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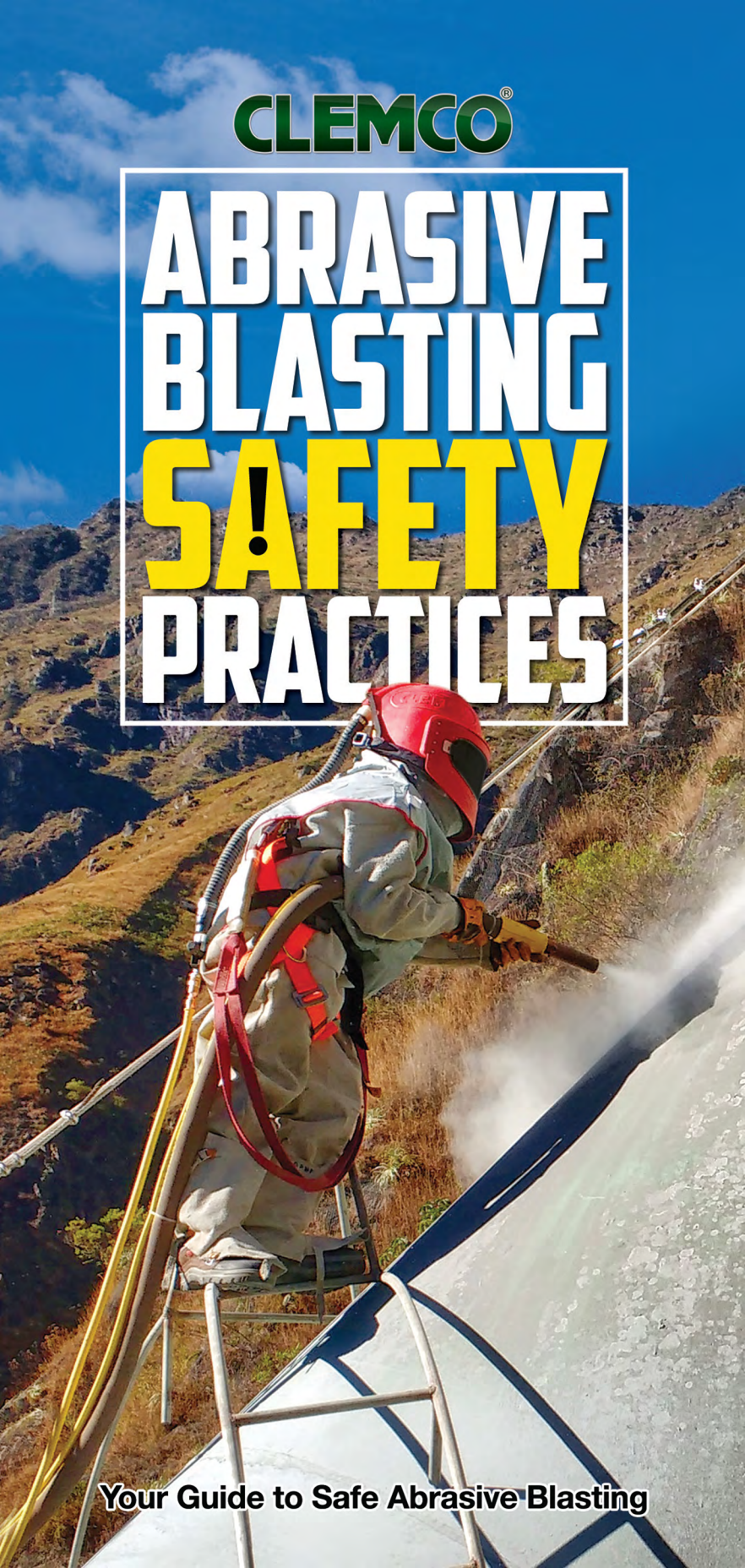
ABRASIVE BLASTING SAFETY PRACTICES



Your Guide to Safe Abrasive Blasting

ABRASIVE BLASTING SAFETY PRACTICES

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CLEMCO®
INDUSTRIES CORP.

NOTICE TO PURCHASERS AND USERS OF OUR PRODUCTS AND THIS INFORMATIONAL MATERIAL

Clemco proudly provides products for the abrasive blast industry and is confident that industry professionals will use their knowledge and expertise for the safe and efficient use of these products.

The products described in this material, and the information relating to these products, are intended for knowledgeable, experienced users.

No representation is intended or made as to: the suitability of the products described here for any purpose or application, or to the efficiency, production rate, or useful life of these products. All estimates regarding production rates or finishes are the responsibility of the user and must be derived solely from the user's experience and expertise, not from information contained in this material.

It is possible that the products described in this material may be combined with other products by the user for purposes determined solely by the user. No representations are intended or made as to the suitability of or engineering balance of or compliance with regulations or standard practice of any such combination of products or components the user may employ.

Abrasive blast equipment is only one component of an abrasive blasting job. Other products, such as air compressors, air filters and receivers, abrasives, scaffolding, hydraulic work platforms or booms, equipment for lighting, painting, ventilating, dehumidifying, parts handling, or specialized respirators or other equipment, even if offered by Clemco, may have been manufactured or supplied by others.

The information Clemco provides is intended to support the products Clemco manufactures. Users must contact each manufacturer and supplier of products used in the blast job for warnings, information, training, and instruction relating to the proper and safe use of their equipment.

For more information about all aspects of abrasive blasting safety practices, visit the Safety Information tab at:

www.clemcoindustries.com

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INTRODUCTION

Abrasive blasting is one of the most powerful methods of cleaning and preparing surfaces. High-pressure compressed air transforms motionless abrasive grains into highly-accelerated, hard impacting particles at velocities approaching sonic speed. Due to abrasive blasting's tremendous force, it is an absolute necessity to thoroughly train operators, install all required safety components, use the best quality equipment, exactly follow instructions, and perform all necessary or recommended maintenance.

Failure to comply with installation, operation and maintenance instructions, and with all safety regulations and requirements will result in serious injury or death to operators and other personnel in the blasting vicinity.

This booklet contains safety information based on Clemco's design, testing, manufacturing experience, and years of field observations. This booklet is intended to express Clemco's own knowledge of safety requirements, in addition to potential hazards reasonably foreseen within the limits of Clemco's field observations. Information contained herein is not all inclusive of safety requirements for abrasive blasting operations or applications. There may be additional local, regional, state, national or job site safety and environmental requirements that must be heeded by employers and users prior to installing and operating abrasive blast equipment.

This booklet should not be considered the sole reference for safe use of Clemco's products or any non-Clemco equipment utilized in blasting systems. Employers and users are advised to thoroughly read and comprehend Clemco's "Blast-Off 2" booklet, equipment operating manuals, and related literature in conjunction with this booklet as well as all printed materials supplied with non-Clemco equipment. This booklet is intended to

supplement other training materials and information from manufacturers of ancillary equipment.

Clemco is not able to research each manufacturer of ancillary equipment, and must not be considered a source of information on safe, efficient operation of other job site support equipment. Clemco accepts no responsibility for the failure of employers and users to fully investigate and comply with safety regulations and required safety practices.

Abrasive blast equipment can be used efficiently and safely only when there is a complete understanding of the vital functions of each component. There is also the need to use plain common sense when using blast equipment. For example, an air leak is an audible warning that something is not right and should be investigated immediately. Safety devices; such as, remote controls and operator protective equipment, must be kept clean and maintained in perfect order for the obvious benefit of preventing injury. This booklet will cover the safety aspects of each component to the best of our knowledge and within the level of our expertise.

This booklet presents safety information in four sections:

SECTION ONE draws attention to potential major hazards associated with blast equipment usage that might be considered relatively normal. Relatively normal usage is defined as job applications in which standard air compressors, blast equipment, and abrasive are employed to perform customary surface preparation work under typical conditions. Relatively normal usage does not include applications where specialized equipment or materials are required, or where surfaces to be blasted are in difficult or unique places, or where the combination of equipment used, or staging required, is other than what is described in this section. There are OSHA regulations dealing with specific safety requirements for work in confined spaces. While all stated potential hazards apply,

there are most likely additional hazards to be identified for which safeguards must be established.

SECTION TWO deals with potential hazards in the order in which they are likely to be encountered on a typical job site application. This section covers preparing equipment for operation, examining the job site conditions, setting up equipment, describing operational procedures, and ends with cleaning up the work place.

SECTION THREE itemizes each system component in a check-off list format, emphasizing precautions which must be taken to prevent harm to persons who install, operate, maintain or work in proximity of abrasive blasting areas.

SECTION FOUR lists OSHA regulations pertaining to abrasive blasting, contact information for federal agencies and industry professional associations. These references are provided for easy access to information that will guide you in setting up a safe and efficient blast operation. The APPENDIX contains useful blast operation reference data. Prior to installing, operating, maintaining and assisting in the operation of abrasive blast equipment, personnel must be thoroughly educated on the blasting process, and trained in the operation of the equipment and related hazards. Furthermore, they must completely understand all safety regulations and requirements applicable to equipment, environment and job site conditions. OSHA regulations specifically place the responsibility for employee's safe working conditions on employers. Employers must provide proper training programs and materials for their employees. Should an employee feel he or she is inadequately or improperly trained, he or she should immediately bring that fact to the attention of his or her employer prior to operating any equipment.

SECTION ONE

GENERAL POTENTIAL HAZARDS

This section lists typical hazards in an attempt to train the reader to look for hazards. It illustrates a number of hazards that exist in normal operation. Common sense and commitment to safe practices will assist employers, safety engineers and users to identify other hazards that may exist.

In this section, hazards are described with brief safety practices and recommendations. The purpose of this section is to alert the reader to some of the possible dangers that may be found in abrasive blasting applications. Section Two provides more detailed information on these hazards and describes effective methods to prevent injuries, or possible death, to equipment operators and work site personnel.

Common sense and a commitment to safe practices will assist employers, safety engineers, and users to identify hazards on the job site.

UNTRAINED OPERATORS

Untrained, unqualified blast operators are “accidents waiting to happen”. Employers must not allow personnel to assemble, operate or repair blast equipment until they have been thoroughly instructed on the blasting process, equipment functions and safety procedures. Training includes reading and understanding all equipment instructional manuals, tags, labels and other printed materials furnished with the equipment, as well as holding specific discussion on proper safe operation and staging a hands-on demonstration of the equipment.

ABRASIVE AND EQUIPMENT HANDLING

Severe back injuries can occur from improper handling of abrasives, blast machines, hoses and other heavy components. Manually moving blast machines is especially dangerous if the person is not physically capable of controlling the machine weight. The popular two-wheeled 6 cuft. (200 liter) capacity machine weighs

about 400 pounds (180 kg) when empty, and is difficult to control during movement by a single person. Not only is there the potential for back injury from strain, but also there is the chance of foot and leg injury if the person loses balance control and drops the machine. The stress and strain from improper lifting of heavy bags of abrasive is a common source of back injury.

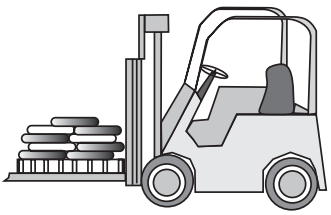
Follow these simple but important rules:

- Use a forklift, crane or other type of lifting device for transporting a blast machine; always use a lifting device when the machine contains abrasive.
- Never manually move a blast machine on wet or slippery surfaces, or where abrasive has been spilled on hard surfaces.
- Never attempt to manually move a blast machine containing abrasive.
- When a two-wheeled, empty machine must be manually moved, use two physically-capable workers, and ensure that the surface is smooth, level and uncluttered by hose, debris or other obstacles that prevent smooth rolling.
- On job sites requiring continual manual machine handling, use a four-wheeled blast machine or towing attachment on a two-wheeled machine; such as, the Clemco “Mule”.
- Always disconnect hoses from machines to avoid interference during movement.

Abrasive loading can be easier to accomplish by using forklifts or vacuum transfer equipment. With forklifts, bagged abrasive on pallets can be raised up and loaded into the top of blast machines.

A better method is to use Clemco’s Easy Load vacuum system that pneumatically draws abrasive from the ground level into storage hoppers mounted over blast

machines. Either method minimizes the possibility of bodily injury.



Working with blast equipment and abrasive requires a certain amount of heavy lifting, even when mechanical devices are available. Physical conditioning and proper technique are required for this type of work. It is wise to use back support work belts which prevent back strain by providing back and abdominal support. Consult with safety and medical experts for advice on the proper work belt design.

FALLING AND TRIPPING

Take precautions at the work site to eliminate hazardous surface obstacles that may interfere with worker mobility. Blast operators wearing helmets have limited fields of vision, and are not always readily aware of surface conditions. They are susceptible to tripping and falling when their work surface is wet, uneven, unstable, and cluttered with hoses or other obstructions.

Falling and tripping hazards can be avoided by providing smooth and clean work areas. Cover surface holes. Remove water, oil and other liquids to prevent slipping. Sweep away or vacuum, loose, scattered abrasive. Install adequate support materials over the surface on irregular walkways. Lay out blast hoses so personnel movement will not be hampered. In general, give blast operators as much clear and clean working space as possible.

On elevated work, blast operators should be equipped with safety harnesses to avoid falls. Secure blast hoses by tying them to scaffolding or personnel platforms to prevent injury from falling hoses on other personnel working below or near blasting areas.

ELECTRICAL SHOCK

Working around electrical power lines and wires is very dangerous. Do not allow blast operators to work near power lines because contact with high voltage exposed wires, connectors or terminals may result in serious injury or death. Before working near electrical lines , turn off power. On blast operator's electrical controls, use transformers that reduce incoming high voltage to 12 or 24 volts. Use dust-tight, moisture-free connectors on all electrical fittings. Keep electrical cords and fittings away from water and other liquids, and prevent intrusion of metallic abrasives or dust.

STATIC ELECTRICITY

Static electricity may cause explosions in the presence of heavy concentrations of flammable gas. Static electricity is generated by the friction of high-speed abrasive through blast hose. When untreated blast hoses and gaskets are used, static electricity intensity builds up through the hose lengths leading to the nozzle. On non-metal blasting jobs, blast operators become the ground connection for static electricity to travel. Blast operators will experience a harmless but annoying shock. On metal blasting jobs, however, a static electric arc may jump from the nozzle to the metal surface. When the metal structure is a gas storage tank and atmospheric conditions (heat, humidity, heavy gas fumes concentration, etc.) allow it, an electrical arc may ignite the fumes.

Always use static-dissipating blast hose and coupling gaskets to prevent static electricity buildup. On

applications where flammable gas is present and cannot be avoided, install additional grounding wires on blast machines and nozzles, and use ventilation systems to reduce the fumes concentrations to an acceptable level. First, however, consult with the job site safety engineer for specific safety instructions. Contact the Painting and Decorating Contractors of America (see Section Four for address) to obtain specific grounding information.

HEARING PRECAUTIONS

Noise from abrasive blast nozzles can be loud enough to damage the hearing of blast operators and others on the work site. The noise level depends on nozzle size and pressure, and noise generated in the surrounding area. The popular 3/8-inch (9.5 mm) nozzle, at high pressure, can produce a noise level as high as 130 decibels (dBA) without abrasive in the air stream. Excessive noise can come from many other sources on job sites, especially when working in enclosures where sounds are trapped by walls and ceilings. Air compressors and other machinery add to the noise volume, all of which may reach a harmful level.

