with the project.
4. The process to approve any new and/or modified equipment should be put on the fast track. However, this is not to suggest dilution of the requirements, maybe consider organizing a special taskforce of personnel from the appropriate agencies that are assigned to the approval process.
5. It seems to us, that if the MSHA is satisfied with our design for this new Rescue Chamber System, and we can prove that we have existing technology, the encouragement could come in the form of a Grant.

We at SAES Pure Gas, Inc. applaud your agencies swift action with this Request for Information. We are looking foreword to the possibility of working along side with you, and the mining industry in the development of a newer, safer, more efficient system of mining operations including rescue operations.

Respectfully submitted

Tim Johnson  
CEO, SAES Pure Gas Inc.

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**ATTACHMENT B**

**B. Breathing Apparatus:**

1. I believe that SPG has the technology to create a better system of breathing support. However, I am not sure that the best place to put it is on somebody's back as indicated below \*. I believe that best thing to do is create a better breathing support system underground, and revise the mutual aid agreements with other mine rescue teams in the region to keep these miners fresh and alert. The combination of these items will foster success, and sustain life.  
\* Based on the physiological demands placed a member of a rescue team, I feel that the current re-breather systems available on the market today that allow for up to four hours of continuous use, is sufficient. I believe that if a system allowed for greater on-air-time, members of the rescue team will begin to experience heat stress, fatigue, and mental confusion. In my opinion, this may jeopardize the rescue mission. I believe a better solution is access to more rescue teams, which would be made available via a mutual aid agreement and a sufficient number of re-breathers available for their use.

**E. Communications:**

1. This is not really my area of expertise, but it has been my experience that hardwire communications systems work the best. (Although the hardwire itself creates the problem of entanglement and travel distance downrange). Based on the fact that all mechanical devices will eventually fail, including wireless hand held radios, I believe in contingency plans. Therefore, we are looking into the best available technology for the miners personal use, with a back-up communications system located in the Rescue Chamber that uses different methodology. This back-up system when complete, will communicate with the Mine Rescue Command Center with both the status of the miners and how many of them made it to the Rescue Chamber. Regarding PEDs, I believe that each miner should be wearing one, and they should have the ability to be two-way. This would allow a trapped miner that is conscious, the ability to provide information to the rescue team. It would also act as the beacon for the rescue team if the miner were unconscious.

**F. Robotics:**

1. If the robot had the ability to give direct reading instrumentation back to the Mine Rescue Command Center (MRCC), regarding the gas readings video images, and temperatures, it would also be good if the robot had the torque to drag two ventilation hoses with it. Based on the direct reading instrumentation provided to the MRCC, they would have the ability to activate either forced air or negative air ventilation. Possibly both, if the circumstances were right. This decision would be made by the MRCC after considering the current content of O<sub>2</sub>, the potential of explosion as defined by the LEL of CH<sub>4</sub>, the toxicity of H<sub>2</sub>S, CO and CO<sub>2</sub>. So, if the robot detected a high level of explosive gases, it may be appropriate to select the negative air ventilation system to lower the concentration to below 10% of LEL. The concept is to remove the potential of explosive gases faster than they can be generated. This would cause infiltration of fresh air into the mine shaft, which would make it safe for the mine rescue team(s) to make an entry and begin their operations. Under other circumstances, where the atmosphere is toxic, the use of forced air ventilation would be used. This fresh air would dilute the ambient conditions in the mine shaft to below the material's PEL, therefore, creating a greater chance of survival for the trapped miner(s). As you can visualize with these examples, the ventilation system would require intrinsic safe motors and training to understand how to control the exhaust emissions outside the mine shaft.

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These are both easy to overcome. In addition to the abilities we have already discussed, it would be great if the robot had either thermal or infra-red light spectrum imaging and an onboard CO<sub>2</sub> fire extinguisher. With these tools added, the robot would be able to detect not only heat from trapped miners, but heat from an area that is smoldering from an explosion. Depending on the circumstances at the time, it may be appropriate for the robot to deploy some CO<sub>2</sub> extinguishing media on the hot spot(s), thereby reducing the generation of CO. The robot would then position a ventilation hose at the hot spot and the MRCC would activate the negative air system to remove the toxic gases. After that operation controlled the possibility of an explosion due to a combination of LEL for CH<sub>4</sub> and that of CO, the robot would deploy the other hose in a forced air mode positioned in breathing zone of the trapped miner(s). The final thing that comes to my mind regarding robot tools is if the robot had that ability to deploy a two-way hard line communications link for the MRCC. With this tool, the robot would simply carry the link from the MRCC to the miners.

2. The role of the robot should be considered as the first member of the mine rescue team that makes an entry into harms way. Once the robot provides the necessary intelligence as described above, then and the human team can safely enter the mine and perform rescue operations.
3. The robot should be capable of delivering all the information described in question #1 of this section.
4. The ability to carry itself along with all its tools and equipment forward, backward, turn left, turn right, go up steep hills, and go down steep hills. It needs to have multiple arms that can perform different functions, such as an arm that holds the thermal or infra-red imaging camera that is moving around constantly looking for any source of heat. This camera needs to operate independently from the arm that holds the visual camera and lighting system which is looking in the direction of travel. Additional arms need to be available that perform other specific functions, such as positioning the ventilation hoses, or have the ability to move a rock, or a piece of temper, or jaws that can cut/crush one of these an obstacles, maybe the ability to dig like an excavator (this tool would be intended for the robot to use for gaining access to a small area).
5. Based on the development of the robot that I have described above, and the circumstance that caused the mine rescue in the first place, I think that the robot should be the first tool of choice in an emergency setting. I think that a Robot needs to be available, however based on the cost of the robot and the skilled operators, it may make more sense to have them available within a two hour request. Possibly, air lifted to the site via the local bomb squad or other agency ?

