CONFINED SPACE SAFETY

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The person in charge of the activity is responsible for applying this procedure.

Contents

LIST OF VERSIONS				
Version No.	**Date**	**Section**	**Page(s)**	**Purpose of the Modification**
1	March 4, 2017			Original version.
2	July 15, 2021	all	all	General revision
3	June 1, 2023	all	all	General revision to reflect changes from IMG to Zijin

DEFINITIONS APPLICABLE TO THIS DOCUMENT	
RGM	Rosebel Gold Mines
Confined space	Space with limited openings for entry and exit; not intended for continuous human occupancy and large enough for a person to enter and conduct work.
OEM	Original Equipment Manufacturer
(Confined Space) Entrant	Person entering a confined space
(Confined Space) Attendant	A trained person who is in charge of managing entry and exit out of a confined space. Also, the person that will raise the alarm if needed but will not partake in any rescue event. The role is also known as Confined Space Sentry.
(Confined Space) Entry supervisor	Person who has the direct supervision over the work that is being done in the confined space
PRCS	Permit Required Confined Space
NPRCS	Non Permit Required Confined Space
Entry Permit	A form that authorizes entry to a permit required Confined Space.
LOTOV (Lock Out Tag Out Verification)	An established procedure for the placement of locking and tagging devices on energy isolating devices, ensuring that the energy isolating device and the equipment being controlled cannot be operated or started while work is being conducted.
UEL	Upper Explosive Limit
LEL	Lower Explosive Limit
ERT member	Emergency Response Team member- trained in confined space rescue and other fire and rescue emergencies

Atmospheric monitoring	The process of testing the atmosphere in a Confined Space. Monitoring is conducted initially before entry, and during Confined Space work based on the space Hazard Assessment.
Bump Test	A method of verifying instrument accuracy. A bump test verifies calibration by exposing the instrument to a known concentration of test gas. The instrument reading is compared to the actual quantity of gas present (as indicated on the cylinder). If the instrument's response is within an acceptable tolerance range of the actual concentration, then its calibration is verified.
Calibration	A method design to adjust of the instrument's reading to coincide with a known concentration (generally a certified standard) of test gas. In most cases, a full calibration is only necessary when an instrument fails a bump test or after it has been serviced. The full calibration and bump test should be conducted in a clean fresh air environment.
Immediately Dangerous to Life or Health (IDLH)	Any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or that would interfere with an individual's ability to escape unaided from a confined space.
Oxygen Deficient Atmosphere	An atmosphere containing less than 19.5 percent or lower oxygen content by volume.
Oxygen Enriched Atmosphere	An atmosphere that contains 23.5 percent or higher oxygen by volume.

1. INTRODUCTION

Rosebel Gold Mines (RGM) recognizes that working in confined spaces can result in serious injury, including fatalities. A confined space is defined as a space that has limited or restricted means of entry or exit, is large enough for an employee to enter and perform work and is not designed for continuous employee occupancy.

2. PURPOSE

To eliminate or minimize the risk of fatalities, injuries & incidents resulting from RGM-controlled activities performed in permit- required confined spaces.

2. SCOPE

This program applies to all RGM employees and contractors working at RGM and the areas that meet the definition of Permit- Required Confined Space.

3. RESPONSIBILTIES

Health & Safety superintendent:

- Provide the necessary resources and technical support for safe entrée/exit of confined spaces.
- Participate in pre-planning; emergency response and other stages of the confined space entry process as requested by the departments.
- Ensure all exposed employees have completed the necessary training as required for confined space entry.
- Review and authorize rescue plans when confined space entry is required.
- Ensure that all standards and procedures related to confined space entry are reviewed and updated.
- Audit with the department the confined space permits and procedures to ensure that the prescribed procedures are valid.

Area Superintendents:

- Ensure all confined spaces are classified (PRCS or NPRCS) and a database is kept up to date.
- Have all entrée point labeled with signs according to confined space standard (see figure 1: confined space sign)
- Ensures all permits and isolation procedures are followed prior to confined space entrée.
- Ensure that the hazard(s) of each confined space are evaluated.
- Review and authorize confined space entree permit.
- Ensure that means of rescue is available and rescue plan is approved by Fire/Rescue department.
- Inspect equipment and calibrate all equipment to be used in a PRCS entry before entry is performed and after work in the confined space is completed.
- To evaluate work areas for potential confined space entry situations prior to authorizing work in the area.
- Keep all completed permits with air monitoring attachments within their area for 2-year period.
- Verify that all necessary tests have been performed and that the isolation, LOTOV entry, and rescue procedures, and equipment are in place before issuing the permit and authorizing entry to the PRCS.
- Authorize entry if all procedures have been followed (including any additional measures) and atmospheric test indicates “acceptable entry conditions”.
- Cancel the entry permit if the scope of work changes or if entry conditions change. Determine and initiate corrective actions, issue a new permit, and list additional measures taken (if any).

