

## **Safety: Guidelines on Refuge Chambers**

### **1. Purpose & Scope**

This standard is developed to maintain the Refuge Chambers in healthy condition always. Refuge Chamber is a critical emergency equipment and must be kept all time readily available which can serve the purpose during an emergency. This standard will help us to prepare the site for refuge chamber in underground mine before shifting the chamber and after shifting, it will also help us to monitor the refuge chamber periodically.

This standard is applies to all Underground Mines of Hindustan Zinc Limited

### **2. Refuge Chamber**

Refuge Chambers (also known as Refuge Stations) are sealed, secure, accessible rooms that preserve life through the monitoring and management of essential gas levels for underground mining. CO<sub>2</sub> and CO Scrubber technology monitors and eliminates toxic fumes for an extended period to allow the safe extraction of personnel from danger. Refuge chambers are commonly available as permanent and semi-permanent chambers, providing a safe 'go-to' area for personnel during an emergency.

#### **Purpose of Refuge Chamber**

Protection from Irrespirable Atmosphere i.e. -

- Fire
- Explosion
- Loss of Ventilation
- Inundation
- Gas Out burst
- Dust

### **3. Design**

- i) **Robust:** Can be placed anywhere in mine and shifted to any place when required.
- ii) **Seals:** provide safety between outer and inner environment. It should not be damaged during transportation. It should be checked whenever refuge chamber is shifted to a new place.
- iii) **Secondary Egress:** to provide another access if main entrance has been blocked. It should be as far as possible from the main entrance and opening inwards.
- iv) **Pressure Equalization:** to maintain the chamber's internal pressure.
- v) **Windows:** To provide visible communication between inside and outside and also help to lessen the feeling of being enclosed. Windows should be strong enough that it should not break in case of any explosion or fire in the mine.
- vi) **Capacity:** capacity should be such that it provides the facility to the geologist, surveyor, supervisor and other service technicians. For this purpose there are two methods:
  - Provide a refuge chamber capacity of more than double that determined from the size of locally operating crews or;

- Should be equal to the maximum no of persons available in that area in any shift. It should be calculated by taking a month time period data

#### 4. Type of Refuge Chamber

There are two types of Refuge Chambers.

1. Permanent Refuge Chamber
2. Portable Refuge Chamber

**Permanent Refuge Chamber** – Permanent Refuge Chamber is fixed type of chamber which can not be moved as and when required. These are large capacity chambers and can be developed near to the active working areas depending upon the size of manpower deployed in the areas.

For smaller mines, Portable refuges can be implemented and relocated alongside the mine's progress. However, with large scale mines, it can be beneficial to have portable refuge chambers complemented by permanent refuge chambers.

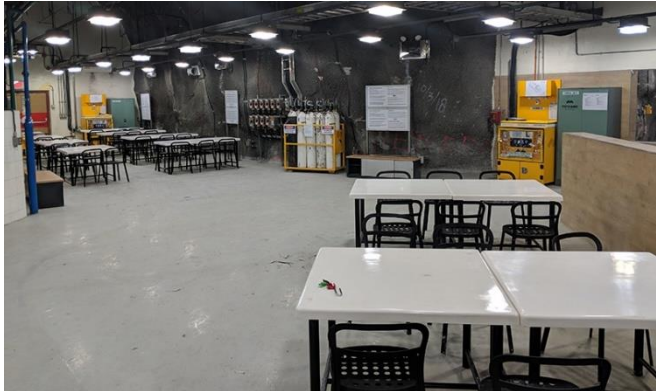
Refuge chambers should be located within a reasonable distance from an active worksite. Some larger sites may choose to incorporate a permanent refuge chamber into their ERP; based on the following:

- There are a large **number of personnel** underground at any one time, where the regular movement of personnel underground remains within certain areas.
- Repurposing crib rooms (lunch rooms) into **multi-functional** areas to be used as an emergency refuge station in the occurrence of a hazardous event.
- New personnel underground may not be familiar with the location of or travel routes to all refuge chambers on their first day; there is a higher likelihood they know the crib room location.
- Excavation costs are low.

Incorporating fixed refuge chambers possess several non-traditional challenges that have to be addressed, specifically: mass ingress, multi-purpose spaces and hygiene.



