

## **Section C - Description/Specification/Work Statement**

### **I. PROJECT IDENTIFICATION AND PURPOSE**

To develop engineering guidelines associated with the location, construction and general application of various refuge alternatives.

### **II. BACKGROUND AND NEED**

Over the years the mining industry has implemented a number of safety protections in the event of explosions, fires and inundations. The recent mine disaster, in which several coal miners died attempting to escape or barricade in the aftermath of a mine explosion, raises questions about existing emergency systems and/or equipment for escape or refuge.

Current requirements include provisions for at least two separate and distinct escapeways for each working section, along with mechanical escape facilities for hosting personnel at mines with certain shaft and slope characteristics. Miners have ready access to maps delineating the escapeways and participate in practice drills every six weeks, which include traveling the escapeways to the surface and every ninety days to the point where the split of air ventilating the working section intersects a main air course. Self-contained self rescuers (SCSRs) worn by miners or cached on working sections provide approximately one hour of oxygen to allow miners to escape in conditions where toxic gases, smoke and dust are present.

While these requirements focus on escape, there are no provisions for refuge, other than barricading, in the event that escape is not feasible. However, refuge chambers constitute an option in several countries, mostly in metal and non-metal mines, where the non-combustible nature of the ore does not offer a threat to the well being of miners. In the United States, the use of refuge chambers in coal mines generated significant debate three decades ago when their use was researched. A consensus for their use never emerged among labor, industry, and government. However, as a result of the mine tragedies earlier this year, the use application of refuge chambers is, or will be, mandated in some States, and the MINER Act directs NIOSH to conduct research concerning refuge alternatives. The work under this contract will provide input into NIOSH's mandate under the Act, and moreover, the timeframe for completing Phases I and II of this contract cannot be changed.

Properly designed refuge alternatives, in combination with technologies developed in the areas of disaster prevention, breathing devices, communications, etc. should improve on the protections available for emergency situations. A refuge station might constitute an element in the escape system and as such, could allow miners to continue the escape procedure if at all possible, or to prepare for refuge chamber occupancy. There are a number of considerations involved with this approach, including the capabilities of stations, the type and location of structures, design criteria, and maintenance and training issues.

Despite on-going debate over the merits of refuge chambers in underground coal mines, consensus is developing among stakeholder groups on refuge concepts as part of an escape and survival strategy. Specifically, the merits of at least two concepts have emerged: inflatable/portable devices for use at the face, and "refuge rooms" for use outby. The refuge chamber located closest to the face could serve as a staging point wherein the miners would communicate with the responsible person, discuss their escape plan, review maps, don their SCSRs and begin their egress, heading towards the first "safe haven," or "refuge station." In the event that egress was impossible, the refuge station(s) would provide a better alternative than a barricade erected by miners during and emergency situation. Consensus on a possible third component of an escape/refuge system is developing, and that is an escape vehicle. This component will not be addressed in this contract.

The "refuge station," or "safe haven," is simple in concept. These rooms could be created at strategic locations either by walling-off a crosscut, a room mined into the rib, or a manufactured chamber. The structural characteristics of the walls or bulkheads may change depending on where the room is located within the mine, and in some cases, it may be desirable to have "bulkheads" which could be easily re-used in new locations. These safe havens should be located at some regular distance determined by the likely mine specific escape conditions outby the mouth of a panel. They could be equipped with water, first aid, and a cache of SCSRs, among other supplies. Where practical, these safe havens could be connected to the surface with a borehole, which would provide ready

communications, power, and compressed air among other services. Although these safe havens would be viewed as way stations as miners made their escape, if miners became trapped, the safe havens would provide a location where mineworkers could survive an extended period. The known location of these rooms would also facilitate the accurate drilling of a large borehole for a rescue capsule. There are of course many technical questions to be addressed related to the design, outfitting, location and use of these havens.

Regardless, of the specific refuge concept, a need exists to evaluate refuge concepts in the context of the documented mine emergencies experienced between 1970 and 2006 in US coal mines. Such an evaluation is really a prerequisite to the establishment of design and performance criteria for chambers or refuge rooms. For the purposes of this Request for Proposals, refuge concepts or “chambers” are grouped into two classes: portable, i.e. those which are intended to be moved with some regularity as mining advances; and fixed, i.e. those which are so located that moves would be infrequent or rare. Bidders may redefine or further classify these into addition sub-categories in their proposal, if needed, to clarify their proposed approach.

### **III. OBJECTIVE**

A NIOSH goal is to facilitate the mining industry’s rapid implementation of viable refuge concepts by addressing technical barriers or knowledge gaps that are hindering the rapid diffusion of refuge technologies throughout the underground coal industry. The overarching objective of this work is to solve engineering problems or develop engineering guidelines associated with the location, construction and general application of various refuge alternatives. This RFP will be used to develop recommended practices documents and other practical guidelines for mines, and to recommend potential criteria for a possible approval and certification process for refuge chambers.