Figure 1: confined space sign

Sentry:

- Remain outside the permit space during entry operations unless relieved by another authorized attendant.
- Perform non-entry rescues when specified by the employer's rescue procedure.
- Know existing and potential hazards, including information on the mode of exposure, signs or symptoms, consequences and physiological effects.
- Maintain communication with and keep an accurate account of those workers entering the permit space.
- Order evacuation of the permit space when:
  - A prohibited condition exists;
  - A worker shows signs of physiological effects of hazard exposure;
  - An emergency outside the confined space exists; and
  - The attendant cannot effectively and safely perform required duties.
- Summon rescue and other services during an emergency.
- Ensure that unauthorized people stay away from permit spaces or exit immediately if they have entered the permit space.
- Inform authorized entrants and the entry supervisor if any unauthorized person enters the permit space; and perform no other duties that interfere with the attendant's primary duties.
- Documents all actions in the sentry form and request approval from department head (see form RGM-F-09)

Rescuers:

- For all PRCS entrée the Fire/Rescue department must be notified in advance. The Fire/Rescue department shall develop in conjunction with the respective department the rescue plan.
- During entrée rescuers shall be on standby at the entrée point of the confined space. The number of rescuers on standby shall be decided based on the risk and number of people entering the confined space.
- Be capable of responding to an emergency in a timely manner.
- Rescue service personnel also must receive the authorized entrants training and be trained to perform assigned rescue duties.
- All rescuers shall be trained in first aid and CPR. At a minimum, one rescue team member must be currently certified in first aid and CPR.
- Employers must ensure that practice rescue exercises are performed yearly and that rescue services are provided access to permit spaces so they can practice rescue operations. Rescuers also must be informed of the hazards of the permit space.

Entrants (including contractors):

- Evaluate the work area for potential confined space entry situations as an integral part of the job before beginning (identify any and all emergency exit routes).
- Understand the potential hazards that may develop associated with entry into the PRCS and the work performed.
- Be alert to the signs and a symptoms of overexposure to any contaminates and / or chemicals used within the confined space.
- Discuss any potential hazards or concerns with the Entry Supervisor.
- Know how to use any and all equipment associated with the entry into and work to be performed within the PRCS (i.e. PPE, lighting, portable radio and air monitoring equipment) as required and / or as assigned.
- Follow the confined space entry procedures.
- Communicate with the outside observer and immediately follow the instructions if told to leave the confined space.
- Notify the outside observer and / or the entry supervisor of any changes in the scope of job (anew permit will be required to be issued).
- Wear full body harness when entering a confined space. Use lifelines or retrieval systems for all spaces, except where their use will not contribute to an effective rescue.

4. MINIMUM REQUIREMENTS

1) Each department shall maintain a central register that identifies and lists all permit- required confined spaces. The register shall be accessible to all relevant personnel, including contractors and emergency personnel.
2) Each department shall have a layout detailing the location of permit- required confined spaces.
3) Identified permitted confined spaces shall be labeled "DANGER—PERMIT-REQUIRED CONFINED SPACE—AUTHORIZED ENTRANTS ONLY" ***(see figure 1: confined space sign)***
4) Each confined space must have a drawing detailing dimension and include isolations points and or strategy.
5) There shall be at least one entry having an aperture:
   a) not less than 450 mm long by 400 mm wide, if rectangular; or
   b) not less than 450 mm in diameter, if circular; or
   c) having major and minor axes not less than 450 mm and 400 mm, respectively, if elliptical.
6) Gas testing and personal monitoring equipment shall be appropriate to the identified hazards, and regularly checked and calibrated in accordance with the manufacturer's recommendations. Records of equipment calibration shall be maintained. Equipment integrity and functionality (that is, tested against a known standard gas) shall be assessed both before and after a test for entry.
7) Atmospheric testing (i.e. bump test or calibration test) shall be done by a qualified person prior to entree.
8) Atmospheric testing equipment shall be tested and calibrated as per OEM instructions.
9) Where it is not feasible to ensure an atmospheric hazard is not present, personnel shall not enter the confined space unless they are equipped with suitable respiratory protective equipment, including as appropriate, supplied air respiratory protective equipment.
10) Rescue service personnel shall be trained and equipped with the correct personal protective and rescue equipment including respirators.
11) Based on the confined space configuration and associated rescue plan the appropriate rescue equipment shall be sourced, available and maintained according to the manufacturer's instructions.
12) Authorized entrants who enter a confined space shall wear a chest or full body harness with a retrieval line attached to the center of their backs near shoulder level or above their heads.
13) Authorized entrants shall fill in the form when entering and exiting of confined space (see form RGM-F-08)
14) A mechanical device shall be available to retrieve someone from vertical type permit spaces more than five feet (1.5 meters) deep.
15) The RGM confined space permit must verify and record that pre-entry preparations have been completed.

