Refuge Chamber Technologies for & Applications

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The world's leading manufacturer of emergency life-saving refuge
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The world’s leading manufacturer of emergency safe-refuge systems.

Emergency refuge forms an integral part of an underground mine, tunnel or chemical operation’s wider Emergency Response Plan (ERP).

Fires, explosions, rock-falls, flooding and the release of smoke and other forms of toxic gas are the types of industrial incidents that occur all too frequently.

In these types of emergencies, when evacuation is no-longer safe or practical, emergency refuge is designed to provide a safe and secure ‘go-to’ area for personnel to gather and await extraction.

The refuge must be capable of supporting life internally for sustained periods – operating in a fully-functioning stand-alone mode, independent of external services (air or power).

MineARC refuges have been successfully used around the world in multiple mine and tunnelling emergencies to save lives.
Turkey in bid to reduce huge toll of workplace deaths

ANKARA - Agence France-Presse

The latest disaster came in October when 18 miners were trapped in a mine in the Central Anatolian province of Karaman's Ermenek district, after water flooded into their shaft from a neighboring disused mine. AA Photo

Turkey has launched a new drive to improve its appalling workplace safety standards that leave hundreds dead every year, two weeks after its latest deadly mining accident.

Prime Minister Ahmet Davutoğlu told reporters on Nov. 12 that the centerpiece of the new reforms would be a carrot-and-stick approach, whereby employers would be financially rewarded for a good safety record and punished for accidents.

'A change of mentality is indispensable'

Toll rises to 12 as flooded mines trap miners
Risks Associated with Entrapment

1. **Compressed Air Failure** • it is common for Victaulic couplings to fail during fires. Once this occurs, it is very likely too that smoke and carbon monoxide will be introduced into the chamber through that line – or perhaps that a vacuum will be formed in the chamber, which may draw those contaminants through any leaks in the system. Either way, oxygen is no longer being replenished, positive pressure will be lost and toxic gases will no longer be flushed from the refuge.

   **The Risk:** Oxygen levels must be maintained between 18.5% and 23%. Physical ability is diminished at levels between 11-18%. At 8-11% fainting will occur without warning. Risk of brain damage and death during extended exposure at levels below 11%.

2. **Heat** • Sources of heat within a portable refuge include ambient heat, electrical equipment, lights, exothermic chemical reactions from CO₂ or CO removal chemicals and from the occupants themselves.
   - Did you know that each occupant produces 400btu (120 watts) of heat per hour? 20 persons = 8,000btu. Add to this humidity delivered through perspiration, breathing and compressed air - and the environment quickly becomes deadly.
   - A maximum apparent temperature (combination of ambient temperature and humidity) of 95°F (35°C) is established by MSHA, and generally accepted as a good rule of thumb.

   **The Risk:** As occupants are no longer able dissipate body heat, at temperatures above 95°F (35°C), a number of heat related illnesses and eventually death can occur.
3. **Carbon Dioxide (CO$_2$)** • Humans exhale 30-50 litres of CO$_2$ per hour and as CO$_2$ levels rise around them, breathing will also increase causing them to emit CO$_2$ at an even higher rate, creating a “snow ball effect” to CO$_2$ production. If CO$_2$ is not removed from the refuge interior, gas levels will rise past the generally accepted level of 1%.

   **The Risk:** CO$_2$ levels above 0.5% cause lung ventilation to increase by 5%. Symptoms of simple asphyxia occur above 2% concentration. At 5%, prolonged exposure may lead to unconsciousness and death. At 10%, unconsciousness and death generally occur in less than 60 seconds.

4. **Carbon Monoxide (CO)** • Carbon monoxide is introduced through failed air lines and also emitted by smokers within a chamber. How will you mitigate CO buildup once it has occurred, and the refuge is no longer being purged with compressed air?
   • Did you know that smokers store CO in their blood stream in the form of carboxyhemoglobin at 4-20% (versus 0.4 to 0.7% in non-smokers)? And that they endogenously produce CO in oxygenated environments?

