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20.0 Drilling Sites

Introduction

Exploration employees who work at drill sites face exposure to hazards associated with drill equipment and sampling processes as well as the inherent hazards of location, terrain and climate. In addition, it is common practice for the senior geologist at a project to be in effect the project manager, and thus wholly or partially responsible for health and safety of both exploration company employees and contractor employees. Exploration companies should select a capable drilling contractor with the correct drill equipment for the job – preferably a drill rig with automated or mechanized rod handling features to reduce the risks of injuries. Drills are required by law to have other safety features such as guards on all moving parts, emergency shut offs and lockout capability (not just unhooking the battery).

This section highlights common risks and hazards associated with drill sites and focuses on safe work procedures and strategies to prevent accidents. The aim is to highlight safety information for exploration geologists and geotechnical personnel etc., rather than for drillers and drilling contractors who should have their own safety programs and safe operating procedures (SOPs). All parties working at drill sites should be required to comply with all relevant regulations of the authorities having jurisdiction (AHJs).

Accident prevention at drill sites depends on planning and preparation in three areas:

- Make certain that drilling contractors apply the highest possible safety standards.
- Make certain that exploration company drill site personnel (e.g., geologists, samplers) and visitors are informed and understand the potential hazards and risks of their roles and follow safe procedures.
- Make certain that project managers have sufficiently detailed technical knowledge of drilling processes to effectively manage drilling projects and monitor contractor's safety compliance.

20.1 Risks, Hazards and Common Injuries Related to Drilling

Safe drilling requires preparation and adherence to safe work practices by all parties. Injuries may result from hazards specific to drilling itself and related to machinery, tools and equipment; to the substances used in drilling and mineral identification; or alternatively to field conditions, such as to terrain and ground conditions, animals, or climate and weather. Lack of experience of the site geologist and/or drill crew members may contribute to increased potential injuries when risks and hazards are not recognized. A wide range of risks may be encountered during a drill program:

Risks related to moving and rotating machinery and equipment:

- Crush injuries caused by catching fingers or feet in “pinch points” between moving machine parts, catastrophic failure of drill tower supports
- Impact injuries caused by hitting fingers or hands when using tools, flying material such as broken cables (winches)
- Entanglement injuries caused by unguarded machinery, loose clothing, jewelry, unconfined long hair

Risks related to high pressure air and hydraulic systems:

- Explosion and fire caused by misting of hydraulic fluids from pin hole leaks contacting an open flame (e.g., a drill shack heater or onto hot engine parts), malfunctions of booster compressors, tiger torches
- Impact injuries caused by hose failures, hose coupling failures, material ejected from cyclones, when sample discharge hoses fail and spray rock chips
- Eye damage due to grit and dust getting into eyes when sampling or cleaning machinery with compressed air
- Tissue damage or embolism caused by high pressure hydraulic fluids piercing the skin from a pin hole leak in a hydraulic hose or when cleaning clothing with high pressure air
- Hearing loss caused by high noise level of operating machinery while wearing inadequate hearing protection
- Injuries caused by the discharge from pressure relief valves when there are inadequate extensions

Slips, trips and falls may be caused by:

- Uneven ground, stumps, rocks, wet, icy ground or surfaces on the drill platform or drill shack steps, unsecured or improper rise and run on steps
- Stepping in spilled drilling muds or additives, sumps, holes
- Inadequate footwear
- Lack of, wrong type, or inadequate use of fall protection equipment
- Working near cliffs or on benches
- Improper illumination and/or inadequate lighting around the drill shack at night, poor housekeeping

Other risks

- Accidents during drill set up, drill moves or tear down (e.g., drill platform collapse, drill tower erection, especially during helicopter set ups)
- Hypothermia caused by wearing inadequate clothing for the weather, wind chill, lack of warm-up breaks
- Hyperthermia and/or sunburn caused by working in sun or heat, wearing inadequate clothing, lack of cooling breaks, inadequate fluid intake (dehydration)
- Drowning or cold water immersion hypothermia caused by falling through ice or breakthrough with equipment
- Electrocution, fire explosion caused by contact with underground gas lines, cables, utilities, or overhead power lines
- Burns caused by contact with hot engine parts, being sprayed by hydraulic fluids, fires
- Injury or death caused by being hit by falling dead trees (chicots), hung-up trees and snags left after pad preparation
- ATV and snowmobile crashes caused by excessive speed, improper riding procedures
- Bear invasion caused by the presence of garbage and rod grease
- Exposure to toxic substances caused by:

  - Lack of, inadequate or malfunctioning PPE
  - Inhalation of toxic additives or fumes, failure to remove hazardous material or exhaust from work area
  - Licking core or samples
- Equipment damage caused by many of the above hazards
- Normal field work risks when travelling to and from the drill, or to and from sites such as the water pump etc., which may be remote from the drill

Common drilling injuries

Generally, most injuries in the drilling sector are caused by (1) slips and falls, (2) improper lifting and (3) vehicle accidents. Most lost time incidents are the result of back and hand injuries to drilling employees. Other injuries of great concern include fingers caught between rods, being struck or hit by falling objects and entanglement – when clothing etc., draws the victim into the machinery or rotating drill rods. While they are less common, these injuries can be very serious or fatal. Winter work adds the potential serious risk of breaking through ice and drowning.

- Slips, trips and falls: Drilling by its very nature creates a difficult working environment – the presence of large amounts of water, drill muds and grease, with wooden planks and drill rods, in an uncontrolled environment compared to a factory floor, means that it is very easy for exposure to these hazards to result in trips and falls. Drilling in winter or during periods of heavy rain can exacerbate this situation. The drilling platform, ladders and access areas can become slippery due to grease, drilling muds or fluids, or ice buildup etc.
- Lifting injuries: Core boxes and samples can be very heavy, especially when the rock is a massive sulphide. Back and hand injuries are common.
- Transportation related injuries: Drill sites are usually remote and may require access using poor roads, ice roads or by aircraft. The modes of transportation including four-wheel drive vehicles, all-terrain vehicles (ATVs), snowmobiles, boats and especially helicopters all expose workers to increased risks. Crashes and/or collisions can result in severe injury or death.
- Impact injuries: Workers may strike or be struck by an object as a result of a fall, or be struck by thrashing high pressure hoses, ejected machinery parts, or the uncontrolled movement of drill rods, winches, cables and tools.
- Entanglement injuries: Loose clothing (e.g., shirttails, jacket drawstrings, boot laces), unconfined long hair and jewelry can easily catch on rotating machine parts. These include rotating drill rods, smooth shafts, spindles, winches and recesses or projections on shafts such as couplings, protruding set screws, keys and keyways. If you are pulled or drawn into the machinery you may be severely injured or killed.
- Crush injuries: It is easy to crush a finger, hand, arm or foot where two machine parts close together (“pinch points” or “nip points”) or where one machine part moves against another (drill rods, core barrels). Samplers at cyclones must beware of this potential injury as it is easy to catch fingers between a cyclone and sampling apparatus. Severed, crushed or damaged fingers are a common injury.
- Entrapment injuries: Part of your body or clothing may catch between "drawing-in" hazards (e.g., drive belts and pulleys, pull-down chains and sprockets, wire ropes and sheaves).
- Burns: Burns may result from contact with hot engine parts such as manifolds, exhaust pipes and mufflers, or if a hose fails and sprays hot hydraulic or compressor oil into the

work area. Burns may also result from contact with tiger torches, oil stoves used for heating the drill shack or with heaters for brine solutions.

- Dust and Noise: Effects of dust and noise are cumulative. Excessive inhalation of dust (especially asbestos, silica and coal dust) can produce fatal lung diseases. Excessive noise produces deafness. Both are preventable so use the correct personal protective equipment (PPE).

20.2 Responsibilities (Due Diligence) Regarding Drilling Sites

Drill site safety has to be a joint effort between the exploration company and the drilling contractor. Every employee on the drill project site has a role to play regarding safety.

Exploration Companies

- Companies should use drilling contractors with a reputation for good performance, safety and environmental responsibility. Work with the contractor to select the right drill for the job and avoid the risks and hazards of situations where machinery or equipment is stressed beyond its capacity. Use a contractor accreditation process (see 20.10 Selecting a Drill Contractor – Evaluation Criteria).
- Develop site specific safe operating procedures (SOPs) and emergency response plan (ERP) procedures.
- Make sure the project manager has experience in working on drill jobs and is appropriately trained. All exploration company employees should be trained to safely carry out their jobs when working around drills.
- Protect the health and safety of all employees.
- Comply with all legislation and regulations of the authorities having jurisdiction (AHJs).

Exploration Company Project Manager or Supervisor

- Choose the appropriate drill and drilling contractor for the job. The equipment should be the correct size and have sufficient power for the job and be properly maintained. Make sure the contractor knows the hole specifications before the project starts and mobilization begins.
- Carry out a drill site risk assessment. Develop a plan to eliminate or mitigate the identified risks. Work with the drill supervisor. Refer to 2.1.5 Risk Assessments.
- Obtain, or make sure the contractor has obtained, all permits required by the authorities having jurisdiction (AHJs). Make sure the appropriate authorities are informed about details of the project.
- Clearly communicate with the drill contractor and make sure the contractor is familiar with the potential hazards and risks of the drill site. If necessary, the drill contractor should visit the site prior to set up.
- Consult with the drilling contractor prior to site preparation to determine the minimum size, shape and preferred layout of the drill site to accommodate drill equipment, ancillary equipment and required vehicles. Helicopter supported drilling, underground operations or drilling on ice may require special site preparations.

- Hold a site induction safety meeting for all employees before work commences. Provide necessary training (e.g., site specific Workplace Hazardous Materials Information System (WHMIS) training).
- Make sure that all employees and visitors are informed and understand the potential hazards and risks at the drill site.
- Hold weekly surprise health and safety audits and weekly drill inspections, as well as safety meetings with mandatory attendance by drilling company employees. These encourage good communication between the exploration company and contractor.
- The onsite drilling supervisor must be able to communicate clearly or provide a means of communication in the required language(s) with all drill site personnel so instructions, requirements, safe operating procedures etc., are fully understood.
- Make sure appropriate PPE is used.
- Be proactive. Monitor the drilling contractor's work to make sure the highest possible safety standards are followed. Work with the onsite drill supervisor or foreman to rectify unsafe practices. Report to the drilling company management and demand action in cases of infractions of safe practices that cannot be dealt with at the work site.

Exploration Company Employees

- Follow company and site specific health and safety policies and SOPs.
- Be familiar with the ERPs and know your personal responsibilities for each situation.
- Attend safety meetings and participate in emergency training exercises (practice drills).
- Wear PPE and protective clothing as required. Maintain PPE and replace it when it is worn, defective or damaged.
- Be familiar with the hazards at the drill rig and stay away from specific exclusion zones unless you have a job related reason to be there.
- Watch out for the safety of co-workers.
- Report unsafe acts and hazards to the drill supervisor and correct the situation, if possible.

Drilling Contractor

- Comply with all legislation and regulations of the authorities having jurisdiction (AHJs).
- It is advisable to hire drillers and driller helpers (drilling assistants) who are trained and certified or have an adequate training program in place. Standardized instruction, such as the Common Core Training Program is recommended. The Common Core (Helper and Runner Level) contain modules which specify the knowledge components of diamond drilling operations and the minimum performance standards required for either underground or surface. The surface diamond driller helper training program is composed of course work and on-the-job training. It is a legislated requirement in Ontario and Québec and is currently being adapted by other provinces in Canada.
- The drilling company should supply a qualified drilling supervisor (drill foreman) or a running foreman in the case of a one-drill operation. It is advisable to hire supervisors who are qualified with the Supervisor Common Core Training Program modules, which are required in Ontario and Québec.

- Supply appropriate drill equipment in safe working condition for the job. Maintain and service equipment as required.
- Remove all temporary installations and markings after drilling has been completed and leave the site clean and free of hazards to people, wildlife or livestock.
- Work with the exploration company to implement safe practices at the site, and take action in cases of violation of good practice.

Drill Supervisor or Drill Foreman

- Supervise drilling employees to make sure that the safety of all employees is protected.
- Instruct and train workers, as necessary. Implement health and safety policies, safe operating procedures (SOPs), and make sure PPE is used correctly.
- Carry out a drill site risk assessment. Inspect the work area; identify and correct health and safety hazards. Work with the exploration company project manager or supervisor to address problems.
- Implement a written fall protection plan that protects employees who must work on the drill mast or at height. Make sure workers use fall arrest equipment as required.
- Be familiar with and implement emergency response plans (ERPs) as required.
- Make sure warning labels are present and legible on all drill equipment. Replace the labels if they are worn or damaged.

Responsibilities that the exploration company should expect from the driller and/or driller helper and "fifth man"[1]:

- Follow the company and contractor SOPs; wear and maintain required PPE.
- Operate the drill and all accessory equipment in a responsible manner in order to eliminate injuries.
- Make daily inspections to make sure the drill unit is in good repair and safe. Carry out maintenance of the rig and equipment according to manufacturer's recommendations.
- Know how to operate all emergency shut off switches and all safety and emergency equipment on the drill and accessory equipment.
- Keep the drill site neat, organized and free of debris that could cause trips; keep the drill platform and steps free of grease, mud and ice that could cause slips and falls.
- Take all possible precautions to make sure that the drill is moved safely from one site to another with minimal environmental damage.
- Provide adequate supervision of the driller helper.
- Be aware of the dangers of working around helicopters, skidders, excavators, dozers or any type of machinery at the drill site and when the drill is moved to a new site.
- Report unsafe acts, hazards, near misses, accidents, injuries and illnesses immediately to the supervisor. Correct unsafe work conditions, if possible.

[1] The "Fifth Man" is a person often added to a drill crew where extra duties are too time consuming for one drill helper. Normally the person is an employee of the drill contractor.

- Be trained and have current certificates in first aid, cardio pulmonary resuscitation (CPR) and Workplace Hazardous Materials Information System (WHMIS), plus any other government or company mandated certificates.

