

Mixing Strength With Satisfaction

UNDERGROUND SHOTCRETE SAFETY GUIDELINES & RECOMMENDATIONS



KING

FOREWORD

King Packaged Materials Company has developed this manual to provide commonsense guidelines and recommendations for the safe use of shotcrete in underground applications.

This manual was developed using observations and experiences obtained through visits with shotcrete users at mines throughout North America, and through consultation with many other personnel involved with shotcrete application.

Information for this manual was collected from mining contractors, equipment and material manufacturers, suppliers, engineers and consultants, all whom represent hundreds of years of collective experience in the shotcrete industry. It should be noted however, that this manual is recommended as a guide only. Safety procedures and policies at your place of work should always take priority over its contents.

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GENERAL INTRODUCTION

Over the past several decades, the volume of shotcrete used in underground excavation has increased significantly. Although methods of shotcrete material supply vary depending on factors such as volume, location, and logistics, much of the shotcrete used today by mining and tunneling industries, is pre-blended in bulk bags that contain 1,000 kg (2,203 lb) of material. Correct handling of these bags, proper attention to workers' health and safety, as well as sound application skills, are aspects essential to a successful shotcreting program.

This manual provides guidelines and recommendations for the safe handling and use of King Packaged Materials Company (King) shotcrete mixes. Although much of the underground shotcrete market utilizes mechanized spraying equipment, this type of application is not addressed in this manual. There are simply too many mechanized spray booms and underground mobile spraying units on the market, and operating underground, to accurately provide guidelines for their safe use. That said, although this manual was created primarily for handheld nozzle applications, much of the information will also apply to mechanized shotcrete applications.

TRAINING

Safety and accident prevention must be considered the number one concern of every person involved in any sector of the mining or construction industry. Although much of the responsibility for everyday safety rests upon the individual, it is critical that everyone involved in the shotcrete process makes safety the top priority. There are many workplace hazards that are unique to the shotcrete industry and an understanding of these hazards is key to ensure that every member of your shotcrete crew returns home from work each day, accident free. For this reason, training related to the safe application of shotcrete must be an integral part of any company's training program.

Shotcrete training programs are available from a number of sources. King Packaged Materials Company and its Minequip Division both provide ongoing training to customers who use King materials and/or equipment. All training, whether hands-on training on the safe operation of shotcrete equipment in an underground environment or classroom training focused on the technical aspects of shotcrete technology, will always have a strong focus on safety.

There are also excellent, industry-sponsored training programs available throughout North America and some are affiliated with shotcrete nozzleman certification programs. The most popular and most widely recognized nozzleman certification program was developed by the American Shotcrete Association and is administered by the American Concrete Institute. Training and certification is available for both the wet and dry processes and can be obtained through the American Shotcrete Association office in Farmington Hills, Michigan.

EFNARC (European Federation of National Associations Representing Producers and Applicators of Specialist Building Products for Concrete), has also recently developed a nozzleman certification program. However, the program does not include any training, as it is currently designed for nozzlemen who have already gained the necessary experience and can demonstrate their technical knowledge and practical ability. The EFNARC program is also specific to underground shotcrete applications and applies only to wet, robotic-sprayed concrete applications.

SHOTCRETE MATERIALS

All cementitious products (shotcrete or concrete mixes) contain both inert and hazardous components that can be harmful if not handled in a safe manner. Ensuring proper ventilation, and carefully handling dry shotcrete materials or plastic shotcrete mixes, will help reduce the amount of hazardous components in the workplace. Understanding that education is the first step to create a safer workplace, all shotcrete crew members should be educated on the effect of exposure to hazardous components of shotcrete mixes. The first step in this education is to understand which shotcrete mix components are considered inert and which components are hazardous.

INERT AND HAZARDOUS COMPONENTS

INERT COMPONENTS – Components with no chemical activity.

HAZARDOUS COMPONENTS – Biological or chemical agents named or described in the Occupational Health and Safety Act as hazardous materials.

Hazardous components in accelerated, silica fume enhanced shotcrete (MS-D1 or MS-D3 Shotcrete Mixes) are listed in “Section II - Hazardous Ingredients” of the King Shotcrete Material Safety Data Sheet. A copy of all King MSDS documents are available on our website, at www.kingshotcrete.com.

THESE HAZARDOUS COMPONENTS ARE AS FOLLOWS:

- Portland Cement
- Quartz
- Portlandite

When in a dry state, these hazardous components can cause irritation to the nose, throat and eyes.

When water is added to a shotcrete mix (either in a pre-dampened state or after it passes through the nozzle), these hazardous components become alkaline and can cause irritation or even burns to the skin.

These burns can be internal if the shotcrete material is ingested.

HAZARDOUS MATERIALS - RESPIRABLE

When working in the presence of hazardous dust that can be common in shotcrete applications, it is necessary to protect against the respiration of those hazardous materials, as to prevent short-term or long-term illness or injury. Respiratory protection suitable for site exposure conditions should be worn and maintained by all members of the shotcrete crew. This protection is especially important when engineering controls alone are not adequate to reduce exposure below the levels permissible by the local, governing authority.

Government agencies such as the Occupational Health and Safety Administration (OSHA) in the United States, have established a Permissible Exposure Limit (PEL) which identifies the maximum amount of airborne crystalline silica that an employee can be exposed to during a work shift. Supervisors and shotcrete crew members should be provided with access to these values and should also be educated to understand what each means.

WHAT IS SILICA AND WHERE IS IT FOUND?

Silica is a non-combustible, colorless (or white), tasteless crystal that occurs naturally in crystalline and amorphous forms. Silica is a general term for the chemical compound, Silicon Dioxide (SiO_2).

TYPES OF SILICA

CRYSTALLINE SILICA, also known as free silica, is an odorless, crystalline solid that can be found almost anywhere. It is the basic component of sand, quartz and granite rock. Occupational exposure to crystalline silica, without properly-fitted Personal Protective Equipment (PPE), has long been known to cause silicosis, a potentially fatal disease of the lungs. Activities such as sandblasting, rock drilling, roof bolting, foundry work, stone cutting, concrete cutting and shotcreting, can create an airborne silica exposure hazard.

AMORPHOUS SILICA has the same formula as crystalline silica but is not crystalline in form. Amorphous silica (e.g. silica fume or diatomaceous earth) does not cause silicosis.

WHAT IS SILICOSIS?

