Safe Operation of Remote Controlled Equipment

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A Health & Safety Ontario Partner

WSN recognizes that individual companies must develop health and safety policies and programs which apply to their workplaces and comply with appropriate legislation. The information contained in this reference material is distributed as a guide only to assist in developing those policies and programs.

While WSN cannot guarantee the absolute accuracy or sufficiency of this information, we will be pleased to respond to individual inquiries about this information at any time.

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Introduction

With the assistance of the Mining Equipment Technical Advisory Committee, MASHA has prepared this updated guideline to help Ontario mines eliminate the incidents occurring with the use of remote controlled vehicles and equipment. This document supersedes a previous version issued by Ontario Natural Resources Safety Association in the 1990s. MASHA would like to thank the Mining Equipment Technical Advisory Committee for their assistance with the publication of this document.

The mining industry has learned that when remote controlled equipment was introduced to enhance mining methods there was a lack of understanding of the potential hazards. Then as radio component reliability and operating practices improved throughout the 1980s, there was a consistent reduction in the relative number of incidents. Unfortunately safety improvements have leveled off and serious injuries continue to happen. Research has told us that the majority of the fatal incidents occurred because the operator or fellow workers were in a poor position relative to the machine or device. In almost every case if the employers and workers were using a “safe location” philosophy, serious incidents could have been avoided. It’s ironic that remote control technology, which was introduced to mining to separate man from machine and make the work safer, actually resulted in incidents and even fatal injuries to operators and others working around them.

Armed with statistics and training materials, mining firms introduced procedures and safe working zones in order to protect the operators. However studies have shown that injuries involving remote control equipment continue to happen for several reasons:

- The design and layout of safety bays or safe locations sometimes does not provide sufficient line-of-sight for the operator who feels he must leave the safe location to see what the machine is doing.
- Operators don’t perceive themselves as being in danger when operating on remote. The concept that the machine could operate erratically at any time is not fully appreciated.
- Poor practices exist because of an inadequate program, inadequate program standard or inadequate compliance to program standards.
- The common denominator found in most incident investigations involving remote control equipment is that the operator or other worker was not in a safe location while the machine was running.

This guideline has been prepared as a guide to help companies develop their own safety-oriented programs including equipment purchasing, training, workplace design, policies and procedures. It can be applied to equipment that can be started or moved by remote control using a system, device or controller that produces radio waves, radiates electromagnetic energy or is

attached with electrical wires, hydraulic hoses or air lines. The safe operating parameters described are for machines that at some point during their operation do not have an operator on board. The equipment referred to could be electric, pneumatic or diesel driven and include:

a) load-haul-dump vehicles (LHD)
b) drills
c) cranes
d) railed locomotives
e) rock breakers
f) aerial platforms, booms or lifting devices

Mine management must develop a procedure or protocol which clearly defines when remote controlled equipment will be used and, just as important, when it won't. Because people, work techniques and equipment change constantly, procedures and work practices must be critically reviewed and revised on a continuous basis.

A Brief History of Remote Control

Remote controls are thought to have made their first appearances in Ontario mines in the 1970s to operate diesel-powered load-haul-dump (LHD) vehicles. The reasons for using the new technology were to increase operator safety and improve production efficiency.

Early units used radio controllers transmitting coded messages on a carrier frequency. The radio frequencies of the sending and receiving units had to match. The receivers connected with a machine's electric, hydraulic and pneumatic systems to control functions such as steering, braking and load handling.

Today, most systems still rely on radio to carry digital control information although some applications such as drills, cranes and rock-breakers may use remote controllers linked electrically, pneumatically or hydraulically.

In some remote applications beyond the range of line-of-sight, video cameras may be required for the operator to see what the machine is doing and how it is responding to his control inputs.

Current research includes the use of sensors and cameras mounted on a piece of equipment which would record and transfer information to a remote workstation in another area. The operator would be provided with the equipment's systems information (speed, temperature, etc.) in addition to the equipment's position and orientation (direction, tilting, inclines and declines, etc.). This new style of workstation complete with control software will support 3D cameras, in addition to pitch, yaw and roll sensors, as well as actuators for the entire machine. Built-in mechanisms for force feedback on acceleration, braking and the bucket operation will enhance the ability of an operator to work at a distance.

Part I: A Remote Control Program

"An analysis should be performed on every task and procedure at a mine to define the hazards and quantify the risks involved in the way these tasks are performed, so that control measures can be identified and implemented."

Recommendation from Rock Lamirande inquest, Oct. 2004

The following sections contain considerations for companies developing a program for remote controlled equipment. With the aid of operators and the Joint health and safety committee, a company should prepare an inventory of critical tasks associated with each type of remote control application.

Some procedures and practices may be required by law. A list of legislated requirements pertaining to remote control at mining plants can be found in the appendices.

1.0 Procurement

1.1 Design Considerations

When purchasing remote control equipment, the process should include the following considerations:

- Ergonomic acceptability: Ensure remote control equipment does not place any undue strain on operators because of poorly designed components (joysticks, placement of controls, weight of a transmitter etc.)
- Compatibility with already-owned technology including orientation of controls, operating characteristics, compatible parts and maintenance procedures
- Availability and usability of operating and maintenance manuals
- Availability of manufacturer training for operators and maintenance personnel if required
- Supplier support
    a) to provide assistance to assemble the equipment
    b) to demonstrate operation (including pre-op checks)
    c) to define maintenance requirements and techniques
    d) to maintain a critical parts inventory
- Remote control selectable only from the machine – not the transmitter
- A visual indicator (usually a flashing light) on the machine to indicate it is being operated in the remote control mode
- Fail-safe design: meaning the failure of any component does not result in a hazardous machine reaction, the inability to shut the machine down or the inability to lower loads

or platforms
- Loss of control signal shuts down the machine in a safe manner
- Transmitter controls that include fire suppression activation (often a two step and therefore deliberate action by the operator), and emergency stop activation
- Avoidance of systems that have delays in reaction times, such as fire suppression, brakes or emergency stop
- A transmitter that is programmed to operate only one, specific receiver
- A transmitter unit that includes a “man down ” tether and tilt switch to instantly shut down the machine should the operator try to leave the transmitter or if the transmitter upsets while the machine is running
- Guards that surround rotating or moving devices must be installed and interlocked with an automatic shutdown
- Detection and automatic shut-down if anyone enters an established danger zone
- Recovery options if equipment becomes disabled

Mines should use teams of knowledgeable employees including operators, supervisors, engineers, mechanics and electricians as well as joint health and safety committee members to examine first the design and then the new, rebuilt or overhauled remote control machines. The team should conduct a risk assessment and ensure there are no unprotected hazards being introduced to the workplace.