20.3 Drill Site Location, Planning and Preparation

The drilling sites should be assessed by the exploration company project manager with the drilling contractor well in advance of the initial drill rig set up or moves. Potential problems should be discussed and addressed. Risks should be identified through the risk assessment process and mitigated when possible according to a risk mitigation plan.

20.3.1 General Preparations

- Permits: Obtain all required permits from the authorities having jurisdiction (AHJs). Permits may be required for access, environmental, cutting trees, water use and course alteration, septic systems, waste disposal, and reclamation etc.
- Power lines, underground cables and utilities: When it is necessary to drill near these hazards, follow regulations of the AHJs, notify the appropriate authorities and use extreme caution. See section 20.3.2 below.
- Plan site specific SOPs and ERPs, as required. This is especially important when it is necessary to drill near power lines or on ice. ERPs should include provision for a safe shelter, as required.

Location

Carefully plan the drill site layout to minimize natural and manmade hazards that contribute to accidents. Refer to section 18.4.1 Site Selection and Location.

- Access: Evaluate the drill site for adequate entry and exit. Take into consideration the drill rig and carrier and required service vehicles and equipment. Plan for adequate parking space for supply vehicles.
- Where there is no road access, carefully plan for an airstrip or helicopter landing site, or for water access or ice road, as required. Plan safe fuel storage areas for all required means of transportation and for drill equipment.
- Address potential drill site hazards such as manual handling, the need for special platforms on steep terrain, guard barriers to prevent falls (e.g., steep slopes, old open mine works), confined work space, adequate access and parking space, aircraft landing areas, fuel storage etc.
- Remove physical hazards such as dangerous trees and branches, stumps and loose rock that could fall or slide unpredictably.
- Assess the stability risk on steep slopes with thick soil cover in regions of high rainfall especially mountainous tropical areas, for example, Papua New Guinea. Water soaking into the ground can invisibly undermine the drill pad – with potential catastrophic failure. Design a drainage system to channel water flow coming down the hill site away from the drill pad.
- Determine if suitable water is available and in sufficient quantity. Secure any required permits. Determine if a holding tank is required. Maintain any required setback of the drill site from watercourses.

- Plan adequate work space at the drill site – both horizontal and vertical – as a restricted work space increases the risk of accidents. Sufficient operating space is very important if the drill will operate at night.
- Make sure the site is stable enough and will take the weight of the drill and equipment. Place the drill and any supporting jacks on firm and solid ground. If it is necessary to construct drill pads on steep slopes using "cut and fill" methods, do not locate equipment on the area of fill until it is properly compacted and sufficient drainage is in place. If drilling on ice, rigorously test the ice thickness and build up the access routes and drill pad as required.
- Plan the site layout with clear escape routes from all areas in case of emergency (e.g., fire, flood). Include at least two routes in ERPs.
- Make sure sufficient firefighting equipment and first aid kits are present at the drill site. All employees must know their location and be trained to use the firefighting equipment.
- Aircraft: If aircraft access is required, carefully plan the location of the airstrip or helicopter landing pad. Include plans for fuel storage that comply with permits and regulations.
- Water: Arrange for water delivery if insufficient water is available. Arrange for safe disposal of excess water. Follow all regulations (e.g., permits, setbacks).
- Where sumps are required, make sure they are of sufficient volume to contain all circulation fluids and are placed an adequate distance from water courses. Calculate the volume requirements from the depth and diameter of the proposed hole.
- Plan for the safe disposal of drill cuttings, drilling muds or sludges, as required.
- Locate the sample and core viewing areas (core shack) well clear of the drill rig, operating machinery, cyclones and high pressure hoses and pumps.
- It should be mandatory to keep appropriate spill kits at the drill site and fuel caches.
- While it is important to minimize environmental disturbance during drilling operations, this must be balanced with the health and safety considerations so employees are not placed in added danger. Refer to section 5.7 Special Terrains in the e3 Plus Environmental Stewardship Toolkit at: www.pdac.ca/e3plus.

Special site considerations

- Old mine sites and chemical hazards: Watch out for possible unidentified or unmapped raises and stopes, old machinery or rails, rotting wood from supports etc. Watch out for dumps that may contain toxic materials etc. Refer to Section 22. Abandoned Surface and Old Underground Mine Workings.
- High pressure gas and water: When the potential exists to encounter high pressure gas and water, particularly when drilling, the contractor must be informed and instructed to use blowout protection on drill equipment. Consider extending the exclusion zone around the rig to prevent potential exposure to other workers.
- Sedimentary terrain: When drilling in some sedimentary terrain, there may be the potential to encounter poisonous or flammable gases such as H_2S or methane. Develop site specific SOPs that address the potential risk of encountering gases. Appropriate equipment such as gas detectors and masks must be available at the drill site.
- Additional hazards may include extreme climate and/or terrain (Arctic, desert or mountainous regions), wildlife (e.g., venomous snakes, insects, bears, wolves) and

cultural, language or security issues. Refer to Sections 9. Weather and Environmental Risks, 10. Wildlife, and 12. Travel Safety and Security.

- Urban areas**:** Drills sometimes operate in urban areas with only one shift during the day due to noise restrictions. Guards or caretakers should be hired to oversee the drill site at night.

Figure 20.1: Drilling on steep slopes requires attention to drill pad stability and fall prevention. © Hy-Tech Drilling Ltd.

20.3.2 Drilling Near Power Lines

When drilling near power lines, use the same precautions as when operating heavy equipment near power lines. Refer to section 21.3.4 Working Near Power Lines for specific details about (1) safe procedures for both overhead power lines and underground power lines, cables and pipelines, (2) the “minimum clearance distance” or “limits of approach”[2] requirements for overhead power lines, and (3) emergency procedures to follow if unintentional contact is made with overhead or underground power lines, cables or pipelines.

Although jurisdictional regulations may state you should maintain a minimum clearance distance of 3 m (10 ft) from some high voltage power lines, a greater minimum clearance distance of at least 6 m (20 ft) is recommended for all power lines. As specified minimum clearance distances vary by jurisdiction and are subject to change, drill operators should consult the regulations of the AHJs before commencing any drilling near overhead high voltage power lines. To be safe:

Verify the following each time it is necessary to drill near overhead power lines. Power lines expand and then sag with changes in temperature and are swayed by winds.

1. Verify the required minimum clearance distance with the AHJ.
2. Verify the height of the equipment (mast), worker(s) and tools at full extension.
3. Verify the height of the power lines.

[2] “Limits of approach” is a typically Canadian term and “minimum clearance distance” is used in the United States, United Kingdom and Australia. Minimum clearance distance is used in this publication.

It is often very difficult to tell high voltage from low voltage power lines; underground utilities, cables, or pipe lines may be in unexpected locations. Always use extreme caution while drilling near these hazards. The following points are minimum safe precautions to take:

- Carry out a site risk assessment to determine the hazards. Comply with regulations regarding permits, permitted methods of digging, blasting plan submissions, and supervision by the utility company etc. Notify utility companies well in advance because they require time to come to the site to locate and mark underground hazards or de-energize, barricade or move overhead power lines.
- Develop site specific SOPs that address drilling near power lines and train employees appropriately. Have ERPs in place to address potential contact, including potential electrocution and burn injuries. Train employees in the correct response if contact is made.
- Maintain the safe minimum clearance distance from power lines. Where no regulations exist, apply a minimum of 20 metres clearance from all power lines.
- To prevent contact with overhead power lines: (1) move the drill only when the mast is completely lowered, (2) be vigilant about maintaining the appropriate minimum clearance distance when placing and operating the drill, (3) use a spotter to inform the drillers when they are approaching the minimum clearance distance and (4) do not move the drill at night unless there are very unusual circumstances and then only with permission from appropriate exploration company and contractor authorities.
- In rural areas there may be only a single power line that may be difficult to see. Where electric trains operate, pay extra attention to the height at designated crossings, especially private crossings.

20.3.3 Drilling on Ice

Winter drilling programs on ice are relatively common in some regions[3]. Exploration companies are advised to develop an ice safety plan for drilling operations on ice and hire drilling contractors with experience drilling on ice and that use trained and experienced employees. All work including transportation to and from a drill site must be carried out only when ice thickness has been tested and determined to be safe. For some projects it may be advisable to consult a professional engineer with expertise in ice mechanics to establish the safe load bearing capacity of the ice cover for stationary and dynamic loads over 5000 kg.

Due to the difficulties in gauging an accurate thickness of ice cover, it is advisable to contract specialists to use ice profiling equipment with ground penetrating radar (GPR). The equipment can produce a detailed picture of the local variations in thickness and features (e.g., cracks hidden under snow, incompletely frozen layers, bubbles). However, it is important to remember that even in sub-freezing temperatures ice thicknesses can change rapidly – especially where water currents are present – and monitoring ice conditions needs to be a continuous process during winter drilling programs. When ice profiling equipment is not available, the ice thickness and quality must be measured by hand, which increases the risks.

Information in this section is based primarily on the following documents, which should be referred to for detailed information:

> *Best Practice for Building and Working Safely on Ice Covers in Alberta:*
> http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf

[3] This section addresses drilling on frozen surfaces such as lakes, rivers and streams. Drilling on glaciers requires special procedures and is not addressed in this publication.

A Field Guide to Ice Construction Safety: http://www.dot.gov.nt.ca/_live/documents/documentManagerUpload/Ice%20Construction%20Field%20Guide%20web.pdf

Policy Subject: Working on Ice: www.uoguelph.ca/~wrs/OMNR.working.on.ice.policy.doc

For additional information about working safely on ice, refer to the following sections in these Guidelines:

9.9 Cold Injuries: For recognition and treatment of hypothermia and frostbite

15.10 Working on Ice: For ice terminology and features, hazards related to ice, equipment lists, guidelines for initial safe ice crossings, and ice testing procedures on foot and by snowmobile

15.11 Cold Water Immersion Hypothermia – Falling Through Ice: For self-rescue and rescue procedures when a co-worker has fallen through ice

21.4.3 Winter Access Routes: For ice roads, moving loads on ice, escape procedures when a vehicle breaks through ice

Risks and Hazards

Specific risks and hazards associated with drilling on ice

- Drowning or cold water immersion hypothermia caused by:
  - Breakthrough due to unsafe practices such as:
    - Not calculating the dynamic loading (reactive forces) generated by the drill on the ice cover
    - Inaccurate calculation of the total weight of the drill, equipment and supplies PLUS the maximum pullback capacity of the drill
    - Inaccurate or unreliable thickness measurements
    - Undetected features such as cracks and subsurface thinning
    - Using the wrong load bearing capacity tables/charts, using the wrong scale on a chart
    - Lack of or not following site specific safe operating procedures (SOPs), not enforcing SOPs
  - Lack of emergency response plan (ERP) procedures, lack of ERP training
- Hypothermia, frostbite caused by working in cold temperatures with inadequate clothing, too few warm-up breaks, wind chill
- Falls and slips caused by slippery surfaces, ice-covered steps and platforms
- Stranding caused by whiteouts, blizzards, transportation breakdown
- Pushing the limits: working on ice too early or too late in the season

Ice Safety Plan

As discussed in 15.10.5 Planning and Preparation for Working on Ice, it is strongly advised that companies develop an ice safety plan that incorporates risk assessment, mitigation of hazards, and a site specific ERP with rescue procedures. Guidance is available specifically directed toward developing an ice safety plan and the relevant emergency response procedures in:

Best Practices for Building and Working on Ice Covers in Alberta: http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf .

Section 3. Ice Cover Hazard Controls

Section 4.1 Design Controls

Section 4.2 Ice Monitoring Controls

Section 5. Developing Your Ice Safety Plan

Appendix D Emergency Procedures

Training

Employees are subject to additional risks and hazards because working on ice is never entirely safe. Additional training and preparation should cover:

- Safe operating procedures (SOPs) – general and site specific:
  - SOPs for testing ice thickness on foot, using a snowmobile, using other equipment, as appropriate
  - Required personal protective equipment (PPE): In addition to regular PPE, employees should wear a flotation snowmobile suit, or a personal flotation device (PFD) or life jacket as long as there is a risk of ice failure during the initial testing and construction phases. Keep a hypothermia kit available and know how to use the contents.
  - Required safety and survival equipment for vehicles, ATVs, snowmobiles, heavy equipment
- As a minimum, training in ERP rescue procedures should include (1) self-rescue, (2) rescuing a crew member who has fallen through ice, (3) escape when a vehicle breaks through ice, (4) escape and rescue when equipment and the driver break through ice and (5) treatment for cold water immersion hypothermia. Refer to “Training for emergency response procedures” in section 21.4.3.2 Planning and Preparation for Winter Access Routes.
- Never wear a seat belt on ice. Roll down vehicle windows or keep a window punch tool immediately accessible. A functioning escape hatch is required in the cab of all heavy equipment.
- Educate workers about the physical properties and characteristics of ice so they understand why it is essential to adhere to safe load limits and comply with safe speed limits.

Planning for drilling operations

Start planning well in advance of the anticipated date for moving equipment onto ice. Pay careful attention to details when calculating the safe load bearing capacity of ice for drill pads. Because the reactive forces involved in drilling processes generate dynamic loading on the ice cover, drill pads must be much thicker than required for static loads. It is best if one experienced person is designated to be responsible for evaluations of ice thickness either by contracting ice profiling specialists or using appropriate equipment and ice testing methods. Engineering expertise in ice mechanics may also be required.

Dynamic loading: During drilling operations, dynamic loading occurs when additional forces beyond the weight of the drill and support equipment are transferred to the ice surface. Maximum dynamic loading takes place when extracting stuck rods. To extract the rods, a pullback force is applied by alternately pushing and pulling against the drill string until the drill string is freed. This

alternating action causes dynamic loading on the ice cover so it flexes rapidly; the ice may even flood during deflection, which adds more weight on the ice cover.