Silicosis is a disease of the lungs caused by continued inhalation of dust that contains crystalline silica particles. It is a disabling, progressive, non-reversible disease that causes scarring of lung tissue which can result from overexposure to respirable dust that contains crystalline silica. This scar tissue lessens the lungs' ability to intake oxygen from the air. Where silica dust is deposited and accumulates, a fibrous tissue grows around the particle. Symptoms of silicosis include shortness of breath, severe coughing, fatigue, loss of appetite, chest pain and fever. The symptoms of silicosis tend to be progressive, especially with continued exposure to free silica and for those of advanced age. **SMOKERS ARE PARTICULARLY SUCCEPTABLE TO THESE SYMPTOMS.**

PREVENTATIVE MEASURES

Although years ago the shotcrete operation may have been dusty and labor-intensive, changes in equipment, packaging and material design have addressed many of these concerns. The shotcrete nozzle, in many cases, has been removed from the hands of the nozzleman and placed on a robotic arm.

Shotcrete equipment set-ups are more compact and easier to move around. Additionally, changes in equipment design have dramatically reduced airborne dust levels.

In an underground environment, it is extremely important to understand the controls and the hierarchy of controls that are required to minimize exposure to hazardous airborne silica. The following controls should be implemented (in order of importance) to control the amount of airborne silica dust created during a shotcrete operation:

1. ENGINEERING CONTROLS

2. TRAINING

3. PERSONAL PROTECTIVE EQUIPMENT



The shotcrete nozzle, in many cases, has been removed from the hands of the nozzleman and placed on a robotic arm.

ENGINEERING CONTROLS

Engineering controls remove a hazard by changing a process or by utilizing substitution, isolation or ventilation. In a shotcrete application, the simplest method to prevent silica exposure is to reduce the amount of airborne silica in the first place. The most common engineering controls used to reduce the amount of airborne silica are:

1. HOUSEKEEPING

Minimize handling of empty shotcrete or cement bags by storing them in an area where they can be contained and prepared for disposal. If bulk bags are used, carefully fold them immediately after they are emptied and store them in an area away from equipment traffic. Wet-down any dry-material spills to prevent the formation of airborne dust and be sure to maintain dust collection systems.

2. ISOLATION

If a shotcrete operation produces excessive amounts of airborne silica dust, attempts should be made to isolate the operation so that exposure levels are reduced for workers. This can be accomplished with the use of a physical barrier (door, polyethylene sheet, water curtain, etc.) or by ensuring that other employees are working upwind from the shotcrete crew.

3. SHOTCRETE EQUIPMENT

When it comes to the production of airborne dust, not all shotcrete materials and equipment are created equal. Consult your material and equipment supplier to ensure that the most suitable mix and equipment are used for your underground operation. Although wet-mix shotcrete operations generally produce less airborne dust than dry-mix operations, there are a number of ways to ensure that the dust created from the placement of dry-mix shotcrete is minimized and kept to an acceptable level. The most important ways to avoid creating unnecessary dust are as follows:

- **Keep the shotcrete placement equipment well-maintained. Inspect wear pads and plates regularly to prevent dust from escaping from the machine.**
- **Keep wear pads and air settings properly adjusted to prevent “blow-back” of dry shotcrete material from the hopper. Consult your equipment supplier for proper equipment operating procedures.**
- **Ensure sufficient water pressure to avoid continuous dry/wet adjustments.**

- **Utilize pre-dampening to greatly reduce the amount of airborne dust at the machine and at the nozzle, and to eliminate static electricity build-up in the hose. Pre-dampening will also improve the shooting characteristics and hardened properties of the shotcrete.**
- **If a pre-dampener is not used, ensure that a hydro-nozzle or semi-wet nozzle (one in which the water ring is moved back several feet in the hose) is used.**
- **When using pre-packaged materials (for both dry and wet-mix operations), ensure that the correct size of air and material hoses are used. Consult the equipment supplier for proper hose selection.**
- **Ensure that your shotcrete material and equipment suppliers have the service personnel required to properly train the shotcrete crew. Proper training by qualified personnel is critical to a safe, low-dust shotcrete operation.**

4. VENTILATION

Airborne Dust Control (Ventilation) – Ventilation of the workplace is essential to prevent the production of excessive amounts of airborne dust. Local ventilation should be modified as necessary to provide adequate airflow away from the points of major dust generation. In a dry-mix shotcrete application, the major points of dust generation are the delivery hopper (also applies to the use of pre-packaged materials in a wet-mix operation), the shotcrete gun and the nozzle. In some circumstances (e.g. underground applications, confined spaces), additional fan capacity may be required to keep an adequate supply of clean air circulating properly.



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In a dry-mix shotcrete application, a major point of dust generation is the delivery hopper (also applies to the use of pre-packaged materials in a wet-mix operation).

TRAINING

The first step to maintain a safe atmosphere for the shotcrete crew and other underground employees is to ensure that the shotcrete crew is properly trained on the correct operation of the shotcrete equipment or concrete pump. An inexperienced, dry-mix shotcrete machine operator, for example, can generate more dust than any other member of the crew, simply by not understanding the correct settings for the air and material flow.

Several training programs are available across North America, through organizations such as the American Shotcrete Association (ASA). ASA is North America's largest sponsoring group for ACI Nozzleman Certification and offers a well-developed training program for every first-time certification. Equally as important is the ongoing training that should be offered by the supplier of the shotcrete materials and equipment. It is important that equipment and material suppliers be able to provide ongoing training because in many mining operations, nozzlemen change work positions often. This leads to the introduction of newer, less experienced nozzlemen to the shotcrete crew. A good material or equipment supplier will have qualified technical personnel available to undertake training in these cases.



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Training related to the exposure to airborne silica (and other hazards) is now required by provincial, state and federal communication standards (right-to-know laws). This type of training should be provided at the time employment begins and before work starts. This training should include:

- 1. An understanding of potential health effects of exposure to respirable crystalline silica.**
- 2. Availability of MSDS sheets for shotcrete mixes, liquid accelerators and other related products.**
- 3. An emphasis on the importance of engineering controls including housekeeping, isolation, equipment operation and ventilation.**
- 4. The use and care of appropriate Personal Protective Equipment (PPE).**

PERSONAL PROTECTIVE EQUIPMENT

Personal Protective Equipment (PPE) may be required to protect the shotcrete crew from exposure to airborne crystalline silica, when it is not feasible to ensure a completely safe work environment. The recommended type of PPE will vary, depending on the exposure level in the work area.

RESPIRATORS

Respirators are designed to remove hazardous materials from the air as it is inhaled. A doctor's permission must be obtained before wearing a respirator, and a thorough fitting procedure (also called a fit test) should be undertaken before any respiratory protection is used. A typical respirator will consist of a tight-fitting face piece, that covers the mouth and nose with a filter cartridge or canister approved to filter the hazardous particulates from the air. Facial hair may interfere with the respirator seal, as will personal weight fluctuations, and can render some respirators ineffective. The employer is responsible for consulting OSHA, MSHA or NIOSH guidelines to ensure that the correct type of respiratory protection is provided to the shotcrete crew members. In environments that require air-purifying respirators, there must be a safe level of oxygen available.