Hearing protection must be worn by all blast operators and personnel in the blasting area.

In compliance with OSHA regulations, job site workers must not be exposed to noise levels exceeding 80 decibels as an eight-hour time-weighted average (80 dBA TWA). Consequently, blast operators and other personnel in the blasting vicinity must wear hearing protection. The type of protection should be based on noise readings taken by a safety engineer. Lack of the proper protection can result in permanent hearing damage. Clemco Apollo respirators are the only OSHA-compliant, Type-CE supplied-air respirators that provide secondary hearing protection.

MECHANICAL LIFT EQUIPMENT

Serious injury or death can occur when scissor lifts, personnel lifts, cranes, forklifts and similar mechanical

equipment are operated improperly. Accidents have happened. Workers not following proper operating procedures have fallen from elevated platforms and have tipped over lift equipment.

Train personnel thoroughly before they operate mechanical equipment. Lower lift equipment to its lowest point before moving it to a new location. Do not overload work platforms and personnel buckets. Make sure job surfaces for lift equipment are level, unobstructed, and provide stable load and mobile support. Study manufacturer's instructions and follow them completely. Train all operators on each specific piece of equipment to avoid dangerous misuse.

AIR COMPRESSOR PRESSURE

Air compressors produce powerful pressures. They require careful attention. Broken air lines and air fittings can unleash strong forces that can cause serious bodily injury. Damaged air fittings have been known to blow off of compressors. Poorly maintained air hoses have ruptured and fiercely whipped around, endangering anyone close by.

Compressors must be properly maintained as instructed by the manufacturer. Air hoses and fittings must be inspected regularly, and replaced whenever there is any sign of damage or wear. Install safety pins and safety cables on every hose connection. Never adjust the compressor pressure setting above the blast equipment maximum working pressure rating (many machines are rated 125 psi [860 kPa/8.6 bar], but check manufacturer's identification plate to confirm).

BLAST MACHINES AND REMOTE CONTROLS

Blast machines are pressure vessels built to accommodate rough field service; however, careless handling may create dangerous results. Dropping a machine off a truck, for instance, may force welded fittings to puncture or severely damage the machine's shell or cone. Any damage to the shell or cone could weaken the machine's structural strength, and may cause highly dangerous ruptures during pressurization. Rupture dangers also exist when the machine's piping, valves and fittings are damaged, so these components

must be inspected frequently. Always use care when moving machines.

Welding on blast machine vessels should be avoided. Welding may affect the strength of the steel and lower the pressure safety factor. Also, welding on a pressure vessel voids its certification. When repair is necessary, welding work must be done by a certified pressure vessel welder, and the machine must be hydrostatically tested according to A.S.M.E. specifications.

High-pitched, bleed-off air noise that occurs when blast machines shut down may provoke severe hearing injury to nearby persons. In addition, uncontrolled bleed-off air usually carries abrasive particles in the air stream, posing another threat of injury. Piping the air outlet to a distant location may seem safe (i.e., outside the building), but someone may be in the area without knowledge of the bleed-off outlet. Noise and abrasive injuries can be prevented by installing and frequently maintaining a Clemco bleed-off muffler.

All blast machines must be equipped with remote control systems to start and stop the blasting process. Remote control systems will not properly respond if they are not well maintained. Dirty, worn-out parts may interfere with the control's ability to shut-off, culminating in potentially serious injuries to blast operators and bystanders. This maintenance advisory also applies to the bleed-off muffler. Increasing depressurization time signals the need to replace the muffler filter element. Substituting component pieces with other manufacturer's parts is an extremely dangerous practice, which has resulted in system malfunctions and accidents.

Circumventing the free movement of remote control handles by strapping or taping down the safety levers bypasses a critical safety feature, and may result in serious injuries.

For prevention of electrical shock with electrically operated remote controls, transformers must be used to reduce incoming high voltage to no more than 12 or 24 volts at the operator's control handle.

Follow the owner's manual installation, operation and maintenance instructions completely. Use only the original manufacturer's replacement parts. Keep remote controls in perfect working order.

NOZZLES, BLAST HOSE AND COUPLINGS

Nozzles, blast hose, couplings, and nozzle holders present a high potential for injury due to internal wear, high pressure, atmospheric exposure and general rough handling. Nozzles can be forcibly propelled out of nozzle holders when nozzle and/or nozzle holder threads are severely worn. Abrasive blow-outs are not uncommon in blast hose, especially in sections where hose is sharply bent during operation. Couplings and nozzle holders are subject to several types of failures when:

(a) couplings and holders are not properly installed on blast hose;
(b) gaskets are worn or missing;
(c) couplings are worn and no longer safely lock together or are not secured with cotter pins;
(d) breakage or distortion occurs from harsh field use.

Invoke job site procedures to prevent heavy vehicles from driving over and damaging blast hose fittings. Always install coupling safety cotter pins and safety cables. Failure to do so invites critical injuries when worn or damaged couplings suddenly disengage under pressure. These events cause unexpected release of high velocity air and abrasive, and uncontrolled whipping of blast hose, which may inflict serious physical harm to anyone in the immediate blasting vicinity.

Special attention must be given to monitoring the condition of nozzles, blast hose and couplings to avoid injuries. Make a daily check of the threads in nozzles and nozzle holders for damage and wear. Correctly install couplings on hose, ensuring a tight seal of the hose end on the coupling shoulder, and a snug fit between the hose O.D. and the coupling I.D. Do not mix different brands of couplings. Always use the proper size and type of coupling screws. Change nozzle washers and coupling gaskets every four hours. Inspect blast hose daily - look for soft spots which indicate tube wear. Do not permit vehicles to run over hoses or couplings. Always install safety cotter pins in couplings and safety cables at every air line connection. Never continue to blast with leaking nozzle holder, couplings or blast hose.

OPERATORS AND BYSTANDERS

Blast operators and nearby personnel will be exposed to several hazards unless vital precautions and safety protection are provided. The powerful force of high velocity air or abrasive can inflict severe and permanent bodily harm. Without hardhat protection head injuries may occur. Loss of hearing is possible from sustained excessive noise levels. Eyes may be injured from abrasive particles. Life threatening respiratory diseases, including silicosis, asbestoses, and lead and other heavy metal poisoning, are constant dangers. There is the potential of operator death from inhaling carbon monoxide and other non-respirable gases.

Blast operators must be fully aware of all workers close to them to avoid accidentally pointing the nozzle in their direction. Blast operators must be equipped with heavy duty clothing to protect them from rebounding abrasive or accidental direct nozzle blast. Steel-toed shoes and leather gloves must be worn. Ear plugs or similar hearing protection for operators and bystanders is absolutely necessary to prevent hearing injury.

In addition to the blast operator, respiratory equipment must be worn by all personnel in the blasting area. The type of respirator must be determined by employers and/or safety engineers based on specific applications and exposure to specific hazards. Hard hats and safety glasses are required on most job sites. Applications involving the

use of crystalline silica (quartz) abrasive containing more than 1% free-silica, and removal of toxic materials, such as lead, asbestos and heavy metal coatings, requires high efficiency respirators with an assigned protection factor of 1000 or more times the permissible exposure limit (PEL). Respirator breathing air must not exceed 10 ppm (parts per million) of carbon monoxide. Plant air used for breathing air must be tested for safe inhalation. Breathing air from any source must be Grade D quality or better. Grade D is described later in this booklet in the Operator Safety Equipment section.

TOXIC DUST

Inhaling dust in a blasting operation is dangerous, and can result in severe lung diseases or death. Before using any blasting abrasive, check the Safety Data Sheets (SDS) to find out the chemical composition of the abrasive material. Investigate the chemical and physical composition of the materials that are to be removed from the surface. Some protective coatings consist of lead, cadmium, chromium, titanium or other metals which, when pulverized to respirable dust particles, can cause harm to the respiratory system. Use the expertise of an industrial hygienist and safety engineer to establish an appropriate and effective respiratory protection program for each and every blasting application.

It is best to assume that all dust can be harmful; consequently, approved and proper respiratory protection must be worn by all personnel within an abrasive blasting zone. The type of protection is predicated on the hazardous dust generated from pulverized abrasive and surface materials. Be aware that standard air fed helmets are not adequate for every type of dust hazard. OSHA(1), NIOSH(2), EPA(3) and other safety agencies have established permissible exposure limits (PEL) for workers, and assigned protection factors (APF) on respiratory equipment for different types and concentrations of hazardous dust.

(1) Occupational Safety and Health Administration
(2) National Institute of Occupational Safety & Health
(3) Environmental Protection Agency

Wearing proper respiratory equipment is not restricted to the blast operator. All personnel within a defined

blasting/dust zone must wear proper, approved, nose and mouth, or helmet respirators. The zone, as determined by an industrial hygienist and/or safety engineer, is an area where any personnel may be subjected to unacceptable levels of respirable dust. On outdoor applications, the zone size depends on atmospheric and other conditions affecting dust travel. Contained applications, where blasting takes place within enclosures, are easier to monitor and control, but they may be more hazardous due to the dust concentration level. Engineering solutions; such as, ventilation systems and dust collectors, are often necessary to mitigate exposures in enclosed conditions.

Risk of dust inhalation can be highest during the clean-up process after blasting is completed. Sweeping, shoveling and other removal activities to clean-up pulverized abrasive and surface contaminants generate vast amounts of airborne respirable dust. Avoid using compressed air as a method of cleaning unless it is used in conjunction with a highly efficient ventilation system. Workers must wear proper approved respirators during clean-up, and until the work site atmosphere has been tested and found safe to breathe without the need of respirators.

Important Note
A proper approved respirator is one that has been specifically designed for protection against specific breathing-air contaminants in abrasive blasting operations.

Dust, spent abrasive and debris removed from surfaces must be disposed of in accordance with the federal and state regulations on solid and hazardous waste. Disposal cost studies should be done and arrangements should be made well in advance of blasting jobs to avoid unanticipated time and expense.

SECTION TWO

COMMON SAFETY PRACTICES

This section describes general potential hazards and preventive safeguards for abrasive blast equipment from start-up to shut-down. It covers equipment and personnel preparation, transporting equipment to the job site, equipment assembly, personnel protection, operating techniques, shut-down procedures and clean-up requirements. Section One identifies many anticipated hazards. It is recognized, however, that many other hazards may exist. It is impossible to list all potential hazards in all possible blasting applications.

The purpose of this section is to encourage the reader to anticipate and look for hazards. The best advice for avoiding hazards is to be observant, use common sense, and if you think a hazard may exist, guard against it. This booklet should be used as a guide for employers, safety engineers and users to develop safety procedures and policies for their own specific applications.

The information in this section should be used in conjunction with all instructional manuals, including safety labels, decals and tags, supplied with Clemco machines, tools, and accessories, and by manufacturers of ancillary equipment and materials (i.e., air compressor, air hose, abrasive, etc.).

A. EQUIPMENT AND OPERATION PREPARATION

OPERATOR TRAINING

Without question, the most important element of a manually-operated blasting system is the blast operator. The finest equipment will not perform to its greatest potential without blast operators who are fully trained on the equipment and totally knowledgeable about the process. Equally critical to production output is safety. Blasting is a powerful cleaning method which requires close attention to safety procedures for operators and job site personnel.

There are several professional organizations offering technical training programs covering blasting and painting techniques. Two of these organizations are the

Society for Protective Coatings (SSPC) and the National Association of Corrosion Engineers (NACE). Contact information is available in Section Four. Employers wishing to enhance their own training programs will find it advantageous to contact organizations within the blasting and painting industry to inquire about training. This section discusses some of the most vital areas of operator safety training.

Blast operators and their assistants must read and fully understand all instructional materials prior to operating equipment. If an employee cannot read or understand the manuals, the employer or supervisor is responsible for instructing the worker on how to install, operate and maintain the equipment in a safe and productive manner.

When instructing operators, most important is the use of all safety devices on the machine. Remote controls must be inspected and tested before turning on abrasive metering valves to guarantee precise start and stop response time. Further instruction should cover proper operation of various accessories furnished with the machines. In essence, blast operators must be completely familiar with the form, fit and function of the machines, and understand the importance of regularly-scheduled maintenance for continued safe operation.

An equally important safety issue is personal protection equipment. Blast operators and other workers must be instructed to never inhale dust...**ANY** dust. No dust is safe to breathe. Even when the blast abrasive is non-toxic, dust from the coatings being removed may be toxic.

NO DUST IS SAFE TO BREATHE.

At a blast site, invisible dust particles hang in the air, stirred by wind or by movement; therefore all personnel in the blast area must wear NIOSH-approved, air-fed respirators at all times, whether or not blasting is in progress. Dust is generated from substances removed from the blasted surface as well as from pulverized abrasive. Dust is present when handling and loading

abrasive prior to and during the blasting process. Dust is in heavy concentrations during clean-up operations when blasting is finished, and when emptying dust collector hoppers or drums. The best way to avoid respiratory injury is to wear NIOSH-approved, properly-rated air-fed helmets or respirators before, during and after the blasting operation, and until the air has been tested for safe breathing. These instructions should be given not only to the blast operators, but also to anyone else within the blasting zone. Remember — the dust causing harm to the respiratory system is often invisible.

Blast operators must wear heavy duty clothing, or blast suits, and leather gloves as necessary safeguards even when it's hot and humid.

EMPLOYER RESPONSIBILITIES

Since 1971, Occupational Safety & Health Administration (OSHA) regulations have made it quite clear that employers are solely responsible for providing safe working environments for their employees. Employers must provide training and must supply all necessary personal protection equipment and enforce effective safety programs to eliminate job hazards. Employers should establish regimented safety and health practices that comply with the standards decreed by OSHA, and should follow the instructions provided by the manufacturers of the equipment and material.

Employers must demand full cooperation on safety and health policies from their employees. Some employees put their health and the health of others at risk by purposely circumventing established safety procedures because they find them cumbersome or troublesome. Such workers, despite their knowledge of the danger of inhaling harmful dust, may wrap rags around their noses and mouths because they find air-fed helmets too bulky.

Employers have a duty and a moral obligation to create effective safety programs and enforce them through training and strict disciplinary action to violators.

Prior to starting up any blasting job, employers should investigate potential application hazards. Use laboratory tests to determine the composition of any unknown materials that will be removed by blasting. Steel structures may have coatings containing lead or other heavy metals. Some coatings may even contain asbestos. Many pipes are wrapped in asbestos insulation. Blasting will release these toxins in the form of fine dust.

Check the blasting abrasive for the presence of arsenic, cyanide, or other toxins. These materials present a physical hazard to the blast operators and anyone else in the vicinity. The safety data sheet (SDS) provides this information.

Employers can avoid unnecessary risks to employees by adhering to manufacturer's warranty stipulations and safety recommendations. These recommendations warn of the hazards of modification and substitution of original equipment components and parts. Employees can be unnecessarily exposed to harm from malfunctions of the equipment caused by use of improper parts. Employers who allow unauthorized modifications and substitutions must assume full liability for the modified equipment. No manufacturer will guarantee or warrant equipment that has been altered. If unclear about equipment use, employers should contact the manufacturer before operating.