1.2 Remote Control Console or Transmitters; and Receivers

It cannot be over emphasized that standardization of the control orientation is critical. A mix of transmitters at a given site, with different controls for forward, reverse, left and right, is an invitation for error. When upgrading remote controls, some mines will replace all their remote controls to ensure the emergency stop, fire suppression, other buttons and stick controls are the same configuration throughout the site.

When the joysticks of a remote console are released (i.e. no forward or reverse signal applied) the machine should come to an immediate stop and not be allowed to roll on. Exceptions to this could be a crane that is carrying a suspended load. For all failure or emergency signals the reaction time should be immediate. The application of a brake, fire suppression and emergency stop device should also result in immediate stoppage of the machine. For diesel engines and loader type machines, an engine shutdown delay may be practical to allow time for the operator to leave his safe location, access the machine and not have to restart the engine. In any event there should be an indication to the operator that the machine is not in gear and brakes are applied.

For equipment that is not mobile, portable transmitters may be used and should be attached to the operator in a fashion that ensures the transmitter and extended controls follow sound ergonomic principles that include alignment to the person so that if the operator were to fall, a built in tilt switch will activate. Tilt switches should be built into the transmitter and when activated the switch should immediately cause the machine to brake and shut down. A tilt switch that will operate reliably at 30 degrees or less from level appears to be the industry standard. Controls such as the fire suppression system should require a deliberate action on the part of the operator as opposed to an accidental action. This safeguard often requires the use of two hands to initiate the suppression system from the remote console or transmitter. Relays on board the machines should be of a shock-resistant type to prevent unplanned engagement of any safety feature. Engine starting interlocks should not allow a machine to be started unless the drive is out of gear. Ideally a warning sound should be initiated before the machine starts.

Most older radio-linked control systems still in operation today use a fixed radio frequency. Though more powerful and able to operate over a greater distance, these systems have several drawbacks. They are subject to radio interference, have a limited choice of available frequencies and frequency matching between transmitters and receivers becomes a critical safety element. Newer systems offer very secure transmitter/receiver communication, and can tolerate high levels of interference. They also permit two-way communication so the transmitter can check and verify data transfer and machine operating information.

Mines should ensure that no two remote control units – transmitter and receiver – operate on the same carrier frequency. The best means of doing this is to keep transmitters and receivers together in matched sets. This does not preclude holding spare transmitters for the purpose of operating on successive shifts or as backups. But, where spare transmitters are kept, procedures must be in effect to prevent more than one transmitter with the same frequency from being used at the same time as the original unit. A procedure must also be in place for charging and maintaining the batteries for the transmitters to avoid mid-shift battery failure.

2.0 Commissioning

Commissioning tests of new remote controls installed on a machine should be carried out in a secure area with attendance strictly limited to necessary personnel. Where the machine is mobile, such as an LHD machine, testing of the remote controls should be conducted from the driver’s seat so that the operator has quick access to alternative emergency shutoff controls. The same testing procedure should be performed every time the control unit or the machine is serviced.

3.0 Operations

3.1 Safe Work Locations (Guarding the Danger Zones)

Safe work locations must be designed, provided and understood by operators of remote controlled machines whether it be LHDs, drills, cranes, locomotives, rock breakers, lifts or mining machines. An operator who has the ability to move about in order to drive the machine may be exposed to danger zones or hazards including entering the path of a moving machine or tripping while focused on the machine control. If it's necessary that the operator move about, a risk assessment should be conducted to ensure all hazards are engineered out or procedures adopted to protect the workers. Electronic barriers between the operator and the machine or between the operator/machine and other workers may be considered. Proximity detectors and light curtains have been used to warn operators and workers who were about to enter a restricted area or getting too close to an active machine. Fences and signs may also be used as warnings. A system and procedure should be in place for warning a remote operator that pedestrians are about to enter the workplace.

3.2 Pre-shift Information

Operators need to know how a machine was running on the previous shift. Control malfunctions should be reported and require the unit to be taken out of service immediately. This information or any other unusual event should also be recorded and passed on to the next shift and to the maintenance department. Operators should be trained to understand when a machine is mechanically unsafe to use. Any changes in the condition of a draw point, drill station or other working location should be noted in the shift log and communicated to the oncoming shift.