MEDICAL EVALUATION

Employers should provide a medical evaluation to determine an employee's suitability for use of a respirator. Periodic follow-up medical evaluations may also be required if the employee exhibits medical signs or symptoms that could affect the employee's ability to wear a respirator. Some examples include shortness of breath, dizziness, chest pain, lung disease and heart conditions.

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HAZARDOUS MATERIALS - CORROSIVE

CEMENT BURNS – Calcium Hydroxide, formed during the cement hydration process, is extremely alkaline with a pH between 12 and 13. In comparison, human skin has a pH of only 5.5. Prolonged exposure, or in some cases even limited exposure, to the corrosive effect of cement paste can result in severe damage to unprotected skin. These cement burns occur when exposed skin remains in direct contact with cement dust or cement paste, for an extended period of time (but can occur in as little time as 30 - 45 minutes). In most cases, contact occurs when wet cement, concrete, or shotcrete passes through permeable clothing (the clothing will usually hold the caustic cement in contact with the skin until the skin is chemically burned). Unfortunately, cement burns usually occur without warning. Also, the pain that accompanies cement burns may be delayed for hours, which increases the exposure to the skin and causes the injury to become more severe.



Cement burns usually occur without warning. The pain that accompanies them may be delayed for hours, which increases the exposure to the skin and causes the injury to become more severe.

If a shotcrete crew member experiences a cement burn, he or she should remove themselves from the shotcrete crew until the burn is healed. Cement burns can be an early sign

of skin sensitivity or an allergic reaction to the cement paste. Cement burns can best be avoided by simply following proper personal hygiene practices and wearing proper clothing.

Clothing should be the type that minimizes contact of cement with the skin. Care should be taken to ensure that shotcrete rebound and cementitious material cannot enter areas of friction such as collars and sleeve cuffs. The initial layer of clothing should be kept clean and dry. If clothing does become saturated with cement paste, it should be removed and changed.

WASHING – If cement is allowed to remain in contact with the skin, it may cause irritation or burns. If underclothing becomes saturated with cement paste, clothing should be removed and the affected skin should be thoroughly washed.

Showers should also be taken by all members of the shotcrete crew after each shift. Hands, arms, and face should be washed before eating.

FIRST AID MEASURES

EYE CONTACT - Irrigate eyes immediately and repeatedly with large amounts of clean water for at least 15 minutes and seek prompt medical attention. Suitable facilities for quick drenching or flushing of the eyes and body should be provided within the work area for immediate emergency use. To determine whether eye-wash facilities are suitable for corrosive materials or chemicals to which employees may be exposed, compliance officers and employers should evaluate the specific job tasks and worksite conditions. This evaluation should include consulting the Material Safety Data Sheets (MSDS) of manufacturers for hazard information and first aid procedures. Depending on the circumstances, hoses and water containers may be suitable eye-wash facilities.

SKIN CONTACT - Flush skin with soap and water for at least 15 minutes. Remove any clothing saturated with wet material. Apply a lanolin cream for mild irritation. Obtain medical attention if irritation persists.

INGESTION - Do not induce vomiting. Obtain medical attention immediately.

STORAGE OF SHOTCRETE MATERIALS

Bulk bags of shotcrete are usually stacked one or two per pallet. Small bags (66 lbs) are usually stacked 56 per pallet. Both packaging options are covered with a large polyethylene bag and stretch-wrapped thoroughly to prevent premature hydration of the shotcrete material.

Despite the extra care taken to ensure that the material stays dry, proper storage of shotcrete bags should not be taken for granted. A clean, level, designated storage area should be chosen for shotcrete, preferably with protection from the elements. Choose a location on relatively high ground to prevent the formation of water pools. If shotcrete material is left exposed, it should be covered with a tarpaulin. If shotcrete bags are left unprotected, rainwater will accumulate and can easily permeate through the polycover, and hydrate chunks of shotcrete.



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If shotcrete bags are left unprotected, rainwater will accumulate and can easily permeate through the polycover, and hydrate chunks of shotcrete.

Bags should be stored in such a way that older bags can be taken first. Do not leave bags exposed to the elements for an extended period of time. Otherwise, hydrated lumps can form in the bag, slowing down the shotcrete operation and creating unsafe conditions (e.g. plugged hoses).

When storing pallets of shotcrete in the designated storage area, always ensure that enough space is left between the pallets so that shotcrete bags are not damaged when maneuvered away from the area.

Bulk bags can be stored two bags high, under most circumstances. It is common practice to keep the bags on the delivery pallets for as long as possible. Handling the pallets with a forklift is the simplest method of re-handling and warehousing on surface. When re-handling to move shotcrete underground, remember to allow the mix to reach ambient temperature before shooting, or use heated mixing water to warm the material. Most underground re-handling and storage is carried out using boom trucks, underground forklifts, and LHD units. It is very important to plan underground storage carefully, to have easy access to materials with minimum re-handling, and to ensure that materials are stored away from pools of water.

Contact your King representative to set-up a review of your bulk bag handling and storage facilities. Recommendations can be made to improve safety as it relates to shotcrete material handling.

SHOTCRETE MATERIALS SUMMARY

- ☑ Ensure that the shotcrete crew is properly trained on the correct operation of the shotcrete equipment or concrete pump (consider the ACI Nozzleman Certification through the American Shotcrete Association).
- ☑ Ensure that your shotcrete material and equipment suppliers have the service personnel required to properly train the shotcrete crew.
- ☑ Modify local ventilation as necessary to provide adequate airflow away from the points of major dust generation.
- ☑ Use pre-dampeners, semi-wet nozzles or pre-dampening nozzles for all shotcrete operations, in order to minimize dust.
- ☑ Ensure that shotcrete equipment is properly maintained (include clean-up and inspection activities at the end of every shift).
- ☑ Wear appropriate, well-maintained, properly-fitted respiratory protection, when required.
- ☑ Wear properly-fitted clothing designed to keep cement, silica dust and rebound away from the body.
- ☑ Shower at the end of every shift. Wet or pre-dampened shotcrete material can cause irritation or burns to the skin.
- ☑ If a shotcrete crew member develops skin sensitivity or an allergic reaction to cement, he or she should remove himself or herself from the shotcrete crew.
- ☑ Keep a supply of clean water available nearby for rinsing eyes, face and hands.
- ☑ Store shotcrete materials in a clean, level, designated storage area, away from the elements.

THE SHOTCRETE OPERATION

The act of placing shotcrete, especially in an underground environment, can expose the shotcrete crew to a number of potential hazards. Understanding what these hazards are and how to minimize each will go a long way to create a safe workplace environment.

SMALL BAG HANDLING

NUISANCE DUST - Reduction of nuisance dust is addressed in the previous (MATERIALS) section. Although a shotcrete operation may have several sources of dust generation, breaking of small-bag shotcrete mixtures at the delivery hopper is one of the main sources. The most effective method to reduce this dust is to direct the airflow away from the source.