Employers should be particularly sensitive to the ability of employees to understand instructions, warnings and all potential hazards associated with their jobs.

If an employee cannot read, or cannot read English, or is a poor reader, employers should have a qualified person meticulously review each equipment manual and all warning decals, labels, tags, etc., with the employee, making absolutely sure that the employee comprehends everything required of him or her.

Properly-trained employees become craftsmen in their jobs; (they) take special pride in their work and become valuable assets to their companies.

It may seem that employers have to take on a tremendous amount of work to prepare employees for their assigned tasks, but in reality, everybody wins. Properly-trained employees become craftsmen in their jobs; they take special pride in their work and become valuable assets to their companies. Workers learn that complying with safe practices prevents injuries that may affect their physical well-being or even their lives. Employers reap benefits from these educational efforts from outstanding employee performance.

EQUIPMENT PREPARATION

Compressed air is a powerful source of energy and must be respected. A wild thrashing air hose that has blown loose is very dangerous, and can inflict serious injury if it strikes someone. Properly-trained personnel must pay special attention to assembly of air lines, valves and fittings. The compressor must be checked initially for air pressure setting. For some blast machines, the operating pressure setting should be no higher than 125 psi (8.6 bar/860 kPa). Always check the National Board plate on the blast machine for the maximum working pressure allowed. While some of the blast system components have higher pressure ratings (i.e. blast hose), pressure to the entire system should not exceed the approved pressure rating of the lowest-rated element, often the blast machine. Be sure the air compressor is not set to exceed the specified working pressure rating.

Choose an air compressor that will generate a steady flow at high pressure and high volume, and that is built to withstand the environmental conditions found at a blast site. For blasting, oil-free rotary vane and screw compressors are best. Blasting operations generate dust; consequently, compressors should be equipped with highly efficient filters to trap air intake dust to prevent excessive engine wear. Sustained use in hot weather increases a compressor's operating temperature so it

is best to use compressors furnished with shut-down devices to prevent over-heating. Severe operating temperatures can cause damage to engine parts and will produce carbon monoxide, a colorless, odorless gas, which is deadly to blast operators, when compressors are also used for helmet breathing air.

Compressors must be equipped with air receiver tanks and furnished with drain valves to release accumulated water. Receiver tanks must include pressure relief valves, set at the maximum working pressure of the blast machine. Pressure relief valves must conform to OSHA regulation 29 CFR 1910.169.

Severe operating temperatures can cause damage to engine parts and will produce carbon monoxide, a colorless, odorless gas, which is deadly to blast operators, when compressors are used for helmet breathing air.

Prior to installing fittings and hose connections, shut down air compressors to prevent injury. Inspect valve and coupling gaskets for wear and distortion, and immediately replace if not in good condition. Carefully install fittings and connections and fit with safety interlocks (safety cotter pins, safety cables, etc.) prior to pressurization. Check air hose and blast hose for internal wear and damaged outer casings so that blow-outs can be avoided. Install steel safety cables on all hoses to guard against dangerous whipping action in the event couplings or fittings inadvertently disengage or fail in some other manner.

On abrasive blasting job sites, position compressors upwind of dust generated by the blasting process. Always avoid entry of dust, dirt or other contaminants into compressor air inlets to prevent premature wear on compressor parts. Locate compressors and ambient air pumps where exhaust fumes from vehicles and any engine-driven machinery will not enter air inlets. The compressor's own exhaust fumes should be directed away

from its air inlet by attaching metal pipe to its exhaust stack and running the pipe downwind from the inlet.

Never attempt to repair anything in the air line system when under pressure. Always shut off compressors and depressurize all air lines when maintenance is to be performed. Make sure overheating devices and pressure relief valves function correctly and accurately.

Always follow compressor manufacturers operation and maintenance instructions.

Before transporting to the job site, all equipment should be laid-out, inspected and, when possible, tested. There is perhaps nothing more aggravating than to set-up equipment at the job site, only to find something is broken or missing. Missing or broken components encourage misuse of the equipment because some workers may not take the time to correct the problem. They may give the equipment a temporary "quick-fix" so that work can begin as soon as possible. This is a dangerous practice that creates potential for equipment malfunction, and could result in serious injury or death. A preventive plan to pre-examine the equipment and carry vital replacement parts will eliminate the danger of "quick-fix" failures.

After laying out all the components required for the blasting job, hook-up air hose and blast hose to the blast machine to run an air test on the remote control system (do not add abrasive to the machine).

WARNING!

All blast machines must be equipped with remote control systems. This is a strictly enforced OSHA regulation (29 CFR 1910.244).

Install remote control air hose (electric cord, if electrically-controlled) and remote control handle assembly. Follow owner's manual instructions for assembly of remote control components and operation of the system.
Make sure hoses or cords are properly connected.
Avoid dangerous incompatibility problems: NEVER mix

components from different manufacturers. Cycle air on and off several times to ensure that the system functions correctly. If there is a hint of slow response time or malfunction, refer to the owner's manual and follow the troubleshooting and maintenance instructions. DO NOT USE the blast machine until the remote control system operates as designed and according to the instruction manual.

Important Note
Clemco pneumatic remote controls use twinline control hoses with 3/16" (4.7 mm) inner diameters in both sides. The internal hose tube is constructed of neoprene rubber to prevent swelling and distortion caused by moisture. Never substitute twinline hose with welding hose. Welding hose rubber tubes, which are not formulated to resist moisture, can expand, restrict air flow and slow down the response time of the remote controls.

Locate the over-riding, shut-down petcock on the remote controls, and explain its use to operators and pot tenders. When opened, the petcock releases air pressure from remote control valves, preventing activation in the event the control handle lever is accidentally depressed. The petcock should be opened every time the blast machine is shut down and unattended.

Check blast machine fittings and valves to ensure they are tight and complete. Replace broken or damaged valve handles, fitting gaskets, worn abrasive trap screens, and any other parts in poor condition. Closely examine the blast machine to find any evidence of dents or punctures that may have occurred from rough field handling. Blast machines are regulated, ASME-code pressure vessels, and must not be used if there is any indication of damage to the shell, head or cone. If the machine is a portable model, inspect wheels for free rotation. Be sure the air outlet muffler functions correctly, and the muffler element is not worn, cracked or clogged. The muffler is an important safety feature because it greatly reduces high-pitched noise from exhausted air, and prevents escape of high-velocity abrasive during the bleed-off cycle.

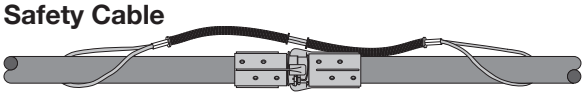
Examine blast hose and hose connections for damage and wear. Squeeze blast hose every 12 inches (300 mm) to

find soft spots that indicate severe wear on the internal rubber tube. Hoses with one or two soft spots may be repaired by cutting out the worn section and installing couplings to join the good pieces together. When repairing hose, ensure that the ends are cut square and smooth, and fit firmly against the coupling shoulders.

Do not use hose with soft spots. Soft spots pose danger of unexpected blow-outs that may seriously injure someone struck by high-velocity abrasive.

Hose ends must come into contact with coupling gaskets to prevent leaks, and to maintain static electricity conductivity throughout the entire hose-coupling assembly. If there are multiple soft spots, the hose should be discarded and replaced with a new hose. Do not use hose with soft spots. Soft spots pose danger of unexpected blow-outs that may seriously injure someone struck by high-velocity abrasive. Never use tape to repair a blown-out hose. Immediately replace hose if a blow-out or leak occurs. Be sure to install blast hose coupling lock pins and safety cables at every connection.

Safety Cable



Closely inspect blast hose couplings for damage and wear. Carefully test the coupling locking lugs for a tight, positive fit. The proper interconnecting of couplings requires strong physical force to compress the coupling gaskets, and twist the coupling lugs into place. If the connected couplings appear to be loose, check the lugs and coupling flanges for wear and replace the coupling gaskets. Immediately replace cracked, damaged or worn couplings. All couplings must be equipped with safety locking pins to prevent accidental disengagement. Bring plenty of spare coupling gaskets, coupling screws, and coupling safety cotter pins to the job site for immediate replacement when required.

All couplings must be equipped with safety locking pins to prevent accidental disengagement.

Inspect blast nozzles for wear and cracks on the inner liner. When a nozzle orifice is worn 1/16" (1.5 mm) larger than its original size, it should be replaced. Continuing to use a nozzle beyond the maximum wear point may result in eroding away the liner to the point where high-velocity abrasive will blow-out through the side of the nozzle. Check nozzles and nozzle holders for deterioration of thread form. Threads on nozzles and their companion holders must not be cross-threaded, worn or distorted.

A common cause of nozzle holder thread wear is the practice of removing the nozzle from its holder and blowing out the machine's abrasive supply to empty the machine through the hose and nozzle holder. This practice is not recommended as it exposes the threads in the nozzle holder to very rapid wear; consequently, it is critical to inspect the threads prior to every use.

It is critical to inspect nozzle and nozzle holder threads prior to every use.

Immediately replace nozzle holders that show the slightest sign of wear to prevent potential disengagement of the nozzle from the holder. The safest method to empty the blast machine is to disconnect the hose and, at low pressure, blow out the abrasive from the machine. This method eliminates holder thread damage risk. Carry spare nozzles, nozzle holders and a generous supply of replacement washers (gaskets) to the job site.

Carefully inspect operator protective equipment to determine that each component is in perfect working order. Check air-fed helmets for damaged or worn parts by using the owner's manual information as a check-off list. Be especially attentive to broken head bands, cracked helmet breathing air hoses, over-stretched inner collars, damaged outer capes, leaking window gaskets, broken window frames, and clogged air supply valves. Do not use helmets that require any kind of repair.

WARNING!

Helmets in faulty condition subject operators to extreme danger of respiratory and other physical injuries.

Always have a supply of spare parts on the job site, including a large amount of correct replacement lenses.

Lay out all components and check the entire operator safety system. Know the specifications and limitations on the use of your safety system. Breathing air hoses must be NIOSH-approved and supplied by the helmet manufacturer to comply with supplied-air respirator certification. Helmet air filters must meet OSHA's breathing air filter criteria with properly-functioning pressure regulator, gauge and pressure relief valve. Check air filter cartridge for cleanliness as described in the owner's manual. Carbon monoxide monitor and alarm systems should include field calibration equipment. Be sure operators are equipped with blasting suits, leather gloves and safety shoes. Follow preparation instructions for all other equipment, including air compressors, supplied by the respective manufacturers.

Finally, carry a tool box with all the essential tools required for field repair. Tool boxes are a convenient place to store gaskets, fittings and repair kits so they are readily available when needed.

ABRASIVE AND RESPIRATORY HAZARDS

There are known facts about the chemical composition of blast abrasive, but there are unknowns about the materials being removed by blasting. Blast operators may be well protected while using approved, filtered, air-fed helmets during the blasting process, but they need to safeguard their respiratory system before and after the blasting process, as well. The greatest danger is often posed by early removal of operator and bystander respirators in dust-laden blast areas. Extreme care must be exercised and strict work practices must be enforced to avoid any risk of respiratory disease to blast operators and all other personnel in the vicinity of the blasting operation.

No dust, from any source, is safe to breathe.

One of the worst respiratory diseases associated with abrasive blasting is silicosis. Severe cases of silicosis may result in death. Silicosis is caused by frequent or prolonged inhalation of tiny, almost microscopic, free-silica particles that collect in the upper part of the lungs. These particles cannot be removed by coughing; they are there to stay. As these silica particles build up, lungs lose their ability to take in oxygen. The affected person becomes short of breath and susceptible to infection, tuberculosis, or other lung disease.

The most common source of high-content free-silica in a blasting operation is from pulverized crystalline silica (quartz) sand. Mineral and some by-product abrasives contain varying levels of free-silica, but many of them have very small amounts. All abrasives have chemical compositions that may or may not cause harm to the respiratory system. Employers should obtain Safety Data Sheets (SDS) to learn about the composition of any abrasive to be used. In any case, the best practice is to avoid inhalation of any dust generated from any abrasive.

In some blasting applications, materials containing asbestos are removed causing asbestos fibers to become airborne. Inhalation of asbestos fibers is highly dangerous, and has been known to cause severe damage to the respiratory system resulting in death. OSHA regulations state the permissible exposure limit to asbestos is 0.1 fibers per cubic centimeter as an eight-hour time-weighted average (0.1f/cm3 TWA) (ref: OSHA 29 CFR 1910, 1915 & 1926). Special respiratory precautions must be taken when asbestos materials are present.

An equally important respiratory hazard is the dust from material being blasted from the surface. Some coatings being removed contain heavy metal elements such as lead. Even when the abrasive itself is safe, inhalation of lead or other toxic particles from the paint is extremely dangerous to the operator and everyone else in the vicinity of the blasting operation. Paint chips should be analyzed by a certified lab to determine the paint composition. Be

aware that aged and unidentified layers of paint may contain some respiratory-damaging properties; therefore, it is imperative to use appropriate, efficient, and approved supplied-air respirators when using any abrasive. When removing lead-based paint, contractors must follow the procedures described in OSHA regulation 29 CFR 1926.62.

Special precautions are important in areas where blasting is being performed. The most dangerous dust to the respiratory system is microscopic particles that are easily inhaled. These tiny, respirable particles tend to linger in the air for long periods until they either settle to the ground or are blown away by the wind. Respirable particles in the work area come from loading abrasive into machines, sweeping or cleaning up after blasting, removing dust-laden clothing, or any other activity that will stir up dust before or after blasting. Operators may be completely protected while they are wearing helmets, but when helmets are taken off, operators and co-workers can expose themselves to dangerously high concentrations of invisible dust. The atmosphere is especially dangerous when cleaning up dust.

Weather, humidity, wind direction, wind velocity, abrasive composition and material being removed by blasting are vital factors that determine the extent of the blasting zone.

The blasting site and surrounding area should be blocked off to prevent unprotected personnel from entering the blasting zone. Safety personnel should use atmospheric dust monitoring equipment to accurately determine the size of the blasting zone. Weather, humidity, wind direction, wind velocity, abrasive composition and material being removed by blasting are vital factors that determine the extent of the blasting zone. Periodic testing of the blasting zone atmosphere should be done and adjustments to the zone restrictions should be made as required.

No one should be allowed within the blasting zone without proper respiratory equipment. Everyone in proximity of the blasting operation should wear NIOSH-approved,

properly-rated air-fed helmets. Other personnel within the blast zone should wear respirators specifically designed and approved for abrasive and toxic dusts. Due to the possibility of invisible dust in the air, respirators should be worn at all times whether or not blasting is in progress. Never use unapproved respirators.

In enclosed applications, such as tanks, rooms, etc., all personnel must wear appropriate air-fed helmets at all times. Enclosures must be ventilated to bring in fresh air and extract dust in sufficient volume to maintain a low concentration of dust within the entire enclosed area (ref: OSHA 29 CFR 1910.1000). Silica sand should not be used in enclosed areas because it generates large amounts of harmful dust and it should never be reused. These are simply good safety practices to minimize any potential of respiratory injury.