16) Signage stating 'Permit Required Confined Space – No Unauthorized Entry' or similar, and appropriate barriers shall be in place during confined space entry activities. Where entry to a confined spaced by multiple entrances is possible, signage shall be posted at each entrance. ***(see figure 1: confined space sign)***
17) Up to date relevant SDS shall be available at the work site.
18) Permit Required Confined spaces shall be isolated from all sources of hazardous materials and energy sources prior to entry.
19) Gas cylinders, other than those used for respiratory protective equipment shall not be taken into a confined space.
20) Personal protective equipment appropriate to the identified hazards shall be available, regularly inspected, and stored and maintained in accordance with the manufacturer's recommendations. This may include, but is not limited to, safety lines, harnesses, self-rescuers, respirators, personal motion detectors and breathing apparatus. All rescue apparatus should be inspected by the rescuers prior to confined space rescue.
21) Ventilation requirements for a confined space entry shall be identified through a risk assessment process. Ventilation shall be by either natural, forced or by extractive means as required to establish and maintain a safe atmosphere during occupancy.
22) All people entering permit required confined spaces shall be informed about:
    a) The confined space entry requirements;
    b) Any identified hazards;
    c) RGM's experience with the confined space, such as knowledge of hazardous conditions; and
    d) Precautions or procedures to be followed when in or near the confined spaces.
23) Relevant training shall be provided for all employees who are required to enter and or work in a confined space:
    - The Confined Space Entrant
    - The Confined Space Attendant (Sentry)
    - Confined Space Entry supervisor
    - Relevant Emergency Response team members

5. INSTRUCTIVE NOTES

5.1 Determine permit required confined space.

Recognizing a permit required confined space is not easy. The same structure may or may not be a permit required confined space depending on the circumstances when the space is entered. E.g. a space may become a permit required confined space if work that is to be carried out in the space would generate

harmful concentrations of airborne contaminants. This means that classification of a confined space is determined based on the structure and a specific set of circumstances.

Temporary control measures such as providing temporary ventilation or achieving a satisfactory pre-entry gas test will not cause a permit required confined space to be declassified. For a permit required confined space to be declassified as a non- permit required confined space, it needs to have undergone sufficient changes in structure and use to eliminate all inherent hazards that define a permit required confined space.

Entry to a permit required confined space is considered to have occurred when a person's head or upper body enters the space.

The questions to determine whether a space is a 'permit required confined space' for purposes of this document. A "Yes" answer to all the questions means the space is a "confined space".

1. **Is the space enclosed or partially enclosed**. Note that the risk of confined space is associated with how much the space is enclosed rather than the size of the space.
2. **The space is NOT designed or intended to be occupied by a human**. This is often the case where there is poor ventilation, lighting and or restricted means of entry or exit. Take in consideration the difficulty or ease to remove an injured person.
3. **The space is NOT designed or intended to be at normal atmospheric pressure while a person is in it**. Where not the case the space must be brought to atmospheric pressure before a person can enter.
4. **Is it likely for the following Health and Safety Risks to exist**?
    - Oxygen level either below or above the 19.6 %- 23.5% range.
    - Contaminants (risk of fire and explosion)
    - Airborne contaminants at levels above the allowable exposure limits.
    - Engulfment (liquid, solids, etc.)

What is NOT a permit required confined space.

A "No" to any of the 4 confined space classification questions allows for the space to be classified as "NOT a permit required confined space". Examples are:

- places that are intended for human occupancy and have adequate ventilation, lighting and safe means of entry and exit, such as offices and workshops
- some enclosed or partially enclosed spaces that at particular times have harmful airborne contaminants but are designed for a person to occupy, for example abrasive blasting or spray painting booths
- enclosed or partially enclosed spaces that are designed to be occasionally occupied by a person if the space has a readily and conveniently accessible means of entry and exit via a doorway at ground level, for example:

- a cool store accessed by a LPG forklift to move stock – although the use of a LPG forklift in a cool store can be hazardous, the door at ground level means that once the alarm is raised, escape and rescue can happen quickly
- a fumigated shipping container with a large ground level opening will facilitate easy escape and rescue.

See figure 2: categorizing confined spaces

- Trenches are not considered permit required confined spaces based on the risk of structural collapse alone but will be permit required confined spaces if they potentially contain concentrations of airborne contaminants that may cause impairment, loss of consciousness or asphyxiation.