200 Persons Permanent Refuge Chamber developed at **Freeport McMoran**, Indonesian Mine



**Crib Room (Lunch Room)** developed as Permanent Refuge Chamber at **DMLZ Mine, Indonesia**

**Portable Refuge Chamber** – The Portable Refuge Chamber can be taken virtually anywhere, anytime; providing personnel with an emergency safe-refuge alternative in every part of the underground mine.

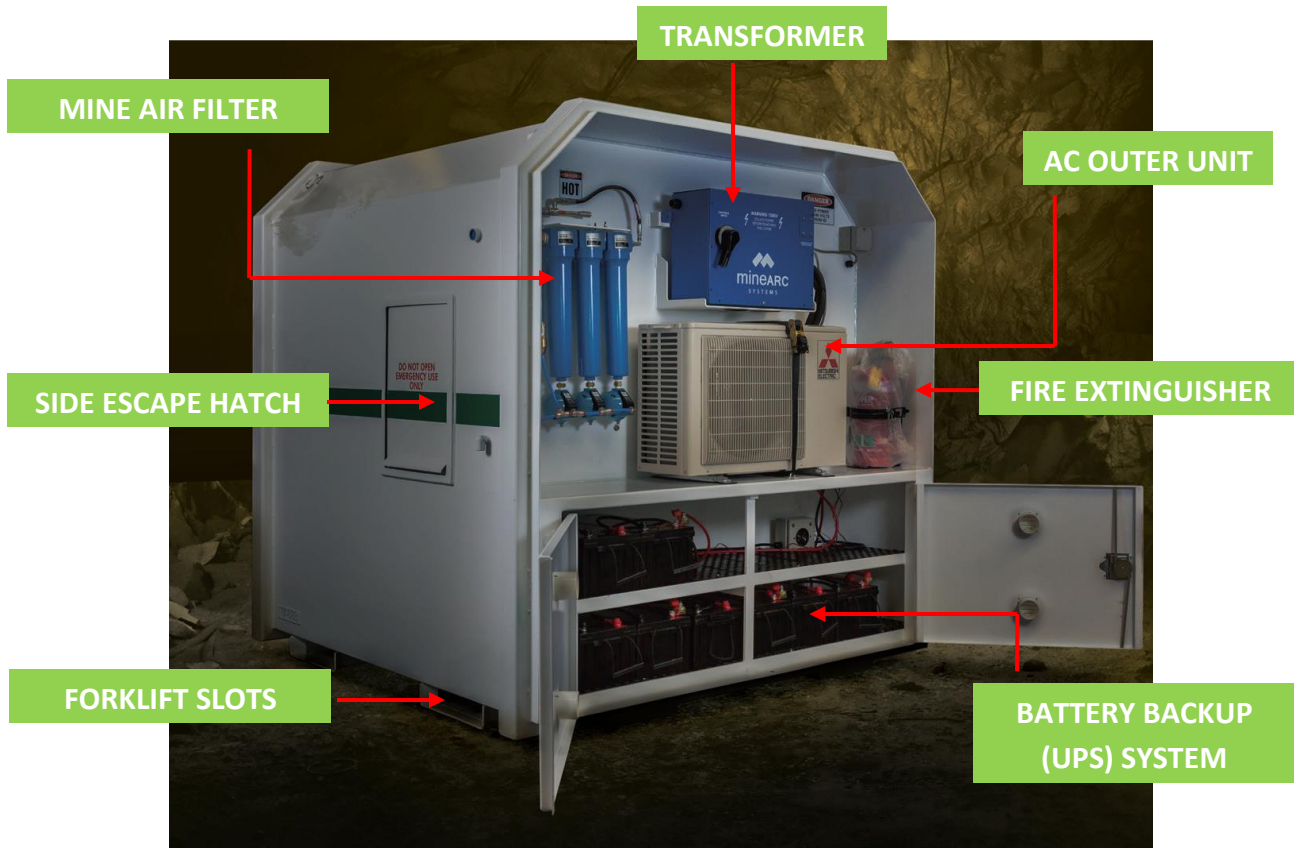
Personnel situated directly at the working face (e.g. drill operators) run the risk of being trapped behind a fire or other hazard further up the decline. The Compact Design refuge station has been engineered specifically for this type of scenario – providing a place of safe-refuge even in the most remote, inaccessible parts of the mine. Various range of portable refuge chambers are available in market in terms of persons capacity ie. 4 persons, 6 persons, 8 persons, 10 persons, 12 persons and more.