The specific objectives of the work are:

- Evaluate the impact, i.e. lives saved, that refuge stations could have made in the outcome of coal mine explosions, fire emergencies, and mine inundations that have occurred since 1970.
- Establish common design criteria for fixed and portable mine refuge stations.
- Develop a selection guide for type, size and location of refuge stations.
- Develop type-specific performance specifications.
- Develop a practicable mine refuge station bulkhead design.
- Develop a user’s guide to select, purchase, or constructing and install each refuge station for US coal mine operators.

### **IV. DETAILED REQUIREMENTS**

The work to be performed in this contract has been organized into three phases; and the phases and the duration of each phase is listed below.

Phase I	DEVELOPMENT OF RECOMMENDED REFUGE STATION CRITERIA
Phase II	DESIGN, SELECTION AND LOCATION CRITERIA
Phase III	USERS GUIDANCE DOCUMENT

#### **Phase I Development of recommended Refuge Chamber criteria**

A. The Contractor shall evaluate the impact refuge stations could have made in the outcome of coal mine explosions, fire emergencies, and inundations that occurred since 1970. This evaluation shall be based on an analysis using event tree shown as Figure 1, and shall:

- a. quantify the number of miners reporting to each node on the event tree diagram.

- b. quantify the number of miners who would have benefited from the availability of refuge stations; those who would have been negatively impacted with the availability of refuge stations and those miners for whom refuge would not have altered the outcome.
- c. quantify (estimate) the time likely to be required to rescue miners who sought refuge taking into account experienced response times during rescue mode.
- d. determine whether the refuge stations would have benefited from thermal resistance and if so at what levels.
- e. estimate possible ranges of over pressure from secondary explosions and inundations at potential refuge station locations which would have assisted the miner in survival. Time of consideration is the time required to rescue from refuge.

This retrospective analysis of how refuge concepts might have changed the outcome of historical mine disasters should provide significant insights into the proposed use of refuge chambers to prevent future loss of life following fires, explosions, or inundations. As such, the findings from this Task A will form an important basis for subsequent work under this contract.

Bidders are encouraged to suggest an alternative formulation of the event tree shown as Figure 1, if appropriate.

- B. The contractor shall provide a detailed list of all common design parameters, which will be required for life support functions of the two types of refuge stations (portable and fixed). The design requirements will consider changes required for varied refuge duration.

The design criteria shall include but not be limited to the following life support elements:

- a. Atmospheric life support
  - b. Communications
  - c. Nutrition
  - d. Sanitation
  - e. Psychological
    - i. Space
    - ii. Ergonomics
    - iii. Entertainment
    - iv. Others
- C. Contractor will develop a Phase I report outlining the design criteria for underground coal mine refuge stations. This report shall include the supporting documentation. Contractor shall provide the Phase I report no later than three months following the award of the contract. A project review meeting at PRL will be held following the delivery of the Phase I report. NIOSH will review the report, and provide approval to begin Phase II within 3.5 months after award of contract.

## **Phase II Design, selection and location criteria**

Given the variety of possible scenarios that could occur in a disaster, consideration should include the feasibility of a staged escape strategy. Such a strategy could include multiple refuge stations to support the miners' needs during the escape process. Refuge stations could provide safe places, in which miners could rest, replenish oxygen, obtain updated information on mine conditions, and decide on the next course of action etc. This approach could include one or more types of refuge station, positioned at appropriate locations, with the capability of temporary or long-term refuge.

One of the critical pieces of a staged escape strategy is the location and type of refuge stations.

- A. Contractor shall develop a decision tree for use by the mine operator allowing for selection and optimum location for each type (portable, inflatable, fixed) of station as a part of an overall escape scenario. Location would depend on a number of variables, including but not limited to:
  - Mining height Effective locations with respect to active working sections
  - Appropriate travel distances, routes and times to next outby refuge station and/or surface

- Pressure, temperature and duration criteria developed in Phase I.
- B. Contractor shall develop temperature and pressure performance specifications for each refuge station type, and shall also develop a recommended testing, certification and maintenance criteria for each station type referencing appropriate standards, where available.
- C. Contractor shall provide a proven design, meeting the previously determined criteria for a practicable, universally applicable, mine constructible refuge station bulkhead. This design shall be provided to meet a variety of opening sizes in variable rock types and mine conditions. Included shall be a materials list and construction instructions for use in universal application.
- D. Contractor shall develop cost estimates for the refuge alternatives studied throughout Phases I and II.
- E. Contractor shall provide a draft phase II report for NIOSH review within 8.5 months from the time of contract award. The report shall include the decision tree developed and the summary of the findings for tasks B and C. The Contractor shall attend a review meeting at PRL within 9 months of contract award to present and discuss the findings of the Phase II report. NIOSH shall authorize the Contractor to finalize the Phase I and Phase II reports within 9.5 months following award of contract. The Contractor shall provide final Phase I and Phase II reports within 10 months following award of contract.