The hazards most common in handling small bags of pre-blended shotcrete are related to the production of nuisance dust at the hopper and to back injuries caused by improper lifting practices.

BACK INJURIES - Nearly 25% of all lost-time injuries in construction are related to back injuries and more than half of these injuries are sprains and strains from lifting, lowering, carrying, pushing, and pulling materials incorrectly. Other back injuries occur over time because of repetitive stresses on the back, and can often result in permanent damage or can end careers. **When handling small bags of shotcrete, the two most critical factors to prevent back injuries are:**

PROPER POSTURE – Your spine, when properly aligned, has a natural curve that keeps the head centered over the hips. To maintain good posture, the head should be kept up and the chin in; keeping the back flat and the abdomen in. When standing, one should feel as if his or her weight is forward and supported on the outsides of the feet.

PROPER LIFTING MECHANICS – When lifting an object, the feet should be kept at least as far apart as the shoulders for a wide base of support, and even further apart when lifting heavier objects. One foot should be kept slightly in front of the other for balance, while the individual faces forward and maintains good body posture. Lift using the strong muscles of the legs, bend at the hips and knees (not at the waist) and keep the back straight. The object should be kept close to the body and lifted in one smooth motion. If turning is required, it should be done with the feet. Do not twist the body.

BULK BAG HANDLING

Bulk bags are produced according to strict levels of quality, and are routinely tested to destruction at capacities far greater than design-load. Although multi-use, returnable bags can be re-filled (after a thorough inspection process), one-use non-returnable bulk bags are preferred for use with shotcrete. These bags have a reduced possibility of undetected damage and/or weakness caused by the corrosive nature of Portland cement.

For obvious safety reasons, damage to lifting straps can be particularly critical. Even slight damage to the straps will render the bulk bag unusable.

Always suspend a bulk bag from all four corner-lifting straps. The lifting capacity of the straps is designed to meet the weight requirement of the bag, only if all four straps are used. If one of the straps is damaged, the bag should be discarded. Do not try to lift a bag with three (or fewer) straps.



Always suspend a bulk bag from all four corner-lifting straps.

When using a forklift for suspended bag handling, make sure that the forks are smooth, and do not have jagged edges that could damage the lifting-strap webbing. Check forks periodically and file or grind them down to create a smooth surface if necessary. The forks should be spaced the same distance apart as the lifting loops, and the forklift should be used with its mast inclined slightly backward. All lifting loops must carry the same load. Do not try to right a toppled bag by lifting it with only one or two loops; you will likely tear the bag. To raise a bag which has fallen on its side, use an endless sling through all four lifting-loops.

When lifting bulk shotcrete bags with an overhead beam and chain hoist, or any type of crane or boom truck, a snap hook is always safer than an open hook.

A lifting cross, designed and stamped by a licensed Professional Engineer, provides the best method for lifting bulk shotcrete bags. In addition to providing a proven, safe method for lifting bulk bags, it also allows for smooth and consistent discharge of the materials from the bag into the shotcrete hopper. If heavier shotcrete bags are introduced to the shotcrete operation, ensure that the lifting cross has been designed to handle the increased load.



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Under no circumstances should someone stand underneath a full, suspended bulk bag. The discharge spout should be untied only if the bag is properly supported and if there is a secure frame to protect the operator's hands. This practice protects against sudden movement of the material handling equipment or a sudden failure of a bulk bag support strap. These frames can be obtained from the shotcrete equipment supplier.

Hopper hoods are also available from most shotcrete industry equipment dealers. These hoods serve the dual purpose to protect the operator's hands in the event of a bag drop and also to prevent excess amounts of nuisance dust from escaping into the atmosphere.



Hopper hoods serve the dual purpose to protect the operator's hands in the event of a bag drop and also to prevent excess amounts of nuisance dust from escaping into the atmosphere.

It should be noted that guards and hoods are not intended to be supports for the bulk bag. The bulk bag must remain suspended by the lifting machine at all times, until fully discharged. The full weight of a bulk bag resting on a hopper guard or hood will adversely affect the operation of the machine and will create serious instability with such a large weight sitting unsupported and high off the floor.

HOUSEKEEPING

A clean and tidy workplace is imperative to provide a safe workplace. An underground storage area for pallets of shotcrete, as well as a set-up location for the shotcrete equipment, should be planned for ahead of time. For large shoots, an overhead beam with a chain hoist should be installed to help provide a consistent flow of material.

When using bulk shotcrete bags, the shotcrete crew should develop a system of handling both full and empty bags. Empty bulk bags left near a shotcrete machine can become a severe tripping hazard, which can easily lead to injury. Reduced potential for tripping is a function of a neat and tidy workplace.

When a shotcrete bag has been emptied, remove the straps from the lifting cross or forks, fold the bag, and place the bag on a pallet situated away from the shotcrete equipment and crew. Continue to pile empty bags on to the pallet until the end of the shift. During clean-up, tie the bags securely to the pallet so they can be easily transported to surface and disposed of.

Hang one of the empty, polyethylene cover bags on the screen and use it to store all of the used polywrap that has been removed from the pallets of shotcrete material.

Find a suitable location for the empty pallets and pile them away from the shotcrete equipment and crew, so they can also be transported to surface.

By following these simple housekeeping recommendations, there is a lessened likelihood for shotcrete crew members to trip over empty bags or pallets. There will also be more room for the nozzleman and other members of the crew to maneuver.

COMMUNICATIONS

In the past, shotcreting was commonly associated with poorly illuminated, dusty and dirty conditions. These conditions are not conducive to a safe, efficient, high quality shotcrete operation. Although reducing the sources of dust and adjusting ventilation will allow crew members to better monitor activity around the worksite, good crew communication is also essential. Voice-activated FM headsets are being introduced in a limited number of underground shotcrete operations, but more commonly used hand signals are also effective.

With loud ambient noise levels, unamplified voice commands alone are useless. The same applies to most light signals which are only truly effective at attracting attention. Hand signals can provide a method of effective communication between the nozzleman and the gun operator if all parties are familiar with the symbols' uses and meanings.

THE MOST COMMONLY USED HAND SIGNALS ARE:

- One finger pointing up = **More air**
- One finger pointing down = **Less air**
- Two fingers pointing up = **More material**
- Two fingers pointing down = **Less material**
- One finger drawn across the neck = **Shut off air and material**

In some underground mines, a two-man shotcrete crew is used for economic efficiency. It should be recognized that certain hazards can arise when using a two man set-up. For example, the gun operator is often away from the controls and may not be ready to respond quickly to a signal from the nozzleman, should the delivery hose plug. This does not necessarily imply that a three-man crew is without such dangers, but an additional pair of eyes can prevent such a hazard.

