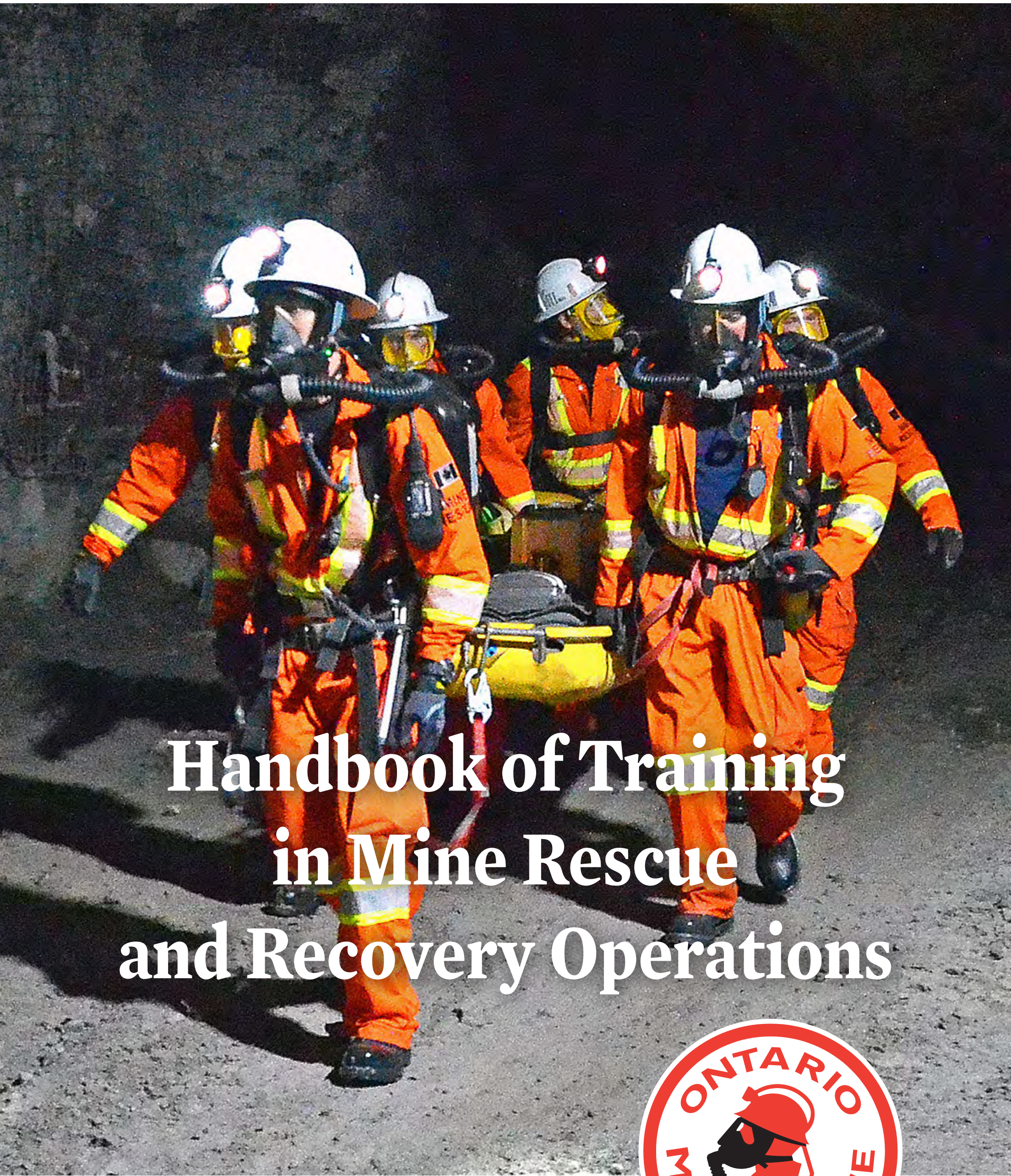


Handbook of Training in Mine Rescue and Recovery Operations

2021

ONTARIO MINE RESCUE

PREPARED SINCE 1929

HANDBOOK OF TRAINING IN MINE RESCUE & RECOVERY OPERATIONS

2021

First printing 1930	Revised 1941
Revised 1951	Revised 1953
Revised 1957	Revised 1961
Revised 1964	Revised 1968
Reprinted 1971	Revised 1973
Reprinted 1975	Reprinted 1978
Revised 1984	Revised 1992
	Reprinted with corrections 1994
Revised 2000	Reprinted with corrections 2001
Revised 2009	Revised 2011
Revised 2014	Reprinted with corrections 2015
Revised 2021	

Written and issued by WSN for the use of persons training in mine rescue and recovery at the main mine rescue stations and substations established in the province.

Box 2050, Stn. Main
690 McKeown Ave., North Bay ON P1B 9P1
tf. 1-888-730-7821 • fax (705) 472-5800
workplacesafetynorth.ca/minerescue

ACKNOWLEDGEMENTS

The revisions of the handbook have been compiled by the Chief Mine Rescue Officer with the cooperation of the Mine Rescue Officers, Workplace Safety North staff, and Ministry of Labour personnel.

Assistance has been rendered by the manufacturers of breathing apparatus and other equipment used in mine rescue work.

Suggestions by a special fire committee set up by the mining industry of Ontario to investigate firefighting operations are gratefully acknowledged and deeply appreciated.

PREFACE

AUTHORIZATION

The responsibilities associated with mine rescue in Ontario are set out in Regulation 854: Mines and Mining Plants of the Occupational Health and Safety Act. The regulation sets out requirements for mine rescue stations, the financing of the mine rescue organization, the direction of the mine rescue organization, the qualification and training of mine rescue team members, the responsibilities of a mine owner in mine rescue, and the use of mine rescue services.

PURPOSE OF THE HANDBOOK

The purpose of the Handbook of Training in Mine Rescue and Recovery Operations is to provide a guide for the training of the members of mine rescue teams in the care and use of apparatus for protection in irrespirable atmospheres, in the detection of noxious gases, specialized emergency response equipment, and in a general knowledge of accepted procedures for rescue and recovery operations during or after a mine emergency. It is meant to serve as a reference guide for the members of mine rescue teams and to assist mine operators during mine rescues or other emergencies.

TABLE OF CONTENTS

SECTION ONE

CHAPTER 1

MANDATE, SCOPE AND STRUCTURE

CHAPTER 2
EMERGENCY PREPAREDNESS

CHAPTER 3
MINE RESCUE PERSONNEL

CHAPTER 4
MINE GAS PROTECTION POLICY

CHAPTER 5
EMERGENCY RESPONSE POLICY

SECTION TWO

CHAPTER 6
MINE GASES

CHAPTER 7
DETECTING MINE GASES

CHAPTER 8
PROTECTION FROM MINE GASES

CHAPTER 9
AUXILIARY EQUIPMENT

CHAPTER 10
SPECIAL EQUIPMENT

CHAPTER 11
GENERAL EMERGENCY PRACTICES

CHAPTER 12
UNDERGROUND FIRES

CHAPTER 13
FIRST AID

APPENDIX A

APPENDIX B

TABLES


West

SECTION ONE

CHAPTER 1

MANDATE, SCOPE AND STRUCTURE

LEGISLATION

Legislation governing the Ontario Mine Rescue services can be grouped into two categories: the administration of the program and the funding of the program.

Administration of the Program

In the Canadian mining sector, governance over safe mining practices falls to each individual provincial government. Within Ontario, this oversight was historically provided by the Department of Mines, which became a division of the Ministry of Natural Resources in 1970. Since the implementation of the Occupational Health and Safety Act (OHSA) in the late 1970s, the regulations pertaining to the safe operation of a mine now fall under the Ontario Ministry of Labour, Training and Skills Development (MLTSD). Under the OHSA, these can be found in Ontario Reg. 854: Mines and Mining Plants.

Ontario Reg. 854: Mines and Mining Plants

Section 17

(1) Mine rescue stations may be established, equipped, operated and maintained, as the Minister may direct, by an entity specified by the Minister that, in the opinion of the Minister, is qualified to perform those functions.

(2) An entity specified under subsection (1) shall,

(a) appoint mine rescue officers; and

(b) establish mine rescue crews.

(3) Mine rescue officers shall,

(a) administer mine rescue stations;

(b) train mine rescue crew members; and

(c) ensure that each mine rescue crew member is competent to perform and physically capable of performing the functions of a mine rescue crew member.

(4) The owner of a mine shall make available, at the owner's expense,

(a) an adequate number of workers to be taught and trained in mine rescue work; and

(b) training facilities and adequate storage for training materials and equipment.

(5), (6) Revoked:

(7) A mine rescue operation at a mine shall be under the direction of the supervisor in charge of the mine and the costs of the rescue operation shall be at the expense of the owner of the mine.

(8) Notice shall be given immediately to a mine rescue officer and to an inspector when the services of a mine rescue crew are required.

Section 41

(1) Procedures in case of a fire at,

(a) the surface of an underground mine;

(b) a surface mine; or

(c) a mining plant,

shall be prepared by the supervisor in charge of the mine or mining plant.

(2) The procedures required by subsection (1) or extracts therefrom shall be set out in writing and shall be posted and kept posted in a conspicuous place or places where they are most likely to come to the attention of a worker.

(3) A suitable number of workers at each mine and mining plant shall be trained in the fire-fighting procedures and,

(a) the names of such workers shall be posted in a conspicuous place;

(b) such workers shall be tested for proficiency at least once a year; and

(c) a written report of the results of the tests shall be made and kept on file.

(4) Fire-extinguishing equipment of a suitable type and size shall be provided at,

(a) the surface of every underground mine;

(b) every surface mine; and

(c) mining plant.

(5) At least once each month, the,

(a) fire-extinguishing equipment;

(b) fire suppression systems;

(c) fire hydrants; and

(d) fire doors,

at the surface of an underground mine, a surface mine and a mining plant shall be inspected by a competent person who shall report thereon to the supervisor in charge of the mine or mining plant, as the case may be.

Funding

Since the inception of the Ontario Mine Rescue program in 1929, funding for mine rescue emergency preparedness and response has been derived without interruption through the same fundamental process. Under the Workplace Safety and Insurance Act, the Workplace Safety and Insurance Board (WSIB) funds the Ontario Mine Rescue program requirements, a process currently overseen by the MLTSD Prevention Office.

Mining employers that fall under Class B of the Workplace Safety and Insurance Act contribute to the WSIB fund annually through insurance premiums paid for each employee. The WSIB then remits from the fund the amount required by the MLTSD to operate the provincewide Ontario Mine Rescue program. This typically represents less than two to four per cent of gross premiums paid into the fund by mining employers.

This mechanism allows for two critical efficiencies. First, funding and associated downstream mine rescue training and response capacity is scalable relative to the size of the province's mining industry. As more mines open, employing more workers requiring mine rescue support, the increased WSIB premiums allow the mine rescue program to purchase resources and hire personnel to meet the growing need. Secondly, because the funding goes toward a provincewide program, changes to the mining sector not involving growth or contraction do not disrupt the level of service as equipment and training capacity can be redeployed within the province. Funding is not lost or sunk into mine operator-specific costs, but shared in a pool of resources maintained to the highest standards.

Categories within scope of WSIB funding:

- Mine Rescue Station facilities
- Training and Certification
- Mine Rescue equipment, vehicles, and related consumables
- Emergency preparedness consulting, planning, auditing, and evaluation
- Emergency response activities

Categories out of scope of WSIB funding, borne directly by mining employers:

- Volunteer responder training and emergency response compensation
- Mine site facilities costs including mine rescue substations and training areas
- Member participation in Technical Advisory Committee activities

Unfunded Liabilities:

Mine operators are not to incur any additional costs in exercising responsibilities under Sect.17 with the exception of the following:

- Replacement of damaged or unserviceable equipment and consumables deployed during a mine rescue emergency operation

- Sponsorship of mine rescue volunteer recognition events organized in parallel with District and Provincial Standardized Evaluations

MANDATE

Primary Functions

The two primary functions of the province's mine rescue program are responding to mine emergencies and preparing mines for an emergency. This applies to the underground and surface workings of operating mines, mines in development, and sites in the process of mine closure.

In the event of a mine emergency, Ontario Mine Rescue must:

- Ensure the affected mine and emergency response District is sufficiently resourced to conduct an emergency response operation
- Make technical rescue advisory services available to mine operations management for the duration of the emergency response operation
- Ensure rescue and extrication equipment stored on site is deployed
- Ensure rescue and extrication equipment shared within the emergency response District is mobilized to the site
- Activate neighbouring emergency response District to standby additional resources
- Prepare and retain a permanent legal record of all operations and communications from the time of notification to the conclusion of mine rescue and recovery operations

In preparation for mine emergency response operations, Ontario Mine Rescue must:

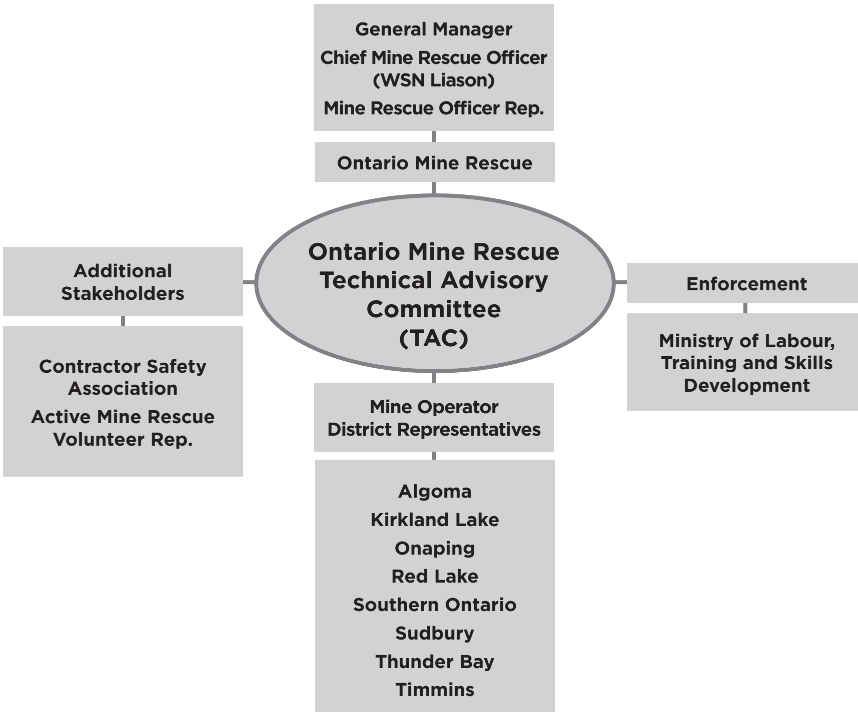
- Train and evaluate a sufficient roster of actively certified mine rescue volunteers

- Train mine operations management with respect to site personnel responsibilities and decision making in various mine emergency scenarios
- Ensure provincewide standardization of the mine rescue program by conducting an annual evaluation of all mine operators in response to a standard emergency response simulation
- Establish procedures for the safe deployment and return of mine rescue volunteer response personnel
- Actively review global mine rescue incidents, as well as participate in research and development advancements in mine emergency response policy and technology
- Maintain a Mine Rescue Station centrally located within an emergency response District of regionally grouped mine sites
- Ensure the provincewide response capacity at all times through the audit process and annual site point-in-time evaluations
- Prepare and retain records of all training, consulting and financial reports pertaining to the administration of the mine rescue program.

  These reports must be made available to the MLTSD for annual review to ensure the program is being administered as required under the terms of the Service Level and Transfer Payment Agreements.

Additional Functions

In addition to the primary functions of the mine rescue program, three roles ensure organization at the district, provincial, and international levels. Those functions are coordination of District Mine Rescue Coordinators Groups, the multi-stakeholder Technical Advisory Group (TAC), and technical knowledge exchange with the International Mines Rescue Body (IMRB).



District Mine Rescue Representatives Groups

Each provincial mine emergency response district must have a standing group of representatives from each mine site which convenes with the District Mine Rescue Officer at regular intervals. This group must set training schedules and policy, provide relevant updates to the District Emergency Response Plan, review, and approve the annual Memorandum of Understanding agreement, as well as initiate, review, and maintain any necessary mutual aid agreements.

Technical Advisory Committee (TAC)

The program must maintain the Ontario Mine Rescue Technical Advisory Committee as a multi-stakeholder working group. The committee is comprised of Ontario Mine Rescue management and program development staff, a Mine Rescue Officer representative, a mine operator industry representative for each emergency response district, a mining inspector or representative of mining legislation enforcement, a representative on behalf of the provincial mine contractors safety association, and an active mine rescue volunteer representative. The committee exists to actively advance research and development programs as well as outline the current and future needs of mine operators from an emergency response perspective.

International Mines Rescue Body (IMRB)

Mining is a comparatively small industry, intensely unique in its technical requirements. Mine rescue and emergency response exists as an extremely small field of study and practice. To build collectively on shared experience, all major mine rescue organizations globally form an information sharing and collaboration organization known as the IMRB.

Ontario Mine Rescue works in collaboration with the mine rescue programs from other provinces to represent Canada as an executive member of the body. Ontario presents technical updates, research work, and incident reports at the biennial meeting of the organization, and on alternating years enters mine rescue teams and Mine Rescue Officer staff as technical experts at the International Mines Rescue Competition (IMRC).

Supplementary Functions

Processes and functions provided by the Ontario Mine Rescue program also include facilitating mine rescue procurement processes as well as supporting the Office of the Chief Coroner.

Mine Rescue Procurement

The program may, at no additional surcharge to a mine operator, assist with the purchase, supply and distribution of standardized specialty mine rescue and emergency response supplies and equipment beyond the existing shared inventory of the Ontario Mine Rescue program.

This process assists mine operators who may wish to purchase like equipment or supplies to the standardized provincial inventory for use outside the scope or service provided by the program (e.g., maintenance work, destructive testing, unique remote site requirements).

Office of the Chief Coroner

In the event of a mine workplace fatality that does not initiate a rescue operation, Ontario Mine Rescue may be called upon to assist in the recovery of the deceased. Though the MLTSD, the local police, and the coroner share jurisdiction over the scene of a mining fatality, it is the coroner's office that holds sole jurisdiction over the body.

As such, Ontario Mine Rescue may be asked by the coroner's office to initiate a body recover operation using mine rescue volunteers who have acceded to an optional request to assist.

Ontario Mine Rescue staff and volunteers may also be called upon as wtinesses to testifiy as part of the coroner's mandatory requirement to conduct an inquest under the Coroners Act.

Discretionary Functions

Requests for assistance outside of the provincial jurisdiction are reviewed on a discretionary basis. External government and private sector mine rescue organizations, as well as private sector mine operators, frequently seek technical support from Ontario given the size of the province's mining sector, strict standards, and comprehensive mine rescue program.

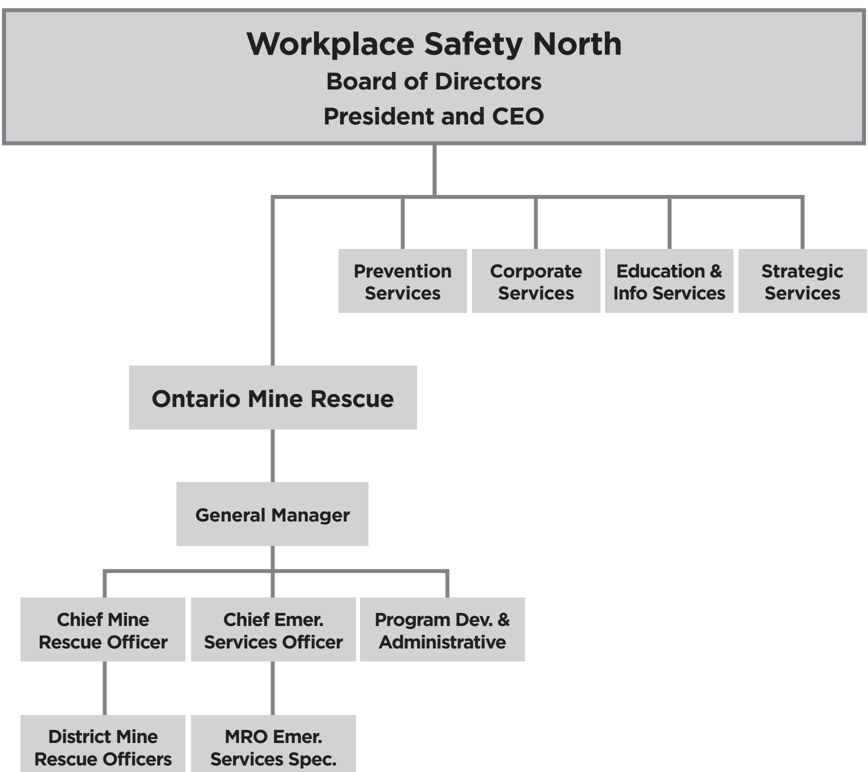
Projects outside of the mandate may only be considered if circumstances within the province have created a window of surplus capacity not required to support an Ontario mine operator.

If all Ontario mine operators are receiving full service and in addition to recovering all direct costs of the work, it can be demonstrated that a project outside of Ontario will return significant economic and/or technical benefit to the Ontario Mine Rescue program, the project will be further reviewed for participation.

Such projects have historically enabled Ontario's program to develop specialized consulting and training expertise, as well as benefit the province's mining industry by adding additional funding to the mine rescue program without the requirement for an employer levy.

Requests from any Ontario emergency services for mine rescue assistance will be reviewed by the Chief Mine Rescue Officer.

ORGANIZATION & STRUCTURE



Ontario Mine Rescue Staff

Vice President Ontario Mine Rescue (General Manager)

Reporting to the President & Chief Executive Officer of Workplace Safety North (WSN), the Vice President of Ontario Mine Rescue (General Manager) is responsible for the leadership, management and supervision of the Ontario Mine Rescue program in accordance with provincial legislation, and terms of the MLTSD Service Level and Transfer Payment Agreements.

Primary functions:

- Conducts annual jurisdictional assessment of current and future mine emergency response requirements of Ontario mine operators
- Develops VP strategic work plan and department plans, ensuring department plans are developed, implemented, monitored and evaluated for both legislated and non-legislated business development programs
- Designs and implements the department structure to ensure resource capability to complete operational plan
- Facilitates the Technical Advisory Committee (TAC) as per the Terms of Reference, as well as any new related committees
- Governs relevant internal and external research studies, projects and committees
- Responsible for the development of the Ontario Mine Rescue long term financial sustainability plan and ensuring strategic future strategic objectives can be achieved through available funding
- Monitors all program operating and capital expenditures to ensure compliance with the annual operational plan and budget forecast. Identifies and corrects deviation from operational plan or budget forecast and makes necessary adjustments to maintain

provincewide emergency response capability

- Sets non-core discretionary revenue generation targets and maintains a forecasted revenue project pipeline
- Reviews non-core discretionary revenue generation contracts to ensure cost control and adherence to terms
- Effective execution and implementation of client, community, and stakeholder engagement plans, financial targets, and related delivery
- Ensures the human resources complement is maintained to meet department objectives by analyzing workload against capacity and adjusting accordingly. Directs recruiting, hiring, deploying, disciplining, and terminating assigned staff
- Establishes relationships with stakeholders and external jurisdictions that will lead to program improvement
- Ensures program technical updates are delivered to all relevant provincial, national, and international forums on mine rescue policy, practice, and technology

Chief Mine Rescue Officer

Reporting to the Vice President of Mine Rescue, the Chief Mine Rescue Officer manages implementation of operational aspects of the Ontario Mine Rescue underground program including supervising the Mine Rescue Officers, assessing program efficiencies through workload analysis and identifying resources aligned with operational objectives. This role provides training, evaluation and direction on standards to Mine Rescue Officers, reviewing audits conducted, evaluating effectiveness, planning for equipment purchases, and controlling costs relative to approved budget forecasts.

Primary functions:

- Maintains mine emergency response capability provincewide for Ontario mine operators at all times

- Builds and maintains working relationships with mining operators in the province. In consultation with Mine Rescue Officers, track industry compliance with program standards and legislated requirements
- Implements process improvements and equipment changes for the Ontario Mine Rescue program
- Acts as WSN Liaison Member according to the Terms of Reference for the Ontario Mine Rescue Technical Advisory Committee (TAC)
- Coordinates the planning, organization, and ensure execution of annual Ontario Mine Rescue District and Provincial Standardized Evaluations
- Delivers Ontario Mine Rescue Management and Advanced Certification courses
- Sets quality control and quality assurance standards and evaluates field level training delivery by Mine Rescue Officers
- Ensures Mine Rescue Officer training records and activity reporting is logged, and validates the province's records
- Identification, scheduling, and execution of Mine Rescue Officer training and certification needs (Instructor Qualification Management Plan) and development of all direct report staff
- Sets and ensures standards are maintained during mine emergency response by Mine Rescue Officers or Relief Officer Personnel, including equipment availability, technical expertise, and emergency response plan consultation with mine operations management
- Manages Mine Rescue Station corporate administration, analyzes costs, and provides recommendations on leasehold improvements and relocations due to mining activity changes in the district
- Manages the mine rescue emergency response vehicle fleet. Analyzes maintenance costs and provides recommendations on fleet usage and replacement

- Manages warehouse inventory levels to ensure an adequate supply of spare parts and supplies

Chief Emergency Services Officer

Reporting to the Vice President of Mine Rescue, the Chief Emergency Services Officer manages implementation of operational aspects of the Ontario Mine Rescue surface and technical rescue programs including supervising Mine Rescue Officer Emergency Services Specialists, assessing program efficiencies through workload analysis, and identifying resources aligned with operational objectives. This role evaluates equipment needs, providing training, evaluation, and direction on standards to program staff, reviewing audits conducted by staff, evaluating effectiveness of program staff, planning for equipment purchases, and controlling costs relative to approved budget forecasts.

Primary functions:

- Implements process improvements and equipment changes for all Ontario Mine Rescue surface and technical rescue programs
- Builds and maintain working relationships with mining operators globally. Core priority focus is given to Ontario firms. In consultation with mine operators, track industry compliance with surface and technical rescue standards and local legislated requirements
- Assists the Ontario Mine Rescue Technical Advisory Committee (TAC) in the development and evaluation of policy, procedures, and equipment relative to the Ontario Mine Rescue program
- Sets quality control and quality assurance standards and evaluates field level training delivery of each Mine Rescue Officer Emergency Services Specialist
- Ensures training, activity reporting, and consulting records for Ontario Mine Rescue surface and technical programs is completed and validates the quality of the data

- Identification, scheduling, and execution of Emergency Services Specialist training and certification needs (Instructor Qualification Management Plan), and development of all direct report staff
- Manages the Mine Rescue Officer Emergency Services Specialist vehicle fleet
- Manages warehouse inventory levels to ensure an adequate supply of spare parts and supplies, essential to keeping Ontario Mine Rescue surface and technical rescue equipment operational
- Oversees technical projects pertaining to surface and technical rescue including research, development of programs, technology, and training initiatives

District Mine Rescue Officer

Reporting to the Chief Mine Rescue Officer, Mine Rescue Officers prepare the mining industry to respond to emergencies and preserve life and property by providing training to mine rescue crew members, ensuring that each person is competent and physically capable of performing their functions, as specified by Reg. 854: Mines and Mining Plants, Sect. 17 (3).

Officers also audit emergency preparedness, inspect, maintain, and repair emergency response equipment, and respond to mine emergencies.

Primary functions:

- Responds to mine emergencies by supplying equipment, providing technical expertise and advice to emergency control groups and rescue teams
- Participates in post-emergency debriefings and make recommendations on areas for improvement
- Manages Mine Rescue Station operational administration including emergency readiness and use as a training facility.

- Coordinates, in conjunction with mine operators, the operational administration and emergency readiness of mine rescue substations
- Maintains a mine rescue vehicle for emergency readiness, as required
- Inspects, maintains, and repairs emergency response equipment to established standards
- Ensures adequate inventory and equipment is provided to each mine rescue substation
- Oversees the active district emergency response volunteer and maintenance technician rosters
- Collaborates with mine operators to develop training schedules
- Develops lesson plans and conducts site visit risk assessments to prepare training sessions for mine rescue equipment, techniques, and procedures.
- Deliver training to mine rescue volunteers and supervise operations conducted during training sessions
- Evaluate the abilities and performance of mine rescue volunteers against established competency standards
- Conduct emergency preparedness and point-in-time audits and make recommendations
- Serve as a technical specialist to the MLTSD regarding the enforcement of mine rescue standards
- Counsels mine operators on issues related to mine rescue such as trainee attendance, emergency preparation, or emergency responses
- Develops District Standardized Mine Rescue Evaluations and collaborates with mine operators to execute the events
- Assists the Chief Mine Rescue Officer in the development and delivery of annual Provincial Mine Rescue Standardized Evaluation

- Provides input into the development of, and standards for use in, mine rescue and recovery operations

Mine Rescue Officer Emergency Services Specialist

Reporting to the Chief Emergency Services Officer, Mine Rescue Officer Emergency Services Sepecialists provide emergency preparedness and response assessments of underground and surface mining operations with traditional and non-traditional firms. The role also provides specialized training to non-underground operations and provides traditional mine rescue training to underground mines.

Primary functions:

- Provides technical consultation and training in areas such as industrial firefighting, mine rescue, emergency response and preparedness, confined space rescue, high angle rope rescue, and hazardous materials and spills response
- Evaluates and provides consultation reports on the state of emergency preparedness of a variety of mining facilities including surface and underground mines, mills, smelters, and refineries
- Evaluates course curriculums and prospective training providers for the purpose of certification
- Participates in the training and evaluation of out-of-province mine rescue site trainers.
- Provides emergency response and training support to District Mine Rescue Officers
- Assists District Mine Rescue Officers in the development and delivery of annual District Standardized Mine Rescue Evaluations and collaborate with mine operators to execute the events
- Assists the Chief Mine Rescue Officer in the development and delivery of annual Provincial Mine Rescue Standardized Evaluation

- Administers emergency preparedness audits, point-in-time evaluations, and risk assessments
- Responds to mine emergencies by supplying equipment, providing technical expertise, and advice to emergency control groups and rescue teams
- Participates in post-emergency debriefings and makes recommendations on areas for improvement
- Coordinates, in conjunction with mine operators, the operational administration and emergency readiness of mine site surface emergency response team facilities
- Maintains a mine rescue vehicle for emergency readiness, as required
- Inspects, maintains, and repairs surface and technical rescue emergency response equipment to established standards
- Collaborates with mine operators to develop training schedules
- Develops lesson plans and conducts site visit risk assessments to prepare training sessions for mine rescue equipment, techniques, and procedures
- Delivers training to surface and technical mine rescue volunteers and supervises operations conducted during training sessions
- Evaluates the abilities and performance of surface and technical mine rescue volunteers against established competency standards
- Conducts emergency preparedness and point-in-time audits and makes recommendations
- Serves as a technical specialist to the MLTSD regarding the enforcement of surface and technical rescue standards

Mine Rescue Stations

Since the inception of Ontario Mine Rescue, the program has a legislated responsibility to establish and maintain a network of Mine

Rescue Stations central to each of the province's mining regions (Reg. 854: Mines and Mining Plants Sect. 17 (1)).

Primary functions:

- Houses mine rescue emergency response and training equipment, as well as consumables in sufficient supply to respond to a district mine emergency without reliance on a neighbouring district
- Houses a mine rescue vehicle capable of being dispatched to a mine emergency with any required equipment or consumables
- Provides facilities for classroom and/or technical and equipment training
- Administrative offices for District Mine Rescue Officers
- Communication and shipping/receiving hub for emergency preparedness and emergency response work

Mine Rescue Substations

As specified in Reg. 854: Mines and Mining Plants Sect. 17 (4)b, mine operators must provide a suitable portion of their surface indoor facilities to function as a mine rescue substation. Substation premises are under the direct administration of the mine operator, while the mine rescue equipment and consumables are under the administration of the District Mine Rescue Officer.

Primary functions:

- Initial fresh air base for establishing a mine rescue operation during an emergency
- Provides facilities for classroom and/or technical and equipment training
- Provides adequate storage for training materials and equipment

Volunteer System

Mine rescue emergency responders are comprised entirely of mine workers who have volunteered through their mine employer for the additional duty. Unlike other jurisdictions that employ full-time mine rescue responders, Ontario's model uses on average, approximately two per cent of the annual production time of a volunteer responder to establish emergency response capability. The system also carries the additional benefit of training and deploying mine workers familiar through their work with the underground workings or surface facilities experiencing an emergency.

MINISTRY OF LABOUR, TRAINING & SKILLS DEVELOPMENT (MLTSD) OVERSIGHT

Service Level Agreement

In 2010, the then Ministry of Labour transferred administration of the Ontario Mine Rescue program from the legacy parent organization (Mines and Aggregates Safety & Health Administration) to the newly formed provincial health and safety association Workplace Safety North (WSN).

Though the Ontario Mine Rescue entity created in 1929 and referenced in Reg. 854: Mines and Mining Plants Sect. 17 (1) has remained functionally unchanged since its inception, WSN entered into a Service Level Agreement with the Ministry of Labour and the Workplace Safety and Insurance Board (WSIB) to outline the responsibilities of all parties to deliver the legislated mandate.

Transfer Payment Agreement

Under the direction of Ontario's Chief Prevention Officer, the province's mine rescue program is provided government oversight by the MLTSD Prevention Office. WSN must submit an annual operational plan for Prevention Office review, and receive an approved schedule of funding and deliverables for the Ontario Mine Rescue program as part of its Transfer Payment Agreement with the MLTSD.

Mining Inspectorate & Enforcement

The operations division of the MLTSD is responsible for application and enforcement of the regulations outlined in Reg. 854: Mines and Mining Plants, including the responsibilities referenced in Section 17 as outlined in Section A of this document. Ontario Mine Rescue Officers have no regulatory enforcement authority but will liaise as technical advisors to MLTSD Mining Inspectors as part of enforcement activities if required to do so.

As the entity specified by the Minister, Ontario Mine Rescue delivers the program on behalf of the MLTSD. Ontario Mine Rescue works proactively with mine operators in the field of emergency preparedness to ensure compliance with the provincial standard and comprehensive mine rescue capability during periods of mine startup, production, and shutdown.

NOTES:

NOTES:

CHAPTER 2

EMERGENCY PREPAREDNESS

To apply an effective response in an emergency situation, there must always be a standard set of procedures and practices to ensure the proper and timely co-ordination of personnel and equipment.

MINE RESCUE POLICY

A five-member mine rescue team will be ready to go underground within 15 minutes of arriving at the mine. Each mine shall have equipment available, such as pressure-demand apparatus, self-rescuers, to equip personnel involved in the immediate evacuation (e.g., hoist personnel, cagetenders and supervisors).

GUIDELINES DURING EMERGENCIES

Every mining company must be able to implement its emergency procedure, and organize and equip the mine rescue team for an underground emergency operation. The following general guidelines have been established for the benefit of mines during an emergency:

- Each mine will initiate a Mine Rescue Officer (MRO) response by calling 1-855-421-9656 and providing the following information:
  – District your mine is in:______________

– Emergency type: Test or Emergency

– Name of mine:___________________

– Address of mine:_________________

– Nature of emergency: Fire, Fall of Ground, Injury, etc. . .

– Name of person calling:_____________

– Phone number to call for additional information:__________

- Once this call is placed, the operator will send a mass text to multiple MROs, as well as the Chief Mine Rescue Officer (CMRO) notifying them of the emergency. Should they not respond to the text within 10 minutes, the operator will start calling each officer starting with the CMRO.
- If a substation at a neighbouring mine serves the mine, the emergency procedure will specify a mode of transportation and list the authorized personnel who will obtain the substation equipment.
- Each MRO will list all available emergency apparatus and equipment in the district emergency plan which will be updated and shared annually with the mine rescue coordinator at each mine site.

PROCEDURE FOR AN UNDERGROUND EMERGENCY

All Ontario mines are to have a standard emergency procedure. **For fire emergencies**, the procedures must include:

1. Any person who detects smoke or discovers a fire that cannot be extinguished, shall immediately notify his/her supervisor or a designated person on surface.
2. The designated person shall arrange to alert all personnel both underground and on surface by means of the stench warning or other approved warning system.

3. Upon receiving the warning, all persons underground shall proceed to a predetermined place, such as a refuge station, a shaft station, or an emergency escapeway, as stated in the fire procedure.
4. When workers are required to go to a refuge station, they shall follow the procedure established for that refuge station.
5. When workers are required to go to an emergency escapeway to surface, they shall immediately proceed to surface and report, in accordance with the established fire procedure.
6. In an underground or tower-mounted hoist room where the normal air supply may become contaminated, a source of uncontaminated air shall be available to the hoist personnel and cagetenders.
7. The person who activates the fire warning system shall notify mine management. Mine management shall follow the fire control procedure and advise persons on the notification chart that there is an underground emergency.

For non-fire emergencies, the procedures must include:

1. Any person who identifies a non-fire emergency underground shall immediately notify his/her supervisor or a designated person on surface.
2. The designated person shall follow the non-fire emergency procedure at their specific mine.
3. Should the use of Ontario Mine Rescue equipment be required, the Mine Rescue Officer call out should be initiated as outlined in **Guidelines During Emergencies** (above).

Mine management has the responsibility to:

- Establish an emergency control group for the direction of mine rescue and recovery procedures
- Ensure personnel underground are located and brought to safety

- Ensure fires are located and extinguished or isolated, or non-fire emergencies are resolved
- Ensure the mine atmosphere and workplaces are in a safe condition before normal mining activity is allowed to resume
- Ensure notices are made to the district MRO as per the regulatory requirements

The district MRO will:

- Ensure that mine rescue equipment is available for use
- Be available at all times to give technical assistance, and if unavailable, ensure a suitable competent person is available
- Ensure that the appropriate Workplace Safety North (WSN) and Ontario Mine Rescue officials have been notified, namely:
  – WSN management personnel
  – The Chief Mine Rescue Officer

– The neighbouring District Mine Rescue Officer

- With his/her superiors, arrange for additional equipment or assistance as needed
- Maintain all Ontario Mine Rescue equipment during an emergency
- Ensure equipment sent to a team underground is first field tested

MINE RESCUE POLICY FOR NUMBER OF PERSONNEL TRAINED

The following information sets out the minimum equipment and trained personnel required on site at all underground mines at startup, during operation and decommissioning. It is recognized that small, new, or decommissioning operations may not be able to support a full mine rescue team, and, in these instances, the mine emergency plan should reflect this. Mutual assistance arrangements should be made with neighbouring properties.

Number of Trained Rescue Personnel Required

Each operating mine in Ontario must have a minimum of 15 mine rescue trained personnel who can respond within 15 minutes of being notified of an emergency without activating a mutual aid response with neighbouring mines.

Additional personnel will also have to be notified to fill the roles of briefing officers and technicians.

Each shift rotation of the mine must be able to satisfy this requirement. The only method used to determine what a fully complemented roster resembles is through realistic point-in-time evaluations done at various hours of the day (i.e., shift change, night shift, holiday weekends, etc.) for each shift rotation.

Active debriefings should be completed after every incident and/or drill to determine if mine rescue volunteer response meets the necessary requirement outlined above.

For mines in startup or care and maintenance, a minimum of one active mine rescue volunteer must be available to act as a guide for teams used through a single-sided mutual aid agreement.

Mutual aid agreements must be in place for large scale emergencies when six- and nine-team rotations are required.

The numbers above are the minimum numbers and, when establishing the mine rescue roster, history has shown that at least 30 per cent of the trained personnel will not be available at any one time, so additional numbers must be included.

Mines that have operating areas with high temperatures, such that modified work schedules are required, should review their personnel needs. During a mine rescue operation, heat exposure limits and additional reserves may be necessary.

Point-in-Time Evaluations

Mine operators should use point-in-time evaluations to assess their response capability and to accurately identify the number of trained personnel required for a site.

To conduct a point-in-time evaluation:

- A point in time is selected.
- All available mine rescue personnel estimates are referenced to this point.
- There is an assumption that an emergency situation requiring mine rescue response has occurred.
- If stench were injected at this point in time, where does the emergency plan require underground workers to report to?
- Establish where all mine rescue personnel identified on the mine rescue roster are at this point in time. They may be underground (unavailable because they are in the refuge station due to the emergency), on surface, at home, etc.
- Are there personnel not available due to vacation, shift work, shift rotation, sickness or other reasons?
- Is there a sufficient number of trained personnel available to respond to this situation?
- This procedure should be repeated on other shifts, varying days of the week and other points in time.
- The results should be recorded in a permanent log book for future reference.
- The emergency plan must be adjusted to ensure an adequate number of trained mine rescue personnel are available.

It is recommended this assessment be conducted regularly until the mine operator is satisfied that the results offer adequate emergency response capability.

It is the responsibility of each owner to assess the emergency response capability so that sufficient mine rescue personnel can be made available on-site.

Personnel requirements are:

- Initial response – one team on site and backup team en route within 15 minutes
- A third team available on-site before a second or backup team can go underground
- Additional teams on-site within six hours

For extended operations, and/or for mines with areas of high operating temperatures, a six- to nine-team rotation will be required.

Ontario Mine Rescue has prepared a Emergency Simulation Guideline for Underground Mines to assist mine operators in conducting effective point-in-time evaluations and emergency simulations.

Arrangements for Mutual Assistance

Mutual aid agreements are intended primarily for mines in the startup or decommissioning stages, as well as for large scale emergencies.

Mine operators are responsible to ensure arrangements are made with other nearby established mining operations for mine rescue assistance. If neighbouring mine rescue teams are required, the property requesting assistance should ensure personnel are available to receive the arriving teams and to act as their on-site guide. The arrangements will be incorporated into the district emergency plan. These are distributed annually to all mines by the Ontario Mine Rescue.

Equipment & Assistance for Small Operations or Operations in Transition

Some mines may not have an on-site mine rescue team, because of startup, decommissioning, or size of workforce. Such mines must prepare a detailed emergency plan that will provide for the prolonged refuge of, or self-evacuation of, employees underground while awaiting the arrival of off-site mine rescue assistance.

This assistance must be prearranged by the operator with neighbouring mines.

Factors influencing the degree and type of protection include:

- Distance of travel, both to site and underground
- Number of people underground
- Location and concentration of employees underground
- Response time for mine rescue assistance
- Underground ventilation system
- Length of time the present transition period will continue (until sufficient personnel for own teams)
- Equipment available at the site
- Whether the emergency plan calls for refuge or evacuation

Options that may be addressed in the emergency plan include:

- Minimum rescue equipment, apparatus and standard equipment available on site
- Temporary or portable refuge stations
- Demand apparatus and jumbo cylinders for hoist personnel and cagetenders as specified in Ontario Reg. 854: Mines and Mining Plants, Sect. 38
- Self-contained breathing apparatus for protection and or self-evacuation of underground employees, i.e., oxygen supplied self-rescuers
- Or any combinations of the above option and/or others

MROs will provide necessary training in the use of breathing apparatus and emergency equipment for mine rescue personnel to ensure the operator can supply an adequate number of guides to responding mine rescue teams.

Seeking Assistance

The Workplace Safety and Insurance Board (WSIB) defines a Mutual Aid Agreement as "a formal agreement between two mining employers under which one employer provides a mine rescue team to the other employer in an emergency."

The participating mine employers must sign the Mutual Aid Agreement, and a copy of the agreement must be submitted to the WSIB for approval and coverage.

Should assistance be required from another mine, in the form of mine rescue teams or equipment from a substation, the mine seeking assistance must notify the district MRO.

It is the district MRO's responsibility to inform the Chief Mine Rescue Officer of the situation. The CMRO will then inform WSN management.

The two mines will co-operate in making the necessary arrangements regarding training, transportation, finances, insurance, etc.

Ontario Mine Rescue has prepared a Health and Safety Report on Mutual Aid Agreements to assist mine operators in creating responsive and effective agreements.

COMPETENCY OF ON-SITE OFFICIAL IN CHARGE

A mine rescue operation at a mine will be under the direction of the supervisor in charge of the mine, and he/she designated as the On-site Official in Charge. To ensure the competency of this person, it is strongly recommended that he/she take the management course in mine rescue offered by Ontario Mine Rescue. Refresher training should be taken every three to five years.

STANDARD MINE RESCUE OFFICER PRACTICES

All District Mine Rescue Officers will:

- Make keys to the Mine Rescue Station available to mine management
- Provide the CMRO and the mine with a schedule of training and monthly itinerary, showing their location in case of an emergency
- Ensure an appropriate number of breathing apparatus are available
- Circulate a written emergency procedure describing the practices in the district to all district mines and all other Mine Rescue Stations
- Be familiar with neighbouring districts and standardize procedures as much as possible for all districts
- Notify the CMRO, local mines, and the neighbouring district MRO, whenever they leave their district

Unless special authorization is obtained from the Chief Mine Rescue Officer, no two adjacent districts will be without the services of at least one MRO.

STANDARD MINE RESCUE SUBSTATION

A substation will be established on a mine site when:

- The size of the operation justifies it.
- Sufficient trained rescue personnel are available.
- The operation cannot be effectively serviced from a Mine Rescue Station or other substation.

A substation will be located as close as reasonably possible to the entrance of the mine, in proximity to the mine's administrative support.

Substations will be equipped as follows. If the time for assistance exceeds:

- One hour – 11 breathing apparatus
- Two hours – 16 breathing apparatus

Acceptable mine rescue facilities must be available before a substation is established. Temporary storage facilities should not be accepted.

The space must be at least 18 ft by 24 ft. The substation should, if at all possible, be on the ground floor with outside access where the Mine Rescue vehicle can be driven to the door. The temperature must be moderate in all seasons, and the space must be lockable and secure.

There must be secure storage space for oxygen cascade systems and spare cylinders. Signs should be provided for both systems, and pressure-indicating devices should be mounted above each cylinder in use. 'No Smoking' signs must be posted near the stored oxygen.

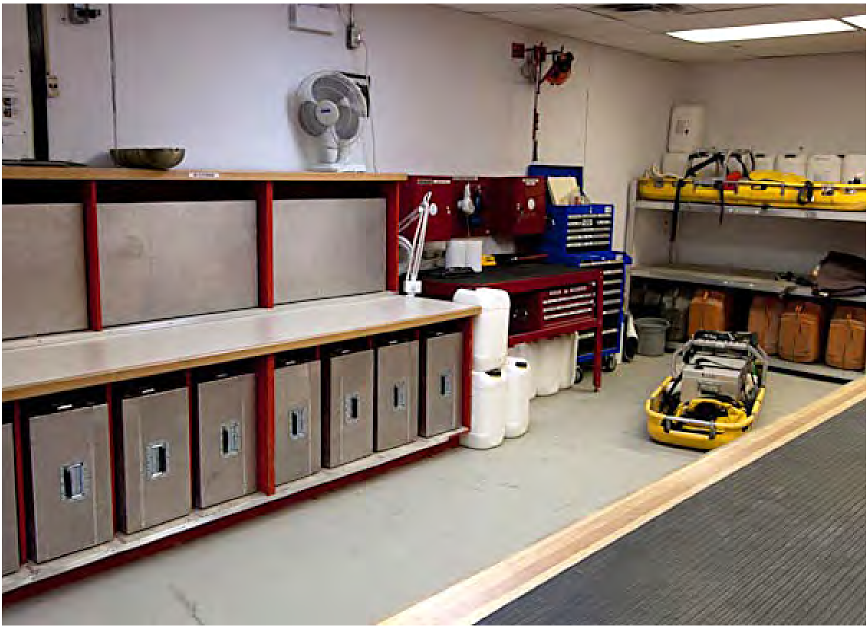
Storage must be provided for the protection of the 11 to 16 Draeger BG4 apparatus and other equipment.