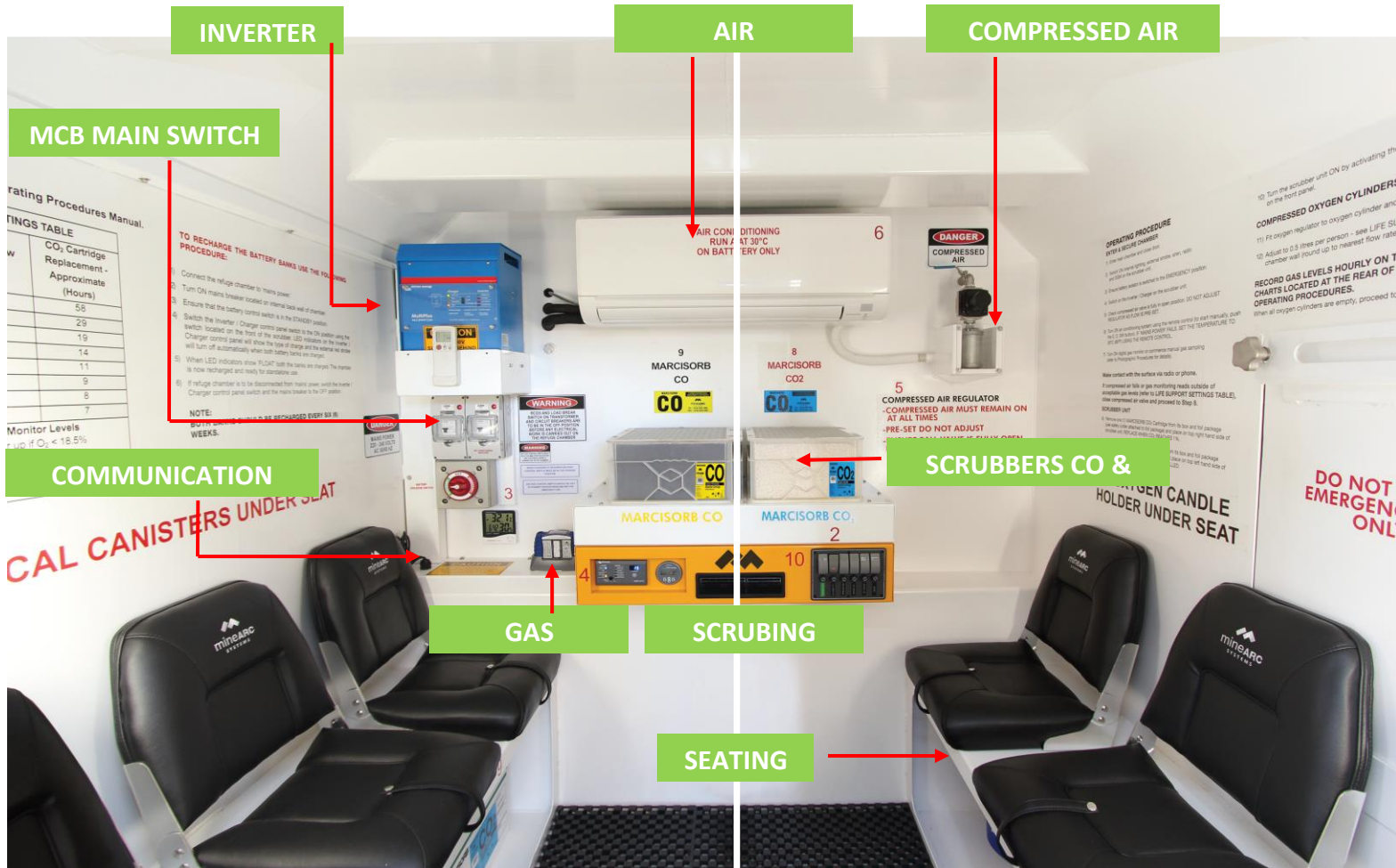
## 5. Components of Refuge Chamber Exterior Front