Poor communication between members of a shotcrete team can also occur if lighting and ventilation are inadequate, or if the nozzleman and gun operator are not in direct line of sight. If this is the case, the use of voice-activated FM headsets is recommended.



Poorly illuminated, dusty and dirty conditions are not conducive to a safe, efficient, high quality shotcrete operation.

LIGHTING

We know that better lighting reduces accidents, increases production, and improves the quality of in-place shotcrete, underground. So why it is still common to see an underground shotcrete crew struggling to illuminate a rock face using little more than the light from a cap lamp? From a safety standpoint alone, it has been well documented that good lighting reduces highway accidents, factory and warehouse accidents, and even accidents in the home. Therefore, it isn't much of a stretch to assume that proper lighting is even more important in an underground environment.

There are a number of specific lighting objectives that should be targeted when working in an underground construction environment. These include:

1. **INCREASE THE VISIBILITY OF HAZARDS** – Because of the low luminance levels and poor contrast in underground environments, hazards are often difficult to identify. Examples of these hazards include frayed or cut cables, uneven ground, shotcrete material and air hoses, rock debris, and other difficult-to-identify objects. The primary goal of lighting in a mining or tunneling environment is to increase the visibility of these objects so that injuries caused by these undetected hazards are reduced.

2. **INCREASE AWARENESS OF HAZARDS IN THE PERIPHERAL FIELD OF VISION** – With only a narrow-beam cap lamp, the movement of personnel and mobile equipment can be difficult to detect when it occurs in a shotcrete nozzleman's (or shotcrete crew member's) peripheral field of vision. While movement can be detected if it occurs within the localized main beam of the cap lamp, members of the shotcrete crew should also be able to detect subtle movement anywhere in their normal field of vision.

Secondary, portable lighting should be used to enhance overall workplace visibility and reduce shadowing.



3. **IMPROVE VISION FOR THE SHOTCRETE NOZZLEMAN** – It's difficult to shoot what you can't see. A shotcrete nozzleman must have a clear view of the rock face when applying shotcrete to ensure that the material is being applied at the correct angle, at the correct distance from the rock face, and at the specified thickness. With the dry-mix process, the nozzleman also controls the water-to-cementitious material ratio (w/cm) and must therefore also be able to clearly see the consistency of the material as it impacts a surface. Without a clear view of the shotcrete consistency, the nozzleman will most likely be faced with dramatically increased rebound levels caused by "too-dry consistencies" or increased sloughing caused by "too-wet consistencies". Remote shotcreting, usually conducted from a mobile shotcrete spraying unit, utilizes a lighting system designed to address the minimum needs of the shotcrete crew. While most of these systems provide enough lighting to illuminate a heading, secondary portable lighting should also be used to enhance overall workplace visibility and reduce shadowing. In many underground projects, shotcrete is also applied through welded wire mesh (a secondary ground support), the ends of which often overlap. In these cases, the nozzleman must be able to detect problem areas and react accordingly so that voids are not produced behind the overlapping screen.

MAINTENANCE OF SHOTCRETE LIGHTING

Maintenance plays an important role in any successful shotcrete operation, but special attention should be paid to the maintenance of the lighting system, especially when shotcreting in an underground environment. Lenses on portable lighting systems should be monitored for build-up of rebound and overspray, and should be cleaned when necessary. High temperatures will accelerate the cement hydration process, making it difficult to remove hardened material from the lense if the cleaning is delayed. Shotcrete crews should always carry extra bulbs or lenses to quickly replace those that are damaged from the rugged underground conditions. Wires or electrical cords should also be monitored for damage, especially in a wet environment where the occurrence of electrical shock can create an unsafe situation.

There are many factors that contribute to a safe and successful underground shotcrete operation, but proper lighting is one of the most critical. Working with insufficient lighting can be like sending a blindfolded shotcrete crew underground. The quality of shotcrete would be suspect, to say the least, and safety would no doubt be compromised.

SHOTCRETE PLACEMENT

The final outcome of a successful shotcreting program includes a strong and durable hardened product on the rock surface, achieved with the minimum amount of dust and rebound, together with the maximum bonding and compaction. Since surface preparation plays as important a role in successful shotcreting, as does the actual application, the following paragraphs outline a complete application process from a handheld nozzleman's perspective.

The area to be shot should be free of all unnecessary equipment and people. The area should be well lit and well ventilated, and the shotcrete crew should have a pre-determined communication system in place. The shotcrete equipment should also be well illuminated so that air and water pressure can be monitored, and any maintenance can easily be carried out. The shotcrete pot, gun, and pump should have been thoroughly cleaned after the last application and there should be sufficient material readily at hand to last the entire shift.

Both the nozzleman and the shotcrete machine or concrete pump operator are responsible for the safety of the operation. Both should check the complete system from material delivery, pre-dampening (dry-mix), shooting equipment, and delivery hose connections, to the adequacy of the water-ring/nozzle combination (dry-mix), before any shooting is attempted. All hose connections must be thoroughly checked and safety-chained. Kinks in the delivery hose will lead to increased wear at the least, and may increase the risk of blockage.

Always run a material hose in as straight a line as practical, to improve flow characteristics and reduce wear. Exercise caution when coupling hoses, to minimize any restrictions at the point of connection. Always use a premium quality hose, manufactured specifically for shotcreting purposes. These hoses are readily available from shotcrete equipment suppliers.

PROPER NOZZLING TECHNIQUES – HANDHELD

Shotcrete placement, when performed correctly, is a learned craft that also requires commonsense. Over the years, experienced nozzlemen have developed a shooting style that maximizes production and minimizes body fatigue. They have learned the art of working the hose rather than allowing the hose to work them. It often appears to an untrained observer that shotcrete nozzling is an easy task to perform, but in reality, it takes a considerable amount of training and experience to handle a shotcrete nozzle safely.

Although it has been debated for years, most agree that the safest nozzling technique is to straddle the hose and place it between the legs, while maintaining the hose directly behind, to act as a counterweight. The hose should then be brought up across the chest using either arm to snake the nozzle around with one hand. This technique allows for approximately 3 feet (0.9 meters) of hose weight to be supported by the nozzleman at any given time. This practice reduces fatigue and lowers the possibility of back injury.



The safest nozzling technique is to straddle the hose and place it between the legs, while maintaining the hose directly behind, to act as a counterweight.

Holding the hose and nozzle to the side of the body, draping the hose over the shoulder or holding the hose directly over the head with arms fully extended can, in the event of a plug, increase the risk of injury to not only the nozzleman, but to other crew members as well. Such techniques also increase body and arm fatigue and can lead to back injury.