The Occupational Safety and Health Administration (OSHA) has stringent regulations on air-fed helmets (classified as Type CE, continuous-flow, supplied-air respirators) for abrasive blasting (ref: OSHA 29 CFR 1910.132 through 1910.134).

OSHA has assigned the task of testing and approving supplied-air respirators to its agency, the National Institute of Occupational Safety and Health (NIOSH). All manufacturers of air-fed helmets must submit their helmets to NIOSH for testing in order to obtain certification. In fact, the NIOSH approval label matrix containing the NIOSH approval number must appear in the product's instruction manual. Use of any helmet that does not display this approval label matrix in its manual is dangerous and a violation of the OSHA regulations, and the owner of the helmet is subject to stiff penalties.

Standard air-fed helmets cannot be used in every blasting application. For example, the dust produced during lead-based paint removal can reach concentration levels that exceed the protection factor of a standard air-fed helmet.

Appropriate engineered ventilation controls should be implemented to reduce dust concentration, especially when coatings contain heavy metals, asbestos or other toxic materials. It is critical to investigate and identify all

materials to be removed from surfaces, and to be aware of any ambient contamination in the work environment, so that adequate personal protection will be given to the employees working in and around the job sites.

NIOSH gives supplied-air respirators an assigned protection factor (APF), which is based on its design and function for a specific environment. Currently, two protection factors exist for Type-CE continuous-flow, air-fed respirators, 1000 APF, when the manufacturer can provide third-party test results, verifying a protection factor greater than 1000, or 25 APF, when testing was not performed or the respirator did not pass the test. To use the 1000 APF, the employer must provide a copy of the third-party test results. This proof-of-testing document is commonly found on the manufacturer's website.

In August 1992, NIOSH published a booklet (DHHS Publication No. 92-102) that describes the dangers of silicosis. Subsequently, several other inhalation hazards have been associated with abrasive blasting, including arsenic and lead poisoning, chronic beryllium disease, and cancer from hexavalent chromium, cadmium, and other heavy metals. Every employer is responsible for reading and understanding the hazards associated with the blast media as well as the substrate being treated. These hazards must be properly controlled and all employees properly informed, monitored, and trained to ensure their adequate protection. In blasting applications in which the employee is exposed to free silica, arsenic, lead, beryllium, hexavalent chromium, cadmium or other heavy metals and toxic substances, the employer should ensure that their employees are using supplied-air respirators with a protection factor of at least 1000. The employer is required to maintain the proof-of-testing document showing that the respirator passed the 1000 APF test, and such proof must be available for OSHA inspection

Highway and bridge reconditioning activity has brought about an awareness of the hazards of dust generated from the removal of lead-based paint. Studies have revealed extremely high exposure levels to all personnel working on these types of jobs. Excessive lead absorption into the body through inhalation and ingestion (breathing and eating) can cause damage to kidneys and other vital

organs. OSHA has published a standard on lead exposure which became effective in June 1993 (29 CFR 1926.62). The standard reduced the previous permissible exposure limit (PEL) to 50 micrograms per cubic meter of air (50 µg/m3) as an eight-hour time-weighted average (TWA). OSHA studies have found some abrasive blasting applications produce airborne lead dust levels as high as 50,000 µg/m3, which is 1000 times the PEL.

Standard air-fed helmets, which have not been specially certified, are adequate only in lead dust environments up to a eight-hour TWA of 1,250 µg/m3 (50 µg/m3 x 25 APF). This low rating requires exceptional engineered ventilation controls to reduce lead dust concentrations to the acceptable limit. In all cases, containment enclosures must be equipped with efficient dust collectors at sufficient air flow rates to lower dust concentrations to safe levels. Periodic air testing is required on enclosures to monitor dust concentrations.

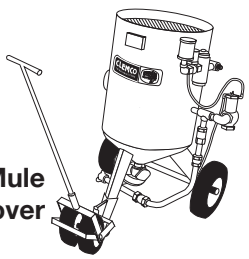
For exposures above 1,250 µg/m3 TWA, specially-certified air-fed helmets or positive-pressure respirators must be used. Specially-certified air-fed helmets with an APF of 1000 are approved for exposures up to 50,000 µg/m3 TWA. Positive-pressure respirators provide an air-supplied mask which firmly seals to a person's face. There are different protection ratings for positive-pressure respirators so check with the manufacturer before purchasing. On all lead-based paint removal jobs, check with OSHA and other safety agencies for advice on personnel protection requirements - not only for the blast operators, but also for anyone in the blasting vicinity.

OSHA has established an action level when lead dust concentrations reach 30 µg/m3. At this point of concentration, safety personnel are to initiate additional engineering controls to prevent the job site environment from exceeding the maximum PEL. Refer to OSHA regulation 29 CFR 1926, in addition to any other regulations, for all the requirements concerning work to remove materials containing lead and other heavy metals.

LIFTING, LOADING, AND MOVING EQUIPMENT

Loading, unloading and moving equipment from storage to the job site should be accomplished with mechanical

lifting equipment. Blast equipment is heavy and bulky to move around; therefore, improper handling may result in bodily injury. Prior to moving blast machines, be sure they are empty of abrasive. Do not attempt to manually move two-wheeled blast machines that contain abrasive because the weight will be too difficult handle. Small two-wheeled machines, with capacities up to two cubic feet (60 liters), are designed to be moved empty by a person who is physically capable of maneuvering this type of machinery. Two-wheeled machines with capacities up to six cubic feet (200 liters), may be moved on smooth, flat terrain with a Clemco “Mule”.



The Mule
Blast Machine Mover

Machines larger than six cubic feet must be moved by mechanical lifting equipment, such as forklifts and cranes rated to handle the load weights.

Use mechanical lifting devices to load machines onto trucks, trailers or any type of transporting equipment. If using forklifts, strap equipment to pallets for maximum security during loading and unloading. When using cranes, attach steel cables or chains to machine lifting lugs - not to steel piping or other machine components, because of the chance of damage during the lifting process.

Prior to loading equipment, disconnect all hoses and neatly coil them to prevent damage during transport. Box small hoses and parts to keep them clean, and to avoid loss on the job site. Include all equipment instruction manuals in the boxes so that they are available when required.

Unload at the job site in the same manner as loading. Find level, uncluttered ground to place the equipment, and use mechanical lifting machinery for unloading. Also use mechanical lifts to move equipment at the job site, especially if the surface area is uneven and littered with

obstacles that may interfere with free movement. Never manually move blast machines over surfaces covered with loose materials or on wet surfaces. These conditions may cause tripping, slipping, or other injury.

IMPORTANT NOTE
Mechanical lifting equipment must be operated by trained and qualified personnel in compliance with manufacturer's operating instructions.

B. JOB SITE CONDITIONS

Job sites present their own sets of potential hazards. Some hazards are easy to identify, however some are inconspicuous, and others can cause chronic illnesses and diseases such as silicosis, chronic beryllium disease, and even cancer long after the worker retires. This is the reason why OSHA requires employers to perform a Job Hazard Analysis and take appropriate precautions including employee involvement, training, medical monitoring, and record keeping for every job. Employers, safety engineers and supervisors must work with every employee or their representative to identify safety threats and take necessary precautions prior to starting any work.

Before setting up equipment, it is imperative that the employer's safety team perform and document a job hazard analysis using good engineering and administrative practices as well as a common-sense approach to identifying potential problems. Take all necessary steps to eliminate every hazard. It is impossible to list all the potential hazards that may exist on job sites; however, some of the most important ones are discussed in this section.

ELECTRICAL POWER LINES
The work area must be inspected for exterior electrical power lines that may endanger operators. This is especially important if blasting is to be done from mechanical personnel lifting equipment. The obvious danger is the possibility of injury or death from contact with high-voltage wires. Additionally, blast operators should use care to avoid directly blasting power lines and insulators.

Indoor work areas should also be inspected for electrical wiring which should be protected from blasting. Blasting could remove the covering and expose the wires. Exposed wires not only create a physical danger but also pose a fire hazard. Electrical wiring should be removed from blasting work areas when possible. If not possible, electrical power should be shut off and not restored until the wiring is inspected for damage and determined to be safe.

Electrical wiring used for equipment on the job site should be constructed of heavy duty casings and equipped with dust-tight, moisture-resistant connectors. Be sure the wiring is in good condition and properly grounded. Keep wiring away from water or any kind of liquid. Electrical control panels and terminal boxes should be UL-approved, dust-tight and moisture-free enclosures. All components of any type of electrical system must be installed by qualified electricians.

HAZARDOUS GASES

Blasting in areas where high concentrations of volatile gas are present is extremely dangerous. Seek expert advice from a qualified safety engineer about grounding requirements and proper grounding procedures.

In addition to special grounding requirements, proper ventilation is needed to eliminate gas concentrations. Air movers or exhaust systems may be installed to extract gas fumes from the blasting area. Consult with a safety engineer to determine that these methods will provide a safe blasting environment. Static electricity, generated by blasting, has been suspected of causing explosions in areas where volatile gases are present. Safety engineers must specify required ventilation systems to prevent any possibility of explosions.

Static electricity, generated by blasting, has been suspected of causing explosions in areas where volatile gases are present.

Equally importantly, safety engineers must recommend the proper respiratory equipment for the blaster and all other personnel who work in gas-contaminated areas.

Important Note
Standard type CE, continuous-flow, supplied-air respirators (abrasive blasting air-fed helmets and hoods) are not approved for use in hazardous gas atmospheres.

OSHA regulation 30 CFR, Part 11 states that type CE respirators are approved for any atmosphere not immediately dangerous to life or health. Therefore, type CE respirators should not be used in any atmosphere from which the wearer cannot escape without the aid of the respirator.

Never knowingly enter a work area where flammable or toxic liquids are present.

Safety engineers must investigate, initiate necessary removal procedures, and test the areas for safe occupancy before any personnel are allowed into contaminated areas.

Never assume that in-plant piping contains compressed air.

Normally, gas piping is equipped with special connections to identify the type of gas. These connections are usually incompatible with air line fittings.

Never replace piping connections without inquiring about the content of the pipeline. Even if the pipeline contains compressed air, the air must be tested to ensure that it is Grade D or better quality. Death will occur instantaneously if the blast operator inhales gas.

WORK SURFACE HAZARDS
Since blast operators usually move around while performing their jobs, special precautions should be taken to keep the work surface clean and free of all obstacles. Operators may have a limited field of vision; they may be preoccupied with handling heavy, pressurized blast hose; it is easy for them to overlook obstacles that may hamper their movement. Surfaces where platforms, scaffolding,

scissor lifts, or personnel lifts are used must be level, dry, free of obstructions and holes, and in compliance with other conditions recommended by manufacturers and safety specialists.

Work surfaces must be free of water, oil, grease, abrasive and any other substance that may cause the operator to slip. Objects, such as tools, nuts and bolts, which may cause the operator to trip should be removed. Air and abrasive hoses should be laid out away from the operator's path. Holes in dirt, concrete and wooden floors should be repaired or covered with appropriate flat materials. In general, the operator needs the best possible working area free of any obstacles that may create a movement hazard.

OPERATOR VISIBILITY

Very simply, blast operators cannot adequately clean what they cannot see. Working in a dust cloud or using a severely-pitted helmet lens or both, inhibits the operator's ability to see the results on a blasted surface. More importantly, obstructed vision greatly increases the possibility of tripping or falling accidents. Immediate corrective actions must be initiated when an operator's vision becomes impaired.

If blasting on dusty surfaces, such as concrete, it is advisable to install dust suppression equipment such as the Clemco Wetblast Injector System on the blast machine. Or invest in the Wetblast FLEX. This equipment can greatly reduce or eliminate the visible dust. If the surface is steel where moisture may not be tolerated, there are several alternatives to improve visibility:

- Use low-dust abrasive and point the nozzle slightly downwind to force dust away from the operator.
- Where practical, install air blowers to direct dust away from the blasting area.
- Erect containment tarps with dust collection equipment.

Helmet lenses should be changed as soon as pitting or frosting takes place. It is false economy to try to extend the life of vision-preserving lenses, when doing so could cause a potential safety hazard. Replacement lenses should be readily available at the job site, and operators

should be encouraged to change them frequently. Use only authentic lenses from the manufacturer because they meet the NIOSH requirements for size, thickness and optical quality.

Important Note
Use only the original respirator manufacturer's replacement lenses. Substituting lenses violates the respirator's NIOSH approval in addition to voiding the respirator manufacturer's warranty.

NOISE HAZARDS
NIOSH requires type CE, continuous-flow, supplied-air respirators (air-fed helmets) to operate with noise levels no greater than 80 decibels (dBA) as an eight-hour time-weighted average (TWA). While the respirators themselves may hold the sound level to a comfortable range, exterior noise from blasting and other nearby sources will elevate the decibel readings inside the respirator. Hearing protection must be worn by blast operators to keep noise level exposure below 80 decibels TWA.

Basic ear plugs may not always be effective for all outside blasting applications. Some applications may demand more sophisticated hearing protection. The type of hearing protection needed is dependent upon the sound attenuation of the surrounding work place enclosure, and noise levels generated from other nearby equipment.

Safety engineers must take job site and respirator sound readings to ensure safe and comfortable sound levels for blast operators.

Important Note
Prolonged exposure to noise levels above 80 decibels (dBA) TWA may cause hearing damage.

Up to this point, much of the text about potential hazards in the work environment has centered around blast operators. Equal attention must be paid to non-blast

operators working in nearby areas. These workers too must be protected from dust, excessive noise and all other hazards present on the job site. Employers and safety engineers must devise safety measures for all personnel entering or working in an established blasting zone.

C. EQUIPMENT SETUP

EQUIPMENT ASSEMBLY

After performing job site inspection, the blast equipment may be put in position. Take time to inspect the area for potential hazards such as water, electrical wires and obstacles. If blast equipment is set up for outside work, ensure that the air compressor is placed upwind from the blasting area to prevent dust from entering the compressor air intake. The air compressor must be of sufficient size and type to provide the required volume and pressure of air to the blasting system, and must be in perfect working condition. The pressure setting on the compressor must not exceed the maximum working pressure of the blast machine (check I.D. plate on machine). Many blast machines have a maximum working pressure of 150 psi (1034 kPa/10.3 bar). Some machines have higher ratings. Refer to the air compressor manufacturer's manual for proper operation and maintenance information.

Before attaching air hose from the compressor to the blast machine, open the safety petcock on the remote control valves.

Install components of the blasting system by following the instructions in the owner's manuals. Before attaching air hose from the compressor to the blast machine, open the safety petcock on the remote control valves. The safety petcock is located on one of the remote control valves for the purpose of relieving air pressure within the valve. When air pressure is released, the valve cannot open to begin the blasting process. An open petcock prevents accidental activation of the remote controls. This is possible when the compressor is running and someone depresses the remote control handle. As long

as air bleeds from the petcock, the remote controls are in a fail-safe mode.

Cautionary Note
As a standard practice, the petcock should be opened whenever a blasting session ends.

It is especially important to open the petcock when the nozzle and blast hose are moved by someone other than the blaster while the air compressor is operating.