   **The Risk:** Exposure at 35ppm causes headache and dizziness within 6-8 hours. At 100ppm volume slight headache will occur in 2-3 hours. At 400ppm, headache within 1-2 hours. Dizziness, nausea and convulsions within 45 minutes at 800ppm. At 2,000ppm, rapid onset of headache and dizziness. At 2,000ppm, death is inevitable within 2 hours.
Minimum Refuge Chamber Requirements

As a standard Code of Practice, MineARC Systems suggests consideration of the following basic systems as a minimum to mitigate risks:

- **External Compressed Air Supply** • Primary source of breathing air / life support used to replenish oxygen and flush toxic gases from within the refuge chamber. At a minimum, the air supply should be filtered and regulated to .09m³ (3 CFM) per occupant, with ability to isolate the system during emergencies (i.e., during air line failure).

- **Secondary Oxygen Supply** • Medical grade oxygen cache, sized to provide O₂ at a rate of minimum 0.5L per occupant, per minute, for engineered duration of refuge. A third source of breathable air is strongly recommended, in the form of a sodium chlorate O₂ (oxygen) candle.

- **Carbon Dioxide Removal** • The CO₂ removal system must be capable of removing no less than 24L CO₂ per person, per hour, for the engineered duration of the refuge, in order to maintain levels at less than 1%.

- **Carbon Monoxide Removal** • The CO removal system must be capable of maintaining levels below the maximum exposure limit of 25ppm.

- **Cooling & Dehumidifying** • A cooling system with nominal capacity of 130 watts per person is recommended to mitigate heat loads of occupants and additional heat sources, with the ability to dehumidify the chamber interior.

- **Atmospheric Monitoring** • Ability to monitor levels of oxygen, carbon dioxide and carbon monoxide within the chamber is essential. It is also recommended that the system be capable of safely monitoring gases outside the chamber during emergency.
Legislation or Industry Guidelines are Key
Products by Industry – Hard Rock Mining (HRM)

- **Standard HRM**
  Series IV

- **HRM-ELVP**
  (Extra Low Voltage Portable)

- **HRM PERM**
  Permanent Refuge Chambers
Hard Rock Mining

Globally recognised as world's best practice.

Three Operating Configurations:
Standby, Externally Supported, Standalone.
- 36 Hours standalone with no external services.
- Max distance: no miner more than 750m from refuge
- Capacity mine personnel plus visitors.
- 3 sources of breathable air, air-conditioning, communications, UPS battery back-up, air scrubbing system.

- Mines Inspectorate action.
- Mining personnel expect refuge. In mining Culture
- Australian companies have adopted in OS operations.
- Ex-Pats have requested as employment criteria.
Products by Industry - Hard Rock Mining (HRM Series IV)

Standard Portable HRM Series IV

- 8, 12, 16, 20, 26, 30 Person Capacity
# Portable Refuge Components

## What's On The Outside:

### Airlock or Single Door Entry

Advantages:
- Provides immediate, 100% sealing from smoke and toxins.
- Airlock purged by compressed mine air connection or by backup reserve bank of compressed air cylinders.
- Incorporates poly carbon viewing portal(s).
- Can be closed and reopened multiple times without compromising seal - eliminating need for traditional sealing materials and allowing “late comers” to enter without issue.

### Pressure Relief Valves

Advantage:
- Provide overpressure protection inside chamber, while keeping contaminants out. Minimum operating pressure: .03psi

### Steel Structure

- Steel structure provides optimum safety from smoke, fire and toxins.
- Fully welded structure with 1/4” (6.4mm) steel plate pressed sections, 4” x 2” (100 x 50mm) channel support wraps, 6” x 2” (150 x 50mm) channel skid base
- Forklift slots and lifting / towing eyes.
- Painted internally with non toxic finish and externally with polyurethane enamel for durability.

## Miscellaneous:

- Smoke piercing red and green LED warning strobes
- Siren (112dB)
- 20lb. ABC fire extinguisher.
Portable Refuge Components

What’s On The Outside:

**Mine Air Supply**
- 3-stage filter assembly
- Auto drains for moisture removal
- One-way check valve (see inset)
- Internally mounted regulator, auto-muffler and emergency shut off valve. (see inset)

**Split Air Conditioning System**
- Sized to manage heat load from occupants and additional sources.
- Dehumidifies interior of refuge.
- Maintains safe apparent temperature.
- Operates on mains electrical power AND battery back-up.