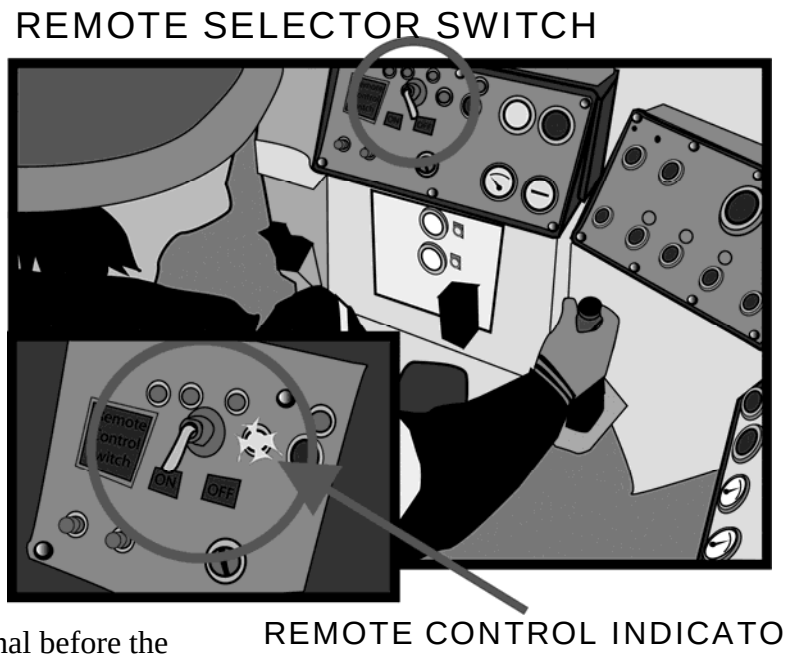
3.3 Pre-operation Checks

Every remote control machine or device should be inspected and function tested by a competent person to ensure it is in a safe operating condition before being put to work. Remote controlled vehicles are required to be operationally checked at least once in each shift of use as per Section 105(7) of Mining Regulation 854. Mines should adopt a process requiring the operator to complete a safety checklist at the beginning of the shift and before using the equipment. The report, noting any operational issues, is then handed to a supervisor at the end of the shift. Inspection reports of this type should be kept on file for a minimum of six months.

3.4 Battery Charging

Between shifts, operators should store transmitters in a designated dry and heated location. In addition a remote control receiver should be removed from equipment when it is not likely to be

used for a period of time, and properly stored. Batteries used to power transmitters which can include a modified cap lamp or another rechargeable type, should be put on charge at the end of a shift.



3.5 Switching Between Manual and Remote Operation

For machines that can be operated both manually and remotely, a hazard assessment should be performed and procedures developed to clearly define the conditions when machinery is to be operated manually or in remote control. The procedure should ensure the transmitter is non-functional before the operator approaches the equipment and takes over manual control. The manufacturer's recommendations for switching must be followed.

Special consideration must be given to those machines which have both on-board and remote controls installed, especially those with remote consoles (drills) which allow an operator to be in close proximity to the moving parts.

1. The control systems only allow for the operation of the manual controls **or** remote controls but not both at once, or

2. Both controls are live at the same time but provision is made for closing and locking out either the remote or manual control and procedures are developed for the lockout program, **and**

3. The moving parts of the machine are securely guarded and equipped with a fail-safe mechanism which stops all machine motion if a guard is opened for any reason.

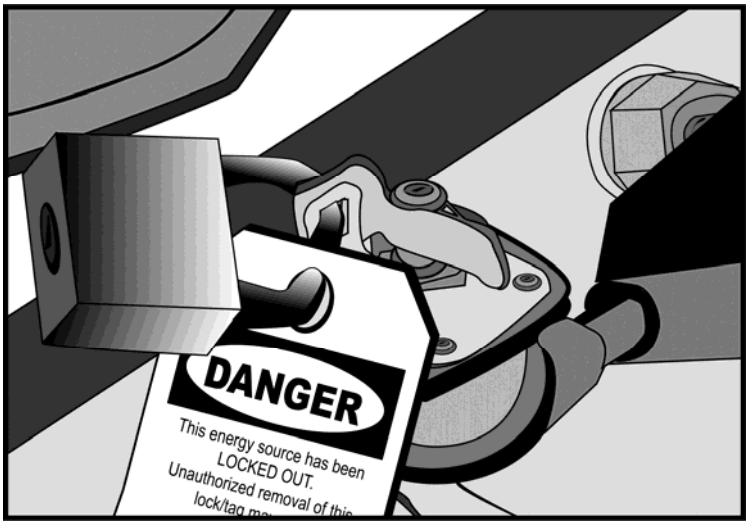
3.6 Shut Down and Lock Out

Safety procedures for all remote control equipment should include:

- Conditions requiring lock and tag procedures

- Identification of all energy sources
- Specific instructions for shutting off all energy sources
- Specific procedures for dissipating all stored energy
- Detailed steps for locking and tagging
- Directions for making lockout log book entries
- Procedures for transferring a lockout situation from one shift to the next
- Procedures for removing locks and tags and restarting equipment

LOCK AND TAG



4.0 Maintenance

A competent person must examine remote control system components at regular intervals. These inspections should follow the manufacturer's recommendations and should include:

- Pre-operational checks
- Preventive maintenance

"Breakdown" maintenance which is applied only when the equipment no longer functions is not acceptable for remote controlled machines and their controls. The need for scheduled service and replacement of deteriorating components in order to avoid system failure is significant considering the cost of down time, the threat of a machine operating out of control or the failure of a machine while suspending a load or deep in a stope under unsupported ground.

4.1 Transmitter/Receiver

The transmitter and receivers are often sent out for service to the manufacturer or supplier because of the specialized knowledge and diagnostic equipment required. However, mine staff may carry out inspections, replace damaged control devices and often troubleshoot solid state components, if suitably trained.

The remote control transmitter and its related receiver should be opened up periodically (some maintainers have suggested three month intervals or 500 hours of service) for servicing and in particular to check for a build-up of moisture. Condensation inside a transmitter box has caused erroneous signals to be transmitted in the past and this threat can often be reduced by proper storage of the transmitter. Like all repairs, this inspection should be documented.

The orientation of the emergency and directional controls on a transmitter should be standardized throughout a mine site. If one assembly is different from another or if wiring changes result in misleading labels, one can imagine the confusion and hazard that may be created. Transmitter/receiver sets should be tested on the machine in a secure area after any maintenance work and before being returned to regular service to ensure the equipment has been assembled properly and is working as expected.

Where radio-based remote controls are used in adjoining mines, agreements and procedures must be in place for managing frequencies and identity codes. It should be noted that on surface where a testing or training area may be set up, radio signals may travel for a few kilometers.