It is essential to factor in the effects of dynamic loading in your calculations; you must also include the additional weight the ice will be subject to by adding in the maximum pullback force the drill is capable of exerting on the ice cover. The pullback force (which is entirely specific to each drill) may effectively double the weight of the drill; it should be noted that when dynamic loading is factored in, required safe ice thickness may be *four times* that required to support the drill and ancillary equipment alone.

Requirements for drill projects on ice

Follow the requirements of authorities having jurisdiction (AHJs) and best practices and test the ice thickness and load bearing capacity on a regular basis. Regulatory authorities may require the use of specific tables to compute the load bearing capacity.

1. Carry out ice assessment procedures and record the results in a log book. Take measurements to determine the ice thickness and quality. Record the test hole locations and any hazards on a diagram. Adjust the test schedule (frequency) and test hole distribution to take into account snow cover, temperature variations and hazards that may develop (cracks, thinning).

    - During the drill pad preparation and construction phases, measure the ice thickness frequently and assess ice growth and characteristics (perhaps daily).
    - During the drilling phase – if the weather and ice conditions are stable – measurements can be taken less frequently, but it is still necessary to verify and monitor the ice thickness routinely as long as work is carried out on ice.
    - Test hole spacing: The required space between test holes depends on the type of water body. Take sufficient measurements to confirm the ice cover is thick enough to safely bear the weight of equipment during drilling activities and the support vehicles for the duration of the drilling project. Refer to:

      Best Practice for Building and Working Safely on Ice Covers in Alberta: http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf

      Table A1 Recommended Maximum Spacing of Auger Test Holes for Measuring Ice Thickness
    - Ice thickness records: Local authorities (AHJs) normally require companies to document ice thickness and features in a log book for the duration of a program on ice. Record all measurements in terms of the “effective ice thickness” (refer to #5 in section 15.10.5.1 Guidelines for Testing and Assessing Safe Ice Thickness). Specific record keeping requirements may vary by jurisdiction. For examples, refer to:

      Best Practice for Building and Working Safely on Ice Covers in Alberta: http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf

      Section 4.1.2 Effective Ice Thickness

      Section 4.2 Ice Monitoring Controls

      Section 4.2.1 Measuring and Recording Ice Thickness

      Appendix A Table A3: Ice Cover Profile Template

      Appendix E Table E1: Ice Cover Inspection Template

A Field Guide to Ice Construction Safety:
http://www.dot.gov.nt.ca/_live/documents/documentManagerUpload/Ice%20Construction%20Field%20Guide%20web.pdf

Section 3.3 Ice Testing

- Record the colour and quality of ice, which indicates its strength (e.g., clear blue ice, white opaque ice). Note and record the thickness and bonding of each layer of ice and the effective thickness.
- Weather changes: Measure the ice thickness at each location immediately after all extreme temperature changes, heavy rains, and if the temperature rises to near or above freezing. Temperature changes may require adjusting work and travel schedules and/or the load limits permitted on the ice. See #4 below.
- Cracks: Note and record the types, size, location and distribution of cracks. Monitor cracks throughout the project. Dry and wet cracks form when ice moves or contracts and they may or may not indicate weaker ice. Follow the guidance of best practices, the recommendations and regulations of AHJs and reduce the load as necessary. Note that references cited do not agree regarding load reductions for specific ice conditions so exercise caution and leave a margin of safety. For definitions and information about cracks, refer to:

  Best Practice for Building and Working Safely on Ice Covers in Alberta:
  http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf

  Section 2.3 Types of Ice Cover Cracks

  Section 4.2.2 Monitoring Ice Cracks

  A Field Guide to Ice Construction Safety:
  http://www.dot.gov.nt.ca/_live/documents/documentManagerUpload/Ice%20Construction%20Field%20Guide%20web.pdf

  Figure 6 Modification of the Ice Loading and Remedial Action for Various Types of Cracks

  Policy Subject: Working on Ice:
  www.uoguelph.ca/~wrs/OMNR.working.on.ice.policy.doc

  Appendix One: Adjustments to Bearing Capacity Because of Cracks or Absence of Blue Ice

2. Calculating safe ice thickness for drilling on ice: During drilling, additional forces are exerted on the ice. The ice deflects from the weight of the drill (and equipment); ice deflects even more when the drill pulls the rods up, especially when rods are stuck. It is essential to:

   a) Base calculations on the thinnest ice measurement in the test area.

   b) Use the correct allowable load tables and ice bearing capacity charts. Load bearing tables and charts for stationary loads (e.g., drills) differ from those for moving loads because ice beneath a stationary load will deform continuously (creep) until it fails.

   c) Calculate the total weight of: the number of people + drill + maximum rod string + water in the rods if experiencing a “wet pull” + ancillary machinery + supplies that can potentially travel on ice and remain at the drill pad at one time + the pullback capability of the rig.

d) Consider the "dynamic loading" the drill rig will exert on the ice when pulling rods or when the drill is required to overcome stuck rods or added rod friction due cave-ins, faults etc.

The safe load bearing capacity of the ice required for drilling equals the thickness of ice that can support the combined weight of all equipment, supplies and people *plus* the reactive load generated by the drill. Do *not* underestimate the total weight – add a safety factor.

The following references contain tables and charts for moving and/or stationary loads, including some allowable time limits for loads on ice:

Best Practice for Building and Working Safely on Ice Covers in Alberta:
http://employment.alberta.ca/documents/WHS/WHS-PUB_sh010.pdf

Section 4. Ice Cover Design, Monitoring and Maintenance

Section 4.1.5 Stationary Loads

A Field Guide to Ice Construction Safety:
http://www.dot.gov.nt.ca/_live/documents/documentManagerUpload/Ice%20Construction%20Field%20Guide%20web.pdf

The most stringent and conservative standards are recommended in the PDAC Health and Safety Guidelines. It is advisable to always exceed the minimum ice safety standards. Remember that tables and graphs for determining the safe load bearing capacity of ice are only guidelines.

3. Install markings and signage:
   - Designate the boundaries of safe ice along the access route and around the drill pad with cones, trees or other means. Surround the perimeter of the drill pad with orange snow fencing to prevent unauthorized visitors and place a sign indicating "DANGER – Heavy Equipment Operating" at the entrance. Maintain markings from the preparation stage through the completion of project work.
   - Determine the safe vehicle speed limits to prevent ice rupture. Post signs with the permitted speed limit and maximum allowable weight for vehicles and equipment. If parking is permitted, signs should indicate the location and length of time vehicles and equipment may remain in the designated area. Update information on road signs to indicate changes in speed limit and permissible vehicle weight as temperature and ice conditions change.
   - Mark the locations of test holes with cones or fluorescent pickets, especially if they may be a tripping hazard.
4. Monitor and verify the ice thickness throughout the drill program. Repairs may be required to maintain the load bearing capacity. Monitor the ice for deflection by measuring the "freeboard" and by other methods as determined through consultation with experts.
   - Take ice samples frequently enough to confirm that the ice remains thick enough to safely support the maximum load. Design the test hole distribution pattern to detect potential hazards such as thinning of the lower ice surface.
   - Freeboard: Monitor ice deflection by drilling a hole to measure the freeboard – a term for the distance between the upper ice surface and the water level in the hole. Ice floats on water and the freeboard measurement should equal 10% or

more of the thickness of the ice cover. If freeboard is less than 10%, it indicates that ice is deflecting due to the load and the freeboard should be monitored while the load remains on the ice. Remove loads before freeboard reaches zero and water flood onto the ice.

- Monitor the daily temperature fluctuations and ice conditions. Increase testing as necessary.
    - An extreme drop in temperature can cause ice to become brittle so the strength is severely compromised. The ice may not be safe to use for at least 24 hours.
    - A sudden rise in temperature can cause ice to thin unexpectedly and dramatically – even when the temperature does not go above freezing. Changes in water temperature and underwater currents may erode the lower surface without any indication on the upper surface. Only GPR ice profiling equipment or other method of testing at close intervals will reveal this.
    - If the temperature rises above freezing for 6 of the past 24 hours, the load bearing capacity of ice is diminished. If the temperature stays above freezing for 24 hours or more the ice will rapidly lose strength and the safe load bearing capacity tables will no longer apply. The ice will no longer be safe.
    - Where cracks are present, do not load the ice to its limit under very cold conditions or when there has been a rapid drop or rise in temperature.
    - Test repaired cracks by drilling into them to determine the depth of healing and whether they pose a safety hazard.

Additional safety tips

- Ice thickness can be built up by pumping water to flood the access road and drill pad. These “lifts” should be thin enough to freeze rapidly (within 12 to 24 hours).
- Carry out all work and travel within the defined limits of the safe ice.
- When drill equipment travels on ice:
    - Make sure both tractors and sloops have loops welded on the front and rear for inserting a long log. The log will stop the machine from sinking immediately if it breaks through. Use the logs when accessing and departing from the drill site, as required.
    - Never wear a seat belt. Verify that heavy equipment has a functioning escape hatch from the cab. Consider lashing it open or removing doors and hatches, which may be required in some jurisdictions. Otherwise keep the windows open and/or have a window punch tool immediately accessible.
- At the drill pad:
    - Do not place the drill near fractures and/or the outer limits of the ice confirmed to be safe. Do not place the drill near other heavy equipment unless the weight has been taken into account (#2 above).
    - Stationary loads must be adequately spaced to prevent sustained ice deformation and eventual failure. This includes storage areas for drill rods, fuel drums and designated vehicle parking areas. Park vehicles and equipment off the ice if possible. When parked on ice, space them at least two vehicle or

equipment lengths apart for no longer than two hours unless the drill pad is designed to support them as stationary loads.

- Do not place a water heater directly on the ice.
- Never bank up snow or ice around a drill shack. Always leave it open underneath so cold air circulates and dissipates the heat.
- The drill pad should have a lifebuoy attached to a 15 m long floating line.
- Collect all sludge or cuttings and properly dispose of them according to requirements of the AHJs.
- Make sure return drill fluids are pumped away from the set up or into containment. Make sure the casing is well seated in bedrock to prevent up-welling of warmer return fluids up along the casing and under the drill site (if total return is not seen at the collar). Collect fluids as required by AHJs.
- For additional information refer to section 16.1 Drilling from Lake Ice on the e3 Plus Excellence in Environmental Stewardship Toolkit at: www.pdac.ca/e3plus

Figure 20.2: Building a thicker drill pad by flooding the ice to create lifts that freeze in 12-24 hours. © Chris Pedersen

20.4 General Safety Guidelines for Drill Sites

Good planning, organization and standards of conduct help drill projects run smoothly.

20.4.1 Emergency Response Plans (ERPs)

- Carry out a risk assessment before the start of drill operations and develop site specific ERPs that address the risks by elimination and mitigation. Send copies of the ERP to the regional exploration company office and the contractor.
- All on site employees must be familiar with the plan and trained to carry out their assigned responsibilities for emergencies.
- If evacuation is part of an ERP carry out a practice exercise (drill) to see if the contacts and plans work.
- Emergency equipment: Both the drill and the base of operations should have required emergency equipment that includes:
    - Suitable and well maintained first aid kits and appropriate stretchers to transport patients (appropriate size and number)
    - Fire extinguishers, firefighting equipment and any required spill containment kits (properly located)
    - Signalling devices, emergency shelter and survival equipment suitable for the climate
    - Bear deterrents, a suitable gun and ammunition (for trained employees) as required
    - Survival shacks should be supplied with seasonally appropriate items including: sleeping bags, stove, lantern, propane canisters, matches and lighter, candles, food and water (in totally animal proof containers), flashlights, extra batteries, extra clothing, mosquito netting, sun screen, bug spray, bear spray etc., as appropriate. Include oxygen at high altitude (more than about 3000 m).

Figure 20.3: Survival shack adjacent to a drill. © Hy-Tech Drilling Ltd.

20.4.2 Communications

Drill sites must have sufficient reliable communication equipment appropriate for the location that enables communication with the base of operations under all emergency conditions. Have suitable backup equipment and spare batteries. Maintain communication equipment in good repair and test it regularly.

- Establish and maintain a regular communication schedule between the drill and base camp or office.
- Post communication procedures in a prominent place (i.e., operation instructions for the equipment, the radio frequencies or telephone numbers, the list of emergency contacts). Operating instructions and emergency procedures should be posted at each communication station and attached to portable equipment, especially satellite telephones.
- Train all employees to use the communication equipment.
- Establish clear SOPs regarding procedures to follow in case communication cannot be established between the base camp and field workers.
- Refer to Section 3. Emergency Response and 19. Communications for information regarding communication equipment, general communication procedures, emergency procedures and contact lists.

20.4.3 Pre-Program Safety Meetings

- Hold a detailed safety meeting for all employees at the start of a drilling program. It is most effective to hold it at the drill or at least include a visit to the drill rig. This makes certain that all drill site personnel understand the potential risks and hazards, the safety policies, safe operating procedures (SOPs) that apply when working around the rig. Encourage responsibility for employee personal safety and for the safety of others.
- At the safety induction, ask the contractor's drilling supervisor or senior driller to physically point out the known hazards and each **exclusion zone** around specific drill equipment such as the high pressure hoses, compressor and cyclone. The hazards are not always obvious to exploration employees, especially those who lack experience around a drill or are only familiar with a different drilling process.
- It is highly recommended for the company geologist/sampler to hold a short safety meeting with both drilling crews when shifts change so that the "off" crew can talk about shift issues with the "on" crew.
- Refer to section 2.1.2 Safety Meetings for additional information including suggested agenda topics.

20.4.4 Inspections

- The supervisor should carry out a drill site safety inspection at the start of a drilling program and prior to starting each hole during long programs. Safety inspections should include the drill rig, accessory equipment, hoses and connections, vehicles, procedures, methods of operations etc. Verify that the emergency shutoff switch is in good working order at the start of the program. Both company and contractor personnel should participate in all inspections. It is advisable to use checklists and maintain these records at base camp.
- The driller should conduct a quick inspection of the work area and rig before work each shift to note and correct any hazards.
- The exploration company representative should continuously look out for hazards and unsafe work practices and inform the drill supervisor so they can be corrected or mitigated. It is advisable to hold frequent surprise inspections (as often as once a week).