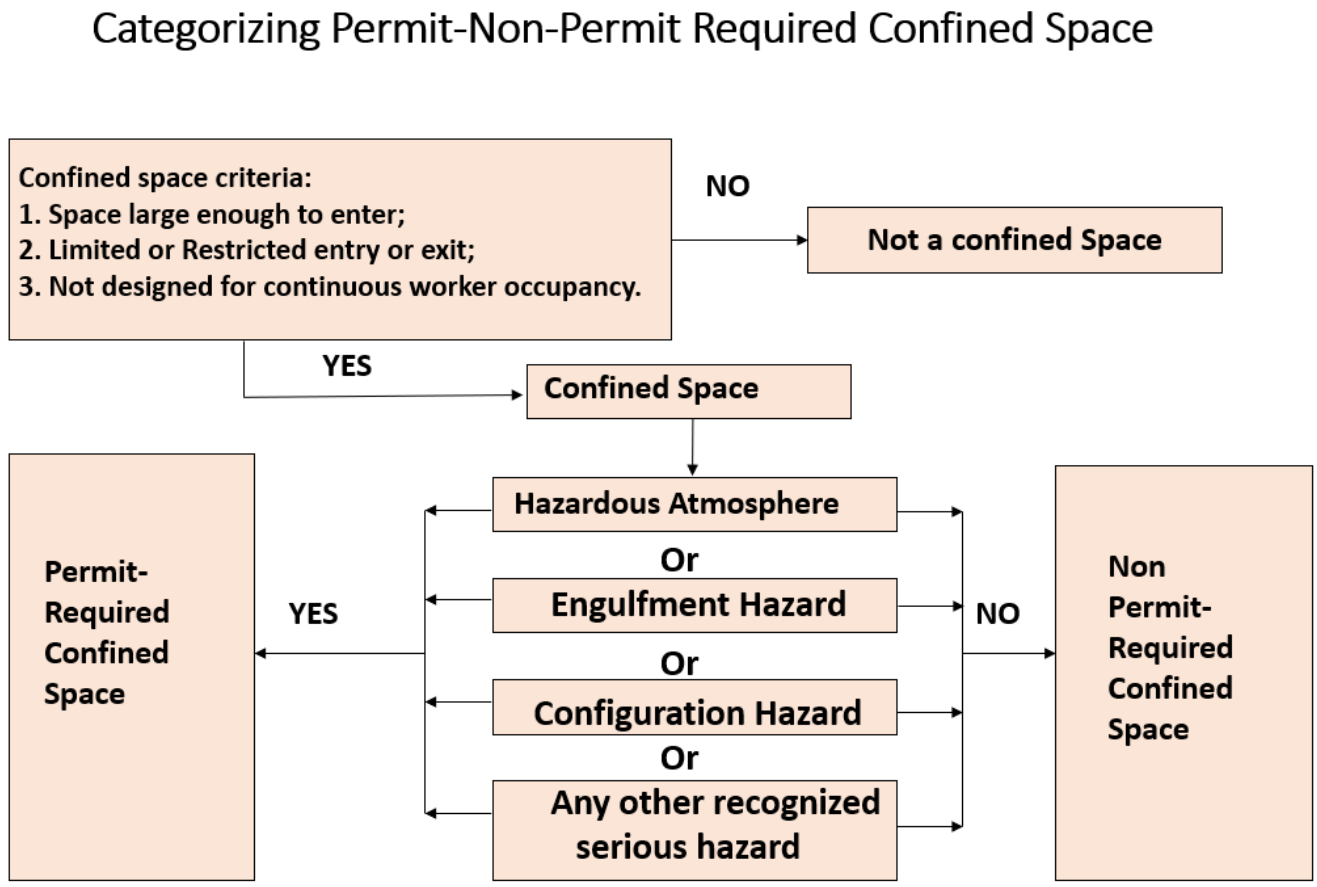

Figure 2: Categorizing Confined spaces.

5.2 Confined Space Entry risks assessment

A risk assessment, considering what could happen if someone enters and or works in a permit required confined space shall be done involving and or in consultation relevant work groups and subject matter experts. The risk assessment will determine the confined space entry risks requiring control. The RGM Confined Space Entry Permit may be used as a record of the risk assessment.

Confined space risks

The typical risk associated with confined space that need to be managed are all or a combination of, but not limited to:

- Restricted entry or exit
- Harmful airborne contaminants
- Unsafe oxygen level
- Fire and explosion
- Engulfment
- Uncontrolled introduction of substances
- Biological hazards
- Mechanical hazards
- Electrical hazards
- Skin contact with hazardous substances
- Noise
- Manual tasks
- Radiation
- Environmental hazards
- Hazards outside the confined space

See Appendix: 1 Typical Confined Space risks

Confined space risk assessment objectives

The main objectives of any permit required confined space entry risk control should be any or a combination of:

- **Ensuring a Safe Atmosphere**.
  - Through gas testing ensure that the atmosphere is suitable for entry by workers.
  - Ensure that work tasks and or environmental conditions do not adversely influence the atmosphere to the point where it is unsuitable for human entry.
- **Providing adequate Isolation.** Ensure that the confined space is isolated from connected plant and services and that all sources of engulfment and or atmospheric contamination have been locked off as per RGM LOTOV procedure RGM-SRCS-02.
- **Preventing unauthorized entry**.
  - Ensuring, so far as is reasonably practicable, that a worker does not enter a confined space until all the duties in relation to the confined space have been complied with, for example entry permit requirements.
  - Prevent unintentional entry through effective communication and safety monitoring, signs and training.