Accurate and up-to-date records should be kept for transmitter/receiver equipment to include at least the following information:

- Make
- Serial no
- I.D. code
- Date entered service
- Model
- Frequency
- Intended use, location or machine
- Maintenance records

4.2 Machine Components

The components which are installed on the machine (hydraulic components, wiring, actuators) are usually serviced by company maintenance personnel using manufacturers' manuals, system diagrams or other materials for guidance. In some cases, suppliers may provide specialized training for maintenance personnel. Prints and schematics should be maintained and updated as improvements are made.

As well as standard vehicle maintenance, such as the monthly fire suppression service, machines equipped with remote control will require additional attention. To prevent excessive heating in electrical circuits, electrical connections to the many solenoids and switches in the machines should be opened, cleaned and retightened. Wire insulation, clamps and raceways should be examined, cleaned and secured. Some mines recommend this electrical service be performed every three months. Brake release mechanisms and boom or load lowering systems that may have to be activated if the machine stops and cannot be driven, should be tested regularly and as recommended by the manufacturer. Any pre-start warning device and control interlocks should be checked and serviced on a regular basis.

A pre-operational checklist should be performed by the operator to ensure the machine is safe to operate. There should be a reporting mechanism in which deficiencies and concerns are recorded and passed on to the maintenance department. Accurate records should be kept of maintenance work which should include when and what work was done and who conducted the work, and for all tests, for the life of the machine.

4.3 Welding

Welding on a machine may induce current flow which can seriously damage on-board computers, radio systems and controllers. The remote control manufacturer's recommendations should be followed in these circumstances. Disconnecting batteries and detaching ground leads may be recommended but might require resetting computers and other devices upon completion of the work.

5.0 Training

5.1 Supervisors

Supervisors should receive training on every type of remote control equipment being used in their area so that they become familiar with the safe use of the equipment and are able to respond appropriately in an emergency. They should be aware that, because of the serious hazards involved, operators of remote controlled equipment should receive more attention during a shift. Scheduled refresher training on equipment under their care is a 'best practice' in the industry. Supervisory Common Core training is required by law for all supervisors.

5.2 Operators

Mine workers in Ontario must complete training in an appropriate common core mining program followed by training in applicable specialty modules that are administered by the Ministry of Training, Colleges and Universities (MTCU) and approved by the Mining Tripartite

Committee. New and experienced mine workers must demonstrate competency for the skills specified in each module before becoming accredited. Competency is defined by the MTCU as the ability of an individual to perform a skill repeatedly and without assistance in the workplace to the standard set out in the training standard. These demonstrations must be administered in an operating mine by a qualified trainer and registered with the MTCU by the company signing authority.

There are two specialty modules currently in place for remote controlled equipment. A worker should be trained according to his or her job tasks. Refer to the appendices for a description of the following modules:

Module U0019; Operate Underground Haulage Train – Remote Control
Module U0020; Operate Scoop Tram – Remote Control

Each company is legally responsible, under the Occupational Health and Safety Act, for providing adequate and effective training for all employees. Company training for remote controlled equipment should follow a sequence where operators demonstrate competency in a manual mode before moving on to training in remote control.

Company policy should define who should receive refresher training and when it should be provided. This timeline should be adjusted based on related incidents or the results of job observations. Training on remote controlled equipment should always take place in a secured area and operating manuals should continue to be accessible for these workers. Training records should be available to supervisors who are expected to verify that their workers are adequately trained for the work they are assigned.

5.3 Maintenance Personnel

Training is required for maintenance workers when new equipment, new control devices or new diagnostic tools are introduced to a mine. Equipment maintainers should also receive training

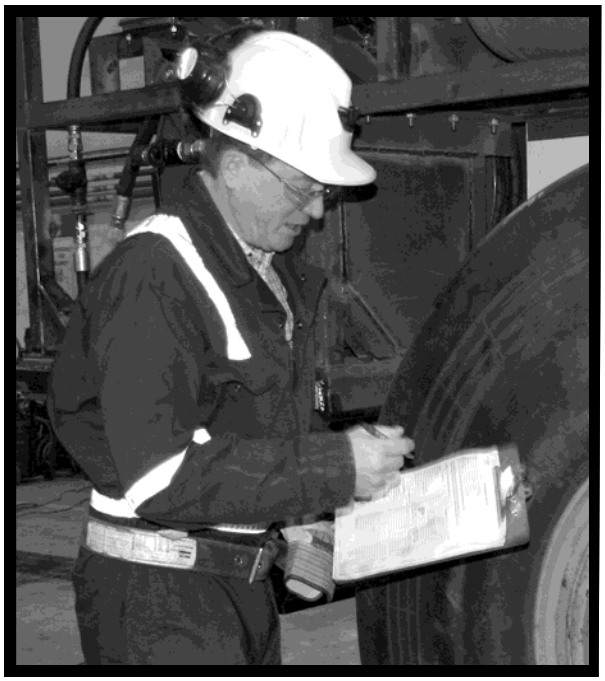
in the applicable specialty modules if they are expected to operate remote equipment for testing and system verification purposes.

6.0 Auditing

Following the development, introduction and implementation of all the necessary systems and procedures associated with the safe operation of remote control equipment, the management of a mine should ensure that there is an ongoing commitment by all personnel to maintain and improve the established systems and procedures.