DRY-MIX

OPERATION OF EQUIPMENT – DRY-MIX

Operating instructions vary depending on the type of shotcrete machine used. Before adding material to the hopper, review the shotcrete machine operating instructions. A copy of the operating instructions for the most common shotcrete equipment can be obtained from the equipment distributor. A list of the most commonly used shotcrete equipment supplied by King Packaged Materials Company or Minequip is located in the Appendix.

Note: Always start the delivery of the air slowly; even a small amount of water left in the hose can knock a nozzleman over if the air is turned on rapidly.

SHOTCRETE APPLICATION – DRY-MIX

After all the start-up checks have been carried out to the satisfaction of all crew members, the nozzleman should begin to spray the receiving surface with high pressure water to remove any dust, loose rock or other contaminants that may adversely affect the bond of the shotcrete. The nozzleman should turn on the water supply at the nozzle, and then call for air. In some cases, the nozzleman may have an assistant to move the delivery hose and lighting, and also to communicate with the shotcrete machine operator. The assistant may also be responsible to ensure that overspray and rebound are kept clear of the working area. A blowpipe may be used to clear away waste material.

The equipment should be set-up so that the nozzleman is shooting in the same direction as the airflow. Do not shoot into the direction of ventilation.

When the nozzle operator has cleaned and prepared an area, he or she should divert the nozzle away from the area to be covered and call for material. The air-material-water mixture should be adjusted to spray an area already covered with shotcrete or an area of bare rock that does not require shotcrete. Once the correct water-to-cementitious-material ratio is achieved, shotcrete placement may commence.

The tip of the nozzle should be about 3 to 4 feet (1 to 1.5 meters) away from the rock surface, and perpendicular to it. The nozzle should be worked across the rock in a series of small oscillating circles starting in the hollows formed where

rock has been removed, and worked toward protrusions from the surface. The nozzleman should start low down on the wall and works his or her way backward and forward before moving up the wall toward the back. Dust and rebound can be kept to a minimum by carefully adjusting the water flow rate, the distance from the rock surface, and the angle between the nozzle and the rock mass, while continuing the circular motion.

Nozzlemen should position themselves so that they are not exposed to fall-outs should excess material be displaced from above.



The tip of the nozzle should be about 3 to 4 feet (1 to 1.5 meters) away from the rock surface, and perpendicular to it.



The nozzleman should start low down on the wall and work his or her way backward and forward before moving up the wall toward the back.



Nozzlemen should position themselves so that they are not exposed to fall-outs should excess material be displaced from above.

HOSE BLOCKAGES - GENERAL

Whether using the dry-mix or wet-mix process, hose blockages can be very disruptive to the shotcrete operation. In addition to slowing down the progress of the shotcrete crew, they can also create an unsafe work condition.

HOSE BLOCKAGES – DRY-MIX

When encountering a hose blockage while placing shotcrete using the dry-mix process, the following steps should be taken to minimize the hazard:

1. Immediately stop the rotation of the rotor or feed bowl and turn off the valve that supplies the conveying air.
2. Remove all personnel from the discharge area.
3. Check the pressure gauge to ensure that the pressure in the hose has been released.
4. Nozzelman should ensure that the nozzle is secured to a stable, external structure (hand-grasping the hose is inadequate and may lead to injury).
5. Start searching for the point of blockage from the nozzle end of the hose (the hose will feel soft until the point where the blockage has been located).
6. Bend and/or pound the blockage at the point where the blockage has occurred in an attempt to loosen it.
7. Slowly turn on the air to free the blockage.

HOSE BLOCKAGES – COMMON CAUSES – DRY-MIX

There are a number of factors that can cause hose blockages during a dry-mix shotcrete operation. The following are some of the common causes of hose blockages during the placement of dry-mix shotcrete:

1. Faulty concrete mix design – The shotcrete mix may have poorly-graded fine and coarse aggregates, incorrect cementitious content, oversized or irregularly-shaped coarse aggregate, or a higher than recommended dosage of fibers.
2. Insufficient material conveyance air – Insufficient conveying air will cause build-up along the inside of the hose and increase the potential for plugs.
3. Kinked hoses – Avoid situations where hoses are kinked or bent, as this can lead to an unsafe build-up of pressure.
4. Conveyance hose and joint deficiencies – The deficiencies include dirty, worn and poor quality hoses, worn or improper hose connections, and improperly sized hoses.
5. Pre-hydrated or partially-set material – Hydrated chunks can form from improperly storing pre-packaged materials, using material with an expired “best before date”, or pre-dampening highly accelerated material (especially in hot temperatures).

SHUT DOWN – DRY-MIX

When the last of the shotcrete material has been blown through the nozzle, the following steps should be taken to ensure a safe and proper shut down procedure:

1. Stop the rotation of the feed bowl or rotor.
2. Allow the air to blow the material hose thoroughly clean.
3. The nozzleman should now shut off the water at the nozzle.
4. Shut off the main air valve to the material hose.
5. Place the nozzle in a down position to prevent any water from running back into the material hose.

CLEAN UP – DRY-MIX

After the machine is shut down, it is essential that a thorough clean-up of the machine, pre-dampener, hoses and nozzle, be conducted. Leaving un-hydrated material in the hopper at the end of the shift will increase the possibility that hardened shotcrete material will create an unsafe situation and prevent the next shift from shooting.

1. Disconnect the power source to the shotcrete equipment after shut down.
2. Strip down and clean the rotor or feed bowl assembly.
3. Remove and clean the wear pads and wear plates.
4. Ensure the exhaust port is clean and free of build-up.
5. Ensure the hopper of the shotcrete machine is completely empty and air-blow the machine to remove dust and material (if using a pre-dampener, completely wash-down the shotcrete machine).
6. Open up and clean the auger and trough of the pre-dampener, and wash down the complete pre-dampener.
7. Inspect the hose at the end of each shift. Listen for small air leaks, check for build-up of hardened material (especially where sharp bends were located), and confirm that all connections are sound and secure.
8. Report any worn parts to the crew Chief or Supervisor, so the parts can be replaced before the next shift begins (worn parts are particularly common when using steel fiber reinforced shotcrete).
9. Spray the inside and outside of the shotcrete machine with a form oil or release agent at the end of each shift to make the machine easier to clean.

WET-MIX

OPERATION OF EQUIPMENT – WET-MIX

Operating instructions vary depending on the type of concrete pump or shotcrete sprayer used. Before adding material to the hopper, review the pump operating instructions. A copy of the operating instructions for the most common shotcrete equipment can be obtained from the equipment distributor. A list of the most commonly used shotcrete equipment supplied by King Packaged Materials Company or Minequip is available on the King website, www.kingshotcrete.com.

SHOTCRETE APPLICATION – WET-MIX

Many of the procedures that apply to dry-mix shotcrete application (above) also apply to the application of wet-mix shotcrete. Housekeeping, lighting, communication and surface preparation, play an equally important role in the application of wet-mix shotcrete as they do with dry.