- **Have adequate Emergency response capability**. Establishing first aid and rescue procedures to be followed in the event of an emergency in the confined space. Unrestricted entry and exit are crucial.

5.3 Confined Space Entry

Workers and their supervisors must have the skills and knowledge to understand the hazards associated with working in the confined space, the contents of the RGM confined space entry permit, and the control measures implemented for their protection.

For confined space entry one must have had a RGM recognised training that at a minimum cover:

- the nature of all hazards associated with a confined space
- the need for, and appropriate use of, risk control measures
- the selection, use, fit, testing and storage of any personal protective equipment
- the RGM confined space entry permit
- RGM emergency procedures

Training needs to be refreshed every 2 years.

Entry Permit

The RGM confined space entry permit provides a formal check to ensure all elements of a safe system of work are in place before people are allowed to enter the confined space. It also provides a means of communication between area management, area supervisors and those carrying out the work and ensures that the competent person has checked and authorised the entry into the confined (see form RGM-F-10). The RGM confined space entry permit must be completed in writing by a competent person and it shall:

- specify the confined space to which the permit relates
- record the names of persons permitted to enter the confined space and the period of time that the work will be carried out
- set out risk control measures based on the risk assessment, and
- provide details of the Entry Attendant or Sentry assigned
- allow for an acknowledgement that work in the confined space has been completed and all persons have left the space

Note: The permit documentation must be kept until the work is completed, or if a notifiable incident occurs, for at least 2 years after the confined space work to which the permit relates is completed

A confined space entry permit must be issued for each entry into the confined space. Each permit only applies to one confined space and allows one or more workers to enter that space. A competent person shall issue the permit on behalf of RGM.

The RGM confined space entry permit is also required when a person enters a confined space to conduct the initial hazard identification or risk assessment. The permit may need to be revised after the risk assessment is completed.

The entry permit must be used as a written record that all workers have exited the confined space on completion of the work. It should be displayed in a prominent place to facilitate signing and clearance. Each worker must be able to understand the entry permit.

The information on the entry permit may be used as a suitable record of the risk assessment that has been carried out. In case of an emergency in the area or the confined space the permit is automatically suspended and need to be reissued before work may continue.

Isolation

All potentially hazardous services should be isolated prior to any person entering the confined space. If liquids, gases or vapours could enter the confined space the pipe work should be physically isolated.

Isolation measures, for example physically locking, tagging, closing and blanking should be done as per RGM LOTOV procedure RGM-SRCS-02. Isolation measures shall be implemented and controlled by persons that have been trained in the RGM LOTOV procedure and have been authorized to carry out isolations.

Signs and Barricades

Before any work in relation to a confined space starts, signs must be erected to prevent entry of persons not involved in the work. Signs must warn against entry by people other than those who are listed on the confined space entry permit and must be placed at each entrance to the confined space. Signs must be in place while the confined space is accessible, including when preparing to work in the confined space, during work in the confined space and when packing up on completion of the work. Leaving the confined space unattended should be minimized as much as possible. In case of leaving the confined space unattended red barricade tape must be used to cordon off the entrée point with information stating that no unauthorized entrée is allowed.

Confined space Entry and exit

For the entire period the confined space entry permit is valid, procedures should be in place to indicate when any worker is in the space, for example by using tags, a system of signing in and out on the entry permit, or having a standby person (sentry or entry attendant) record who is in the space.

Atmosphere measurement and monitoring

Initial entry monitoring is conducted from outside the space at the point of entry. Measurements are collected as far into the space as possible without actual bodily entry. The instrument is calibrated each 3 months (90 days) and bump tested each shift prior to use.

Measurements must be taken every 1.2m for vertical and horizontal entries to profile the gas levels throughout the confined space. For horizontal entries, the space will be evaluated as far into the space as possible using sampling probes, tubing, poles etc. All efforts will be exercised to collect samples from outside the space that characterize the atmosphere at the work site. Once the entry point has been proven to be safe to enter, the permit will be issued and the initial entrant will take a multiple gas meter and sampling apparatus and proceed to the work area at a rate that will allow the meter adequate time to collect and analyze the atmosphere.