If not included, add an appropriately-sized filter/moisture separator and pressure regulator to the air inlet on the blast machine. Be careful when choosing both of these essential accessories. There are many sizes and types of filter/separators and regulators which serve myriad applications. Many, however, are designed for much lower air volume than required for abrasive blasting, despite being able to provide high pressure. Check with the supplier to ensure that these accessories have the required air volume capacity. When adjusting the pressure regulator, do not exceed the maximum working pressure of the blast machine. The filter/moisture separator must be designed and adequately sized to remove excessive liquids and mists from the air supply.

Prior to attaching compressor air hose, install steel safety cables on the compressor outlet where the air hose connects, and on the opposite end of air hose where it connects to the blast machine piping. When multiple sections of air hose are used, install steel safety cables at every connection point.

Safety cables prevent the dangerous whipping action of hose if the air hose couplings disengage.

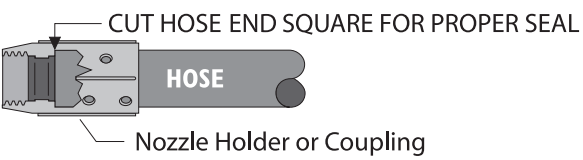
The blast machine bleed-off muffler must be pointed in an upward, vertical position to operate properly. All hose and pipe fittings must be cleaned of dust and dirt prior to attachment. Handles on manual valves should

open and close without difficulty. Check all fittings for tightness.

WARNING!
Examine all piping and fittings for damage.

Replace damaged parts before pressurizing machines to prevent injury from ruptured parts.

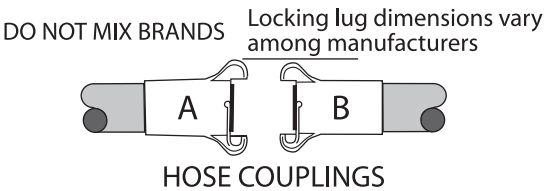
Stretch out blast hose from the blast machine to the work area. Even though inspection should have been done during the equipment preparation stage, double check couplings and nozzle holders for wear, damage, cleanliness and missing gaskets. When couplings or nozzle holders (hose ends) need to be replaced, follow these instructions: Place hose end on a flat surface - preferably in a miter box. Wet the hose and a very sharp knife to make cutting easy and clean. Cut the hose about 6 inches (150 mm) from the existing coupling. Cut the hose so that the end will be smooth and flat and will seat uniformly against the coupling's or nozzle holder's internal shoulder.



If cutting produces a jagged or angled end, re-cut it. Hose ends that do not seal correctly on the internal shoulders will allow abrasive to erode the exposed coupling or holder bodies. This contact with abrasive will cause premature wear, and may result in an injury from a hose end blow-out. Nylon couplings, in particular, require solid contact between the hose end and gasket to provide uninterrupted static electricity conductivity. Insert the hose into the hose end using a twisting action until the hose end seats firmly against the shoulder. Hose must fit tightly into hose end.

Important Note
High quality blast hose and hose ends are manufactured to industry tolerances. Most blast hose is manufactured on a long mandrel with a standard specification to hold the

outer diameter (OD) to a tolerance of +/- 1/16" (1.5 mm). Most coupling and nozzle holder manufacturers keep equally stringent tolerances on their connectors, but it is not true with every manufacturer or supplier. The result of loose tolerances is very sloppy fit between connectors and hose. It is absolutely essential to obtain a tight fit between connectors and hose to minimize the risk of accidental detachment that could cause a serious injury. Do not use tape to compensate for improper fit. Re-cut or replace hose and replace connectors until the proper fit is obtained.



HOSE COUPLINGS

The safest practice is to NOT mix different brands of hose couplings. Clemco nylon couplings are injection-molded. Injection molding produces precisely-dimensioned parts. The safest and most secure coupling connection mates nylon to nylon rather than mating dissimilar materials with likely dimensional differences. Manufacturers offer mixed-alloy couplings made of bronze, aluminum, steel and iron, all of which are normally produced from sand cast molds. While the coupling locking lug design is an industry standard, the tolerance range between manufacturing sources is not the same. Sand cast molds tend to have a limited life span resulting in gradual dimensional changes to the parts. However, periodic mold tooling maintenance keeps coupling production within the tolerance specifications. The combination of different materials and changing mold conditions affects the fastening efficiency when mixing various manufacturer's parts. To be sure couplings always connect securely and safely, use a single brand of coupling on blast hose.

Always use manufacturer-supplied coupling screws, Clemco screws are sized to securely grip the inner tube of the Clemco hose. Do not use screws that are not the correct length and thread form. Longer screws may penetrate the inner rubber tube, allowing abrasive to wear through the screw holes. Protruding screws also interfere with abrasive flow. When installing couplings, insert a wooden dowel in the hose to support the wall of the hose, and to prevent the wall from collapsing. Insert the screws. Do not over-tighten screws, which may tear the rubber and weaken screw strength. Short screws and those with the wrong thread form will not provide enough gripping power, and may result in couplings or nozzle holders slipping loose from the hose. Coupling or nozzle holder failure may cause serious injury from high-velocity abrasive blowing out of an uncontrolled, whipping blast hose.

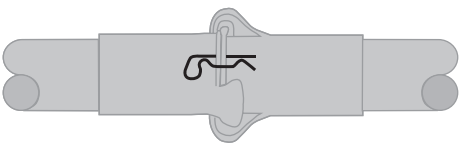
Replace coupling and nozzle holder gaskets when they leak or show any sign of wear or distortion. Always keep a plentiful supply of gaskets on hand. Worn and leaking gaskets create expensive and dangerous conditions by causing premature wear on couplings and nozzle holders. A leaking gasket causes coupling locking lug erosion which can result in separation of the mating couplings. A nozzle holder gasket protects entrance ends of the nozzles. When the gasket is worn or distorted, leaking abrasive eats away at the nozzle and nozzle holder threads. This erosive action not only damages these parts, but also creates a potential hazard from the nozzle blowing out of the nozzle holder. A serious injury can occur, in addition to destroying the nozzle.

The recommended practice is to inspect all gaskets daily or before each use.

Before attaching blast hose to a blast machine, install a steel safety cable (Clemco stock numbers 15012, 15013 and 27405) between the hose end and the machine piping. When connecting multiple sections of blast hose, install safety cables at each connection. Safety cables

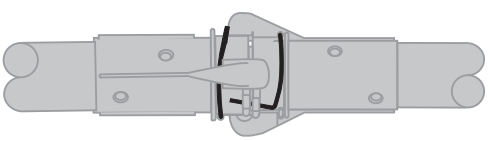
prevent injury from whipping pressurized hoses, in the event they accidentally become detached. Install a safety cable at the connection of the compressor hose and the blast machine inlet. Safety cables are also vitally useful for supporting the weight of blast hose when it is hung vertically to reach elevated work. Do not rely upon hose couplings to support blast hose weight. They are designed for internal air pressure resistance—not tensile loading. Excessive weight on couplings may tear the screws from the hose, and create a potential hazard from falling, pressurized hose.

COUPLING SAFETY PIN



When couplings are connected, insert Clemco safety pins (stock number 11203) through flange holes in the matching couplings. Clemco nylon couplings are equipped with integral locking pins which automatically engage in flange holes on companion couplings. Safety pins prevent accidental disconnection of couplings from twisting and turning of blast hose during field use.

NYLON COUPLING SAFETY SPRING



While blast hose is stretched out, secure remote control twinline hose, or electric cord, to the blast hose with nylon ties or strong tape every four to six feet (1.2 to 1.8 meters). This procedure eliminates tripping hazards from loose, scattered hoses. It also is a convenient method of keeping hoses together for ease in moving from one location to another. Do not, however, strap helmet breathing hose with other hoses. Blasting operators must be able to move freely without hindrance from other hoses.

In applications where more than one blast machine is used or where multi-operator machines are used, install

color-coded hose identification kits on blast hoses. These kits contain colored straps to accurately distinguish an operator's blast hose, remote control twinline hose or electric cord, and blast machine connection from another's. Use of these kits is especially important on bulk blast machines where two to four operator stations are in proximity of each other. There is a distinct possibility of inadvertently crossing blast hoses or remote control lines, which will result in activating the wrong blast nozzle.

In applications where more than one blast machine is used or where multi-operator machines are used, install color-coded hose identification kits.

Assign a specific color to each blaster from the identification kit. If the color assigned to one blaster is red, attach a large red strap to the nozzle end of the hose, another large red strap to the machine end of the hose, and a third large red strap to the hose piping on the blast machine. Smaller red straps are provided for remote control hose and any other hoses that may be used by the blaster. The small straps are placed in the same locations as the large ones. Specific instructions are provided with the kits. Two kits are available: Two Outlet Kit (2 colors), Clemco stock no. 15890 and Four Outlet Kit (4 colors), Clemco stock no. 15891. When more than one length of blast hose is used, additional kits are required.

Color identification kits provide obvious safety benefits. Each blaster is assigned a specific color, helping to ensure he uses only the hose and nozzle tagged with his assigned color. Color identification kits also make adjustments to media valves easy for multi-machine tenders.. Whenever hoses are replaced, color straps should be replaced, as well.

Depending upon the application, blast machines may need grounding to eliminate static electricity. Standard Clemco blast hose is static-dissipating, and the electrical charge is returned to ground through the leg of the blast machine, but added grounding safeguards are required for flammable environments. If the job site is in the vicinity

of flammable gases, vapors or liquids, machines must be grounded. Blast machines mounted on four wheels; such as, large bulk blast operators and four-wheeled machines, must be grounded. Consult with the job site safety engineer before operating any equipment.

When all parts are assembled on the machine, run an air-only test. Do not load abrasive into the machine at this time. Start the air compressor, following manufacturer's instructions, and pressurize the air hose to the blast machine. Close the safety petcock on the remote control. Check the function of the remote control by depressing and releasing the remote control handle lever several times, allowing air to enter the machine and bleed-off. When satisfactory response time of the remote control is obtained, the machine is ready for operation.

Set up blast operator's staging or mechanical lift equipment following the manufacturer's instructions. Carefully check to determine that all safety devices are in place for the blast operators and any other personnel in the blasting zone.

STATIC ELECTRICITY

Static electricity is an inherent by-product of abrasive blasting. It is generated primarily by friction from high-speed abrasive skimming on the rubber tube through the hose. Usually, static electricity will not harm anyone. Its effect is much like rubbing your shoes on a wool rug in low-humidity weather, touching a piece of metal with your finger and experiencing an electrical arc between your finger and the metal. Static electricity generates high voltage but without any significant amperage, which is the harmful element of electricity. Higher friction creates higher voltage; consequently, abrasive flowing through hose produces more static electricity than shoes rubbing on rugs. There are, however, blasting applications where the presence of static electricity in highly-volatile atmospheres can be a serious hazard.

Static electricity has been known to cause fire and explosions; therefore, it is critical to use proper grounding techniques.

In most abrasive blasting applications, the jolt from an electrical arc is an uncomfortable nuisance to blast operators. Despite posing no harmful effect, blast equipment should be grounded to eliminate unnecessary blaster discomfort. Grounding procedures involve driving a steel stake three feet (one meter) into the earth, and attaching a grounding wire to connect one of the blast machine legs and the stake, ensuring that there is positive metal-to-wire contact. In addition, static-dissipating blast hose and hose couplings with specially-treated, static-dissipating gaskets should be installed between the blast machine and nozzle. The dissipation treatment in the rubber components sends an electrical current back to the blast machine, through the steel stake and into the earth. Clemco uses static-dissipating materials for its blast hose, coupling gaskets, and nozzle washers.

When abrasive blasting where highly-volatile products are present (i.e. gasoline), extra precautions must be taken to prevent ignition from static electricity. The blast machine, nozzle, operator and any ungrounded metal objects must be equipped with grounding wires. Static electricity has been known to cause fire and explosions; therefore, it is critical to use proper grounding techniques. Check with the job safety engineer for expert advice on grounding requirements. Further information may be obtained from the Painting and Decorating Contractors of America.

ELECTRICAL COMPONENTS

Special attention must be paid to electrical equipment and components that are used around blasting jobs. The presence of dust and moisture demands the use of dust-tight, moisture-proof enclosures to prevent malfunctioning of electrically-operated components. Metallic dust, in particular, can be ignited by electricity. All electric equipment must be installed and serviced by qualified electricians to ensure safe operation.

Electric remote controls for blast machines are low voltage. The blast operator's control switch sends a signal to an electro-pneumatic valve in a terminal box attached to the blast machine. Electric service to the box is either 120- or 240-volt, and a transformer reduces the output to the blast operator's control switch to a safe 12-volt. Always use the manufacturer's electrical cords and

accessories designed to protect against ingress of dust and moisture. Never alter electrical systems that could subject blast operators to dangerous high voltages.

OPERATOR SAFETY EQUIPMENT

Anyone working with a powerful stream of sharp particles and removing surface contaminants needs personal protection equipment of the highest caliber of safety and quality.

Personal safety equipment for blast operators and any personnel in the immediate work area is an absolute necessity to prevent a variety of injuries.

Throughout the world, there are laws governing abrasive blasting safety. All of these laws have been established to recognize known hazards and develop injury prevention programs. Generally, foreign safety standards on personal protection in the blasting industry are similar to U.S. standards of OSHA, NIOSH and ANSI. If work is to be done outside the U.S., consult local safety agencies for current regulations.

In addition to the health benefits derived from personal protection equipment, there is substantial benefit from providing the highest level of comfort to operators who work under harsh environmental and application conditions. Properly-attired operators who have the best possible safety and comfort equipment will perform more efficiently and will have a better attitude toward their jobs.

Breathing air supplied to an operator's air-fed helmet must be free from toxic gases; such as carbon monoxide, which causes death. Strict safeguards must be enforced to eliminate any chance of inhaling dust generated by pulverized abrasive, especially abrasive containing free-silica known to cause the life threatening lung disease, "silicosis". Inhalation and ingestion of dust from lead, asbestos, heavy metals, and other toxins created from

the blasting process must be prevented. Personnel must be protected from noise that exceeds the permissible exposure limit which could cause permanent hearing damage. Head impact protection is required in most applications.

It is vital that operators and other personnel in the blasting area be properly and completely equipped with the required safety equipment to avoid all possible hazards.

Important Note
Close attention should be paid to the following text on safety components and their requirements.

Do not, however, solely rely on the information contained in this booklet because continual advancements are being made to the design and efficiency of protective products. Always obtain the most current technical information on safety equipment to ensure that state-of-the-art equipment is used.

Breathing air must be clean, dry, contamination-free and provided at NIOSH prescribed pressure and volume. Breathing air quality is heavily-regulated to precise specifications. Therefore, special attention must be paid to the source and composition of air and its required filtration system. Carefully read ALL instructional materials on ALL equipment employed in the air producing and conveying system.

WARNING!
FAILURE TO COMPLY WITH ALL INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS WILL RESULT IN SERIOUS RESPIRATORY INJURY OR DEATH.