## Exterior Rear



**Interior**



## 6. Criteria for Refuge Chamber

- a. **Maximum Safe Distance**: Maximum and minimum distance from the working area should be calculated on the basis of SCBA used in mines and should take only 50% of the nominal duration during calculating these distances. If we assume the average walking speed in a mine is 50m/min and the working of SCBA is 30 min then max distance should be around **800m** from the active working area
- b. **Capacity**: Built to accommodate the number of personnel during each shift within walking distance, as well as accommodate additional visitors and contractors in the immediate area.
- c. **Duration**: In the event, the external air supply is severed an independent supply of oxygen is required for a minimum of **36 hours** at the nominated capacity.
- d. **Power Supply**: Under normal conditions, power is provided from the primary electrical system. If this fails a backup supply, e.g. batteries are required.
- e. **Communications**: Secure communications to a control room or other staffed position are essential; options can include the use of leaky feeder systems, radio, and IP phone.
- f. **Positive Pressure**: Overpressure, relative to the external environment prevents the ingress of toxic gases and air contaminants.
- g. **Sealed Environment**: Refuge chambers are closed environments to prevent the entry of pollutants such as smoke and hazardous gases from entering the enclosed space.
- h. **Oxygen Supply**: A supply of oxygen, from mine air or oxygen cylinders, needs to be continuously monitored and controlled to levels no less than **19.5%** and no greater than **22%** by volume of oxygen.
- i. **Air Scrubbing**: Refuge chamber scrubbing systems use chemical reactions to remove contaminants, carbon dioxide and carbon monoxide, from the air by changing the composition of gases exhaled by inhabitants.
- j. **Gas Monitoring Equipment**: Electronic or manual equipment to determine the breathability of air within the refuge chamber must be supplied.
- k. **Environmental Control**: Temperature and humidity can effectively be controlled through refrigerated air conditioning. Equipment should be robust and of sufficient capacity to handle underground conditions
- l. **Hygiene**: Toilet facilities are essential
- m. **Potable Water**: Safe, drinkable water is required for the minimum duration; recommended at least **4.5 litres** of water per person.
- n. **First Aid Box**: Shall be kept inside the refuge Chamber
- o. **Fire Extinguisher**: Shall be kept nearby the Refuge Chamber as well inside the chamber.

## 7. Location & Site Preparation

- i) Location of refuge chamber should be as secure from hazards as possible but it should be easily accessible to people in need of its protection. Should not be near any hazards i.e. **explosive magazine, fuel storage, substations, mono pumps or vehicle parking bays**. Location should not possess any hazards of rock fall, flooding, fire, explosion, or damage from mine vehicle. Risk Assessment should be done before deciding the location of refuge chamber.
- ii) Air: **Dedicated fresh air supply** through compresses air if available.
- iii) Location of refuge chamber shall be well illuminated

- iv) Distance from working safe area: maximum and minimum distance from the working area should be calculated on the basis of SCBA used in mines and should take only 50% of the nominal duration during calculating these distances. If we assume the average walking speed in a mine is 50m/min and the working of SCBA is 30 min then max distance should be around 800m from the active working area.
- v) Ensure Easy Access and adequate protection of the chamber. Housekeeping of the site where refuge chamber has been placed. **No vehicle or any obstruction** should be placed in the access of the chamber at any time.
- vi) Should not be placed too **deep near the working face** which will lead to hazard of accumulating water in case of pump failure during emergency.
- vii) **Ground condition** should be checked before placing the refuge chamber in that location. The location should be supported as **permanent support** and should consider it for long term excavation.
- viii) **Identification:** chamber should be fitted with a **high intensity light (Preferably Green Light)** so that it can be identified even in low visibility conditions.



Concrete wall shall be avoided at entrance

*20 Seater Refuge Chamber installed at Kayad Mine, HZL*



*6 seater RC at RA Mine, HZL*

## 8. Commissioning of Refuge Chamber

Commissioning and Tests: following tests should be done when refuge chamber has been installed first time in underground or change its location:

- Differential Atmospheric test
- Positive pressure test
- Testing of electrical power in stand-by mode and stand-alone mode
- Testing of chamber air

## 9. Shifting, Relocation of Refuge Chamber

Whenever refuge chamber is being shifting or relocating, the **Relocation Form** has to be filled by concerned persons and must be submitted to Safety Department.