Proper washing and disinfecting facilities must be available. Sinks must be made of polypropylene, fibreglass or stainless steel as these materials do not damage breathing apparatus. Cement laundry tubs are not acceptable.

The sinks must not be used for any other purpose, such as washing floors. They must only be used to disinfect breathing apparatus. A drying rack or air drying system should be provided.

Strong durable tables are needed that can accommodate six personnel field testing breathing apparatus. These tables should be large enough to hold 12 sets of apparatus for service. Stacking chairs are needed for classroom work.

A blackboard or a whiteboard, a cork or bulletin board, and a television or monitor are needed for class work and for team briefings.



A convenient and easily accessible storage space must be available for standard and auxiliary equipment, and briefing maps. A tall metal cabinet with adjustable shelves works well for this purpose.

In the event the equipment stored must be moved to the site of an emergency, a large box or other suitable means must be provided to transport both standard and auxiliary equipment safely and efficiently. An inventory must be kept to ensure no equipment is forgotten.

Mine management must provide the district MRO with a key for the facility.

Minimum Equipment Required at Substations

The purpose of a substation is to enable a mining company to cope with a minor incident. The amount of equipment kept at the substation is determined by the distance from a Mine Rescue Station to that substation.

The following equipment is supplied and maintained by OMR:

- BG4 breathing apparatus (stored with 200 bar/3,000 psi cylinders)
- Spare 200 bar/3,000 psi cylinders for each BG4
- 500 lb soda lime
- Anti-fog dispensers
- Spare masks for BG4s
- Spare gaskets, O-rings and seals for BG4s
- Disinfectant and sterilizing equipment
- Tools for servicing all equipment
- Freezer and ice molds
- Dryer
- Standard Equipment:

  – One iBrid MX6 for each team set of BG4s

  - Four SSR 90 M rescue units
  - Captain's tablet/clipboard, chalk, probe stick, first aid kit, and whistles

The mining company may choose to store its emergency equipment, such as stretcher, jacks, lifting bags, cutting saws, firefighting equipment, and other breathing apparatus in the substation.

The mine must provide the following approved equipment:

- 4 50-ft lengths of 1.5-in fire hose
- 2 firefighting nozzles
- Site-specific adapters fittings and necessary tools
- Additional first aid supplies:
  - Cervical collars
  - Speedsplints
  - Femoral splints
  - Triangular bandages
  - Pressure dressing
  - Bandaids
  - Medical tape
  - Non-stick dressings
  - Burn gel
  - AED (Automated External Defibrillator)
- Assorted spare batteries – i.e., AA, AAA, C, D, and 9-volt
- Hand-held flashlights
- Portable lighting system
- Extension cords, water hose, airlines
- Hand-held tools such as saws, hammers, wrenches, etc.

All equipment must be properly stored and regularly tested to ensure it is emergency ready. Review the Substation Monthly Inspection Checklist in Appendix B (also available on the Ontario Mine Rescue website) for guidance.

TRANSPORTATION/CONVEYANCES

Cagetenders must be trained in the use of self-contained breathing apparatus (SCBA). SCBA for cagetenders must be stored in a known fresh air location and available to the cagetender at all times. Jumbo cylinders of air should be stored in the same area on a cart that can be secured in the conveyance.

Cagetenders must do a pre-operation inspection prior to start of each shift.

During a fire or suspected fire emergency, the cagetender must don a SCBA and move at least two jumbo cylinders of air to the conveyance.

While in the conveyance, the cagetender must use the air from the jumbo cylinders. Should it become necessary for the cagetender to leave the conveyance, he/she must disconnect from the jumbos and use a backpack air source.

Cagetenders must not do arduous work. Aside from running the cage, they should only be given light tasks, such as moving equipment a short distance or closing a nearby door.

Should a cagetender not be available, each mine rescue volunteer at the site must be trained annually on the use and operation of the conveyance.

NOTES:

CHAPTER 3
MINE RESCUE PERSONNEL

SELECTION

It is recommended that new applicants be at least 21 years old, and no older than 45.

The successful selection of suitable personnel for work in mine rescue and recovery depends on the judgment of mine management, the examining physician, and the Mine Rescue Officer (MRO), based on four criteria:

1. Common Core Underground
2. Medical requirements
3. Physical requirements
4. Assurance of qualifications

Common Core Underground

While mine rescuers need not be experienced underground miners, it is important that they have a clear understanding of the underground environment and operations. Applicants must have successfully completed the minimum Common Core Underground modules required to go underground, as well as modules designated by Ontario Mine Rescue (OMR).

The required modules are:

i. U0000 Follow Surface and Underground Induction

ii. U0001 Perform General Inspections

iii. U0002 Scale Loose Rock

iv. U0012 Perform General Lock Out and Tag

Medical Requirements

To identify medical conditions that could put rescuers at risk during a mine rescue operation, applicants must be examined by a physician and certified fit for mine rescue training. If accepted, they must be examined and certified fit annually thereafter to remain in active training.

Mine rescue personnel and other persons assigned to wear SCBA shall have a pre-placement (baseline) medical examination. Special attention should be paid to:

- History of, or presence of, disease of the respiratory system
- History of, or presence of, disease of the cardiovascular system
- Presence of perforated eardrum
- Visual acuity
- X-ray, as prescribed by a physician

The following special tests should be included in the preplacement examination where possible to establish a baseline norm:

1. Electrocardiography
2. Pulmonary function tests
3. Complete blood count
4. Biochemical profile of blood

The examination must be repeated at an annual interval, as well as following a significant illness, to confirm the ability of the person to

safely use self-contained breathing apparatus, and to identify deviations from previous norms.

Volunteers with an expired medical examination will not be allowed to don breathing apparatus.

It is the responsibility of the physician to determine whether the candidate is fit for mine rescue work.

A copy of a physical demands analysis for mine rescue work is available on request for physicians.

Immunization against Hepatitis B is recommended for successful candidates.

The annual medical report form for an applicant for training in mine rescue and recovery consists of two sections – the original of the physical exam is kept by the physician; a section signed by the physician indicating the candidate is fit for mine rescue is kept by the employer, and a copy of that section is submitted to the MRO.

Physical Requirements

No specific height, weight, or strength standards exist for mine rescue, but the physical demands may be extreme for extended periods. It is a highly demanding activity with a high risk of a heat stress or cardiovascular event. Applicants should have healthy, active lifestyles.

It is the responsibility of the examining physician to be aware of the physical and emotional demands put on workers during a mine rescue and recovery operation. Successful applicants, however, should commit to regular fitness activities to help protect themselves from injury, including heat strain.

Introductory and refresher mine rescue training will challenge the fitness of applicants and participants.

Persons over the age of 60 should not engage in rescue and recovery work that involves wearing oxygen breathing apparatus.

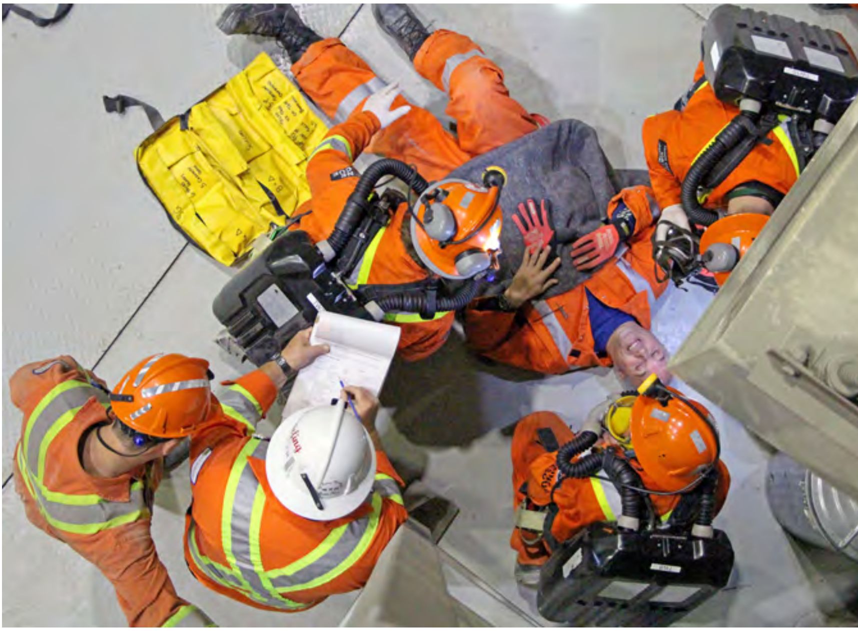
Assurance of Qualifications

The MRO must be assured that a candidate has good potential for developing into a qualified member of a mine rescue team, and that a current member has the ability to remain as a qualified team member.

To qualify as an active mine rescue team member, a person must successfully complete the introductory and refresher mine rescue training as required, and demonstrate the necessary physical and mental abilities to do mine rescue work.

A member of a rescue team should be:

1. In good health, physically fit, and regularly engaged in fitness activities
2. Clean-shaven, with no facial hair that at any point comes between the face and the seal of the facemask (even a day's growth of stubble can impair the seal)



3. Calm and self-controlled in emergency and danger
4. Known to be of good judgment and initiative
5. Capable of performing long and arduous physical labour
6. Familiar with underground mining conditions and practice
7. A holder of a valid first aid certificate with training in all components designated by the Handbook of Training in Mine Rescue and Recovery Operations (See Chapter 13 – First Aid for a list of required components.)
8. Able to communicate in the working language of the mine

MAINTENANCE OF ACTIVE STATUS

Volunteers will maintain active status provided:

- They attend and participate in all refresher training sessions.
- They demonstrate competencies as required in refresher sessions.

- They are certified fit by a physician following an annual medical examination.
- They hold a valid first aid certificate, including the modules designated by OMR.
- They are clean-shaven, with no facial hair that at any point comes between the face and the seal of the facemask.
- They attend all refresher sessions and emergency call-outs clean shaven and physically fit to wear breathing apparatus.

Note: Attending all refresher training sessions is critical. Volunteers who miss or fail to complete one session will have their status reviewed based on past attendance, mine rescue experience, emergency call-out involvement and competition experience. Should their evaluation fall below minimum expectations, they will be deemed inactive.

Further, volunteers who miss or fail to complete two refresher training sessions within a 12-month period will be immediately deemed inactive.

Inactive volunteers will not be permitted to don OMR-owned breathing apparatus during an emergency.

To regain active status, the volunteer must successfully complete six consecutive refresher training sessions or, once again, successfully complete Introductory Mine Rescue Training.

TRAINING

The primary focus of mine rescue training is on mine rescue team members, who require an on-going training regime to maintain and improve their skills and knowledge of mine rescue techniques and procedures. However, training for support roles, as well as post-secondary students in mining programs, is also an important component of mine rescue.

Ontario Mine Rescue

HAS CONFERRED UPON

OF

FOR KNOWLEDGE OF MINE RESCUE BREATHING APPARATUS AND THE DEMONSTRATION OF LONG AND ARDUOUS PHYSICAL LABOUR UNDER LIMITED VISIBILITY CONDITIONS

Introductory Mine Rescue Certification

CERTIFICATION QUALIFIES UNDER ONTARIO OHSA R.R.O. 1990, REG. 854: MINES AND MINING PLANTS SEC. 17(2)(B). TO RETAIN CERTIFICATION, COMPETENCY MUST BE DEMONSTRATED DURING REGULAR MINE RESCUE TRAINING AND EVALUATION.

TRAINED UNDER THE DIRECTION OF

MINE RESCUE OFFICER
RED LAKE DISTRICT

ONTARIO MINE RESCUE
PREPARED SINCE 1929

JANUARY 31, 2020

APPROVED BY

SHAWN RIDEOUT
CHIEF MINE RESCUE OFFICER
ONTARIO MINE RESCUE

TED HANLEY
VICE PRESIDENT
ONTARIO MINE RESCUE

CERTIFICATE NUMBER
RL-1396-20

Workplace Safety North™

In all courses, participants who place their safety or the safety of other participants at risk can be suspended and dismissed from further training by the MRO.

Introductory Mine Rescue Training

To qualify as an active mine rescue team member, a candidate must successfully complete the competency-based five-day, 40-hour introductory training course. Topics include legislated requirements governing mine rescue, mine gases, and basic mine rescue equipment, operations and procedures.

Successful candidates are qualified to use and service the BG4 breathing apparatus. Whenever possible, some practical training is done in smoky and irrespirable atmospheres.

Candidates must pass a practical exam, and a written exam with a mark of at least 70 per cent. Successful candidates receive an Ontario Mine Rescue Certificate with a seal.

Refresher Mine Rescue Training

Active members must receive at least six eight-hour standardized training sessions annually to cover basic and advanced training topics. The sessions, normally scheduled on a bi-monthly basis, consist of customized, on-site training delivered by MROs.

Practical sessions resemble as closely as possible actual emergency situations with the MRO acting as the briefing officer/on-site official in charge. They are conducted in an underground environment and apply standard competency-based mine rescue practices and procedures.

Refresher training is necessary to maintain the competency of mine rescue team members and will challenge their physical fitness. Mine rescue personnel may be deemed inactive should they miss or fail to complete one session and will be deemed inactive if they miss or fail to complete two within a year. Volunteers must also demonstrate competency in the use of critical mine rescue equipment, such as breathing apparatus.

Training for district and/or provincial mine rescue evaluations will not be considered a substitute for refresher training.

Advanced Mine Rescue Training

Any individual active in OMR for two or more years may attain Advanced Certification through a one-day course. It involves competency evaluation in the use of special rescue and extrication equipment, techniques, and procedures, as well as more detailed coverage of breathing apparatus and standard equipment.

Participants are required to successfully complete a written test on OMR functions and procedures, demonstrate the use of primary and secondary breathing apparatus, standard equipment, and randomly selected special equipment.

Upon successful completion, participants are provided with a gold seal to attach to their Ontario Mine Rescue Certificate.

Mine Rescue Technician Training

The Technician program is a comprehensive introductory three-day, 24-hour course, that trains individuals in procedures for maintaining and repairing key equipment used by OMR. Topics include Draeger BG4 apparatus troubleshooting and repair, Panorama Nova and FPS 7000 facemask rebuilds, oxygen booster pump operation, servicing the SSR 90 M, and maintaining other specialty equipment.

Upon successful completion of this course, participants will receive a Basic Technician Certificate. To remain competent, technicians, if active mine rescuers, must successfully complete a one-day technician refresher session delivered by a MRO annually. If not active mine rescuers, technicians must attend at least two regular mine rescue refresher training sessions, successfully complete a one-day technician refresher session annually, and complete a substation audit as directed by a MRO.

Briefing Officer Certification

The Briefing Officer Certification is a three-day theory and practical course to provide individuals with the skills and knowledge to serve as a briefing officer during a mine emergency. It is recommended that participants have experience in mine rescue or emergency response services.

Topics include the roles and responsibilities of a briefing officer, the use of mine rescue equipment, mine rescue hazards, and mine rescue operations and procedures. Participants must also demonstrate the ability to prepare mine rescue team assignments in a timely manner, and the ability to make safe and effective decisions.

Participants must pass a three-part exam with a mark of at least 80 per cent to receive Ontario Mine Rescue Briefing Officer Certification.

To remain active, successful applications must attend at least two refresher training sessions a year.

Supervisory Mine Rescue Training

Supervisory mine rescue training, or Day 1 of the Supervisory/Management course, is designed for underground supervisors who have no previous training in mine rescue. Training covers the history of mine rescue, mine gases, breathing apparatus, and underground emergencies. A written examination with a passing mark of at least 70 per cent is required. Successful candidates will receive a Supervisory Mine Rescue Certificate.

Management Mine Rescue Training

Management mine rescue training is a two-day, 16-hour course designed to give management a thorough knowledge of Ontario's mine rescue program and management's responsibilities during an emergency.

Participants with mine rescue experience need not attend Day 1, the supervisory mine rescue training portion of the course. The second day consists of numerous case studies that require extensive problem-solving and decision-making skills that control group members will exercise during a real-life emergency.

Refresher training should be taken every three to five years depending on frequency of incident response involvement. Successful candidates will receive a Management Mine Rescue Certificate.

A mine rescue operation at a mine will be under the direction of the supervisor in charge of the mine. To ensure the competency of this person, it is strongly recommended that he/she take the management course in mine rescue training.

Student Mine Rescue Training

Student Mine Rescue Program is a modified, four-day introductory course that has been offered for more than 40 years to students at participating post-secondary institutions including Haileybury School of Mines, Queen's University, Laurentian University, University of Toronto, and others with mining programs. Successful students are awarded a Mining Student Training Certificate. Student training does not qualify a participant to be an active mine rescue volunteer. Would-be volunteers must be employed by an Ontario mine and complete an Introductory Mine Rescue Training.

ANNUAL STANDARDIZED EVALUATIONS

Annual standardized evaluations, commonly referred to as competitions, are required to ensure mine rescue volunteers within each district and across Ontario are trained to respond using the same best-practice procedures and to the same high standards. Annual standardized district evaluations are performed within the first two weeks of May.

For the evaluation, each operating mine must, at a minimum, release one six-member team, a briefing officer and a technician to attend three days of training for the evaluation, and the four consecutive days required for the evaluation.

Mines in startup or care and maintenance will be required to release at least one active mine rescue volunteer to assist with setup and/or judging of the district evaluation.

The top rated team and technician in the district standard evaluation, must also be released for five days of training for the provincial evaluation (Ontario Mine Rescue Provincial Competition) as well as a week to participate in that evaluation, which occurs within the first two weeks of June. Each mine is responsible for all travel expenses for their team to participate in the district and provincial evaluations.

EMERGENCY SERVICES TRAINING DIVISION

Ontario Mine Rescue's Emergency Services Training Division offers specialize emergency response training for surface operations at mines and industrial operations. Courses may be customized to on-site requirements or limited to individual emergency response components, such as rope rescue.

Industrial Fire Brigade Training – a comprehensive course offered on-site covers firefighting in-depth including fire behaviour, suppression techniques, and more. It also covers associated emergency response tasks such as self-contained breathing apparatus, and search and rescue. This course is NFPA 1081 Industrial Fire Brigade compliant.

Hazardous Material Spill Response – a three-day course offers a combination of knowledge and skills development. Classroom presentations and course materials cover the basics of material identification systems, while practical exercises focus on containment, detection and decontamination activities.

Confined Space Rescue – a knowledge and skills development course, which may be presented on-site if suitable facilities are available, covers legislation imposing rescue requirements, suspension trauma, rope rescue equipment and techniques, as well as rigging configurations, rescue knots, and anchorages.

NOTES:

CHAPTER 4

MINE GAS PROTECTION POLICY

BREATHING APPARATUS APPROVALS AND STANDARDIZATION

The Ontario Ministry of Labour, Training and Skills Development only permits the use of approved respiratory protection in underground mines. The breathing apparatus referred to in this handbook are those used by Ontario Mine Rescue. The following approvals are accepted:

1. The National Institute for Occupational Safety and Health (NIOSH) in the U.S.
2. The European Norm Standard (EN Standard)

The approvals of other similar qualified authorities may also be accepted.

TEAM PROTECTION

The first team entering a mine where there is a report of smoke or potential gases will get under apparatus in fresh air before entering the mine. No other team shall enter the mine without apparatus until there is a proven clear travel way to an advanced fresh air base or a designated work area.

TIME LIMITS

No mine rescue team member should remain on shift longer than six hours. During this period no one should be permitted to remain under oxygen longer than two hours, except in an extreme emergency.

Further, no one should be permitted to undertake a second shift until they have had at least six hours rest. Personnel exposed to extreme heat and work under the time limits of the Ontario Mine Rescue Heat Exposure Standard, must have 24 hours rest.

GAS CHECKING GUIDELINE

Legislation and guidelines, such as the Occupational Health and Safety Act (OHSA), the American Conference of Industrial Hygienists (ACGIH), and the U.S. National Institute for Occupational Health and Safety (NIOSH) set exposure limits or threshold limit values based on the time an individual is exposed to a hazardous substance and the concentration of the hazardous substance.

Unless otherwise indicated, Ontario Mine Rescue references the threshold limit values established by the OHSA, including Reg. 833: Control of Exposure to Biological or Chemical Agents, which may vary from and takes precedence over those established by the ACGIH, which reviews and revises its TLVs annually. Hence, this book should not be used as a gas checking authority.

USE OF ONTARIO MINE RESCUE EQUIPMENT FOR GAS CHECKS

Requests to use mine rescue equipment for gas checks is not common and is not encouraged, however, requests will be considered. Examples for the need of the BG4 apparatus for gas checking include but are not limited to:

- Travelling long distance through contamination to clear an area of blast gases where the means of travel is limited to walking and the use of PremAire or other dual supply apparatus is not an option

- Having to undertake a large vent job to reventilate an area with an irrespirable atmosphere.

Any mine wishing to use mine rescue equipment for non-emergency gas checking shall contact the district Mine Rescue Officer (MRO) with a written plan on how they wish to use the equipment. The request will be reviewed by the district MRO and the Chief Mine Rescue Officer who reserve the right to decline the request.

NOTES:

CHAPTER 5

EMERGENCY RESPONSE POLICY

SIMPLIFIED ONTARIO MINE EMERGENCY INCIDENT COMMAND

As defined in Ontario Reg. 854: Mines and Mining Plants Sect. 17 (7), in the event of a mine emergency, oversight of the mine rescue and emergency response operation is the legal responsibility of the mine operator's senior On-site Official in Charge.

At the first report of a mine emergency requiring a formal mine rescue operation, it is the responsibility of the On-site Official in Charge to form a Control Group. Reporting to the On-site Official in Charge, the Control Group will act as the central communication and decision-making point during a mine rescue operation.

Control Group ideal composition:

- Technical services (planning, ventilation, ground control)
- Mine production (senior supervisors)
- Site central control and communications (security, safety, systems)

The roles and responsibilities overseen by the senior On-site Official in Charge and Control Group are numerous and include critical activities outside of the emergency response deployment. However, specific to the deployment of a formal mine rescue response, the Control Group must communicate and issue instructions directly to:

- Fresh air base coordinator organizing teams
- Briefing Officer assigned to each team
- Mine Rescue Officer (MRO)

ESTABLISHING A MINE RESCUE OPERATION

Call Out & Activation Requirements

It is the responsibility of the mine operator to implement and maintain a rapid call-out and notification system that is capable of tracking responder availability, and notifying and confirming that the required number of volunteers will be en route within 15 minutes of initiation.

Function of the system itself must be tested on a monthly basis (does not require volunteer notification), and a test of the notification and confirmation process must be completed every six months (requiring volunteer test notification).

Fresh Air Base & Advanced Fresh Air Bases

It is the responsibility of the mine operator to ensure the site mine rescue substation is maintained in an emergency-ready state at all times for initial organization of the fresh air base of operations. When not in use for mine rescue training, the ubstation must not be used for purposes that would render it temporarily unavailable should a mine emergency occur.

At the onset of a mine emergency, additional space outside of the substation must also be identified as part of the fresh air base for the temporary rallying of mine rescue standby personnel, equipment, and logistical supplies outside of the work area of mine rescue teams preparing to deploy.

It is the responsibility of the Control Group to identify, at the earliest possible opportunity, the location of an advanced fresh air base and begin preparations to establish the location by advancing standby teams and equipment. This initial identification and preparation for advanced staging should be conducted during every mine rescue operation, regardless of eventual duration as the groundwork for reducing critical travel times for teams.

Briefing Officer & Communications

Each Briefing Officer assigned to an individual team must be given an independent workstation that is separated visually and audibly from both the Control Group and fresh air base. The workstation should be within reasonable distance of both.

This policy is to ensure the Briefing Officer experiences no distractions from his/her primary objective of maintaining continual communication and record keeping with the deployed mine rescue team assigned to them. History has shown that Briefing Officers assigned to work in the same location as the Control Group and On-site Official in Charge experience errors in their record keeping and team communication.

The Briefing Officer workstation must be equipped with all available forms of site communication (e.g., phone, site radio and/or mobile reception, Wi-Fi, and network).

Team Composition

During the initial organization of the fresh air base and once information has been relayed from the Control Group regarding the nature of the emergency response, selection and composition of the responding teams is a critical role. Ontario Mine Rescue best practice stipulates that the most senior mine rescue responder or official act as fresh air base coordinator (to be replaced as necessary) and work in conjunction with the responding Mine Rescue Officer to review available responders and select teams.

This allows the fresh air base coordinator to apply relevant filters or restrictions known to the mine operator regarding responder capability (e.g., medically inactive), as well as the MRO to make recommendations regarding the training competencies and experience. Additionally, available responders should be canvassed for technical skillsets specific to the information provided by the Control Group.

In the event of a report of a fire or contamination of the working ventilation, standard deployment of a five-member mine rescue team under breathing apparatus is required.

In the event of a mine emergency unrelated to fire or contamination of the working ventilation, multiple teams of as few as two individuals may be formed and deployed, but must be backed up by an equivalent number of standby responder teams.

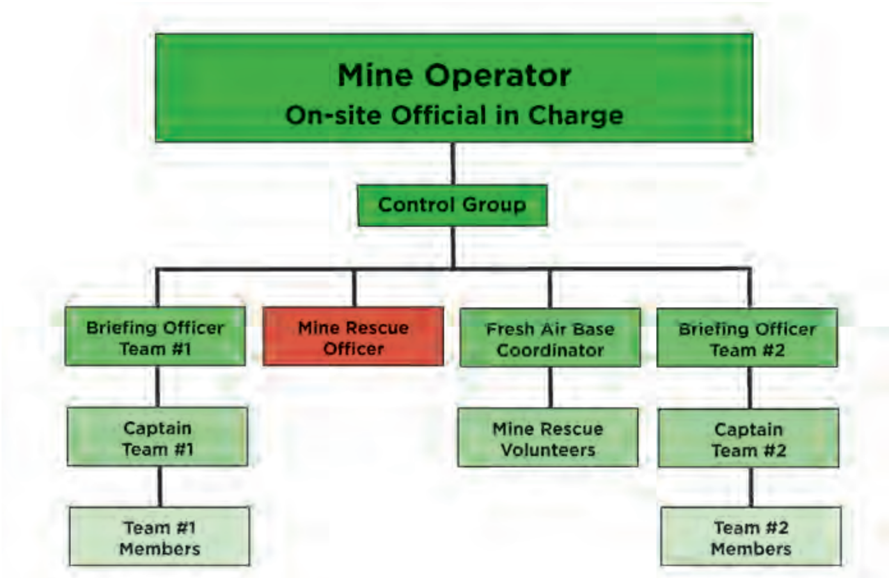
MINE RESCUE OFFICER

Proceeding to an Emergency

Once notified of a mine emergency, Mine Rescue Officers travelling to a mine site in an Ontario Mine Rescue vehicle must travel in accordance with the Highway Traffic Act. However, the act defines Ontario Mine Rescue vehicles as an "emergency vehicle" (Sect. 159 (11)c) as it pertains to the use of flashing lights and the statutes surrounding yielding to emergency vehicles.

Technical Advisory Role

It is the responsibility of the responding MRO to make themselves available to the On-site Official in Charge, Control Group, fresh air base coordinator, Briefing Officers and responding volunteers in a technical advisory capacity. The MRO has the responsibility to consider all team deployment and mine recovery plans made by the Control Group and Briefing Officers and provide feedback regarding the risk profile of those plans.



If during the course of a mine rescue operation instructions are to be issued that would endanger responders or miners taking refuge, it is the responsibility of the MRO to notify the Control Group and request a change of plan. If no change is agreed to and the instructions pose an immediate danger to those involved, it is the responsibility of the MRO to either notify the attending Ministry of Labour, Training and Skills Development Mining Inspector and/or de-activate and de-mobilize the Ontario Mine Rescue equipment to be used as part of the operation as a means of delaying the hazardous instruction until it can be further reviewed.

Record Keeping

It is the responsibility of the On-site Official in Charge to ensure a member of the Control Group or support staff is present in the Control Room and performs comprehensive time-stamped record keeping of all events following the initiation of an emergency response, from beginning to end. Record keeping includes but is not limited to, initial collection of information, decisions made, instructions issued, communication with underground workers, and communication with surface mine rescue personnel including the Fresh Air Base, Briefing Officers and Mine Rescue Officer.

In addition, it is the responsibility of the responding MRO to maintain a record of his/her participation following the initiation of an emergency response and continuing to its conclusion.

POST EMERGENCY

Incident Reporting

It is the responsibility of the responding Mine Rescue Officer to compile his/her own incident notes, as well as a collection of information pertaining to the mine rescue emergency response into an Ontario Mine Rescue incident report. A list of MRO reporting requirements is shown below. It is the responsibility of the mine operator to provide information, relevant to the mine rescue operation only, to the MRO in a timely manner for the completion of the incident report.

List of mandatory incident report requirements:

- Date of incident
- Mine site
- Underground/surface location
- Time of incident (or report of)
- Time first mine rescue team on site
- Time Mine Rescue Officer notified
- Time Mine Rescue Officer arrives on site
- Responding Mine Rescue Officer(s)
- Relief Mine Rescue Officer on-call (if applicable)

- Total number of responding volunteers (or teams on site)
- List of responding volunteers
- Was mutual aid required
- Time Team #1 deployed to emergency
- Number of injured personnel
- Number of personnel in refuge stations
- Number of mine rescue volunteers in refuge stations
- Number of active mine rescue volunteers at time of incident
- List of teams activated, team members including Briefing Officer
- List of oxygen times of activated teams
- Chronological/time-stamped narrative of events
- List of recommendations
- Captain Reports
- Briefing Officer Reports
- Mine plans

Debrief

It is the responsibility of the mine operator to conduct a debrief meeting with the responding Mine Rescue Officer following the conclusion of an emergency operation. Should the mine operator be unable to permit the Mine Rescue Officer to an internal debrief, a separate meeting must be scheduled to allow the Mine Rescue Officer to collect missing information, receive feedback from the mine operator, and discuss his/her recommendations. It is recommended senior mine rescue personnel, team captains, and briefing officers be considered for participation in all debrief meetings for accurate review of the events.

Critical Incident Stress Support

Following a mine rescue operation, it is the responsibility of the mine operator to have available a process or service in support of critical incident stress management for site personnel involved in the emergency.

Best practice dictates this support process or service should have a pre-established relationship with the mine operator and have been reviewed for validity and availability in the past six months. Support services must be offered, and in some cases scheduled as a return-to-work requirement, as soon as is reasonably possible following the incident and not to exceed a delay of one week.

NOTES:

NOTES:

SECTION TWO

CHAPTER 6

MINE GASES

AIR

Air is the transparent medium surrounding the earth in which plants, animals and human beings live and breathe. It is a mixture of several gases, which, though ordinarily invisible, can be weighed, compressed to a liquid, frozen to a solid, and have their own specific gravity or weight. Air has a specific gravity or weight of 1.0.

Pure, dry air at sea level contains, by volume:

- Nitrogen (N_2) – 78.09 per cent
- Oxygen (O_2) – 20.94 per cent
- Argon (Ar) – 0.94 per cent
- Carbon dioxide (CO_2) – 0.03 per cent

Traces of gases such as hydrogen and helium are also present.

Mine air may be contaminated by other gases such as:

- Carbon monoxide (CO)
- Sulphur dioxide (SO_2)

- Hydrogen sulphide (H_2S)
- Methane (CH_4)
- Oxides of nitrogen (NO_x)

The presence of these gases may be due to:

1. Blasting or other explosions
2. Mine fires
3. Naturally occurring gas emissions
4. Absorption of O_2 by water, timber or ore
5. The use of diesel engines underground

Except in the case of fire, any dangerous accumulation of these gases or a depletion of O_2 content can be prevented by proper air ventilation.

Gases may be considered harmful if they are:

- Combustible or explosive
- Poisonous
- Capable of displacing O_2

The effects may depend on atmospheric conditions, including altitude, temperature, and humidity.

EXPOSURE LIMITS

Legislation and guidelines, such as the Occupational Health and Safety Act (OHSA), the American Conference of Industrial Hygienists (ACGIH), and the U.S. National Institute for Occupational Health and Safety (NIOSH) set exposure limits or threshold limit values based on the time an individual is exposed to a hazardous substance and the concentration of the hazardous substance.

Unless otherwise indicated, Ontario Mine Rescue references the threshold limit values established by the OHSA, including Ontatio

Regulation 833: Control of Exposure to Biological or Chemical Agents, which may vary from and take precedence over those established by the ACGIH, which reviews and revises its TLVs annually. Hence, this book should not be used as a gas checking authority.

Reg. 833 defines the time-weighted average limit (TWA) as the time-weighted average airborne concentrations of a biological or chemical agent to which a worker may be exposed in a workday or a workweek.

It also defines the short-term exposure limit (STEL) as the maximum airborne concentration of a biological or chemical agent to which a worker may be exposed in any 15-minute period, no more than four times during an eight-hour work shift, with at least one hour between exposures.

Individuals exposed to hazardous gases beyond the TWA or the STEL will experience an adverse reaction.

Immediately Dangerous to Life or Health (IDLH) refers to an atmosphere that poses an immediate threat to life, will cause irreversible adverse health effects, or will impair a worker's ability to escape from the environment.

An IDLH situation, requiring the use of breathing apparatus, must be assumed in the presence of any of the following:

1. A known contaminant in an IDLH concentration
2. A known contaminant, but at an unknown concentration
3. An unknown contaminant
4. An O_2 deficiency
5. A confined space
6. Contaminants at or above their lower explosive limit
7. Firefighting

MEASUREMENT

Mine gases and contaminants are typically, but not always, measured in parts per million (ppm). Some gases, notably oxygen, are measured in per cent volume. The ratio to convert from one measurement to the other is 10,000 ppm to 1 per cent volume.

For example, O_2 at 20.94 per cent volume is 209,400 ppm, and CO at 1,200 ppm is 0.12 per cent volume.

Formula: 10,000 ppm = 1% volume

Examples: O_2 at 20.94% = 209,400 ppm

CO at 1,200 ppm = .12% volume

Further, combustible/flammable gases may be also be measured as a per cent of their lower explosive limit (LEL). The LEL is the lowest concentration of a gas or vapour that will produce a flash when an ignition source is present.

For example, methane (CH_4) is explosive in the range of 5 to 15 per cent volume, or 50,000 to 150,000 ppm, so its LEL is 5 per cent or 50,000 ppm.

Example: CH_4 explosive range 5 to 15% volume or 50,000 to 150,000 ppm

0.05% vol = 500 ppm = 1% LEL

0.5% vol = 5,000 ppm = 10% LEL

5% vol = 50,000 ppm = 100% LEL

Stating combustible gas measurements as a per cent of LEL is a clearer statement of the risk level. CH_4 at 5 per cent volume or 50,000 ppm is 100 per cent LEL.

Nitrogen (N_2)			
Spec. Gravity:	0.97	**Explosive Range:**	No
Colour:	No	**Combustible:**	No
Odour:	No	**Taste:**	No
Toxic:	No		
Other: Dangerous if displaces O_2			

NITROGEN (N_2)

Nitrogen is inert, colourless, odourless, tasteless, and the most abundant gas in the atmosphere. It will not burn or explode, nor will it support combustion. It has no physiological effect on humans and is only dangerous if it has displaced the O_2 below a safe limit. Nitrogen has a specific gravity of 0.97, slightly lighter than air.

Higher than normal concentrations of N_2 may be caused by the oxidation of various substances, the burning of an active fire or the consumption of O_2 by water in confined spaces.

In the mining industry, N_2 is used to purge storage tanks and electrical installations, and to operate pneumatic hand tools. It may be found stored in large (2,200 psi/152 bar) compressed gas tanks on surface.

Oxygen (O_2)			
Spec. Gravity:	1.11	**Explosive Range:**	No
Colour:	No	**Combustible:**	No
Odour:	No	**Taste:**	No
Toxic:	No		
Other: Required to support combustion; essential to life			

OXYGEN (O_2)

Oxygen is a colourless, odourless, tasteless gas and is the most important constituent of air. It is necessary to sustain life and though on its own, it will not burn or explode, O_2 is needed for combustion to occur. Oxygen has a specific gravity of 1.11.

People breathe most easily and work best when the air contains approximately 21 per cent O_2. When the O_2 content is about 17 per cent, people at work will breathe a little faster and more deeply. The effect is about the same as when going from sea level to an altitude of 1,700 metres.

A person breathing air containing as little as 15 per cent O_2, usually becomes dizzy, notices a buzzing in the ears, has a rapid heartbeat and may have a headache. Very few people are free from these symptoms when the O_2 level falls to 10 per cent.

The effects of O_2 deficiency near or below sea level are the same as those of a reduction in O_2 at high altitudes. At approximately seven per cent O_2 the face becomes leaden in colour, the mind becomes confused, and the senses dulled.

When there is no O_2 in the atmosphere, loss of consciousness occurs quicker than in drowning. Not only is the supply of O_2 cut off, but the O_2 in the lungs is rapidly depleted. Loss of consciousness is followed by convulsions, then cessation of respiration.

Effects of Oxygen (O_2) Deficiency	
Concentration	**Symptoms**
18-20%	None, normal pulse & respiration
14-18%	Increased pulse & respiration, muscular co-ordination disturbed
10-14%	Abnormal fatigue, disturbed respiration
7-10%	Nausea, vomiting, collapse, loss of consciousness
<6%	Convulsions, respiratory collapse death

Oxygen deficiency is one of the greatest gas hazards in underground mining. The effects of extreme O_2 deficiency are so rapid that a person's life is in peril before he/she realizes the danger.

Causes of O_2 deficiency underground are:

- Absorption by water or certain types of rock or fill
- Breathing by people in confined spaces
- Displacement by CH_4, CO or other gases
- Combustion or heating situations

Mine air must have a partial pressure of 18 kpa which is approximately 21 per cent oxygen.

Breathing O_2 in concentrations higher than the normal 20 to 21 per cent has no injurious effect. The inhalation of 100 per cent O_2, as used in breathing apparatus, for up to 16 hours a day for many days at atmospheric pressure, has caused no observed harm to humans. At atmospheric pressure, it is believed to have no serious effects for a continuous exposure of 24 to 48 hours.

The inhalation of pure O_2 at a pressure of three atmospheres (3.0 bar) is safe for a period of 30 minutes. After three hours of inhaling 100 per cent O_2 at more than one atmosphere (1.0 bar), neuromuscular co-ordination and the power of attention may be adversely affected.

An oxygen-enriched atmosphere, 23 per cent oxygen or greater, according to the Ontario Ministry of Labour, Training and Skills development, is a potentially serious fire hazard. Such a situation may be created when O_2 breathing apparatus or other O_2 equipment is being used, particularly in confined spaces such as tanks, wells, or enclosed rooms.

Carbon Dioxide (CO_2)			
Spec. Gravity:	1.53	**Explosive Range:**	No
Colour:	No	**Combustible:**	No
Odour:	No	**Taste:**	Acidic if breathed in large quantities
Toxic:	Yes, in high concentrations	**IDLH:**	40,000 ppm
TWA:	5,000 ppm	**STEL:**	30,000 ppm
Other: Toxic only in high concentrations			

CARBON DIOXIDE (CO_2)

Carbon dioxide is a colourless, odourless gas that, when breathed in large quantities may have a distinct acid taste but is otherwise tasteless. It will neither burn, nor support combustion.

Increases in CO_2 could cause headaches, dizziness, restlessness and disorientation, followed by paralysis of the central nervous system. Moving around or working increases the effects.

Carbon dioxide has a specific gravity of 1.53, and is often found in unventilated areas and abandoned mine workings. It is normally found

Effects of Carbon Dioxide (CO_2)	
Concentration	**Increase in Respiration**
0.5%	Slight
2%	50%
3%	100%
5%	300% & labourious
10%	Cannot be endured for more than a few minutes

in mine air but the concentration can be increased by breathing, the burning of fires, as well as explosions and blasting.

Carbon dioxide is produced by the decomposition and the combustion of organic compounds in the presence of O_2, and also by the respiration of humans and animals.

When the concentration of CO_2 in the air is more than five per cent, the O_2 content is usually considerably lower than normal and the distinct acid taste is noticed.

Carbon Monoxide (CO)			
Spec. Gravity:	0.97	**Explosive Range:**	12.7-74%
Colour:	No	**Combustible:**	Yes
Odour:	No	**Taste:**	No
Toxic:	Yes	**IDLH:**	1,200 ppm
TWA:	25 ppm	**STEL:**	---
Other: Blood has greater affinity for CO than O_2			

CARBON MONOXIDE (CO)

Carbon monoxide is a colourless, odourless, tasteless gas that, when breathed, even in low concentrations, will produce symptoms of poisoning.

Carbon monoxide is one of the greatest gas hazards in underground mining. It is produced by combustion in blasting operations, the operation of diesel engines, mine fires, and gas explosions.

CO results from incomplete combustion when organic compounds are burned in an atmosphere with too little O_2 to carry the burning or oxidation to completion.

Carbon monoxide will burn, and in concentrations of 12.5 to 74 per cent, will explode if ignited. It is only slightly soluble in water and is not removed from the air to any extent by water sprays. It is slightly lighter than air, having a specific gravity of 0.97.

The TWA of CO is 25 ppm or 0.0025 per cent.

Carbon monoxide causes increasingly severe toxic effects as the concentration and duration of exposure increases. The effect of high concentrations may be so sudden that one has little or no warning before collapsing.

Effects of Carbon Monoxide (CO)	
Blood Saturation	**Symptoms**
0-10%	None, normal pulse & respiration
10-20%	Tightness across forehead, possible headache
20-30%	Headache, throbbing in temples
30-40%	Severe headache, weakness, dizziness, dimness of vision, nausea, vomiting & collapse
40-50%	Inceased effect of earlier symptoms, greater possibility of fainting & collapse, increased pulse & respiration
50-60%	Fainting, increased pulse & respiration, coma with intermittent convulsions
60-70%	Coma with intermittent convulsions, depressed heart action & respiration, possible death
70-80%	Weak pulse & slow respiration, respiratory failure & death

Physiological Effects of CO

Oxygen absorbed from the air in the lungs is normally absorbed by the hemoglobin in red blood cells and carried to the tissues where it is used.

Hemoglobin, however, has an affinity for CO 300 times greater than for O_2. When there is even a small percentage of CO in the air, the hemoglobin will absorb it in preference to O_2.

When CO is absorbed by hemoglobin, it reduces the capacity of the hemoglobin to carry O_2 to the tissues to a proportionate extent. This interference with the O_2 supply to the tissues produces the symptoms of poisoning.

A person exposed to high concentrations may experience few symptoms. The rate at which a person is overcome, and the order

Symptoms of Carbon Monoxide (CO) Poisoning Relative to CO Level & Exposure Time		
CO Level	**Exposure Time**	**Symptom**
25 ppm	8 hours	No adverse effects
200 ppm	2-3 hours	Mild headache
400 ppm	1-2 hours >3 hours	Severe headache, nausea Life-threatening
800 ppm	45 minutes 2 hours 2-3 hours	Headache, nausea, dizziness Collapse, unconsciousness Death
1,000 ppm	1 hour	Unconsciousness
1,200 ppm	**Immediately Dangerous to Life or Health**	
1,600 ppm	20 minutes <1 hour	Headache, nausea, dizziness Death
3,200 ppm	5-10 minutes 30 minutes <1 hour	Headache, nausea, dizziness Unconsciousness Death
6,400 ppm	1-2 minutes 10-15 minutes	Headache, nausea, dizziness Unconsciousness, danger of death
12,800 ppm	0 minutes 1-3 minutes	Immediate effects Unconsciousness, danger of death
Onset of symptoms and effects begins more rapidly with higher physical activity. **Source: NFPA Fire Protection Handbook, 20th Edition**		

in which the symptoms appear, depend on the state of the person's health and individual susceptibility, the temperature, humidity, and air movement to which they are exposed, as well as the concentration and period of exposure.

Exercise, high temperature, and humidity with little or no air movement, tend to increase respiration and heart rate, and, consequently, result in more rapid absorption of CO.

The most important measures for the treatment of CO poisoning are to avoid further exposure and to keep the patient at rest.

When a person is suffering from acute poisoning, it is important that CO be eliminated from the blood as quickly as possible, thus decreasing the possibility of serious aftereffects, including death.

As soon as the patient begins to breathe air in which there is no CO, the process of eliminating the gas from the blood begins naturally. However, this normal, unaided elimination is slow and does not always prevent serious aftereffects. It may take the body as long as eight to 15 hours to reduce CO saturated hemoglobin to 10 per cent of the total hemoglobin. However, if the casualty inhales pure O_2, the CO will be removed from the blood four to five times faster.

Hydrogen Sulphide (H_2S)			
Spec. Gravity:	1.19	**Explosive Range:**	4.3-46%
Colour:	No	**Combustible:**	Yes
Odour:	Rotten egg	**Taste:**	Acidic
Toxic:	Yes	**IDLH:**	100 ppm
TWA:	10 ppm	**STEL:**	15 ppm
Other: Paralyzes sense of smell in concentrations >100 ppm			

HYDROGEN SULPHIDE (H_2S)

Hydrogen sulphide is a colourless gas that has both an acidic taste and a smell, depending on the concentration. When explosions of dust occur in blasting operations in sulphide ore bodies, the resulting gases may contain varying amounts of H_2S, along with sulphur dioxide and possibly other sulphur gases.

In low concentrations, its distinctive rotten egg odour is noticeable, but in concentrations of 100 ppm or more, the sense of smell is paralyzed and cannot be relied on for warning.

The gas has a specific gravity of 1.19, and may collect at low points. A concentration of 4.3 to 46 per cent of H_2S in the air is explosive. Hydrogen sulphide may also indicate the presence of methane.

Hydrogen sulphide, inhaled in sufficiently high concentrations, can produce immediate asphyxiation. In low concentrations, it causes irritation to the eyes and respiratory tract, and sometimes leads to bronchitis and pneumonia.

Subacute poisoning may be produced by long exposure to concentrations as low as 50 ppm. Immediate collapse usually results from exposure to concentrations greater than 500 ppm and death quickly ensues. The TWA for H_2S is 10 ppm and the STEL is 15 ppm.

Methane (CH_4)			
Spec. Gravity:	0.55	**Explosive Range:**	5-15%
Colour:	No	**Combustible:**	Yes
Odour:	No	**Taste:**	No
Toxic:	No		
Other: Explosive in as little as 12% O_2			

METHANE (CH_4)

Methane is a colourless, tasteless, and odourless gas. It may be accompanied by an odour caused by other gases, such as H_2S. Methane will burn with a pale blue, non-luminous flame.

Air that contains five to 15 per cent CH_4 and as little as 12 per cent O_2, will explode, methane's greatest danger. The flammable and explosive range of CH_4, however, is variable and all occurrences of the gas should be considered dangerous. Where the presence of CH_4 is suspected or known, adequate ventilation to dilute the gas to a harmless percentage is important.

Under Ontario Reg: 854: Mines and Mining Plants, Sect. 35 (6):

If concentrations of flammable gas exceed 1.0 per cent in an area, all of the following precautions shall be taken:

1. All sources of ignition in the affected area shall be eliminated.
2. All electrical equipment in the affected area shall be de-energized.
3. All persons, other than competent persons necessary to measure the concentration of flammable gas and to make ventilation changes, shall be removed from the affected area.

Methane or marsh gas, is encountered in most mining districts of Ontario. The length of time the gas will flow into a mine depends on the size of the pocket tapped. It is formed by the decomposition of organic matter in the presence of water and the absence of air or O_2. It can be seen in the form of bubbles in stagnant pools, hence the name marsh gas.