There are several common sources of breathing air ranging from small air cylinders to large, oil-lubricated,

air compressors. No matter how or from where the air is furnished, it must comply with strict standards for high-quality breathing air. NEVER attach breathing air hose to plant or stationary fittings without first testing the air quality in the line. Some of the most common sources of breathing air are discussed in this section, though greater emphasis is placed on the issues associated with using lubricated compressors.

Lubricated air compressors pose great danger when used to produce breathing air due to their potential for producing carbon monoxide. Carbon monoxide is produced by overheated compressors that burn lubricating oil to the point where carbon monoxide gas is formed in the compressor compartment and fed into the air line. Carbon monoxide kills; therefore, safety steps must be implemented to prevent exposure to this odorless deadly gas. Always service air compressors at the intervals recommended by the manufacturer. Equip compressors with high temperature (overheating) shut-off devices and/or carbon monoxide alarms. When only a high temperature alarm is used, the air must be tested frequently for carbon monoxide. Refer to OSHA regulation 29 CFR 1910.134 for specific details.

Breathing air quality must meet the minimum requirements described in the Compressed Gas Association Commodity Specifications ANSI/CGA G-7.1 as specified by OSHA regulations 30 CFR, Part 11, Subpart J, para. 11.121 (Grade D or higher quality). The ANSI/CGA specifications state the following characteristics for Grade D breathing air:

- Oxygen Content ... 19.5% minimum to 23.5% maximum
- Oil (condensed) ... 5 µg/m3 (1) maximum
- Carbon Monoxide ... 10 ppm (2) maximum
- Carbon Dioxide ... 1000 ppm (2) maximum
- No toxic contaminants at levels which would make the air unsafe to breathe.

(1) micrograms per cubic meter.
(2) parts per million.

Further details may be obtained from:

Compressed Gas Association

14501 George Carter Way • Chantilly, VA 20151
Phone: (703) 788-2700 • email: cga@cganet.com
www.cganet.com

SOURCES OF BREATHING AIR

Compressed air tanks are sometimes used for breathing air when blasting is done in remote or isolated areas, or when contractors prefer the extra insurance of contamination-free air. These tanks should be obtained from qualified suppliers who certify that the air meets or exceeds Grade D breathing air quality. Pressure regulators are necessary to set the pressure for the helmet or hood requirements. NEVER use oxygen cylinders to supply breathing air. Breathing air contains a certain amount of oxygen but it is predominantly nitrogen and smaller amounts of other gases.

Important Note

When using self-contained breathing apparatus (SCBA), which includes its own air tank, check the OSHA regulations on equipment limitations in removal of lead-based and other heavy metal paints. (OSHA regulations 29 CFR 1910, Subparts G & I and 29 CFR 1926, Subparts C, D, & E).

Air pumps are pneumatically- and electrically-powered, oil-free, air-producing units that are specially designed to supply breathing air to low pressure (up to 15 psi [1 bar/103 kPa]) helmets and hoods. Air pumps are especially convenient for movement around job sites because of their small size and light weight. They offer a major safety advantage because there is no chance that these units will produce carbon monoxide, and since they are furnished with integral filters, there is no need for overheating shutdown devices or in-line filters. Air pumps are generally available in two sizes; one and two operator models.

Air pumps do not compress air; they merely draw in atmospheric (ambient) air and push it through the hose. Normal atmospheric air pressure is 14.7 psi (1 bar/100 kPa), which explains why air pumps cannot generate higher pressures. The internal mechanism of the pump is coated with friction-resistant materials requiring no lubricants, so there is no danger of producing harmful gases from overheating. Great care, however, must be taken to ensure that no harmful gases are drawn into the pump's air inlet. The pump must be located away from vehicle and air compressor exhausts, and any other gas-producing equipment.

There are a number of high-pressure air compressors on the market that operate without using oil to lubricate the air-producing chamber. These units are ideal for breathing air applications because they do not create carbon monoxide and do not contaminate air with oil mist. They develop high pressures to sustain the maximum 100 psi (680 kPa/6.8 bar) requirements for high-pressure helmets. Overall, this type of compressor is the best choice for breathing air due to its ability to supply large-volume, high-pressure and contamination-free air.

Oil-less compressors are available in portable and stationary models. Both types are offered in various capacities to support multiple-operator and equipment needs. They are usually equipped with pre-filters and after-filters to remove particulates and moisture. Stationary units often incorporate air dryers and/or after-coolers, ensuring the optimum of clean, dry air. Oil-less air compressors are expensive, but the advantages far outweigh the cost drawback.

When using air from lubricated compressors for supplying breathing air, it is absolutely essential to have compressors in perfect operating condition and equipped with well-maintained safety devices. OSHA regulation 29 CFR 1910.134 states: "If an oil-lubricated compressor is used, it shall have a high-temperature or carbon monoxide alarm, or both. If only a high-temperature alarm is used, the air from the compressor shall be frequently tested for carbon monoxide to insure that it meets the specifications in paragraph (d)(1) of this section." Paragraph (d)(1) refers to Grade D quality breathing air.

Most commonly, the compressors used to supply breathing air on abrasive blasting jobs are the same compressors furnishing air to the equipment. Those compressors are usually the type that use oil to lubricate the air-generating component of the unit.

WARNING!

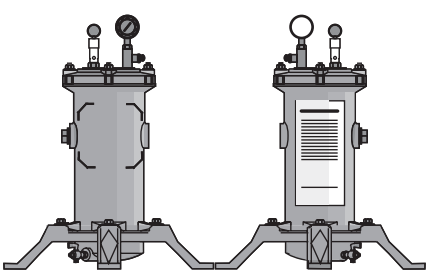
DO NOT use piston-type, oil-bath, air compressors for breathing air. This type of compressor poses an extreme danger of producing unacceptable levels of carbon monoxide that will result in death to the operator.

While lubricated compressors are popular for operating many kinds of air tools, extra precautions must be taken when these compressors also supply breathing air. Some manufacturers prohibit the use of their compressors for breathing air. OSHA regulations are very specific about compressor safety features for breathing air. Appropriate filters must be used to capture excessive particulates, oil mist and moisture to comply with the prescribed Grade D levels. Inlet air must be free of toxic gases that may be produced by vehicle exhaust and other gas combustion-operating equipment. Compressors and their related components must be serviced at the manufacturer's recommended maintenance schedules.

When choosing an air compressor, remember to add the air volume required for helmets to the air volume required for blast equipment. Helmets with air temperature control valves require approximately 20 cfm (0.6 m3/min); helmets with standard air control valves require 15 cfm (0.4 m3/min). Strictly adhere to the compressor manufacturer's maintenance instructions and schedules.

BREATHING AIR FILTERS

Air supplied to helmets must be cleansed through efficient filtering systems. It is not only a good idea to clean the air, but also it is an OSHA regulation (ref: 29 CFR 1910.134). OSHA demands that filters comply with the requirements for Grade D quality breathing air. The filter's role is to remove oil mists, water vapor and particulates larger than 0.5 microns. Filters that cannot conform to these requirements should not be used for breathing air.



CLEMCO CPF FILTERS

There is a vast selection of filters on the market. Unfortunately, many users choose small, inadequate filters because of their low cost rather than seek efficiency.

Choosing ineffective filters is false economy, and violates the OSHA regulations. Dust, dirt and other foreign matter, mixed with oil and water mists, clog air passageways and sound deadening materials inside the air-fed helmets. When filters become contaminated, air flow is restricted, air pressure diminishes, and operators experience unpleasant odors. The same problems occur if filters are too small to handle continuous volume and pressure of air. Poorly-chosen filters result in frequent and costly maintenance on air-fed helmets, and a reduction in safety levels for operators.

WARNING!

Particulate air filters, such as Clemco's CPF models, DO NOT remove carbon monoxide or any other toxic gases.

Breathing air systems require high-capacity, super-efficient filters. These filters should have quickly-replaceable filter cartridges. These filter bodies must handle the required air volume and pressure by allowing inlet air to expand, cool and slow down prior to entering the filtering media. These filters must be equipped with pressure regulators and gauges to set the required air pressure, and to indicate when cartridges need replacement. Gauges, installed on the clean air side of filters, will show declining readings when cartridges begin to saturate with liquid and solid matter. As an extra precaution, pressure relief valves are mounted on filters to discharge excessive pressure.

There are limits to the cleaning capacities of any filter unit. When compressors are old, worn or poorly maintained, they discharge greater than normal amounts of moisture and oil mists. In conditions of extreme heat and humidity, discharged air can contain a great amount of water vapor that quickly condenses to a liquid. When either of these conditions exists, small filters cannot handle the excessive volume of oil and water for very long. Pre-filters and/or expansion tanks are needed to remove abnormal amounts of liquids, thus, preserving the effectiveness of the cleansing features of the filter media.

It is a common practice to install air dryers or after-coolers where environmental conditions produce large

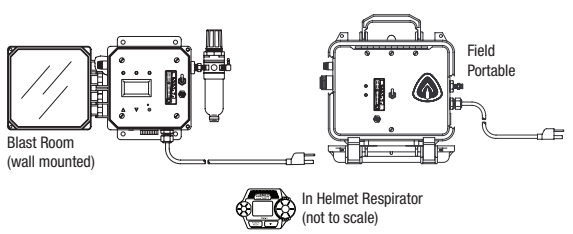
quantities of moisture in compressed air systems. In blast rooms where multiple blast machines are used, breathing-air stations are installed to ensure high-quality air. These stations consist of an air dryer, after-cooler, air receiver tank, carbon monoxide alarm and cartridge filters. This combination of components, when properly maintained, eliminates any possibility of contaminated breathing air.

CARBON MONOXIDE MONITORS AND CONVERTERS

Two types of carbon monoxide detection equipment are available to perform two different functions. One monitors supply air and sets off an alarm if carbon monoxide reaches an unacceptable level. The other converts carbon monoxide (CO) to carbon dioxide (CO_2), a less dangerous gas.

Carbon monoxide monitor/alarm systems are designed to continuously take samples of air and test it for the presence of carbon monoxide. These systems are calibrated to precisely measure the quantity of carbon monoxide gas in the air supply, and trigger alarms if the gas reaches the maximum permissible limit of 10 parts per million (10 ppm). They can be set to alarm at lower limits in accordance with differing regional requirements.

The more sophisticated carbon monoxide converters use chemicals to change carbon monoxide (CO) to carbon dioxide (CO_2). This works because the human respiratory system can tolerate much more CO_2 than CO. The permissible level of CO_2 is 1000 ppm, whereas the PEL of CO is only 10 ppm (ref: Grade D air). Carbon monoxide converters incorporate alarm features similar to the monitor systems. These units include an elaborate air drying and moisture-purging system, necessary to keep reactive conversion chemicals dry.



Three models are available from Clemco; one is for fixed installations, such as blast rooms; another is field-portable; a third is mounted inside the blast operator's

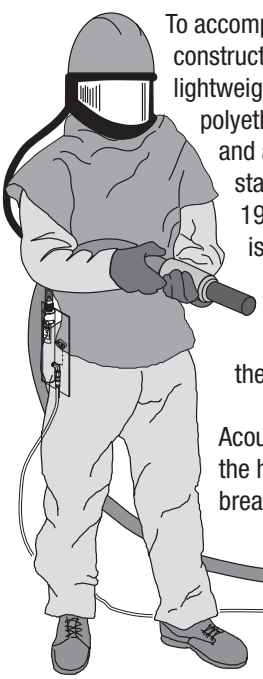
respirator to immediately and directly warn the operator of an unsafe condition.

AIR-FED HELMETS

One of the most critical components of an operator safety/comfort system is an air-fed helmet. In the U.S., OSHA classifies an air-fed helmet for abrasive blasting as a Type CE, continuous-flow, supplied-air respirator. The term respirator causes considerable confusion because many people think of a respirator as a device (with or without small filter cartridges), that fits over the nose and mouth area of the face which may or may not be supplied with air. To eliminate confusion and clarify the terminology used in this section, we will often refer to an abrasive blasting supplied-air respirator as an air-fed helmet or, simply, a helmet.

The objectives of an air-fed helmet are:

- to furnish an operator with clean, fresh breathing air
- to protect head and face from rebounding abrasive
- to provide a wide field of vision
- to muffle excessive noise
- to offer head impact protection



To accomplish these objectives, Clemco constructs its Apollo 60 helmet of lightweight, high-impact, molded polyethylene which has been tested and approved to protective headgear standards. (ref: OSHA 29 CFR 1910.135). The interior of the helmet is configured to circulate air flow throughout the entire top section, while directing a gentle air stream toward the view window to keep the lens from fogging.

Acoustical materials are installed in the helmet to reduce noise from the breathing air source, and to assist in lowering exterior noise. OSHA regulations (OSHA 30 CFR 11.120) dictate the maximum sound level generated by the air flow measured inside an air-

fed helmet, must not exceed 80 dBA (decibels on the "A" scale). Apollo helmets conform to the OSHA regulations. Almost all of the time, exterior noise generated from job site equipment, primarily from blast nozzles, will exceed the OSHA permissible level; therefore, operators must wear appropriate hearing protection.

A critical component of the helmet is the window lens because it protects the operator's face from ricocheting high speed abrasive. OSHA requires a single, fixed helmet lens with a thickness of no less than .040" (.01 mm). This lens does not protect the eyes from rocks or similar heavy objects. Wear safety goggles or safety glasses for eye protection. A thick, single lens is fixed to the helmet window opening with a dust-tight molded rubber gasket. A hinged window frame with a spring-tension latch firmly seals additional replacement lens to the rubber gasket. Replacement lenses, placed in front of the fixed lens, are offered to minimize maintenance costs by preserving the more expensive fixed inner lens and to allow quick change of the outer lens when it becomes frosted.

Helmet lenses are important for reasons other than facial protection. Lens quality is essential for clear visibility and operator eye comfort.

Important Note
Replacement helmet lenses must be genuine parts from the original helmet manufacturer to comply with the OSHA regulations and maintain NIOSH approval and the manufacturer's warranty.

The practice of cutting lenses from locally-purchased plastic is ill-advised not only because it voids the helmet's NIOSH approval, but also because typically the optical quality of available plastic sheets is extremely poor. The plastic may be rippled and distorted and not of the appropriate thickness. Cheap plastic lenses cause headaches and eye strain and seriously affect the operator's comfort and performance. Helmet manufacturers are required to supply lenses with high-grade optical quality and stringent thickness tolerances in order to obtain NIOSH approval. There is simply no logical justification for saving a few pennies by using cheap plastic lenses when they cause operator discomfort,

reduce operator performance, affect surface finish, violate NIOSH approval, and void the manufacturer's warranty on the complete helmet system.

Cheap plastic lenses cause headaches and eye strain and seriously affect the operator's comfort and performance.

Two of the most often neglected parts of a helmet are the window frame and window gasket. The frame and gasket are exposed to constant bombardment from rebounding abrasive. Consequently, the window frame becomes distorted and loses its sealing pressure against the window gasket. Rapid wear on the rubber window gasket affects the sealing efficiency. Damaged frames and gaskets cause leakage of abrasive and dust into the helmets. Some operators mistakenly resort to taping the window area in a futile attempt to prevent leakage. Tape is neither an adequate nor a safe alternative to replacing worn parts. Careful attention must be paid to the condition of the window components, and worn parts must be promptly replaced.