**Battery Backup**
- 100% backup power supply in the event of mains power failure for engineered duration of refuge (ie: 36 hours).
- Provides uninterrupted, full operation of air conditioning, gas monitoring, CO2/CO scrubbing system, emergency communications, lighting and siren.

**Rear**

- Optional step-down transformer mounted and pre-wired for 220/240V, single phase power supplies.

**Inset**: Exterior mine air filter components.
Portable Refuge Components

What's On The Inside:

Oxygen Supply
• Medical grade oxygen cache
• Sized to provide safe levels of breathing air for occupants, for engineered duration of refuge.
• Includes medical grade O₂ regulator for proper metering.
• Back up oxygen supply (oxygen candle) also included.

Air Conditioning
• Cools and dehumidifies refuge interior (with heat option). See exterior view for full description.

Digital Gas Monitoring
• Monitors oxygen, carbon dioxide and carbon monoxide both inside chamber and out.
• Powered by mains electrical supply and/or UPS battery backup.

Scrubbing / Controller System
• Maintains CO2 and CO at acceptable levels.
• Simple 1-touch operation.
• Powered by main power and battery back-up.
• Provides 24/7 battery monitoring
• 12-hour system self-test diagnostics
• Diagnostics data logging.
• System sleep mode protection
• Remote systems monitoring.
• Ability to add remote camera monitoring.

Standard Interior Includes:
• Fluorescent Lighting
• Raised non-slip flooring.
• Easy-to-follow Operating Instructions.
• Emergency food, water, chemical toilet and psychology of entrapment kit.
• Pre-wired antenna and sealable communications penetrations.

Seating
• Marine grade cushioned seating with backrest and storage beneath.

Interior

www.minearc.com
HRM-ELVP
(Extra Low Voltage Portable)
- Mine Inspectors recognized an issue.
- Ideal for Development heading
- Double battery bank
- 4, 6, 8 Person Capacity
- Built to same standard as HRM
- Bogger Frame or IT Hitch options
- Blast Resistant Options
Products by Industry – Hard Rock Mining (HRM PERM)

HRM-PERM
(Permanent Refuge Chambers)
(Underground safety zones, rest, break (crib) areas)
• Up to 500+ Person Capacity
• Air lock and Vestibules
• Using existing working to create room
• Multiple units and drone scrubbers

Engineered for accurate life support
• Room size  Floor and Volume
• Internal Obstacles
• Rock Temperature
• Entrapment period
• Number of persons
Permanent Refuge Installation Example

Shown with optional equipment from MineARC Systems including airlock, battery backup, scrubber and air conditioner on bulkhead wall:

- **Exterior**
  - Bulkhead wall
  - Battery backup (UPS) with A/C condenser atop.

- **Interior**
  - Airlock attached via bulkhead door frame assembly.
  - Scrubber with air conditioning system and compressed oxygen cylinders.
  - Optional Sealing Door
Products by Industry – Coal Mining

The CoalSAFE
Coal Secure Area For Evacuation
• 8, 12, 16, 20, 24 Standard Capacity
• Intrinsically Safe (non-electrically powered)
• Liquid CO2
• 96 hours Stand-Alone Duration
• CO & CO₂ scrubbing
• Air-Conditioning
• 3 x Air Supply
• Real time Gas Monitoring
• Air lock Option
• The MARCis
Products by Industry – Coal Mining

The CoalSAFE

Standard

Modular

High Seam

Low Seam
Legislation is key

Coal Mining
USA MSHA (Mines Safety Health Administration)
‘Final Rule’
Globally recognised as world’s best practice in coal mining.

- 96 hours standalone
- Designed to withstand 15 PSI over pressure
- Internal apparent temperature to not exceed 95°F
- The breathable air sustains each person for 96 hours
- Average internal carbon dioxide concentration to ≤ 1%
- Shall provide refuge to accommodate all persons underground
- Located within 1,000 ft from working areas
- No more than 30 minutes walking distance in out-bys
- Over-ruled West Virginian regulation (considered weak)
- Adopted and modified by China as their standard
Products by Industry - Tunnelling

- Used in road, rail, drainage, Tunnelling.
- TBM (Tunnel Boring Machine) gantry mounted.
- Drill & Blast model.
- Cross-passage model.
- Custom design based on varied regulations.
- Varied entrapment durations including ITA compliant.
Thank You.
PenaMaden represents MineARC Systems in Turkey