At a specific gravity of 0.55, CH_4 is lighter than air, and when found in mines, is usually near the back or roof or at higher elevations. The gas may be encountered issuing from diamond drill holes, in unused and poorly ventilated mine workings, or when old workings are being de-watered. It may also be caused by the decay of old timbers.

In addition to its explosive nature, methane may also displace the O_2 in the air to such an extent as to cause oxygen deficiency.

Nitrogen Dioxide (NO_2)			
Spec. Gravity:	1.59	**Explosive Range:**	No
Colour:	Reddish brown in high concentrations	**Combustible:**	No
Odour:	Yes	**Taste:**	No
Toxic:	Yes	**IDLH:**	20 ppm
TWA:	3 ppm	**STEL:**	5 ppm
Other: Colourless in low concentrations			

OXIDES OF NITROGEN (NO_X)

The oxides of nitrogen are formed in mines by diesel engines, and the burning and detonation of explosives. It is also formed by nitric oxide readily converting to nitrogen dioxide in the presence of O_2 and moisture.

When inhaled in sufficient concentration, it causes pulmonary edema, an accumulation of fluids in the lungs, that blocks the body's natural respiration processes and leads to death by suffocation.

The oxides of nitrogen (NO_X) exist in various forms in the gaseous state: nitric oxide (NO), nitrogen dioxide (NO_2) and dinitrogen tetraoxide (N_2O_4). Though all are harmful, NO_2 has the most profound effects on humans.

Nitrogen dioxide can appear as a reddish brown gas with a strong, suffocating odour. The colour deepens at higher temperatures. Inhalation can cause irritation to the nose and throat in concentrations

Effects of Nitrogen Dioxide (NO_2)	
Concentration	**Symptoms**
15-25 ppm	Nose & throat irritation, coughing, headache, nausea
25-100 ppm	Pneumonia, bronchitis; effects can be reversible
>150 ppm	Pulmonary edema, progressive blockage of small airways that is potentially fatal

as low as 15 to 25 ppm. In concentrations of 25 to 100 ppm, more severe symptoms can occur which may include bronchitis and pneumonia.

The symptoms may develop in three stages which include: initial exposure, relief of symptoms when the casualty is removed from further exposure, and the slow development of bronchitis or pneumonia over a period of three to 36 hours.

Treatment must include removal of the patient from further exposure, O_2 therapy, and monitoring for a full 24-hour period.

Nitrogen dioxide has a specific gravity of 1.59, a TWA of 3 ppm and a STEL of 5 ppm.

Sulphur Dioxide (SO_2)			
Spec. Gravity:	2.26	**Explosive Range:**	No
Colour:	No	**Combustible:**	No
Odour:	Strong sulphur	**Taste:**	Acidic in high concentration
Toxic:	Yes	**IDLH**	100 ppm
TWA:	2 ppm	**STEL:**	5 ppm
Other: Very irritating to breathe			

SULPHUR DIOXIDE (SO_2)

Sulphur dioxide is a colourless, suffocating, irritating gas with the familiar strong sulphurous odour. It is sometimes given off by the detonation of explosives and is produced by mine fires in sulphide ore bodies.

Sulphur dioxide is very poisonous, but owing to its irritating effect on the eyes and respiratory tract, is intolerable to breathe for any length of time. Exposure to this gas for even a short period will cause pulmonary edema and damage to any moist tissues of the body by the production of sulphurous acid.

Sulphur dioxide is a heavy gas with a specific gravity of 2.26 and has a TWA of 2 ppm. The STEL is 5 ppm.

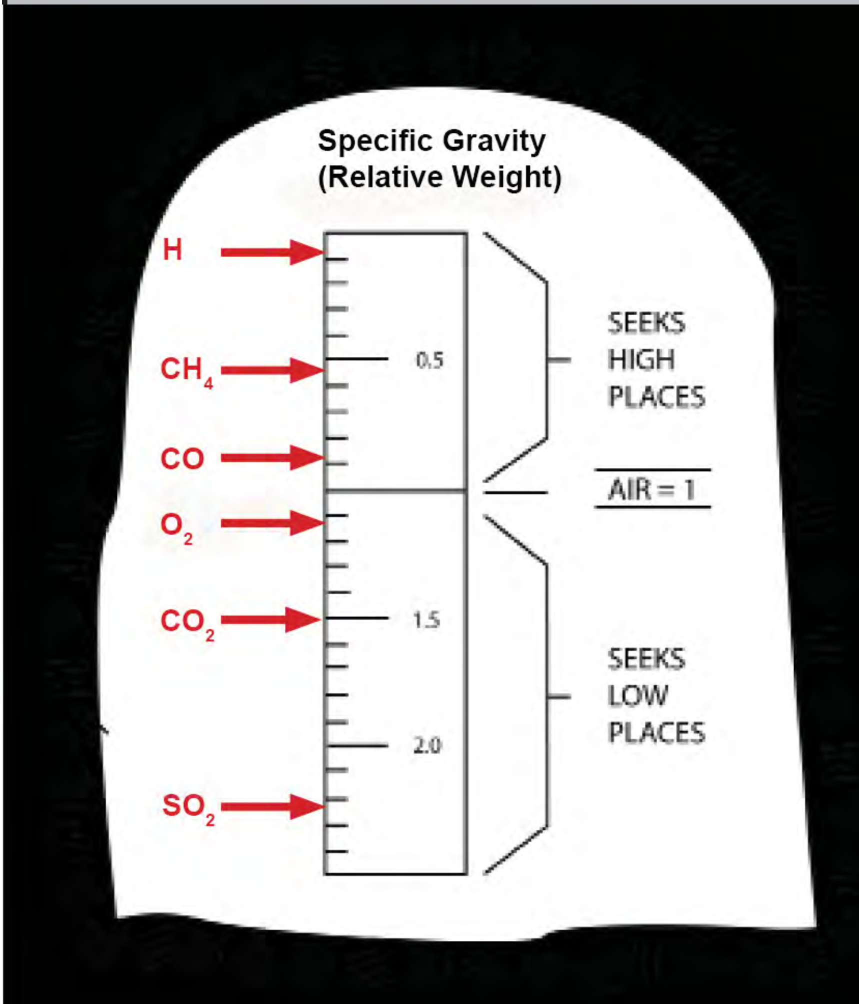
Hydrogen (H_2)			
Spec. Gravity:	0.07	**Explosive Range:**	4.1-74%
Colour:	No	**Combustible:**	Yes
Odour:	No	**Taste:**	No
Toxic:	No		
Other: Highly explosive with as little as 4% O_2			

HYDROGEN (H_2)

Hydrogen is a colourless, odourless, tasteless gas and a normal constituent of air. It is not dangerous to breathe but is dangerous because it is combustible in the range of 4.1 to 74 per cent in as little as five per cent O_2. It can collect in high places as the specific gravity is 0.07. In addition, during a mine fire it may unite with carbon to form explosive concentrations of hydrocarbons.

Hydrogen is found in normal air in very small quantities. It is sometimes found in higher concentrations in the mine atmosphere during or after a fire, particularly when rocks have been heated to incandescence. It is also a product of electrolytic action during battery charging.

Specific Gravity of Mine Gases



The specific gravity, sometimes called relative weight, of a gas is the ratio of the density of the gas at a standard pressure and temperature to the density of air at the same pressure and temperature. The specific gravity of a gas indicates whether it will rise or sink relative to air.

ACETYLENE (C_2H_2)

Acetylene is a colourless, odourless, and tasteless gas that is used underground in oxy-acetylene welding and cutting procedures. Commercial grades have a garlic odour added for the purpose of detection.

It is explosive in the range of 2.5 to 81 per cent and, with a specific gravity of 0.91, is only slightly lighter than air.

Acetylene is essentially a non-toxic gas at concentrations below the lower explosive limit. At higher levels it has an anesthetic action and, if allowed to displace O_2 levels, may cause asphyxiation.

AMMONIA (NH_3)

Ammonia is a colourless gas with an intensely irritating odour. It can be found when blasting in backfill or cement structures underground, or it can be present in recycled underground water.

At a specific gravity of 0.60, it is lighter than air and is explosive in the range of 15 to 28 per cent.

Irritation to the respiratory tract may occur in levels as low as 20 to 25 ppm. Immediate, severe irritation to the eyes, nose and throat will occur at 400 to 700 ppm. Brief exposure to levels as high as 5,000 ppm, may cause rapid death due to suffocation or pulmonary edema.

The TWA for ammonia is 25 ppm and the STEL is 35 ppm.

Treatment for casualties suffering from inhalation of ammonia should include respiratory support and to seek medical aid.

SMOKE

Smoke consists of fine particles of solid and liquid matter suspended in the atmosphere. These particles are composed mostly of soot

or carbon, together with tarry substances, mainly hydrocarbons. Asphyxiating and irritating gases and vapours are usually mixed with the smoke. Hydrocarbons in sufficient concentrations may be explosive.

GAS HAZARDS DURING AND AFTER MINE FIRES

During and after mine fires, two of the greatest hazards to life are poisoning from CO and suffocation in an oxygen-deficient atmosphere, but other dangers also exist.

- **Carbon monoxide** – This gas is always present during or after an underground fire, though there will be little or no sign of its presence.
- **Oxygen deficiency** – This condition results when O_2 is consumed by combustion or a chemical reaction, and is replaced by other gases, either poisonous or inert.
- **Smoke** – The danger from smoke is that it is irritating and obstructs vision. It may be explosive and poisonous, if it

contains the products of the decomposition of synthetic materials due to heat.

- **Danger of explosions** – Hydrocarbon gases created or generated by fire (as in smoke) may explode.
- **Methane** – This gas is not produced by mine fires or explosions, but it may cause them. Its presence may then create a hazard.
- **Sulphur dioxide** – This gas may be present during the mining of sulphide ore bodies. Because of its irritating properties, it gives advance warning when in less than toxic concentrations.

TREATMENT FOR GAS POISONING

The treatment for gas poisoning is:

1. Remove patient to fresh air as soon as possible
2. If breathing has stopped, give artificial respiration continuously until the patient is breathing normally again
3. Give pure O_2 at atmospheric pressure as soon as possible and for as long as necessary
4. Keep the patient warm with blankets
5. Keep the patient at rest, lying down to avoid strain on the heart
6. Seek medical attention

ADDITIONAL GAS HAZARDS

In fires caused in conveyor belting by friction heating, the cotton carcass is usually responsible for the ignition, but once the belting is ignited, the rubber cover allows the fire to spread. Grease, oil, and other material will support the burning of the belt.

In some fires, the heat may be so intense that conveyor belts, tires, ventilation tubing, and other items composed of fire-resistant plastics,

Gases Produced by Burning Rubber, Neoprene & PVC		
Gas	Time-Weighed Average	
	PPM	Percentage
Ammonia (NH_3)	25	0.0025
Arsine (AsH_3)[1,3]	0.005	0.000005
Carbon monoxide (CO)	25	0.0025
Chlorine (Cl_2)[1]	0.5	0.00005
Hydrogen chloride (HCl)[2]	2	0.0002
Hydrogen cyanide (HCN)[2]	4.7	0.00047
Hydrogen sulphide (H_2S)	10	0.001
Nitrogen dioxide (NO_2)	3	0.0003
Phosgene ($COCi_2$)[1]	0.1	0.00001
Phosphine (PH_2)[1,3]	0.05	0.000005

Note:
1. Note the toxicity of these gases compared to that of carbon monoxide
2. HCl and HCN have a Ceiling exposure limit, not a TWA. A Ceiling limit is the maximum airborne concentration of a biological or chemical agent to which a worker may be exposed at any time.
3. These gases will be found only if the carcase is impregnated with certain fungicidal or fire retardant compositions

polyvinyl chloride (PVC), rubber, neoprene, and other materials become involved.

Many gases are produced by the decomposition and burning of conveyor belting and rubber tires, urethane foam, and plastics. For example, PVC covered belting is practically non-flammable, but when heated both PVC and neoprene, as is found in rubber tires, give off chlorine gases.

PVC contains 55 per cent chlorine by weight, while synthetic rubber and neoprene contain about 40 per cent.

Some of these gases are so dangerous that CO is among the least poisonous. Though proper respiratory protection should provide adequate control for most of these hazards, mine rescuers should be aware of them.

Arsine (AsH_3) – Arsine is a colourless gas with a mild, garlic-like odour. Arsenic compounds may be used as fungicidal additives in fabrics, plastics, rubbers or pressure-treated woods. Burning these materials may produce AsH_3.

Arsine is a very toxic gas. Inhalation of even low concentrations may destroy red blood cells resulting in bloody urine, headaches, weakness, dizziness, nausea, vomiting and abdominal cramps and tenderness. There may be a delay between exposure and the onset of symptoms.

Nerve damage may result from exposure and AsH_3 is classified as a potential carcinogen. Arsine is also explosive in a range of 5.1 per cent to 78 per cent in normal air.

The TWA for AsH_3 is 0.005 ppm. The IDLH is 3 ppm.

Chlorine (Cl_2) – Chlorine is a greenish-yellow gas with a pungent, irritating odour. The odour may be described as "bleach-like" at low concentrations.

Liquefied Cl_2 is used for water treatment or as a process chemical in mills. It may be produced by the burning of PVC-coated fabrics and rubbers (ventilation ducting or conveyor belts). Chlorinated compounds are used as components or additives in many rubbers and plastics and burning these materials may produce chlorine gas.

Chlorine is a toxic gas and is very irritating. Exposure to even low concentrations will cause eye, nose and respiratory irritation. Higher exposures can cause pulmonary edema, and damage to the eyes and respiratory tract. Edema may not be apparent for some time after exposure. Chlorine is not flammable or explosive but is a strong oxidizer and may support fires.

The TWA for Cl_2 is 0.5 ppm. The IDLH is 10 ppm.

Hydrogen Chloride (HCl) – Hydrogen chloride is a clear, colourless gas with a pungent, irritating odour. High concentrations may have a slightly yellow colour. It may be produced by the burning of PVC-coated fabrics and rubbers. Chlorinated compounds are used as components or additives in many rubbers and plastics, and burning these materials may produce HCl.

Hydrogen chloride is a severe irritant. Exposure to even low concentrations will cause eye, nose and respiratory irritation. Higher exposures can cause pulmonary edema, damage to the eyes and respiratory tract. Edema may not be apparent until some time after exposure.

It is strongly acidic when dissolved in water (hydrochloric acid).

The Ceiling exposure limit (maximum airborne concentration of a biological or chemical agent to which a worker may be exposed at any time) for HCl is 2 ppm. The IDLH is 50 ppm.

Hydrogen Cyanide (HCN) – Hydrogen cyanide is a colourless gas with a characteristic bitter almond odour and taste. At higher concentrations, a pale blue colour might be seen. Hydrogen cyanide can be formed during the burning of nitrile and urethane plastics, and rubbers. These plastics and rubbers may be used in tires, hoses, pipes, conveyor belts, stopping and sprayed liners for ground control. Hydrogen cyanide may also be formed by contact between cyanide salts, solutions, and acids.

Hydrogen cyanide is a chemical asphyxiant. Inhalation of HCN can cause weakness, headache, confusion, nausea, and vomiting. Exposure limits for HCN have a SKIN notation, indicating that it can be absorbed through intact skin, the eyes and moist tissues of the nose and mouth.

While there is ample human evidence of HCN being absorbed from solutions and from contact with cyanide salts, there is no information on what airborne concentration of HCN is potentially hazardous by skin absorption.

Hydrogen cyanide is also explosive in a range of 5.6 per cent to 40 per cent, in normal air.

The Ceiling exposure limit for HCN is 4.7 ppm (SKIN). The IDLH is 50 ppm.

Phosgene ($COCl_2$) – Phosgene is a toxic, colourless gas with a suffocating "musty hay" or "cut grass" odour. It may be produced by the burning of PVC-coated fabrics and rubbers. Chlorinated compounds are used as components or additives in many rubbers and plastics and burning of these materials may produce phosgene.

Phosgene is a severe irritant. Exposure to even low concentrations will cause eye, nose and respiratory irritation. Higher exposures can cause vomiting, shortness of breath, chest pain, and pulmonary edema. Effects of exposure may not be apparent for some time after exposure.

The TWA for $COCl_2$ is 0.1 ppm. The IDLH is 2 ppm.

Phosphine (PH_3) – Phosphine is a toxic, colourless gas with a fishy or garlic odour. Phosphorus compounds may be used as flame retardants in fabrics, plastics, or rubbers. Smoldering, oxygen-starved fires involving these materials may produce PH_3.

Phosphine is an irritant, and may cause pulmonary edema and neurotoxicity. It may also produce chest pain, abdominal or muscle pain, nausea, vomiting, and diarrhea. The onset of symptoms may be delayed. Phosphine becomes explosive when it reaches a concentration of 1.79 per cent in normal air, and at higher concentrations, it may spontaneously ignite.

The TWA for PH_3 is 0.05 ppm. The IDLH is 50 ppm.

BATTERY GAS HAZARDS

Off-gassing is the release of a gas byproduct as a substance or material undergoes a chemical reaction, such as changing from a solid to a liquid. The leakage of battery electrolytes, the fluid contents of batteries, are flammable – the newer chemistries moreso, corrosive and off-gas, though batteries do not need to leak to off-gas. When electrolytes come into contact with metals, hydrogen gas is formed, as well as other toxic gases and corrosive substances.

Inadequate storage, poor maintenance, damage, defects, and overcharging can result in batteries leaking or off-gassing combustible and/or toxic substances. If the gases are not adequately vented, exposure to a heat source, such as an overheating battery, can lead to a fire or explosion. Off-gassing is accelerated during fire when the transition from substance to vapour is hastened.

The gases and substances released will depend principally on the type of battery electrolyte. Volume and rate will depend on the size and number of batteries and cells involved, as well as the means of damage or cause of release.

Though numerous hand tools and small equipment in mines use small-sized standard batteries, batteries in larger, heavier equipment, such as locomotives, haul trucks, bolters and the like, are substantially bulkier and come in a wider range of electrolytes, often lithium, nickel or other metal-based compounds.

Common battery types and hazards include:

- **Lead acid** batteries can off-gas combustible hydrogen and oxygen while charging. Spilled sulphuric acid from a damaged battery is highly corrosive. When sulphuric acid comes into contact with metal, it can result in the creation of highly toxic sulphur dioxide (SO_2) and hydrogen (H_2).
- **Nickel-cadmium (NiCad)** batteries contain a strong colourless alkaline solution, which is extremely corrosive and can damage protective clothing and harm skin, even when diluted by water. When involved in fire, they may produce toxic fumes including oxides of nickel, cobalt, lanthanum, and other metals.
- N**ickel-metal hydride (NiMH)** batteries involved in fires can also produce oxides of nickel, cobalt, aluminum, manganese, and other metals. If water is used to extinguish a fire involving NiMH, hydrogen gas may be created, creating an explosion hazard.
- **Lithium-ion** or li-ion batteries can off-gas carbon dioxide (CO_2), and smaller amounts of hydrogen fluoride (HF) and phosphoryl fluoride (POF_3). All are colourless gases. Hydrogen fluoride can be corrosive in high concentrations with water, becoming hydrofluoric acid. Phosphoryl fluoride hydrolyzes or decomposes rapidly. The formation of hydrogen gas is also possible.

As noted, the amount and type of off-gassing will depend on the size and content of the batteries, and potentially the proximity of other batteries. Due to the variety of batteries used in underground mobile equipment and tools, mine rescuers should be aware of the types of batteries in use at their operation, and be familiar with manufacturers recommendations and their Safety Data Sheets.

More information on battery fires can be found in Chapter 12 – Underground Fires.

Properties of Principle Gases Described in Handbook

Gas	Specific Gravity	Explosive Range %	Com-bustible	Colour	Odour	Taste	Toxic
Air	1	--	No	No	No	No	No
Oxygen (O_2)	1.11	--	No	No	No	No	No
Acetylene (C_2H_2)	0.91	2.8-81	Yes	No	No	No	Yes[1]
Ammonia (NH_3)	0.6	15-28	Yes	No	Burning	Burning	Yes
Carbon dioxide (CO_2)	1.53	--	No	No	No	No	Yes[2]
Carbon monoxide (CO)	0.97	12.5-74	Yes	No	No	No	Yes[3]
Hydrogen (H_2)	0.07	4.1-74	Yes	No	No	No	No
Hydrogen sulphide (H_2S)	1.19	4.3-46	Yes	No	Rotten egg	Acidic	Yes[3]
Methane (CH_4)	0.55	5.0-15	Yes	No	No	No	No[4]
Nitrogen (N_2)	0.97	--	No	No	No	No	No
Nitrogen dioxide (NO_2)	1.59	--	No	Reddish brown	Strong suffocating	No	Yes[3]
Sulphur dioxide (SO_2)	2.26	--	No	No	Strong sulphur	Acidic	Yes[3, 4]

1. C_2H_2 - non-toxic below its lower explosive limit
2. CO_2 – dangerous to breathe in concentrations above 5%
3. CO, H_2S, NO_2, SO_2 – extremely dangerous to breathe even in very low concentrations
4. CH_4, SO_2 – sometimes accopanied by H_2S

Properties of Additional Gas Hazards Described in Handbook

Gas	Specific Gravity	Explosive Range %	Com-bustible	Colour	Odour	Taste	Toxic
Arsine (AsH_3)	2.69	5.1-78	Yes	No	Yes	No	Yes
Chlorine (Cl_2)	2.48	--	No	Yes	Yes	Yes	Yes
Hydrogen chloride (HCl)	1.27	--	No	No	Yes	No	Yes
Hydrogen cyanide (HCN)	0.94	5.6-40	Yes	No[1]	Yes	Yes	Yes[2]
Phosgene ($COCl_2$)	1.39	--	No	No	Yes	No	Yes
Phosphine (PH_3)	1.17	>1.79[3]	Yes	No	Yes	No	Yes

Note:
1. HCN – may have a pale blue colour in high concentrations
2. HCN – SKIN notation, may be absorbed through skin
3. PH_3 – may spontaneous ignite in higher concentrations

NOTES:

NOTES:

CHAPTER 7
DETECTING MINE GASES

INTRODUCTION TO THE MX6

The MX6 iBrid Multi-Gas Monitor is a sturdy, hand-held device capable of effectively monitoring up to six different gas concentrations in the air in a temperature range of -20 to 55 C. For mine rescue and recovery operations, the MX6 is configured to monitor only three gases – carbon monoxide (CO) in parts per million (ppm), and methane (CH_4) and oxygen (O_2) in per cent volume (% vol).

Non-mine rescue gas detection devices are usually set to measure methane, as a per cent of the lower explosive limit (LEL), however, mine rescue units measure CH_4 in per cent volume. To avoid confusion and ensure proper operation for mine rescue needs, teams should not use a non-mine rescue gas detection device without the expressed direction of the emergency control group.

For an explanation on the significance of the different measurements and how to convert from one measurement to the other, see Chapter 6 – Mine Gases.

Warnings that this apparatus is "For Use with Mine Rescue Breathing Apparatus Only" and that the "Alarms are Altered" are displayed on the storage case, indicating the equipment is for the use of mine rescue personnel only.

The monitor(s) should lie on top of the other components in the storage case, to be easily viewed to see the charge level.

Each storage case contains:

- One or more iBrid MX6 Multi-Gas Monitor
- Calibration cup with attached polyurethane tubing (the other end of the tubing is attached to the top of the brass cylinder on/off valve)
- Calibration gas cylinder
- Calibration log
- Brass cylinder on/off valve (with regulator and pressure gauge) in protective covering
- Battery charger

While the monitor(s) are in the storage case, the battery chargers must be plugged into a 120V outlet. This trickle charges the lithium-ion battery on a continuous basis to ensure the units are always ready for use.

COMPONENTS

Liquid Crystal Display Screen – The LCD screen is a graphical, colour display with a software-controlled backlight. The display provides clear readings in all lighting conditions. A backlight is enabled for five seconds each time a button is pressed. Any additional button press during the five seconds resets the timer for an additional five seconds.

When activated, the display shows gas readings as sampled by the MX6 and the battery level. A menu bar is hidden during normal operations, but can be displayed by pressing the centre of the Navigation Button.

Navigation Button – The single, Five-Way Navigation Button provides easy positioning and item selection from the LCD. The menu system allows the user to select different modes and actions. The navigation button has five pressure sensitive positions (Up, Down, Left, Right, and On/Off/Enter).

Most navigation is controlled by a single button push, though some operating modes are only accessible by holding the button for several seconds, or by pressing the button twice.

MX6 Sensitivity Range		
Gas	**Range**	**Resolution**
CO – low range	0 to 999 ppm	1 ppm
CO – high range	1,000 to 10,000 ppm	50 ppm
O_2	0 to 30% vol	0.1% vol
CH_4	0 to 5% vol	0.01% vol

Sensors – MX6 units used by Ontario Mine Rescue have sensors only for carbon monoxide (CO), methane (CH_4) and oxygen (O_2).

The sensors are inside the top, front portion of the device behind the sensor grid. Sensor openings in the grid permit the sensors to monitor ambient gases. A gas-permeable filter covers the sensor openings to limit the amount of dust and contaminants that might enter the

internal sensor chamber and affect sensor readings. The sensors and the sensor grid area must be kept clean and clear of obstruction for the device to work and to give accurate measures.

Be aware of the possibility of cross-contamination, when on rare occasions, an unmonitored gas affects the reading(s) of a monitored gas. For example, a high concentration of hydrogen may affect the accuracy of the CO sensor.

Every effort must be made to prevent sensor poisoning by keeping the unit away from chemical cleaners, aerosols, oils, paints, and other potential poisons.

Audible Alarm Indicators – An audible alarm port is located at each of the bottom front corners of the device. A 90-decibel (dB) at three feet alarm (one meter) sounds when any one of the installed sensors exceeds an alarm set point.

Visual Alarm Indicators – The MX6 has four visual alarm LEDs beneath the translucent sensor grid at the top of the unit. The ultra-bright indicators provide a visual indication when any one of the installed sensors exceeds the alarm set point. During an alarm, the LEDs are activated and illuminate the upper portion of the device.

I/R Communications Port – An optical media interface is on the bottom on the MX6 and used for infrared (I/R) data transmissions to a host computer.

Battery Charging Contacts – A charger is used to charge the MX6's internal batteries. A combination transformer and power cord is supplied with the charger. A Datalink charger can be used to charge the device and download data directly to a host computer.

Rechargeable lithium-ion battery – When fully charged, this battery will operate for approximately 24 hours. A depleted battery should recharge in about five hours.

While in the charger, the LCD screen will show that it is charged or that it is charging. If charging, a bar shows the existing charge as an approximate percentage of total battery life. When the display shows "Charge Complete", the device is ready for use.

If the MX6 is charging, it is NOT ready for use. The internal battery must be fully charged before the device is used. When a battery pack starts to fail and no longer charges to full capacity, it must be replaced.

MX6 Alarm Points		
Gas	**Low Level (1) Alarm**	**High Level (2) Alarm**
CO	9,999 ppm	–––––
O_2	–––––	17.5% vol 23.5% vol
CH_4	1.0% vol	2.0% vol

ALARM POINTS

Sensor Alarms – The MX6 has three types of alarm indicators: audible alarm indicators, visual alarm indicators, and an optional vibration alarm indicator.

The alarms activate at the following gas readings:

Note that:

- The CO alarm has been disabled.
- O_2 alarm is set to activate a High Level (2) both for O_2 depletion at 17.5 per cent, and O_2 enrichment at 23.5 per cent.

For all sensors, except oxygen, the alarm level will change as the gas concentration increases or decreases. For example, if the gas reading is above the High Level (2) alarm point, the instrument sustains the alarm until the gas reading falls below the High Level (2) point, then the instrument switches to the Low Level (1) alarm until the gas reading falls below the Low Level (1) alarm point.

The audible Low Level (1) alarm is a low frequency beep followed by a slow series of beeps. The alarm will continue to signal until either gas concentrations return to safe levels, or in the case of CH_4, reach levels initiating the High Level (2) alarm.

The audible High Level (2) alarm is a high frequency, dual-toned beep followed by a fast series of beeps.

For Low Level (1) alarms, the LEDs are pulsed on and off with a long delay between pulses. For the High Level (2) alarm, the LEDs are pulsed on and off with a short delay. As well, the LCD display backlight flashes as part of all alarm sequences, except for the "battery low" condition.

The visual alarm is also used as a confidence indicator which, when enabled, blinks the LEDs once every 30 seconds.

The MX6 has an optional vibrating alarm used for limit alarms and as a confidence indicator. When enabled, this alarm vibrates for two seconds approximately every 30 to 60 seconds.

Battery Alarm – The battery icon on the LCD display will indicate a declining charge in 25 per cent increments, and turn yellow when a maximum five per cent of a full charge remains.

When less than an hour of charge remains, the battery icon will flash and an audible low battery alarm will sound.

When less than 10 minutes of charge remains, the battery icon will turn red and a "Low Battery" warning is visible on the lower central part of the display.

USING THE MX6

Before use, the MX6 must be removed from storage fully charged. If it is not fully charged, the MX6 cannot be used.

The MX6 is easy to use and includes the following steps:

Power Up – The MX6 is turned on by pressing and holding the centre, [ENTER], point on the Five-way Navigation Button for several seconds until the backlight turns on, the red LEDs flash, and a beep is heard.

Startup Self-Test – The self-test lasts for several seconds, displays a series of screens and tests all of the main components in the instrument. The results of the self-test are displayed and saved into memory. The user must acknowledge the results of the self-test by selecting OK and pressing [ENTER]. If the device fails the self-test, it should be removed immediately from use.

Normal Operation Mode – After the Startup Self-Test is completed, the instrument displays the Normal Operation Mode. The Normal Readings Screen is the default screen displayed while the instrument is in Normal Operation Mode. The screen indicates the gases being monitored and their levels in the appropriate measurement. The battery icon appears in the lower left corner and a time display in the lower right corner.

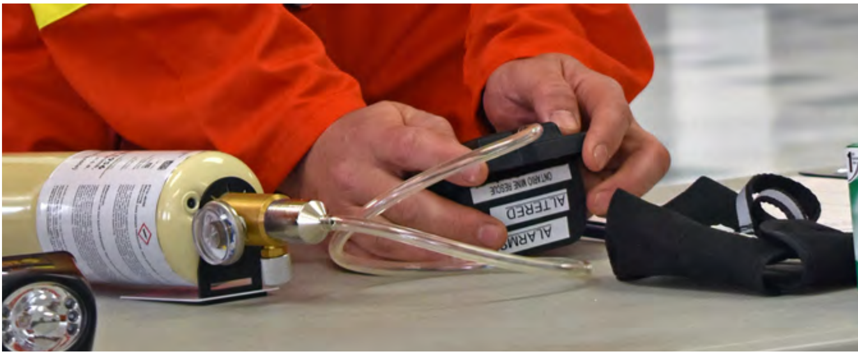
Calibration – Each gas sensor in the MX6 must be calibrated each time the device is to be used. If any sensor fails calibration, the MX6 cannot be used until it has been serviced and shown to be safe for use.

Shut Down – To shut down the instrument, hold the centre [ENTER] navigation button until a confirmation screen is displayed to provide verification of the shutdown. Confirm or cancel shutdown by selecting the appropriate response and pressing [ENTER].

Battery Use – During its use, the MX6 will display a blue battery icon runtime indicator in the lower left-hand corner of the LCD to indicate approximately how much battery capacity remains.

After use, the MX6 must be properly cleaned before it can be stored. Cleaning consists of removing the MX6 from its carrying case, wiping the unit with a clean dry cloth and then wiping the carrying case, if required. Cleaners, particularly those in aerosol or spray, can contaminate the sensors and must never be used on an MX6.

The device is then placed into the storage case, with the battery lead attached, and stored in a clean environment, away from chemicals and cleaners, with the battery charger plugged in so that the MX6 will be ready for its next use.



FIELD TEST

Before being used, the MX6 must be field tested to ensure its proper operation.

To field test the MX6:

1. Remove the device from its charging station and turn it on
2. Observe the startup self-test of the audible, visible, and vibrating alarms
3. Check for a full battery charge
4. Perform a calibration
5. View and clear peaks
6. Return the MX6 to normal operating mode
7. Report results to the Captain
8. Leave the device on

The MX6 must be operated continuously after field testing and while on assignment, so that it can monitor the mine air effectively.

If the device fails any stage of the field test, it cannot be used and must be removed from service until repaired.

The MX6 can be attached to a person or equipment in the appropriate manner, and is ready for use in the field.

NOTES:

CHAPTER 8
PROTECTION FROM MINE GASES

BREATHING APPARATUS APPROVALS & STANDARDIZATION

The Ontario Ministry of Labour, Training and Skills Development only permits the use of approved respiratory protection in underground mines. The breathing apparatus referred to in this handbook are those used by Ontario Mine Rescue. The following approvals are accepted:

1. The National Institute for Occupational Safety and Health (NIOSH) in the U.S.
2. The European Norm Standard (EN Standard)

The approvals of other similar qualified authorities may also be accepted.

RESPIRATORY PROTECTION

Ontario Mine Rescue uses multiple breathing apparatus for protection from mine gases. One limitation is applicable to all respiratory protective equipment – certain gases can enter the body by means other than the respiratory tract. Ammonia, for example, in concentrations of approximately three per cent or higher can cause skin burns (particularly on moist skin). Similarly, appreciable amounts of gases, such as hydrogen cyanide, can penetrate the skin and cause systemic poisoning.

To avoid this possibility, protective clothing such as hazmat suits, should be worn in addition to respiratory protection when facing such hazards. Gases such as these will not normally be found underground, but mine rescuers must know which dangers exist at their specific site, including the hazards posed by the products of material combustion. Safety Data Sheets (SDS) for materials – equipment batteries, vent tubing, conveyor belting, etc. – that may be burning should be checked prior to any assignment.

RESPIRATORY HAZARDS

There are three ways in which poisons can enter the body:

1. Through the stomach
2. Through the skin
3. Through the lungs

Of these three methods, the human respiratory system presents the quickest and most direct means of entry. That is because the respiratory system is closely associated with the circulatory system, and is constantly supplying O_2 to every cell in the body.

Respiratory hazards can be classified as:

1. Oxygen deficiency
2. Gas and vapour contaminants:
    a) immediately dangerous to life and health
    b) not immediately dangerous to life and health

3. Particulate contaminants (including aerosols, dust, fog, fumes, mist, smoke and spray):
    a) immediately dangerous to life and health
    b) not immediately dangerous to life and health
4. A combination of gas, vapour and particulate contaminants:
    a) immediately dangerous to life and health
    b) not immediately dangerous to life and health

Respiratory protective devices fall into three classes:

1. Air-purifying
2. Air-supplied
3. Self-contained breathing apparatus

SELF-CONTAINED BREATHING APPARATUS

A self-contained breathing apparatus provides complete respiratory protection against toxic gases and O_2 deficiency. The wearer is independent of the surrounding atmosphere because the breathing system admits no outside air. The apparatus itself provides the O_2 or air needed by the wearer.

There are three types of self-contained breathing apparatus:

1. Self-generating apparatus
2. Oxygen-cylinder rebreather
3. Pressure-demand apparatus

Self-Generating Apparatus

This apparatus differs from conventional cylinder rebreathing apparatus in that it has a chemical canister that produces O_2 and removes the exhaled CO_2 in accordance with the breathing requirements of the user. It eliminates high-pressure O_2 cylinders, regulating valves, and other mechanical components.

The canister, which contains potassium dioxide (KO_2), generates O_2 when contacted by the moisture and CO_2 in the exhaled breath, and retains CO_2 and moisture. Retaining moisture is important as it aids in preventing fogging of the lens.

In some models, a quick-start cartridge is included to provide an initial supply of O_2 at the beginning of use. Some models require a quick starter only at apparatus temperatures below 0 C (32 F).

Chemical O_2 apparatus have variable service times. The time is determined by the breathing rate.

An example of this type of apparatus is the SSR 90 M.

Oxygen-Cylinder Rebreathing Apparatus

This type includes the lung-governed type that automatically compensates for the breathing demand of the user, the constant flow type, and combinations of the two.

The unit has a relatively small cylinder of compressed O_2, reducing and regulating valves, a breathing bag, face piece, and a chemical container to remove CO_2 from the exhaled breath. The operating time of approved rebreathing units ranges from 30 minutes to four hours.

The rebreathing principle permits the most efficient use of the O_2 supply. The exhaled breath contains both O_2 and CO_2 because the human body extracts only a small part of the O_2 inhaled. As the user exhales, the CO_2 is removed by the chemical, and the O_2 that is left is used again. This method of operation applies to all O_2 cylinder rebreathing-type apparatus as well as those using liquid O_2.

Each time the apparatus is used, the O_2 cylinder must be refilled and the carbon dioxide-removing chemical replaced.

An example of a rebreather is the Draeger BG4.

Positive Pressure-Demand Apparatus

The positive pressure open-circuit demand apparatus is available from many manufacturers and in different models for specific applications. All consist of a high-pressure air cylinder, a regulator connected either directly or by a high-pressure tube to the cylinder, a face piece, a tube assembly with one exhalation valve or valves, and a frame-and-harness assembly for mounting the apparatus on the body.

The pressure-demand apparatus provides positive pressure to the face piece during both inhalation and exhalation to prevent inward leakage during inhalation.

CONDITIONING

No method of breathing protection should be considered perfect. The physiological structure of a human is such that it is impossible to manufacture a portable apparatus that will suit everyone on all occasions for all purposes.

It is a simple matter for most people to use a breathing apparatus for a short time in familiar, safe and normal conditions. But it is a different matter to wear a breathing apparatus in an emergency where physical stress from high temperature, poor visibility and arduous work add to the emotional and psychological stress. Constant training in simulated emergencies is essential so wearing the breathing device itself does not become part of the problem.

THE VALUE OF SLOW, DEEP BREATHING

To use gas masks or other breathing devices properly, the art of deep breathing should be practised until it becomes a habit. The value of slow, deep breathing at all times can be demonstrated whether wearing breathing devices or not. This is best shown by doing exercise that causes panting or quick breathing.

Energy Consumption, Oxygen Consumption & Volume of Air Breathed			
Activity	**Energy Used (calories/ min)**	**O_2 Consumption (L/min)**	**Volume of Air Breathed (L/min)**
Resting in bed, fasting	1.15	0.240	6
Sitting	1.44	0.300	7
Standing	1.72	0.360	8
Walking, 3 km/h (2 mph)	3.12	0.65	14
Walking, 6 km/h (4 mph)	5.76	1,200	26
Slow run	9.60	2,000	43
Maximum exertion	14-20	3,000-4,000	65-100
In studies by NASA-NRC, the average oxygen consumption for persons under stress in a confined space was 0.42 litres per minute			

Draw in several deep, controlled breaths slowly and evenly, inhaling as much air as possible through the nose, and exhaling through the mouth. It will be noticed that the normal rate of breathing can be resumed quickly and easily without panting.

Heat and resistance from the apparatus must be expected when breathing devices are worn. The resistance can vary from slight to as much as three or four pounds per square inch (psi), and must be overcome.

The heat may vary from normal to an intolerable temperature, depending upon the type of apparatus and local conditions.

If the apparatus wearer is breathing fast, the wearer will be unable to overcome the resistance and obtain enough air before starting to exhale. When this happens, the wearer begins to suffer from air hunger. This, in turn, induces a suffocating feeling and the tendency is to remove the breathing device at all costs.

When wearing a breathing device of any make or type, it is essential to breathe deeply and slowly. The habit can be acquired only by continual practice and training.

SELF-CONTAINED RESPIRATORY PROTECTION

Self-contained protective breathing equipment may be classified by its method of operation, either self-contained closed-circuit or self-contained open-circuit.

Self-contained closed-circuit apparatus used in mine rescue can be of various designs and may use compressed, liquid, or chemically produced O_2, which when breathed, is circulated through a chemical compound that absorbs CO_2 and is rebreathed. Examples of this type are the Draeger BG4 and the SSR 90 M.

Self-contained open-circuit apparatus use purified compressed air, which once breathed, is passed to the outside air and not reused. Example of this type are pressure-demand apparatus such as the Draeger PSS 3000, the Scott Air-Pak 75, and the MSA Firehawk.

SELF-CONTAINED OXYGEN BREATHING APPARATUS

Physiological Effects of Breathing Pure Oxygen

The quantity of O_2 consumed by the body varies with the amount of energy expended. A human at rest uses approximately 0.26 litres (16 in^3) of O_2 a minute. During strenuous exercise the consumption may increase to more than eight times that amount, but the body uses no more O_2 than it requires.

The pure O_2 breathed by the wearer of a self-contained O_2 breathing apparatus causes no noticeable ill effects, even after several successive periods of use, unless the wearer is subjected to air pressures greater than the normal atmospheric pressure of 1.0133 bar (14.7 psi), such as might be encountered in caisson work, or for continuous exposure for 24 to 48 hours.

Eliminating Dangerous Amounts of CO_2 in the Apparatus

One of the most important functions of any closed-circuit self-contained oxygen breathing apparatus is the elimination of dangerous amounts of CO_2 from the circulatory system of the apparatus.

In an open-circuit pressure-demand type of apparatus using compressed pure air, the exhaled air passes through a valve to the outside atmosphere.

A closed-circuit oxygen-producing (chemical) apparatus removes CO_2 through a chemical reaction with potassium dioxide (KO_2) resulting in the consumption of CO_2 and the production of O_2.

The Draeger BG4 apparatus removes CO_2 by a refillable canister that uses soda lime

THE BG4

General Description

The BG4 is a self-contained closed-circuit, O_2 breathing apparatus which enables the wearer to work in irrespirable and toxic atmospheres for up to four hours.

The air in the BG4 is inhaled and exhaled in a closed breathing loop. The positive pressure in the breathing loop protects the wearer by preventing contaminated atmosphere from entering the system.

Exhaled air travels from the facemask along the exhalation hose to the refillable CO_2 scrubber canister. Soda lime in the canister removes the CO_2 from the exhaled air. The chemical reaction to remove CO_2 from the air produces heat and raises the temperature of the breathing loop. To counteract this increase in air temperature, inhalation draws the air through an air cooler, which effectively lowers the temperature of the inhaled air.

Cooled air and the addition of larger diameter exhalation/inhalation hoses help to ensure low breathing resistance and reduce the physical strain on the wearer.

Oxygen is replenished in the breathing loop, whether the wearer is experiencing normal breathing or extreme breathing conditions. The wearer can also feed extra O_2 into the breathing loop via the manually operated bypass valve.

Performance of the BG4 is continually monitored by the Electronics system. The system generates an audible and visual alarm when residual or low pressure is reached or in the event of a malfunction.

The BG4 is lightweight (15 kg/33 lb when fully charged) and extremely durable. The unit is able to withstand demanding applications and extreme environments.

The BG4 is comprised of four major systems:

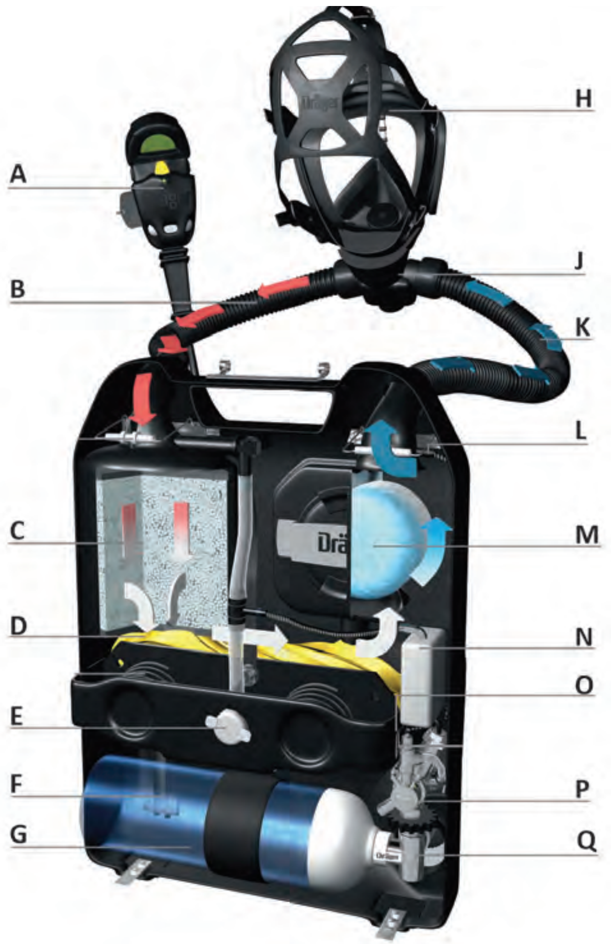
1. Pneumatics
2. Breathing Loop
3. Electronics
4. Backplate and Harness Assembly

Pneumatics

The pneumatic system is responsible for oxygen distribution to the breathing loop. The pneumatic system consists of the following parts:

- O_2 Cylinder
- O_2 Pressure Reducer
- Minimum (Demand) Valve
- O_2 Lines

O_2 Cylinder – The O_2 cylinder is attached to the frame of the BG4 with a pull strap which is secured using a Velcro closure and buckle.



BG4 Major Components

A – Sentinel
B – Exhalation hose
C – Scrubber canister
D – Breathing bag
E – Pressure relief valve
F – Drain valve
G – O_2 cylinder
H – Facemask
J – Connector assembly
K – Inhalation hose
L – Constant dosage
M – Air cooler
N – Switchbox
O – Minimum valve
P – O_2 pressure reducer
Q – Cylinder valve

The cylinder has a volume of two litres and is available in high-grade alloy-steel or carbon composite construction.

A fully charged O_2 cylinder is under a pressure of about 200 bar (2,900 psi). The cylinder contains at least 400 litres of 99.5 per cent O_2. Under normal breathing conditions, this is rated to last for four hours.

Each cylinder is equipped with a brass on/off valve. To prevent over-pressurization, the on/off valve contains a safety cap that will burst when the internal pressure of the cylinder reaches about 275 bar (4,000 psi).

Steel cylinders must be hydrostatically tested every five years to 345 bar (5,000 psi) to comply with Transport Canada regulations.

O_2 Pressure reducer – The O_2 pressure reducer is in the lower right-hand corner of the BG4. The assembly performs the following functions:

- The O_2 pressure reducer distributes high and medium pressure O_2 to the breathing loop.
- High pressure from the O_2 cylinder activates the Electronics system.
- High pressure is reduced to a medium pressure output of 4.0 to 4.4 bar (58 to 64 psi).
- A relief valve is activated at 6.0 bar (87 psi) to prevent over-pressurization.
- In normal operation, O_2 consumed from the breathing loop is replaced by the constant dosage metering orifice at a rate of 1.5 to 1.9 L/min.
- When the minimum (demand) valve is activated, medium pressure O_2 is supplied to the valve at a flow rate of 80 L/min.
- A manually operated bypass valve injects O_2 into the breathing loop at a flow rate of 50 L/min.

The O_2 pressure reducer is attached to the O_2 cylinder by a hand-tightened connector.

Minimum (demand) valve – The minimum valve is on the right side of the breathing bag. During extreme physical effort, more O_2 may be needed than is supplied by the constant dosage system. The minimum valve is activated when the breathing loop pressure drops to between 0.1 and 2.5 millibar (mbar). In such circumstances, deflation of the breathing bag activates the valve's rocker arm. This opens the minimum valve and injects additional O_2 into the breathing loop.

Pressure drop is induced in the breathing loop by excessive breathing demand or a leak in the system. The minimum valve utilizes medium pressure O_2 from the O_2 pressure reducer to provide approximately 80 L/min directly to the breathing loop.

O_2 Lines – The O_2 lines are a series of yellow, blue, and clear lines that carry O_2 from the pressure reducer to various components of the BG4.

A yellow medium pressure O_2 line connects the minimum valve located at the breathing bag to the O_2 pressure reducer.