In terms of safety, field of vision is an important consideration in helmet window design. Some helmet window shapes restrict vision to a small area of the blasted surface. Peripheral vision is important because operators need to be aware of obstacles that may hinder their movement.

Another important safety feature is the chin strap. The chin strap, when properly adjusted, holds the helmet in the desired position on the operator's head. It ensures that the operator's head is firmly nestled into the helmet's suspension for proper fit, maximum comfort, and stability. It is unsafe for the operator's head to move freely inside the helmet. Without a properly adjusted chin strap, the operator may find himself looking at the side wall of the helmet.

The cape assembly, another vital part of the helmet system, requires frequent inspection, periodic cleaning and immediate replacement when damage is found. Three main components make up an efficient cape assembly -

an inner collar, an outer cape and a helmet attachment. There are two general types of inner collars. One is an elastic cloth material with one half of a zipper that fastens onto the other half of the zipper on the outer cape. The other type, without a zipper, is sewn onto the outer cape. The outer cape should be fabricated from dense, wear-resistant, nylon material, and should be furnished with adjustable metal clasps to closely fit the cape to the operator's body. A plastic attachment strap or wire cable connects the outer cape to the bottom of the helmet. All of these features are incorporated to deter entry of dust and abrasive into the helmet.

Inner collars play an important role in the helmet air flow process. Air introduced at the top of the helmet exits through the porous inner collar. When combined with a snug elastic fit, the collar keeps the helmet slightly pressurized, yet allows continuous air flow. The collar serves as a guard against ingress of dust that may enter from under the outer cape. When putting on the helmet, the collar should be tucked around the neck inside other clothing. To prevent any possible path for entry of dust, there should be no interference in the snug fit between the collar and operator's neck. Over time, collars stretch out of shape, and become soiled. To maintain safety and comfort, inner collars should be laundered frequently and replaced when stretched or worn.

WARNING!

Never use a helmet without an inner collar. The inner collar is a vital component of the helmet system THAT prevents the entry of harmful dust.

Nylon outer capes are designed to offer impact protection from rebounding abrasive for the operator's upper body, from neck to waist. It is important to replace the outer cape as soon as there are any signs of wear. Outer capes are essential to keep dust from entering the helmet. It is imperative to replace outer capes when holes appear around the attachment area of the helmet. Holes near the helmet edge may allow dust to enter the helmet and expose the operator to harmful dust.

The helmet's breathing tube, which connects the air

control valve to the helmet inlet, is a critical component of the helmet system. The tube is engineered to offer maximum flexibility so it does not interfere with head movement. Unfortunately, workers often use the tube as a handle to carry the helmet, damaging its casing which results in air leakage. Air leakage robs the helmet of required air pressure and volume. Anyone handling helmets must be instructed to use the carrying strap or handle usually supplied with higher-quality helmets.

A high-pressure helmet is available with a fixed-flow orifice, an adjustable air control valve, or an air temperature control valve. Regulations require the air control valve to supply a minimum of 6 cfm to a maximum of 15 cfm (0.2 to 0.4 m3/min) of air to the helmet. Clemco's air-fed helmet provides a minimum of 7 cfm for an added margin of safety when air supply is set at minimum recommended pressure settings. Pressure requirements vary according to air control device and respirator air supply hose length. These requirements have been established by OSHA in the United States. Its agency, NIOSH, is the government agency with the authority to test and approve air-fed helmet systems (classified as supplied-air respirators). An operator may adjust the air flow within these ranges to reach an acceptable comfort level. The valves cannot be adjusted to shut off air flow completely, and cannot be adjusted to exceed the maximum flow setting. The air flow range has been determined by NIOSH to maintain a continuous flow inside the helmet to prevent entry of dust. At no time should the air control valve be altered in any manner to circumvent the required settings. Never substitute the air control valve with other types or brands of valves.

Clemco's air-fed helmet provides a minimum of 7 cfm for an added margin of safety when air supply is set at minimum recommended pressure settings.

Low-pressure helmets are designed for use with low-pressure air pumps. Low-pressure helmets require 8 to 15 psi (0.6 to 1 bar/55 to 103 kPa) at 6 to 15 cfm (0.2 to 0.4 m3/min) with the standard air control fitting with a

fixed orifice. The air control fitting must never be removed, modified or replaced with any other type of valve. Any alteration of the helmet's original air flow system will adversely affect the helmet's breathing air efficiency. Cool temperature valves may not be used with some low-pressure helmets or hoods due to the high amount of pressure needed to produce the cooling action. Be sure to check the owner's manual for air control valve limitations.

A major advantage of using low-pressure helmets is the ability to use non-lubricated breathing-air pumps. Pneumatically- and electrically-driven air pumps do not use oil to lubricate their moving parts; consequently, there is no chance of producing dangerous carbon monoxide or oil contamination in air lines. Air pumps, however, must be placed in areas where engine exhaust or other contaminated air will not enter the pump's air inlet. Check the manufacturer's instruction manual for the pump's operating specifications to ensure it will provide the required volume and pressure of air to the helmet.

WARNING!

Supplying helmets with less than 6 cfm of air may allow dust to enter. Supplying helmets with more than 15 cfm of air (20 cfm when equipped with temperature control valves) may irritate or injure eyes, lungs and respiratory passages.

Helmet air supply hose is regulated by the approval process of NIOSH. Since hoses are made by various manufacturing methods, breathing air hose is subject to stringent manufacturing controls. Breathing air hose must meet NIOSH specifications for size, strength, rubber composition and manufacturing techniques. Metal hose connectors must also be approved by NIOSH.

There are good reasons for breathing hose regulations. Various types of chemical releasing agents, some of which may cause irritation, are used to separate the internal diameter of hose from its mold mandrel. Many chemical residues left in ordinary hose give off a strong, unpleasant odor that becomes more noticeable when the hose is warmed from heat generated by compressed air friction. The odor can become strong enough to cause nausea and

dizziness to an operator under the helmet. In fact, some mold release compounds may contain harmful chemicals. Hose specifically manufactured for breathing air does not use harsh chemicals as releasing agents. Additionally, size is an important factor for unrestricted, steady flow of air. The appropriate inner diameter should be held to a close tolerance throughout the entire hose length. High-quality neoprene rubber tubing does not swell or distort from moisture.

To ensure continuous safety and comfort, it is absolutely essential to follow a strict maintenance program.

Helmet manufacturers cannot foresee all the conditions that can exist in the wide variety of working environments. Therefore, operators, maintenance personnel and employers must enforce maintenance policies that comply with instructions stated in the helmet owner's manual, and they should implement additional maintenance steps that relate to their specific application.

Here are some important points to follow for proper care and maintenance of air-fed helmets (refer to helmet owner's manual for complete instructions).

- No one should use an air-fed helmet before thorough training on its operating and safety functions, upkeep and care. Untrained personnel can injure themselves and cause costly damage to the equipment.
- At the end of every work shift, dust should be vacuumed from the helmet before the operator removes it. Clean helmets should then be enclosed in plastic bags and stored in a dust-free area. Helmets should not be dropped or left in areas where they may collect dust and dirt.
- At least once a day, inspect all components for wear . Never use tape to repair holes or to seal worn areas. Replace window frames and window seals immediately if there is any sign of leakage. Replace outer capes when worn sections are noticed. Replace inner collars when elastic is stretched out of shape. Replace breathing air hoses when any damage is found.

- At least once a week, the inside of the helmet, the inner collar, and the cape, once they're removed from the helmet, should be washed with warm water and mild detergent.

AIR TEMPERATURE CONTROL VALVES

For maximum operator comfort, optional air temperature control valves may be used to warm or cool incoming air. These valves allow operators to adjust the temperature of the air entering their helmets so they can work comfortably in a wide range of job site environmental conditions. One type cools the air coming into the helmet. The other either cools or warms air to the helmet.

DO NOT use valves of different brands because substitution of any component on helmet systems voids the NIOSH approval of the entire system.

Air temperature valves are tested and approved by NIOSH in conjunction with the original manufacturer's helmet. DO NOT use valves of different brands because substitution of any component on helmet systems voids the NIOSH approval of the entire system. Air temperature control valves consume greater air volume, approximately 20 cfm (0.6 m3/min) complete with helmets with air valves, which consume 15 cfm. Pressure requirements vary according to air control device and respirator air supply hose lengths. As with the air control valves, Clemco temperature control valves are designed to furnish no less than 7 cfm (0.2 m3/min) and cannot be completely shut off.

PROTECTIVE CLOTHING

Abrasive moving at high velocity can inflict serious injury upon unprotected operators performing blasting jobs; therefore, it is essential that they wear protective clothing. OSHA regulations 29 CFR, Subpart I, 1910.94 and 1910.134 state that operators should wear heavy-duty clothing, canvas or leather gloves and safety shoes. Lightweight clothing does not provide sufficient protection. Blast suits with leather panels protect against

ricocheting abrasive, and may afford some protection from momentary direct blasts of high speed, sharp abrasive. Specially-designed blast suits constructed of a combination of leather and cotton materials are ideal. This type of suit provides maximum protection where it is needed, but allows the escape of body heat.

The combination of leather and cotton provides protection and comfort without overburdening weight.

Leather or heavy canvas gloves must be worn by operators. Lightweight, cotton gloves do not give adequate protection. Gloves should have sufficient cuff length to cover wrists and lower arms. Safety shoes must be worn when working with heavy materials and during any blasting operation to protect the operator's feet from accidental nozzle blast.

REGULATIONS

Regulations concerning operator safety equipment are extensive, and for good reason. Failure to use required equipment, misuse of equipment, lack of required maintenance, and disregard for manufacturer's written instructions invite serious injury or death.

It is extremely critical for employers, supervisory personnel, operators, and operator assistants to learn all safety requirements and practice every safety precaution relating to the abrasive blasting process.

It is noteworthy that OSHA not only specifies equipment and operating procedures, but also emphasizes the necessity of adhering to manufacturer's recommended maintenance programs. A safety product's effectiveness is only as good as the quality of service it receives. Tape, for example, is an inadequate repair for a worn or leaking air-fed helmet. Carefully-documented maintenance procedures, which comply with OSHA and other local regulations, must be implemented and enforced by every employer to protect their employees' welfare.

A safety product's effectiveness is only as good as the quality of service it receives.

Regulations stated throughout this section on operator safety equipment are, for the most part, taken from OSHA regulations. Federal law declares that abrasive blasting respirator systems must be approved by NIOSH. Respirator systems include helmets, hoods, air control valves, air temperature control valves, breathing air supply hoses, and every individual part of the helmet system. OSHA regulations and NIOSH approval specifications do not permit substitution or modification of any part of a respirator system. OSHA also issues specifications on breathing air quality, air filters, gas detection equipment, air valves, air fittings and other related parts of respirator systems.

OSHA regulations and NIOSH approval specifications do not permit substitution or modification of any part of a respirator system.

Most, if not all, air-fed helmets and hoods designed for abrasive blasting are classified and approved by NIOSH as Type CE, continuous-flow, supplied-air respirators. These respirators are also approved by the Mine Safety and Health Administration (MSHA). They are "approved for respiratory protection in any atmosphere not immediately dangerous to life or health with at least 19.5% oxygen, and from which the wearer can escape without the aid of the respirator." In essence, these respirators can be used only in working conditions that do not contain toxic solid and gaseous elements. OSHA/NIOSH/MSHA have determined permissible exposure limits on certain toxic materials and their regulations should be consulted prior to working in any application in which toxic materials may be present.

So far in this publication, only the federal regulations have been addressed. There are, or may be, additional state, local or job-site directives that must be followed. It is the responsibility of the employer to be aware of all job safety

requirements prior to initiating any work. This is true also on jobs performed outside the United States. While OSHA does not enforce its regulations outside the USA, other nations have similar rules that must be followed.

ABRASIVE HANDLING

Abrasives are heavy—often too heavy for workers to handle without the risk of injury. Provisions should be made for transporting, loading, unloading, cleaning up and disposing of abrasive. Abrasive, supplied in 50 or 100 pound (25 or 50 kg) bags, should be stacked on pallets and moved by forklift. Fill blast machines and storage hoppers with vacuum equipment; this eliminates, or at least minimizes, physical lifting.

Abrasives are heavy—often too heavy for workers to handle without the risk of injury.

Clean up used abrasive with vacuum equipment equipped with sealed containers. Use mechanical lifting equipment when disposing of used abrasive containers. Avoid physical strain that could result in back or other injuries. When lifting equipment is not available, ensure that workers lift properly by providing instruction on proper physical lifting procedures.

Vacuum equipment can be used to quickly and easily load blast machines and storage hoppers with new abrasive. This eliminates the risk of injury from physical lifting.

Large positive-displacement blower vacuum systems, powered by electric motors or diesel engines, are available from Clemco for high volume abrasive movement. Also available from Clemco are pneumatically-operated Easy Load Systems, which are ideal for smaller blasting applications. Both of these systems are utilized for recovery of used abrasive, as well as for loading purposes. These systems offer tremendous cost savings in time and labor.

Probably the single, most beneficial use for vacuum equipment is the collection and containment of contaminated spent abrasive. When blasting with high silica abrasives or when removing toxic materials from surfaces, it is extremely important to capture the dust and prevent it from becoming an airborne respiratory risk.

Vacuum equipment should be used to remove loose abrasive from surface areas where blast operators and other personnel walk. Loose, scattered abrasive on smooth surfaces can be a slippage hazard to workers. When AVS or Easy Load systems are on the job site, they can be used for floor cleaning. If these systems are not available, small industrial vacuums may be adequate for cleaning.

Important Note
In applications where lead and other heavy metal based paints, or any toxic materials are being removed, vacuum systems that discharge air indoors or inside containment enclosures must be equipped with HEPA (high efficiency particulate air) filters.

WARNING!

NIOSH-approved, properly-rated respirators must be worn by all personnel working with abrasives during loading, unloading, transporting, clean-up, disposal and any other abrasive handling activity. This warning applies to all persons in the vicinity of abrasive handling activity whether or not they are actually engaged in the work process.

Prior to performing any work with any abrasive, personnel must put on proper air-fed helmets. Simple paper paint masks, cloth bandannas or similar filtering masks do not offer adequate or acceptable respiratory protection for abrasive applications. Harmful dust is present during all phases of handling of new and used abrasive; therefore, it is absolutely essential to wear correctly-rated respirators at all times. It is imperative to use air-fed helmets which are designed to protect against specific types of dust generated from the abrasive, such as silica, and the materials being removed from the surface by blasting; such as lead, asbestos, heavy metals, corrosive elements, etc.

RELATED JOB SITE EQUIPMENT

Pay special to all the equipment used in a blasting application and to the conditions under which blast operators must work. Blast operators lack some freedom of movement because of nozzle pressure force, heavy protective clothing and working with cumbersome hoses. They have a smaller field of vision from wearing protective head gear. All of these factors, plus others, must be taken into account when selecting and using equipment for the job site.

Pay special to all the equipment used in a blasting application and to the conditions under which blast operators must work.