20.4.5 Reporting

Make certain accident reporting and investigations are done in accordance with applicable regulations (i.e., what constitutes a reportable event varies by jurisdiction).

- Immediately report injuries, accidents, incidents, near misses, unsafe conditions and any serious safety concerns to the supervisor.
- Report all accidents or incidents to the exploration company site representative within 24 hours. Contractors must provide a written copy of an accident/incident report to the exploration company as soon as possible (a verbal report is required within 24 hours).
- Make sure reportable events are reported to the correct AHJ within the required timeframe. Firmly established whether the exploration company or the contractor is responsible for reporting to AHJs on required forms.

- Investigate all accidents and incidents promptly. Immediately implement new SOPs that arise from an investigation of any injury or safety incident to prevent recurrence. The drilling operation must not recommence until the site and/or equipment is made safe.
- Document training, inspections etc., as required by the AHJs. Refer to section 1.2.5 Documentation for relevant information.

20.4.6 Employee Conduct

Responsible behaviour is essential at all times at the drill site.

- Do not distract your co-worker while he or she is concentrating on a job.
- Never throw objects in the drilling or work area. Hand them to your co-worker or set them in their correct place.
- Operating machinery or vehicles under the influence of alcohol or deleterious drugs is extremely dangerous and is an offence that should be addressed in a company alcohol and drug policy. It is important for everyone's health and safety that consequences are enforced.
- Horseplay must not be tolerated around operating drilling machinery. Fighting must not be tolerated at any time. These offences should be addressed in a company conduct policy. It is important for everyone's health and safety that consequences are enforced.
- Walk – do not run – in drilling and work areas. Haste frequently contributes to accidents.
- Employees may only use firefighting equipment for the correct and intended use (e.g., water hoses, compressed air hoses, electrical tools, hand tools). Such equipment must never be used for pranks or practical jokes. Do not clean clothing with compressed air as air, dirt and grit may be driven into your skin, or eyes.
- All employees and contractors are required to adhere to regulations of the AHJs and company guidelines or policies related to the use of (1) firearms and (2) the recreational use of company vehicles, ATVs, snowmobiles, boats etc., including license requirements.

20.4.7 Site Visitors

No visitors should enter or remain at the drill site without a work-related reason.

- Visitors to drill sites should receive a safety induction so they are aware of and understand the hazards and keep clear of all operating machinery. A trained and experienced employee (such as a supervisor) should always accompany all visitors if they must approach operating machinery.
- Visitors must wear required PPE.
- Visitors should view samples and core only in an area well clear of operating drills, cyclones, compressors and high pressure water or air hoses.
- Visitors should park vehicles in a designated area well clear of the drill site.

20.5 Guidelines for Safe Work Practices

Companies should develop safe operating procedures (SOPs) that include the use of personal protective equipment (PPE), fall protection when working at heights, good housekeeping practices and manual handling and lifting practices. While there are additional topics that SOPs

should cover, it is important to address these issues as many injuries are associated with these activities.

20.5.1 Personal Protective Equipment (PPE)

All employees must use the correct PPE as specified by regulations, company and contractor SOPs, chemical warning labels, materials safety data sheets (MSDSs), or specific hazardous site conditions.

- All personnel within 30 m (100 ft) of an operating drill or operating ancillary equipment (skidder, bulldozer, pump etc.) must wear and use all required PPE. Display appropriate signs that indicate PPE is mandatory. For some work, special PPE may be required (e.g., fall arrest equipment or special protective clothing).
- PPE: Inspect PPE frequently and maintain it in clean, good working condition. Select PPE carefully – if it fits poorly or is uncomfortable, it may not function correctly and it may be ignored. Replace damaged or worn PPE.
    - Head protection: Hard hats must be government approved. Use add-on sun brims in very sunny locations. Use hard hat liners for cold weather but make sure the hard hat is properly adjusted and fits correctly.
    - Foot protection: Safety boots should be sturdy and have steel-capped toes. Soles should be in good condition.
    - Eye protection: Approved safety glasses with side shields must be worn at all times by all personnel at a drill site. Combination sun/safety glasses may help promote the use of eye protection. Notify the supervisor if you wear contact lenses. Generally, contact lenses should not be worn at the site; workers who require corrective lenses should wear prescription safety glasses, or safety glasses designed to be worn over regular prescription glasses.
    - Hearing protection: When the drill is operating, always wear correctly fitted earplugs and/or earmuffs correctly rated for the noise level. Double hearing protection should be used when noise levels are above 105 dB(A). The risk depends on the intensity of noise and length of exposure. While most cases of industrial deafness are due to years of exposure to moderate noise levels, hearing may be permanently damaged by exposure to very high noise levels for relatively short periods. Do not neglect to wear auditory PPE.
      Personal entertainment devices should not be worn for many reasons, including the fact that ear plugs or headphones do not provide hearing protection. Refer to section 4.2.4 Hearing Protection.
    - Respiratory protection: Wear suitable respiratory protection in the vicinity of any drill using compressed air as the circulation medium, when processing dry samples and when working in dusty conditions. Project managers should be aware of jurisdictional requirements for respiratory PPE. Seek professional advice if necessary. While dust masks may provide acceptable protection, certain working conditions may require a respirator that must be fit tested. For example, disposable filter-type dust masks do not provide adequate protection in the presence of high concentrations of hazardous atmospheric contaminants such as silica, asbestos or coal dust. Regular dust masks are meant to protect against sawdust and are entirely inadequate. Do not neglect to wear respiratory PPE.
    - Hand protection: Properly fitting gloves reduce hand injuries, which are one of the most common lost time injuries at drill sites. Wear appropriate gloves to handle core trays and chemicals etc. Drillers should wear close-fitting gloves

when handling drill rods, winch cables and ropes etc. A variety of gloves that provide various types of hand protection (cut resistant, chemical resistant, insulated) should be available on every work site. Wear warm gloves/mitts when working outside the drill shack in winter conditions.

  - Fall protection: A full-body harness and shock-absorbing lanyard is mandatory when working on the drill mast. Make sure the lanyard is set so a fall is stopped short of the ground. See section 20.5.2 below.
  - Clothing: Some jobs may require special clothing worn only at the drill site (e.g., for radioactive, asbestiform or other hazardous minerals). All employees should wear suitable work clothing for warm or cold climates. Wear overalls, jackets and hardhats with high visibility reflective strips. Reflective vests should not be worn in the drill shack and immediate vicinity of the drill due to the risk of entanglement. NEVER WEAR loose, unbuttoned, torn or ragged clothing, loose gloves with wide cuffs, jackets or "hoodies" with drawstrings, lacings or straps, loose boot-laces, unrestrained long hair, necklaces, rings or other jewelry. Injuries from being drawn into moving machinery are often serious or fatal.

- Refer to Section 4. Personal Safety for additional information regarding PPE.

20.5.2 Working at Height – Fall Protection

Unrestrained falls due to improper fall protection have been the cause of fatalities and serious injuries. Comply with the regulations of the AHJs regarding the use of fall protection. When drilling employees climb the drill mast they are required to wear and use fall protection equipment. If working in an area where there are no regulations, the exploration company should implement stringent fall protection standards and enforce them.

A fall protection system may be required (1) for work that could result in a fall of over a certain specified height (1.5 m is usually specified) or (2) to prevent a fall from a lower height that could result in injury greater than the risk of injury from the impact on a flat surface (i.e., working over dangerous equipment or objects). A fall protection system includes both a travel restraint system[4] and a fall arrest system. Travel restraint and fall arrest equipment must meet CSA standards and approved engineering standards.

- A travel restraint system *prevents* an employee from approaching an unguarded edge. A work-positioning system includes the use of a body belt or full-body harness attached to a lifeline and anchor, which is set to a length that prevents a worker from approaching a hazard. A travel restriction system prevents a worker from falling from a hazardous edge (e.g., guardrails, guards or protective barriers). Guardrails must be built to meet regulations of the AHJs. They must be high enough to prevent a fall and strong enough to bear the employee's weight during a fall. Guardrails are required to have mid-rails and toe boards.
- A fall arrest system protects *after* a fall so you stop before hitting the surface below. A fall arrest system requires a full-body harness and shock-absorbing lanyard or lifeline and a secure anchorage. The lanyard must be a length at full extension that will prevent impact on the surface below.
- A written fall protection plan may be required for employee safety. Components include but are not limited to:
  - Risk assessment and identification of fall hazards at the site

[4] Also referred to as a fall restraint system

  - Training: Before employees are permitted to work at heights, they require training regarding (1) when fall protection is required, (2) the fall protection systems used at the site, (3) instruction and training regarding both the use of correct fall arrest equipment and (4) the rescue of a fallen worker who cannot initiate self-rescue.
  - Appropriate training also includes inspections, maintenance, cleaning, storage, and the removal from service requirements of fall protection equipment.

- Inspect all fall protection equipment each time before use – including new equipment. Check for damage, discolouration, wear, insecure fastenings, ripped stitching etc. When receiving new equipment, check out *every* detail to make sure it is correctly assembled. Just because it is new does not mean it is perfect quality. Check that all stitching is present, all clips and clamps are securely mounted etc. Lanyards and harnesses have expiry dates, usually five years after the date of manufacture.
- Do not reuse fall protection equipment that has arrested a fall. The equipment may have been stressed so it no longer functions properly.
- Additional information regarding fall protection is available on the following websites:
  http://www.ccohs.ca/oshanswers/prevention/ppe/belts.html
  http://www.worksafebc.com/publications/health_and_safety/by_topic/assets/pdf/fall_protection.pdf

20.5.3 Housekeeping

Drillers should keep the drill site neat, organized and free of debris as an important ongoing part of a drilling program. An orderly site improves working conditions and reduces the risk of trips, slips, falls, sprains, cuts and more serious injuries.

- Organize the drill site to allow sufficient space for easy access to drilling supplies. Use designated areas for unloading equipment and supplies. Store them in designated convenient places where they will not become a hazard and cause injuries.
- Make sure all flooring is solid and secured.
- All hoses should be up off the floor and secured.
- Use proper signage in the appropriate places.
- Storage: Use suitable racks for storing drill rods, casing, augers and tools that prevent them from sliding, rolling or falling off. Store drilling additives, fuels and oils according to regulations and in ways that prevent harm to employees and the environment.
- Keep access ways and passages within the site tidy and free of personal items and equipment. Keep them free of grease, oil, ice, mud and other slipping and tripping hazards. Keep work areas and passageways well lit, especially at night.
- Keep areas near emergency equipment clear at all times (e.g., fire extinguishers, hoses and emergency PPE).
- Keep the drill mast free of loose objects at all times.
- Clean and return tools and equipment to their proper storage space. Tools left lying around create a tripping hazard and get damaged or lost.
- Roll up hoses, cables, slings and extension cords and other items that may cause tripping hazards after use. Store them correctly. Replace worn or damaged hoses and cords.

- Remove garbage from the drill site regularly (each shift). Regularly dispose of it in designated containers according to local AHJs. Do not burn garbage unless permitted. Place oily rags in sealable metal cans – not with other garbage.
- Keep the drill platform flooring stable and free of debris, oil and mud etc. There should be no nails sticking out or holes that could cause injury. In winter, do not allow ice to build up on drill platforms, steps or drill equipment.
- All steps must be safe – securely built, kept free of objects, cleaned of grease, ice and other slippery deposits. Where feasible, all steps should have secure handrails.
- Keep ladders free of mud, ice etc. Use ladders only for their designated purpose. Secure them carefully at the top and keep the area around the base and top of the ladder clear of unnecessary items. When moving ladders, especially aluminum ladders, beware of overhead electrical wires and never allow them to touch exposed electrical conductors.
- Barricade or rope off any unsafe working areas. This includes sumps, areas with drilling muds and hose discharge areas.
- If drilling mud is used, minimize the spillage of mud as it can cause very slippery conditions. Even a minor mud spill immediately becomes a slipping hazard.
- Good housekeeping is mandatory wherever core saws are used, as water-laden dust that covers the floor, clothing and machinery will dry out allowing the dust to become airborne and respirable.
- Cover materials to protect them from weather, as required.
- Immediately clean up any leaks and spills according to regulations and company environmental guidelines. Understand and follow the regulations regarding reportable spills. Keep appropriate spill containment kits at appropriate places. Immediately cover over a spill area with a non-slip material to prevent slips and falls.

20.5.4 Manual Handling

Note: For exploration personnel, most manual handling injuries occur when handling bagged samples or heavy core trays. Most drill related injuries to drill crews occur while handling drill rods or using tools.

Plan the drill site layout carefully to eliminate manual handling as much as possible. Identify and eliminate the high risk tasks and encourage the use of mechanical lifting and handling devices.

- Follow correct lifting procedures.
    - Do not lift heavy loads unaided. Use hand trucks and trolleys etc., or get help – including for fully loaded core boxes.
    - Do some warm up exercises when a job requires lots of lifting and use extra caution if lifting is necessary when it is cold or you are tired; fatigue increases the likelihood of back strain or injury.
    - Take your time and take frequent rest breaks when performing continuous, strenuous tasks or lifting (e.g., moving core boxes, tripping rods and casing).
    - For safe lifting procedures, refer to section 4.3 Lifting and Back Protection.
- Storage areas should facilitate both manual handling and the movement of personnel around the site. Materials should be easy to access and stow away.

- Store materials according to requirements of AHJs, which may include specified distances between certain materials, fire walls and special ventilation.
- Organize tool storage and label storage bins.
- Store heavier items on lower shelves but not necessarily on the lowest shelf.
- The contractor should provide safe racks to stack and secure all rods, casing and drilling stores so they cannot roll or be knocked down. Place racks on stable ground.
- Be alert for slipping or tripping hazards when lifting or moving heavy items. Identify and eliminate the hazards.
- Use gloves when handling core trays. Drillers and helpers should use gloves for handling wire rope and drill rods etc.