The air cooler is connected to the constant dosage metering orifice at the O_2 pressure reducer via a blue medium pressure O_2 line.

A branch off the blue medium pressure O_2 line connects the low pressure side of the Electronics to the pneumatic system.

A clear O_2 line joins the manually operated bypass valve to the constant dosage metering orifice in the O_2 pressure reducer.

Breathing Loop

The air in the BG4 is exhaled and inhaled in a closed breathing loop. Carbon dioxide is removed from exhaled air by the CO_2 scrubber canister. Inhaled air is cooled by the air cooler and replenished with O_2.

The breathing loop consists of:

- Panorama Nova Mask/FPS 7000 Mask
- Connector Assembly
- Exhalation/Inhalation Hoses
- CO_2 Scrubber Canister
- Breathing Bag
- Pressure Relief Valve
- Moisture Relief Valve
- Air Cooler

Panorama Nova Mask – The Panorama Nova Mask is available in black ethylene propylene diene terpolymer (EPDM) and yellow silicone. Both have a double internal seal and are held in place by a five-strap, quick adjusting, head harness and neck strap.

An internal nose cup helps direct the exhaled breath to the connector assembly and helps to focus speech. The mask is equipped with a stainless steel speech diaphragm to facilitate communication while under O_2.

The facemask has a curved full-view visor which allows 90 per cent of peripheral vision. It is equipped with a manually operated wiper to keep the inside surface of the lens clear.

FPS 7000 – The FPS 7000 is available in either hypoallergenic silicone or EPDM. An ergonomic five-strap, quick adjust, web head harness and double sealing frame with threefold edges offers a secure fit for almost all face shapes.

It has a large distortion-free polycarbonate visor, which provides a 180-degree field of vision. It is equiped with a wiper.

An internal nose cup helps direct the exhaled breath to the connector assembly and helps to focus speech into the stainless steel speech diaphragm.

The FPS 7000 can be integrated with various modules offering voice amplification, tactical push-to-talk radio, and a hydration option, incorporating a CamelBak water reservoir.

Connector Assembly – The facemask is attached to the breathing hoses via the connector assembly. The connector assembly consists of a plug-in connector, an inhalation valve, an exhalation valve, and the main body.

The main body of the connector assembly is labelled with breathing flow indicators. The plug-in connector is equipped with a silicone O-ring connector seal and comes with a sealing cap to protect the assembly when it is not coupled to the mask. The inhalation and exhalation valves have different housing diameters so they can not be confused. The valve disks in each valve are identical and interchangeable.

Exhalation/Inhalation Hoses – The corrugated exhalation and inhalation hoses are identical and interchangeable. Constructed of EPDM, the hoses are flexible making it easy to don and doff the BG4.

Each hose has a long collar and short collar on opposite ends to facilitate proper union with the adjoining component. Quarter-turn bayonet rings secure the four ends of the breathing hoses to the adjoining components.

The exhalation hose is connected to:

- Connector assembly (long connector)
- CO_2 scrubber canister (short connector)

The inhalation hose is connected to:

- Air cooler (long connector)
- Connector assembly (short connector)

Anti-crush reinforcing rings can be placed on the breathing hoses in the shoulder area to provide constant support. The breathing hoses are secured to the shoulder straps with safety loops.

CO_2 Scrubber Canister – The CO_2 scrubber canister sits in a metal retaining bracket and is secured to the frame of the BG4 with a roller clamp tensioning bar. It is connected to the exhalation hose with a quarter-turn bayonet ring, and to the breathing bag with a sleeve and collar connection. A safety clip connects the pressure relief valve hose to the scrubber canister.

The canister removes CO_2 from exhaled breath using soda lime. It can be a single-use, factory-packed style or a refillable one. Under normal breathing conditions, either can be used continuously for up to four hours.

The components of the refillable canister are:

- Metal stabilizer disk
- Lid with quick tab lock connectors
- Neoprene O-ring seal
- Top and bottom dust filters
- Top and bottom screens

The refillable canisters are translucent and marked with a fill line to ensure proper filling. It is essential that the refillable canisters be completely filled with soda lime and packed correctly.

Under-packing the canister will not provide sufficient soda lime to effectively remove CO_2 from the breathing loop. Over-packing the canister may cause channelling in the soda lime. Channelling interferes with the proper absorption of CO_2 from the exhaled air. Both under- and over-packing reduce the effective operating time of the BG4.

The scrubber canister is designed for easy removal and servicing.

Breathing Bag – The breathing bag assembly is held in place within the frame of the BG4 by a retaining bar. The CO_2 scrubber canister, air cooler, minimum valve, and moisture relief valve are attached to the breathing bag with sleeve and collar connectors.

The 5.5-litre breathing bag has sealed seams and is constructed from yellow puncture-resistant polyurethane.

With the aid of two large springs, the breathing bag is able to generate positive pressure throughout the entire breathing loop.

The breathing bag assembly consists of:

- Two springs
- Pressure plate
- Breathing bag

Pressure Relief Valve – The pressure relief valve is mounted to the frame of the BG4 at the breathing bag. Excess air is routed from the breathing loop at the scrubber canister along a clear tube to the valve.

The pressure relief valve prevents over-pressurization of the breathing loop. Too much air in the breathing loop causes the breathing bag to over-inflate. This pushes the pressure plate against the relief valve tappet, opening the valve and expelling the excess air into the atmosphere. The valve opens when breathing pressure reaches between 2.0 and 5.0 mbar.

The internal components of the pressure relief valve are interchangeable with those of the moisture relief valve.

Moisture Relief (Drain) Valve – The moisture trap and valve are at the bottom of the breathing bag. They are attached to the frame of the BG4 with a retaining clip.

The moisture relief valve drains moisture that accumulates in the breathing bag. The valve opens when the pressure in the moisture trap is equal to or greater than 15 mbar. The moisture drains out at the base of the unit into the atmosphere.

A sintering filter is located at the top of the valve housing to prevent soda lime particles from entering the valve.

The internal components of the moisture relief valve are interchangeable with those of the pressure relief valve.

Air Cooler – The air cooler is between the breathing bag and the inhalation hose. It is secured to the frame by a roller clamp. The cooler is attached to the breathing bag with a sleeve and collar connection and to the inhalation hose with a quarter-turn bayonet ring. The molding seams on the hose connection are used to ensure proper alignment with the inhalation hose during assembly.

The air cooler is a simple heat exchanger with the ice chamber isolated from the breathing loop. The cover on the ice chamber helps keep condensate and melted ice from entering the body of the BG4.

When filled with preformed ice, the air cooler lowers the temperature of the inhaled breathing air, reducing the physical strain on the wearer.

The constant dosage system enriches the breathing loop with O_2 at the air cooler.

At a breathing rate of 30 L/min and an ambient temperature of 24 C (75 F), the temperature of the breathing air can be maintained below 37 C (98 F) for up to four hours.

Air temperature and breathing rate will affect how long the ice lasts and the air cooler remains effective. Ice packs which are small, broken

up or not completely frozen will reduce available service time allowing the temperature of the breathing air to rise above 37 C (98 F).

Ontario Mine Rescue uses two different BG4 models, each with a different air cooler. The newer black cooler is not interchangeable with the older grey cooler unless the BG4 backplate has been modified. When assmbling a BG4, if the black air cooler does not fix easily into the unit, do not force it. Merely replace it with an older, grey air cooler.

Electronics

The Electronics system is comprised of:

- Sensor
- Switchbox
- Sentinel

The system continuously measures the pressure in the O_2 cylinder, indicates this pressure on the Sentinel, tests and monitors the correct functioning of the BG4, and generates alarms when residual (low) pressure is reached, as well as in the event of a malfunction.

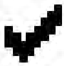
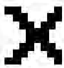
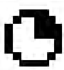
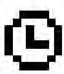
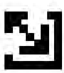
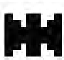
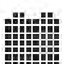
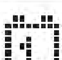
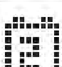
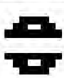
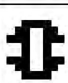
The sensor and the switchbox are on the right-hand side of the BG4. The sensor converts the pressure reading from the O_2 cylinder into an electronic signal. This signal is transmitted through the switchbox to the Sentinel which monitors the performance of the BG4. The electronics system is powered by a commercially-available nine-volt DC alkaline battery, which can be replaced quickly and easily, in the Sentinel.

Sentinel – The reinforced cable from the switchbox to the Sentinel is secured to the shoulder strap with snap loops.

The housing of the Sentinel is designed for use in tough environments to explosion-proof standards.

The Sentinel features:

1. LCD digital display of O_2 cylinder pressure in psi/bar
2. LCD digital display of time remaining in minutes to first low pressure alarm
3. Icon for minutes
4. Yellow panic button to manually activate Distress Signal Unit (to deactivate press and hold the right- and left-hand buttons)
5. Right-hand button to display ambient temperature (display automatically switches back)
6. Green LED for visual operational signal
7. Tally key, a movement sensor and Automatic Distress Signal Unit
8. Red LED indicators for visual alarm signals

Sentinel Icons	
Symbol	**Meaning**
	Test completed successfully.
	An error has occurred. The error is indicated by the letter in front of the X. Further information can be obtained from Dräger.
	The numbers to the left of this symbol give the remaining period of use in minutes.
	The leak test is currently running.
	Infrared connection between Bodyguard and IR interface.
	The function key has been inserted. The motion sensor is disabled.
	The function key has been removed. The motion sensor is activated.
	Battery symbol
	first battery warning
	second battery warning
	Open cylinder valve!
	Close cylinder valve!

9. Left-hand button for LED backlight to illuminate display for five seconds
10. Analog display of O_2 cylinder pressure

The main function of the Sentinel is to provide the following information:

- Indicate O_2 cylinder pressure
- Display time remaining until first low pressure alarm
- Indicate results of the high pressure leak test
- Indicate results of the battery test
- Provide low pressure alarms
- Provide no pressure warning

The Sentinel has three alarm points:

- 1st low pressure alarm @ 55 bar (800 psi), the Sentinel beeps intermittently for 30 seconds and the red LEDs flash
- 2nd low pressure alarm @ 10 bar (145 psi), the Sentinel beeps continuously and the red LEDs flash until it switches off
- No pressure warning @ 1.40 mbar, the Sentinel beeps once and the red LEDs flash indicating the O_2 cylinder is closed or empty and there is no pressure in the system.

Backplate & Harness Assembly

The ergonomic design of the backplate and harness assembly provides the wearer of the BG4 with improved comfort over the previous model.

Notable features of the backplate and harness assembly are:

- Constructed of lightweight composites
- Shaped carrying shell for ergonomic fit
- Padded harness for comfort

- Waist belt
- Shoulder straps
- No-tool design for easy harness removal and cleaning
- Carrying handle and feet for easy handling
- Flame tested to 1,093 C (2,000 F)

THE SSR 90 M

A self-contained closed-circuit oxygen breathing apparatus with a lifespan of at least 90 minutes (European Norm Standard) at a medium heavy workload is essential to rescue conscious trapped miners. This length of protection is essential because of the distances involved. The SSR 90 M is one unit that suits mine rescue needs.

The MSA/Auer SSR 90 M is a compact closed-circuit, self-contained, oxygen-generating rescue device with potassium dioxide (KO_2) as the active chemical.

Oxygen is generated when the wearer's exhaled breath, containing CO_2 and water vapour, reacts with the chemical in the canister.

The rate at which O_2 is produced is proportional to the demand of the wearer. If the wearer is breathing deeply and filling his/her lungs, the oxygen-generating chemical will more than satisfy his/her requirements.

When the wearer is breathing at a sedentary rate, less CO_2 and water vapour are exhaled. Therefore, the rate at which O_2 is produced slows. If the person begins to move vigorously and to consume large amounts of O_2, the increased demand is satisfied immediately.

The total weight of the unit in the case is 6.7 kg (14.7 lb). The unit itself weighs 4.7 kg (10.3 lb).

Description of Parts

The apparatus consists of five main parts:

1. Facemask and mouthpiece
2. Breathing bag and breathing tube
3. Oxygen-generating canister
4. Carrying harness
5. Stainless steel carrying case

Facemask and Mouthpiece – The full-facemask is foldable and has a twin lens, speaking diaphragm, and threaded breathing tube connection. The mouthpiece, with threaded breathing tube connection and noseclip and goggles is included for special applications.

Breathing Bag and Breathing Tube – The breathing tube is connected to the valve housing on the top of the breathing bag. The valve housing contains the inhalation and exhalation check valves, heat exchanger, particle filter and connection for the internal exhalation tube. The breathing bag is made of rubber. The relief valve is on the front of the breathing bag. The breathing bag has a capacity of approximately five litres.

Oxygen-Generating Canister – The canister is a metal container filled with an oxygen-producing chemical (KO_2). It is connected to the bottom of the breathing bag and has a central tube that delivers the exhaled air to the bottom of the canister. Oxygen is then liberated into the breathing bag by the chemical reaction of moisture and CO_2 with the KO_2.

Pulling the ring removes a pin on the bottom of the canister that activates the Quick-Start Cartridge. The cartridge contains sodium chlorate ($NaClO_3$) that is pressed into a candle. The chlorate candle is highly susceptible to moisture. Removing the pin releases a spring-loaded plunger that strikes a percussion cap causing the sodium chlorate to ignite.

The primary purpose of the chlorate candle is to generate heat to make the KO_2 more receptive to activation by CO_2. The ignition of the chlorate candle results in the creation of O_2 at a rate of four litres per minute for about 2 1/2 minutes.

Since heat as high as 205 C (400 F) is produced when the cartridge is ignited, care must be taken not to touch the area around the pin after igniting the cartridge.

Carrying Harness – The carrying harness consists of an adjustable neck and waist strap connected to a felt canister support that insulates the wearer from heat being produced by the canister.

Stainless Steel Carrying Case – The unit is stored in a case made of stainless steel that can be sealed to prevent air from entering.

SSR 90 M Rated Service Times	
Breathing Rate	**Approx. TIme**
At rest	Up to 300 min.
30 L/minute	90 min.
40 L/minute	60 min.

General Information for Use

The units should not be used on unconscious casualties as their breathing volume may not be adequate to ensure sufficient production of O_2. An attempt, however, may be made with one SSR 90 M. If the breathing bag does not inflate, the unit should be removed immediately.

Since after hard work the canister will produce more O_2 than will be needed, the breathing bag will become over-inflated. The excess O_2 is vented through the relief valve on the breathing bag.

There are two indications that the canister is becoming expended: fogging of the lenses on inhalation and increased resistance during exhalation. These two indications will not normally appear until after 90 minutes but may become noticeable during extremely hard work.

Maintenance

Reconditioning After Use – The SSR 90 M has a chemical canister that can be changed easily and quickly without special tools. All components can be used again after being cleaned, disinfected and thoroughly dried. After a new canister has been installed, the SSR 90 M is pushed back into the case, closed airtight, and resealed.

Never allow any substance, such as water, oil, gasoline, or grease, to enter the neck of the canister. The chemical produces O_2, which may cause any flammable material to catch fire.

Disposal of Canister – To dispose of a canister, punch a small hole in the front, back, and bottom and place in bucket of clean water deep enough to cover the canister by at least three inches. When the bubbling stops, any residual O_2 will have dissipated and the canister will be expended. Neutralize the solution by adding a dilute acid. Then pour the water down a drain or dispose of it in any other safe manner and discard the canister.

Monthly – The exterior must be checked for damage and the condition of canister and lead seal.

Annually – The unit must be checked with a tightness tester to ensure the canister contents have not been exposed to humidity.

Three Years – Interior random sample checks must be made of three per cent of the units in service.

Ten Years – The shelf life of the unit expires and it must be rebuilt. Note that the shelf life of units exposed to mechanical vibration is only three years, after which those units must be rebuilt. The date of the last rebuild is labeled on the bottom of the canister. Rebuild dates may also be labeled on the lid of the SSR 90 M.

Training

For reasons of economy, Ontario Mine Rescue uses the SSR 90 M Training Unit for training purposes. This apparatus is identical to the SSR 90 M in design, weight, dimensions and use. However, it does not contain a KO_2 canister. Therefore, it must not be used for training in contaminated atmospheres. The label and the breathing bag are blue to distinguish them from emergency units.

CAREvent AUTOMATIC RESCUE VENTILATOR

The CAREvent Automatic Rescue Ventilator was developed by Draeger Safety to meet the specific challenges of underground

mine rescue. These include a low O_2 atmosphere and/or potentially toxic environment, entrapment, long rescue times, distance to fresh air, performing artificial resuscitation and/or cardiopulmonary resuscitation on a downed casualty, multiple casualties requiring O_2 therapy or resuscitation, and compromised breathing supply.

The CAREvent provides a safe and effective means of providing demand breathing or artificial ventilation to casualties suffering respiratory difficulty and/or cardiac arrest. It is a portable and extremely durable unit, pneumatically powered, and effective in confined space rescue or Immediately Dangerous to Life or Health (IDLH) environments.

Casualties requiring respiratory support can demand breathe from the apparatus, while those requiring ventilation support receive automatic intermittent positive pressure O_2. A manual override button allows the operator to control ventilations at a rate and volume they desire.

The ventilator allows the breathing casualty to “demand breathe” on 100 per cent O_2 while their inspiratory efforts causes the automatic cycling to cease. Should the casualty stop breathing, the ventilator will automatically restart.

The pneumatic logic circuit can be run on either approved compressed breathing air or medical O_2. The unit is self-contained and only requires to be attached to a regulated O_2 or air supply for immediate use.

Exhaled breath from the wearer is released to ambient air, limiting the CAREvent’s duration to approximately 60 minutes.

Parts

The CAREvent consists of:

- An aluminum storage case
- Two carbon fibre O_2 cylinders
- Regulator
- Air supply hose
- Resuscitator
- Facemask

The face piece is a Panorama Nova facemask of similar design to that used with the BG4. The O_2 cylinders are interchangeable with those used with the BG4.

Performance Specifications

Tidal volume:	0.5 litres
Breaths per Minute:	10
I:E Ratio:	1:2
Automatic Flow Rate:	15.0 L/min

Manual Flow Rate:	15.0 L/min
Delay to Automatic Cycling Re-start after Manual Button Depression:	20 seconds
Demand Breathing Flow Rate:	0 to 120 L/min
Demand Breathing Triggering Pressure @ 100 L/min:	-5 cm H_2O
Input Pressure (working pressure):	50 psi (3.5 bar)
Maximum Airway Pressure (relief valve pressure):	60 cm H_2O
Operating Temperature:	-18 to 50 C (0 to 140 F)
Storage Temperature:	-40 to 60 C (-40 to 140 F)
Input Connection:	9/16" DISS
Patient Connection:	Unique fitting
Weight:	.37 kg (13 oz)
Size:	140 x 63 x 73 mm (5.5 x 2.5 x .9 in)

NOTES:

CHAPTER 9
AUXILIARY EQUIPMENT FOR THE BG4

BG4 TEST UNITS

The Draeger Test-it 6100 and RZ 7000 are sturdy, portable test devices in a compact suitcase design, intended specifically to test the functions of Draeger closed-circuit breathing apparatus, including the BG4. The two test units fulfill identical functions, but have differences in features, the RZ 7000 being a newer model.

Test units should be stored in a dry place at room temperature and kept sheltered from direct sunlight. They can be wiped clean with a damp cloth.

To operate a test unit, place the case on a flat surface next to the apparatus.

The Test-it 6100

The Test-it 6100 has:

- A hand pump and hose
- Air hose adapter
- Sealing plug

Open the case and connect the Test-it 6100 to a power supply. Press the On/Off button to turn the device on and allow the unit to complete an automatic sensor offset. When the offset is completed, the unit is ready for use.

The operating panel is clearly divided into flow and pressure measurement areas. An integrated display in the centre of the panel shows either the flow or the pressure. The display indication can be switched by pushing the button below the display. If this button is pressed for a longer period, a sensor adjustment is carried out. The measuring scale for the flow is L/min and for pressure either mbar or hPa can be selected.

The components – RD40 connector, the hand pump connection piece, shutoff valve, and pressure relief valve, are arranged on the pressure side of the operating panel. A supplied adapter is used to connect the air hoses of the BG4 to the RD40 connector.

The Test-it 6100 includes a dosing cap used to connect the flow sensor to the input of the hand pump. This design means the BG4 can remain connected to the unit. In addition, the flow side has a stopwatch for time measurement.

The RZ 7000

The RZ 7000 has:

- A lithium-ion battery, eliminating the need for an external power source
- A battery charger
- A simplified user interface
- Illuminated display with integrated timer
- An integrated air pump
- A venting mode

Open the case and connect the RZ 7000 to a power supply. If an external power supply is not available, a fully charged internal battery can power the unit continuously for up to 24 hours. Press the On/Off button to turn the device on and allow the unit to complete an automatic sensor adjustment. When the adjustment is completed, the unit is ready for use. Through the new self-locking adaptor, the BG4 is connected to the test device securely and without additional fittings during the entire test procedure.

FUNCTION TESTING

Both the Test-it 6100 and the RZ 7000 function test the BG4 to ensure the apparatus works as intended. Function testing must be performed whenever the apparatus has been used and serviced, and before being stored. Function testing of the apparatus must also be performed in accordance with the required maintenance interval (example: replacing the soda lime at a six-month interval).

The main objectives of the function test are to ensure the BG4 is free of leaks, the components of the BG4 are ready for use, and the apparatus is operating to specification.

A function test includes the following inspections and tests:

- Apparatus Inspection
- No (low) Pressure Warning
- Inhalation Valve
- Exhalation Valve
- Moisture Relief (drain) Valve
- Positive (low) Pressure Leak Test
- Pressure Relief Valve
- Bypass Valve
- Constant Dosage (flow) Rate

- Minimum Valve
- Low (residual) Pressure Alarm
- Battery Charge
- Facemask Inspection

Apparatus Inspection – The BG4 must be thoroughly inspected for wear and damage during assembly prior to function testing. The harness and straps of the BG4 must be free of any damage that could compromise wearing the apparatus, and the harness assembly is to be fully extended for easy donning.

If link lines and belts are stored with the BG4, they should also be inspected for defects.

Additionally, the hydrostatic test date of the O_2 cylinder must be inspected to confirm the cylinder is within the five-year test span required by Transport Canada. Both steel and composite O_2 cylinders used by Ontario Mine Rescue are to be hydrostatically tested every five years. The date of testing must be marked on all cylinders. The cylinder must not need retesting within the next six months.

No Pressure Warning – Alerts the wearer that no O_2 pressure is sensed within the apparatus. The warning should activate at 1.4 mbar or less.

If the warning is functioning properly:

- The backlight of the Sentinel turns on indicating a red LED
- The open cylinder icon is shown
- Audible alarm beeps once

Inhalation Valve Test – Ensures the inhalation valve seat and valve disc are in good order. By squeezing off the exhalation hose and directing the positive pressure against the valve, the system should reach a pressure of +10 mbar or more.

The inhalation valve is a one-way valve allowing the wearer to inhale cool air. During exhalation, the valve closes and directs exhaled air to the soda lime canister which will absorb the CO_2 from the wearer's exhaled breath.

This valve, in good order, ensures the wearer does not rebreathe exhaled CO_2.

Exhalation Valve Test – Ensures the exhalation valve seat and valve disc are in good order. By squeezing off the inhalation hose and applying negative pressure against the valve, the system should reach a pressure of -10 mbar or less.

The exhalation valve is a one-way valve that allows the wearer to exhale CO_2 to the soda lime canister which will absorb the CO_2 from the exhaled breath and prevent the CO_2 from being rebreathed.

The exhalation valve, in good order, ensures the wearer does not rebreathe exhaled CO_2.

Pressure Relief Valve (PRV) Test – Ensures the PRV will activate between 2 mbar and 5 mbar when positive pressure is applied to the system. The activation of the valve prevents over pressurization to the breathing loop.

This test ensures the spring pressure of the valve is correct and the valve is not blocked or sticking.

Moisture Relief Valve (MRV) Test – Ensures the MRV will activate between 15 mbar and 25 mbar when positive pressure is applied to the system. The activation of the valve relieves the BG4 of excessive moisture during use.

This test ensures the spring pressure of the valve is correct and the valve is not blocked or sticking.

Positive Pressure Leak Test – Ensures that with a positive pressure of 7.0 mbar to 7.5 mbar applied to the system, there is no leakage within the components of the BG4 greater than 1.0 mbar over a one-minute duration.

If there is a leak within the BG4, it will affect the service time, and potentially allow contamination into the apparatus, affecting the wearer.

Bypass Valve Test – Ensures that when the oxygen cylinder is open, the bypass valve will activate and shut off when pressed and released.

Constant Dosage Test – Ensures the dosage rate, after starting the test at 1.7 L/min, will stabilize between 1.5 and 1.9 L/min.

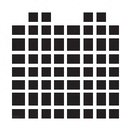
If the constant dosage rate does not stabilize between the set parameters, it will affect the operation of the BG4 as there could be defects within the unit including a faulty pressure reducer, damaged or dirty dosage orifice, or leak with the BG4 components.

Minimum Valve Test – Ensures the minimum valve activates between 0.1 mbar and 2.5 mbar with the oxygen cylinder on supplying the wearer of additional oxygen at a flow rate of 80 L/min when required, such times of heavy workload when additional O_2 is needed.

Oxygen Cylinder Pressure Test – Ensures a pressure of 185 bar or greater before use. With a lower O_2 pressure, the service time of the BG4 will be reduced.

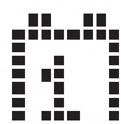
Low Pressure Alarm Test – Ensures that the low pressure alarm will activate at 55 bar, alerting the wearer and team that the BG4 is running low on oxygen. When performing this test, after the oxygen cylinder is turned off and pressure has dropped to approximately 55 bar, if the alarm is functioning properly:

- An audible alarm beeps intermittently
- A red indicator flashes constantly

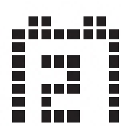


Battery Test – Ensures the battery charge is sufficient to power the BG4.

- A fully shaded battery displayed on the Sentinel indicates a good battery.
- A “Battery Warning 1” indicates sufficient charge to power the BG4 for four hours.



- A “Battery Warning 2” indicates the battery is discharged.



The battery must be replaced immediately if a “Battery Warning 2” is observed during the battery test, or if the battery has reached its six-month service time.

Facemask Inspection – The facemask, either a Panorama Nova or FPS 7000, must be inspected to ensure there is no damage or defects, so it functions properly and can maintain a facemask seal on the wearer. To ensure the mask is safe for the wearer, it must be inspected for:

- Mask body overall condition
- Free of wear and damage to the head straps

- Freedom of movement on the adjustment rollers
- Clarity of the visor
- Damage to the visor
- Damage to the speech diaphragm
- Wear or damage to the visor wiper
- If equipped, FPS 7000 communication components, including battery, must be inspected as well

If a leak is suspected, the facemask should be set aside for a facemask leak test.

BG4 Unit Sealed & Dated

After the function test has been completed and the cover of the BG4 replaced, the apparatus is sealed with a tamper seal and dated six months from the date the soda lime was refilled.

The next individual to wear the BG4 will check this seal during the BG4 field test, prior to donning, to ensure the soda lime and function test are within six months of the date on the BG4.

FACEMASK LEAK TEST

If repairs are made or a leak is suspected in either the Panorama Nova or FPS facemask, the mask must be leak tested. To leak test a mask, a Draeger test head and either a Test-it 6100 or RZ 7000 is required.

To leak test a facemask:

1. Test the test unit
2. Connect the test unit to the test head
3. Fit the mask on to the head ensuring proper placement
4. Tighten the head harness in proper sequence – neck straps (A), temple straps (B), and front strap (C)

5. Use the sealing plug from the test unit to seal the mask
6. Apply a negatice pressure to the mask from the test unit of -7 to -7.5 mbar. The maximum allowable pressure loss is 1 mbar over a minute
8. If leakage occurs, a technician should replace or repair any defective parts and retest the mask

HIGH-PRESSURE OXYGEN BOOSTER PUMPS

No oil or grease of any kind should be used in any type of high-pressure oxygen pump. A chemical reaction between the oil or grease and the oxygen is possible and is likely to result in an explosion. When using any oxygen pump, ensure good ventilation in the pumping room to dilute the concentrations of oxygen.

Oxygen booster pumps are multi-valve, piston-type pumps for compressing oxygen and transferring it from one cylinder to another at a desired higher pressure. Pumps are available in either hand-operated or power-driven types.

Draeger Masterline Booster

The Masterline Electric Booster Pump Model 7000A is used for pumping oxygen, allowing users to fill oxygen cylinders up to 5,000 psi (345 bar) from low-pressure supply cylinders. The booster has a 10:1 boost ratio, is capable of quickly filling four cylinders at a time, and has an auto stop.

The booster pump operates at a low noise level and requires minimal maintenance. The booster is oil-free and uses only two low-friction dry seals. The seals can be replaced in about 20 minutes with only a few tools. The piston guides and the lower piston bushings are the only other parts that need replacement after several years of service.

Step-by-Step Pumping of an O_2 Cylinder

During the filling cycle, the temperature in the oxygen cylinders will rise in direct proportion to how fast the cylinders are filled. Cylinders should be allowed to cool to room temperature before being removed from the pump. Warm cylinders will give a false high reading resulting in a low fill pressure after they cool. If the pressure in the cylinders drop after they have cooled, restart the booster pump to bring the cylinders up to the desired pressure.

Opening the valve on a oxygen cylinder or within an oxygen system too quickly can cause an explosion or fire, particularly if any contamination is present in the system.Take care to open all valve slowly.

To fill oxygen cylinders:

1. Ensure clothing and work area are clean and free of all oil and grease

2. Check all cylinders to be filled for expired hydrostatic test dates
3. Check the status of all cylinders:
   – Cylinders that have been hydrostatic tested or below 500 psi (34 bar) must be purged
   – Cylinders that have their dust caps wrench-tight are full
   – Cylinders that have their dust caps only hand tight need to be filled

4. Ensure all isolation valves and the bleed valve are closed
5. Slowly, fully open the valve on the supply oxygen cylinder
6. Ensure the selector switch on the pump is set to 3,200 psi
7. Connect the cylinder(s) to be filled to the connection of the pump then:
   – Slowly open the cylinder valve
   – Slowly open the shutoff valve to the cylinder
8. Slowly open the inlet shutoff valve on the oxygen booster pump:
   – The pressure should now register on the inlet and outlet gauge (allow pressure to equalize)
9. Push the start button on the booster and the pump will now fill the cylinders and shut off automatically
10. Allow cylinders to cool to room temperature, if required after cooling bring the cylinders up to the desired pressure

11. Close the supply oxygen cylinder valve
12. Close the valves on the filled oxygen cylinders
13. Close the outlet shutoff valve
14. Slowly open the bleed valve to relieve pressure from the manifold
15. Disconnect the filled oxygen cylinders from the fill connectors
16. If no more oxygen cylinders are to be filled bleed all residual oxygen from the system

Only trained personnel are allowed to operate oxygen booster pumps.

NOTES:

CHAPTER 10
SPECIAL EQUIPMENT

EDRAULIC SPREADER/CUTTER/RAM

Each eDraulic or electro-hydraulic device is equipped with two lithium ion batteries and a charger unit. Each fully charged battery, lasts approximately 60 minutes, and is interchangeable between devices. The tools may also be run on alternating current with a 110 Volt adapter to an external power supply. The battery or external power supply powers a hydraulically operated piston(s) that activate the arms of the spreader or cutter, or the extension/retraction of the ram.

All eDraulic devices are equipped with lights to facilitate work under poor operating conditions and illuminate the work area. These tools are not intrinsically safe as sparks could be created while cutting steel, so should not be used in a potentially explosive environment.

The **Hurst SP 310E2 Spreader** has a maximum spreading force of 72,800 lb (324 Kn), and a maximum pulling force of 9,900 lb (44 Kn). The SP 310E2 has a maximum spread of 28.5 in (725 mm). It weighs 52.7 lb (23.9 kg). The spreader can be used to spread open, pinch, or pull open objects.

The **Hurst S 700E3 Cutter** has three distinct cutting angles, and at its maximum opens to 7.6 in (192 mm). It weighs 49.4 lb (22.4 kg). The engineered curved blades close at the tips and then pull the object to be cut towards the point where maximum cutting force is applied.

The **Hurst R 411E Ram** has a retracted length of 21.3 in (542 mm) and an extended length of 35.4 in (900 mm). The ram has a maximum pushing force of 23,180 lb (103 Kn). It weighs 37.4 lb (17 kg). The ram is equipped with "claws" on both ends to ensure its safest possible use.

Field Test

1. Ensure both batteries are fully charged
2. Check general condition and for damage (i.e., tips, blades, claws, etc.)
3. Turn on device and examine for easy opening/closing (spreader/cutter) or extension/retraction (ram)
4. Listen for quiet operation/suspicious noises
5. Ensure the 'dead man's switch' stops the operation of the device
6. Close spreader/cutter or retract ram
7. Turn device off
8. Report to the captain

Spreader – Operating Procedures

Before work begins, ensure the obstacle is stabilized, and the area is cleared so that no one is unnecessarily at risk from the movement of the obstacle, the device or from flying fragments. Never stand between the load (being pulled or spread) and the spreader.

The spreader is not designed to be used as a jack. Only in an extreme emergency may the tool be used to lift a load. The load could easily tip over because of the small surface area of the tips. Therefore, never work under a load being lifted by the device alone. Make sure the load is blocked properly as it is lifted.

Spreading – The spreader is designed to do the spreading and pinching only with its tips. Never use the arms for spreading or pinching material.

Insert the tips of the spreader in the opening between the objects to be spread. If the access point is too small, spread the arms and insert only one tip. Close the arms and bend the fixed material away. Repeat this until both tips can be inserted in the opening and then start spreading.

Pulling – When pulling, use only the special high-tensile chain and adaptor supplied with the unit, then:

- With the spreader open, connect one of the chains to the article to be pulled
- Securely anchor the other chain to a solid object
- Fix the adapters to the arms and make sure the hooks point upwards
- Place the fastpins from below through the adapter and the special holes in the arms
- Connect both the chains to the hooks on the adapters and pull

Cutter – Operating Procedures

Before work begins, ensure the obstacle is stabilized, and the area is cleared so that no one is unnecessarily at risk from the movement of the device or from flying fragments.

The blades of the cutter should be positioned at a 90° angle to the object to be cut, if possible. Higher cutting capacities can be achieved by cutting as close as possible to the blade's pivot point.

During cutting, the gap between the blade tips (in the transverse direction) must not exceed 0.1 in (3 mm), otherwise the blade is in danger of breaking.

Ram – Operating Procedures

Before work begins, ensure the obstacle is stabilized, and the area is cleared so no one is unnecessarily at risk from the movement of the obstacle, the device or from flying fragments.

Before using the ram, ensure it is adequately supported and has the required substructure. Where this support is not adequate, additional supports, cylinder attachments and the use of holding straps may be required.

Basic Extrication Techniques

These extrication techniques are for a Landcruiser-type underground vehicle, but the basic steps can be applied to other underground vehicles.

1. **Scene Assessment:** Assess the safety of the area before approaching. Hazards such as other vehicles, compromised ground support and structures, compressed air and water lines, fuel spills, electrical cables and explosives may be present.
2. **Vehicle Stabilization:** Before starting work, wheel chocks must be installed and the master switch, if safely accessible, shut off. Cribbing and wedges can be used at structural points on the vehicle to minimize movement during the operation.
3. **Glass Management:** Before using eDraulics, glass around the casualty must be removed in a controlled method. Laminated windshield glass must be cut with a glass saw or cutter. Use a small water spray and a blanket or tarp to protect the casualty from fine glass dust while cutting. On newer vehicles, laminated glass may be used on side and rear windows, but on most vehicles side and rear windows are tempered glass, which can be broken in the bottom corner with a fine tipped object. Again, protect the casualty with a tarp or blanket. If time permits, taping the entire window will reduce the glass shards inside the vehicle.
4. **Battery Access**: If the hood latch cannot be reached, pinch the front fender near front of the wheel well with spreaders (do not pinch the hood) to create an access point between the fender and hood. Place spreader tips in the point and spread the hood upward to create space to access the battery. Make two cuts at least two inches (five cm) apart in the negative cable.

5. **Door Removal:** Several options are possible if the door cannot be opened.
    - **A Post Vertical Push –** After glass management and all hazards along the A Post are identified, place the spreader so one tip contacts the upper A Post at mid-length of the window frame, and the other tip contacts the top of the door window sill, roughly 12 in (30 cm) from the A Post. Since the spreader opens in an arc motion, position the spreader so that the handle will be pointing upwards on a 45-degree angle. This will push the door outward from the vehicle as the spreader is opened, and create space between the casualty and the door, as well as access to the hinge and Nader bolt.

- **Hinge Approach –** Pinch the front fender behind the wheel well to create an access point, enough space to insert the spreader tips between the fender and the door panel to pry apart the material and gain access to the front door hinges. If necessary, remove the front fender to improve access and make a relief cut for dash displacement easier. Use a post-and-sweep technique between the A Post and bottom of the window to create more space for the casualty and gain access to the top hinge. Cut the top hinge with the cutters for smoother operation and reduced movement. If more space is needed, cut the bottom hinge and use the spreaders to increase the gap. With the bottom hinge cut, clamp the spreaders on the hinge end of door for leverage, and use controlled movements to open the door and pry down to gain access to the Nader bolt. Use a rope or seatbelt to tie the B Post and door window frame together to limit movement, then cut the Nader bolt. Untie and remove door.

- **Nader Bolt Approach –** Use a rope or seatbelt to tie the B Post and door window frame together to limit door movement. Create a purchase point in the paneling near the Nader bolt with a pry bar or use the spreaders to pinch downward at the bottom of window opening. Pinch the door paneling near the Nader bolt and peel away. Using small movements, spread the door structure and paneling away from the Nader bolt. If enough space is created, use the cutters to cut the Nader bolt for smoother operation and to reduce unexpected movement. If there is not enough space, use the spreaders to pop the bolt from the mechanism. Remove the tie from the B Post, so it is only on the door window frame. Clamp the spreaders on the end of the door for leverage and using controlled movements open the door to access the hinges. Cut the limiting strap/arm, then cut the top hinge. If more space is needed to access the bottom hinge, spread door downward with the spreaders and then cut the bottom hinge and wiring. Remove the door from area.

6. **Dash Displacement –** If more space is needed to access and remove the casualty, use the cutters to cut a V pattern from the top of the front fender and structure. Make a horizontal cut below the bottom hinge towards the front of the vehicle. Using the ram, place the control end in the bottom corner of the B Post and the working end in the corner of the A Post and the dashboard. Ensure that the windshield has been removed. Maintaining light pressure on the ram, cut the A Post high. Then while monitoring the casualty's feet and legs, extend the ram to create more space between the casualty and the dashboard. The ram may be retracted and removed to swing the casualty's legs for extraction provided dashboard rebound does not restrict movement.

Basic Maintenance and Storage

After Use – Clean the eDraulic by using a wire brush to remove metal particles and a rag to wipe off fluids and grease from both the metallic and the mechanically movable parts. The lock of the spreader plug-on tips should also be greased from time to time. Greasing provides protection against excessive wear and tear or corrosion. The outside of the tool should be cleaned with a damp cloth (not the electrical contacts in the connection slot on the battery or on the power supply). In addition, the metal surfaces are to be coated with a suitable medium to counteract corrosion (not the electrical contacts in the connection slot, on the battery or on the power supply).

Storage – Never store the eDraulic with fully closed arms or a fully retracted piston. By fully closing the arms or retracting the ram piston, hydraulic and mechanical tension may develop in the device.

Avoid storing eDraulics in a damp environment.

- Operating Temperature is -20 to 55 C
- Storage Temperature is -30 to 60 C

Servicing – As eDraulics are subject to high mechanical stresses, a visual inspection must be carried out after every use and at least once every six months. Inspections enable the early detection of wear and tear, and the punctual replacement of wearing parts preventing breakage.

CRIBBING

Cribbing is often an essential tool during rescue operations when using eDraulic tools, lifting bags, jacks, and other devices, or just to stabilize a load. Cribbing is the structure or material required to build a structure to stabilize equipment or objects (the load). Cribbing can also be used as a base to support lifting operations. To effectively stabilize a load, direct contact must be made with the load and the lower surface. When the lower surface is soft, such as mud or snow, a solid base must be created, with materials such as muck, plywood, or steel.

Loads should be stabilized in the position found, using simple, quick methods. This may involve de-energizing power sources, chocking tires, step chocking, wedging, or cribbing. Throughout rescue operations, stabilization and cribbing should be monitored.

When using cribbing, care must be taken not to expose team members or casualties to unstable loads. Keep unessential personnel at a safe distance, and when required, use pieces of cribbing or other tools to place cribbing. Never place any part of your body between cribbing and the load.

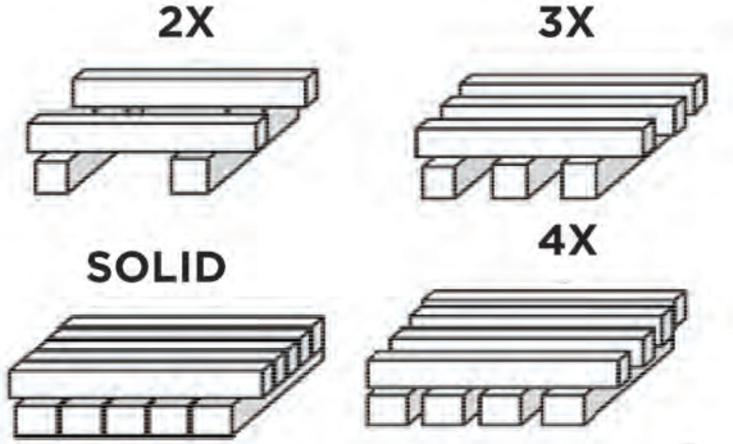
Access to the load will determine the location of cribbing and lifting devices, which should be placed at structural points of the load. If the load is a vehicle or equipment, outer panels, covers and roofs should be removed to gain access to strong structural points. When cribbing or lifting at mechanical/hydraulic implements, manufacturer-designed locking pins or devices should be used. Never rely on hydraulic check valves for proper cribbing. Steering lock devices should be used, if possible, before lifting. Cribbing should not be placed where it could potentially interfere with lifting or displacement.

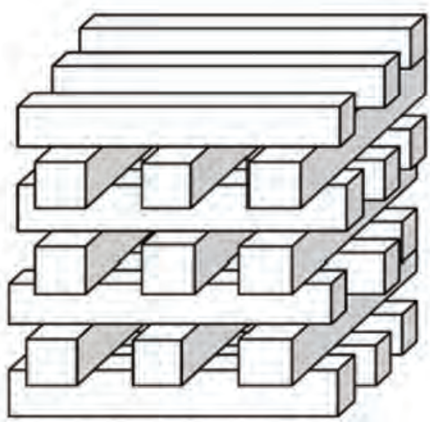
Cribbing material may be shaped as various sized wedges, blocks, and step chocks. Manufactured cribbing materials may be made of wood, steel, rubber, plastic or other material. Wood cribbing should be unfinished and unpainted. The ends may be painted or tagged only for identification purposes.

Prior to using cribbing, it must be inspected for damage and deterioration, including wear, splitting/checking, cracking, crushing and compression. Checks are separations in wood that transect the grain. Damage or deterioration occurs not only with use, but due to age, moisture, and exposure to chemicals. Damaged cribbing must be removed from service, including training. Cribbing should be stored in a clean, dry, and ventilated location.

Cribbing is stacked in aligned layers and pieces to form vertical columns to provide strength and support the load. Improper alignment will reduce the safe height of a stacked crib. Varied lengths of cribbing may be used when stacking material, however, the height of a stacked crib should not exceed twice its footprint, according to the Field Operations Guide of the U.S. Army Corps of Engineers. The footprint is the shortest width of the crib.

A two-by-two construction technique uses two pieces of parallel cribbing per layer, each at right angles to the previous and/or





subsequent layer, creating four columns. A three-by three construction technique uses three pieces of cribbing per layer creating nine columns. A three-by-three technique increases the structure's weight-bearing capacity but uses 50 per cent more material.

Cribbing must be overlapped so that should pieces slip minimally, structural integrity is still maintained. Also with overlapping, failure warning signs at the end of cribbing pieces will be visible. Cribbing ends should overlap the preceding layer by the width of that particular piece. In a cribbing structure of four-inch timbers, each piece should overlap the lower layer a minimum of four inches.

Rescue situations often dictate that cribbing be placed in shapes other than squared timber or blocks. Wedges can be used to fill voids between the load and the cribbing. Wedges can also be used to alter the vertical direction of a stack crib, allowing rescuers to support a sloped load. Alignment, however, is critical and important to maintain. If a modified shape is used, the safest stack height is limited to one times the footprint.

Wedges should be the same width, and preferably the same length as the other cribbing pieces. For four-inch timber cribbing, use four-inch wedges. Also the wedge length should not exceed six times the width. For four-inch cribbing pieces, the maximum wedge length is 24 in.

The weight-bearing capacity of a cribbing structure is determined by the material used, and the cribbing technique, including the number of contact points with the load. The weight-bearing capacity of manufactured cribbing should be identified before its use.

AIR LIFTING BAGS SYSTEM

Air bag systems are multi-application, portable inflation systems used for the lifting and displacement of heavy rigid objects.

They are designed for use in emergency situations such as structural collapse and containment, vehicular extrications, industrial entrapment, and excavation collapse. Since the air bags contain no spark producing parts, they may be used in explosive environments.

Air lifting bags have several advantages over mechanical and hydraulic jacks. They have no moving parts; they are capable of lifting heavier loads; and because they are no more than one inch (2.5 cm) thick, they can be used in lifting situations where using mechanical and hydraulic jacks would be impossible.

High-pressure air bags work on a simple physical formula:

The pressure of air forced into bag **X** Area of bag in contact with load **=** Lifting Force

System Components

Systems and system components are available from various manufacturers. Ontario Mine Rescue uses the original Paratech Maxiforce and new generation Paratech Maxiforce G2 Air Lifting Bag systems. The original Maxiforce Air Lifting Bag Systems can lift and displace heavy rigid objects, up to 146,000 lb (66,637 kg). The newer G2 Air Lifting Bag Systems can lift and displace heavy objects up to 178,400 lb (80,920 kg). Both have a total lift height (using two stacked bags) of 40 in (100 cm).

The basic air bag system consists of six components:

1. Air source
2. Pressure regulator

3. Controller
4. Interconnecting hoses
5. Air bag
6. Safety in-line relief valve

Air Source – The most common air source for use with an air bag system is a compressed air cylinder, typically of the type used in self-contained breathing apparatus.

With the use of special adapters, alternate air sources may be used such as portable compressors, a mine's compressed air system, or a hand or foot pump, provided they are capable of supplying 118 psi (8.1 bar) or more of pressure.

Pressure Regulator – Pressure regulators are available to reduce the supply of air pressure to a maximum 135 psi (9.3 bar) from as much as 5,500 psi (380 bar) but the standard regulator used is designed to reduce an inlet pressure of up to 3,000 psi (207 bar).

The G2 pressure regulator will control the delivery pressure up to 200 psi (13.8 bar) maximum. A safety relief valve is installed to prevent delivery pressures exceeding 200 psi (13.8 bar).

These are self-contained, direct acting, pressure-reducing, diaphragm regulators. They use spring loading to balance the outlet pressure and thereby reduce the effect of, the decreasing of, or variations in the inlet pressure. The regulators are designed for use with an SCBA air cylinder.

Controller – Controllers are equipped with quick disconnect hose fittings at the inlet and outlet, a pressure gauge to monitor the pressure applied to the air bag, valves to apply and release air pressure to the bag, and a relief valve set at 118 psi (8.1 bar).