One of the key differences however, is the weight of the material conveyance hose. In wet-mix applications, the hose is usually filled with plastic concrete and therefore weighs much more than the hose used in a dry-mix application. This property makes the hose more difficult to maneuver and like with dry-mix, care must be taken to ensure that the nozzleman is not using a technique that places undue stress on the back.

The tip of the nozzle should be about 3 to 4 feet (1 to 1.5 meters) away from the rock surface, and perpendicular to it. The nozzle should be worked across the rock in a series of small oscillating circles starting in the hollows formed where rock has been removed and working toward protrusions from the surface. The nozzleman should start low down on the wall and work his or her way backward and forward before moving up the wall toward the back. Rebound can be kept to a minimum by monitoring the air supplied to the nozzle, ensuring proper dosage of accelerator, keeping the correct distance from the rock surface, and maintaining the angle between the nozzle and the rock mass while continuing the circular motion.

Nozzlemen should position themselves so that they are not exposed to fall-outs should excess material be displaced from above.

HOSE BLOCKAGES – WET-MIX

When encountering a hose blockage while placing shotcrete using the wet-mix process, the following steps should be taken to minimize the hazard:

1. Stop the pump immediately (if necessary, hit the emergency stop button) and warn the nozzleman to secure the nozzle.
2. Turn off the accelerator pump and compressed air-line to the nozzle.
3. Remove all personnel from the discharge area, as air may be introduced into the placing-line during this process.
4. Reverse the pump to relieve line pressure.
5. Using extreme caution, disconnect the conveyance hose from the nozzle assembly.
6. Slowly stroke the pump in forward, and try to dislodge the blockage. If you are moving the blockage, continue to do so slowly and gently.
7. If you are unable to move the blockage, locate the source of blockage. Plugs will be found (in order of likelihood) at the reducers, nozzle, hoses, elbows, and pipe.
8. Dislodge the blockage using mechanical means (e.g. hammer).

If the initial attempt to remove a blockage fails, the following procedure should be followed:

1. The nozzleman should ensure that the nozzle is secured to a stable, external structure (hand-grasping the hose is inadequate and may lead to injury).
2. The pump operator should pump in reverse for at least two strokes, and then stop the pump. Do not allow anyone to open the system until this is done.
3. To locate where the blockage has occurred, start by carefully removing and cleaning the smallest reducer. Wear face protection, and turn away from the pipeline when opening the clamp.

4. Forward stroke the pump to determine if the blockage is in the pump or the hose. If concrete exits the pump, the plug must be in the hose.
5. Reassemble the hose to the reducer, disconnect the next clamp in succession and forward stroke the pump to determine if the blockage is in the identified section of hose.
6. Continue the sequence until the source of the blockage is determined and removed.

HOSE BLOCKAGES – COMMON CAUSES – WET-MIX

There are a number of factors that can cause a hose blockage during a wet-mix shotcrete operation. The best way to avoid blockage is to understand the causes and take the necessary steps to avoid those causes. The following are some of the common causes of hose blockage during the placement of wet-mix shotcrete:

1. Faulty concrete mix design – The concrete may not be a “pumpable” mix. In order for the mix design to be considered “pumpable”, sufficient cementitious contents and correctly-graded fine and coarse aggregates must be present.
2. Inadequate line size – The line size should always be at least 3 to 4 times greater than the diameter of the largest aggregate.
3. Worn concrete valve parts – Worn parts allow for the finest material or water to escape back into the hopper when pressure is applied. Ensure wear plates, cutting rings and piston cups are in serviceable condition.
4. Pipeline and joint deficiencies – The deficiencies include dirty pipes (pipes that have not been cleaned properly), worn and leaking pipe joints that allow for loss of concrete fines and water, pipes that haven’t been properly lubricated or primed before starting, or inferior quality or badly worn hoses.
5. A pump inadequate for the application – The pump selected for the job must have enough pressure or horsepower available for the required duty.
6. Concrete setting-up in the pipeline – This occurrence may be caused by on-site delays, by attempting to pump “old” concrete, or by reduced setting times caused by hot weather. A good rule of thumb is: if in doubt, wash out.
7. Foreign matter in the concrete can include pieces of hydrated concrete, mixer parts or oversized aggregate.

SHUT DOWN – WET-MIX

When the last of the shotcrete material has been blown through the nozzle, the following steps should be taken to ensure a safe and proper shut down:

1. Turn off the concrete pump and accelerator dosage pump.
2. Close the valve that feeds compressed air to the nozzle.
3. Place the nozzle on the ground and point it away from the work area. If using a remote sprayer, direct the nozzle in a downward direction, away from the work area.

CLEAN UP – WET-MIX

After the machine is shut down, it is essential that a thorough clean-up of the machine, dosage pump, hoses and nozzle be conducted.

1. Fill the hopper with water and pump until only water comes out of the nozzle.
2. Remove the suction pipe from the accelerator tank and run water through the accelerator line until only water is discharged through the line.
3. Open the clean-out door at the bottom of the hopper and thoroughly clean the hopper and agitator assembly.
4. Disconnect the elbow or reducer from the discharge of the concrete pump. With the clean-out door of the hopper clean-out open, run the pump in reverse with a water hose running into the discharge of the pump, until all of the aggregate has been removed from the concrete cylinders.
5. Ensure all reducers, elbows and hoses are clean and have no aggregate remaining inside of them. The use of a sponge clean-out ball in the hose is an effective way of cleaning the concrete hose.
6. Disassemble the nozzle assembly and clean it. Ensure the accelerator and air inlet ports are thoroughly cleaned.
7. Reassemble and install the nozzle assembly, reducers and elbows, and concrete hoses.
8. Connect the accelerator hose and air supply to the nozzle assembly.
9. Close the clean-out door at the bottom of the hopper.

FALL-OUTS

A section of 4 ft² (0.4 m²), 4" (10 cm) thick insitu shotcrete will weigh approximately 700 lbs (320 kg). If a slab of concrete this size was dropped from a height of 12 ft (4 m) and allowed to hit the ground, the sound of the impact alone would startle anyone within the area. Now imagine the damage caused if an unsuspecting person was impacted by that slab of falling concrete. No experienced underground miner would consider walking under unsafe, unsupported ground. For the same reason, no one should ever consider walking under freshly placed, non-supporting shotcrete. Fall-outs represent the most dangerous hazard to a shotcrete crew and there have been documented cases where even experienced shotcrete crew members have been injured or killed after being struck by falling sections of shotcrete.

There are many variables that contribute to the possibility of fall-outs in an underground shotcrete application. Some variables are related to the shotcrete mix, including the mix design (the normal set time and rate of strength gain of the shotcrete mix), the temperature of the material and mix water, and the water-to-cement ratio. External factors such as the ambient temperature, surface preparation, skill of the nozzleman, thickness of the application, activity in and around the area, vibration, the presence of welded wire mesh and the process (wet-mix versus dry-mix), may also have an effect on the likelihood of fall-outs to occur.