Each mine should develop a review or auditing program whereby all aspects of the use of remote control equipment are continually monitored to ensure the safety of all personnel in the workplace where the equipment is being used. The procedure should specify, as a minimum, annual audits, the personnel responsible for conducting the audits and the reasons or goal for conducting the audit. A checklist inspection coupled with worker interviews will often be enough to expose operational details which require attention. Examples of questions to ask are:

- Are identified equipment deficiencies reported and acted upon efficiently?
- Is contracted equipment examined and meeting company policy?
- Is there a system in place to ensure manufacturers' alerts, bulletins and recalls are routed and communicated to the correct workers?
- Does the operator have a good line of sight from the safe work location so there is no temptation to leave the location and enter restricted areas?
- Are there records of remote control:
  - Equipment selection and purchasing details
  - Workplace inspections
  - Testing and maintenance
  - Training and competency assessment
  - Hazard reporting and follow-up
- Are records properly completed and stored?



Development and application of operational reviews should involve:

- Managers
- Supervisors
- Equipment operators

- Maintenance personnel
- Equipment suppliers
- Purchasing agents
- Joint health and safety committees or health & safety representatives

7.0 Evaluation

A mining operation should annually evaluate the effectiveness of its entire remote control program. Based on the audit findings, job observations, site inspections, incident reports and stranded equipment retrieval reports, management and the Joint health and safety committee must determine if changes or improvements are necessary. Use of outside resources and comparison to other successful programs can often help to reveal areas that need attention.

Part II: Applications at Ontario Mines

Remote controls have been adapted to operate machinery of all types at Ontario mining plants. Although these devices were originally intended to separate man from potentially hazardous conditions, John Waudby, the author of a technical paper from Western Australia wrote in 1998, "…any claim that remote controls are used to improve operator safety is unfounded. Removal of the driver from the conventional driving seat has introduced significant new hazards for both driver and others and accidents have occurred."

Given our recognition of this significant risk, following are considerations for specific types of equipment.

1.0 Load-Haul-Dump Vehicles (LHD)

An LHD is a low-profile front-end loader used underground to load muck in its scoop, haul it to a truck, ore pass or other location, and dump it. LHD operations have adopted remote controls in order to allow operators to work the machines in stopes under unsupported ground where workers are forbidden entry for obvious safety reasons. Adapting an LHD to operate on remote requires the installation of electrically driven hydraulic valves on the machine to replace manual controls handled by the operator. As well as these hydraulic and electrical changes, manual operating controls such as the gear shift levers and throttle controls should be protected from falling rocks in order to reduce the chance of having a machine quit in an inaccessible area. Making the transition from remote to manual operation can be safer if the orientation of controls in the cab and on the transmitter are the same. Care should be taken with the mounting of a receiver on the equipment so as not to impair any operator line of sight.

1.1 Incidents

- While operating on remote, in reverse, an LHD operator was pinned against a wall.
- While mucking on remote a run of muck came down and pushed the LHD back from the brow against the operator.
- While mucking on remote a rock shot out from under a tire, and hit and injured the operator.
- A worker was walking away from a scooptram after starting the machine when his clothing caught on some screen. As he was falling forward he activated the scooptram by remote causing the bucket to pin him to the wall.
- The LHD hit the portable remote control the operator was wearing, knocking him against the wall.
- While backing up, the LHD mounted the safety bay pad and injured the operator's foot.

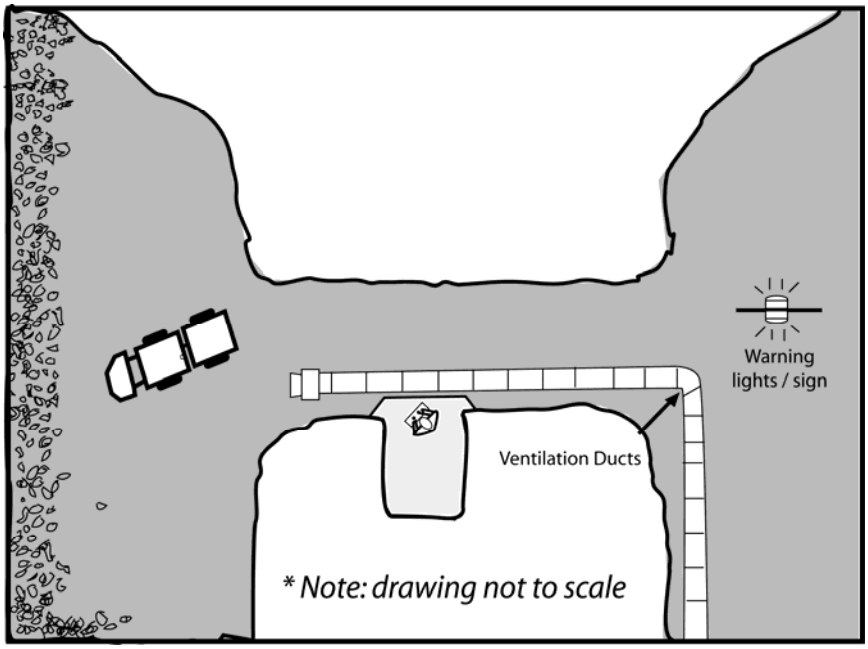
- An LHD flipped over while mucking in a stope.
- An 8-yard LHD was cleaning off the top of a raise when the front wheels went over the edge of the raise and the back end went up hitting the back of the drift, wedging the machine in that position at an angle of approximately 70 degrees.
- When backing an LHD out on remote, the machine contacted and overturned the remote stand, pinning the operator.

Source: WSN Incident Investigation Database (formerly MASHA)

1.2 Safe Workplace Design Considerations

For line-of-sight operations, the safest workplace for an operator of an LHD on remote control is on a stand designed and constructed so that it is impossible for the machine to contact the operator under any circumstances. A complete safe location will consist of a raised platform, capable of withstanding the impact of the largest LHD used on remote control, surrounded by a suitable railing and equipped with stairs. Stands may be made of steel, concrete, or both materials and may be reusable and portable. The stand should be located so that a worker does not have to walk around the vehicle to access the driver's compartment. If stands are carried or towed into place they must be secured to ensure the stand doesn't move if contacted by a machine. Any tow bars or cables must be removed and if the stand design includes separately located deflectors, they should be installed and anchored.