The G2 controller has 155 psi (10.7 bar) non-adjustable safety relief valves to limit the applied air pressure and prevent over pressurizing.

The valves may be the turn-on turn-off type, or push button or joystick "deadman" type. They may be single controllers for operation of one air bag, or dual controllers for operation of two air bags at a time.

Hoses – Hoses convey air from the air supply to the controller and from the controller to the air bags. All hoses are equipped with quick disconnect fittings.

Hoses are available in various colours for ease of identification. When using more than one air bag, each should be connected by a different coloured hose.

All hoses should be rated for a working pressure of at least 300 psi (20.7 bar).

Air Bags – Maxiforce air bags are composite units fabricated from neoprene, reinforced with six layers (three per side) of Kevlar

or aramid-reinforced fabric for strength and rigidity, even at their full inflation pressure of 118 psi (8.1 bar). The G2 air bags have a maximum working pressure of 150 psi (10.3 bar).

All air bags incorporate non-slip, molded surfaces designed for maximum friction and holding capacity. A bright yellow “X” is molded into each side to provide high visibility during pre-inflation centering. They are equipped with the male half of a quick disconnect hose coupling, that needs to be protected when storing and transporting.

Each bag is proof tested at twice the operating (full inflation) pressure and has a minimum burst pressure of four times the operating pressure.

Do not drag or drop the bag on the nipple area, which can damage or break the fitting.

Safety In-line Relief Valve – The in-line shutoff/relief valve is designed to keep air bags fully and properly inflated:

- When the air bag is disconnected from the controller (safety relief valve and control valve)

- When excess pressure must be automatically relieved due to shifting loads and for temperature changes

The shutoff/relief valve consists essentially of an air inlet and an air outlet with quick disconnect hose fittings, a shutoff valve to isolate the associated air bag, and an internal, non-adjustable spring-loaded mechanism to relieve air bag pressure in excess of 135 psi (9.3 bar). The G2 in-line relief valves are pre-set to 165 psi (11.4 bar).

Preparation & Positioning

To exerting maximum lifting force and achieving maximum lifting heights position the air bag as close as possible to the underside of the load at the start of the lifting operation. As much as possible centre the bag under the load, and never lift with a lifting bag directly in contact with sharp or pointed objects that may puncture, abrade or otherwise damage the lifting bag.

When an object is so heavy that the largest bag will be able to move it only a short distance, build a solid-top crib that will place the deflated bag as close as possible to the underside of the load. Then build cribs as required to appropriately support the load.

Slowly inflate the bag and lift the load just enough to add a new layer of cribbing to the two support cribs. Slowly deflate the bag and add another layer of cribbing to the bag support crib. Slowly inflate the bag and add cribbing to the support cribs. Continue this sequence until the load is lifted to the desired height.

Increasing Lifting Heights & Forces

Two bags stacked one upon the other will lift only the rated load capacity of the smaller bag. Stacking bags, however, will increase lifting height.

Under no circumstances should more than two bags be stacked. If two bags are stacked, the smaller of the two bags must be stacked on top, and the bottom, larger bag must be inflated first until it contacts the load. The top air bag is then inflated to achieve the desired lift. If additional lift is required, the bottom bag is further inflated.

As the bottom bag approaches full inflation, however, the stack becomes less and less stable until finally the effect is like trying to balance an object on top of two footballs. For this reason, it is good practice to never inflate the bottom bag to more than 50 to 75 per cent of capacity, thus creating a pillow for the top bag.

Lifting forces can be increased by placing two or more bags side by side and inflating them simultaneously. This works by increasing the surface area in contact with the load.

Field Test

1. Open case if not sealed. If sealed, go to Step 4
2. Compare list of components with contents of the case
3. Close case
4. Check for a minimum of two full air cylinders or air line connections
5. Select proper size lifting bag and inspect the condition of the bag and the air inlet nipple
6. Report to the captain

At the Scene

1. Assess the safety of the area before approaching
2. Stabilize the object in the position found before performing any work (i.e., chock wheels, set parking brake or cribbing on the sides or corners of object)
3. Build a separate crib for the lifting bags. The closer the bag is to the load, the more effective it will be.

4. Centre the lifting bag under the load to prevent it from being ejected under pressure by the load.
5. As the load is raised, supplement all the stabilizing cribbing so that any drop of the load will be less than the thinnest piece of blocking available

There may be only one layer placed on top to protect the bag or rubber matting may be used.

All blocking must be stacked, cribbing style, to create a stable base which should not tip if the load shifts slightly. To ensure a stable base, blocking should not be stacked any higher than the footprint.

The top level of the blocking where the air bag will be located must be a solid deck or platform.

Never be under a load supported only by a lifting bag. Always stand clear of a load.

System Operation

An air bag system operates as follows:

- After air bags are properly positioned for a lift or displacement, the air source is turned on.
- High pressure air is reduced to 130 psi (9.1 bar), or for the G2 system to 150 psi (10.3 bar). The reduced air pressure is supplied via air hose to the controller.
- Valves on the controller are operated to permit air to flow via air hoses to either one or two bags, permitting a controlled lift/displacement.
- In the line between the controller and each bag is an in-line shutoff and relief valve, designed to permit isolation from the controller, and to ensure that any excess pressure will be relieved from the air bag. The shutoff/relief valve should be located at the controller and not the air bag to prevent damage.

- As air flows into the bag it increases in height resulting in a corresponding lift/displacement. Maximum lift/displacement force occurs at approximately one inch (2.5 cm) of inflation height (minimum reduction of the air bag cross section).
- When air bags are to be partially or fully deflated, controls on the controllers are operated to perform the function, as well as prevent any further inlet air pressure from flowing beyond the controller.
- At the conclusion of the operation the air supply is turned off, any residual system air pressure is bled off through the controller, and the system components are disconnected. All system components should be inspected before being stored for future use.
- The team member operating the controls must concentrate on the gauges, not on the lift and take direction from the captain only.

Shutdown Procedure

1. Shut off air
2. Bleed air from system
3. Disconnect hoses from system

DARDA HYDRAULIC SPLITTER

The Darda Hydraulic Splitter is a wedge-type splitter that can achieve a splitting force of 350 tons at a maximum 7,100 psi (490 bar) when inserted into a hole drilled into a rock.

The main parts of the splitter consist of two cylinders. The upper cylinder houses the piston which moves the wedge in the lower cylinder. The control valve that extends or retracts the wedge is operated by a single lever on top of the unit.

When the control lever is turned to the forward position, the wedge advances and the two feathers are forced sideways against the wall of the hole and, with hundreds of tons of pressure, tears rock or concrete apart.

The wedge and feathers should be completely advanced into the drilled hole. Never try to use just the “tips” to break the rock. This can cause serious damage to the splitter. Depending on the material, a break usually occurs within 10 to 60 seconds.

Before Going Underground

Make sure you have everything you will need for the air/electric model being used:

- Splitter
- Hydraulic pump
- Air and water hoses, and fittings
- Four 1 3/4-in diameter bits, two 48-in drill steel and drill gear
- Lubricating grease (graphite) and extra hydraulic oil
- 36-in measuring stick

Check the level of hydraulic oil in pump.

Before Startup

1. Check all fluid levels, hoses and power connections
2. The air hose should always be blown free of water and dirt before connecting
3. Check that wedge and feathers are in good condition. End of retracted wedge should be approximately 1 1/4 in from tip of feathers
4. Lubricate the wedge and feathers
5. Always start power unit with lever on rock-splitting cylinder in neutral position

Operation of the Splitter

1. The splitter is operated by a lever at the top of the unit. It has three positions:

   – Lever to left – Wedge extends

– Lever to centre – Wedge is in the neutral position

– Lever to right – Wedge retracts

2. Always pause in neutral when going from forward to reverse, otherwise you will damage the splitter
3. When the splitter is working, keep an arm's length away from the cylinder. There may be a sudden movement when the break occurs
4. Once the rock is cracked, do not attempt to spread the rock with the splitter
5. Never use the splitter as a prying tool
6. Proper scaling and barring safety precautions should be taken

Lubrication of Wedge & Feathers

1. Use only a molybdenum disulphide lubricant
2. The wedge and feathers generate up to 350 tons of pressure. If not properly lubricated, they can freeze together, and the feather tops can be pulled out of the cylinder causing damage to both feathers and cylinder
3. To lubricate:

   – Extend the wedge fully and lubricate both sides of the wedge

   – Use lubricant sparingly, but often
4. It is recommended that it be lubricated every two or three splits – under extreme conditions, every split
5. Good lubrication means almost twice the power as compared to neglected lubrication

Drilling Holes for Splitter

1. For efficiency, drill straight and proper-sized holes, 1 3/4-in diameter and a minimum of 26 in (66 cm) deep

2. The breaking results are best when holes are drilled 30 to 36 in (76 to 91 cm) deep
3. The hole pattern will vary according to rock density and method of excavation. Distance between holes will vary from eight to 36 in (20 to 91 cm)
4. Try to split with the rock grain when possible

Controlling Direction of Break

1. This is a simple operation. Line up the handle in the same direction as the intended break
2. The wedge and feathers will then be in the proper position for a controlled break

Field Test

1. Check general condition of splitter and pump
2. Splitter: check feathers and wedge, hose condition, caps on ends of hoses
3. Pump: check hydraulic oil level, lubricator, hoses capped for dirt
4. Materials required:
   – Air hoses and fittings
   – Four 1 3/4-in diameter bits, two 48-in drill steel and drill gear
   – Extra hydraulic oil
   – Lubricating grease (graphite)
   – Water hoses and fittings
   – 36-in measuring stick
5. Repack and report to the captain

RECIPROCATING SAW

The variable speed reciprocating saw is used for a variety of cutting applications including vehicle extrication, conveyor belts, wood, and various types of metal and clearing debris to facilitate safe rescues. The unit is equipped with metal and wood cutting blades, and with spare battery packs allows approximately one hour of cutting.

Safe Operating Procedures

As with any tool personal safety is the priority:

- Personnel protective equipment must be worn when cutting, such as eye protection and gloves.
- Keep good footing and proper balance at all times.
- The reciprocating saw must not be used in the presence of explosive gases or flammable liquids.

- The saw is fitted with a locking device on the power switch. This lock should be engaged when the saw is not in use or when changing the blade or battery pack.
- There is a variable speed trigger on the saw. Use of very slow speed is recommended only for beginning a cut. The saw cuts best at maximum speed. Prolonged use at very slow speed may damage it.
- Use clamps or other practical means of securing the item being cut if necessary.
- Do not force the saw; the correct blade will cut at the rate for which it is designed.
- When cutting metals, spread a thin film of oil or other coolant along the line ahead of the saw cut for easier operation and longer blade life.
- The tool must be held by the insulated gripping surface if there is a chance the blade may contact hidden wiring.

Field Test

1. Check contents:

   – saw/two batteries/charger

   – a variety of new blades (wood, metal, and lengths)
2. Remove battery (if installed), install blade, re-install battery
3. Check operation of saw
4. Ensure trigger is locked
5. Remove battery, remove blade
6. Repack and report to the captain

Note that the team should bring water or a coolant, or ensure it will have access to a water or a coolant at the site.

HAMMER DRILL

The cordless Milwaukee rotary hammer drill is used by Ontario Mine Rescue to drill holes in various types of material in emergencies, for example to establish anchor points in rope rescue operations.

Safe Operating Procedures

- Personnel protective equipment must be worn when drilling, such as eye protection and gloves.
- Keep good footing and proper balance at all times.
- Do not use the hammer drill in the presence of explosive gases and flammable liquids.
- The hammer drill is fitted with a locking device on the power switch. This lock should be engaged when the drill is not in use or when changing the drill bit or battery pack.
- Always use the side handle when using the drill. Grip both handles firmly.

To use the rotary hammer drill:

1. Be sure the workpiece is secure. Use backing material, if required, to prevent damage to the workpiece during breakthrough
2. Ensure the correct mode has been selected, and release the locking device on the power switch
3. When starting, place the drill bit on the work surface and apply firm pressure. Begin drilling at a slow speed, gradually increasing the speed. Speed is controlled by pressing on the trigger
4. Apply pressure in line with the bit
5. Use moderate pressure when drilling, enough to keep the drill biting, not enough to stall the motor
6. Reduce pressure and ease the bit through the last part of the hole
7. While the tool is still running, pull the bit out of the hole to prevent jamming

Field Test

1. Check contents of the case for the drill, spare batteries, charger and drill bits, and their condition
2. Remove battery (if installed), install drill bit, install battery
3. Check operation of drill
4. Ensure hammer function works
5. Remove battery, remove drill bit
6. Repack case and report to the captain

ROPE RESCUE SYSTEM

Ontario Mine Rescue requires all rope rescue system components to be G-rated for general use. G rating ensures that the component can support a load of 2.7 kilonewton (kN) or 600 pound-force (lbf).

Rescuers will strive to maintain a 10:1 safety factor when setting up all rope rescue systems. For ease of calculation in the field, assume one kN is required to support the weight of the average person (100 kg or 225 lbf). Thus, with a 10:1 safety factor, components must have a 10 kN rating to support the weight of one person. For the maximum two-person load, the weakest link in a rescue system must have a 20 kN rating.

System Components

Rope Rescue Kit – The rope rescue system compiled for Ontario Mine Rescue includes two colour-coded kits, red and blue, with identical components in each kit. Each kit contains enough components to rig its corresponding colour of rope for raising, lowering, or belaying. These kits are accompanied by an auxiliary component bag.

Each kit contains:

- 1 bag containing 100 m (300 ft) of 12.5 mm (1/2 in) life safety rope
- Two 30 m (100 ft) lengths of 9.5 mm (3/8 in) life safety rope, for anchoring purposes only

- Six 40 kN auto-locking carabiners (for anchoring)
- Ten 29 kN auto-locking carabiners (for personal hookup/ rigging)
- 1 Multipurpose device (MPD)
- 1 AZTEK
- 1 adjustable anchor strap
- 1 anchor plate
- 2 single pulleys
- 1 single Prusik minding pulley (PMP)
- 1 double pulley
- 4 sewn Prusiks
- 4 web slings
- Two 10 m (30') lengths of 1 in webbing
- 2 canvas edge guards
- 1 canvas mat
- Small diameter rope for tag lines or securing items in place (such as edge protection devices)

The blue kit, which will be used for belay, will also include one Petzel ASAP Mobile Fall arrester.

The auxiliary equipment bag(s) will include:

- Teflon edge protectors for ropes
- Edge rollers
- Vertical-lift basket harness
- Basket harness bridle
- Vehicle hitch anchor plate
- Rescue harnesses

- Rescue cradle
- Rescue helmets
- Leather gloves
- Lanyards and shock absorbers for fall arrest applications only

The complete system should be stored in covered plastic containers that are tagged to indicate the system has been inspected and is ready to deploy in an emergency.

Life Safety Rope – Each kit uses static kernmantle life safety rope. Static rope has little stretch under load and is ideal for rescue operations. Kernmantle rope is comprised of two parts: the inner core or kern that supplies most of the rope's strength, and a protective outer layer or mantle.

The 12.5 mm (1/2 in) rope is used for suspending rescuers and casualties. It has a minimum breaking strength of approximately 40 kN (9,000 lbf), leaving a safety factor of 15:1 for the maximum rated 2.7 kN (600 lb) two-person load.

The 9.5 mm (3/8 in) rope CANNOT be used to suspend rescuers or casualties during rescue operations. It has a minimum breaking strength of 26 kN (6,000 lbf), but can be used to create safe anchoring and fall restriction systems.

When using life safety rope:

- Do not step on the rope
- Do not straddle the rope
- Protect the rope from sharp edges
- Avoid exposure to chemicals
- Rescuers and casualties, while suspended, must be connected to two ropes at all times

Ropes must be inspected after every use for cuts, worn out mantle, and variations in diameter, and should be retired from use if they fail inspection. A logbook is required for each rope, and the book must be completed during each inspection. Ropes exposed to shock loads during operations must be retired after use.

Ropes can be washed, if necessary, and should be dried away from direct sunlight. They should be stored away from heat, sunlight, moisture, and chemicals.

Knots – Volunteers are required to be competent in the following knots:

- Figure 8
- Figure 8 on a Bight (used to create an attachment point at the end of a rope)
- Figure 8 Bend (used to attach two ropes together)
- Figure 8 Follow Through (used to create an anchor using the end of a rope)
- Alpine Butterfly (used to create an attachment point in the middle of a rope)
- Double Fisherman's Knot (used to join the end of two ropes together, specifically to create a Prusik)
- Prusik Hitch (used as a rope grab)
- Water Knot (used to tie webbing together)
- Web Braid (used to store webbing)
- Round Turn and 2 Half Hitches (used to tie off webbing around a stretcher bar)
- Clove hitch (used as a temporary hold)

The Bowline and long-tailed Bowline are useful for anchoring and basket rigging. It is recommended that mine rescue volunteers learn these knots. The in-line Figure of 8 may still be used if tied and used properly.

With the exception of the Bowline, a backup knot is not required for the knots used by OMR. However, any knot tied at the end of a rope must have a tail of at least 15 cm (6 in) when dressed and set, except for the Double Fisherman's Knot which should have a tail of five cm (2 in). A knot tied in webbing, such as a water knot, should have a tail of at least eight cm (3 in).

Anchor Systems

An anchor is a structural component used alone or in combination with other structural components to provide a mass capable of withstanding the force and/or potential force a rescue system may place upon it.

An anchor is considered "bombproof" if it will hold 10 times the intended load on the system. A single bombproof anchor is always preferred, such as structural steel points on a building. Both rope systems (main and belay) can be attached to the same bombproof anchor point if necessary, but it is good rigging practice to have a separate anchor for each line.

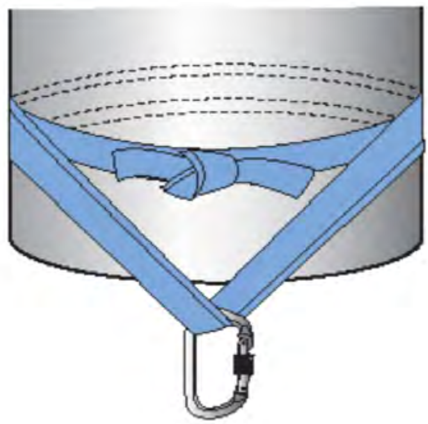
At times it may be difficult to find obvious bombproof anchors where they are needed. It may be necessary to create a bombproof anchor by back-tying to other structures or load sharing over several marginal anchors such as trees or guard rails. "If it isn't strong enough, make it strong enough." Guard rails can also be made stronger by lashing several sets of guard rails together at corners to distribute the forces applied to them.

If anchoring to trees or guard rails, attach the anchor rigging as low as possible to minimize the amount of leverage applied to these structures.

Simple Anchors – Bombproof single point anchors are always preferred and are quick to set up.

Anchor straps and anchor plates are always ideal due to their strength and ease of use.

The Wrap 3, Pull 2 anchor receives widespread use in rope rescue. As the name implies, wrap a length of one-inch webbing around an object three times and join the ends with a water knot. Centre the knot on the inside of the object, pull the other two wraps tight, then secure a carabiner around those two wraps. Because little force is applied to the knot in this configuration, it is usually easy to untie.

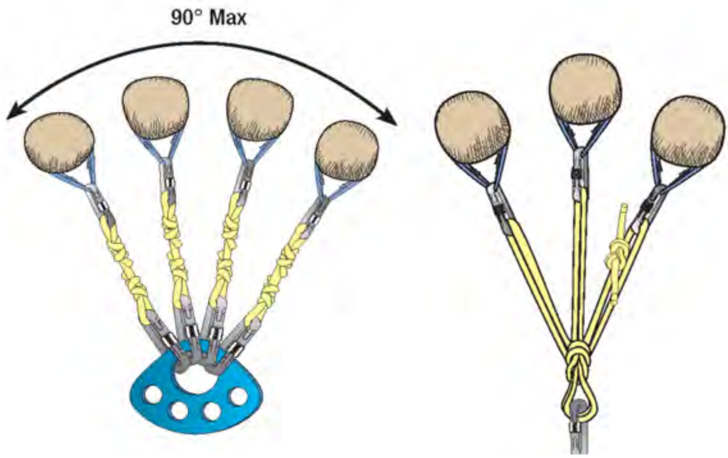


Wrap 3, Pull 2

One-inch flat webbing has a minimum breaking strength of 26 kN (6,000 lbf). When used as a Wrap 3, Pull 2 anchor it has a minimum breaking strength of 46.7 kN (10,500 lbf).

Pre-tension Back-tie – For anchors distant from an edge, it may be necessary to secure the anchor rigging around a closer focal point to create a better working position. The focal point must be supported by a suitable bombproof anchor point with pre-tensioned back-tie rigging.

Pre-tensioned rigging between the focal point and the anchor point is usually set up as a 3:1 ratio with carabiners. Three strands of static rope or cord are used to reduce stretch over the rigging distance. The strands must be tightly tensioned and tied off using several half hitches.



Load Sharing – A load sharing anchor system can be established using two or more anchor points of equal or near equal strength. The idea is to construct a strong anchor system from several marginal anchor points.

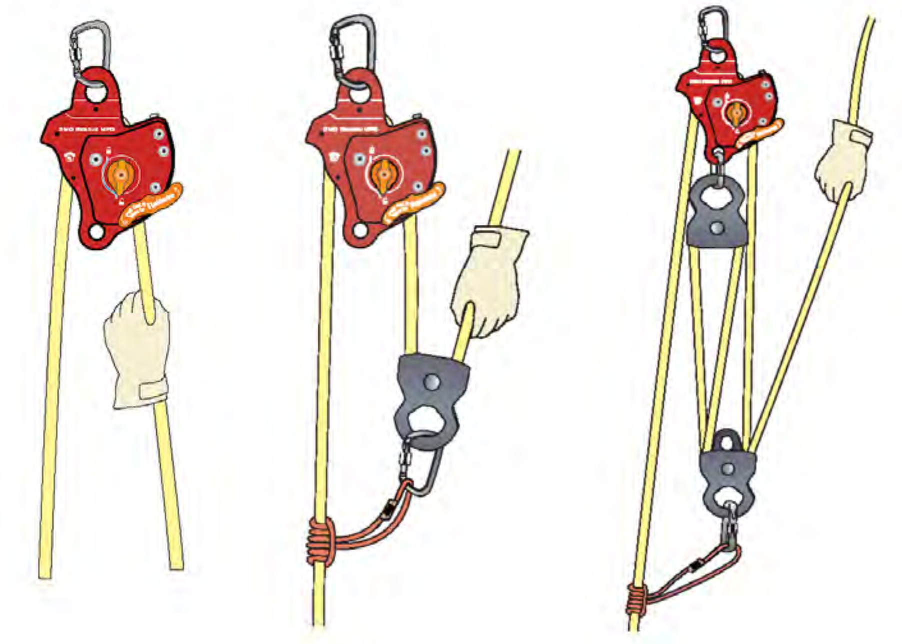
The primary safety advantage of the load sharing anchor is the reduction or elimination of extension forces if an individual anchor point fails.

Even if a single anchor point is considered bombproof, this anchoring method is useful to center the fall line over a casualty's location.

This type of anchor can be constructed from either webbing or rope. Ensure the interior angle between the outer anchor points is no greater than 90 degree to avoid the risk of applying exponential forces on the anchors.

Mechanical Advantage

Mechanical advantage allows heavy loads to be raised with less effort, but requires more rope to be pulled than a standard 1:1 pull. For example, in a 3:1 mechanical advantage system, one kilogram of force applied to the rope gives three kilograms of lifting force, but for each metre of lift height gained, three metres of rope must be pulled.



1:1 *3:1* *5:1*

Mechanical Advantage

OMR recommends the use of 3:1 or 5:1 mechanical advantage. Using higher than 5:1 mechanical advantage is inefficient due to the amount of rope that must be pulled and the resets of the rope grab that must occur.

Mechanical advantage is created by installing moving pulleys in the hauling system as in the diagrams above.

Arizona Technicians Edge Kit (AZTEK)

The Arizona Technicians Edge Kit (AZTEK), found in each kit bag, is a lightweight, versatile mechanical device that can be secured to a rescuer and used for a multitude of rigging applications. The "set-of-

Arizona Technicians Edge Kit (AZTEK)

fours" included in one pouch consists of two pre-rigged double pulleys. It is easily changed between 4:1 and 5:1 mechanical advantage ratios. The second pouch contains and adjustable travel restraint system ideal for edgework.

Multipurpose Device (MPD)

The multipurpose device incorporates a one-way pulley and braking system that makes it suitable for descent control when lowering, progress capture when raising, or for belaying loads. The MPD used by Ontario Mine Rescue is designed for and only to be rigged with 12.5 mm (1/2 in) rope. Loading the rope into the MPD is easy, allowing it to be stored without being attached to the rope.

To load rope into the MPD:

- Ensure parking brake is disengaged
- Rotate backplate fully open
- Insert rope with the running end (to the rope bag) between the V-groove and

pulley as per the diagram on the backplate

- Close backplate and secure in place with a carabiner

Multipurpose Device (MPD)

Once the MPD is connected to an anchor point, a safety check should be performed by pulling quickly on the load end of the rope. The device should lock and not allow the rope to feed out.

If the MPD needs to be left unattended, it must be tied off using an overhand on bight and a half hitch on a bight.

To belay with the MPD while lowering, grip the load end of the rope keeping enough tension to eliminate slack. Feed the running end into the MPD a little faster than the descent rate.

To belay with the MPD while raising, simply pull hand over hand on the running end of the rope to keep enough tension on the belay line to eliminate slack.

To lower with the MPD:

- Grip the running end of the rope and pull back against the V-groove, maintaining a more than 90 degree angle with the load line
- Ensure the parking brake is disengaged
- Pull the release handle to engage the release mechanism
- Rotate handle completely counterclockwise to initiate lowering. DO NOT control lowering speed with the release handle
- Control the lowering speed with the angle of the running end of the rope as it enters the V-groove

- For heavier loads, add additional friction by threading the rope over the secondary friction post

Conditional vs. Unconditional Belay – A conditional belay is a system where the integrity of the belay is dependent on factors such as reaction time, gripping ability, and the attention of the belay operator. Should any one of these factors fail, the load will not be belayed. If the main line should fail, the load could fall to the ground.

An unconditional belay is a system that eliminates these factors. Should the main line fail, the belay system will capture the load quickly without action required by the operator. Unconditional systems are the safest and preferred method of belaying a rope system.

Mirrored System – A mirrored or shared-tension system exists when both lines are capable of acting as the main or belay line. A mirrored system requires two MPDs with the same mechanical advantage and ideally set up on separate anchors. Each MPD must be secured to a separate anchor plate.

The load is shared by both lines during operations. If one line fails, the other line acts as a belay and holds the load. Because some of the load is already supported by this line, drop distance and shock should be less than a standard belay system, if operated correctly. The main disadvantage of a mirrored system is that it is a conditional belay system when used to lower. It requires the operator to react by letting go of the brake release handle. OMR modifies the standard mirrored system by applying a Petzl ASAP mobil fall arrester to the belay (blue) rope to convert it to an unconditional belaying system.

To begin a lowering operation with a mirrored system, one MPD acts as the main line supporting the entire load, while the second MPD acts as the belay line that maintains only enough tension in the line to eliminate slack. Once the edge transition is complete and the load is below the edge, the belay line is allowed to share the load for the rest of the lower.

To begin a raising operation with a mirrored system, identical mechanical advantage systems are set up on both lines for hauling. The edge transition is completed with one line hauling and the other acting as a standard belay.

Tandem Prusik Belay – If the second MPD in the mirrored system fails or is otherwise unavailable, operators should know how to set up a safe belaying system with a single MPD system. The tandem Prusik belay is simple to set up and use.

A tandem Prusik belay is constructed by attaching two Prusik hitches of different lengths to the belay line. The longer one should be closest to the load. Both Prusik hitches are then attached to an anchor point separate from the hauling system.

A safety check should be performed after setup and the Prusik hitches are set by quickly pulling on the load end of the rope to see if they engage and stop the pull.

When raising, the hand closest to the load grasps the Prusiks to keep them from gripping the rope. The hand on the running end of the rope pulls to keep enough tension on the belay line to eliminate the slack. When lowering, the hand farthest from the load grasps the Prusiks to keep them from gripping the rope. Do not grasp with the thumbs to keep them out of the way in case the system is suddenly loaded.

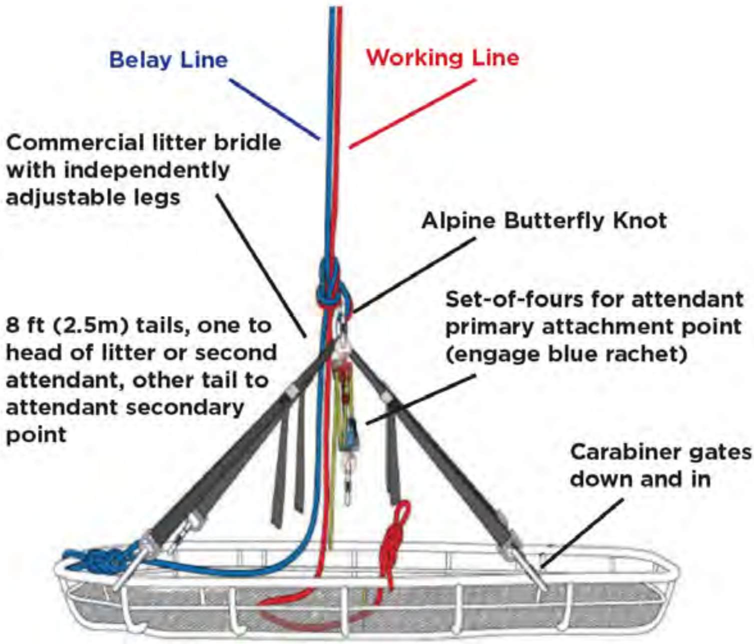
Pull about 30 to 60 cm (1 to 2 ft) of rope with the hand closest to the load and keep enough tension on the line to be able to feel the load.

Let the load pull out the bight you have created, then quickly pull another length of rope.

Repeat this process until the load is on the ground.

Basket Rigging

Vertical Basket Rigging – The CMC Vertical Lift Basket Harness allows for easier edge transitions when no overhead anchor points are



available or tight spaces need to be negotiated. The casualty must be secured in the basket with webbing to act as a safety in the event of a buckle failure.

To rig the vertical lift harness:

1. On both sides, feed the webbing around the bar at the middle of the basket and pass the webbing back through the buckles on each side. Back up with an overhand knot
2. Feed the main line through the top hole on the orange plastic piece to the quick link
3. Attach the belay line to the top rail of the basket. Attaching the belay line to the quick link using a butterfly knot allows for easier basket management if using a shared tension system
4. Attach two large carabiners to the lifting points at the casualty's shoulders

For raising, the webbing should be placed through the shoulder carabiners and the belay line should be connected to the quick link on the harness. For lowering, these should not be connected at the start of the operation.

When raising with the vertical lift harness, haul until the basket is ready for the edge transition. Ensure that rescuers have a firm grip on the basket. Disconnect the webbing from the shoulder carabiners and the butterfly knot from the quick link. Begin hauling on the main line slowly. The basket should continue to rise vertically while the webbing is pulled toward the anchor until it is high enough to easily pivot over the edge and be managed by the rescuers.

When lowering, place the basket at the edge. Slowly lower with the main line, allowing the basket to pivot over the edge from horizontal to vertical until the top of the basket is below the edge. Connect the webbing to the shoulder carabiners and the butterfly knot to the quick link (if using a mirrored system). Lower until the basket is on the ground.

If an overhead anchor point is available to facilitate an easy edge transition, standard basket rigging using the CMC basket harness bridle may be used in place of the vertical lift harness. The harness must be attached at two suitable lifting points on the basket, including the top rail.

Horizontal Basket Rigging – To raise a horizontal basket, the CMC Basket Harness Bridle should be connected to the basket at the four designated lifting points with the carabiners gate side in. Again, the casualty must be secured in the basket with webbing to act as a safety in the event of a buckle failure.

The bridle should be attached to both rescue ropes using long tail bowlines or alpine butterfly knots. The ends of the ropes should be attached to the head of the basket unless an attendant is required, in which case one line will be secured to the rescuer as a secondary attachment.

If an attendant is required to negotiate obstacles or tough edge transitions, the set-of-fours found in the AZTEK provide an excellent primary attachment to the bridle. This would allow the attendant to adjust their position on the basket easily.

The high position (above the basket) is helpful for negotiating undercut edges and straight vertical areas. The traditional low position allows easy access to the casualty and gives better stability for less than vertical terrain.

Tag lines should be used to control the basket during raising and lowering. Tag lines can be any type of rope that is strong enough for the purpose. Either two tag lines or one tag line with two attachment points on the basket is recommended to maintain optimum control.

Pickoffs – The pickoff of a suspended casualty (such as in a fall arrest emergency) is performed with great efficiency using the set-of-fours provided in the AZTEK.

To prepare for a pickoff:

1. Set up a mirrored lowering system
2. Connect the rescuer to the main line with the low front D-ring of the harness and to the belay line with the high front D-ring on the harness
3. Attach the AZTEK to the rescuer, feeding it through the harness to prevent it from falling
4. Ensure the blue Prusik on the AZTEK is pinned in place (4:1)
5. Extend the AZTEK a minimum of two metres (6 ft) and connect the orange pulley to the main line using a Prusik hitch and carabiner
6. Make sure the rescuer has a long Prusik and a carabiner secured to their harness to use to attach the casualty to the belay line. Carrying a backup set it recommended.

To perform a pickoff:

1. Lower the rescuer to the casualty
2. Connect the blue pulley on the AZTEK to the casualty's dorsal D-ring and remove the slack in the orange rope
3. Connect the belay line to the casualty's D-ring using a long Prusik and carabiner
4. The rescuer will lift the casualty using the AZTEK until the tension is released from the casualty's fall arrest line. Keep in mind that releasing the tension on the running end of the AZTEK too slowly may prevent the blue Prusik hitch from fully engaging
5. Disconnect the casualty's fall arrest system from their harness
6. Lower the rescuer and casualty to the ground

Knot Pass – There are areas where a rescue may require more than the 100 metres of rope in the rescue system rope bag. In this situation, two ropes would need to be joined using a suitable rescue knot. An additional mechanical advantage system would need to be rigged to pass the knot through the MPD and mechanical advantage system. The set-of-fours in the AZTEK is an effective tool for performing this operation.

To perform a knot pass when lowering:

1. Ensure the orange Prusik on the AZTEK is pinned in place (5:1)
2. Connect the blue pulley on the AZTEK to the same anchor as the original system
3. Connect the orange pulley on the AZTEK to the load end of the rope with a Prusik hitch
4. Extend the AZTEK one metre (3 ft) past the MPD
5. Haul on the AZTEK to take the tension off the rope and MPD. Secure the AZTEK using an overhand on a bight and half hitch on a bight if grip must be release from the rope

6. Disconnect the MPD from the anchor
7. Reload the MPD so that the knot is on the load side of the MPD
8. Reconnect the MPD and ensure the park brake is engaged
9. Lower with the AZTEK until the load is fully on the MPD
10. Disconnect the AZTEK from the line

To perform a knot pass when raising:

1. Ensure the orange Prusik on the AZTEK is pinned in place (5:1)
2. Connect the blue pulley on the AZTEK to the same anchor as the original system
3. Connect the orange pulley on the AZTEK to the load end of the rope with a Prusik hitch, below the knot to be passed
4. Haul on the AZTEK to take the tension off the rope and mechanical advantage system. Secure the AZTEK using an overhand on a bight and half hitch on a bight if grip must be release from the rope
5. Disassemble M/A system and disconnect the MPD from the anchor
6. Reload the MPD so the knot is far enough on the load side of the MPD that it will not interfere with the mechanical advantage system
7. Reconnect the MPD and ensure the park brake is engaged
8. Lower with the AZTEK until the load is fully on the MPD
9. Disconnect the AZTEK from the line
10. Set up the mechanical advantage system

Arizona Vortex

A high directional, such as a pulley anchored to an overhead beam, is desirable to allow for efficient edge transitions. Often in rope rescue situations, there is no permanent structure to provide a high directional. The Arizona Vortex (AZV) is a lightweight, versatile artificial high directional (AHD). It is an adaptable anchor and edge management device. The AZV allows rescuers to elevate rope lines above edges, entries, or other obstructions, and is capable of adapting to various terrain and set-up locations. It is ideal in edge-mitigation for confined spaces and mines.

It can be arranged in multiple configurations including conventional and easel leg tripod, conventional and sideways A-frame (bipod), and monopod.

The AZV kit consists of:

- Head set (two pieces)
- Head set pulley wheel
- Head set pins (four)
- Head set backpack
- Inner legs (three)
- Outer legs (seven)
- Leg/foot pins (17)
- Leg bags with shoulder straps (three)
- Flat (omni) feet (three)
- Raptor (claw) feet (three)
- Foot storage sleeves (2)

- Pin bag, orange
- Pin flags, hi-viz orange (21)
- Hobble straps, adjustable (three)
- Safety tether cord – 8 mm cord, 12 m (40 ft) length

The AZV come with two sets of feet. The flat (omni) feet work well on flat surfaces where the surface area helps prevent penetration. The raptor (claw) feet have carbide tips that penetrate downward to gain purchase in soft surfaces and on various rock features, such as small holes and cracks. The feet can be rotated for better placement.

Assembling the AZV – For ease and speed of assembly, the AZV should be assembled by two or more people, but only one person should direct the set up. Communications should be deliberate and precise.

Depending on location and personnel available, the AZV can be assembled either in place at the edge, away from the edge and then moved to the edge, or a combination of the two. It is difficult to changes pins at the head while standing at an edge, so these changes should be made away from an edge with the AZV moved into position and the feet secured after the final changes. This may require several attempts.

Travel restraint will be required when assembling or installing the AZV at an edge without handrails.

Always attach a tether cord to individual sections or the entire unit until the AVZ is secured. Tether cords should be belayed on a separate anchor to prevent the AVZ from toppling over during installation. The cords may be left in place during operations for later disassembly. An unsecured AVZ should never be left unattended, and an AVZ near an edge should always be tethered.

Safety Guidelines – The AZV can topple if the user does not properly account for the forces occurring in a specific situation and configuration. It is important at all times to follow these safety guidelines:

- Always maintain a second belay line independent of the AZV
- All feet must be securely anchored to resist sideway, spreading and uplift forces
- Do not couple more than three outer leg sections on any one leg
- Ensure the connection pin that inserts through the head feeds through an inner hole when the leg is at full extension. When assembled correctly, the top of the leg should be flush with or extend above the top leg sleeve of the head
- Personal safety lines should have anchors independent of the AZV
- Always tether equipment to prevent items from falling or being knocked over the edge
- The main line should never enter and exit the same side of the AZV

Anchoring/Securing the AZV – The AZV must be anchored or secured for any possible unexpected event.

In a tripod configuration, this includes securing the rear easel leg for compression and tension. The easel leg should not be able to move forward or back from the edge. The ideal method to secure the easel leg is to anchor the rear foot to the surface. Ideally, each foot is secured in the same fashion. Connecting the feet together using hobble straps is acceptable.

In an A-frame or bipod configuration, the front legs must be restrained from spreading apart. This is accomplished by anchoring the feet to the surface. If this is not possible, the feet can be connected using a hobble strap.

Disassembling the AZV – With adequate personnel on travel restraint, the anchoring at each foot can be removed and the AVZ carried out of the hazard zone. A tether cord must be attached to the AZV until it has been removed from the edge. It can then be disassembled, inspected and stowed.

Inspection

All rope rescue components should be inspected before and after each use, and at least once every 12 months by a competent person. Each inspection must be logged. The AZV should be examined for cracks, dents, and distortions of the carabiners and the pin holes. Webbing and cording should be examined for cuts, fraying, thinning, discolouration, and chemical damage.

Components should fit easily together and not appear deformed or bent. The head unit should rotate easily but not be loose. Pins should have a retaining ball and function smoothly. If a fault is found, or the equipment has been subjected to shock loads, fall loads, or abuse beyond normal use, the equipment must be removed from service for repair by the manufacturer or disposal.

During use, transportation and storage, components should be kept away from acids, alkalis, rust, strong chemicals, and flame or high temperatures.

Voice Commands

Rescue operations require clear commands that avoid confusion. The ideal command protocol is:

- Captain: "On Belay?" – Response: "Belay on"
- Captain: "On Main?" – Response: "Main on"
- "Down rope" – Begin lowering rope
- "Up rope" – Begin pulling rope in
- "Faster" – Increase rate of movement
- "Slow" – Decrease rate of movement

- “Stop” – Discontinue raising/lowering
- “Rope free” – Rope is clear and no one is relying on it for support

Suspension Trauma

Suspension trauma or orthostatic intolerance, which can be fatal, occurs when the body is suspended in vertical or near vertical position without any movement for a time, usually 20 minutes or more. Symptoms may occur in minutes, and other injuries may increase the likelihood of it occurring.

During suspension trauma, blood pools in the legs, putting extra pressure on the heart as it attempts to pump blood to the brain and other organs. The situation can be made worse by the constrictions of the harness. Casualties with head injuries or who are unconscious are particularly at risk.

Typical symptoms are pallor, sweating, shortness of breath, blurred vision, dizziness, nausea, hypotension, and numbness of the legs. Eventually it leads to fainting.

If conscious, the casualty should be encouraged to move his or her legs to prevent blood pooling.

Once rescued, the casualty should be kept in a sitting position with the knees bent to the chest. The pooled blood should be released from the legs slowly to give the body more time to filter the blood. The casualty should receive medical assistance as soon as possible.

THERMAL IMAGING CAMERA

The MSA Evolution 5200 and the Draeger UCF 9000 are thermal imaging cameras (TIC) used by Ontario Mine Rescue to assist mine rescuers in low and poor visibility situations created by smoke and darkness.

The hand-held units detect thermal energy radiated and/or generated by surrounding objects and converts this energy into a visual image on a large screen, high definition display that allows multiple personnel to view the image.

In the image:

- Cold objects appear black.
- Hot objects appear white.
- Colour hues, from light yellow to dark red, indicate high heat levels.

The cameras can be used in:

- Search and rescue situations
- Initial and followup scene assessment
- Locating the seat of the fire
- Determining entry, exit and ventilation points

Parts

- Thermal imaging camera
- Lithium ion battery
- Strap and carabiner
- Charging kit

Before any assignment, the battery must be fully charged. The MSA Evolution 5200 has a battery life of two hours when charged. A second, fully charged battery must always be taken on an assignment. The Drager UCF 9000 has an internal battery with a battery life of four hours. A second battery is not required while on assignment.

The cameras are capable of withstanding heat, waterspray, and impact experienced during mine emergencies, but care should be exercised not to run the camera for extended periods in high-heat conditions.

TICs should not be relied on as the sole means of navigation during use in dark, smoky environments. The user could become disoriented or lost, if the system becomes inoperative.

Maintenance

After each use the camera should be inspected for:

- Structural, heat and/or chemical damage
- Loose parts and screws
- Cracks and breaks in the lenses, display screen
- Intact warning labels

The camera should be cleaned by wiping it with a solution of mild detergent and water, and then dried with a dry, soft, lint-free cloth.

The battery must be recharged after use.

MSA Evolution 5200

The MSA Evolution has a 55-degree horizontal field of view and a 64 mm (2.5 in) display. It weighs 1.3 kg (2.8 lb). The Evolution is NOT rated as intrinsically safe and should not be used in environments where static or sparks may cause an explosion.

To operate the Evolution 5200:

1. Ensure the battery is fully charged.
2. Press and hold the green power button on the handle for one second.
3. Wait about five seconds for the camera to self-test.
4. Verify the camera is working by aiming at an object or person until the thermal image appears in the viewer. Do not point the camera at the sun.

To activate standby mode, press the green power button until the display shuts off and the system status LED flashes green.

To return to normal mode, press the green power button until the display reactivates without warmup, and the system status LED turns solid green.

To turn the camera off, press and hold the green power button for four seconds.

Evolution 5200 On-screen Indicators

The high-definition display monitor provides rescuers with valuable information.

The **Low Sensitivity Mode Indicator** – the letter L in the lower left corner of the display – is activated when the camera senses an environment above 160 C (320 F). The TIC's dynamic range increases in this mode to make a better distinction between objects and people.

The **Shutter Indicator** – a green square in the upper left corner of the display – alerts the user that the camera is "shuttering" or refreshing the focal plane for proper operation. Shuttering freezes the image temporarily for about a second and occurs more frequently in high heat conditions.

The **Quick-Temp Indicator** – a central on-screen spotter and a vertical bar on the side of the display – indicates the approximate temperature of objects located in the spotter.

The **Over Temperature Warning** – a red LED at the bottom left corner of the monitor – is normally off, but turns flashing red when the TIC has exceeded the recommended operational thermal limits.

The **System Status Indicator** – a single LED, in the bottom central part of the monitor – shows the TIC's operational status. Green indicates the camera is on and fully operational. Flashing green indicates the camera is on and in power-saving standby mode.

The **Battery Status Indicator** – three coloured LEDs at the bottom right corner of the monitor – shows the remaining battery capacity.

Green indicates full or near full capacity. Yellow indicates marginal capacity. Red indicates battery warning and 15 minutes or less of capacity remaining. Flashing red indicates shutdown is imminent, in about one minute.

The **Heat Seeker Plus Indicator** adds shades of colour to objects to allow some details to be seen for easier identification.

In **High Sensitivity Mode,** for lower temperature ranges, the colour of objects reaching 135 C (275 F) will be lighter shades of yellow transitioning to darker shades, then shades of orange as the temperature increases. Once objects reach a temperature of 147 C (297 F), they transition to lighter shades of red and then darker shades up to 160 C (320 F).

In **Low Sensitivity Mode**, for higher temperature ranges, the colour of objects reaching 450 C (842 F) will be lighter shades of yellow transitioning to darker shades, then shades of orange as the temperature increases. Once objects reach a temperature of 490 C (914 F), they transition to lighter shades of red and then darker shades up to 560 C (1,040 F).

The **System Fault Indicator** – all five LEDs – will flash if a system fault is detected by the camera's internal computer.

Field Test for Evolution 5200

1. Check general condition of the camera.
2. Turn on the camera and check battery for full charge.
3. Verify operation by viewing image.
4. Turn off camera and remove battery.
5. Install second battery.
6. Turn on camera and check battery for full charge.
7. Turn camera off.

8. Inspect and attach the carrying strap (carabiner to the camera).
9. Take spare battery.
10. Report results to the captain.

Draeger UCF 9000

The Draeger UCF 9000 has a 57-degree horizontal field of view and a 90 mm (3 in) display. It weighs 1.4 kg (3 lb). The UCF 9000 is rated as intrinsically safe, but caution should be used in environments where static or sparks may cause an explosion. Temperature range of -40 to 1,000 C (140 to 1,800 F).

The camera automatically shifts into and out of standby mode. Sixty seconds after the handle is released, the display screen will dim. Following a 25-second countdown on the display, it shifts into standby mode. The camera will immediately reactivate when the handle is touched.

To operate the UCF 9000:

1. Ensure the battery is fully charged.
2. Press and hold the green power button on the handle for three seconds.
3. Wait for the camera to self-test.

4. Verify the camera is working by aiming at an object or person until the thermal image appears in the viewer. Do not point the camera at the sun.

A blue, four-way toggle switch above the on/off button and the display is used to determine other settings on the TIC.

To turn the camera off, press and hold the green power button until the camera shuts itself off, about five seconds.

UCF 9000 On-screen Indicators

The high-definition display monitor, along the bottom from left to right, provides rescuers with valuable information.