Most hazards in Confined Spaces do not have adequate warning properties such as an odor or color to indicate danger. The multiple gas monitor must be used to determine the oxygen (O2), Combustible LEL HCN gas, Carbon Monoxide (CO) and Hydrogen Sulfide (H2S) levels in the confine space prior to entry and at a frequency specified in the entry procedure. The multiple gas monitor must be calibrated by a trained person at least every 3 months. A bump test must be performed at the beginning of each shift prior to use.

The difference between a functional (bump) test and a full calibration:

A functional (bump) test is defined as a means of verifying calibration by using a known concentration of test gas to demonstrate that an instrument's response to the test gas is within acceptable limits.
A full calibration is defined as the adjustment of an instrument's response to match a desired value compared to a known concentration of test gas.

The frequency for verification of calibration:

A functional (bump) test or full calibration of direct reading portable gas monitors should be made before each day's use in accordance with the manufacturer's instructions using an appropriate test gas. Any instrument that fails a functional (bump) test must be adjusted by means of a full calibration procedure before further use.
If environmental conditions that could affect instrument performance are suspected to be present, such as sensor poisons, then verification of calibration should be made on a more frequent basis.

Atmospheric Testing is conducted:

- Before any entry into a permit-required confined space.
- Periodically throughout the duration of the entry as specified in the entry procedure.
- Always prior to re-entry and additionally as indicated by the hazard assessment.
- If continuous monitoring is performed, results must be recorded hourly for entries of less than one shift and every two hours for entries of duration in excess of a single shift.

Acceptable levels considered safe for entry:

- Oxygen (O_2) MUST be greater than 19.5 % and less than 23.5 %.
- Combustible gas level or LEL must be less than 10%.
- Carbon Monoxide (CO) must be less than 25 ppm (efforts should be employed to reduce the CO levels as low below 25 ppm as possible).
- Hydrogen Sulfide (H_2S) must be less than 10 ppm (parts per million)
- Hydrogen Cyanide HCN 10 ppm per 8 hr TWA

If acceptable levels are not attained, the area should be cleaned or purged to achieve an acceptable atmosphere. Continuous ventilation must be used to improve air quality. Proper respiratory protection specified by the H&S department may also need to be used.
Full Calibration and Bump Testing of the Sampling Equipment must be documented.
Full Calibration is required and conducted prior to manufacturer's specifications.
Full Calibration is conducted every 3 months (90 days).

The calibration records and bump test records must be kept for one year in the Department Areas. A safe atmosphere must be ensured, as far as is reasonably practicable, during work in a confined space. A safe atmosphere can be achieved within the confined space using methods such as cleaning, purging and ventilation.

Purging is done using an inert gas, such as nitrogen, to clear flammable gases or vapours before work in the confined space begins. Purging is often followed by ventilation.

Ventilation of a confined space with fresh air, by natural, forced or mechanical means, may be necessary to establish and maintain a safe atmosphere and temperature for as long as anyone is in the confined space.

Clean and or Purge

Person(s) Responsible: Entry Supervisor to coordinate cleaning/purging. Materials or residual products that could constitute a hazard should be removed from the confined space through proper cleaning. Cleaning should be performed from outside of the space, if possible. Confined spaces that contain volatile or toxic atmospheres should be purged to displace the volatile material or toxics from the atmosphere prior to entry.

Note: When purging or ventilating potential flammable atmosphere in confined spaces, be aware that a flammable atmosphere may be created when providing outside air to a space where flammable vapors are above the Upper Explosive Limit (UEL).

Ventilate Confined Space

Person(s) Responsible: Entry Supervisor – Crafts leader to coordinate ventilation.

Adequate continuous ventilation in a confined space is essential to prevent the build-up of flammable, toxics or oxygen-deficient air. To determine if ventilation is needed, test Confine Space with the multiple gas monitor. Atmosphere must be maintained at 19.5 % - 23.5 % O2, less than 10% of LEL combustible, HCN 10 ppm per 8 hr TWA and less than 25 ppm CO.

Note: while work is being carried out in a confined space, ensure that the concentration any flammable gas, vapour or mist in the atmosphere of the space is less than 5% of its LEL, so far as is reasonably practicable.

If it is not reasonably practicable to ensure the confined space contains a safe oxygen level, or safe levels of airborne contaminants, then appropriate respiratory protective equipment must be provided and used.

Communication and safety monitoring

There shall be continuous communication with the worker from outside the confined space. Depending on the conditions in the confined space, communication can be achieved by voice, radio, hand signals or other suitable methods.

A trained Sentry, Entry Attendant or standby person shall be monitoring conditions within the confined space. If practicable, the Sentry, Entry Attendant or standby person shall be observing the work being carried out.

See Appendix 2 Confined Space Risk assessment questions.