### **Phase III Users Guidance Document**

The focus of Phase III is to translate the technical outputs from Phases I and II into one or more “guidance” or “suggested practices” documents. The goal is to develop plain-language documents to assist underground coal mine operators in providing sound refuge options for mineworkers. The document(s) will provide mine operators with the ability to make informed decisions regarding location, type, size, construction, and outfitting of refuge stations in their mines. The document will also provide mine operators with an example of a bulkhead design which can be erected by mine personnel to establish refuge stations in crosscuts or dead end cuts.

The following tasks will be required to be completed to meet the objectives of Phase III.

- A. The Contractor shall develop a detailed plan to address the Phase III tasks and shall present this plan at a Phase III “kickoff” meeting. NIOSH will schedule the Phase III kick off meeting at its facility in Bruceton, PA within 11.5 months of contract award.
- B. The Contractor shall develop a decision tree style tool to aide in the determination of refuge station type, location and size. Detailed instructions in the use of the tool, including examples shall be developed. The mine conditions of the example will be provided by NIOSH at the kickoff meeting.
- C. The Contractor shall develop a matrix for determining life support supplies and infrastructure required for a refuge station based on size, occupant load and anticipated length of stay. The matrix shall include but not be limited to:
  - a. Air Supply:
    - i. Personal oxygen supplies (SCSR’s)
    - ii. Borehole to surface (size and design)
    - iii. Compressed air from surface (line sizing and protection)
    - iv. Compressed gas stored in the station
    - v. Air purifying systems and associated power requirements
    - vi. Other available technologies for Oxygen supply
  - b. Air Quality Control:
    - i. Gas monitoring equipment and associated power requirements
    - ii. Carbon Dioxide removal and associated power requirements for all available technologies
    - iii. Carbon Monoxide removal and associated power requirements for all available technologies
    - iv. Temperature and Humidity control and associate power requirements
  - c. Other Life Support supplies and systems:
    - i. Potable water supply
    - ii. Gas monitoring outside the station
    - iii. Air lock size and purge requirements
    - iv. Materials to repair station seals and systems

- D. The Contractor shall develop a matrix for determining general supplies and infrastructure required for a refuge station based on size, occupant load and anticipated duration. The matrix shall include but not be limited to:
  - a. Food supplies, both quantity and type.
  - b. Sanitary facilities and supplies
  - c. First Aid equipment and supplies including body pouches
  - d. Lighting requirements and associated power requirements
  - e. Communications to surface and associated power requirements
  - f. Sleeping arrangements
  - g. Entertainment, exercise & psychological needs
  - h. Waste disposal/management
- E. The Contractor shall develop a matrix for use of the Universal Refuge Bulkhead in a range of mine opening geometries with appropriate construction instructions and materials lists. An example of the matrix use, associated design and construction drawings and materials list shall be included. The mine opening size for the example will be provided by NIOSH at the kickoff meeting.
- F. The Contractor shall develop guidelines for the inspection, testing and maintenance of the universal refuge bulkhead including a sample inspection checklist.
- G. The Contractor shall deliver a draft guidance document to NIOSH within 15.5 months of contract award. The document shall include but not be limited to the following components:
  - a. The type, size and location decision tree tools, developed in Item B above, and supporting documentation for use of the tools, including an example, in plain language.
  - b. The life support supply and systems matrix, developed in Item C above, and supporting documentation for use of the matrix, including an example, in plain language.
  - c. The general supply and systems matrix, developed in Item D above, and supporting documentation for use of the matrix, including an example, in plain language.
  - d. The Universal Refuge Bulkhead design matrix, developed in Item E above, and supporting documentation for use of the matrix, including an example design, in plain language and with construction drawings.
  - e. Guidelines for inspection, testing and maintenance of the Universal Refuge Bulkhead, developed in Item E above, including an example inspection and testing checklist in plain language.
- H. The Contractor shall provide the final guidance document to NIOSH within 19 months from date of contract award.
  - a. The Contractor shall develop a proposed format for the guidance document(s), and submit it to NIOSH for approval, within three months after the start of Phase III. NIOSH will review and approve the proposed format within four months after the start of the Phase III.
  - b. The contract will develop the draft guidance documents and present them to NIOSH at meeting in at NIOSH's Bruceton, PA facility. This shall occur no later than 16.5 months after the start of the contract.
  - c. NIOSH will review and provide comments no later than 17.5 months after the start of the contract.