## 10. Inspection and Maintenance

Chamber should be checked regularly and basic tests conducted to ensure full functionality. A check list (Annexure – 1) should be made to check those things weekly. These checks are to be conducted by the site safety department.

All the refuge chambers shall be covered under **Annual Maintenance Contract** and sufficient inventory of required spare parts shall be maintained at site to ensure proper functioning of refuge chamber.

- **Inspection by BP Safety Officer** – Refuge Chamber shall be checked as per checklist provided inside the chamber on daily basis by concerned business partner safety officer/ area in-charge.
- **Inspection & Maintenance by AMC personnel/ Technicians** – refuge chamber shall be checked and inspected thoroughly once in a week by AMC technicians and report shall be submitted to HZL safety department. These inspections are to identify any missing items within the chamber and to visually examine the refuge chamber for any structural damage. It is necessary to maintain a documented record to ensure that any necessary maintenance is identified and completed promptly.

### Maintenance Procedure/Guidelines:

#### 1. Refuge Chamber External

- 1.1. Inspect chamber for any cracks and or corrosion
- 1.2. Check towing and lifting points for damage
- 1.3. Check rubber bollards are in place
- 1.4. Ensure that signage and reflective tape are not damaged
- 1.5. Check operation of the doors
  - 1.5.1. Check door seals for damage
  - 1.5.2. Check hinges for damage and in working order
  - 1.5.3. Check that doors open and lock correctly
- 1.6. Check external fire extinguisher and bracket for damage. Ensure fire extinguisher is correctly tagged and in date.

#### 2. Refuge Chamber Internal

- 2.1. Ensure refuge chamber is clean and remove any trash (**Do not clean refuge chamber with water**)
- 2.2. Ensure operating procedures are located on top of scrubber frame
- 2.3. Check refuge chamber internally for any damage
- 2.4. Check seats and seat backs for any damage
- 2.5. Check floor mating, cabinet locks, signages
- 2.6. Check escape hatch handles are tight (Do not open escape hatch)
- 2.7. Check communication systems are operational
- 2.8. Check that First Aid Kit, Water (Min. 150L) are there and in good condition

#### 3. Toilet

- 3.1. Check that toilet is clean and not damaged
- 3.2. Check that secure toilet deodorant liquid container is in the chamber and is at least half full.
- 3.3. Check toilet paper is on toilet roll holder

#### 4. Battery Box

- 4.1. Check battery box doors and hinges for damage. Ensure doors open and close fully.
- 4.2. Check batteries for any damage.

- 4.3. Check batteries for loose terminal connections and retighten, Check battery voltage (13.5V to 14V)
- 4.4. Check battery temperature compensator for damage and make sure it is stuck to top of battery housing
- 4.5. Place terminal grease on terminals
- 4.6. Inspect battery matting for any damage

## 5. Compressed Air System

- 5.1. With Air Isolated
  - 5.1.1. Check filtration pack for damage
  - 5.1.2. Remove filter housing and replace pre-filter, coalescing and odor removal elements
  - 5.1.3. Replace 1" Non-Return Valve
  - 5.1.4. Replace internal silencer
- 5.2. With Compressed Air Operational
  - 5.2.1. Check regulator is set using flow meter (0.3 cfm per rated occupancy of refuge Chamber)
  - 5.2.2. Check air isolation ball valve operation
  - 5.2.3. Check external compressed air connection
  - 5.2.4. Check auto drain system

## 6. Compressed Oxygen Cylinder

- 6.1. Remove oxygen regulator and check for any damages
- 6.2. Check oxygen cylinders are at least four months within expiration date
- 6.3. Check that all cylinders are full by placing regulator on oxygen cylinder and monitoring pressure. Replace cylinders if less than 80% capacity

## 7. Scrubber Unit

- 7.1. Check CO<sub>2</sub> & CO chemical absorbers are intact and container seals not broken. Ensure chemicals are dated within at least four months
- 7.2. Check scrubber frame for any damage
- 7.3. Check moisture removal tray for any damage (Blue tray)
- 7.4. Replace scrubber tray filters mats
- 7.5. Test operation of Refuge Chamber Control System (**push 'TEST' button on Refuge Chamber Control Panel**). During test procedure ensure that both blower fans are working