SAFETY BAY AND DRAW POINT LAYOUT



The remote control transmitter should be solidly mounted on an adjustable pedestal that faces the direction of the remote operation. Provision should be made on the same pedestal for a monitor if closed circuit television is required to complete the excavation. Ergonomic and human factors should always be considered when designing a work station. Shoulder-mounted remote controls should be avoided since they allow for operator mobility and have been involved in several incidents. If it's necessary that the operator move about, a risk assessment

should be conducted to ensure all hazards are engineered out or procedures adopted to protect the workers.

When it becomes necessary to operate beyond the line-of-sight, some mines use magnetically-mounted video cameras with monitors. It should be noted that additional training and practice is required before a miner should be allowed to operate a remote control LHD using video.

As well as lines of sight for the operator and access to the cab or the equipment, a safe area to which an operator can retreat should be considered during the engineering stage of the excavation. Most mines today have procedures and specifications for locating LHD safety stands a certain distance back from the brow leading into a stope. This setback may also take into account the length of the longest machine, the angle of repose for the muck being handled, the height of the brow, line-of-sight visibility and other operating and safety factors. In order to maintain adequate draw point lengths a communication process should exist that allows for changes in design as development proceeds. Continuous feedback from the operators to the engineers is critical as it will ensure ground control issues and draw point lengths are suitably addressed as the ore contact is exposed. To maintain a safe environment there must be adequate distance between the brows and the draw point entrance.

In many mines, due to layout and distance, operators will load on remote then manually drive the LHD to a dump point and return. This transition may be required several times a shift. Operators have experienced slip/strain injuries when they step down from the safety stand, walk to the idling vehicle and climb up into the driver seat. Use of three-point contact and good housekeeping become very important elements in minimizing injuries. The safest and most efficient approach might be to load, tram and dump into a chute, muck bay or haulage drift totally under remote control with the operator securely stationed on the safety stand. This is only safe, however, as long as exits are not inadvertently blocked and pedestrian and vehicle entry into the working area is strictly controlled. Good practices include a procedure where remote operators are contacted before anyone enters the LHD haulage area.

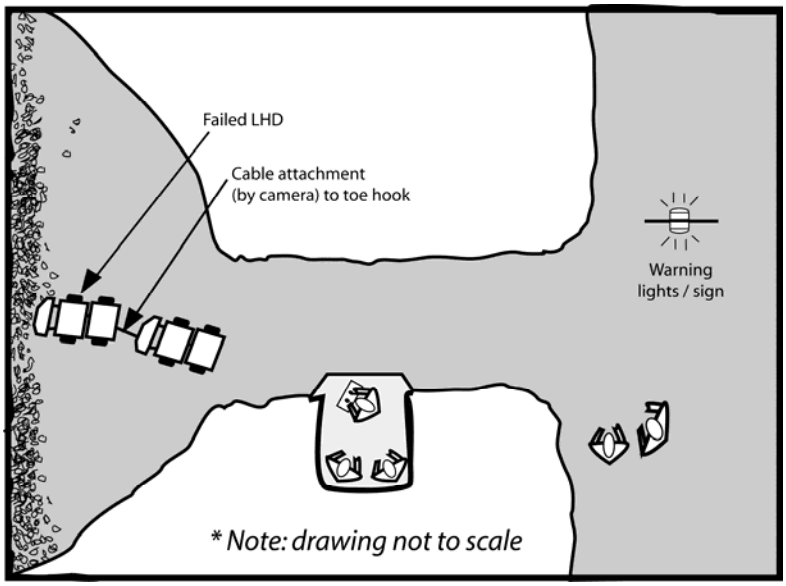
It is not recommended to have a remote controlled LHD working in the same area as another LHD because of a chance of collision.

1.3 Retrieval of Stranded Load-Haul-Dump Machines

Retrieval of a stranded LHD should be treated as a non-routine hazardous task. Ensure that details of every retrieval are entered in the shift log and audited on an annual (or more frequent) basis for opportunities to improve operating and retrieval methods and stope design. At no time should workers be allowed to work in unsafe conditions to retrieve a disabled LHD. An LHD retrieval requires the combined efforts of maintenance and operational workers and at no time should a worker attempt to retrieve the LHD on his own. Effective retrieval procedures usually involve the use of a second remote-control LHD, equal to or greater in size than the stranded

unit, which can be safely maneuvered to place some sort of towing device on the disabled unit to pull it to a safe location. This may also require the releasing of automatic brakes on the disabled machine. Recovery procedures must be tested and practiced in a safe location.

STRANDED LHD RETRIEVAL



2.0 Drills and Bolters

This class of equipment includes muck conditioners (block holer), in -the-hole drills, long-hole drills and bolters.

2.1 Machine Designs

Drills can be equipped with remote controls. The intent is to keep the operator a safe distance away from rotating equipment and noise, in a position to observe the drilling process. Bolters and block holer vehicles incorporate remote controls so the operator may work from a position under properly supported ground.

Drills generally have a console-type remote control which may allow an operator to approach the machine while it is working. Section 185 of Regulation 854 specifically requires guarding which keeps the operator from coming in contact with any moving part of the machine. The installation of a fail-safe mechanism is recommended, with guards which automatically stop all machine movement if a guard is opened or removed.

At times, a mine may use a drill on remote control to drill into rock which has been previously drilled and blasted and may contain unfired explosives. This should be considered a non-routine hazardous task and a risk assessment should be completed.

2.2 Incidents

- The operator of a rock bolter was found pinned between the boom guard rail and the machine console.
- The operator of a block holer was going to drill a safety bay. While realigning the machine on remote he was pinned against the wall by the drill assembly.
- The operator of a jumbo left the drill rotation in slow speed and attempted to break the

drill string with a wrench when his hands and clothing were caught in the rotating machinery.