The **Digital Zoom Indicator** – a green box with a + symbol in the lower left corner of the display shows whether the camera is in standard view or using 2x or 4x digital zoom. To zoom in and out, press the left side of the blue toggle switch under the display.

The **Mode Indicator** – alerts the user to which of the nine modes the TIC is currently set. The camera defaults to and will most commonly be used in Standard Mode. To change modes, press the bottom of the blue toggle switch. The current mode will be shown in the bottom of the display. Then press the right side of the toggle switch to move to the desired mode. When the desired mode is reached, press the bottom of the toggle switch.

The **Laser Indicator** – indicates when the laser pointer is activated. Activate and deactivate the laser point by pressing the right side of the blue toggle switch. The pointer can be used to mark hot spots or display the fill level of tanks.

The **Battery Indicator** – a green four-bar icon shows the battery capacity. Four bars indicates full or near full capacity. Two orange bars indicate a maximum 50 per cent charge remains. One red bar indicates a maximum 25 per cent charge, approximately one hour of operating time remains. A flashing red icon indicates shutdown is imminent, within five minutes.

The **Temperature Display** and the **Temperature Display Indicator** – a temperature reading and a vertical colour code bar on the side of the display, indicate the exact temperature of the object in the crosshair box in the centre of the display, and the temperature range of other items in the image.

In the low temperature range 110 to 130 C (230 to 266 F), and in the high temperature range at 300 to 1,000 C (572 to 1,800 F) heated objects are tinted yellow. As their temperature increases, the colour will deepen and transition to orange and then solid red.

At the top of the display, from the left, is the **High Temperature Range Icon** which will be visible when the TIC automatically shifts into the high temperature range.

Also at the top is the red **High Internal Camera Temperature Warning** which is normally off, but turns on when the TIC has exceeded the recommended operational thermal limits.

Modes

Standard Mode is the default mode of camera operation and will be the mostly frequently used mode. The image display automatically shifts between low and high temperature ranges.

There eight other modes:

- **Person Mode** concentrates details on cooler objects to more clearly identify people, possibly casualties.
- **Fire Mode** concentrates detail on hotter objects for extreme heat situations.
- **Thermal Scan Mode** highlights a set temperature threshold or temperature scan range set using the blue toggle switch.

- **Scan PLUS Mode** integrates a thermal image into a real image to help users determine what objects are hot. A temperature scan range can be set using the blue toggle switch.
- **Hazmat Mode** is designed to indicate liquid levels and leak detection
- **Outdoor Mode** uses high contrast in lower temperature environments to locate people outdoors.
- **Real Image Mode** allows the TIC to be used as a camera to record a video or still image. This permits users to "look" around corners.
- **Custom 1 Mode** allows the colour palette to be customized used computer software.

Field Test for UCF 9000

1. Check general condition of the camera.
2. Turn on the camera and check battery for full charge.
3. Verify operation by viewing image.
4. Turn off the camera
5. Inspect and attach the carrying strap (carabiner to the camera).
6. Report results to the captain.

THE KESTREL

The Kestrel 3500 Pocket Weather Meter is a lightweight environmental measuring device used by Ontario Mine Rescue to assess a team's heat exposure during operations.

The Kestrel display has an aviation green electroluminescent backlight. The device is powered by a long-life, lithium button battery. Should the display dim or disappear, the battery must be replaced. The Kestrel is factory calibrated and requires no addition on-site calibration.

The Kestrel is capable of reading:

- Time
- Wind speed (SPd)
- Maximum gust (SPd MAX)
- Average speed (SPd AVE)
- (Dry bulb) Temperature (dEG)
- Wind chill (chill)
- Relative Humidity (r.h.)
- Heat Stress Index (H.I.)
- Dewpoint (d.P.)
- Wet Bulb Temperature (bulb)
- Barometric pressure (bAro)
- Altitude (ALt)

For mine rescue purposes, however, only the temperature (dry bulb) indicated by dEG, and wet bulb temperature indicated by bulb on the Kestrel, are measured, monitored and recorded.

Temperature – The Kestrel provides the instantaneous temperature of the thermistor, located at the end of the long coiled leads in the open cavity below the impeller. The exposed thermistor will respond quickly to changes in temperature when air flows past it. For the fastest response wave the unit side to side for 15 seconds.

Wet Bulb Temperature – WBT is calculated based on temperature and relative humidity measurements, as a measure of evaporation rate. If the wet bulb temperature is close to the air temperature, the aid is humid.

The key parts of the Kestrel are:

- Cover
- On/off button
- Left and right scroll buttons
- Display
- Impeller
- Thermistor

Field Test

The team's No. 2 member will be responsible for field testing, carrying and using the Kestrel.

To field test the Kestrel 3500:

1. Examine the cover for cracks and/or damage
2. Slide off the cover and examine the device for cracks or damage
3. Turn on the Kestrel by pressing the centre button
4. Ensure the backlight stays on for about 10 seconds
5. Turn the Kestrel off by pressing the centre button for several seconds
6. Slide the cover on
7. Report to the captain

Operation

To use the Kestrel:

1. Slide off the cover
2. Press the centre button to turn on the device, the backlight will activate
3. Use the right or left arrow buttons to scroll through the measurement modes
4. Record the (dry bulb) Temperature – dEG, and the Wet Bulb Temperature – bulb
5. Ensure the readings are C (Celsius)
6. Turn off the Kestrel by pressing and holding the centre button

Note that the Kestrel will automatically turn off in 45 minutes if no buttons have been pressed.

NOTES:

NOTES:

CHAPTER 11
GENERAL EMERGENCY PRACTICES

PERSONAL PROTECTIVE EQUIPMENT

Before going underground for training or emergency response, mine rescue volunteers must be properly dressed with clean (oil and grease stain-free) personal protective equipment including protective headwear, cap lamp, chin strap, protective eyewear, high visibility apparel, protective footwear, and hand protection.

Hard hats must have a cap lamp, a chin strap, and retro-reflective striping applied to the front, back, and sides. They must meet Canadian Standards Association (CSA) standard, Z94.1-05, Industrial Protective Headwear – Performance, Selection, Care and Use.

Protective eyewear must be safety spectacles with permanent side shields. Eyewear must fit properly and meet CSA standard – Z94.3-07 Eye and Face Protectors.

High visibility apparel must be Class 3, Level 2 coveralls or pants and long sleeve shirt. Apparel must meet National Fire Protection Association standard – NFPA 2113 to provide suitable protection against the possibility of arc flash. Apparel also must meet CSA standard – Z96-09, High-Visibility Safety Apparel, and comply with Ontario Reg. 854: Mines and Mining Plants, Sect. 262 (2), 263 (2).

Protective footwear must be rubber, leather, or ballistic nylon. All footwear must have puncture resistant and electric shock resistant soles, integral or external metatarsal protection, and meet CSA Grade 1 impact requirements. Leather or ballistic nylon boots must be omega rated. All footwear must meet CSA standard – Z195-09 Protective Footwear.

Gloves should provide protection from friction, cuts and punctures, as well as be suitable for a variety of tasks including rope work, firefighting, and the use of a variety of hand tools.

Relevant hearing protection must be available.

Light, breathable undergarments are advisable on assignments involving heat exposure.

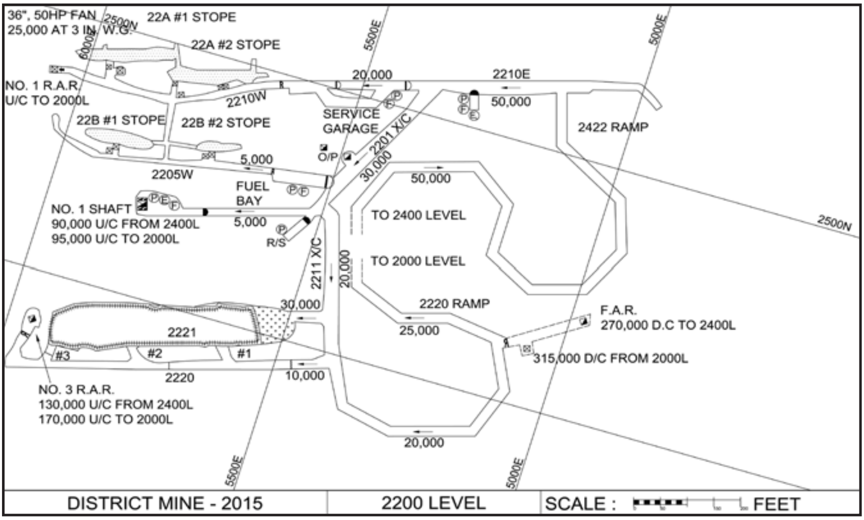
Volunteers must also wear a watch and keep a "Go" bag prepared for cross mine training and callouts.

RESCUE TEAM GUIDELINES

All mine rescue team personnel should report ready to work and fully equipped with suitable clothing. All members of rescue teams sent underground should have had adequate training in such work.

In order that rescue team personnel may keep physically fit and healthy during mine rescue and recovery operations, the following arrangements should be made and adhered to:

1. No one should be permitted to work in irrespirable air with breathing apparatus without having been examined and found physically fit by a physician, or in the absence of a physician, sent. Personnel with colds or other ailments affecting their breathing are not permitted to go underground in breathing apparatus.
2. No member should remain on shift longer than six hours. During this period, no one should be permitted to remain under O_2 longer than two hours, except in an extreme emergency.
3. No one should be permitted to undertake a second shift until they have had at least six hours rest. Personnel exposed to extreme heat and work under the time limits of the Ontario Mine Rescue Heat Exposure Standard, must have 24 hours rest.
4. Plain, well-prepared food, not too rich in sugar and fats, should be eaten in moderation. No food, including candy, should be eaten for one hour before taking an active part in rescue and recovery work.
5. Plenty of potable water should be available before and after assignments to keep rescue team personnel well-hydrated.
6. Comfortable, clean sleeping quarters should be provided, where necessary, for rescue team personnel.



In the event of a long emergency, medical aid should be available 24 hours a day and every participating team member should be examined by a medical professional before and after duty at least once a day, more often if any indication of weakness, nausea, stomach, or mental disorder appear.

Should it be necessary to call mine rescue personnel from home, care should be exercised so personnel who have consumed any substance, including prescription drugs, that may influence their or the team's well-being are not permitted underground in apparatus.

Consideration might be given to the methods used in getting team members from their homes to the mine. Mine rescue personnel proceeding to a mine emergency do NOT have emergency vehicle status and must obey all traffic laws.

OBJECTIVES OF RESCUE & RECOVERY WORK & EXPLORATION

Careful consideration should be given to the method and extent of the exploration plan and whether it is justified by the possible results.

Can the plan be carried out without danger to the rescue teams, and will it increase the possibility of saving lives?

The four main objectives of mine rescue and recovery work, in both fire and non-fire incidents, are:

1. Ensure the safety of mine rescue teams
2. Find trapped or missing workers and bring them to surface
3. Respond to and resolve fire and non-fire emergencies
4. Examine the mine for dangerous concentrations of any noxious gases that would prevent normal operations in any part of the mine

When making plans, the On-site Official in Charge should consider:

1. Probable conditions, including possible heat exposure, in the part of the mine to be explored
2. Route of travel
3. Visibility
4. Familiarity of the teams with the location
5. Number of trained personnel available
6. Limitations of the mine rescuers and apparatus
7. Urgency, risk to life, of the situation

During emergencies, the On-site Official in Charge may have to make decisions concerning the welfare of both personnel and the mine. These decisions vary from one situation to another and require input from many sources of information, both on-site and off-site.

For example, rescue teams may be able to fight mine fires at close range and direct the streams of water so as to extinguish the fire quickly. When a mine fire, however, cannot be fought directly, due to size or conditions, teams can put in seals or barricades to restrict ventilation or allow high-expansion foam generation.

Later, when a sealed area is opened, teams with suitable breathing apparatus may explore it and evaluate the fire before the ventilation is restored.

NUMBER OF PERSONNEL REQUIRED FOR MINE RESCUE AND RECOVERY WORK

Oxygen breathing apparatus should be used only when there are enough trained mine rescuers available to form a five-member team to perform the assigned work. A second team should be on site or en route to site.

To begin the team organization at the fresh air base, 15 trained mine rescuers are needed, as well as at least one trained as a briefing officer. They could be assigned as follows:

1. Five rescuers constitute a standard mine rescue team for work in irrespirable atmospheres.
2. Five rescuers, in apparatus but not under oxygen, should remain at the fresh air base as a standby team.
3. Five rescuers, acting as a backup team in reserve, may be used as assistants at the fresh air base until they are needed as the standby team.

Although this organization is the ideal to be strived for, during the early stages of the emergency, the deployment of the five-member team is dictated by the urgency of the situation or the danger to human lives. It is also noted that one standby team can support two teams underground, depending upon the emergency situation.

However, in situations where heat exposure is a factor, two standby teams are required, both to permit teams to adhere to the Ontario Mine Rescue Heat Stress Standard which may shorten assignment times, and to provide adequate support for a team in distress because of heat exhaustion.

Within six hours, additional mine rescue teams must be on site, and for extended operations, a six- to nine-team rotation will be required.

FRESH AIR BASE

Fresh air bases (FAB) are used as the headquarters from which rescue and recovery work in irrespirable atmospheres is conducted or as an advanced staging area.

A Mine Rescue Officer or a suitable designate, with the necessary assistants, should be stationed at the base. Initially, the role of fresh air base coordinator should be filled by the best person available. If there is more than one base, it may be necessary to set up a general headquarters.

The base may be on surface or underground, as conditions require, and should be as near the scene of operations as possible. The essentials of a FAB and an advance staging area are:

1. An assured supply of fresh air
2. An assured travelway for personnel and materials to surface in fresh air, if the base is underground
3. Communication with headquarters on surface by telephone or messenger
4. The best illumination possible
5. Enough room to permit efficient work without confusion
6. A backup power source

The FAB should be equipped with tables, benches for the reserve teams, benches for overhauling rescue apparatus, tools and repair parts for maintaining the apparatus, and the necessary tools and supplies for carrying on the work at hand.

There should be enough staff to direct the work and maintain operations on the fresh air side of the base.

Six-Team Rotation

This arrangment of six teams allows for six hours duty per team, the last two hours on active assignment, followed by six hours rest. As more teams become available, and if the emergency requires extensive operations, additional teams can be slotted in after #6 team. This would increase the rest time for the teams. See nine-team rotation.

Date:

Team #	Descrip-tion	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs
1		Active				Reserve	Standby at FAB	Active				Reserve	Standby at FAB
2		Standby at FAB	Active				Reserve	Standby at FAB	Active				Reserve
3		Reserve	Standby at FAB	Active				Reserve	Standby at FAB	Active			
4			Reserve	Standby at FAB	Active				Reserve	Standby at FAB	Active		
5				Reserve	Standby at FAB	Active				Reserve	Standby at FAB	Active	
6					Reserve	Standby at FAB	Active				Reserve	Standby at FAB	Active

Nine-Team Rotation

This arrangement of nine teams allows for six hours on duty per team followed by 12 hours rest.

Date:

Team #	Descrip-tion	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs	2 Hrs
1		Active							Reserve	Standby at FAB	Active		
2		Standby at FAB	Active							Reserve	Standby at FAB	Active	
3		Reserve	Standby at FAB	Active							Reserve	Standby at FAB	Active
4			Reserve	Standby at FAB	Active							Reserve	Standby at FAB
5				Reserve	Standby at FAB	Active							Reserve
6					Reserve	Standby at FAB	Active						
7						Reserve	Standby at FAB	Active					
8							Reserve	Standby at FAB	Active				
9								Reserve	Standby at FAB	Active			

Equipment sent to a team underground should be first field tested by fresh air base personnel.

Advanced staging areas may be established in refuge stations and other suitable locations.

TIME LIMITS FOR RESCUE TRIPS

All watches should be synchronized – team members' with that of the briefing officer, the briefing officer with that of the control room. Any instructions regarding time limits must be strictly followed. For returning to the fresh air base, a team should ordinarily be allowed twice the time used on the ingoing trip.

If the O_2 in the apparatus bottle worn by any team member has been reduced to twice the amount used on the ingoing trip, the whole team shall return to the fresh air base immediately.

An exception may be made when extensive exploration or gas testing has been done on the way to the objective. Only the time or O_2 required for a direct return trip to the fresh air base need be considered.

Intermediate time limits will be set by the briefing officer for a rescue team to travel to a destination and for work to be done. The briefing officer and team captain must use strict realistic time limits that do not exceed 30 minutes without a report. Exceptions may be necessary if there is a problem with communications.

In situations where the team is exposed to high operating temperatures or incidents creating high temperatures, more severe time limits may be required under the Ontario Mine Rescue Heat Exposure Standard.

If a rescue team is overdue in returning to the fresh air base, the standby team shall be sent to assist, even at the cost of delaying operations. Note that in incidents involving heat exposure, it would be advisable to send two standby teams due to the likelihood that the number of casualties and/or team members in distress or approaching distress, would exceed the capabilities of one standby team.

BRIEFING A TEAM

A team should be briefed by the designated briefing officer as soon as the specific assignment or task for the team has been determined.

If possible, the briefing should be done in a quiet room where questions may be asked and answered, and the work to be done by the team explained thoroughly without confusion and distraction.

All pertinent instructions should be issued in writing to the team captain. The time limits of the trip should be understood and watches synchronized to the briefing officer's.

Each team underground should have its own briefing officer.

Briefing Officer

Many things must be done during any emergency. It is the responsibility of the briefing officer to obtain all information about the area affected that a team may encounter. This information, listed below, will assist the emergency control group and is given to each team through the briefing officer.

- Mine fire procedure and up-to-date maps showing the location of:
  - Refuge stations
  - Communications
  - Garages
  - Fuel storage
  - Fire hoses

  - Fire hydrants
  - Electrical installations
  - Hot zones or potential hot zones
  - Potential rest or cooling areas that may assist the team in recovery from heat exposure
- Information about the mine's equipment such as:
  - Ventilation and fans
  - Mining methods
  - Ground conditions
  - Timbered areas
  - Equipment used
  - Other hazards
  - Type of hoist
  - First aid equipment
  - Mine rescue equipment
  - Other equipment
- Information about the emergency:
  - Type of emergency
  - Location of the emergency
  - Missing personnel
  - Availability of mine rescue personnel
  - Special skills required by mine rescue team

These three basic responsibilities consist of a number of tasks, some of which may be done by the briefing officer. Some tasks may be delegated to other individuals, but it is the briefing officer's responsibility to see that they are completed, organized, and presented in a briefing to the mine rescue team.

Briefing Content

Every briefing of a mine rescue team should include:

1. Information available
2. Persons missing, location, and any trained persons
3. Action(s) taken so far
4. Whether the incident is a potential heat exposure incident (fire, explosion, loss of ventilation, unknown nature, etc.)
5. Intention
6. Fresh air base location and standby teams
7. Communications
8. Installations such as air, water, electricity

9. Location and status of refuge stations
10. Route of travel
11. Conditions on route of travel, including real or potential heat exposures
12. Potential rest or cooling areas for relief from heat exposure
13. Ventilation
14. Visibility
15. Mine rescue equipment available
16. Firefighting equipment and hydrants
17. First aid equipment and stretcher
18. Tools and supplies
19. Time limit
20. Written instructions

Should the incident involve a mobile equipment fire, the briefing officer must also advise the team:

- Location of the fire on the mobile equipment
- Source of the heat
- Intensity of the heat
- How long the tire(s) have been heated
- Amount of smoke from the tires
- If there were any sparks
- If the equipment became electrified, whether there was any arcing
- If the equipment is battery-powered, the content/location of the manufacturer's Safety Data Sheet

Once the team is underground, communication is vital. Mines should have a radio channel dedicated to mine rescue communications. Information to and from the briefing officer must be specific and to the point so the control group may decide the best course of action the team should take.

The briefing officer must inform the control group before a team passes a hazard, such as a fire area or fall of ground, as it may compromise the safety of the team.

The briefing officer must ensure equipment sent to a team underground is first field tested.

If the incident involves heat exposure, the briefing officer must monitor temperature and time exposures, as well as work/rest regimens reported by the team captain, and report this information to the control group.

On exploration, the team must report all conditions found with the exception of items that are normal to mining operations (doors, fans, air flow and team condition). These should only be reported if they are different than expected. Conditions need not be reported if they are the same as the initial exploration.

The conditions the team encounters must be recorded in the captain's log and must coincide with the briefing officer's report that is turned into the control group after the team has completed its assignment. All original documents prepared by the team and briefing officer must be given to the Mine Rescue Officer for the incident report. Copies may be retained by the mine.

DUTIES OF A RESCUE TEAM CAPTAIN

The success or failure of mine rescue and recovery operations depends a great deal on the ability of captains to lead their teams.

The team captain shall take charge of and be responsible for; the discipline, general safety, and work performed by the team. The captain should take orders only from the briefing officer.

BRIEFING OFFICERS REPORT

ONTARIO MINE RESCUE
PREPARED SINCE 1929

Time Under O_2: 14:44	Date: June 10/17
Team No.: 1	Time: 14:30
Captain: O. Osborne	Mine: District
BO: S. Osborne	MRO: A. Young

Ontario Mine Rescue Heat Exposure Standard

Wet Bulb Temperature														
38								19	19	19	19			
37								20	19	19	19	19	19	
36							22	22	21	20	20	19	19	19
35							24	23	22	22	22	21	20	20
34						27	26	25	24	23	23	22	22	22
33						29	28	27	27	26	25	24	23	23
32					33	32	31	30	29	28	27	26	26	25
31					38	36	35	33	32	31	30	29	28	27
30				46	44	42	40	38	36	34	33	32	30	30
29				53	50	48	45	43	41	39	38	36	34	32
28			63	60	57	55	52	50	47	45	43	41	39	37
27			72	69	66	63	60	57	54	52	49	47	45	43
26		87	83	79	75	72	68	65	62	59	56	54	51	49
25		99	95	90	86	82	78	75	71	68	65	62	59	56
24	119	114	108	103	99	94	90	85	81	78	74	71	67	64
23	*	*	*	118	113	108	103	98	93	89	85	81	77	73
	24	26	28	30	32	34	36	38	40	42	44	46	48	50

Dry Bulb Temperature

Time	Location	Smoke	CO	O_2	CH_4	DOOR	Fan	Flow	Team	Time Limit	Destination	Report
14:40	FAB									20	H/F	
14:55	H/F	M	877	20.6	Ø					10	Level	
15:00	Level	M	876	20.6	Ø					15	Shop	
15:10	Shop	M	878	20.6	Ø					15	shaft	go to shaft for lifting bags, mech pinned
15:20	Shaft	SAME								15	shop	
15:30	Shop	N	25	20.9	Ø					30	shop	extricate and prep for transport

ONTARIO MINE RESCUE
PREPARED SINCE 1929

CAPTAINS REPORT

Standard Equipment
✓MX6 ✓Whistles
✓SSR 90 ✓First Aid Kit
✓Clipboard ✓Probe Stick
✓Chalk/paint
✓Kestrel
✓KED

Captain: George McPhail	MR Officer: Percy Smith
Mine: District Mine	Date: March 2, 2018
Team No.: 1	Location: 2200 Level

Auxillary Equipment
Fire fighting equipment: Hose & Nozzle
Tools
Stretcher ✓
SSR 90 1 ✓
Level Plans ✓
TIC
Special Equipment
Communications
Carevent ✓

Name	App. No.	Field Test: Press	Field Test: Test	Under Oxygen	Bottle Pressures: Time	Time	Time	Time	Time	Time	Time	Time
				9:17	9:33	9:51	10:16	10:30	10:33			
Captain George McPhail	15	210	ok	206	187	169	151	134	∅			
No.2 Ron Eveson	18	213	ok	208	189	171	149	133	∅			
No.3 Malcolm Smith	17	209	ok	205	186	168	152	130	∅			
No.4 Charlie Burton	14	211	ok	207	184	170	147	129	∅			
V/Capt Shawn Rideout	12	212	ok	209	188	168	150	134	∅			
No.6												

Time	Location	Smk	CO	O_2	CH_4	Doors	Fans	Flow	Time Limit	Destination / Report
9:10	FAB								20	Head frame
9:25	H/F	N	0	20.9					15	2200 Level station
9:39	2200 sta	N	2	20.8					15	Ref. Sta.
9:53	Ref. Sta	N	0	20.7					30	R/S established, prep cas.
10:18	Ref. Sta								20	Surface
10:31	Surface									cas. with EMS, Get out of O_2

Preparatory to Going Underground

Prior to going underground the team captain should:

1. Ascertain that team members are in fit condition, including adequately hydrated, to undertake the job
2. Make sure each team member inspects and completes the field test on the apparatus he/she is about to wear
3. Check or have team members field test the team's standard equipment. It is suggested that:
   - No. 2 member field tests the MX6 and Kestrel
   - No. 3 member field tests the first aid kit. If the kit is sealed, it does not need to be opened
   - No. 4 member field tests a SSR 90 M as a backup for the team
   - No. 5 member field tests the captain's equipment
4. Check or have team members field test any additional equipment – e.g., CAREvent, stretcher – to be taken underground
5. Understand the instructions clearly and discuss them with the team so each member will understand what he/she has to do
6. Note the time the team has been allowed for the trip and synchronize watches those of the briefing officer and the team
7. See that the necessary tools, portable communication devices, guidelines, and materials, if required, (including firefighting equipment, if there is a fire burning) are on hand. It is important that all items are distributed equally among the team members so each member will carry his/her share
8. Make sure that he/she has level plans, notebook, pencil and chalk/spray paint to take underground
9. Ensure hoist personnel are contacted to confirm availability of the cage

Shafts & Ramp Entrance

Anytime breathing apparatus is used and a mine rescue team enters a mine via a shaft or a ramp, several precautions must be taken, including:

1. Note if the shaft/ramp is upcast or smoke is present
2. As hoist personnel in an internal shaft or on a tower mounted hoist is the link between surface and underground, a second person should be available as backup. A SCBA must be used for protection if there is a possibility of exposure to contamination. Hoist personnel must be trained and competent in the use of self-contained breathing apparatus. Where possible, this person should be checked to ensure a proper facemask seal and the apparatus is functioning correctly

3. Ensure sprinklers are functional if the shaft is timbered
4. The first team must get under O_2 in fresh air outside the headframe or portal entrance. Once a clear route of travel has been established by manual gas checking, the second and subsequent teams may get under O_2 in a clear environment underground.
5. The captain should inspect each team member's breathing apparatus and other equipment as follows:

   a) Inspect head straps and buckles for twists

   b) Inspect facemask for correct position and tight seal

   c) Try main bottle valve

   d) Observe gauge reading and record pressures

   e) Check overall condition of member (by sign or verbally)

   f) Vice-captain to make similar check of captain's apparatus
6. It is not required to take conditions and report to the briefing officer until the portal entrance or headframe is entered.
7. The air quality and air flow at shaft collar or ramp entrance must be determined.
8. A trial run must be performed of the hoist and cage if more than two hours have elapsed during a fire situation, especially if the location of the fire is unknown.
9. Contact the hoistperson and request that the cage be left near the level to minimize response time when it is released

After Going Underground

After going underground, the team has many procedures it must follow to ensure its safety. The conditions teams encounter will dictate the procedures they will have to follow.

It is understood the captain is responsible for the team and must:

1. Discourage excessive talking but keep the team informed of the plan of action after talking to briefing officer.
2. Have a team member take MX6 air quality tests at the shaft stations or levels. Note fire hoses, fans, or any other installations. All mine rescue equipment used should be returned with the team, if possible. Mark all obstructions and unusual conditions on the level plans. Bear in mind the team will have to overcome the same obstructions and unusual conditions on the return trip.
3. Designate a team member to check an area, provided the area is explored and the team is not split. As long as the captain has care and control of the team (such as visual contact, signals with rope, radio, whistles, voice, fire hose, contact with the thermal imaging camera) in all situations at all times, the team is not considered split.
4. The team will be considered split any time the captain and the team member do not maintain two methods of contact. Daisy chaining team members is not an acceptable method of contact.

   Accepted forms of contact:

   – Visual
   – Signal with rope
   – Radio
   – Whistles
   – Voice
   – Firehose
   – Link line, basket
   – Thermal imaging camera

   Example: If the team is working at a specific location in smoke and a team member must travel 50 ft alone, the captain can maintain two forms of contact by voice communication and using the thermal imaging camera to monitor the team member.

5. Consider an area explored if a responsible person, such as a supervisor or a mine rescuer, informs the captain that he/she has travelled the area. The team's line of sight is also considered explored. The captain will make the decision about explored territory after consulting the team.
6. Maintain contact with the surface by using either radio or telephone communication, setting strict time limits and destinations.
7. Rest and check the team during travel, and after strenuous work or during exposure in hot environments give

additional rests as often as conditions warrant. During halts, observe gauges and function of the apparatus. Remember it will be just as necessary to halt, rest and check apparatus when retreating as when advancing. If the rescue of a casualty is involved, speed may be necessary but should be governed by conditions.

8. Keep the team from becoming disorganized if anything should happen to a member or if an apparatus should fail to function properly. At any time, a team member in distress takes priority over all assignments. Advise the briefing officer and have the team return to the fresh air base as quickly as possible.

   A team member in distress due to heat exhaustion indicates other team members may be experiencing heat stress and close to exhaustion.

9. Before allowing any team member to remove a breathing apparatus underground, be certain the air is safe to breathe. The captain must be certain that the MX6 functions normally and the CO level is zero.

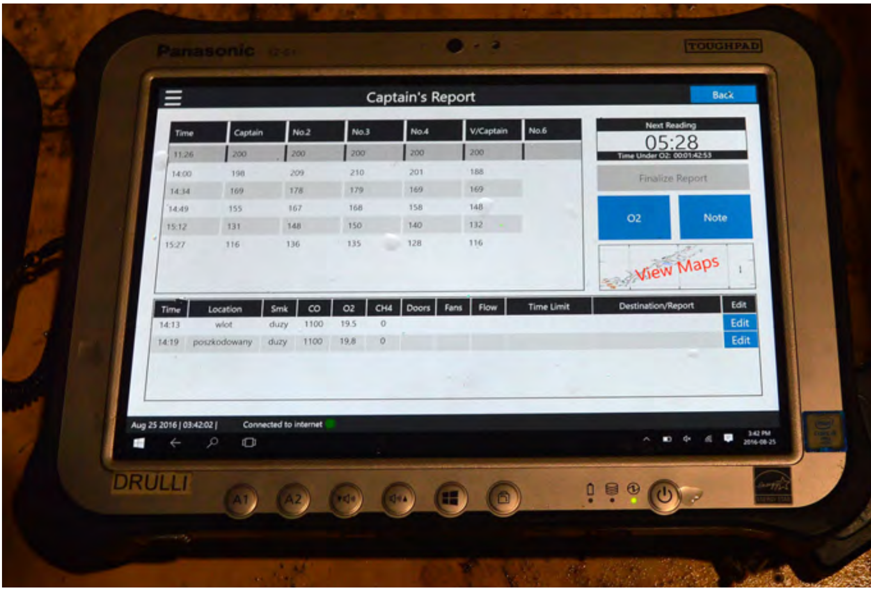
10. Whenever possible, maintain communications with surface or report frequently, at least every 30 minutes.

11. Give careful consideration to turning off an auxiliary fan if it is blowing contamination into an isolated area. Consult with the briefing officer before taking action.

12. Not alter main ventilation unless approval is given by the control group.

13. While proceeding to the shaft station with a casualty, call the briefing officer and have additional equipment brought to the team for a return trip into the mine.

14. An acetylene cylinder must be moved to the return air side of a fire if it is leaking or damaged. Caution should be taken if the cylinder is hot.



In case of fire, allow the gas to burn if the flow cannot be shut off immediately. Apply water from a safe distance to cool the container and protect the surrounding area. When the cylinders are moved, do not drag or roll them. Use a suitable hand truck for cylinder movement.

15. Ensure the team follows all mine rescue procedures.
16. Carry out the orders given by the briefing official. Bring the team back to the fresh air base on time, even if the work assigned has not been completed.
17. On return to the fresh air base, get the team out of oxygen. The captain must get out of oxygen first, and then give the order for the team to get out of oxygen.
18. Make a detailed, accurate written report to the briefing officer, including time log, additional details, maps, and photos. All original documents prepared by the captain and the briefing officer must be given to the Mine Rescue Officer for the incident report. Copies may be retained by the mine.

Team Checks

1. A captain must perform 20-minute team checks to ensure each apparatus is functioning correctly and allow members to rest periodically. The team must check and report their cylinder pressures and condition to the captain, who must record the findings in the log. It is not necessary to squeeze hoses.
2. When a team first enters contamination, members must squeeze hoses, and report their cylinder pressure and condition. The captain will record each member's pressure and condition in the log.

   If contamination is encountered in the shaft, it is expected that the team will, at a minimum, squeeze hoses and report condition to captain. They may complete the contamination check once they reach the level.

TRAVELLING UNDERGROUND

Rescue Team Guides

In a major fire or non-fire emergency, it will generally be necessary to bring in rescue teams who are not familiar with the mine workings. To facilitate the necessary work, mine rescue personnel familiar with the mine should be assigned to each team.

Order of Travel

In mine rescue, as in any other teamwork, discipline is essential to efficiency. This discipline must be maintained, both in training and in actual operations.

The captain or No. 1 person will always lead, whether the team is advancing or retreating. The No. 5 member assumes the responsibilities of vice-captain.

The rate of travel cannot be laid down by any hard and fast rules. It will be governed by:

1. Visibility
2. Obstructions to travel
3. Mental and physical condition of the team members
4. Amount of O_2 in the bottles
5. Anything that may be applicable to local conditions

Travelling 'under oxygen' on ladders should be done only after the captain has considered carefully whether the value of doing so outweighs the dangers.

Fastening Team Members Together

When travelling in strange territory or in atmospheres where visibility is limited or may become so, the members of the rescue team are fastened together by means of a link line.

In emergencies, where the link line is liable to become an additional hazard (e.g., when carrying a stretcher or casualty), the lines may be disconnected as long as there is some means of keeping team members together.

The following terms have been standardized for mine rescue work:

- A guideline consists of a line or telephone cable stretched from the fresh air base or shaft station to the working face in such a manner a team may guide itself through strange territory or dense atmospheres.
- A link line is a lanyard suitable for linking the team together and as fall restraint protection provided the lamp belts used by mine rescue teams are turned to the back.

The team does not need to be linked together when conducting a fire hose drill.

Passing a Team through Ventilation or Fire Doors

A captain should make certain that all doors are left as found unless he/she has received definite instructions, preferably in writing, to the contrary. To ensure this is done the captain should:

1. Halt the team and disconnect the link line
2. Examine door for damage, air flow, heat, and position
3. Determine if there is anyone behind the door
4. Open and hold the door open
5. While at the door, advance the team through the door until the last member is through
6. When the last member is through, halt the team
7. Leave the door as found, move to the head of the team, fasten the link line and give the signal to advance

Air quality should be tested if the conditions are different once the team has proceeded through the door.

Travelling in Smoke

When travelling in smoky atmospheres, team members will find it helpful to carry their cap lamps in their hands and use a probe stick to feel for obstructions and hazards. There is a disadvantage in carrying the light on the hat as the reflection cast back by the solid particles of smoke close to the member's face tends to be blinding.

If the smoke is very dense, it is better to have the cap lamp as near the ground as possible letting it hang by its cord so that light is directed toward the feet. The probe stick must be used.

The thermal imaging camera can be used as a navigation aid, but should not be used as the sole basis for navigation. Glow sticks in the first aid kit can be used to mark navigation and routes of travel.

Recording Route of Travel

Routes of travel can be recorded by three main methods:

1. Radio communication, using leaky feeder or phones, is subject to strict time limits and require specific destinations to allow for monitoring of the team's progress. These methods allow for greater mobility and requires strict controls. Caution should be used when relaying information to the briefing officer because radio communications are not secure, and proper radio etiquette should be practised (no foul language, limit personnel names, and maintain team discipline during radio communication).
2. Guidelines installed in areas of zero visibility will save a great deal of time for team movements and will allow a team to find its way to fresh air again. If more than one team is required to advance the guideline, as each team completes the installation of its allotted section of the guideline, the captain should mark the place where the line ends with an obstacle across the drift. This may be a pile of rocks, boards, timber or anything that can be identified by touch. On reaching fresh air, the captain should describe each obstruction clearly in the report.
3. At a turnaround point, radio communication will suffice if the turnaround point can be identified by a distinctive landmark, such as a refuge station, shop, garage, electrical substation, etc. If radio communication is not possible or no distinctive landmark exists, a turnaround point consisting of three vertical lines, time, date, team number and the captain's initials, must be clearly marked at the farthest point of advance into any drift or heading. All times are recorded using the 24-hour clock. A turnaround point must be cancelled only if the same team is advancing past the point that was marked.

When visibility is at zero, the sense of touch must be relied on. If the team is travelling into drifts or crosscuts where track is laid, it is simple

to follow the track by sliding one foot along a rail. When a switch is reached, it should always be left so that it makes a continuous track to the fresh air base that can be followed by a retreating team. Again, glow sticks can be used to show the route of travel. If there are no tracks, much time can be saved by having several teams, in apparatus, install a guideline to the emergency scene.

Use of Vehicles for Transportation

Where mobile equipment is the preferred mode of transportation underground, a mine must dedicate a vehicle, capable of transporting a team under apparatus with casualty, for mine rescue teams. Where mobile equipment is not used, a wheeled-cart for transportation of a casualty should be available.

The conditions teams encounter will dictate the procedures they will have to follow. The regulations for the use of motor vehicles in mines are the basis for the use of vehicles by the team.

The team captain and the briefing officer shall note the normal walking speed on the mine plans. This will give some indication how far the team would travel on foot if the vehicle needs to be abandoned.

It is not recommended to drive a vehicle in heavy smoke, but there may be times in which teams may have to drive a vehicle in light smoke.

The following must be adhered to:

1. The vehicle must be equipped with good lights and the necessary emergency equipment and tools.
2. The horn must be sounded often.
3. If the vehicle is abandoned, it should be parked at the side of the roadway to maintain a clear roadway for other vehicles. The engine must be turned off. Warning reflectors or signals should be left to warn other teams.
4. Control doors may need to be opened manually, in which case they will have to be held open while the vehicle passes through. The captain will be responsible for the correct positioning of the doors.

COMMUNICATIONS

Between Fresh Air Base & Team

It is essential that communications be established between the fresh air base and teams working ahead of the base. When breathing apparatus is worn, communication may be conducted by radio or by telephone, either permanent or portable battery-powered.

Radio communication is the ideal method as briefing officers are in constant touch with active teams should an unexpected hazard or new information become known. A radio channel should be dedicated for the sole use of mine rescue. If available, teams should use Draeger FPS communication masks.

When a team is on an exploration trip, radio and/or telephone communications must be checked for proper operation and to ensure backup communications. If there is more than one phone in an area, only one phone need be checked. Radios may be used at any time an unexpected hazard is encountered or new information is to be relayed.

When a team is on a return trip or when a casualty is being transported, a sense of urgency must be demonstrated. A time limit longer than 30 minutes may be given to the destination for the return trip. All other communication points may be bypassed. If there is a hazardous location that must be evaluated during retreat and if conditions of the hazard have changed, the briefing officer must be contacted as soon as possible.

Information to and from the briefing officer should be specific and to the point. When the team is on an exploration trip, they must report conditions as found. Teams reporting on atmospheric conditions as clear are indicating there is no smoke, zero CO, zero CH_4 and normal O_2. If conditions haven't changed when they return to that location, the conditions may be reported as the same. It is not necessary to repeat the specifics – CH_4, doors, fans, flow and team condition – if they are the same as already noted.

Information on items and conditions found during exploration by a team must be recorded by the captain and must coincide with the briefing officer plans to be included with the final report.

Conditions recording and reporting will be required when:

- Conditions along the route of travel change, otherwise conditions along the route will NOT be recorded or reported
- Entering a head frame or adit
- Entering a level
- Reaching assignment area where the team does work
- Upon encountering a casualty

If radios are not being used, it is advisable a team never pass a refuge station without phoning the briefing officer, who may have new information for the team.

When establishing a refuge station, if the standards are met, conditions do not have to be recorded or reported. The captain need only report that the refuge station has been established.

The captain does not need permission to fight a fire, nor does the captain need permission to pass a hazard – e.g., fire area, fall of ground – during exploration, if the area is assessed as safe by the team. Such a hazard must be identified on the map and communicated to the briefing officer on the next update.

Between Team Members

Although team members may talk to one another, it is essential that conversation be limited. Whistle signals are used for team travel from one point to another and other team movements. The Code of Signals is as follows:

1 – Stop

2 – Advance

3 – Turnaround

4 – Attention or Emergency

When the captain gives a signal by a mechanical means, such as a whistle or horn, the vice-captain repeats the signal. The Attention or Emergency signal need not be repeated.

Whistles are used for team travel from one point to another. They are not required for the hose drill, while extinguishing a fire, or work performed in close proximity to each other such as loading the cage, building a barricade, pushing a vehicle or other local movement.

STANDARD MINE RESCUE PROCEDURES

Electrical

Some situations during mine fires will require switching the electricity off/on. It is highly recommended that an electrician be placed on the team when such assignments arise. The following procedures must be followed:

1. Arcing cable or equipment must be de-energized as soon as possible. Permission from the control group is not required.
2. When decided by the control group, the briefing officer must be informed what the results of switching the power off/on will be, and the team must then be informed to turn power off/on.
3. The whole team must stand back while the switch is being thrown.
4. The person turning the power off/on must stand at arm's distance to the right of the disconnect switch, avert eyes to avoid possible flash, and pull the switch with his/her left hand. The main objective is to avoid having one's body being directly in front of the switchbox when the power is being turned off/on.
5. The team must follow standard lockout procedures when necessary.

Use of Burning & Welding Equipment

The danger of burning and welding while under O_2 must be emphasized as there is the possibility that hot slag will burn into the oxygen-enriched breathing apparatus through the rubber parts of the apparatus and then erupt into flames. The recommended emergency procedure is:

1. A competent person is selected for the operation and must be trained in mine rescue and be properly equipped for burning

and welding, working under the supervision of the captain at all times.

2. The appointed person will be an extra member, not part of the mine rescue team.
3. This person must be equipped with self-contained air breathing apparatus, preferably a pressure-demand apparatus for connecting to a supplementary air supply with an extension hose. Care should be taken to ensure that the recharge hose is in a safe place.
4. The team must bring a water hose, nozzle, or a water-type fire extinguisher.
5. The area must be wetted down before welding or burning commences.
6. The area must be wetted down after burning is finished. The area should be checked periodically.
7. When the assignment is completed, the person should be returned to fresh air immediately.

Rescue Operations in High Temperatures

When mine rescue teams conduct operations in areas with high temperatures and/or humidity levels, they must follow the mission limits as determined by the Ontario Mine Rescue Heat Exposure Standard.

The standard, adopted by Ontario Mine Rescue, was developed by the Institute of Occupational Medicine (IOM) for Mine Rescue Services Ltd., in the United Kingdom. IOM has determined the standard is suitable for mine rescuers using the Draeger BG4, the apparatus used by Ontario Mine Rescue.

This standard accounts for the four principle variables in heat exposure – workload (all mine rescue activities are 'heavy work'), temperature, relative humidity (factored in difference between dry and wet bulb temperature), and the time exposed.

The standard cross-references dry and wet bulb temperatures to determine the maximum mission time limit in minutes.

The time limit includes:

- Time spent entering and leaving
- Time spent at rest

The maximum time limits must be strictly followed.

The heat exposure standard will apply whenever a team is exposed to a Hot Zone, a Potential Hot Zone and/or a Heat Exposure Incident.

A Hot Zone is a location or area in a mine where, under normal operating conditions, heat exposure is an issue and control measures are required.

A Potential Hot Zone is a location or area in a mine where heat exposure may be an issue if normal operating conditions and controls, such as ventilation, fail or are inoperative.

A Heat Exposure Incident is an incident involving fire, explosion, loss of ventilation, or other factor that could result in a heat exposure hazard. Incidents of an unknown nature should be considered potential heat exposure incidents.

During such assignments, the team captain will ask for and record temperature and wet bulb temperature, when:

- The team approaches and enters an identified hot zone
- The team approaches and enters a potential hot zone
- The team approaches and enters a potential or real heat exposure incident
- The captain experiences or is told by a team member the member experiences an unexpected increase in the ambient temperature

Ontario Mine Rescue Heat Exposure Standard

Wet Bulb Temp.														
38								19	19	19	19			
37								20	19	19	19	19	19	
36							22	22	21	20	20	19	19	19
35							24	23	22	22	22	21	20	20
34						27	26	25	24	23	23	22	22	22
33						29	28	27	27	26	25	24	23	23
32					33	32	31	30	29	28	27	26	26	25
31					38	36	35	33	32	31	30	29	28	27
30				46	44	42	40	38	36	34	33	32	30	30
29				53	50	48	45	43	41	39	38	36	34	32
28			63	60	57	55	52	50	47	45	43	41	39	37
27			72	69	66	63	60	57	54	52	49	47	45	43
26		87	83	79	75	72	68	65	62	59	56	54	51	49
25		99	95	90	86	82	78	75	71	68	65	62	59	56
24	119	114	108	103	99	94	90	85	81	78	74	71	67	64
23	*	*	*	118	113	108	103	98	93	89	85	81	77	73
	24	**26**	**28**	**30**	**32**	**34**	**36**	**38**	**40**	**42**	**44**	**46**	**48**	**50**
	Dry Bulb Temp.													

Cross referencing the Wet Bulb and Dry Bulb temperatures indicates the maximum time exposure in minutes.
Exposure limits include time for entry, exit, and rest breaks.
Exposure limits must not be exceeded.

The time the measurement is taken, and the exposure time limit, if any, must be recorded and reported to the briefing officer.

If there is a strong concern about heat exposure, Draeger FPS hydration masks are available for use. Other control measures, such as extended rest breaks, if possible in 'cooler' areas, and more detailed team checks, should also be undertaken during such operations.

REFUGE STATIONS & SAFE AREAS

Most mines have permanent or portable refuge stations for miners to take shelter in the event of an emergency. WSN has prepared Guidelines for Mine Rescue Refuge Stations to assist mine operators in establishing safe, effective refuge stations.

Under Ontario Reg: 854: Mines and Mining Plants Sect. 26, , where the procedure in case of a fire in an underground mine provides for the use of a refuge station for workers, the refuge station shall:

1. Be constructed with materials having at least a one-hour fire-resistance rating;
2. Be of sufficient size to accommodate the workers to be assembled therein;
3. Be capable of being sealed to prevent the entry of gases;
4. Have a means of voice communication with surface;
5. Be equipped with a means for the supply of:

   a) compressed air

   b) potable water.

A permanent refuge station is usually a stub or drift cut in the rock and closed at one or both ends with permanent bulkheads and doors.

A portable refuge station is a moveable steel or fiberglass enclosure usually provided for remote areas in the mine and where travel to a central refuge station is uncertain or unsafe. These units are small enclosures designed for from six to ten workers. This type of refuge station is generally equipped with compressed air or oxygen and a CO_2 absorbent to compensate for the limited air content.

Refuge stations are usually strategically located and large enough to accommodate all the workers in the area.

Teams must also be aware of temporary emergency shelters, shelters of last resort, not covered under Regulation 854. They may or may not have access to compressed air or a secure airline, and are usually of value only for a limited duration.

They are most commonly do-it-yourself shelters or barricaded areas. Mines may also use manufactured emergency shelter devices, such as emergency fresh air stations, or drop down tents. Temporary emergency shelters cannot be used as a substitute for refuge stations.