6. DOCUMENT CONTROL

Document	Primary File Location	Frequency of Review/Update
RGM-PR-21 Confined Space Entry	RGM-DMS	Annually
RGM-F-08 Confined space Entry-Exit Log	RGM-DMS	Annually
RGM-F-09 Confined Space Sentry Sign Off	RGM-DMS	Annually
RGM-F-10 Confined space Entry Permit	RGM-DMS	Annually
RGM LOTOV procedure RGM-SRCS-02	RGM-DMS	Annually
RGM Fall prevention standard RGM-SRCS-03	RGM-DMS	Annually

If you have any comments, questions or requests for corrections regarding this document, please contact one of the signatories.

REFERENCES:

OSHA standard 1910.146 Permit Required Confined Spaces

APPENDICES

Appendix 1 Typical Confined Space risks

Biological hazards

Contact with micro-organisms, such as viruses, bacteria or fungi, may result in infectious diseases, dermatitis or lung conditions such as hypersensitivity pneumonitis. Sewers, grain silos and manure pits are examples of confined spaces where biological hazards may be present.

Environmental hazards

Environmental hazards associated with work in a confined space may cause or contribute to harm. Examples of environmental hazards include:

- heat or cold stress arising from the work, process or conditions
- slips, trips and falls arising from slippery surfaces or obstacles
- inadequate lighting.

Engulfment

Engulfment means to be swallowed up in or be immersed by material, which may result in asphyxiation. Examples of materials that may pose a risk of engulfment include plastics, sand, liquids, fertiliser, grain, coal, coal products, fly ash, animal feed and sewage. Stored materials such as sand and grain can form a crust or bridge when a container is emptied from below, leaving the top layer in place. Workers walking on the bridge or working below the bridge on the floor of the container may be engulfed if a bridge collapses.

Electrical hazards

Electrical hazards may cause electrocution, shocks or burns, and can arise from cables, transformers, capacitors, relays, exposed terminals and wet surfaces where electrical circuit and electrically powered plant are used.

Fire and explosion

A fire or explosion requires the presence of three elements: an ignition source, air and a fuel (gas, vapour or mist) capable of igniting. A flammable atmosphere is one in which the flammable gas, vapour or mist is likely to exceed 5% of its lower explosive limit (LEL).

Flammable atmospheres in confined spaces may result from the evaporation of a flammable residue, flammable materials used in the space, a chemical reaction (such as the formation of methane in sewers), or from the presence of combustible dust (such as that in flour silos).

If an ignition source, such as a sparking electrical tool or static on a person, is introduced into a space containing a flammable atmosphere, an explosion is likely to result.

Harmful airborne contaminants

The following table illustrates the kinds of harmful atmospheres that may be present in a confined space, and how they may be created.

Source	Examples
Substance stored in the confined space or its by-product(s)	• build-up of hydrogen sulphide in sewers and pits • release of toxic substances e.g. hydrogen sulphide in tanks of decomposing organic material, especially when the material is disturbed
Work performed in the confined space	• use of paints, adhesives, solvents or cleaning solutions • welding or brazing with metals capable of producing toxic fumes • exhaust fumes from engines used in the confined space • painting or moulding glass-reinforced plastics
Entry of natural contaminants e.g. groundwater and gases into the confined space from the surrounding land, soil or strata	• acid groundwater acting on limestone with the potential to produce dangerous accumulations of carbon dioxide • methane released from groundwater and from decay of organic matter.
Release of airborne contaminants	• when sludge, slurry or other deposits are disturbed or when scale is removed
Manufacturing process	• residues left in tanks, vessels etc., or remaining on internal surfaces can evaporate into a gas or vapour
Entry and accumulation of gases and liquids from adjacent plant, installations, services or processes	• the contamination of underground confined spaces by substances from plant in the vicinity of the confined space • carbon monoxide from the exhaust of LPG-powered forklifts operating in, or in the vicinity of, the confined space

Hazards outside the confined space

Where the confined space has a vertical opening, there is a risk that people could fall in.

Traffic hazards are a concern where confined space entrances or exits are located on footpaths or roads. There is the potential for workers entering or exiting the space to be struck and injured by vehicle traffic.

Work done outside the space, but near openings to it, can contaminate the atmosphere inside the space. A common example is the exhaust gases from an internal combustion engine. There may also be potential for fire or explosion where hot work is done in areas next to confined spaces that contain flammable atmospheres.

Manual tasks

Hazards arising from manual tasks may be exacerbated by physical constraints associated with working in a confined space. Additional hazards may arise from the use of personal protective equipment that restricts movement, grip and mobility.

Mechanical hazards

Exposure to mechanical hazards associated with plant may result in entanglement, crushing, cutting, piercing or shearing of parts of a person's body. Sources of mechanical hazards include plant such as augers, agitators, blenders, mixers and stirrers.

Noise

Noise generated in a confined space from the use of plant, the work method or process may be amplified due to reflections off hard surfaces. Exposure to hazardous noise may result in hearing loss, tinnitus and other non-auditory health effects. Hazardous noise may also prevent workers hearing warning signals and distract workers from their work.