20.6 General Hazards Associated with Drills and Specific Equipment

Drill site employees must be fully informed regarding relevant drilling methods and sampling procedures. While most tasks related to drilling are the responsibility of drillers, the company employees (geotechnical, samplers and project geologists) who work around the drill need to be familiar with the drillers' work so they can spot hazards, risks, report problems to the contractor's supervisor, as well as take responsibility for their own safety.

The following publications are additional sources for information regarding drilling safety:

Canadian Diamond Drilling Association: *Safe Work Methods Surface Handbook*

Environmental Remediation Drilling Safety Guideline:
http://www.riskworld.com/nreports/2005/ERDSafetyGuidelines.htm

Exploration Drilling Hazards Checklist:
http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/178720/IGA-003-Exploration-Drilling-Hazard-Checklist.pdf

20.6.1 General Safety around Drill Sites

- Exclusion zones: It is advisable to establish an exclusion zone around hazardous areas of the drill rig and associated machinery. Exclusion zones (for people other than the drill crew) might include the drill shack during drill operations and should include the drill mast area, rotating drill rods, unguarded moving parts, compressors, high pressure air and hydraulic hoses, sample discharge hoses, high pressure water pumps, mud pumps, and wherever drill rods are being handled or hoisted. Exclusion zones should also be established where ground is slippery from the use of drilling products and the air is dusty or contains harmful products. Inform all employees and visitors of the exclusion zones through a site safety induction. Each zone should be pointed out at the drill and again whenever circumstances indicate a review is necessary. NO ONE – drilling crew, company employees and visitors – should enter an exclusion zone without a work-related reason. Everyone is required to wear appropriate PPE.
- Do not distract or speak with the drill operator during rod changes and while the drill rods are rotating. Request the driller to stop the drill when it is necessary to hold discussions or inspections. Make sure you are seen and approach from a direction that eliminates the need for anyone to cross in front of rotating drill rods, which is especially important when drilling inclined holes.

- Be vigilant and stand back at least the height of the drill mast, especially during hoisting, handling or changing drill rods. Rods sometimes fall from the mast.
- Always avoid walking near the rotating drill rods – a slip or fall could be fatal.
- Drills are very noisy so it is advisable for everyone who works around the drill rig to use standardized and universally accepted hand signals (that have been discussed and verified between all parties) for communication regarding operations if radio communication is not available.

20.6.2 General Safety Tips Regarding Drilling Methods

Drillers are responsible for working safely, but the company geologist or person in charge should be familiar with the drillers' work in order to assess whether safe work procedures are being used. The geologist should be prepared to make unannounced visits to the drill to audit whether safety guards are in place during operation and whether contractors are wearing appropriate PPE. Tolerating infractions of safety rules may leave the geologist or project manager partially liable if there is a safety incident.

- Only authorized contractor employees are permitted to operate, drive, climb, work on, repair or service a contractor's drill rig, vehicles or equipment. Operators must be qualified and fully trained.
- Drill stability: Do not operate the drill before it is levelled and securely anchored. Operate the drill from the operator's station and do not leave the controls while the drill is running. Stop the engine for discussions.
- Lock out the drill before carrying out maintenance – don't just shut it down. Never carry out maintenance while the drill is running. Replace all guards for moving parts etc., after maintenance is completed. Complete the maintenance log.
- Working at heights: A full-body harness must be worn and anchored when working on the mast. The wearer should inspect his/her harness each time it is used. See the previous section 20.5.2.
- Tower erection:
    - A fall arrest system is required by those working on the tower.
    - Proper working platforms must be used during tower erection.
    - Lay out all materials in an orderly manner to provide for an efficient and safe operation.
    - All tools used in the tower construction must be secured.
    - All material being raised on the mast must be tied securely so there is no danger of ropes becoming undone or objects falling.
    - Drill towers are raised by hydraulic rams. They require support by braces, stays or mast locking pins, as this provides a backup in the event of a hydraulic failure.
    - Secure the mast by guy lines if applicable.
    - Provide lighting at the mast as required.
- Tools:
    - Use the correct tool for its intended purpose. If it isn't working properly, it probably isn't the correct tool.

- Securely store all hand and power tools in their designated storage place. Cover knife blades and other sharp objects and store them separately.
- Do not climb the mast, ladders or to heights while holding tools. Use a tool hoist or a bag. Never leave tools unsecured in the helper's bag.
- Never leave tools where they might be knocked down or fall onto a person (e.g., overhead work spaces, on ladders). Do not throw or drop tools and do not leave tools on the ground.
- Never store a pry bar sticking into the ground as serious injury may result if someone falls onto it.
- Replace worn tools; watch for worn jaws on pipe wrenches.

- Drill rod safety: The immediate area around rotating drill rods is exceedingly dangerous regardless of the drilling method. Injuries are usually serious and often fatal when workers (or clothing) become drawn into or entangled in rotating drill rods. Although some guards exist, effective guarding of rotating drill rods is difficult to achieve.
  - Drill rods should not be lifted and placed against the mast unless they are securely held. There should be a safe means for safe vertical storage or lay them flat in a safe place.
  - When a driller or helper is handling drill rods, they should:
    - Wear gloves.
    - Never let rods slide through their bare hands. Rods may have small metal burrs that will cut hands badly.
    - Never grab a drill rod while it is rotating – even when wearing gloves or when greasing the rods.
    - Keep their hands clear from the pin and box ends to avoid fingers being pinched or severed. Never place fingers or hands over the end of an open rod when they could become pinched between the rod and something else.
    - Never reach behind or around rotating drill rods for any reason.
    - Never touch a frozen rod with bare hands.
  - When a driller or helper is handling core barrels or geotechnical soil sample tubes, they should:
    - Wear gloves.
    - Never place their hands over the bottom of the core barrel and inner tube when inserting or removing it from drill rods, augers or casing.
    - Keep hands away from the sharp ends of the split spoon or Shelby tube – only hold the mid portion of the tube.
    - Use a mechanical means – water or mud and not compressed air – if it is necessary to pump core or soil samples from core barrels or sampling tubes.
    - Beware of the weight of drill core in the core tube especially when handling rock with high density such as massive sulphides. This also applies to core boxes with high density rock.

- When a lightning storm threatens, shut the drill down and move all personnel to a safe location because the drill mast may act as a lightning rod. Lower the drill mast if time permits. Refer to section 9.2 Lightning.
- Do not operate truck mounted drills during high winds or any drill when there is insufficient light.

20.6.3 Specific Hazards Regarding Drilling Methods

Depending on the job, different drilling methods and equipment may be required – each with its own hazards that samplers should be aware of. In mineral exploration, the commonly used drilling methods are: diamond drilling, reverse circulation (RC), air core, rotary air blast (RAB) and auger drilling.

20.6.3.1 Specific Drilling Methods

Diamond drills

- Diamond drills are used for core recovery. Core boxes are heavy and require careful lifting and handling to avoid back and hand injuries (e.g., massive sulphides). Core boxes should be designed to hold safe weights of core, taking into account the core diameter.
- Drills with automated drill rod handling equipment offer increased safety over rigs where employees must handle the drill rods.
- Always avoid placing any part of your body near the wireline drum while it is rotating. Never touch the cables on the rig that haul core barrels or logging tools as they may move at any time without notice. Drums and winches should always be guarded.
- Many modern diamond drills use hydraulic systems. Hoses and hose couplings should be properly secured with whip checks or safety chains because hose and coupling failure is a serious hazard. Restraining cables or safety chains should be used for hose/water swivel connections at the top of the drill stem to restrain the hose in case of failure.

Reverse circulation (RC) and air core drills

Reverse circulation is a drilling method that provides rock chips for samples. Compressed air, sometimes with water, mud or a foaming agent is blown down the outer section of a double wall drill pipe and rock chips are forced up the inner tube. The capacity of the air compressor determines the speed and depth of the drilling as well as the rate at which cuttings are obtained. The larger the compressor, the greater the risk of injury from blown hoses. When failures occur, the higher pressures may cause severe consequences – serious injuries or fatalities. Hazards related to RC drilling include the following:

- Dust – a serious hazard due to the volume of compressed air employed and expelled. The cyclone should be set up downwind from the primary working areas around the drill and unless necessary; no worker should linger near the cyclone while the drill is operating. Everyone who works around the drill rig should be supplied with the proper respiratory protection and use PPE when working around the cyclone or drill collar.
- High noise levels: Wear hearing protection.
- Blown hoses may result in severe injury when high pressure air lines burst due to blockages or come uncoupled. See section 20.6.3.6 below.
- Explosions associated with booster compressors

- When approaching an RC drill, do so away from the collar blow-out pipe to avoid being hit by flying rocks or foam, if used. Normally, a long PVC pipe or hose diverts the discharge away from traffic areas, people and machinery. The area should be an exclusion zone that no one enters except to take samples.
- Cyclone hazards: Rock chips are ejected at such speed that a cyclone is required to separate the rock cuttings and dust from the return air. Samplers must be aware of the hazards:
    - Dust, vibrations and high noise levels are common hazards.
    - Make sure cyclones are firmly secured with safety restraints. If a cyclone breaks loose, the high air pressure can propel it away from the drill potentially causing serious injury to a sampler or anyone in its path. In addition, the return hose connection to the cyclone must be restrained with whip checks to prevent the hose whipping out of control and impacting anyone nearby.
    - Keep hands clear of the rim and the inside of a cyclone. NEVER reach up into the cyclone to retrieve a sample bag or clear a blockage as the knife valve may close and sever your fingers.
    - Either dry or wet samples may be taken from cyclones. Develop and follow appropriate SOPs for the sampling procedures.
    - When cleaning or maintenance work is done on a cyclone, the knife valve MUST be locked out and the air pressure turned off.
    - Wear respiratory PPE, eye protection, hearing protection and steel toed boots that provide good traction. The sampler should obtain samples quickly and leave the area.

Rotary air blast drills (RAB)

RAB is a dry drilling method. Compressed air circulates down the drill hole to remove cuttings that are blown up outside the drill rods and collected on the surface.

- Wear respiratory PPE, eye protection, hearing protection and steel toed boots that provide good traction. The sampler should obtain samples quickly and leave the area.

Auger drills

Augers are used for drilling through soils and unconsolidated sediments to take geochemical and alluvial mineral samples. Handheld augers are also used for soil sampling and test holes to measure ice thickness.

- Many of the principles of working with drill rods apply to working with augers. Auger flights are very sharp and cuts are common. If loose clothing is caught, the operator can be drawn into the rotating flight resulting in serious injury or death. Augers that drill through buried geotextile etc., can pull the operator off his/her feet and into the flight unless the drill is operated from a platform.
- For large augers, use tool hoists to handle auger sections whenever possible.
- Use a long-handled shovel to move auger cuttings away from the auger. Never use your hands or feet.
- Refer to sections 5.4 Augers and 15.10.4 Ice Testing Equipment for information about working with handheld augers.

20.6.3.2 Exposed Machine Parts

- Guards should be placed over:
  - All accessible moving parts e.g., rotating drill rods, pulleys, gears, shafts and belts, winches, unguarded pull-down sprockets or sheaves
  - Hot machinery parts, when possible
- Make sure machine guarding does not present a hazard (i.e., loose enough to catch clothing, sharp edges).
- Pinch points or nip points: Most “caught between” or “drawing-in” injuries involve drill rod handling, rotating drill rods, rod wrenches, rod clamp jaws, pull-down cables, pulleys, drive belts and sheaves, or pull-down chains and sprockets.
- Auger blades cannot always be guarded. They are very sharp and can catch and draw in loose clothing.

20.6.3.3 Mechanical Failures

It may be difficult to detect early signs of mechanical failure. Mechanical failures are less likely to occur when drill crews are properly trained and they adhere to the manufacturer’s recommended maintenance and inspections schedules. Keep accurate maintenance log books and store them in a secure place, as they are useful in an accident investigation.

- The failure of machinery, components and tools etc., may result in serious impact injuries and/or death. Examples include structural cracks in the mast that cause it to collapse, metal fatigue in tools such as stilsen wrenches (powered rod wrenches) and the ejection of failed parts such as fan blades.
- Specify a requirement in the contract that only engineered and inspected towers may be used; confirm this through an inspection before drill operations commence.
- Welds: Make sure all welds made in a shop or at the drill site conform to the manufacturer’s specifications and standards.
  - Drillers should make sure that any welds made in a camp are done by a qualified person. Do not use “camp welded joints” for operations where safety is critical, such as for slinging or lifting.
  - Do not sling or lift heavy objects by parts (e.g., welds) that are not designed to take the weight.

20.6.3.4 Hydraulic Systems

Nearly all drills incorporate some form of hydraulic system. To reduce risks, contractors should make sure that (1) hydraulic pressures do not exceed the manufacturer’s recommendations, (2) hoses are inspected frequently and properly secured, (3) damaged hoses or couplings are replaced immediately, (4) replacements are correctly pressure-rated and compatible with hose fittings being used and (5) applicable safety guards are properly installed and used. Guards should be engineered – not “homemade” or constructed in camp. There are risks with homemade guards including failure due to poor welding, improper protection, and in fact they may increase safety hazards instead of reducing them.

- Loads: Never stand under any object being lifted or held up solely by hydraulic cylinders (rams). Set the load down prior to turning off the machine to relieve pressure from cylinders, components and hoses.
- Hydraulic failure can produce projectiles such as whipping hose ends, loose fittings, or streams of pressurized and/or hot oil. See the section on hose safety below.
- Pinhole leaks: Never try to find a leak in a hydraulic hose with your hands. Use a soap solution or piece of cardboard. The escape velocity of hydraulic oil from a pinhole leak can penetrate the skin and enter the blood stream, which may cause serious infection leading to gangrene, amputation or death.
- Burns: As hydraulic systems generate considerable heat, a burst hose can spray hot oil or water and cause severe burns.
- Fires and explosion: Leaks of hot hydraulic fluids (especially a mist) can cause a fire and/or explosion when sprayed onto hot machinery.