## 8. Air Conditioning System

- 8.1. Check air conditioning system is operational via remote control
- 8.2. Clean air conditioner internal filter using cloth
- 8.3. Replace remote control batteries
- 8.4. Clean external condenser using air duster (do not use excessive pressure on filter). **DO not clean rear of refuge Chamber with water Hose**

## 11. Training

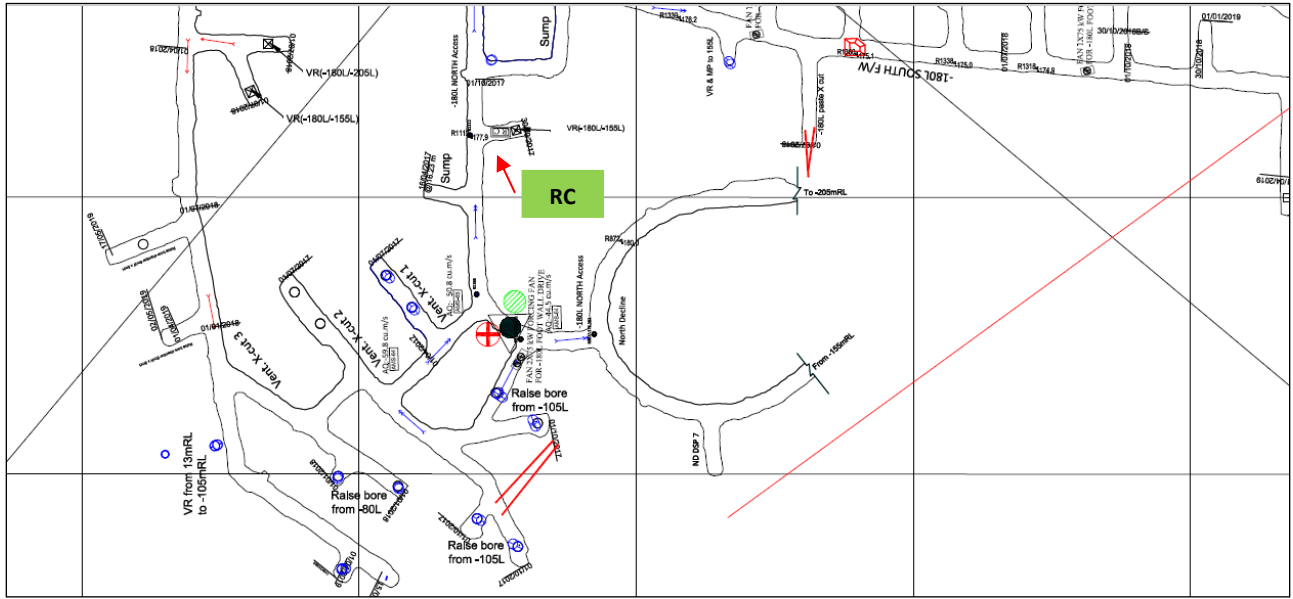
Basic training including induction and use of chamber on site should be provided to each and every person working in underground. Regular training should be provided so that each and every person should be competent enough to operate in during any emergency. Training should be covered following things:

1. Use of communication equipment

2. Procedure for activating life support
3. Use of first aid resources

Mock Rehearsal of emergencies and drills should be done on the regular basis so that inadequacies can be found out.

## 12. Marking Location of Refuge Chamber on Plan



Location of Every Refuge Chamber must be maintained in Level Plan and shall be updated regularly. A copy of updated plan shall also be kept inside the Chamber.

At the entrance of every level, signage showing the location of refuge chamber shall be displayed at regular interval so that in case of an emergency, work persons could easily evacuate the mine workings and safely reached to the Refuge Chambers location.

**Review of Emergency Management Plan** – Whenever any Refuge chamber is shifted or its location changed then it must be updated in Emergency Management Plan also and accordingly, work persons shall be educated.

**Note: A Board showing the locations of all refuge Chamber shall also be displayed at Allocation Area**

## 13. Audit Protocol:

**Monthly** audit shall be carried out as per the identified **FSIPPs** (Fatal & Serious Injury Prevention Plan) and observations shall be recorded in prescribed format to ensure the healthiness of Chambers. It is a responsibility of Mine Manager to ensure all the refuge chambers are working well and always ready to serve an emergency.