Source: WSN Incident Investigation Database (formerly MASHA)

2.3 Safe Workplace Design Considerations

Operators of drills and bolters need adequate space to work, especially if other machines are tramming through the area. Drill bays, which later may be converted to shops, tool storage or pedestrian shelters, can be especially helpful in relieving congestion around drills. Guards with interlocks or in combination with safety tethers and floor mats with compression sensors may be used to keep drill operators from walking into unsafe locations (danger zone) around booms and rotating equipment.

3.0 Overhead Cranes

3.1 Machine Designs

Remote controlled overhead cranes are used extensively in underground shops and crushing stations as well as for surface ore processing operations. Either radio controls or cable-linked pendant controls are used by the operators to direct travel in forward or reverse modes and side-to-side as well as lifting and lowering loads. Incidents are likely to involve other workers being struck by traveling or swinging loads.

3.2 Incidents

- A radio-controlled electric overhead crane malfunctioned after the radio transmitter unit became cracked, and dust and moisture got into the unit. The crane had been switched on, and then left unattended while other tasks were being performed. The crane began to raise and travel on its own, until the cable hook snagged. Fortunately, no one was injured.

Source: WSN Incident Investigation Database (formerly MASHA)

3.3 Safe Workplace Design Considerations

Space and designated travel ways must be provided so that at no time does a load pass over the head of the operator or another worker. By law, warning devices in the form of flashing lights, horns, sirens or bells must be provided to warn everyone in the vicinity that a load is being moved by a powered overhead crane. Clearances from walls, equipment, machines and other obstacles must be maintained.

The operator should have a clear view of the load and the travel way at all times. There must be a means for determining the weight of a load prior to picking it up and moving it to make sure the lifting capacity of the crane or rigging is not exceeded.

Slings, chains, hooks and other rigging devices must be safety-inspected by a competent person before use. Based on the innate hazards of servicing the controls on an overhead crane, procedures to maintain the controls should be jointly developed to ensure a worker's safety.

4.0 Locomotives (Trains) on Rails

4.1 Machine Designs

Remote controlled track haulage underground is primarily used to tow ore cars from a fixed loading area of a mine to a distant dump point on the same level. Using a variety of sensors coupled to a control system, ore trains may be directed to load, unload, accelerate, slow, stop and reverse. The actual operator may be a hoist person or crusher operator watching the train on a video monitor from a remote location.

4.2 Incidents

- A train operator was pinned against his locomotive by a car from another train that was being operated remotely on the same track
- A pedestrian was jammed between the wall and the moving train

Source: WSN Incident Investigation Database (formerly MASHA)

4.3 Safe Workplace Design Considerations

To keep locomotives and trains operating effectively and safely, pedestrian and vehicle access must be controlled using signs, restricted walkways, doors, barriers or other means of traffic regulation. A remote operator can't see or feel the track conditions so regular inspection and maintenance is required if derailments and incidents are to be avoided.

5.0 Rock Breakers

5.1 Machine Design

Rock breakers are hydraulic or pneumatically-operated machines designed to break up large pieces of muck before they enter the primary crushing machine. Some mines have the operator stationed in

an enclosure which is well removed from the actual operation. This remote operator may be the crusher operator or someone who is able to monitor one or more rock breakers on video screens while breaking the oversized rock.

5.2 Incidents

- A maintenance worker was struck by the swinging arm of a remote-control rock breaker. The operator did not know the maintenance worker was going to be in the vicinity and couldn't see him on his video screen.
- A worker who was passing by a grizzly was struck by a piece of fly rock when the rock breaker shattered a piece of oversize material.

Source: WSN Incident Investigation Database (formerly MASHA)

5.3 Safe Workplace Design Considerations

Pedestrian control using a combination of barricades and signs and/or other warning devices to keep personnel out of the area is an important part of safety design. The remote operator needs to be notified ahead of time if maintenance or other personnel will be working in the area or passing through. This information should be included in the pre-shift lineup. Lighting for the grizzly area should be sufficient to allow the operator to see the entire workplace clearly.

6.0 Aerial Lifts or Booms

6.1 Machine Designs

This type of machinery includes shotcrete applicators, anfo loaders, emulsion loaders, scissor lifts and boom lifts. In remote operations an operator may control the boom and attachments from a man basket attached to the boom arm or from a remote console on the ground. The control signals are generally sent through hard-wired cables but radio-controlled devices are becoming more popular because they provide improved separation of man from machine. Like all remote controls, the radio transmitter should be placed in a secure area away from the machine's moving parts so that the operator is not required to walk in the machine's vicinity with the transmitter once the machine is switched to remote control.

Provision must be made to allow a supervisor or other person to lower any man-lift machine in the event of an incident or medical emergency.

6.2 Incidents

- The operator of a remote control shotcrete applicator was injured when his feet slipped and he accidentally actuated the machine's boom which struck him across the back.

Source: WSN Incident Investigation Database (formerly MASHA)

6.3 Safe Workplace Design Considerations

It's critically important to prevent or at least control pedestrians entering or crossing through an area where aerial lifts or booms are operating. Vehicles which could impede the remote operation or endanger the operator should be prohibited from the area.

The working area must be kept clean to provide good footing for the operator and non-slip stability for the machine. Wheels should be chocked and stabilizing jacks placed to secure the machine as per the manufacturer's instructions. Nothing must interfere with the operator's ability to see the remote control machine and the entire work area clearly. Auxiliary lighting may have to be provided for the operator to be able to see the work process clearly.

7.0 Tele Remote

Some mines have used semi and fully automatic equipment such as haul trucks and jumbo drills which use programmable systems that can be monitored from a distance or operate autonomously. While there are obvious benefits, their use may create some special hazards.