20.6.3.5 Compressed Air Systems

Compressed air is used as the circulation medium for reverse circulation (RC), rotary air blast (RAB), air core, and rotary percussion drilling. Failure of a high pressure hose or hose coupling may cause the hose to break away with explosive force and thrash about; a sample discharge hose that fails may eject rock chips. The impact from any of these may result in serious injury or death. Because of the complexity of compressed air systems, exploration companies usually rely heavily on the standard of the contractor's maintenance and inspection procedures to manage the risks and hazards of compressed air systems.

- Establish an exclusion zone around all compressors and high pressure air hoses. Train all employees to understand the destructive capability of breakaway high pressure air line hoses.
- Compressors discharge compressed air intermittently and whenever a compressor shuts down. Surface dust or gravel may be blown up from the ground. Stay away as you won't know when this may occur.
- All air compressors must be equipped with a fully operational pressure relief valve. All air hoses must be fitted with safety chains or whip checks at both ends.
- Never direct compressed air toward the body or use it to clean clothing. If air is forced through the skin, air bubbles may enter the blood and cause an embolism, which can be life-threatening.
- Do not use compressed air to pump core from a triple-tube core barrel.

20.6.3.6 High Pressure Hoses

There is potential for any pressurized hose to fail if the external surface is deformed, cut or damaged. Even a minor cut may lead to rust and corrosion of the internal wire braiding. Hoses subject to internal blockages may fail without warning.

- To prevent hose damage:
    - Hoses should have no twists, kinks or bends.
    - Each hose should be the correct length – long enough to flex, but not too long.
    - Do not place hoses under tension.

- Do not permit hoses to rub or abrade against other objects. Use wraps (snakeskin) on hoses in high wear areas, including where subject to vibration wear.
- Do not drive over pressurized hoses.

- To prevent hose failure:
  - Always check that hydraulic hoses and couplings are correctly installed. To be safe, hoses, clamps and couplings must match and lock completely into the stem groove as shown below. The coupling assembly should never contain mismatched parts. Company personnel should be able to identify incorrectly fitted hose couplings. They should observe hose couplings and hose conditions during their work operations as part of proactive safety behaviour.

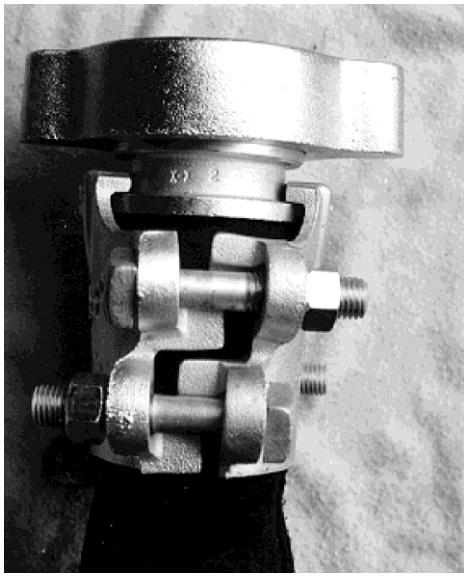

Figure 20.4: Hose clamps are locked correctly into the stem groove.

  - Contractors are required to carry out regular safety checks on all air hoses, sample hoses, hose couplings and hose restraining devices (whip checks).
- Do not hold a discharge hose or place your feet near them. A coiled hose may suddenly whip out of control and the impact can cause serious or fatal injuries.
- Whip checks: Always make sure whip checks, safety chains or restraints are securely attached to each end of high pressure hoses. Stocking type whip checks are recommended because they provide the best protection (see below). Two cable stocking type whip checks – one at each end – are recommended.

Figure 20.5: Standard whip check (left) and cable stocking whip check (right) © Bill Mitchell

20.6.3.7 High Pressure Pumping Systems

- Although most supply pumps do not pump at high pressure, some supply pumps are required to pump at high pressure if the lifts are extreme. Pressures can reach 400-500 psi if the lifts approach 300 m and a high pressure waterline is employed. A surge tank on the pump is recommended.
- Pressure relief (PR) valves. High pressure pumps, especially the triplex circulation pump, may explode if they lack a functioning pressure relief (PR) valve. At the start of all drilling programs, have the driller demonstrate that all pump PR valves actually open at the preset relief pressure under operating conditions.
- Establish an exclusion zone around high pressure mud and water pumps.
- Locate water pumps at least 5 m from the banks of a lake, a permanent or intermittent water course. Install them to prevent spills of fuel or lubricants. It is advisable to set them up in a berm and over a metal pan to catch drips when fuelling.
- Make sure a spill kit and absorbent media are present at the supply pump to soak up any hydrocarbons from the drip pan.

20.6.3.8 Fire

Fire is always a hazard, as drill sites contain many combustible materials. When the location is dry or very cold, fire is an even more serious risk. Whenever possible, clear the drill site of material such as long dry grass.

- Comply with the jurisdictional requirements for firefighting equipment. Depending on the minimum required equipment, it may be advisable to supply additional or larger fire extinguishers.
- One of the greatest risks of potential fire and explosion occurs when a mist of hydraulic fluid from a pin hole leak comes in contact with the open flame of a drill shack heater. External heaters, remote ignition or double walled stoves may reduce this fire risk.
- Leaking or broken fuel lines and ruptured hydraulic or compressor oil hoses may cause fires. Make sure the drill engine exhaust exits the rig or drill shack so it is not near combustible material. Consider placing spark arrestors on engine exhausts in hot, dry weather.

- All drill sites and camps are required to have the appropriate equipment and procedures to address local fire risks (e.g., forest fire, brush fire, grass fire). Keep informed about local fire hazard ratings.
- Mount approved fire extinguishers in readily accessible places (near exit) to fight a fire and escape. It is advisable to have two clearly labelled ABC type 9 kg (20 lb) fire extinguishers at the drill although AHJs may require only one smaller extinguisher. Fire extinguishers are required at oil storage locations, water pump shacks, on all support trucks and personnel vehicles. Check extinguishers regularly and recharge them immediately after use. Know the location, limitations and use of all firefighting equipment at the site (refer to section 18.4.2 Fire Safety).
- Follow safe smoking rules. Do not smoke or allow open spark producing equipment within 15 m of drill equipment, fuels, fuel storage areas etc.
- Isolate fuels, oils and gas cylinders in a cleared designated area. Do not store empty or full containers of flammable liquids within 15 m of drill rigs, pumps and other machinery. Secure all tanks and cylinders to prevent tipping over.
- Pay strict attention to the safe use and storage of flammable materials (refer to sections 20.7.4 Hazardous Materials and 18.4.5 Fuel Handling).
- Never fuel engines, machines, or heat sources while they are running. Allow mufflers, exhaust pipes and hot components time to cool off before fuelling.
- Keep engines free of excessive dirt, grease, oil, spilled fuel and accumulated leaves, twigs or other flammable material.
- Pay special attention to safe handling of wood or oil stoves, propane tiger torches and electrical wiring in drill shacks, as these items may easily start a fire.
- Do not hang wet clothing to dry where they may catch fire, including near lanterns, over oil stoves or heaters, or draped over electrical cords strung from the ceiling.
- Do not leave fires unattended, including camp fires.
- Keep a fire extinguisher nearby when maintenance is carried out. Do not weld or perform maintenance using a heat source near the fuel or oil system of machinery, including compressors.

20.6.3.9 Waterline Heaters

Waterline heaters have the potential to cause fires if they are not operated correctly. Follow instructions in the manufacturer's operator manual. Some tips:

- The fire box must be set up away from the motor end of the pump.
- At least four lengths of stove pipe should be used for a smoke stack.
- If the pump stops, shut down the fire as quickly as possible to avoid overheating the copper coil.
- When shutting down the coil, make sure the fire is nearly out before shutting down the pump. If the coil is dirty, it may burn for a considerable time after the oil is shut off.
- Adjust the amount of oil going into the burner so there is no smoke coming out of the smoke stack. If it is smoking, you are causing the coil to become dirty, which will insulate the coil and keep it from absorbing the heat. Also, if too much fuel is fed, the unburned fuel may leak out of the heater and cause a fire hazard.

20.7 Health Hazards

General health issues are addressed throughout this section. In addition:

- Keep the drinking water supply in a clearly marked, clean and closed container at the drill site and in sample handling facilities. Drink this water only. Provide clean cups for drinking purposes. Keep potable water clearly separate from water that is not potable.
- Provide soap and water and hand sanitizer to prevent the spread of disease and infections.

20.7.1 Noise

Noise hazards are covered in previous sections. The most important points are:

- Wear appropriate hearing PPE when working at or near the drill. See section 20.5.1 above.
- The driller should temporarily shut down when it is necessary to hold discussions.
- Wearing personal entertainment devices including iPods and MP3 players with earphones should never be permitted while operating or working around the drill, when driving heavy equipment, or when working in sample processing areas. For detailed information on this subject, refer to section 4.2.4 Hearing Protection.

20.7.2 Respiratory Hazards

Dust may be a serious problem when working around drills using compressed air circulation and when processing samples.

- Wear approved respiratory protection as required and change the filters frequently. Make sure respirators are fit tested regularly; keep appropriate records. See section 20.5.1 above and section 4.2.7 Lung Protection.
- Stand upwind whenever drilling additives (powders) are used.
- For additional information, see sections 20.7.4.1 Silica Dust and 20.7.4.2 Asbestos and Amphiboles (below). For information about dust control at drill sites refer to section 10.9 Dust on the e3 Plus Excellence in Environmental Stewardship Toolkit at: www.pdac.ca/e3plus

20.7.3 Radioactive Mineral Sampling and Storage

Extensive safety information is located in Section15. Guidelines for Radiation Protection during Exploration for Uranium in the e3 Plus Excellence in Environmental Stewardship Toolkit at: www.pdac.ca/e3plus.

20.7.4 Hazardous Materials

Some substances used at drill sites require caution, training and/or PPE when used. All employees should receive general WHMIS training and site specific WHMIS training that addresses the hazardous materials they work with or risk exposure to (refer to section 18.1.4).

Workers should be familiar with the appropriate Materials Safety Data Sheets (MSDSs) and follow the specific instructions for PPE, storage, handling, first aid, spill response and disposal specifications. Jurisdictional regulations require that workers have access to MSDSs. In addition to electronic copies, it is advisable to keep paper copies of MSDSs in a binder where products are stored and in a central location (e.g., drill shack or drill truck).

Workers should read the MSDS before handling a product for the first time, as they contain information about PPE, safe handling and storage, first aid and more. Should exposure occur and medical treatment be required, take a copy of the MSDS sheet to the hospital so the medical personnel know what product is involved. Correct treatment can begin sooner. Train employees to know that hazardous substances can enter the body through:

- Breathing (inhalation)
- Contact with skin or eyes
- Swallowing (ingestion)
- Direct contact through injection (e.g., compressed air or hydraulic pinhole leaks)

20.7.4.1 Silica Dust

Exploration employees are exposed to airborne silica dust during core splitting, rock cutting, drilling, rock crushing activities etc. Freshly fractured silica is more reactive than old silica dust and both long term and heavy short term exposure to airborne silica affects the lungs. Silica dust is carcinogenic and long term exposure may result in silicosis, a fatal lung disease. Use the following methods to reduce employee exposure to silica dust:

- Engineering controls: Use local exhaust ventilation or water spray systems to reduce dust levels. Restrict access to work areas so no one may enter without PPE.
- PPE: Provide and require the use of appropriate PPE such as respirators and protective clothing.
- Training: Inform workers about the dangers of silica exposure, how to use dust controls and PPE, proper wet cutting methods and proper wet clean-up methods.
- Supervisors should make sure employees follow SOPs, use PPE and follow training protocols, including the use of correct wet methods for cutting and cleanup.
- It is advisable to reduce exposure limits to silica dust from the threshold limit values (TLVs) in situations where exposure exceeds an 8-hour workday and a 40-hour workweek. This is common practice in many field camps.
- Because you breathe more rapidly at high altitude, exposure to silica and other airborne contaminants and gases may be greater than at lower elevations. Companies should work to reduce the risk of exposure.
- For large projects, it may be advisable to develop and implement a silica exposure plan. An effective plan includes: purpose and responsibilities, risk assessment, controls, education, training, written safe operating procedures, washing or decontamination facilities, health monitoring and documentation.

Information regarding respirable crystalline silica is available at the following websites:

http://www2.worksafebc.com/i/posters/2009/WS%2009_04.html
http://www.worksafebc.com/publications/health_and_safety/by_topic/occupational_hygiene/default.asp#silica
http://www.msha.gov/alliances/formed/IG103.pdf

20.7.4.2 Asbestos and Amphiboles

Asbestiform minerals: Work with asbestiform minerals can release very small sharp mineral fibres that become embedded in the lungs. The fibres are carcinogenic. With sufficient exposure (long term or heavy short term), employees may eventually develop asbestosis, mesothelioma and other forms of lung cancer. Exploration companies must be aware of and comply with jurisdictional OHS regulations regarding exposure limits to asbestiform minerals (which includes all amphiboles minerals in some jurisdictions). Regulations may stipulate core shack set up, ventilation specifications, required PPE including respirators and separate work clothing that must be washed and kept only for core logging purposes. For example, Québec has specific regulations regarding asbestiform and amphibole minerals.

Refer to Québec regulations O.C. 885-2001, s. 42. and s. 66 and s. 67 at the following website: http://www.canlii.org/en/qc/laws/regu/oc-885-2001-2001-go-2-3888/latest/part-1/

To protect employee health, it is advisable to set up sample handling facilities with the following features:

- Equip facilities with high quality ventilation systems.
- Use wet core saws rather than dry splitters.
- Provide asbestos rated dust respirators, as required.
- Provide clothing such as overalls that are kept and laundered at the facility, as required.
- Provide a floor surface that is easily cleaned. Maintain clean facilities and use wet mopping techniques and/or a compound that keeps dust down.