## 14. Standard Operating Procedure to Use Refuge Chamber

In case of an emergency mentioned above in the standard, below steps shall be followed to use the Refuge Chamber. We are taking MinaArc make refuge Chamber and its guidelines.

**1**

### STEP – 1 ENTERING INTO REFUGE CHAMBER

Rotate handle clockwise to unlock the door of Refuge Chamber



Secure door by rotating handles clockwise to “lock” position



**2**

### STEP – 2 ACTIVATE LIGHTS, SIREN, GREEN STROBE & RADIO

Turn ON the switches marked LIGHT, SIREN, STROBE, RADIO, and DGM located on the right hand side of the scrubber unit.



**Note:** Leaving the siren and strobe ON in an emergency will help personnel locate the chamber in smoke.

**3**

### STEP – 3 ROTATE BATTERY CONTROL SWITCH TO EMERGENCY

Locate the battery control switch on the back wall. Rotate the switch to the EMERGENCY position. The system is now operating on the emergency battery bank.



**4**

### STEP – 4 SWITCH ON INVERTER / CHARGER

Turn the inverter/charger switch, located on the front of the scrubber to the **ON** position.

**Note:** This will allow the air conditioner to operate. If the battery control switch is activated out of order a low battery alarm may show on the inverter. Switch the inverter off, then on again to reset.



**5**

**STEP – 5 CHECK COMPRESSED AIR (if available)**

Check the compressed air valve is fully in the open position. **DO NOT ADJUST AS FLOW IS PRE-SET.**



Check the vent valve by covering with hand to feel for outward flow (air EXITING the chamber).

**If Compressed Oxygen line is not available, then Use Compressed Oxygen Cylinders kept inside the Refuge Chamber.**

LIFE SUPPORT SETTINGS TABLE		
Number of Persons	Set O <sub>2</sub> Flow Rate At (Liters)	Approximate CO <sub>2</sub> Cartridge Replacement (Hours)
1	0.5	58
2	1	29
3	2	19
4	2	14
5	3	11
6	3	9
7	4	8
8	4	7
<p><b>Acceptable Gas Concentrations</b>                      Adjust O<sub>2</sub> Regulator up if O<sub>2</sub> &lt; 18.5%                      Adjust O<sub>2</sub> Regulator down if O<sub>2</sub> &gt; 23%                      Replace CO<sub>2</sub> Cartridge if CO<sub>2</sub> &gt; 1%                      Start Scrubber Unit if CO &gt; 30ppm</p>		

Adjust Oxygen regulator to **0.5 liters per person** - see **LIFE SUPPORT SETTINGS TABLE** and also on refuge chamber wall (round up to nearest flow rate marked on regulator).



**6**

**STEP – 6 TURN ON AIR CONDITIONER**

Turn **ON** air conditioning system using the remote control located on the side of the inverter.

**Note:** If ‘mains power’ fails, set the temperature to **30°C (86°F)** using the remote control.



**Note:** If remote control is missing start air conditioner manually by pressing the E.O. SW button on the front of the unit.

**7**

**STEP – 7 COMMENCE GAS MONITORING**

Turn ON digital gas monitor to take readings of O<sub>2</sub>, CO<sub>2</sub>, CO & Temperature.



**Make contact with the surface via radio or phone**



**Note:** The DGM will periodically alarm when it detects changes in gas levels. ONLY ALARMS DISPLAYING OUTSIDE ACCEPTABLE LEVELS REQUIRE ACTION.

**If compressed air fails or gas monitoring reads outside of acceptable gas levels (refer to LIFE SUPPORT SETTINGS TABLE), close compressed air valve and proceed to Step 8.**

**START THE SCRUBBING SYSTEM**

**8**

**STEP – 8 INSTALL ABSORBER CO<sub>2</sub> CARTRIDGE**

Remove one (1) CO<sub>2</sub> (carbon dioxide) cartridge from its storage location. Remove cartridge from its packaging



Place the CO<sub>2</sub> cartridge on the right hand side of the scrubber. Cartridge should slot into place with rubber seal on bottom side