Refuge Station Procedures

A team should never pass a refuge station without contacting the briefing officer and checking for occupants. Team must follow specific procedures when dealing with refuge stations and barricades.

1. Assuming there is contamination outside a refuge station or barricade, there are questions that a team must ask when first encountering people inside a refuge station or barricade who have not been in communication with surface:
   - Knock on the door/call out
   - Identify as mine rescue
   - Determine the number of personnel inside, if they are trained in first aid or mine rescue, and if anyone has a beard
   - Ask if people are alright and if there are any injuries
   - Determine if they have self-rescuers and whether they have been used

- Ask about missing personnel or information on the fire/ incident
- Ask if the compressed air is available/blowing and the door is sealed
- Ask if the phone is working
- Tell the people to stay inside

2. Where people inside a refuge station or barricade are without communication with the surface, a team captain must ask the appropriate questions and relay the information to the briefing officer. The captain must leave a note outside the station, saying the station has been checked and the number of occupants.

3. If the people inside a refuge station or barricade have contact with the briefing officer, the team is not required to ask for all the information the briefing officer should know, nor leave a mark on the outside of the people inside.

   Teams should not enter a refuge station or barricade without a risk assessment and justification of the need to enter.

4. At a refuge station, when the team knocks or calls out and receives no response it is imperative to enter immediately with the stretcher, turn on compressed air, check air quality in the area, and contact the briefing officer, thus "establishing" the refuge station. No mark is required outside the refuge station.

5. Should it become necessary to enter an occupied refuge station, instruct the individuals to move to the back of the refuge station and turn the compressed air on fully while the team enters quickly. If there is no compressed air, treat as a barricade.

6. A telephone outside the refuge station is ideal for communicating with people inside and to the briefing officer. If it is not available, the team must not enter as it would expose the occupants to contamination unnecessarily.

   Someone inside could phone the briefing officer on the team's behalf and relay messages. Because information may be received from other parts of the mine, it is important to wait for a reply from the briefing officer before continuing with the original assignment.

7. The captain may use the phone in a refuge station with the team remaining outside providing the air outside is not contaminated. The door must be kept open to maintain contact with the team. The whole team must enter if there is contamination outside and the captain wishes to use the telephone.

8. There may be circumstances when it is necessary to get out of O_2 underground, whether it is the team or casualties in refuge stations. It is essential to test the air quality.

9. The team must take precautions to minimize contamination of a barricaded area if no compressed air is available. Consideration should be given to:
   – Size of area
   – Amount of contamination
   – Number of personnel, injuries, and if they are willing to stay
   – How long they have been there
   – If self-rescuers are available and, if so, have they been used?
   – Determine information on the fire or missing personnel
10. Circumstances may dictate the team enters a barricaded area to remove personnel with suitable apparatus. If so, the area must be ventilated or the amount of contamination allowed to enter must be restricted.
11. A barricade that has been built to seal off a fire should not be unsealed unless the On-site Official in Charge has given definite orders to do so.

BG4 EMERGENCY PROCEDURES

Ontario Mine Rescue acknowledges the following emergency procedures for the BG4 are not recommended by the manufacturer, but may be required under extreme circumstances, including:

1. Entrapment procedure
2. Team member in distress
3. Use of the BG4 as a rescue unit
4. Gradual loss of oxygen pressure

Entrapment Procedure

Before using this procedure in an emergency situation, mine rescue teams must consider all other available options, be informed of the hazard of hypoxia, and be able to demonstrate knowledge of the entrapment procedure.

Hypoxia – Hypoxia literally means deficient in oxygen. When the body doesn't receive the required amount of O_2, it results in a low O_2 content in the blood. This leads to hypoxic hypoxia. The major causes of hypoxic hypoxia are high altitude climbing, inadequate ventilation, or heart mechanism failure.

Hypoxic hypoxia may occur while performing the entrapment procedure with the BG4 when the O_2 cylinder is off. The concentration of nitrogen and carbon dioxide in the breathing circuit may increase. The high nitrogen concentration together with low oxygen may be fatal.

Signs and Symptoms – Hypoxia is difficult to recognize in its onset. The signs and symptoms can be different for each person and may not occur in the same progression.

Signs and symptoms include:

- Cyanosis
- Poor coordination

- Lethargy/fatigue/tiredness
- Executing poor judgment
- Air hunger
- Dizziness
- Headache
- Mental and muscle fatigue
- Nausea
- Hot and cold flashes
- Tingling sensation
- Visual impairment
- Euphoria

Entrapment – The following procedure requires **strict discipline and careful monitoring** on the part of team members. **One team member will always be under oxygen** on an alternating basis when this procedure is being performed.

Mine rescue teams should consider all options such as retreating to fresh air, using installations such as garages or electrical substations as a fresh air location, travelling to another level via a manway/ramp, or using cached self-rescuers before using this procedure.

If the entrapment procedure is used in the first half-hour of BG4 use, the breathing circuit will need to be flushed of nitrogen by using the bypass valve to fill the breathing bag several times.

A mine rescue team member who weighs 75 kg (165 lb) requires approximately 0.5 litres of O_2 per minute at rest. A BG4 with a cylinder pressure of 100 bar would contain 200 litres of O_2. At 0.5 litres per minute, 200 litres would provide O_2 for the user for 400 minutes or 6.5 hours.

A BG4 that has been in use for 30 minutes and has 150 bar with 300 litres of O_2 remaining would provide oxygen to the user for approximately 600 minutes or 10 hours.

Procedure:

1. The captain will select a safe site where the team can sit together comfortably.

2. Team members will remove each others' BG4 cover so the breathing bags can be monitored.
3. The BG4 harness can be loosened for comfort.
4. The captain will record cylinder pressures and condition of team members initially and every 10 minutes thereafter.
5. The captain will remain under oxygen for the first rotation of the procedure to check team members' alertness and observe breathing bags. The buddy system should also be used to observe breathing bags and condition of team members.
6. Another team member or captain will push the bypass valve and **ensure the breathing bag is not overfilled**.
7. Team members will turn off their O_2 cylinders and breathe in slow controlled breaths. The time the cylinders are turned off should be noted by each team member. Breathing difficulty may be noticed as the breathing bag empties and bottoms out on inhalation.

8. Team members will turn on the cylinder every 10 minutes or sooner, if a breathing bag is empty or a team member is in distress.
9. The #2 member will remain under oxygen to check team members' alertness and observe breathing bags for the second rotation of the procedure. This step will be repeated until everyone has had a turn with their cylinder left on. The cover of the BG4 should be on when the cylinder is on.
10. Another team member or captain will push the bypass and **ensure the breathing bag is not overfilled**.
11. Team members will turn off their O_2 cylinders and breathe in slow controlled breaths.

Team Member in Distress

There may be times when a team member experiences breathlessness, exhaustion, anxiety, or collapse. This may be a result of BG4 malfunction, physical condition, illness, overexertion, hyperventilation, or exposure to high heat and humidity.

Mine rescue volunteers may avoid falling into distress by maintaining physical fitness, and undertaking mine rescue assignments only while healthy and hydrated. Mine rescue teams may avoid having a team member in distress by working at a slow, even pace, and breathing slowly and deeply while wearing a BG4.

There may be occasions when the inspired air temperature in a BG4 becomes hot. This can be avoided if mine rescue teams take rest breaks that are long enough for body cooling and recovery to occur. Cooling stations such as fresh airways, air conditioned refuge stations, or mobile equipment can also be used during rest breaks.

Excessive use of the emergency bypass valve should be discouraged. **The emergency bypass valve should not be used to cool the inspired air or provide additional oxygen.**

Team members should be aware of the factors that contribute to heat stress, the dangers posed by heat stress, and precautions a mine rescue team can use to prevent heat stress.

If a team member experiences distress, the team should return to surface immediately.

Procedure:

1. Remove BG4 cover of the team member in distress to monitor breathing bag
2. Check cylinder pressure and function of apparatus
3. Check facemask seal using hands
4. Push the bypass valve to fill the breathing bag with oxygen. Ensure the breathing bag is not overfilled
5. Have the team member in distress breathe slowly and deeply
6. Observe the breathing bag
7. Repeat Steps 4 to 6 until the team member recovers

When team member is unconscious:

8. Place team member in the stretcher in the recovery position
9. Loosen harness

BG4 as a Rescue Unit

The BG4 could be used on conscious casualties when there is not enough SSR 90 Ms for everyone requiring evacuation or if the service time of an SSR 90 M is not sufficient to transport people to fresh air. It is not practical to use a BG4 in all rescues because of its size and weight. Untrained people should not perform work while wearing the BG4.

The BG4 shall not be used on unconscious casualties as it cannot be used without twisting or turning the breathing hoses or facemask to prevent kinking.

Procedure:

1. Place facemask and hoses over BG4 cover
2. Assist patient with donning and adjusting harness for fit
3. Place facemask and hoses over patients head
4. Have patient take a deep breath
5. Ensure head straps are folded over the lens and position mask on the face
6. Slide head straps over the patients head and adjust
7. Check for a facemask seal by squeezing breathing hoses
8. Turn O_2 cylinder on fully back 1/4 turn
9. Check cylinder pressure
10. Report to captain
11. Reassure patient to breathe normally
12. Captain to check facemask seal and record bottle pressure

Gradual Loss of Oxygen

A team member may experience a gradual loss of oxygen during a mine rescue response. A gradual loss of oxygen is usually caused by a small leak, poor facemask seal, excessive use of the bypass valve, or high oxygen flow. When the loss of oxygen is caused by a small leak or poor facemask seal, the minimum valve will be heard with each breathe, regardless of the work being performed. The captain may also note a team member's oxygen supply is being consumed at a higher rate than other team members when 20-minute team checks are compared.

When the captain notes a gradual oxygen loss, the team member affected should recheck his/her facemask seal. The team member's apparatus should be inspected for obvious problems. If the cause of the leak is not found the team should return to fresh air.

If a team member runs out of oxygen before reaching fresh air, the team should consider applying an SSR 90 M or using an O_2 cylinder from a CAREvent.

The team member with the faulty apparatus should not perform any work, such as carrying a stretcher.

NOTES:

NOTES:

CHAPTER 12

UNDERGROUND FIRES

CONTAMINATION PREVENTION

While different substances such as conveyor belts, tires, batteries, and fluids emit different products of combustion with different toxicities when burning, all products of combustion should be considered toxic.

Coveralls, gloves, hardhats and other clothing worn while firefighting should be considered contaminated and measures should be taken to avoid spreading that contamination.

Best practices include:

- After the response and getting out of oxygen, avoid unnecessary travel and go directly to a change area.
- Avoid sitting down, if possible, to prevent contact spreading.
- Remove coveralls and other items, and place them directly into a large plastic bag.
- Shower thoroughly washing your entire body using soap and shampoo (shower within the hour).
- Dress in clean clothes, avoid sitting in possibility contaminated chairs until they have been cleaned.
- Clean your hardhat, inside and out, with wipes or soap and water

- Wash contaminated clothes as soon as possible after the incident.
- They should be washed and dried in isolation from uncontaminated clothes.
- Even after washing, they should be kept separate from other clothes.
- Severely contaminated clothing and items should be discarded.

THE NATURE OF FIRE

Fire is the chemical reaction that occurs when a material unites with oxygen so rapidly that it produces heat and light energy in the form of flame.

The nature of fire, from its ignition through the complete burning process, is entirely predictable. This well-defined pattern is a chemical reaction called combustion.

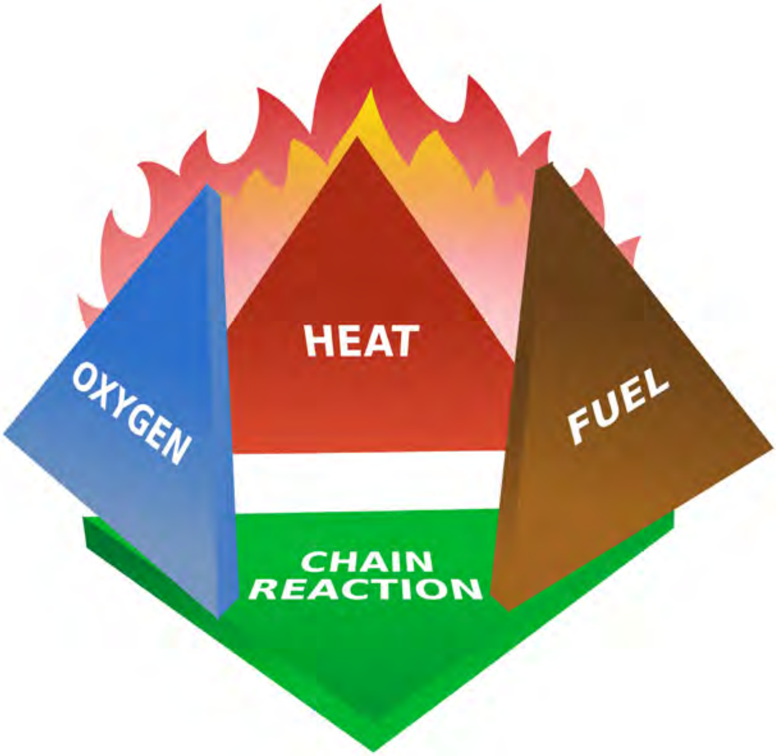
Whenever oxygen, in any form, combines with fuel, a chemical reaction known as oxidation occurs. In combustion, material is oxidized rapidly, causing a release of energy in in the form of heat. When the heat reaches a sufficient temperature, the result is fire.

This chemical reaction is characterized by a four-sided geometric figure called a tetrahedron which consists of four elements.

Heat – Heat is the energy necessary to increase the temperature of the fuel to a point where sufficient vapours are given off for ignition to occur.

Fuel – Fuel can be any combustible material: solid, liquid, or gas. Most solids and liquids become a vapour or gas before they will burn.

Oxygen – Normal air has about 21 per cent oxygen. Fire needs an atmosphere of at least 16 per cent oxygen. As the concentration of oxygen increases, the likelihood of fire increases.



Chemical Chain Reaction – Oxidation, a chemical chain reaction, can occur when the other three elements (oxygen, fuel and heat) are present in the proper conditions and proportions. Fire occurs when rapid oxidation, or combustion, takes place.

Fire can be prevented or extinguished by removing any one element of the tetrahedron.

Heat Reduction – Perhaps the most common method of extinguishing fire is cooling the burning material with water. This lowers the temperature of the fuel to below its combustion point. Enough water must be applied to absorb the heat generated by combustion. Cooling with water is ineffective on gas and most liquid fires.

Fuel Removal – Removing the source of fuel, by stopping the flow of a gaseous or liquid fuel, or by removing solid fuel, can extinguish fires. Allowing a fire to burn until all the fuel is consumed is considered a method of fuel removal.

Oxygen Starvation – Removing or reducing the oxygen available for combustion can extinguish a fire. Oxygen starvation can occur by displacing the oxygen supplying a fire with an inert gas such as carbon dioxide, or by separating the fuel from air by blanketing or covering the fire.

Chain Reaction Inhibition – Some extinguishing agents, such as halon, interrupt the chemical reaction. They are particularly effective on gas and liquid fires. These agents are sometimes called chain breakers.

CAUSES OF MINE FIRES

Most fires occurring underground can be classified according to their cause:

1. **Diesel-powered equipment** – mobile, locomotive, or portable equipment
2. **Electrical** – battery locomotives, power cables, trolley wires, motors, electric heaters, and even electric light bulbs
3. **Burning and welding** – use of compressed gases, electrical welding
4. **Friction** – conveyor belts, drive units, brakes and clutches, gear boxes
5. **Spontaneous combustion** – sulphide ores, tailings backfill, accumulation of combustible materials
6. **Smoking or open flame** – Either deliberate or accidental

The causes of fires are listed in order of their occurrence in recent years. Almost 70 per cent of all fires involve diesel equipment. Also high on the list are fires caused by electrical equipment, and burning and welding, which account for another 20 per cent.

Though battery-related fires are uncommon, the risk remains and heightens as the use of battery-powered large and small-scale equipment in mining increases. Inadequate storage, poor maintenance, damage, overcharging, poor ventilation, exposure to heat, and other factors can lead to a fire or explosion.

CLASSES OF FIRE

Since not all fires are the same, fires are classified based on the fuel that feeds them so that an appropriate method of safely and efficiently suppressing or extinguishing them can be used.

The five classes are:

Class A fires involve ordinary combustible materials (such as wood, cloth, paper, rubber and many plastics) and require the heat-absorbing (i.e., cooling) effects of water or water solutions, or the coating effects of certain dry chemicals that retard combustion.

Class B fires occur in the vapour-air mixture over the surface of flammable liquids such as greases, gasoline and lubricating oils. A smothering or combustion-inhibiting effect is necessary to extinguish Class B fires. A dry chemical, foam, vapourizing liquids, carbon dioxide, and water fog can all be used as extinguishing agents depending on the circumstances of the fire.

Class C fires involve live electrical equipment where safety to the extinguisher operator requires the use of electrically non-conductive extinguishing agents. Dry chemical, carbon dioxide, and de-ionized water mist extinguishers are suitable. Because foam, water, and water-type extinguishing agents conduct electricity, their use can kill or injure the person operating the extinguisher and cause severe damage to electrical equipment. (Note: when electric power is disconnected, Class A or B extinguishers may be used.)

Class D fires involve certain combustible metals (such as magnesium, titanium, zirconium, sodium, and potassium) and require a heat-absorbing extinguishing medium that will not react with the burning metals. Specialized techniques, extinguishing agents, and extinguishing equipment have been developed to control and extinguish fires of this type.

Class K fires involve cooking oils and fats. Outside of North America, these are Class F fires.

EXTINGUISHMENT

Mine rescue teams have a range of resources available to them in fighting and extinguishing fires, but before going underground to fight a fire or a potential fire, members must wear breathing apparatus and

coveralls that meet the National Fire Protection Association standard – NFPA 2113, to provide protection against arc flash.

Whatever firefighting resource (extinguisher, hose and nozzle, foam) is used, must be appropriate for the class and size of fire. It must be tested for proper operation before approaching the fire.

Whenever possible, the team should approach from the downcast side of a fire, and must maintain an adequate safety zone. The team should never approach a fire so closely that it is exposed to the flame, and should always leave itself an escape route. When fighting Class B fires, the team cannot allow unignited liquid fuel from approaching or cutting off the escape route.

Scene assessment and ground monitoring are a necessity for team safety. Fire can have a detrimental effect on ground conditions and the support (rebar, resin, screen) installed within it.

If the fire does not go out, the team should back away, leaving the area. When leaving an active fire area, the team must always pay attention to the fire even if it appears to be extinguished. Never turn your back on a fire.

If the fire is extinguished, watch the area in case it re-ignites.

Safety of the team, not extinguishing the fire, is paramount.

Portable Fire Extinguishers

To fight different classes of fires, there are different types of portable fire extinguishers. Extinguishers are typed based on the class of fire on which they are effective and are rated on their size and/or duration. Some extinguishers are of value primarily on one class of fire only. Some are suitable on two or three classes. None is suitable for all classes of fire.

Portable fire extinguishers are best suited for small fires, and fires in the preliminary or decaying stages.

In mines without a water supply, mine rescue teams must take at least two fire extinguishers as standard equipment to protect the team whenever smoke is reported, even if the assignment is not to fight a fire.

Water extinguishers (Type A) use the simplest firefighting medium available. The water may be pumped or stored under pressure in suitable containers. Water-type extinguishers are effective and safe on Class A fires only. Water does not mix with flammable fuels and used on Class B fires may spread the liquid fuel and flames. Water is a good electrical conductor and used on Class C fires can result in electrocution.

Foam extinguishers (Type AB) use AFFF or aqueous film-forming foam. They are effective on and safe on Class A and B fires. In addition to cooling the fuel, the foam smothers the fire, separating the fuel from oxygen. Foam extinguishers should not be used on Class C fires, as the foam is conductive, as well as destructive to electronics.

Carbon dioxide extinguishers (Type BC) are safe to use on Class B and C fires, but are only moderately effective on Class A. The extinguishing agent, carbon dioxide is liquid while in the extinguisher, but discharged in a gaseous form. It extinguishes fire by excluding or diluting oxygen. CO_2 extinguishers are preferred on Class C fires because they do not leave a chemical residue.

Dry chemical extinguishers (Type BC) are safe to use on Class A, B, and C fires, but are highly recommended for Class B and C fires. The extinguishing agent is sodium bicarbonate or potassium bicarbonate in powder form, to which has been added an ingredient to repel moisture and maintain a free flow. The powder is expelled under pressure, produced either by compressed air stored in the extinguisher or by carbon dioxide stored in a small cartridge attached to or confined within the extinguisher.

The expelled powder separates the fuel and the oxygen in the air, and also works to prevent the unburned gases rising above the fire from igniting. This is called a chain-breaking reaction or flame interrupting.

Multi-purpose dry chemical extinguishers (Type ABC) are safe and effective on Class A, B, and C fires. The extinguishing agent is monoammonium phosphate. This agent, when heated, decomposes to form a molten residue that adheres to heated solid surfaces (Class A fires), thus excluding oxygen from the fire.

Dry powder (Type D) extinguishers are similar to dry chemical extinguishers except that they extinguish the fire by separating the fuel from the oxygen element or by removing the heat element of the fire tetrahedron. They are for Class D fires only, and are ineffective on all other classes of fire.

Wheeled Fire Extinguishers

Dry chemical wheeled extinguishers are available in sizes ranging from 50 to 350 lb (22.5 to 159 kg).

They can be used on Class A, B, or C fires depending on the extinguishing agent.

Wheeled fire extinguishers offer a combination of mobility and ease of operation. They can be used in places where large fires may occur, and water is not readily available.

Extinguisher Ratings

Underwriters Laboratories of Canada devised a rating system to indicate the effectiveness of portable fire extinguishers, based on extinguishing pre-planned fires of determined sizes. The rating on the extinguisher's label indicates the extinguisher's fire-suppression ability.

For example, a 10 lb multi-purpose dry chemical extinguisher has a U.L.C. rating of 4A, 40B, C, based on use by a non-expert. The 4A refers to the equivalent firefighting capability of four Imp. gallons of water (4.8 U.S. gal, 18 litres). The 40B refers to a Class B fire 40 ft^2 (3.6 m^2) in area, and the C rating indicates it is also safe on a Class C fire.

Fire Attack with Extinguishers

The fire extinguisher's label also contains instructions on its use. General procedures when fighting small fires with a fire extinguisher are:

1. Check to ensure the extinguisher is the correct type for the fire class
2. Pull the pin that allows the extinguisher to be discharged (Note that on some fire extinguishers the release mechanism may not be a pin)
3. Test the extinguisher for charge and range a safe distance from the fire with a short burst
4. Approach the fire to within range of the fire extinguisher
5. Aim low at the base of the fire

6. Squeeze the lever below the handle to discharge the extinguishing agent
7. Sweep rapidly from side to side, moving toward the fire and aiming at the fire's base until the fire is extinguished or the extinguisher is depleted. Back away from the fire

The procedure is often simplified to the mnemonic "PASS":

- Pull the pin (release mechanism)
- Aim at the base of the fire
- Squeeze the lever
- Sweep from side to side

Move forward or around the fire area as the fire diminishes. Watch the area in case of re-ignition.

If possible, a second fire extinguisher operated by a second person should be available to support the initial attack. The second extinguisher should be used if the fire is not extinguished, and to allow the initial firefighter to safely back away.

Hose & Nozzle

A fire hose and nozzle are standard firefighting equipment to be taken to protect the team whenever smoke is reported, even if the assignment is not to fight a fire.

Hoses are available in a variety of sizes or diameters. A standard hose length is 15 m (50 ft), though shorter lengths are available. Nozzles are classified on flow capacity and are usually adjustable to allow for the creation of different water streams, ranging from solid to broken to fog.

In mine firefighting, the procedure for using a hose and nozzle is to:

- Ensure electrical power has been turned off
- Place the stretcher and other equipment so they will not get wet

- Flush the water header to ensure clean water and adequate pressure
- Attach the hose to the water header
- The captain will lead the team away from the fire, while a team member unrolls the hose. Once the hose is half unwound, the captain will turn the team and proceed back to the water header
- Connect the nozzle and charge the hose to check for leaks, water pressure
- When the fire is extinguished, leave the nozzle on wide pattern and directed at the fire's remnants to prevent reignition

Water Fog

Water fog is a firefighting technique for Class A and B fires. Water fog is composed of fine particles of water expelled from a water hose through a special high-pressure nozzle. As the very fine spray hits the fire, the water is turned to steam reducing the heat, cutting off the oxygen and extinguishing the fire.

Water fog is useful as a heat barrier for advancing toward the fire. It also causes much less water damage than straight stream nozzles.

Though hose and nozzle are generally associated with using water as the extinguishing agent, hose and nozzle are also used in several types of foam applications.

FOAM

Foaming agents are effective in controlling and extinguishing Class A and B fires.

The foaming agents, consisting of biodegradable fluorocarbon and hydrocarbon surfactants, are diluted with water, and discharged in a mass of bubbles containing air or a non-combustible gas. The water content cools the fire as the foam holds steam, smoke and oxygen-deficient atmosphere around the fire, sealing it and preventing fresh air from reaching it.

Foam is particularly effective on Class B fires because it can float on the surface of liquids. Specific foams have been designed for Class A and Class B fires, while specialized Class B foams can be used for different chemical fires, or for use on un-ignited spills of hazardous liquids.

Foam's effectiveness depends on the rate of application, the expansion ratio and the stability of the foam. Low- and medium-expansion foams are produced with the use of a foam generator system or a fire hose with a pickup eductor and foam concentrate. High-expansion foam is mechanically generated using a powered (engine or water) foam generator.

Aqueous Film-forming Foams (AFFF)

Low-expansion foam, or Aqueous Film-forming Foams, usually have an expansion of 10:1, and are recommended when there is close access to the fire without undue risk to team members. It is best used on two-dimension fires, such as fuel spills, and has limited effectiveness on three-dimensional Class A fires. It is effective on larger diesel vehicle fires, such as scooptrams and trucks.

AFFF can be used in both aspirating and non-aspirating mechanical foam hardware. Aspirating nozzles are specifically designed to entrain air in certain proportions into the diluted foam-water solution to produce a fully aspirated foam extinguishing agent. Non-aspirating type foam hardware is designed primarily for the application of water in the appropriate stream setting.

The eductor uses the venturi principle to introduce a proportional amount of liquid concentrate into a water stream. When water at high pressure exits the venturi (the constricted portion of the waterway near the eductor inlet), it creates negative pressure to siphon concentrate through a metering device, like a straw, and into the waterway.

The flow of concentrate through the metering device will remain constant. The flow of water, however, will vary with inlet pressure. The higher the inlet pressure the lower the solution of concentrate. The lower the inlet pressure, the higher the solution of concentrate.

Flush the system with clear water after use to ensure that dried concentrate does not clog the metering device and cause the ball check valve to stick closed. This valve is in the metering device immediately inside the nipple which connects the pick-up tube assembly to the metering valve.

By removing the clear plastic hose from the nipples, the ball can be visually inspected in the nipple opening. If it is stuck, it can be dislodged with a pencil or blunt tool.

As with any water-based firefighting, this nozzle must never be used in fighting electrical fires. It is important to open and close the valve slowly. Rapid opening will produce a sudden thrust. Rapid opening or closing can cause water hammer.

When using the nozzle do not use the shutoff valve to throttle back water pressure with an eductor in line as doing so can cause the eductor to shut down.

Procedure for AFFF

Low-expansion foam is recommended when there is close access to the fire area without undue risk to the team members. A team should have an adequate supply of concentrate, two pails, before beginning.

1. The team should perform a field test on all parts before proceeding underground (eductor, nozzle, foam tube, concentrate, and sufficient hose).
2. The electricity must be turned off.
3. The system must be assembled according to manufacturer's instructions.

4. The foam should be sprayed indirectly toward the fire to ensure a high-quality blanket of foam covers all the material that is burning.
5. Shut off the nozzle to allow foam to act as a blanket to exclude oxygen and cool the material.
6. The area must be checked for hot spots, and foam repeatedly reapplied if necessary.

Ensure that there are no kinks in the hose, which can reduce the quality of the foam.

Compressed Air Foam Systems

When the supply of water is limited or non-existent, or where the use of large quantities of water is not advisable, compressed air foam systems use compressed air or nitrogen to deploy a foam solution to extinguish the fire.

Compressed air foam systems consist of a water tank, a compressed air/gas cylinder, a foam reservoir, a water-powered proportioner, and a dispensing hose. The system may be operated on a vehicle, trailer, or skid.

When air/gas is released from the cylinder, the air/gas simultaneously enters the water tank and the foam solution. The pressurized water tank forces water through the water-powered proportioner, which pulls in foam concentrate from the reservoir and mixes it with water. The solution exits the proportioner and air/gas is injected to create foam.

To operate the system:

1. Release and remove the hose from the tray, pulling it clear of kinks, and hold the nozzle valve off
2. Open the cylinder safety cap
3. Open the cylinder valve to pressurize the water tank

4. Close the cylinder safety cap
5. Open the master valve to activate the system and charge the hose
6. Open the nozzle valve as fully as possible to project foam

Foam will be expelled immediately when the nozzle valve is opened.

When deploying foam, move quickly. To attack a fire, shoot foam at its base and work up. To fight a fire or protect a fuel spill from fire, broadcast foam indirectly to no more than two inches in depth. Be prepared to monitor the extinguished fire for foam touch up or re-application.

If the system is not to be used for three or more minutes, it should be shut off at the master valve to prevent pressure buildup. (There are pressure relief valves to prevent excessive pressure.)

PROpak

The PROpak is a complete foam storage, injection, and application system for use with an assortment of foam concentrate, including AFFF, for use on both Class A and Class B fires, as well as spill control on flammable liquids.

The PROpak consists of a 9.5 litre (2.5 U.S. gal.) foam reservoir with a built-in eductor, three types of quick connect nozzles for different expansion applications, a short hose, and a shoulder strap. Flow is controlled by a convenient and easy to use twist grip valve that can also function as a carrying handle, in lieu of the shoulder strap.

A fire hose supplies PROpak with water, but the device operates effectively at low pressure, allowing it to be used where compromised water pressure prevents or hinders the use of AFFF systems.

Its portability, ease of use, and quick deployment make the appliance useful when working in tight quarters, such as shrinkage stopes, where hose management can pose difficulties.

Fire Attack Using Low- & Medium-Expansion Foam

Roll-on Method – the foam stream is directed at the front edge of a burning liquid, and the foam then rolls across the surface of the liquid. The foam is applied until the entire surface is covered and the fire is extinguished. The stream may be directed to different positions along the edge of the liquid.

Bank-down Method – the foam stream is directed at an elevated object, such as a wall or tank, near or within the area of a Class B fire. The foam then runs down the surface of the object onto the surface of the liquid. The stream may be directed to different positions along the object or edge of the liquid, and is applied until the entire surface is covered and the fire is extinguished.

Rain-down Method – when the size of the fire or spill area is too large or there is no object from which to bank the foam, the stream can be directed into air over the fire or spill so that the foam falls gently onto the surface of the fuel. The stream should be swept from side to side over the surface until the surface is completely covered and the fire extinguished.

High-Expansion Foaming Agents

High-expansion foaming agents, with expansion ratios ranging from 100:1 to 1,000:1, are suited for flooding three-dimensional Class A and Class B fires, particularly where close access to the fire is not possible due to location and/or heat. High-expansion foam can also be useful for deep-seated fires that are difficult to extinguish. A mass of in-depth foam can provide an insulation barrier for exposed materials not on fire, preventing the spread of the fire.

The foam is a mass of bubbles generated mechanically by the passage of air or other gases through a net, screen, or other porous medium that is wetted by an aqueous solution of surface-active foaming agents.

High-expansion foam is a unique vehicle for transporting wet foam to inaccessible places, for total flooding of confined spaces, and for displacing vapour, heat and smoke.

Tests have shown that under certain circumstances high-expansion foam, when used in conjunction with water from automatic sprinklers, will provide more control and extinguishment than either extinguishing agent by itself.

High-expansion foam has several effects on fires:

1. When generated in sufficient volume, it can prevent air, necessary for continued combustion, from reaching the fire.
2. When forced into the heat of a fire, the water in the foam is converted to steam, reducing the oxygen concentration by diluting the air.
3. The conversion of the water to steam absorbs heat from the burning fuel. Any hot object exposed to the foam will continue the process of breaking down the foam, converting the water to steam and thus being cooled.
4. Because of its relatively low surface tension, the solution from the foam that is not converted to steam will tend to penetrate Class A materials. However, deep-seated fires may require further control.
5. When accumulated in depth, high-expansion foam can provide an insulating barrier for protecting exposed materials or structures not on fire, thereby preventing the spread of the fire.

A high-expansion foam generator consists of a fan, a one-cylinder diesel engine, a plenum chamber, a bank of spray nozzles, and a

knitted terylene net on which the foam is formed. Water is fed into the unit through a hose, and an 'in-line' proportioner, which draws foam concentrate into the water stream through a metering orifice.

A mixture of foam concentrate and water is sprayed through the nozzles onto the terylene net creating a constant spray pattern for equal wetting of the net. The foam, created by air passing through the netting, is delivered through tubing. A suitable barricade should be constructed at a safe distance between the fire and the generator to help contain the foam and safeguard the team.

When foam is generated from the gases of combustion it becomes toxic and no one should attempt to enter a space filled with foam without self-contained breathing apparatus. The foam mass also obscures vision and hides hazards. Link lines must be used if entering it. All team members must be accounted for.

Operation of Diesel-Powered Foam Generator

The water hose is connected to a hydrant or pipe valve. The water should be reasonably free of dirt or scale that might clog the inlet strainer.

The reading on the water pressure gauge should remain constant, even though the supply pressure varies. If the pressure reading falls below the mark on the gauge dial, the pressure is too low, or the inlet strainer is plugged with dirt.

The stainless steel pickup tube is fitted with a fine screen to keep foreign material out of the metering orifice.

The proportioner and pickup tube should be flushed with clear water after use. Check the screen on the pickup tube for cleanliness, run water through the nozzles to be sure they are not clogged, and check the screen at the hose inlet. Foam detergent will corrode metal.

It is important that members of mine rescue teams become proficient in the use of the high-expansion foam machine. A trained operator can vary the quality and quantity of foam being generated.

Procedures for Using the Foam Generator

The following procedures will assist the team when using the foam generator:

1. The foam generator must be field tested before taken underground.
2. A second foam generator should be made available as a backup.
3. The electrical power must be off where foam is applied as it largely consists of water.
4. A team should take extra fuel, oil, foam concentrate, and disposable tubing with the foam generator to ensure the assignment can be completed without interruption.

5. The opening in a barricade must be at least 36 in (90 cm) to accommodate the barrel of the generator.
6. The foam generator should be set on a platform to elevate the unit.
7. It is highly recommended to have ventilation to move the foam. A good supply of air will ensure that the foam machine will operate efficiently. An air hose may be used to direct air from the pipes to the air breather of the generator when the atmosphere is deficient in oxygen.
8. When investigating the status of a fire, a team must always have a charged water hose and nozzle. The team must 'knock' the foam down by using water spray. The area must always be checked for loose ground created by the fire.
9. The foam machine may be used as a fan when there are instances when the ventilation is not sufficient to clear the area of smoke.
10. The stretcher can be left at a strategic location to be picked up later, if the team is required to transport the foam generator.

Water-Powered Foam Generators

Most water-powered foam generators will produce low-, medium-, or high-expansion foam. The high-expansion foam agent, used with diesel-powered foam generators, is compatible with water-powered foam generators.

Water-powered units may be hand-held for advancing on a fire or set up to push foam beyond a barricade. The water-powered foam generators can be used where portability or a quick response is required.

JET-X-PFG-7 Portable High Expansion Foam Generator

Turbex High Expansion Foam generators are designed to produce large capacities of high expansion foam, up to 200 cubic metres

(7,000 cu.ft.) per minute for fast and effective flooding of large and inaccessible spaces with minimal water consumption.

The lightweight units are also capable of rapid smoke extraction, positive pressure ventilation and removal of foam once the fire is extinguished.

The generator is powered by an enclosed maintenance-free water turbine driving an aerofoil fan, so that only a pressurised water supply is required for operation and a low oxygen environment will not hamper its effectiveness.

Fire Attack with High-Expansion Foam

The tremendous volume of foam being discharged into an area seals it and prevents fresh air from reaching the base of the fire. Once the fire has been reached, the foam continues to exclude fresh air and holds the steam and oxygen-deficient atmosphere around the fire.

When the water film of the bubble wall approaches a fire, radiant heat vapourizes the water in the foam front. The one-part water in 1,000 parts air expands 1,700 times in forming steam.

The resulting mixture of steam and air has an oxygen content of around 7.5 per cent, well below the level required to support combustion.

Large volumes of steam formed in this way displace additional hot gases and tend to create inert areas above the fire and limit the fire's speed.

Bubbles cannot exist in contact with a dry surface. As a result, high-expansion foam wets everything it touches and limits the spread of the fire. The surface tension of the water in the foam is quite low and penetration is thus deeper than with the same amount of plain water.

Since a fire is cooled and extinguished best by a high steam atmosphere, the generator should be operated to produce foam at as high a rate as possible.

After the burning material has been covered, the foam covering should be maintained to cool the hot material.

TIRE FIRES & PYROLYSIS

Underground mobile equipment or vehicles can catch fire under a range of circumstances. In some cases, there is potential for tires to become heated or catch fire. Whenever excess heat is applied to a tire, it can initiate a process within the tire called pyrolysis. This can cause a buildup of flammable gases and pressure within the tire, which may rupture or explode.

Common sources of heat that can cause tire pyrolysis are:

- Tires run below the specific pressure or when flat

- Overload/over speed of the tire compared to tire design
- Mechanical damage to the tire
- Contact with high voltage power lines
- Overheated brakes
- Wheel motor fires
- Welding on rims while the tire is inflated
- Oxyacetylene heating of wheel nuts
- Major vehicle fires with tire involvement

Tire explosions, resulting from the ignition of the gaseous vapours created by pyrolysis within the tire, can unleash energy many orders of magnitude greater than that of a tire blowout, often leading to significant equipment damage, serious injuries or fatalities. They pose a significant hazard during a mine emergency.

Pyrolysis-related explosions are unpredictable and can occur immediately or up to 24 hours after initiation. A violent explosion can occur when no fire is visible, and the danger area can be as far as 300 metres (1,000 ft) or more from the tire. Pressures at the time of the explosion are in the order of 1,000 psi (69 bar) or more, with the production of shock waves.

The pyrolysis or chemical decomposition of the tire, usually the tire's inner liner, produces flammable gases, such as methane, styrene, butadiene, hydrogen and other hydrocarbons. Some canned materials used to seal punctures or leaks from the inside of the tire may also produce explosive vapours.

A tire explosion due to pyrolysis will occur if there is:

- An explosive concentration of flammable gases
- Sufficient oxygen, only 5.5 per cent, to support combustion
- A source of ignition

The rubber liner of some tires will begin to pyrolyze or decompose at about 185 C (365 F). Explosions have occurred when as little as 20 grams (0.7 oz) of rubber has been pyrolyzed.

Mines may inflate tires with nitrogen rather than air to reduce the risk of a tire explosion. The use of nitrogen, however, does not prevent pyrolysis and should adequate oxygen be available (possibly through an inadvertent top-up with compressed air or oxygen), an explosion can still occur when a critical concentration of flammable gases is reached. Consequently, all tires known to or suspected of having been subjected to a heat source should be treated as a potential explosion hazard.

No visible flame or spark is necessary to ignite the explosive gases created by pyrolysis. Heat or energy sources can prompt the gases to reach their auto-ignition temperature. Carbon dust, a product of pyrolysis, has an auto-ignition temperature of 200 C (392 F). During a mine emergency possible sources of heat/energy that will result in tire pyrolysis and may lead to auto-ignition include:

- Equipment contact with high voltage power lines
- Any fire, but particularly tire or equipment fires

During a mine fire involving heated tires, teams should approach the site with extra caution to assess the situation before commencing operations. In assessing a mobile equipment fire, mine rescuers should:

- Use a thermal imaging camera. If external tire temperatures are higher than 95 C evacuate the area and isolate the equipment
- Determine the location of the fire on the equipment and whether the tires are involved
- Evaluate the intensity of the fire
- Determine what the equipment/vehicle was transporting
- Determine other potential hazards, such as nearby electrical power, fuel, oil, grease or explosives
- Evaluate contamination levels, temperature and ventilation flows

To determine if a tire has exploded, as opposed to just having ruptured, mine rescuers should look for:

- A charred patch on the liner
- Soft tacky patches on the liner, or tacky fragments in the tire
- Rupture in the casing opposite the point of heating
- An identifiable heat source in most cases
- An eyewitness report of a fireball

Extinguishing Tire Fires

Rubber-burning fires are difficult to extinguish. Hand-held extinguishers are ineffective and expose personnel to extreme risk from the fire, potential explosion and smoke. Without breathing apparatus there is also the risk of harm from the respiration of toxic fumes given off by the burning tires.

The initial attack should be with foam for an extended period. Water should be used as a last resort as it poses the potential of spreading molten rubber.

If attempts are made to bury the tire while still mounted, it should be done using a haul truck to back up and tip a load. This still leaves the operator at risk of flying debris if a tire explodes. Care should be taken to use only fine particulate fill material to prevent large fill material from being projected if the tire explodes.

The vehicle should be isolated for 24 hours after removing of the source of heat from the tire.

BATTERY FIRES

Batteries have a long history of use in mines. They are stable, seldom burn and, when properly maintained, catch fire only with difficulty. However, when they do catch fire due to external damage, inadequate maintenance, improper charging, defects, external heating from fire or other heat sources, or malfunctioning charging systems, they are difficult to extinguish.

Where lead acid was once the primary electrolyte for batteries, a variety of flammable compounds – nickel-cadmium, nickel-metal hydride, lithium-ion, and others are now commonly used. The type of electrolyte, size and charge of the battery, number of batteries, type of battery construction, and source of heating are some of the variables that will affect a battery fire.

Incipient battery fires will not be easy to identify. Even during a fully developed battery fire, flames may not be visible, but smoke or steam coming off the battery, or popping sounds will indicate a thermal event. Some batteries, particularly lithium-ion, can experience thermal runaway. Thermal runaway occurs when a battery cell has reached the temperature at which the temperature will continue to increase on its own, becoming a self-sustaining reaction, further igniting additional cells.

Battery fires pose several hazards. Off-gassing toxic fumes, and toxic, corrosive combinations of water, electrolyte, and metal will increase in volume with the size and number of batteries and battery cells involved. These will be partly contained and concentrated in the confines of a drift.

Attempts to cool the fire with water can expose mine rescue teams to high voltage, while in some cases water or foam may increase the intensity of the fire with possible explosive hazards.

Vehicle and equipment batteries may also contain stored or stranded energy capable of energizing the body or frame of the equipment or vehicle, even after the fire appears extinguished.

Battery fires tend to burn extremely hot and may threaten to involve mine infrastructure or other combustible material. They may take a long time to extinguish, and when extinguished, there is significant risk of re-ignition.

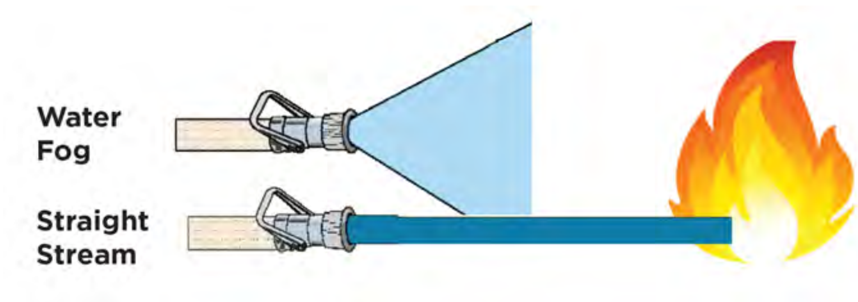
Firefighting Measures

Fires involving small, lower voltage battery-powered tools should be isolated, if possible, and sprayed with a continuous stream of water. They may be isolated in containers and submerged in water.

Whenever a battery-powered vehicle or equipment is involved in a fire, the manufacturer's safety data sheet (SDS) should be consulted as soon as possible. That information will help a team identify specific hazards and precautions, determine a plan of action, and choose the best firefighting tools for the actions to be taken.

Teams also should note the specific location of the battery modules on the vehicle, and information on how to disable power components, such as ignition and master power shutoffs, and the location of high voltage cables. Teams should always operate under the assumption the battery and associated components are energized and fully charged.

Holding a defensive position to prevent fire spread by cooling around the fire and allowing the battery to burn itself out is an effective means to handle most situations.



Suffocating extinguishing agents, such as foam and dry chemical, will extinguish a battery fire but are unlikely to adequately cool a battery to prevent re-ignition. Water is the best agent to cool a battery, but since the battery is sealed, the direct application of water may be almost impossible. In either event, a significant quantity of water will need to be applied for a lengthy duration, possibly hours, to ensure re-ignition does not occur. Poor water supply and/or low water pressure may make this last choice option impossible.

Should it be necessary to use this option, teams should use a two-hose firefighting technique, using the first hose to approach and fight the fire behind water fog for thermal and electrolyte protection. The second hose should be used to apply water in a long, low, continuous straight stream directed at the hottest spot of the fire, as determined by a thermal imaging camera. The stream should not be swept, but may alternate between hot spots.

When the fire is extinguished and a thermal imaging camera shows the battery has cooled, the area should be covered with a blanket of AFFF. The extinguished battery must be monitored and additional water directed at it as soon as it starts to re-heat.

NOTES:

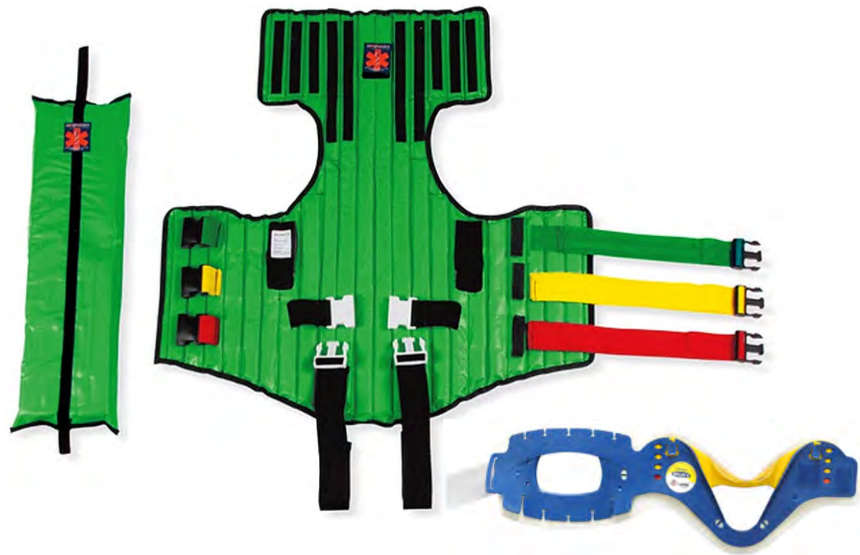
CHAPTER 13

FIRST AID

THE KED

(Kendrick Extrication Device)

References to the KED in Ontario Mine Rescue are limited to the original KED (created in 1978 by Richard Kendrick) and NOT to the use of the KED PRO. The KED used by OMR does not have high angle rescue properties or metal reinforced straps. The original version is green, and the KED PRO is orange.