20.7.4.3 Drilling Additives and Fluids

Chemical drilling fluid additives may be used by contractors to alter the physical properties of drilling mud. Most are highly alkaline and can cause skin burns and eye injuries. Follow the MSDS directions for handling and storing drilling additives. Drilling and exploration companies should endeavour to always use environmentally friendly drilling additives, for example, those that are biodegradable.

- Stand upwind when additives are used to avoid breathing the particles. Wear a dust mask or respirator; wear goggles to prevent dust entering your eyes.
- Store the following chemicals in the correct space and conditions – keep them dry. Make sure all bags and containers are correctly labelled.
    - Potassium chloride, potassium hydroxide and soda ash may be used to increase pH levels.
    - Sodium chloride (common salt) is commonly used as a weighting agent to increase fluid density, to aid in drilling water-sensitive clays and shales, and as antifreeze in very cold regions.
    - Calcium chloride, which is exothermic, is used to prepare low solids high-density drilling mud for use in permafrost.
    - Sodium bicarbonate is used to lower pH and treat cement contamination.
- Two-part chemical foam mixes are widely used in RC and RAB drilling to seal around the drill hole collar pipe. Follow the MSDS directions.

- Information regarding drilling fluids (drilling muds) is located in section 10.5 in the e3 Plus Excellence in Environmental Stewardship Toolkit at: www.pdac.ca/e3plus.

Caustic Soda (NaOH)

There are less hazardous chemicals available for raising the pH of drilling fluids and there is no reason to use caustic soda. It can seriously damage your skin on contact and your lungs if it is inhaled.

20.7.4.4 Other Hazardous Materials

Most of the following materials are commonly found in drill camps. Most materials are cross referenced to the e3 Plus Environmental Stewardship Toolkit. Examples of MSDSs are provided with some products.

- **A combination of developer/fixer chemicals** may be used to process films from down-hole survey cameras. The chemicals are slightly caustic so follow the MSDS directions for the specific ingredients.
- **Acids and bases:** Refer to section 10.7 Acids and Bases in the e3 Plus Environmental Stewardship Toolkit at: www.pdac.ca/e3plus
- **Antifreeze:** Refer to section 10.8 Antifreeze in the e3 Plus Environmental Stewardship Toolkit at: www.pdac.ca/e3plus
- **Bear bangers:** http://www.truflare.ca/MSDS12gaBBangers.html
- **Battery acid:** Battery acid is very corrosive. It can burn the skin and cause blindness if splashed in the eyes, or if a battery explodes when charged. Always wear eye protection. http://www.eastpenn-deka.com/assets/base/a.pdf
- **Bleach:** Bleach is used for sanitizing purposes in camp kitchens. In an emergency it can also be used to purify drinking water or for part of that process. Refer to section 12.8.3.3 Water Treatment in Remote Areas or Developing Countries.

  http://www.frontiersd.mb.ca/safety/MSDS/Imperial%20Soap/Javex-12.pdf

  http://fastweb.mrjanitorialsupplies.com/msds/0130030.pdf
- **Fuels and petroleum products:** Refer to section 10.1 Fuels and Petroleum Products in the e3 Plus Environmental Stewardship Toolkit at: www.pdac.ca/e3plus
- **Hydrofluoric acid (HF): Avoid the use of hydrofluoric acid** as it is an extremely toxic and corrosive acid. For additional information, refer to the subsection covering HF in section 20.9.6 Toxic Substances used for Mineral Identification.
- **Propane, propylene, butane, butylene:** Refer to section 10.2 Propane and Other Liquefied Petroleum Gases in the e3 Plus Environmental Stewardship Toolkit at: www.pdac.ca/e3plus
- **Solvents and paints:** Refer to section 10.4. Solvents and Paints in the e3 Plus Environmental Stewardship Toolkit at: www.pdac.ca/e3plus

20.8 Guidelines for Safe Drill Moves

Carry out a risk assessment of the route and site before all drill moves. Mitigate the risks as much as possible through careful planning, good communication and following SOPs. Follow the instructions in the manufacturer's operator manual.

Risks and hazards

- Equipment damage or loss caused by:
  - Contact with overhead hazards (power lines, tree branches, canopies of service stations)
  - Overturning or becoming stuck due to steep terrain, soft, rough or unstable ground
  - Breaking through ice
- Oversize equipment may cause collisions with vehicles, heavy equipment or obstacles when the drill is too long to safely navigate the route.
- Impact injuries caused by unsecured equipment
- Electrocution and/or burns caused by contact with overhead power lines
- Slinging accidents caused by poor planning, marginal weather conditions, poor ground conditions, lack of training, lack of or poor communication between ground staff and pilot, pilot fatigue, forceful clients or contractors who push pilots to complete the job
- Drowning or hypothermia caused by equipment breakthrough on ice (see section 20.3.3 Drilling on Ice)

Preparation and prevention

Preparation and planning are important before all drill moves. Verify that the location is adequate (e.g., slope, clearance, free of obstructions and dangerous branches). Complete site preparations before the move commences. The exploration company representative should show the foreman/senior driller the next site prior to completion of the current hole so arrangements can proceed for the move. Inspect the drill transport conveyance (skidder, truck/flatbed etc.) to make sure it is in good working order. Be vigilant while the drill move is underway**.**

For all moves:

- Carry out an inspection to make sure the drill rig and transporting conveyance, including skids, are in good condition to accomplish the move. Verify the brakes are in good working order before all moves.
- Know the overhead clearance, width, length and weight of the drill rig and conveyance.
- Never move the drill with the mast in the raised or partially raised position.
- Secure and check all loads.
- Use a spotter to assist when lateral or overhead clearance is close and when it is necessary to back up, check for power lines or when it is advisable to stop traffic.
- Remove ignition keys when the equipment is unattended. Set all brakes and locks when the move is completed.
- No passengers may ride on the drill rig.

- If private roads are used, secure permission and be aware of specific driving habits and rules when sharing the road with other vehicles (e.g., logging trucks). Use radios with frequencies that allow you to hear communications of other traffic using the roads.

When moving a drill rig on public roads:

- Verify the brakes are in good working order before all moves. Refer to section 13.5.2 Regular Vehicle Inspections.
- Only licensed operators may drive the vehicle. Operate according to federal, provincial, territorial, and state and local regulations (AHJs).
- Check out the route and assess the hazards. Depending on the route, there may be bridges, power lines, steep and/or rough roads, sharp corners, soft shoulders, slippery conditions, protruding rocks or overhanging branches etc.
- Know the highway and bridge load restrictions as well as other restrictions on load, width and overhead clearances. Allow for the mast overhang when turning corners or approaching other vehicles or structures.
- Watch for low hanging electrical lines, high voltage power lines etc., particularly at entrances to drilling sites or commercial sites.

When moving a drill off road:

- Walk the route before moving the drill rig to assess the slope of the land and inspect the terrain for obstacles and other potential hazards.
- Use established tracks whenever possible. Do not cause unnecessary damage to trees, pasture or other vegetation.
- Always check the brakes before travelling, particularly on rough, uneven or hilly ground.
- When possible travel directly uphill or downhill. Use caution when traversing slopes as any added weight (e.g., tools) may raise the centre of gravity and cause it to tip more easily. Avoid traversing slopes that are slippery or rough.
- Consider a back-up piece of moving gear (cat, skidder) if the route is steep (one on each end of the rig).
- Do not leave a rig or carrier idling on slopes or loose ground. Block the wheels if it is stopped on an incline.

When moving a drill at night:

Moving a drill at night (in darkness), especially off road, has unique hazards. Some companies do not allow any night moves. No night move should be considered when it will soon be daylight. Even if just reorienting the drill for the next hole at the same drill pad, great care should be taken if doing so during darkness. Do not consider any moves during night time darkness, unless the following minimum conditions are met:

- The whole area of the move must be very well lit with powerful lights.
- The move route has to be well surveyed and inspected during daylight.
- Extraordinary efforts should be made to make sure the route is clear of all obstacles that could cause problems during the move.
- Everyone has to wear high visibility reflective clothing.

- Everyone – employees and all equipment should keep a safe distance from operating equipment until they receive a signal to approach or pass.

Helicopter assisted drill moves (slinging)

Slinging drills between drilling locations is common practice where access is limited, especially in northern Canada. Slinging requires specially trained pilots, trained ground personnel and clear communication between all personnel regarding the task at hand. For information regarding safe slinging procedures, refer to Section 16. Aircraft.

20.9 Core Facilities and Sample Preparation

Core examination and sample preparations are often heavy dirty work that may be carried out in uncomfortable conditions – often for long periods of time. Common problems include injuries from handling bagged samples or heavy core trays, breathing dust and getting grit in the eyes.

20.9.1 Risks and Hazards

- Back strains or injuries and neck strains caused by lifting heavy core boxes, logging core for long periods of time, working at an improper height or in an awkward body position
- Cuts and impact injuries caused by lifting sharp core boxes, saw blades, samples that disintegrate when cut, dropped samples or core boxes
- Hearing loss caused by high noise levels when insufficient PPE is worn around drills, core saws, crusher equipment etc.
- Eye injuries caused by flying particles
- Electrocution or shock caused by short circuits when using electric core and slab saws with wet cutting methods, improper installation of electrical equipment
- Fires caused by sparks from gasoline powered core or slab saws, smoking, improper fuelling practices, setting hot saws on combustible material
- Fire, explosion, spills caused by improper fuelling practices such as not attending the fuelling nozzle (never block it open), using matches or a lighter rather than a flashlight to check contents or the level in a fuel tank or container
- Burns caused by improper fuelling practices, hot motor parts, mixing acid for mineral tests
- Sunburn, heat illness, or hypothermia caused by exposure to sun, heat, rain or cold in open sample collection or core logging areas, wearing inadequate clothing
- Impact injuries caused by collapsing core storage racks, examining tables and benches
- Radiation exposure caused by radon accumulations when radioactive samples are kept in closed storage sheds
- Lung diseases caused by exposure to silica or amphibole dust around core saws and cyclones
- Repetitive strain injuries caused by repeating the same task too frequently

20.9.2 General Safety Practices

- Develop and implement SOPs for each type of equipment used for sample collection, preparation and logging. Written SOPs should take into account the manufacturer's operator manual and any additional precautions required at the site. The site ERP should include procedures that address potential injuries that may happen in the core and sample preparation facilities.
- Training: Employees should receive training to safely handle equipment and core. Include SOPs for each type of equipment used.
- Personal protective equipment (PPE) should include the following:
    - Safety glasses with side shields or goggles
    - Respiratory protection is essential when working in sample and core cutting facilities and when sampling from cyclones.
    - Steel toed boots with good traction to prevent slips and falls and injuries from dropped rocks, core boxes etc.
    - Gloves help prevent cuts, provide thermal protection and prevent insect and scorpion stings etc.
    - Waterproof clothing to protect from water spray when using wet cutting methods.
    - Clothing – wear appropriate clothing for protection from the sun, heat, cold and wind.
- Hearing protection should be worn, as required, but especially when working with saws. People working in the core processing area should not wear personal entertainment devices including iPods and MP3 players as they may be distracted from the sound of malfunctioning machinery or warning signals etc. Ear plugs or headphones do not provide hearing protection. Refer to section 4.2.4 Hearing Protection.
- Monitoring and sampling: Some sample splitting and bagging etc., must be done in the vicinity of the drill. Company employees must use the same PPE as drillers to minimize hazards such as noise, dust, falling objects or pressure hose blowouts and follow the same clothing restrictions to minimize the potential risk of being caught in moving parts. Use the correct tools – use a long handled shovel to collect cuttings – never use your hands. Do not place your hands where they can be crushed, severed or harmed by machinery (e.g., cyclones).

20.9.3 Core Facilities

- Set up core handling and logging facilities away from the drill to avoid the hazards associated with the rig and site. Build facilities with sufficient light to avoid eyestrain. Provide protection from sun, wind and rain with a roof or tarps. Make sure the roof can withstand snow loading, if necessary.
- Prevent water, snow, mud and ice from causing slipping hazards. Use nonslip rubber mats or deck tread on walkways and work areas where water and snow may be tracked-in.
- Construct core storage racks so they are strong enough and stable enough to bear the weight of fully loaded core boxes. Check the stability and strength of core racks periodically, especially if the core storage area is old, as racks deteriorate over time.

Racks should not be built too high. Manual lifting problems increase when it is necessary to lift objects above shoulder height.

- Build tables and benches at a comfortable height for core loggers to prevent back and neck strain. They should be stable and built strongly enough not to collapse under the weight of fully loaded core boxes.
- Electrical safety: Electrical equipment should be installed by a qualified electrician. All electrical equipment including saws, power cords and cables should be grounded and incorporate ground fault circuit interrupters (GFCIs) for protection against electric shock and potential electrocution e.g., earth leakage. Do not take short cuts with electrical wiring just because a drill site is a temporary location (refer to Camp 18.4.6 Electrical Safety).
- Be alert for snakes, spiders, scorpions, bees or wasps, spiders and other critters that may take up residence in core boxes and between stacked boxes.

Figure 20.6: Unexpected visitor in a tool box. © Kim Bilquist

20.9.4 Sample Preparation

Some sample preparation may take place at the project site. Design sample preparation areas to minimize handling and utilize mechanical lifting devices whenever possible.

- Everyone – not just the machine operators – who enters or works in a sample preparation area should wear all required PPE.
- Follow SOPs and wear PPE when sampling rock cuttings directly from cyclones.
- Refer to section 5.10 Rock and Core Handling and Cutting Equipment for information regarding specific core saws and other cutting equipment.