### **I. Mine Rescue Teams:**

1. Currently, a mine is required to have two mine rescue teams at each mine site. I believe that both teams should have duplicate caches of equipment, and the equipment list needs to be performance based just like that of the confined space regulation. This is not to suggest that the mine is required to have a tripod, but if their operation has the potential of that type rescue, then they need to have that type of equipment. In addition to the equipment that we have already described in our Rescue Chamber System, I think that each team's cache needs to have webbing, ropes, and pulleys to build mechanical advantage systems. If the MSHA enters into an agreement with our company and allows us to visit some underground mine operations, we will develop a suggested list of rescue equipment that is performance based.
2. The number of SCBA on hand needs to be at least a ratio of 1:1 per team member with at least one spare cylinder per unit. There should also be at least spare SCBA in the cache per team in the case of mechanical failure. Based on your current regulation's requirements for two teams of five, plus

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one alternate and twelve SCBAs, I think that's good. However, the mine needs to have a system in-place to re-fill the empty cylinders during a rescue operation. I think it would be acceptable to have a plan and contingency plan, whereas the mine could use any of the following combinations; the mine has it's own compressor and filling station that delivers grade D breathing air, a mutual aid agreement with the local fire jurisdiction to deliver a portable filling station; or a contract with a local vendor that can shuttle empty cylinders either back to their location or the location of the closest fire jurisdiction. *Note:* I feel the size of the rescue team's membership also needs to be performance based. This includes the physical size of the mine, the length of the shafts, the estimated travel time by foot to the working end, the number of miners underground at any given time, and the final thought, is the daily assignment of the mine rescue team. Meaning, if the team was acting as a rescue squad, and members of the squad were assigned underground operations at the time of the emergency, they may need to be the rescued verses the rescuer. This will jeopardize the entire operation.

3. Like all Personal Protective Equipment (PPE) there needs to be a ratio of 1:1 with a least one spare in each team's cache. In addition to having a spare piece of equipment, each cache needs to have tools and replacements parts as-well. This includes light bulbs, straps, batteries, etc. The second part to the question has to do with direct reading instrumentation. Currently, *each cache* has two CGIs, I think that *each team* needs to have two CGIs. My experience tells me that *each team* needs to have the ability to bump check these monitors, re-calibrate them as needed, replace the sensor heads, and replace the batteries. If the unit still does not function correctly, you activate the spare unit, that's it's purpose. The other justifiable reason I have to support the need for *each team* to possess two CGIs, is based on the potential of simultaneous rescue operations at different locations of the mine during a catastrophic event. If this were the case and the cache was not accessible for replacement parts or recalibration, there would be a delay with the rescue operation. Even worse would be for the rescue to continue with malfunctioning equipment, which would further endanger the lives of the mine rescue team. This could prove to be fatal !
4. Each rescue team's equipment cache needs to be stored separate. The storage locations need to be outside the mine (aboveground) in a clean area that is not exposed to temperature extremes. If the team were acting as a squad that was assigned above ground operations, the squad should conduct a daily inventory check of their equipment. Furthermore, the CGIs and SCBAs would need to be inspected in greater detail on a monthly basis as recommended by the manufacturer and MSHA.
5. I think that when the MSHA has reviewed all the technological recommendations for mine rescue equipment, they will revise the 30 CFR, part 49. This will create an equipment revision, which will drive the revision of the entire document including an emphasis on the training and maintenance elements.
6. If the team has a plan or a contingency plan for utilizing the transportation equipment to support their emergency operation, they should know how to use it. However, if the team only needs to respond to an accident with the transportation equipment, they need to know how to secure the equipment, so they can safely execute their emergency operation.
7. Consider making the mine rescue caches and the mine rescue teams, part of the conditions/permit to operate the mine. This could be administrated by either the BLM, or MSHA, or both?
8. Yes, but it must be proven safe and effective, and *in that order* !

### **J. Government Role:**

1. This entire document speaks to this question.

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2. If 30 CFR, part 49 were performance based regulation, a mine's status, (the size of the mine or its remote location or special circumstances), the mine shall have in-place an approved system to rescue trapped miners under the worse conceivable condition(s). This may either increase or decrease the size of the rescue team as well as the caches they utilize.
3. I think this document request is a great step in achieving this goal.
4. If the MSHA decided that a Rescue Chamber System were going to be the major part of supporting life during underground emergencies, then there should be no doubt that the miners need to know how to use it.
5. I think this is another example of creating performance based regulation that has some sort of decision matrix (Appendices). Maybe consider developing a specific appendix that would be generated from historical data. If the matrix were designed properly, the mine operator would have the ability to answer queries. When the mine operator was finished answering the site specific information, the matrix would define the *list of must have* items versus *nice to have* items. This list would be quantifiable for compliance by MSHA.
6. Regardless of the mine's status, compliance should be rewarded with either a discount on the mine's annual permit to operate or better yet, a formula that reduces the taxes that mine is required to pay. This would create incentive for safety that is truly quantifiable from stand point of the business. Therefore in the eye of the businessman there would be no excuse, why not create a safe and healthful workplace.
7. I feel that if the MSHA acts on the recommendations from private industry as you have requested in this document, it should meet and exceed your expectations.

I hope that you will consider the information in Attachment A from SPG, and that of Attachment B, from myself, as recommendations to sustain life during catastrophic events, and against all odds.

Submitted with Respect and Enthusiasm

Tom Bass  
EH&S Manager, SAES Pure Gas Inc.