(Additional) Physiological and psychological demands

Working in a confined space may impose additional physiological and psychological demands over and above those encountered in a normal working environment. Consideration should be given to a worker's:

- physical ability
- ability to work in a restrictive space (for example claustrophobia)
- ability to wear the personal protective equipment required to do the work (for example respirators).

Radiation

The health effects associated with radiation depend on the type of radiation involved. Sources of radiation include radioactive sources, x-rays, lasers, welding flash, radio frequency and microwaves.

Restricted entry or exit

Small entrances and exits make it difficult to rescue injured workers or to get equipment in or out of the confined space. In some cases, entrances and exits may be very large but their location can make them difficult to access. For example, accessing pits or openings high up in silos may require the use of ladders, hoists or other devices, and escape and rescue from such spaces may be difficult in emergency situations.

Skin contact with hazardous substances

The nature of a confined space could give rise to an increased likelihood of skin contact with surface contaminants. Skin contact with hazardous substances may result in immediate health effects such as burns, irritation or allergic dermatitis, or longer-term systemic effects.

Uncontrolled introduction of substances

The uncontrolled introduction of substances such as steam, water or other liquids, gases or solids may result in drowning, being overcome by fumes or other harm depending on the nature of the substance. Vehicles and LPG forklifts operating close to the opening of the confined space can cause a build-up of exhaust gases, including carbon monoxide, in the space.

Unsafe oxygen level

Air normally contains 21% oxygen by volume, although oxygen levels of 19.5% — 23.5% by volume are considered to be safe.

Some situations can cause the level of oxygen to dramatically decrease, leading to an oxygen-deficient atmosphere and possible asphyxiation. This may occur, for example, if oxygen in the atmosphere is:

- displaced by gases produced during biological processes, for example, methane in a sewer
- displaced during purging of a confined space with an inert gas to remove flammable or toxic fumes
- depleted inside metal tanks and vessels through surface oxidation (for example, when rust forms)
- consumed during combustion of flammable substances
- absorbed or reacts with grains, wood chips, soil or chemicals in sealed silos.

Too much oxygen can increase the risk of fire or explosion. Oxygen-enriched atmospheres may occur if:

- chemical reactions cause the production of oxygen, for example certain reactions with hydrogen peroxide
- there is a leak of oxygen from an oxygen tank or fitting while using oxy-acetylene equipment.

CUTTING and WELDING in CONFINED SPACES:

- A Cutting and Welding (Hot Work) Permit is required for all cutting or welding in posted or hazardous locations. Never take any compressed gas cylinder or welding machines into Confined Space.
- All hoses containing compressed gasses that pass through the entry point into a Confined Space shall be equipped with shut off valves that is immediately accessible to the Outside Observer.
- All welding hoses and electric welding lines must be removed from the confined space when the space is not occupied.
- Local exhaust ventilation shall be used to remove welding fumes from the space where possible.

Appendix 2 Confined Space Risk assessment questions

When undertaking a risk assessment to determine the risks requiring control the following factors should be considered:

- does the atmosphere in the confined space allow for human occupation (is testing or monitoring to be undertaken)
- is there a risk of engulfment of a person
- do the proposed work activities the potential to cause a change to the conditions in the confined space.

- Should the number of persons occupying the space be limited
- Is the integrity of the structure such that it is safe to enter. Is there a need for lighting.
- Do we know what the substances last where contained in the confined space
- are risk control measures needed to bring the confined space to atmospheric pressure
- how many persons required outside the space:
  - to maintain equipment essential for the task being undertaken within the confined space
  - to provide continuous communication with the persons within the confined space, and
  - to properly initiate emergency response procedures
- are there risks associated with other hazards, such as noise or electricity
- Is there a tailored emergency response plan
- Are there more than normal or acceptable physiological and psychological demands of the task and the competency of persons involved in the tasks or emergency response duties
- Are relevant persons familiar/ trained with all the required procedure, particularly those that are unusual or non-typical, including the use and limitations of any personal protective equipment and other equipment to be used
- Have we determined the appropriate personal protective equipment and emergency equipment for all persons likely to enter the confined space?
- Is there a need for additional risk control measures, including:
  - prohibiting hot work in adjacent areas
  - prohibiting smoking and naked flames within the confined space and adjacent areas
  - avoiding contamination of breathing air from operations or sources outside the confined space, for example, from the exhaust of an internal combustion engine
  - prohibiting movement of equipment in adjacent areas, for example forklifts
  - prohibiting spark-generating equipment, clothing and footwear
- Is purging or cleaning in the confined space necessary
- Is hot work necessary
- Are there conditions that could impede entry and exit or the conduct of the tasks in the confined space