- Additional core saw safety tips include:
  - Core saw operators should be required to wear a full-face shield and hearing protection. As core saws use water to wet down the dust generated from the cutting procedures, a waterproof apron, gloves and steel toed rubber work boots may also be required. If core saws are operated in a confined area, enough silica dust may become airborne to create hazardous breathing conditions and require extraction ventilation equipment. It may be necessary to use a dust mask or a respirator (see 20.7.4 Hazardous Material above).
  - Before sawing rocks or splitting core, check the conditions of the saw/splitter, the ventilation and drainage of the overall workspace to prevent respiratory hazards, slips and falls, and possible electrocution. Replace the blade if there are broken teeth on the saw blade.
  - To prevent carbon monoxide poisoning, gasoline fuelled cutting equipment should only be used outdoors and the exhaust should be vented away from the operator. Follow safe fuelling procedures.
  - When using a core saw, wear non-flammable clothing and change clothes if you spill fuel, oil or grease on them. Sparks generated while cutting may cause clothing to catch fire. Fabrics with a fuzzy finish (e.g., flannel shirts, fleece) may catch fire due to the oxygen surrounding the fibres. Wool fibres do not support combustion well and are safer than cotton. Avoid wearing synthetic fabrics (polyester or nylon) as they melt onto the skin when they ignite.
- Drying ovens may present a fire hazard so keep a fire extinguisher nearby.
- Crushers and pulverisers: These machines present several hazards for which even short term exposure can create serious health problems (e.g., deafness, lung disease).
  - Wear hearing protection at all times.
  - Dust is generated so wear respiratory protection at all times.
  - Never place fingers or hands inside a crusher or any place where they could potentially be caught or crushed.

20.9.5 Core Logging

- Follow the regulations of authorities having jurisdiction (AHJs), especially regarding ventilation and PPE. For example, when working with asbestiform and amphibole minerals in Québec, regulations specify required PPE, including respirators, and that separate work clothing must be washed on site and kept only for sample preparation purposes. See section 20.7.4.2 Asbestos and Amphiboles.
- Follow safe lifting and manual handling procedures as logging is physically demanding work. It is advisable for core loggers to do stretching exercises and take regular breaks to avoid neck and back strains. Do some warm-up exercises before a job that requires lifting lots of core boxes.
  - Establish regular personnel rotations to reduce long term exposure to noise, dust and provide respite from arduous sampling activities.
  - Check your footing and route before lifting or moving core, especially near the drill where the ground may be slippery.
  - Use mechanical lifting devices whenever possible to reduce physical exertion. Use extra caution when it is necessary to lift objects above shoulder height.

  - Try to store core temporarily at waist height. For example, use a pickup truck to transport core to a temporary stand at waist height or to a core rack.
  - Try to build core viewing racks that are waist height (avoid putting core on the ground).
  - Refer to sections 4.3 Lifting and Back Protection and 20.5.4 Manual Handling.
- Do not lick core. Provide water at the drill and core logging sites to wet the core for examination. Licking core without knowing what drilling additives are present is risky, as several additives are poisonous.
- Chemicals: Use caution when handling chemicals to test mineralogy. See section 20.9.6 below.
- Radioactive core:
  - When moving core containing radioactive minerals, wet the core and wear dust masks.
  - Core storage: Place core on a concrete floor. The floor should be sealed and painted a different colour from the core so the dust is visible.
  - Only use wet methods to cut core.
  - For detailed information refer to Section 15. Guidelines for Radiation Protection during Exploration for Uranium in the e3 Plus Environmental Stewardship Toolkit at: www.pdac.ca/e3plus.

20.9.6 Toxic Substances used for Mineral Identification

The following substances may be used to indicate the presence of ore minerals or carbonate mineralization. Follow safe practices when using chemicals. Whenever a controlled substance is transferred from its labelled container, the new container must be clearly labelled unless it will be entirely used up during the work shift *and* it will never leave the control of the person using the substance. Internet links are provided to some material safety data sheets (MSDSs) for educational purposes. Refer to 18.2.3 Workplace Hazardous Materials Information System (WHMIS).

Blue Juice

"Blue Juice" is composed of 5 grams of potassium ferricyanide per litre of 10% HCl. It is used in gold exploration to differentiate between the various carbonate alterations associated with gold mineralization. It is usually sprayed on drill core.

- PPE: It is advisable to wear gloves and safety glasses or goggles when using blue juice.
- Label the container and follow the directions below if it is necessary to make up the 10% HCl solution from concentrated HCl.
- An MSDS for potassium ferricyanide is available at the following website: http://www.anachemia.com/msds/english/7630.pdf

Dilute Hydrochloric Acid (10% HCl)

Dilute HCl is often used in the field for testing minerals and core for the presence of carbonates. Use care as dilute HCl can cause burns to the skin and damage clothing.

- PPE: Wear safety glasses or splash goggles and gloves. Use HCl where there is good ventilation to avoid breathing fumes. Be familiar with first aid procedures which include removing clothing and thoroughly washing skin and flushing eyes if they come in contact with dilute HCl.
- If it is necessary to prepare a 10% solution of HCl, place the appropriate amount of water in a container and add the correct amount of concentrated acid to the water. Note: *Do not do the reverse.* If water is added to concentrated acid, the mixture may boil and splatter, which will cause burns on contact. Label all containers or bottles that contain HCl – do not presume that co-workers will be able to identify the contents because it is a small bottle that contains an eyedropper.
- Additional information regarding dilute HCl can be found at the following website: http://www.sciencestuff.com/msds/C1816.html

Hydrofluoric Acid (HF)

Hydrofluoric acid is an extremely toxic and corrosive acid. Burns from HF on the skin may not become evident for several hours; the fluoride penetrates the skin to deep tissue and reacts with calcium and magnesium in the body (in bones, heart, liver, kidneys etc.). Exposure to HF requires immediate medical attention.

Whenever possible, companies should use alternative downhole survey methods rather than hydrogen fluoride. It is advisable for contracts to stipulate that hole orientation surveys use an alternative method (e.g., single and multi-shot cameras, and magnetic and non-magnetic digital downhole survey techniques).

- K-feldspar staining requires the use of concentrated HF. The preferred and recommended place to carry out staining is in a controlled laboratory environment in an exhaust/fume hood with the extraction fan operating. If staining must be done outdoors, do it well away from people and equipment where fumes can dissipate quickly. Wear PPE and remain upwind of any fumes as they can severely burn the lungs.
- Training is essential.
    - If the chemical is on site, develop a site specific SOP for handling HF and an ER procedure that addresses hydrogen fluoride spills and inadvertent exposure.
    - Workers required to use HF *must* be trained in the correct procedures for use, transport, and storage. This includes WHMIS training to be familiar with the MSDS, and appropriate first aid. It is essential to use PPE and work where there is good ventilation.
    - Minimum PPE: protective goggles and face shield, gloves, boots, and a respirator, as appropriate
- HF can poison and kill with little or no warning.
- Symptoms: Inhalation can be fatal.
    - Low concentration – shortage of breath, coughing, sore throat
    - High concentration – severe headache, dizziness, impairment, mental confusion, collapse or fainting, burns to all tissue exposed. When it is absorbed into the bloodstream, HF reacts with calcium and magnesium in the body and is life-threatening.
    - Extreme concentration – unconsciousness, coma, death

- Symptoms: Skin contact with liquid or gas causes severe burns and permanent tissue damage. Chemical burns to as little as 2% to body surface can be fatal.
- Additional information about HF is available at the following websites:
  http://www.jtbaker.com/msds/englishhtml/H3994.htm
  http://www.osha.gov/SLTC/healthguidelines/hydrogenfluoride/index.html

Nickel Powder

"Nickel powder" is dimethylglioxime, a compound applied to drill core or rock samples to indicate the presence of nickel.

- PPE: It is advisable to wear gloves and safety glasses. Work in an area with good ventilation to avoid breathing the powder. As it can irritate the skin, avoid contact and flush skin and eyes with water if exposed. Wash contaminated clothing.
- An MSDS for dimethylglioxime is available at the following website:
  http://www.anachemia.com/msds/english/3608.pdf

Zinc Zap

"Zinc Zap" is a solution of chemicals (hydrochloric acid (HCl), potassium ferricyanide, and oxalic acid and N, N-diethylaniline). Although the individual chemicals are potentially dangerous in concentrated form, they are very dilute in a zinc zap solution and therefore it is not considered dangerous or hazardous goods. Nevertheless, take care when using zinc zap solutions. Wash your hands thoroughly after use to prevent oral contact. When zinc zap is applied to a specimen a bright reddish-brown colour indicates the presence of zinc.

The following instructions are adapted from the *Field Geologists' Manual, 4th ed.* by D. A. Berkman.

To prepare a zinc zap solution: Wear safety goggles, a splash apron, gloves, and work in a well ventilated area (preferably a fume hood with the fan operating). Label the containers.

Solution #1: Dissolve in one litre of distilled water:

9 mL of concentrated hydrochloric acid

30 g of oxalic acid

5 mL diethylaniline

Solution #2: Dissolve in one litre of distilled water:

30 g potassium ferricyanide

Mix equal parts of solution #1 and solution #2 to create "zinc zap". Each solution kept separately has a shelf life of about three months. When mixed together, the shelf life is about one week.

MSDS sheets for zinc zap component are available at:

Potassium ferricyanide: http://www.jtbaker.com/msds/englishhtml/p5752.htm

Oxalic acid: http://www.jtbaker.com/msds/englishhtml/o6044.htm

N,N-diethylaniline: http://www.sciencelab.com/xMSDS-N_N_Dimethylaniline-9923806

Hydrochloric acid: http://www.jtbaker.com/msds/englishhtml/H3880.htm

20.10 Selecting a Drill Contractor – Evaluation Criteria

When selecting a drill contractor, look for contractors whose management demonstrates leadership accountability for health and safety. Look for reputable contractors that have well trained workers who know the safety expectations, have a positive attitude and behaviour (e.g., Safety Culture – Zero Harm). Note whether or not the contractor has the appropriate equipment for the job and the condition of the equipment, which may disclose a lot about the contractor's ability to do the job and attention to maintenance. Contact other companies that may have used the drill contractor in the past and check references.

Documented proof of the following should be considered as essential requirements when evaluating proposals from a drill contractor:

- Contractor is registered with the jurisdictional Workers' Compensation Board authority or regulatory equivalent
- Contractor has a Health & Safety Statement, Health & Safety Policy and Program
- Contractor has a structured program of Health and Safety training and education
- Contractor does regular inspections and audits of the workplace (e.g., safety and environmental)
- Contractor records, tracks and communicates his safety performance
- Contractor has a 24-hour Crisis Management Program
- Contractor can provide proof of adequate vehicle and third party liability insurance

When evaluating a contractor, look for these additional criteria:

- Qualified and experienced personnel
- Training provided by the contractor
- Safety plans, procedures, protocols, guidelines (SOPs)
- PPE requirements
- Emergency procedures
- Occupational Hygiene Program
- Safe, Fit for Work Program
- Risk Management Program
- Fire protection
- Isolation (Lockout and Tag Out) Program and procedures
- Incident Management Program
- Injury Management Program

20.10.1 Suggested Drilling Contract Requirements

In addition to stipulating the general work provisions for drilling, the contract should include a requirement for the contractor to provide a site specific safety plan that includes details of the health and safety requirements for carrying out the work. There should be a requirement for the

drill contractor to provide workers with appropriate experience and training. Employees with surface "Common Core" training, a required training program in Ontario and Québec, will fulfil many of the requirements. Ideally, the training requirements should include but not be limited to:

- First aid, CPR
- WHMIS
- Fall arrest
- Propane handling
- "Common Core" (Ontario and Québec surface driller and driller helper qualifications)
- Chainsaw operation
- ATV training
- Contractor policies and procedures, such as:
    - Company induction
    - Contractor's Emergency Response Plan
    - Contractor's policies regarding Environment, Health, Safety, Sustainable Development, and Community Relations

List the required PPE in the drilling contract schedule.

The following should be included:

- Steel toed safety boots with good tread on sole
- Hard hat
- Hearing protection
- Safety gloves (insulated in winter)
- Safety glasses with side shields/prescription safety glasses/safety sun glasses, a required
- Proper clothing and gear (snug, long sleeve, approved reflective markings)
- Approved helmets for ATV and snowmobile use
- Approved chainsaw gear (hard hat, face shield, chaps, gloves, safety boots)

List the minimum safety requirements for the drill.

Verify that the contractor uses rod handling procedures/systems that eliminate the need for crews to lift heavy weights, jump off elevated platforms or run with drill rods. Use engineered and inspected towers only; confirm this through inspection before drill operations commence.

The following should be required:

- Mechanical rod handler
- Guards on all rotating parts
- Kill switch (emergency shut off switch)
- Automatic wire line spooler (level winder)
- Safety pictograms (warning signs, decals)

- Proper secure stairs on all exits
- Fire extinguishers (20 lb)
- Fall arrest, guards, rails
- Lockout system for maintenance

Minimum safety equipment that should be present at the drill:

- Fire extinguishers – 20 lb on drill, at pumps, generators, fuel storage. 10 lb may be acceptable on each vehicle and truck. The 20 lb size may exceed the requirements of the AHJs but it provides better protection.
- Emergency contact telephone numbers (ERP)
- Communication system – appropriate for location, terrain, in good working condition
- First aid kit – approved for job, contains sufficient and appropriate supplies for drilling incidents
- Back board (spine board)
- Stretcher basket
- Blankets
- Splints
- Neck brace
- Spill kit
- MSDS sheets (WHMIS)
- Eye wash station (appropriate size)
- Appropriate signage – “equipment working” warning signs

20.11 Resources

The Prospectors & Developers Association of Canada (PDAC) thanks the following for granting permission to include material from their publications.

Association for Mineral Exploration British Columbia (AME BC)

Australasian Institute of Mining and Metallurgy

Canadian Diamond Drilling Association

Hy-Tech Drilling Ltd.

Work Safe Alberta

Their permission does not imply that they endorse the PDAC Health and Safety Guidelines. The PDAC is solely responsible for the content of these Health and Safety Guidelines.

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