The automated working areas should be clearly defined and posted to keep all personnel from inadvertently entering while work is in progress. Some important considerations may include:

- A de-energize and lockout program for the protection of workers performing start-of-shift workplace and vehicle inspections. The lockout system should be located outside the automatic working zone
- A means for switching the equipment securely to manual control so that maintenance personnel can drive it to fuel bays and service garages
- Work zones should be wide enough for a person to be able to avoid being hit by an automatic vehicle
- Work zones should be fitted with trip wires (similar to those installed on conveyors)

which would shut down automated vehicles if pulled by a worker

- Automatic fire suppression systems should be installed on remote control and automated vehicles
- Emergency procedures should be in place to respond to out-of-control automated vehicles – the response should be practiced with frequent exercises
- The system must have detection and automatic shut-down capability if anyone enters the work zone

8.0 Appendices:
Appendix A: Legislated Training Requirements

Ministry of Training, Colleges and Universities
Modular Training Standards
Program #770010
Specialty Module U0019.0

U0019.0 PERFORM TRACK HAULAGE—OPERATE UNDERGROUND HAULAGE TRAIN REMOTE CONTROL

GENERAL PERFORMANCE OBJECTIVE

Perform track haulage—operate underground haulage train remote control by: identifying and responding to workplace hazards; inspecting and scaling the workplace; performing pre-operational checks on the train/motor; starting up the motor manually; performing pre-operational checks on the train/motor in remote control mode; conducting operational checks on the train/motor; operating the train in remote control mode; loading/dumping muck; hauling muck; and shutting down the haulage train.

NOTE: To be trained and accredited in this module, the prerequisite modules from Program #770010 are U0000, U0001, U0002, U0012 and U0067. The other prerequisite modules where applicable are U0006, U0007, U0011 and U0068a.

8.0 Appendices:
Appendix A: Legislated Training Requirements (cont'd)

Ministry of Training, Colleges and Universities
Modular Training Standards
Program # 70010
Specialty Module U0020.0

U0020.0 PERFORM TRACKLESS HAULAGE—OPERATE SCOOP TRAM REMOTE CONTROL

GENERAL PERFORMANCE OBJECTIVE

Perform trackless haulage—operate scoop tram—remote control by: identifying and responding to workplace hazards; inspecting and scaling the workplace; performing pre-operational checks on the scoop tram; starting up the scoop tram; conducting operational checks on the scoop tram; performing pre-operational checks on the scoop tram in remote control mode; operating the scoop tram in remote control mode; loading muck in remote control mode; hauling muck in remote control mode; dumping muck in remote control mode; and shutting down the scoop tram in remote control mode.

NOTE: To be trained and accredited in this module, the prerequisite modules from Program #770010 are U0000, U0001, U0002, U0012 and U0068a. The other prerequisite modules where applicable are U0011, U0015, U0025 and U0068b.

8.0 Appendices:
Appendix A: Legislated Training Requirements (cont'd)

MTCU Trainer Qualification and Criteria Guidelines for Basic Common Core and Specialty Modules

A trainer in the Miner programs must:

Be certified and accredited in the appropriate Miner Common Core Program and Specialty modules;
Be accredited in the module he/she will in instructing;
Take a Train-the-Trainer (T-T-T) program;
Be highly skilled in the area of expertise he/she will be instructing;
Be trained in application of the Act and the regulations pertaining to the specific modules being instructed;
Be trained in the company standards;
Prepare lesson plans and outline course materials to be used;
Have an appreciation of the serious nature of issues/concerns addressed at an inquest. (video, presentation, etc.)

Appendix B: Legislation that applies to Remote Control

The Ontario Regulation for Mines and Mining Plants (Regulation 854) contains a number of sections related to the operation of remote control vehicles and devices. The following excerpts were up to date at the time this guideline was published. Other sections or legislation may also apply.

119. Motor Vehicle Brakes

119(10) Before a motor vehicle is first put into service, the following systems shall be tested by a competent person for proper operation:

1. Service brake.
2. Emergency brake.
3. Parking brake.
4. Steering.
5. Warning devices.
6. Lighting

119(11) A record of the tests described in subsection (10),

(a) shall be signed by the competent person who performed the tests;
(b) shall be kept as long as the motor vehicle is in service; and
(c) shall be made available to the joint health and safety committee or the health and safety representative, if any.

154. Protection of Blasting Operations

154(2) If electrical blasting operations are undertaken, an employer shall ensure that the operations are conducted so as to ensure that there is no interference from any system, device or controller capable of producing radio frequencies or radiating electromagnetic energy.

154(3) An employer shall ensure that a system, device or controller that is capable of producing radio frequencies or radiating electromagnetic energy does not set off detonators.

174. Radio Controlled Equipment

174(2) An employer shall ensure that the system, device or controller is not capable of operating or moving equipment unless it is intended to do so.

174(3) An employer shall ensure that only one system, device or controller can be used at a time to operate or move the equipment.

174(4) The system device or controller must be equipped with a device that enables the operator to

stop the equipment in an emergency.

174(5) The employer shall establish procedures to ensure that the operator and other workers are in a safe location when the equipment is being operated or moved.

195. Cranes

195(5) Every production crane and every service crane shall be provided with,
(a) protection against inadvertent operation by radio frequencies when equipped with radio frequency controls,
(b) an operating procedure to guard against colliding with other cranes on the same track,

202. Locomotives

202(10) The owner shall give notice to the joint health and safety committee or the health and safety representative, if any, before installing remote or automatic controls for the operation of a locomotive.

Appendix C: References

1. Waudby, John. 1998, *Guidelines for the use of Remote Controlled Mining Equipment,* Department of Mineral Resources, New South Wales, Australia.
2. Pitzer, C.J. 2000, *A study of the Risky Positioning Behavior of Operators of Remote Control Mining Equipment*, Department of Mineral Resources, New South Wales, Australia.
3. Brown, Denis. *Remote Control of Load Haul Dump Machines in Underground Mines*, Department of Minerals and Energy, Western Australia.
4. *Safe Operation of Remote Controlled LHD Equipment*, Ontario Natural Resources Safety Association, 1991.