The KED is a tool used in the immobilization of a casualty who has a possible head, neck, back, femoral, or pelvic girdle issue. The KED is meant to limit further injury to a casualty and will most likely be used with other pieces of first aid equipment such as the cervical collar, backboard, and basket.

Made of heavy duty vinyl-coated nylon, the flexible KED wraps and secures in many different ways to immobilize affected body parts in a semi-ridged embrace. Colour-coded, sewn-in securing straps and snap-lock buckles allow for quick, easy use on a casualty and help provide rigidity.

Adjustable, fold-back sides permit easy access to the casualty's chest, while built-in handles enable rescuers to get a firm grip on the casualty and the KED as one unit.

Field Test

Take the KED out of the bag, inspect its general condition, individually check each strap and buckle, as well as ensure a cervical collar is in the bag. Stand the KED straight up and gently apply pressure to the side. If the KED folds over, it is damaged and not emergency ready. Set it aside and field test another KED unit.

Operation

No one should use a KED without proper training and with at least one other trained mine rescue volunteer available to assist.

For Suspected Back/Neck Injury

1. Stabilize head
2. Apply cervical collar
3. Slide KED carefully behind casualty
4. Ensure the KED is aligned properly
5. Apply straps in the following order:
   Middle-**B**ottom-**L**egs-**H**ead-**T**op
6. Recheck and tighten straps
7. Loosen chest and leg straps once the extrication is complete and the casualty is placed horizontal

For Suspected Pelvic/Upper Femoral Fracture

The use of the KED for these types of injuries requires training and extended practice of the application process. It has been proven that most of these injuries benefit greatly from reduced immobilization and rigidity which the KED can provide in these situations.

1. Stabilize the affected area and ensure the casualty doesn’t move.
2. Place the KED beside the casualty so the head piece is at the bottom (inverted).
3. Depending on the type/location of the injury, the application of the KED will vary. It may be necessary to completely lift the casualty, or do a modified roll, or a combination of both.

4. In many situations, the casualty will be treated also for spinal injuries.
5. Verbal communication is key when performing these applications to reassure and keep the casualty calm.

STANDARD FIRST AID REQUIREMENTS (ONTARIO MINE RESCUE EQUIVALENT)

To improve provincewide standards in the Standard First Aid training given by various training providers to mine rescue volunteers, Ontario Mine Rescue is implementing minimum curriculum requirements.

First aid training providers will cover a set curriculum established by Ontario Mine Rescue – the Standard First Aid/Mine Rescue (SFA/MR) program. First aid training need not be limited to the designated components, but must cover all the components in a minimum two-day training session. The entire curriculum is available to any provider by request to the Chief Mine Rescue Officer.

Every training provider who signs off on SFA/MR must include the following components:

- Emergency scene management
- Detailed information in relation to contents of the OMR First Aid Kit
- Shock/unconsciousness/fainting
- Choking – adult
- Cardiovascular emergencies with one- and two-rescuer CPR
- Automated External Defibrillator (AED) and its use in the mining sector
- Severe bleeding and wound care
- Burns (use of Water-Jel)
- Medical conditions

<table>
<tr><td colspan="2">10 – Triangular bandages</td><td colspan="2">10 – Pairs medical gloves
5 – Casualty cards
5 – Glow sticks
Pulse oximeter</td></tr>
<tr><td colspan="4">XL 36” Sam Splint, 36” Sam splint
Asherman chest seal
4 – 4.5 x 15” Pressure dressings
8 x 18” Burn Dressing
2 x 6” Burn dressing</td></tr>
<tr><td>3 – 4 x 4”
Pressure dressings
10 – 4 x 3”
Non-sticks</td><td colspan="2">3 – 6” x 12’ Roll gauze
3 – 3” x 12’ Roll gauze</td><td>Scissors
Insta-Glucose
Athletic tape
Medical tape
12 – Band-Aids
2 – Quick Clots</td></tr>
</table>

Internal layout of opened Ontario Mine Rescue First Aid Kit

- Secondary survey
- Bone and joint injuries
- Head/spinal/pelvic injuries and the proper use of appropriate OMR equipment
- Open and closed chest injuries
- Triage (multiple injury management)
- Eye injuries
- Poisoning-cross contamination
- Heat and cold injuries in relation to mining

FIRST AID KIT

The Ontario Mine Rescue First Aid Kit, used for decades, has served its purpose well and continues to evolve with the development of new first aid materials. The existing soft exterior pack is versatile and well designed for mine rescue use.

The kit contains first aid supplies inline with procedures taught in the SFA/MR program. The contents list is subject to change with developments in medicine and first aid supplies, as well as changes to the role of the first responder.

Each time a kit is used, the contents must be checked and restocked. A tag indicating the date of restocking must be affixed to the kit, sealing it. A first aid kit field test consists of checking the date of resupply and that the seal is intact. If the seal has been broken, set the first aid kit aside, and field test another first aid kit. If the seal is intact, consider it field tested and emergency ready.

CASUALTY FIRST AID

To minimize the effects of gases or injuries on casualties:

1. In contaminated air it is not recommended that untrained personnel carry the stretcher. The team could use their link lines to link personnel to the stretcher so they do not wander away.
2. The team may remove their masks to reassure casualties being evacuated in fresh air.
3. Team members must rotate clockwise around the stretcher, two positions at a time.
4. When first sighting a casualty, evaluate the history of the incident, check the area for hazards, and remove the casualty from danger if it is present. Always ensure the safety of the team.
5. When dealing with conscious casualties, team members should consider the history of the casualty. Airway and breathing should be checked verbally, while circulation should be checked visually for gross bleeding, and the pulse with permission.

Responder bag

6. A CAREvent is to be used on an unconscious casualty or a conscious casualty in breathing distress, e.g., not breathing, heart attack, stroke.
7. Casualty cards must be completely filled out by team members when treating casualties and must be turned over to medical aid.
8. A stiff-neck cervical collar, head restraint and towel are provided in each responder bag to immobilize the casualty.
9. Be sure to cover over and under the casualty to prevent or minimize shock.
10. To avoid placing further stress on a casualty, DO NOT place equipment on a casualty while in the stretcher.
11. Avoid standing, walking, or passing equipment over a casualty.
12. Casualties who have been unconscious must continue to be carried after they become conscious.
13. While casualties are being protected, the air quality at the scene must be measured and the briefing officer informed of the level of exposure involved.

14. There may be times in which the team finds a casualty with a beard, or a burnt or bleeding face. If the casualty is conscious, you may use the mouthpiece, nose clip and goggles of the SSR 90 M rescue unit. With unconscious casualties, the team will have to seal the facemask of the CAREvent as best they can.
15. It may be necessary to leave a casualty while another is evacuated. If so, evacuate the casualty with the least protection or in the most serious condition.
16. The team may leave casualties in a refuge station if there is someone qualified available. Instructions should be given to monitor the casualty closely and remove the mask should complications occur. If not, the casualties must be evacuated to the shaft.
17. When an injured casualty wearing a SSR 90 M must be left alone, always place them in the recovery position.

18. Should there be several casualties and the team does not have sufficient equipment for protection, the casualties must be placed in the recovery position, treated for shock, and the area ventilated as soon as possible.
19. There may be occasions when a team has two unconscious casualties protected with O_2 breathing apparatus, and one must be left alone. The apparatus left with that person should be kept out of harm's way. It is vital that the team not leave the level and go to surface if a casualty is alone wearing an O_2 breathing apparatus as the team may be delayed in returning. In the case of a casualty being placed with qualified personnel in fresh air (e.g., refuge station, fresh air raise), then a team may leave the level to take another casualty to surface.
20. The captain must monitor the casualty while the team is at rest or during a team rotation.
21. Briefing officer must make sure medical assistance is available for casualties when the team gets to surface.

'Load and Go'

'Load and go' means dealing with any life-threatening injuries, then loading and transporting the casualty immediately without conducting a secondary survey other than a pulse and respiration count.

Though the decision to 'load and go' must be made early when a casualty is encountered, it does not mean 'do nothing, just go'. A prompt attempt must be made to treat or correct the life-threatening injury, and all actions, including the decision to 'load and go', must be documented on the casualty card.

Examples of 'load and go' situations include (this list is not all-inclusive):

- Any airway problem in which there is a risk of loss of the airway
- Cardiac/respiratory arrest or chest pain

- Any head injury no matter the level of consciousness
- Anaphylaxis
- Abdominal evisceration
- Major fractures, such as a fractured femur or pelvis
- Uncontrolled hemorrhage
- Partial or complete loss of a limb
- Critical burns
- Spinal injuries
- Multiple casualties
- Deteriorating vital signs

MINE RESCUE POLICY IN RELATION TO NON-VIABLE CASUALTIES

If a casualty is obviously dead, the casualty is non-viable and the body is to remain 'as is' until the coroner releases the person for recovery (See Ontario Mine Rescue Body Recovery Report).

"Obviously dead" means death has occurred if gross signs of death are obvious, including by reason of:

a) Decapitation, transection, visible decomposition, putrefaction; or

b) Absence of vital signs and:

  i) A grossly charred body

  ii) An open head or torso wound with gross outpouring of cranial and/or visceral contents

  iii) Gross rigor mortis (limbs)

  iv) Lividity (fixed, non-blanching purple or black discolouration of skin)

These criteria do not solely define non-viable casualties. Various factors such as transportation time, environmental conditions, possibly the event and patient health history, should also be taken into account.

If a mine rescue team is unsure whether a casualty fits any of the above criteria, they are to treat the casualty as viable until the next level of care takes responsibilty for the person.

HEAT STRESS

The nature of mine rescue work and the development of deeper, hotter mines place mine rescuers at a significant risk of heat stress.

Recognizing the factors that contribute to heat stress, understanding how the body responds to heat, knowing the dangers posed by heat stress, and taking preventive measures, should not only safeguard the individual, but also the team, and allow the best opportunity for a successful assignment.

Factors in Heat Stress

Heat stress is the heat burden on the body from the combination of environmental sources, the body's metabolism as determined by workload and clothing requirements, as well as exposure time.

Environmental Factors – Air temperature, relative humidity, air movement, and heat sources such as auto-compression and powered-equipment play a role in creating heat stress.

Mine Rescue Factors – During mine emergencies mine rescuers can face extreme heat loads not only due to environmental factors that will be less than ideal, but also to their work conditions and requirements.

In an emergency situation, existing engineering controls may have limited effectiveness or no longer work. Environmental factors may be subject to new influences, such as fire, that pose increased variables and dangers.

Mine rescuers may travel long distances on foot over uneven terrain at extreme depths, wearing a cumbersome breathing apparatus and other personal protective equipment. They usually carry heavy loads, and do physically and often psychologically demanding work.

Mine rescuers may already have put in partial or full work shift when called to action, contributing to fatigue and dehydration. During rescue operations, they have little ability to drink fluids to rehydrate their bodies, and rest conditions are often less than ideal.

Exposure Time – The longer a person is exposed to heat, the higher level of heat stress he or she will experience. Researchers have developed often complex formulas to measure heat stress and establish safe work level/time exposure guidelines.

The Ontario Mine Rescue Heat Exposure Standard was developed by the Institute of Occupational Medicine (IOM) for Mine Rescue Services Ltd. in the United Kingdom. IOM has determined the standard is suitable for mine rescuers using the Draeger BG4, the apparatus used by Ontario Mine Rescue.

Physiological Response to Heat

Normal core body temperature of 37 C (98.6 F) must remain relatively constant for the body to work well. Variations in this temperature indicate that the body is under stress. As body temperature rises, the body automatically takes a combination of steps to cool or lose heat to maintain a relatively constant temperature.

Vasodilation – The circulatory system – blood vessels, heart – acts as a human radiator. Blood vessels and capillaries near and in the skin increase in size and the heart beats faster to increase blood flow. This encourages heat dissipation and body cooling. As blood warmed by the metabolic rate nears the skin surface, it transfers heat to the skin. If the air is moving and skin exposed or lightly covered, body heat passes more easily to the environment than if the air is still and skin more fully covered. When air temperature exceeds body temperature, vasodilation ceases to cool the body.

Sweat – As blood circulation to the skin fails to adequately cool the body, the body produces sweat for evaporative cooling, the body's most effective cooling mechanism. The rate of cooling depends on the rate of evaporation based on temperature, humidity, and skin exposure. When relative humidity exceeds 70 per cent, the air has a limited ability to absorb moisture and cooling is minimal. The body, however, will continue to sweat until it is dehydrated. Dehydration reduces the blood volume in the body, resulting in lower blood pressure and increased strain on the heart.

Decreased heat production – Meanwhile inside the body, the increased blood flow to the skin, as much as 25 per cent of the cardiac output, and a rising body temperature causes blood flow to internal organs to decrease to produce less heat. The diminished blood flow, however, places the internal organs and the brain at risk.

Heat Stress Disorders

When the heat burden overcomes a body's ability to cool itself, heat stress disorders result. These disorders can be considered a progressive spectrum of health issues from mild to severe, with potentially fatal results as the body attempts to control a rising core temperature.

Heat Rash – Red, bumpy rash with severe itching. Though uncomfortable, heat rash does not pose a danger to life and health.

Heat Cramps – Painful cramps in arms, legs, or stomach that occur suddenly. Though painful, heat cramps do not pose a danger to life and health.

Heat Syncope (fainting) – Suddenly passing out while doing or after doing physical work in a heated environment. Cool, moist skin; weak pulse.

Heat Exhaustion – Heavy sweating; cool moist skin, body temperature over 38 C (100 F) weak pulse; normal or low blood pressure; fatigue; person is weak, clumsy, upset or confused; is very thirsty; panting or breathing rapidly; vision may be blurred.

Heat Stroke – High body temperature over 41 C (106 F) and any of the following: the person is weak, or acting strangely; has hot, dry, red skin; a fast pulse; headache or dizziness. In late stages, a person may pass out, have convulsions and die.

Standard treatment for heat disorders includes moving the patient to a cooler environment, cooling the body, drinking water, and in severe cases, seeking medical aid and monitoring vital signs.

Prevention

Early prevention of heat stress incidents begins well before any exposure to the hazards and focuses on the individual preparation for working in hot, humid environments.

Nutrition – A regular, balanced diet can help prevent the depletion of salts that could lead to early heat stress. If the majority of meals are dry or dehydrated, the risk of dehydration is greater. A diet of junk food, high fat and caloric foods can also increase the risk of dehydration.

Fitness – Fitter individuals tolerate work and heat better. Their bodies have higher water content, use energy more efficiently, and are better able to stay hydrated. Heavier, less fit individuals reach their maximum level of activity more quickly than their lighter, fitter counterparts, and experience an increased susceptibility to heat stress disorders.

Health – Health problems, large and small, can compromise the body's ability to cool itself. Even temporary acute problems – mild

fever, runny nose, hangover, constipation – can compound and be compounded by heat stress. Healthy individuals tolerate work and heat better.

Rest – Adequate rest prior to heat exposure, during exposure, and between work periods allows the body to cool and recover.

Acclimatization – The more an individual works in the heat, the better his or her body becomes at keeping cool. A body requires one to two weeks of acclimatization to adjust to work in a hot environment.

Precautions – Precautions are measures that should be taken by teams and personnel prior to, during, and after a mine rescue emergency.

Before exposure:

- Be rested
- Be properly hydrated
- Avoid drinking coffee

- Not have consumed a significant quantity of alcohol in the past 24 hours
- Be in good health (i.e., not have a cough, cold, or any other infection or sign of infection)
- Be reminded of the signs and symptoms of heat stress

During the assignment:

- Work at a slow, even pace with a minimum of movement
- Take frequent rests, long enough for cooling to occur
- Watch each other for signs of heat stress
- Immediately notify the captain at the first sign of heat stress, in one's self or someone else

After exposure:

- Cool down slowly by resting
- Wait to shower until sweating ceases
- Drink fluids, water is best
- Rest, avoid heavy work or driving long distances
- Not be called back to duty for 24 hours

CRITICAL INCIDENT STRESS

Critical incidents, such as those that require a mine rescue response, can cause strong emotional reactions that overwhelm an individual's ability to function in a normal manner at work, at home, or in any other aspect of their life. This strong emotional reaction is referred to as critical incident stress.

Factors Contributing to Stress

Anyone exposed to the incident, directly or indirectly – mine rescue team or control group member – can experience critical incident stress, though it can be more pronounced in those directly involved, particularly if the incident involved severe injury or death. Other factors that influence a person's emotional reaction include:

- Magnitude of the incident
- Duration of exposure
- Degree of personal danger
- Individual personality and emotional stability
- Past experience
- Recent and/or current stress
- Personal acquaintance with the victim(s)
- Support of family, friends, co-workers, and employer
- Training/knowledge of critical incident stress

During the incident, personnel suppress their emotions to concentrate on getting the job done. When the incident ends, and a more normal routine resumes, these repressed feelings begin to surface. Stress-related anxiety is normal, but if the emotions are not dealt with in a healthy, effective fashion, they can result in emotional turmoil and even harmful behaviour.

Ontario Mine Rescue considers it imperative that all mine rescue team members be debriefed prior to leaving a mine site post-incident.

Critical Stress Symptoms

Symptoms may appear immediately after the incident, several days after the incident, several weeks or months, or in some instances even years.

Symptoms can be far ranging and may include:

- Physical – fatigue, headaches, weakness, dizziness, muscle tremours
- Cognitive – confusion, nightmares, poor attention, memory problems

- Emotional – anxiety, guilt, anger, grief, irritability, feeling overwhelmed
- Behavioural – withdrawn, emotional outbursts, antisocial, change in appetite

Managing Stress

Most professional emergency response services now have critical incident stress management teams to help first responders deal with stress. To support mine rescue volunteers, Mine Rescue Officers are trained in Critical Incident Stress Management, and have access to specialists should the need arise for greater expertise.

OMR, however, should be considered as a resource and the primary responsibility for providing critical incident stress management and support to their mine rescue team volunteers and control group personnel belongs to each individual mining company.

Mine operators may have access to this type of assistance through employee assistance plans or can provide service through other private programs. Mine management can help individuals effectively manage critical incident stress with policies and procedures that centre on a humane, sensitive response. Management could consider designating a critical incident stress management co-ordinator to take proactive and reactive measures to help personnel deal with stress.

Proactive measures focus on education, including:

- Making personnel aware of the hazard of critical incident stress
- Making personnel aware of the symptoms of critical incident stress
- Making personnel aware of steps they can take to cope with critical incident stress
- Making personnel aware of support services available
- Making support services available

Post-incident measures that help mine rescuers deal with stress include:

- A full regular debriefing
- An optional defusing briefing led by a professional or trained peer
- Optional one-on-one sessions with a professional or trained peer
- Providing time to heal

Considerations for after a critical incident:

- Expect an emotional reaction
- Accept that a reaction is natural
- Maintain a good diet and exercise
- Take time for leisure activities
- Spend time with family, friends, and co-workers
- Avoid excessive use of alcohol
- Avoid legal or illegal substances to numb emotional response
- Acknowledge that getting help is not a weakness
- Accept help if it is offered or recommended

NOTES:

APPENDIX A

HISTORY

Hollinger Gold Mines in 1913.

Mining and quarrying have been part of the history and economic development of Ontario for more than 200 years. Clay, slate, limestone, sandstone, granite, gypsum, salt, were extracted as European settlement expanded. With the discovery of major mineral deposits, silver, gold and nickel in the late 19th century and early 20th century, and the expansion of railways, mining became a major industry in the province. From the late 1880s to 1920, Sudbury, Cobalt, Timmins, and Kirkland Lake became established mining centres.

Mining incidents claiming lives and injuries due to fire were unknown, or at least unreported. It was commonly held the risk of fire was minor, if at all possible, in a hard rock mine. A fire that claimed the lives of 39 miners in Timmins in early 1928 changed that, and led to the establishment of Ontario Mine Rescue.

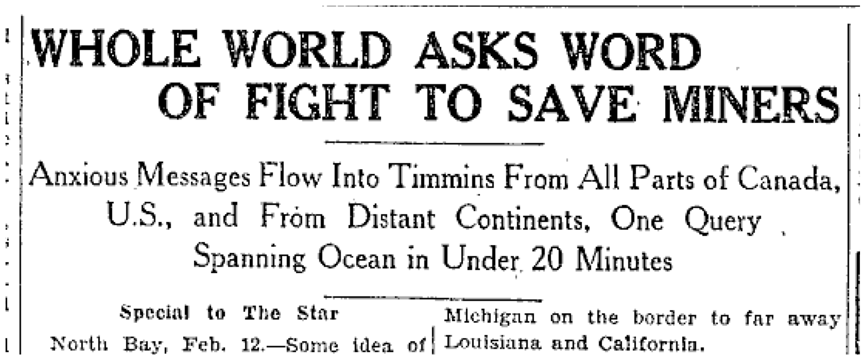
Hollinger Mine Fire, Feb. 10, 1928

An estimated 900 carloads of flammable waste – paraffin wrapping paper, carbide, powder boxes, sawdust, fuse ends, and some detonators – was stuffed in Stope 55A, east of crosscut 12 on the 550 level. The area, 12 by 100 ft, was filled with refuse to a depth of approximately 45 ft.

Known to many, the waste was seemingly of concern to no one. No one seemed to think a damp, hard rock mine could experience a fire, so no precautions were taken – the waste remained underground, no alarm system, no fire doors, no evacuation plan, no emergency plan, nothing.

When fire did break out at approximately a quarter after nine the morning of Friday, Feb. 10, 1928, dense smoke and deadly carbon monoxide quickly moved through North America's largest gold mine, endangering the lives of hundreds of miners and killing 39, making headlines around the world.

Neither the mine, nor the town, or even the province, had the expertise or the resources to respond to save miners' lives or adequately fight the fire. The United States Bureau of Mines was called. Mine rescue teams left Pittsburgh about 9 a.m. Saturday and travelled for almost 22 hours, some 1,600 kilometres. They arrived about 6:20 a.m. Sunday, by railway car equipped with special equipment and breathing apparatus to extinguish the fire.



WHOLE WORLD ASKS WORD OF FIGHT TO SAVE MINERS

Anxious Messages Flow Into Timmins From All Parts of Canada, U.S., and From Distant Continents, One Query Spanning Ocean in Under 20 Minutes

Special to The Star

North Bay, Feb. 12.—Some idea of Michigan on the border to far away Louisiana and California.

These special rescue personnel and their equipment subdued the fire, restoring normal air currents, while local mine management directed recovery operations. At the same time, on Feb. 13, Justice T.E. Godson was appointed to lead an inquiry into the tragedy.

Eight months later, Godson made 15 recommendations including: equipping mines with a stench gas system to alert miners of emergencies, removing all flammable waste to the surface, limiting the amount of oil and grease kept underground, placing fire doors at each station, the installation of fire protection measures, and posting emergency exit signs.

The most significant recommendation, however, was the creation of a provincial mine rescue service.

"I recommend that rescue stations be located at a place selected by the Chief Inspector of Mines in the Timmins, Kirkland Lake and Sudbury mining areas, and be in charge of one man, to be appointed by and under the control and direction of the Department of Mines. It should be the duty of such employee to take care of the apparatus, train men in the mines in his area in rescue work and inspect and report upon the apparatus, if any, maintained at any such mine."

Regulation 98 by the (then) Workman's Compensation Board was approved and ordered by the Ontario government on June 20, 1929.

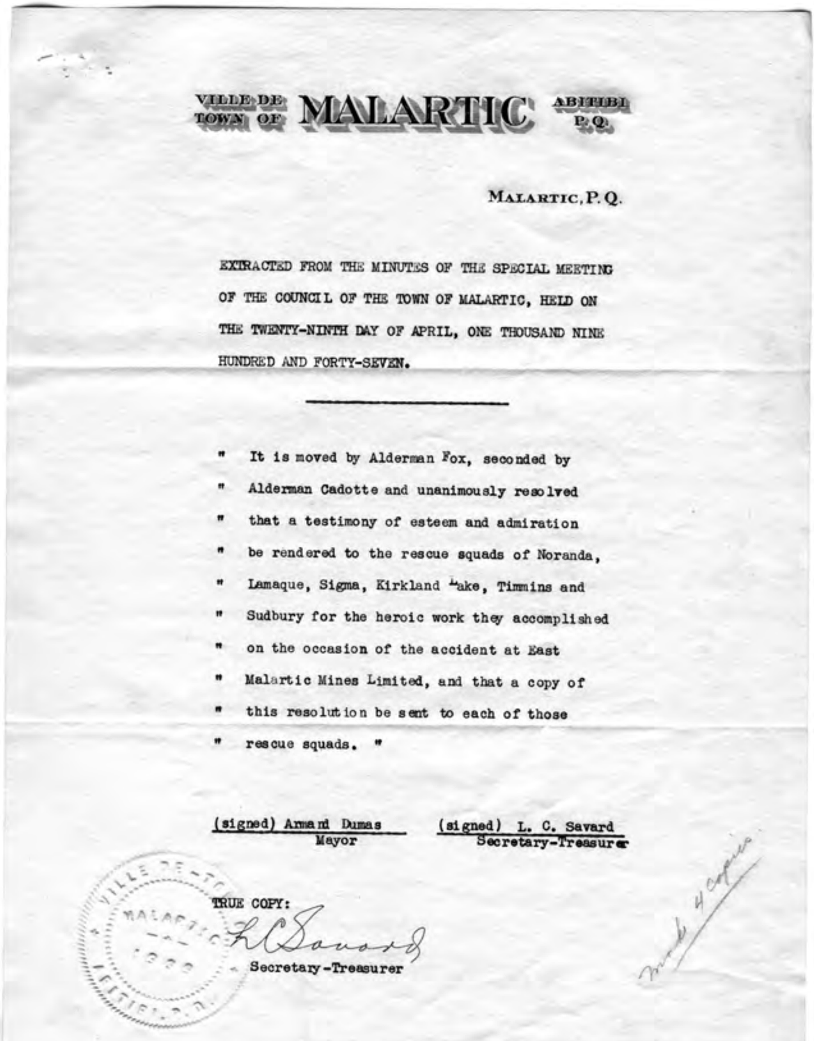
A Timmins mine rescue team stands prepared in 1929.

The United States Bureau of Mines continued to play a significant role in the early development of Ontario Mine Rescue. Its first mine rescuers were trained in Pittsburgh in January 1929, before establishing the first Ontario Mine Rescue station, equipped based on Bureau of Mine Standards, in Timmins that same year. The first Ontario Mine Rescue Handbook, published in 1930, gratefully acknowledged the Bureau for its assistance.

East Malartic Gold Mine Fire, April 24, 1947

The first time teams from different districts worked together during a rescue operation was also the first and only time Ontario mine rescuers responded to an emergency outside of the province. The emergency resulted in Ontario setting provincewide mine rescue standards and provided Quebec with the impetus to establish its own mine rescue system.

Teams from Kirkland Lake, Timmins and Sudbury districts rushed to the East Malartic Gold Mine, about 70 kilometres east of Rouyn-



VILLE DE TOWN OF **MALARTIC** ABITIBI P.Q.

MALARTIC, P.Q.

EXTRACTED FROM THE MINUTES OF THE SPECIAL MEETING OF THE COUNCIL OF THE TOWN OF MALARTIC, HELD ON THE TWENTY-NINTH DAY OF APRIL, ONE THOUSAND NINE HUNDRED AND FORTY-SEVEN.

" It is moved by Alderman Fox, seconded by
" Alderman Cadotte and unanimously resolved
" that a testimony of esteem and admiration
" be rendered to the rescue squads of Noranda,
" Lamaque, Sigma, Kirkland Lake, Timmins and
" Sudbury for the heroic work they accomplished
" on the occasion of the accident at East
" Malartic Mines Limited, and that a copy of
" this resolution be sent to each of those
" rescue squads. "

(signed) Armand Dumas
Mayor

(signed) L. C. Savard
Secretary-Treasurer

TRUE COPY:
L C Savard
Secretary-Treasurer

A sincere thank you to the mine rescue volunteers attending the Malartic Gold Mine Fire.

Noranda April 24, 1947, to help Quebec mine rescue teams battle a fire that claimed the lives of 12 miners.

At about 1:30 a.m., a crew of 16 men was mucking out a round at the bottom of No. 4 Shaft, when the shift leader noticed smoke coming down the shaft. He promptly went to 10 Level in a skip to investigate, leaving the crew working at the bottom of the shaft.

Seeing the shaft and the level were full of smoke, he notified the hoistman at the hoist above 10 Level, the only other person underground, to warn the crew at the bottom of the shaft by bumping the skips up and down several times, while he hurried to No. 3 Shaft and surface to spread the alarm.

When the shift leader reached surface, he rang the nine-bell alarm signal and went to get assistance. Several attempts were made to rescue the missing miners and fight the fire, but it wasn't until 7 a.m. that mine rescue teams from Noranda and Val d'Or arrived.

Realizing the need for more trained personnel and equipment, officials called on Ontario Mine Rescue for help. The first Ontario rescuers, 22 men, left Kirkland Lake at 3 p.m., arriving at the mine to begin rescue operations at 7 p.m. A contingent of 11 mine rescuers from Timmins arrived later that night, and another 27 from Sudbury the next evening.

Despite the valiant efforts of the teams, numerous blasts from exploding carbon monoxide and a continuous increase in carbon monoxide concentrations forced rescuers to abandon efforts to control the fire from underground. It was decided to seal all surface openings and smother the fire.

Only the hoistman and two crew members survived. Officially, the fire was started by a discarded cigarette in the 10 Level lunchroom.

The Kirkland Lake teams, the first to arrive, were after four days of hard work the last Ontario contingent to leave, while the Noranda teams remained for recovery work when the mine was opened.

Working together, it became evident each Ontario district had different training and equipment standards. As a result, Ontario

A mine rescue team is briefed prior to going underground to fight the McIntyre Mine Fire.

District Inspector of Mines L.K. Walcom reviewed the incident, and recommended the position of Inspector of Mine Rescue be created to ensure provincewide standards in mine rescue training and equipment maintenance.

McIntyre Gold Mine Fire, Feb. 8, 1965

The McIntyre Mine Fire, which involved 140 mine rescuers from Timmins, Kirkland Lake and Sudbury in a week of intensive firefighting, confirmed the wisdom of setting provincewide standards. It also underlined the need to replace the McCaa, the primary breathing apparatus of Ontario Mine Rescue for more than 30 years.

At 1:56 a.m. on Feb. 8, 1965, a warning light indicated that an underground pump had failed to start and that somewhere in the mine water would soon be overflowing a sump. Upon investigation, smoke was found at the 4900 Level.

The Mine Fire Procedure was put into operation and the search for the fire began at 7:30 a.m. by crews wearing the two-hour McCaa breathing apparatus.

Investigation found that the fire, started by a collapsed timber ignited by a damaged electrical cable, was in almost the worst place possible, 6,500 ft below surface and 5,200 ft from the main shaft, more than three-and-a-half kilometres from fresh air.

So intense was the fire that carbon monoxide was present in the shaft house, requiring the seven-kilometre round trip to be made under oxygen in McCaa apparatus. In fact, a skiptender, working more than two kilometres from the fire, was overcome by carbon monoxide and died.

Mine rescuers discovered that by the time they had arrived at the scene to fight the fire, they had little time to apply any effective control measures before the reduction in their oxygen supply forced them to return to the surface. Some teams did not even reach the fire.

Following extensive efforts, including the redirection of ventilation and the use of high-expansion foam generators, the fire was extinguished after a week of hard work. Recovery operations took several more weeks.

As a result of the fire, the Ontario Mining Association asked the Ontario Department of Mines to investigate newer, longer-duration breathing apparatus since some mines had grown too large for apparatus of only two-hour duration. The short limitation not only restricted firefighting activity, but prolonged the emergency and increased the number of hazardous trips by mine rescuers.

To provide a comfortable margin for travelling and still allow sufficient time to produce effective results, several four-hour apparatuses were studied. The deciding factor was the weight difference. The Draeger BG174, approximately nine pounds lighter than the other models studied, was chosen.

Falconbridge Mine Rockburst, June 20, 1984

A series of tremours that shook the Falconbridge Mine, near Sudbury, in June 1984, did more than collapse backfill, killing four miners. It played a significant role in reshaping and expanding the role of Ontario Mine Rescue from fighting fires to full mine emergency services.

The first tremour at 10:12 a.m., June 20, measuring 3.4 in Richter magnitude triggered the collapse of backfill in an undercut-and-fill stope about 4,200 ft underground, trapping four miners in the fill.

Several times mine rescue teams went underground to try to locate and make contact with the missing men, but had to retreat without success as the ground continued to move, causing rockbursts as high as 3.5 in magnitude.

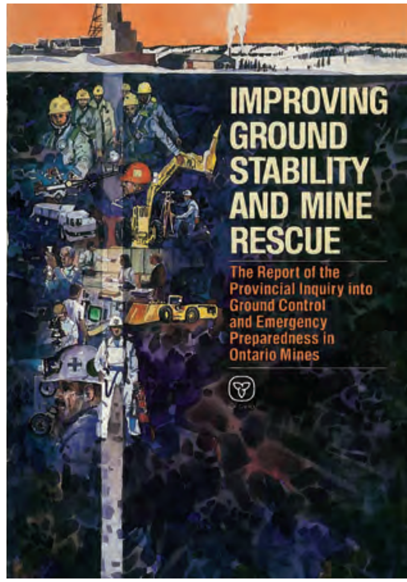
By 4 p.m. seismic activity had subsided, contact had been made with a lone survivor, and six rescue teams, with emphasis on members with square set timber experience, had been selected for rotation under the extremely confining, and extremely hazardous conditions.

Almost 24 hours later, mine rescuers succeeded in extricating the miner, who despite high hopes he would survive the ordeal, died just after being rescued.

Almost two years later, an inquiry led by Trevor Stevenson into ground control and emergency preparedness at Ontario mines acknowledged and commended the skill and bravery of the rescue workers. The inquiry concluded that there was a need for more diversified training and equipment to reduce the length of time rescue workers are imperiled and to improve the chances of saving trapped workers.

The commission believed that Ontario Mine Rescue was capable of dealing with non-fire emergencies and to achieve this, mine rescue should be expanded and improved.

The Stevenson Commission recommended that:



- The current mine rescue organization be expanded to handle all underground emergencies
- The necessary additional training in non-fire emergencies be developed by a tripartite committee of representatives of mine management, unions, and government
- A tripartite committee also be established to advise on all aspects of mine rescue equipment and emergency warning systems
- Mine rescue personnel suffer no loss of income as a result of injuries arising from mine rescue activities
- The Ministry of Labour mine rescue organization be responsible for identifying and introducing specialized equipment needed for use in non-fire emergencies, and for developing or finding sources for such equipment

As a result, better training in rescue and recovery operations related to non-fire emergencies was instituted, and specialized lightweight, portable equipment for reaching and extricating workers was made available. In addition, improved first aid equipment and training was also implemented for mine rescue and underground workers.

Recent Decades

Ontario's mine safety record has improved dramatically during the last 50 years with fewer incidents, fewer fatalities and fewer critical injuries. In 1980, Ontario Mine Rescue volunteers were called out to 100 mine rescue operations. By 1989, that number was down to 40, and by 1999, 23 operations occurred. OMR continues to respond to between 15 and 25 fire and non-fire emergency operations annually.

Responsibility for Ontario Mine Rescue was transferred from the Ministry of Labour to the Mines and Aggregates Safety and Health Association (MASHA) in January 2001. Nine years later, MASHA and Ontario Mine Rescue became a part of Workplace Safety North (WSN).

With the transfer to MASHA, the mine rescue program was modernized with state-of-the-art equipment including the Draeger BG4 self-contained breathing apparatus, the iTX Multi-gas Monitor, and the CAREvent DRA Automatic Rescue Ventilator. Standardized competency-based training programs were developed to ensure consistent delivery of information to mine rescue teams across the province.

As mine rescue progressed in Ontario, similar progress occurred internationally. Mine rescue organizations from various nations sought to expand their expertise in emergency preparedness and response capability by sharing their knowledge and experience. A half-dozen nations began to formalize a relationship with the first International Mines Rescue Competition (IMRC) in 1999 hosted by the United States. The founding conference of the International Mines Rescue Body (IMRB) was held in 2001 in Bytom, Poland.

Ontario Mine Rescue, whose general manager Alex Gryska served as the first secretary treasurer of the IMRB, played a leadership role both in Canada and internationally, a role the organization continues to undertake. OMR hosted more than 200 delegates from 20 nations at the sixth IMRB conference in Niagara Falls and Sudbury in 2013. Three years later, OMR hosted 20 international teams from 11 nations and seven Canadian teams from four provinces at the IMRC in Sudbury in 2016.

APPENDIX B

MINE RESCUE SUBSTATION MONTHLY CHECKLIST

Mine Rescue
Substation Monthly Checklist

DATE:		INSPECTION COMPLETED BY:		
Substation:			**Yes**	**No**
1	Outside entrance	Lockable?		
2	Under counter storage **for 11 - BG4s**			
3	Cupboard Storage for equipment			
4	Stainless Steel or Polypropylene sinks	Is it clean?		
5	Proper disinfecting facilities	**"To be used to clean Apparatus ONLY"** *signage above sink*		
6	Dryer	Is it clean?		
		Does the heater work?		
7	Tables	Large enough for a six-man team		
		Are they clean?		
8	Stacking chairs	Put away properly?		
9	White board	Is it clean?		
		Are there dry erase pens?		
10	Cork Board or Bulletin Board	Checked/Updated information?		
11	Telephone	Is contact numbers posted and up to date?		
12	Room Lighting	Is it all working?		
13	110 Volt electrical outlet	Mounted on or near tables for function testing BG4s, in good working order.		
14	Proper Storage to secure large oxygen cylinders (oxygen cascade system)	If applicable		
15	Signs identifying:	• "Oxygen, no smoking or open flame" • "Mine Rescue Substation" • "Authorized personnel only"		
16	Tool Box & hand tools-for working on BG4s.	Neat and organized?		
17	*Spare BG4 cylinders (6) in wood Box	Are the cylinders full?		
18	*Soda Lime	*10-12 pails or jugs		
19	*Filters & seals	Are there enough?		
20	*SSR 90s (4)	In Date?		
21	*Vittal Germicide (1)			
22	AFFF Foam , Hi EX Foam	Quantities AFFF____ HI EX Foam ____		
23	Cap lamps c/w radios (6-10)	Charging, tracked & all in working order?		
24	*Anti-fog (3-klar-pilot) & wipes	Is there enough?		
25	*Standard Equipment Check	1. *Captains clipboard (all paperwork)		
		2. *Whistles		
		3. *probe stick		
		4. *chalk		

Workplace Safety North
Revised April 2016

ONTARIO MINE RESCUE
PREPARED SINCE 1929
Page 1 of 7

Mine Rescue
Substation Monthly Checklist

DATE:		**INSPECTION COMPLETED BY:**		
Substation:			**Yes**	**No**
		5. *First Aid Kit ▪ check Pulse Oximeter-batteries ▪ sealed emergency ready		
		6. *Kestrel		
		7. KED (packed with collar)		
26	*CAREvent	Emergency ready?		
27	*IBRID MX6	Calibrate and put back on charge		
28	*Freezer & * ice molds (ice blocks for BG4s)	Is there enough made? How many moulds?		
29	Barricade Materials	1. caristrap		
		2. cable tie		
		3. plastic		
		4. snow fence		
		5. aluminum poles		
		6. black tape		
		7. knife		
		8. pliers		
		9. battery drill		
		10. anchors		
		11. hacksaw		
		12. bolt cutters		
30	BO Sheets	1. Captains sheets		
		2. pens/pencils/highlighter		
		3. *casualty cards		
31	Hoses	1. 1 ½"Fire Hoses (4-6) 2. 1 ½" Brass Nozzles (2-4)		
32	CAF Units – Serviced and ready to go!	If applicable		
33	Stretchers	1. How many? ___________		
		2. Are they emergency ready?		
		3. Splints (2-small multi-purpose, 1-femoral)		
		4. Blankets (3)		
		5. Black bag (Ferno head restraint, collar, towel or roll, probe stick, femoral padding & foot strap, backboard bar)		
		6. Stretcher bridge (CAREvent)		
34	Stretcher Buggy	If applicable		

Workplace Safety North
Revised: April 2016

ONTARIO MINE RESCUE
PREPARED SINCE 1929
Page 1 2 of 7

Mine Rescue
Substation Monthly Checklist

DATE:		INSPECTION COMPLETED BY:		
Substation:			**Yes**	**No**
35	Company Owned Auxiliary equipment (Examples: reciprocating saw, battery powered hammer drill, bolt cutters, lifting bags, etc.)	Is it all in working order? List Equipment Here:		
		1.		
		2.		
		3.		
		4.		
		5.		
		6.		
		7.		
		8.		
		9.		
		10.		
36	Housekeeping	Is all equipment stored appropriately		
	COMMENTS/DEFICIENCIES:			
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

Items Identified with an Asterisk (*) are supplied by Ontario Mine Rescue.

Mine Rescue
Substation Monthly Checklist

Draeger BG4

Apparatus #	Reducer Serial #	Date:	Sentinel Serial Number	Sealed?

Mine Rescue
Substation Monthly Checklist

Industrial Scientific MX6

Serial #	Calibration (pass/fail)

SSR 90M

Serial #	Expiry Date	Sealed?

CareVent

Resuscitator Serial #	Expiry Date	Bottle #1 Expiry Date	Bottle #2 Expiry Date

Mine Rescue
Substation Monthly Checklist

Test it 6100 / RZ7000

Type	Serial #	Calibration Date:

Thermal Imaging Camera

Model	Serial Number	Condition

Spare Cylinders

Expiry Date	Expiry Date

Mine Rescue
Substation Monthly Checklist

eDraulics

Model #	Serial #	Condition	Battery

MEASUREMENTS

The measurements in this handbook are copied from documentation provided by equipment manufacturers. Where manufacturers have provided measurements in only one unit of measurement (e.g., metric or imperial), Ontario Mine Rescue has converted to the other unit (e.g., metric or imperial). Some rounding may have occurred.

Table of Equivalent Measures		
Measure	**British Imperial**	**S.I.**
Weight	1 lb	0.453 kg
Linear	1 ft	0.3048 m
Liquid	1 gal	3.7853 L
Volume	1 cf	0.0283 m^3
Force	1 lb-force	4.448 Newtons
Pressure	1 lb-force/sq. inch	6.895x103 pascals

Examples

- Experiments have shown that a person in a confined space requires approximately one cubic yard of air (0.76 m^3) per hour.
- A BG4 oxygen bottle is charged to 200 bar = 2,900 psi = 20,000 kilopascals. The capacity of the bottle at this pressure is 400 litres.

Metric Conversion			
Measure	**To convert**	**To**	**Multiple by**
Pressure	atmosphere	bars	1.01325
Pressure	atmosphere	lb/sq in	14.70
Pressure	atmosphere	kilopascals (kPs)	101.325
Temperature	Celsius	Fahrenheit	9/5C + 32
Temperature	Fahrenheit	Celsius	5/9 x (F-32)
Length	centimetre	inch	0.3937
Length	feet	centimetre	30.48
Length	feet	metre	0.3048
Length	metre	feet	3.281
Length	yard	metre	0.9244
Volume (solid)	cubic foot	litres	28.3
Volume (solid)	cubic centimetre	cubic inch	0.06102
Volume (solid)	cubic metre	cubic yard	1.308
Volume (solid)	cubic yard	litre	764.6
Volume (solid)	litre	cubic inch	61.02
Volume (liquid)	gallon (Imp.)	litres	4.5459
Volume (liquid)	gallon (Imp.)	gallon (U.S.)	1.201
Volume (liquid)	gallon (U.S.)	gallon (Imp.)	0.8327
Volume (liquid)	gallon (U.S.)	litres	3.785

- A person at rest uses approximately 0.26 litres, 260 cubic centimetres or 16 cubic inches of O_2 a minute.
- The BG4 is lightweight (15 kg/33 lb when fully charged).
- Cylinders capable of being charged to 2,000 psi (135 bar) are tested to 3,400 psi (235 bar). Cylinders charged to 3,000 psi (205 bar) are tested at 5,000 psi (345 bar).

- Compressed air foam systems consist of a water tank (up to 100 Imp. gal., 120 U.S. gal. or 455 litre capacity), a compressed air/gas cylinder, a foam reservoir (up to four Imp. gal, 4.8 U.S. gal., or 18 litre capacity), a water-powered proportioner, and a dispensing hose.
- Ontario Mine Rescue has water-powered units available that range in size from 21 to 565 m^3/minute (750 to 20,000 cu. ft/min).

Contact Us

Sudbury Office/Mine Rescue Station
235 Cedar St.
Sudbury, ON P3B 1M8

T: 705. 671. 6360

Vice President
Ted Hanley **M**: 705. 690. 0928
tedhanley@workplacesafetynorth.ca

Chief Mine Rescue Officer
Shawn Rideout **M**: 705. 665. 6933
shawnrideout@workplacesafetynorth.ca

Chief Emergency Services Officer
Tim Ebbinghaus **M**: 705. 923. 8263
timebbinghaus@workplacesafetynorth.ca

Executive Assistant
Penny Pagan **M**: 705. 665. 1380
pennypagan@workplacesafetynorth.ca

Mine Rescue Assistant
Becky Barrett 705. 671. 6360 x 325
beckybarrett@workplacesafetynorth.ca

Emergency Services Specialist
Matt VandenHeuvel **M**: 519. 441. 1057
mattvandenheuvel@workplacesafetynorth.ca

Sudbury & Onaping Stations

235 Cedar St.
Sudbury, ON P3B 1M8
T: 705. 671. 6360

Levack Highway
Levack, ON P0M 2R0

Mine Rescue Officers

Dan Davidson — **M**: 705. 698. 3496
dandavidson@workplacesafetynorth.ca

Jeff Farquharson — **M**: 705. 929. 7244
jefffarquharson@workplacesafetynorth.ca

Scott Gillett — **M**: 705. 665. 1073
scottgillett@workplacesafetynorth.ca

Algoma Station
2 Broadway Avenue
Wawa, ON P0S 1K0

Mine Rescue Officers

Mike Krell	**M**: 807. 228. 1178 michaelkrell@workplacesafetynorth.ca
Ted Greenwood	**M**: 807. 629. 8263 tedgreenwood@workplacesafetynorth.ca

Delaware Station
1172 Longwoods Road
Delaware, ON N0L 1E0

Mine Rescue Officer

Dan Rulli	**M**: 519. 281. 2336 danrulli@workplacesafetynorth.ca

Kirkland Lake Station
140 Government Road East
Kirkland Lake, ON P2N 3L8

Mine Rescue Officers

Wayne Baker	**M**: 705. 568. 7708 waynebaker@workplacesafetynorth.ca
Shawn Shail	**M**: 705. 568. 7470 shawnshail@workplacesafetynorth.ca

Red Lake Station
20 Dickenson Road
Balmertown, ON P0V 1C0

Mine Rescue Officer

Grant Saunders	**M**: 807. 727. 0275 grantsaunders@workplacesafetynorth.ca

Thunder Bay Station
615 Squier Street
Thunder Bay, ON P7B 4A7

Mine Rescue Officer

Duane Croswell	**M**: 807. 621. 0325 duanecroswell@workplacesafetynorth.ca

Timmins Station
48 Shamrock Avenue
South Porcupine, ON P0N 1H0

Mine Rescue Officers

Jason Leger	**M**: 705. 698. 6279 jasonleger@workplacesafetynorth.ca
Danny Taillefer	**M**: 705. 288. 7137 dannytaillefer@workplacesafetynorth.ca


2
Dräger
PSS BG4 plus

235 Cedar Street
Sudbury, Ontario P3B 1M8

T: (705) 671 6360
workplacesafetynorth.ca/minerescue