REPLACE CARTRIDGE WHEN GAS TESTING SHOWS  $\text{CO}_2 > 1\%$  OR AS INDICATED BY CHART LOCATED ON THE CHAMBER WALL

**9**

### STEP – 9 INSTALL MARCISORB CO CARTRIDGE

Remove the CO (carbon monoxide) cartridge from its storage location. Remove cartridge from its packaging



Place the CO cartridge on the left hand side of the scrubber. Cartridge should slot into place with rubber seal on bottom side



ONCE INSTALLED THE CO CARTRIDGE DOES NOT NEED REPLACING FOR THE DURATION OF ENTRAPMENT

**10**

**STEP – 10 ACTIVATE THE SCRUBBER UNIT**

Turn the scrubber ON by activating the switch marked **SCRUBBER** on the front panel.



**\*\*\*\*\*End of SOP\*\*\*\*\***

**Annexure – 1: Checklist for Refuge Chamber checking – Daily (To be filled by BP Safety Officer/ Area In-charge)**

Refuge Chamber Check List													Month.....																			
DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Electric Power																																
Power charger																																
Lights																																
Air Conditioner																																
Drinking water																																
Oxygen cylinders																																
Oxygen Regulator																																
Cylinder spanner																																
Radio																																
Telephone set																																
Gas Detector																																
DGM Charger																																
User Instruction LCD																																
Scrubber																																
First Aid																																
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## Corporate Guidelines on Refuge Chamber

**Doc No.** : HZL/Guidelines /08/2020  
Revision Number: R-00

Date of First Issue : 01/10/2020  
Last Revision on : 00

**Appendix – 2: Weekly Inspection Format (To be filled by AMC Personnel)**

<b>APPENDIX 2 - WEEKLY INSPECTION</b>			
Checked by: _____		Time _____	
Refuge Chamber SL _____		Date _____	
Function	Description	Initial	Comments
<b>INTERNAL</b>	Deodorizer & Toilet Paper		
	Internal Extinguisher		
	Compressed Air Fitting		
	Air Conditioner Operational		
	Radio/Phone Operational		
	Operating Procedure Present		
	Carbon dioxide Absorbent Present		
	Carbon monoxide Absorbent Present		
	Moisture Removal Sealed		
	Digital Gas Monitor Operational		
	Oxygen Cylinders		
	Oxygen Cylinder Regulators		
	Internal Lighting		
	Water (150 Liters)		
First Aid Kit			
<b>ENSURE REFUGE CHAMBER IS CLEAN INTERNALLY AND ALL RUBBISH IS REMOVED</b>			
<b>EXTERNAL</b>	Chamber Seal/Lock Intact		
	Steel Structure		
	Compressed Air Elements		
	Escape Hatch Seal (DO NOT OPEN)		
	External Fire Extinguisher		
	Red Strobe LED		
	Green Strobe LED		
	Location Alarm		
	Radio Antenna		
	Stretcher		

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	Door Handle & Hinges		
	External Door Seal		
	Air Conditioner Condenser (Dust)		

**Note:**

**PLEASE PRINT ALL COMMENTS LEGIBLY**



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### Annexure – 3: Refuge Chamber Relocation Form

### REFUGE CHAMBER RELOCATION CHECKSHEET

Old Location		New Location	
Date		Shift	
Name – Foreman (s)			
Signature/s			
Section In-charge			
Safety Officer – Business Partners			

#### 1. Relocation site set up

TASK	COMPLETE	SIGN
Workplace inspection & quality		
Area thoroughly check scaled		
If required, area to be bogged clean & level		
Access free of obstructions, mud & puddles		
Availability of electric power source		
Availability of illumination		

#### 2. Before moving the refuge chamber:

TASK	COMPLETE	SIGN
Power disconnected		
Air/Oxygen cylinders secured		
Loose objects secured/stowed		
Lines and cables taped up and secured		
Shift Supervisor notified when ready		

#### 3. Reconnecting the refuge chamber:

TASK	COMPLETE	SIGN
Power connected		
2 way radio working		

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Battery Charging		
Air-conditioning working		
Internal Lights Working		
Siren / Warning lights working		
Oxygen cylinder properly connected and secured		
Signs in place (refuge chamber & Arrows)		
Refuge chamber clean on inside		

### 4. Commissioning the refuge chamber:

TASK	COMPLETE	SIGN
Refuge chamber inspection check list and chamber log completed		