Every individual is ultimately responsible for his or her own safety, and understanding when a shotcreted area is safe to enter is an important part of that responsibility. Shotcrete material suppliers should be able to provide early age strength results for any mix that is placed in an underground application. New technology is now available to test the strength of shotcrete mixes as early as 1 – 2 hours after placement. These tests are conducted using an apparatus called an end-beam tester. Consult ground control engineering personnel to establish guidelines for minimum compressive strength and correlate these values to minimum re-entry times for shotcreted areas. Ground control engineers can consult the shotcrete material supplier to provide the necessary technical data for early age strength gain but the supplier's technical staff should be available to assist with site-specific, early-age testing.

THE RULE OF THUMB IS:

AVOID EXPOSURE UNDER FRESHLY PLACED SHOTCRETE UNLESS THE AREA HAS BEEN CLEARED FOR ENTRY.

THE SHOTCRETE OPERATION – SUMMARY

- ☑ Always follow proper bulk bag handling procedures.
- ☑ Always ensure safe, well maintained, proper shotcrete equipment is used.
- ☑ Always ensure the workplace is clean and organized, with a designated place for storage of discarded polywrap, empty bulk bags and pallets.
- ☑ Develop an effective communication system using either predetermined signals or voice-activated FM headsets.
- ☑ Always ensure proper illumination from an adequate number of light sources.
- ☑ Always follow proper start-up, operating and shut down procedures.
- ☑ Never remove the screen and place hands or other objects in the hopper while the equipment is operating or connected to the power source.
- ☑ Always take the necessary time at the end of each shift to properly clean and maintain the equipment.
- ☑ Since proper training is critical to a safe and successful shotcrete operation, ensure adequate initial training with follow-up sessions to update new crew members on proper equipment operation.
- ☑ Learn and practice the correct and safe procedure for dealing with plugged hoses, for both dry and wet procedures.
- ☑ Avoid exposure under freshly placed shotcrete unless the area has been cleared for entry.

DO'S AND DON'TS OF SHOTCRETE SAFETY

DO'S

DO ensure that you receive proper training from qualified personnel before you start to work on a shotcrete crew.

DO wear properly fitted and maintained Personal Protective Equipment (PPE) when working on a shotcrete crew (includes respiratory protection, hearing protection, safety glasses and appropriate clothing).

DO use NIOSH or MSHA approved, powered, air-purifying respirator with a filter, if the crystalline silica concentration is above the maximum allowable TLV.

DO ensure that the shotcrete machine is properly maintained (inspect all wear pads and hoses daily).

DO examine the straps of bulk bags when lifting, to ensure no tears or damage to straps is evident.

DO use a pre-dampener, a semi-wet nozzle or a pre-dampening nozzle for all shotcrete operations, to minimize dust.

DO remove yourself from the shotcrete crew if you experience burns or irritation to your skin from either an allergic reaction or sensitivity to shotcrete mix.

DO wash hands, arms and face before eating and take a thorough shower at the end of each shift, when shotcreting.

DO keep shotcrete materials stored in a clean, level, designated storage area away from the elements.

DO ensure that good housekeeping practices are followed when working on a shotcrete crew. Always find a suitable location for empty pallets and bags, and stack them away from the shotcrete equipment and crew.

DO ensure that sufficient lighting is available for the shotcrete crew, both at the equipment location and at the nozzle.

DO ensure that a lifting cross, designed and stamped by a licensed Professional Engineer, is used to lift shotcrete bags. Lifting the bag with the forks of a forklift is also an acceptable method when done properly.

DON'TS

DON'T remove the screen from a shotcrete hopper unless the machine has been shut down and disconnected from the power source.

DON'T try to lift bulk bags with three or less straps.

DON'T, under any conditions, stand underneath a suspended bulk bag.

DON'T use a lifting cross to lift heavy shotcrete bags unless the lifting cross has been designed to handle the load.

DON'T rely on workers yelling to communicate with other shotcrete crew members. Develop an effective communication system (e.g. hand signals) before starting.

DON'T attempt to untie a bulk bag spout that is suspended over a hopper unless an adequate safety frame has been fastened to the hopper.

DON'T point the shotcrete nozzle in anyone's direction when trying to dislodge a plugged hose.

DON'T stand beneath shotcrete ground until the area has been cleared for entry.

CONCLUSIONS

Shotcreting has become an accepted method of providing active ground control in many underground mines and tunnels around the world. There is no magic involved in successful shotcreting, but a certain degree of care and diligence is required by all members of the team involved. The engineering designer, the materials and equipment specifier, the materials supplier, the warehousing and trans-shipping team, and the underground shotcrete crew must all exercise caution.

It is critical that proper training is provided for all members, to ensure the safe, effective application of shotcrete.

It is recommended that the contents of this document be used as the basis for a program of instruction for underground worker safety with the use of shotcrete.

APPENDIX

SHOTCRETE EQUIPMENT SUPPLIED BY KING PACKAGED MATERIALS COMPANY OR ITS KING SHOTCRETE SOLUTIONS DIVISION

DRY PROCESS EQUIPMENT

- Aliva AL-246.5
- Aliva AL-257
- Aliva AL-267
- Allentown Meyco Piccola
- Allentown GM 060

WET PROCESS EQUIPMENT

- Allentown Powercreter 10 and 20 Concrete Pump
- Putzmeister Thom Katt Concrete Pumps

REMOTE SPRAY ARMS

- Aliva AL-302 Arm
- Aliva AL-503 Arm and Crawler

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IMPORTANT FOREWORD & DISCLAIMER

King Packaged Materials Company has developed this document to provide general, commonsense information regarding the safe use of shotcrete in underground applications.

This document was developed on the basis of observations and experiences obtained through visits with shotcrete users at mines throughout North America, and through consultations with many other personnel involved with shotcrete application.

The safety information in this document should be reviewed and heeded by all users of King Packaged Materials Company shotcrete products. However, review of, and adherence to, the guidelines in this document is NOT an alternative to careful use of the product by properly trained crew members exercising their professional judgment with respect to the site, the conditions and the project at hand. Safety procedures and policies at your place of work should always take priority.

Although the information in this document is supplied in good faith and is believed to be correct, King Packaged Materials Company makes no representations or warranties as to the completeness or accuracy of the information.

In no event will King Packaged Materials Company be responsible for damages of any nature whatsoever resulting from the use of, or reliance upon, information in this document.

Version #04: This version of the King “Underground Shotcrete Safety Guidelines & Recommendations” document supersedes any and all previous versions produced or distributed.

Mixing Strength With Satisfaction

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