FORKLIFTS, CRANES, AND SIMILAR EQUIPMENT

Wherever possible, use mechanical lifting equipment to move blast machines. When blast machines contain abrasive, they should never be moved manually. There are towing carriages specially designed to pull empty blast machines on smooth, flat surfaces.

However, when the surface area is rough, uneven and cluttered or when machines must be elevated, use mechanical lifting equipment for lifting and moving blast machines and all other heavy objects.

Securely strap blast equipment to the mechanical lifting equipment. Do not depend solely on forklift blades to support equipment. When using cranes or other types of hoists, be sure the cables, chains or straps have more than sufficient strength to handle the weight of the blast equipment. Never lift blast machines by their piping or protruding components. Lay down equipment on pallets or use machine lifting lugs to properly support the equipment weight. Due to the possibility of injury, personnel should not ride with the equipment when it is being mechanically transported.

SCAFFOLDING AND PERSONNEL-LIFT EQUIPMENT

Scaffolding offers lateral movement flexibility for blast operators, but requires extra precautions to ensure the operator's safety. Scaffolding planks, which tend to shift, should be clamped or tied securely to the framework. Planks must comply with weight load specifications. Make sure abrasive and debris are removed from planks to provide a slip-free surface for the operator. Correctly position guard rails on scaffolding. Consult with the scaffolding supplier for guard rail requirements. Blast hose and air hose should be tied snugly to scaffolding framework to give the operator relief from the hose weight. Tying down vertically-positioned hoses also minimizes the risk of injury to workers below the scaffolding should the hoses accidentally drop. Make sure operators wear safety harnesses to prevent serious injury or death resulting from a fall from the scaffolding. Safety harnesses must be appropriate for specific work heights and job conditions. The job superintendent or safety engineer should specify the correct type of harness for the operator to wear.

Personnel-lifts, scissor-lifts, telescopic personnel buckets and similar mechanical machinery require safety precautions. Check with the equipment supplier to determine if the equipment can be used in abrasive blasting applications. Some lift equipment is not suitable for this application because of potential equipment damage from dust and abrasive rebound. Also, check the terrain where the mechanical equipment will operate. Movement is often controlled from the personnel platform or bucket while it is elevated; therefore, the surface area must be smooth and level to avoid tip-over possibilities. Check with the equipment supplier for information on types and conditions of surfaces on which the equipment can operate safely.

As advised for scaffolding, tie down blast hoses on mechanical lift equipment to relieve weight and prevent accidental dropping. When tying hoses, be sure to avoid kinks and sharp bends, which will cut off or reduce air flow and abrasive supply. Make sure operators wear safety harnesses to prevent dangerous falls. Never override the blast machine remote control handle by tying the handle lever down, substituting the control handle, or

altering the operation of the handle in any manner. While it may seem convenient to keep the control handle in the "on" position, it is an extremely dangerous practice. If the blaster drops the nozzle, or if the blast hose ruptures near the nozzle, blasting will continue as the control handle is fixed in the "on" position. The result will be a dangerously whipping nozzle and hose in the personnel compartment or platform, or on workers below, all of which may cause serious injury from high-velocity abrasive to the blaster or bystanders. The control handle must always be allowed to function as designed so that injuries will be prevented.

To prevent injury, the remote control handle must always be used as designed.

Forklifts, lift trucks and cranes should never be used to elevate personnel. These types of lifting equipment are designed to transport materials - not people.

JOB SITE ACCESSORIES

Safety practices are important not only with blast equipment, but also with any accessory equipment that is used on the job site. Each piece of equipment has instructions that must be followed; how- ever, there are some additional precautions to take when the accessories are operated in an abrasive blasting application. First, read the manufacturer's instructions and follow the recommended operating procedures. Next, check on job site safety requirements for each piece of equipment. Suggestions that follow in this section are intended as check points.

Always consult with the job site safety engineer or supervisor.

Lights used to illuminate the work surface should be dust-tight and equipped with shatter-proof lenses. These features are especially important if the lights are fastened to the blast hose or nozzle. Dust from some materials removed from the surface may be flammable and, if allowed to leak into the light fixture, may cause an explosion. Shatter-proof lenses guard against light damage from hard-hitting rebounding abrasive. Lights

fastened to blast hoses and nozzles should be low voltage to avoid dangerous electrical shock to the operator. There are a number of blast lights available that convert 115-volt service to harmless 12-volt to power the lights.

Very strict safety requirements affect the use of lighting in blasting applications where combustible gases are present. In most if not all cases, explosion-proof light fixtures, switches and wiring are required when blasting within enclosures. It is essential that the employer and/or safety engineer thoroughly investigate the atmospheric working conditions of the job and furnish the appropriate electrical safeguards.

Air exhausters, or air movers, are commonly employed in confined areas where air circulation is a problem. Usually, fresh air enters one end and the exhauster pulls out dust-laden air on the opposite end. Choosing an efficient exhaust is predicated on several factors, including dimensions of the work area, the free air inlet, the dirty air outlet, and the volume of dust to be removed. In some applications, where air inlets are too small, air pumps are used to increase the volume of free air. The job site safety engineer uses air flow measuring instruments to ensure that properly-rated exhausters and, if necessary, air pumps are used.

Two important reasons for ventilating confined spaces are worker respiratory protection and visibility in the work area. Ventilation controls dust concentration to ensure that the protection factor of the workers' respirators is not exceeded. And, ventilation preserves visibility for operators, who cannot efficiently clean a surface they cannot see. Dry blasting creates dust, even when blasting with a relatively dust-free steel or iron abrasive, because dust is generated from the material removed from the surface. To assure safe conditions, it is important to continually monitor dust levels.

Many areas have strict regulations for discharging contaminated air into the environment. Engineering controls are usually required to limit emissions to an acceptable level. Dust collection equipment captures and retains exhausted dust particles. Dust control is especially critical when the blasting dust contains lead, asbestos,

heavy metals, silica or any other toxic contamination. Several high-efficiency dust collection systems are available that comply with the most stringent regulations on air and soil contamination. It is wise to learn about all the job site regulations prior to blasting.

ENCLOSURES AND CONTAINMENT

There are various reasons for enclosing abrasive blasting operations; among them are environmental and nuisance controls, and production efficiencies. Whatever the motivation, field enclosures must conform to safety and environmental regulations.

A substantial environmental benefit to enclosing a blasting operation is the elimination of air and water pollutants from surrounding areas. The main source of hazardous dust is substances removed by blasting. These substances may be toxic, and include asbestos, lead or other heavy metal paints. Dust generated from silica sand and other abrasives composed of high amounts of crystalline quartz are also classified hazardous. In open, uncontrolled blasting operations, dust can travel over wide areas and, if heavily concentrated, it can contaminate structures, ground, water and other environmentally-sensitive places. Dust can be a source of irritation even in small amounts. In proximity to blasting jobs, the wind can deposit thin layers of dust on cars and homes.

In field applications, blasting operations can be contained with tents made of heavy-duty fabric, vinyl or rubberized materials. Tents are used on job sites where parts can be brought in for blasting and painting prior to installation. A typical example is blasting and painting steel fabrications in a tent before assembly on construction projects. Not only does the tent contain pollutants, it also eliminates possible health hazards and annoyance to other workers in the job area.

Common Army surplus tents are not suitable for blasting. Effective lighting, adequate ventilation and abrasive recovery are needed. Specially-designed tents with clear vinyl ceilings and windows which allow sunlight to illuminate the tent work area are available. Additional lighting may be used to increase lighting intensity. Tents must be equipped with properly-designed atmospheric air

inlets and dust collector outlets for ventilation. Ventilation requirements for tents follow OSHA regulations for fixed-site blast rooms.

Several companies market and install containment products to incrementally surround large structures. These containments prevent atmospheric and environmental contamination from abrasive and dust. The companies marketing these special containment products have a distinct expertise in rigging them on structures. Containments are used extensively on bridges, buildings, storage tanks, ships and other large structures. These products are of particular benefit when toxic coatings are to be removed by blasting. Used in conjunction with containment products, dust collectors ventilate and capture dust. Dust collection is essential to keep dust concentrations at a safe level for workers inside enclosed areas. The new containment technology allows toxic paint removal in areas never before considered appropriate for blasting due to various potential health hazards and environmental considerations.

Referred to as "engineering controls", the ventilation equipment needed for job site containment of abrasive blasting must comply with OSHA regulations.

These regulations are the same for field-installed enclosures as for stationary blast room facilities (ref: OSHA 29 CFR 1910.94). As in any blasting environment, personnel working inside enclosures must be protected from heavy concentrations of harmful dust. While exhaust fans perform the vital function of extracting dust from an enclosure, they contaminate the environment with the dust they expel. All blasting enclosures need properly-engineered ventilation systems that not only remove dust, but also retain it. These systems must conform to local air quality regulations on atmospheric emissions.

There is specific design criteria for abrasive blasting ventilation equipment. Enclosure size, shape and type of abrasive are important factors affecting volume and speed of ventilation air and area of filtering material.

Dimensions and location of air inlets and air outlets are critical to creating the internal air flow through the enclosure. Not just any size filtering and exhaust system will do. The system must have sufficient filtering capacity to handle anticipated dust loading, and its exhauster must be correctly rated for flow speed and volume of air required for efficient ventilation. No matter what kind of containment is involved, the ventilation and dust collection equipment must be formulated by qualified companies so that personnel in the enclosure have adequate visibility and are protected from excessive dust exposure.

The process of abrasive recovery and disposal must be carefully considered due to its financial impact. For long-term jobs, it may be most cost-effective to install automatic abrasive recovery and recirculation systems to reduce labor expenses associated with loading, unloading and disposal of vast tonnages of abrasive. For short-term jobs, vacuum recovery equipment, available in a variety of designs, is cost-effective. All types of recovery systems offer abrasive cleaning features that permit reuse of recyclable abrasives. Recycling dramatically lowers operating expenses of field blasting operations, and equally importantly, controls contamination.

The need to remove lead-based paint from large structures created the demand to use steel grit abrasive in outside blasting applications. Using steel grit eliminates the majority of waste normally produced when using expendable abrasives, such as sand. Steel grit may be recycled many times; however, it must be thoroughly cleaned before each reuse to remove lead dust and other toxic contaminants. Specially-designed portable equipment, has been engineered to recover and process steel grit on a job site. A series of cleaning mechanisms remove all contaminants and store them for disposal. Due to the hazardous nature of these stored contaminants, strict safety rules must be enforced. OSHA has issued specific workplace regulations in 29 CFR 1926.62 and 29 CFR 1910.1025 that must be followed. In addition to complying with the manufacturer's operating instructions, the Society for Protective Coatings (SSPC) has produced several excellent guides for containing and disposing of dust and debris from lead-based paint removal jobs. Refer

to these and other related documents to be completely familiar with the safety requirements for lead and other heavy metals.

D. EQUIPMENT OPERATION

EQUIPMENT STARTUP

When all equipment is assembled and checked-out, the machine is loaded with abrasive, and the air compressor is ready, the blaster is prepared to start working. When two or more blast operators are working in the same location, each blaster should check the colored strip on the blast hose for his assigned color. If working on an elevated platform, workers need safety harnesses and any other necessary fall-protection safety devices. Be sure that the working space is uncluttered and allows for free movement in all directions. Make sure the walking surface is stable. In preparation for blasting, the operator should firmly grasp the blast hose with both hands so that the hose is under his control and he is prepared to handle the recoil force of high pressure air at the nozzle. It is best to keep hands at a safe distance from high-velocity abrasive coming out of the nozzle.

To start blasting, close the safety petcock on the remote control valve. When in position and ready to blast, the operator pulls down on the spring-loaded, safety lever lock and depresses the remote control handle lever. Holding the nozzle itself during blasting is not recommended. The operator should also be careful to point the nozzle only at the surface to be cleaned. The operator must maintain full pressure on the handle lever for uninterrupted operation. Blast operators are often tempted to tape down or tie down the lever to eliminate the need to physically hold it down. This is an extremely dangerous practice which must not be allowed. If the lever cannot freely open, the safety feature of remote controls is completely circumvented. Without remote controls, when an operator loses control of a pressurized blast hose, it will wildly whip around blowing high-velocity abrasive in every direction. Uncontrolled blasting is especially dangerous if the operator trips and falls, and lets loose of the blast hose. Not only is the operator at risk of being injured, but everyone in the vicinity is in danger. Never tape, strap, or tie down the remote control handle lever.

The remote control handle assembly is designed to function with specific remote control valves on the blast machine. Neither the handle assembly nor, for that matter, any component of the remote control system should ever be replaced with parts of another brand.

WARNING!

Substitute parts may cause the remote control system to malfunction which may result in serious injury to the operator and other personnel in the immediate area.

This is also true when exchanging other manufacturers parts for Clemco parts. Manufacturers have unique designs that may not be compatible with other manufacturer's equipment. Not only is substitution of parts a safety hazard, it also voids the manufacturer's warranty and places full liability on the owner of the equipment. Don't gamble with safety equipment because jeopardizing an employee's safety is simply not worth it.

WARNING!

Install AN antifreeze injector when blasting in sub-freezing weather.

An anti-freeze injector is an important safety device to be used with pneumatic remote controls when blasting during freezing weather. The adjustable Injector unit automatically releases antifreeze mist into the air stream to eliminate the danger of freeze-up. When warm, moist compressed air travels through long air lines it can cool to the freezing point and cause ice build-up in the remote control handle. The ice build-up can divert bleed-off air back to the remote control valves and unintentionally activate blasting. When blasting is to be done in freezing conditions, install a Clemco Antifreeze Injector on pneumatic remote controls, or switch to electrically-operated remote controls.

STOPPING PROCEDURES

To stop blasting, release the remote control handle lever. The handle lever and lever lock should quickly spring open at the same time. If there is the slightest delay in reaction time of the handle lever or lever lock to open, check for

dust and dirt build-up around pivot pins before resuming blasting. Also, test the tension on the lever springs, and replace them immediately if they do not respond rapidly.

When the handle lever is released, there will be a momentary time lapse for air pressure to bleed out of the nozzle. Remote control valves act quickly to shut-off air to the blast machines, but air pressure left in blast hose must escape through the nozzle. The operator should hold onto the blast hose until the air pressure from the nozzle drops off to zero. The longer the hose, the more time it will take to depressurize. Time will vary according to nozzle size, but will not exceed a few seconds. Large nozzles will exhaust air pressure out of the hose faster than small ones.

When all air is exhausted, the hose should be carefully laid down. Hose should never be dropped or thrown down because such actions may damage the nozzle and remote control handle assembly. Keep the handle assembly out of dust and dirt to prevent clogging the bleed-off hole. Accumulation of dust and dirt on the handle assembly may interfere with the free movement of the handle and safety levers.

Before removing the air-fed helmet, open the safety petcock on the remote controls. Opening the safety petcock prevents accidental activation of the blast machine. With the petcock open, the handle assembly can be depressed, but the remote controls will not function because no air reaches the handle assembly. The petcock should be closed only immediately before blasting is to begin.

At the end of the blasting work day, always empty the blast machine. Leaving abrasive in the machine overnight causes absorption of moisture. To empty the machine, uncouple the blast hose at the bottom of the machine, adjust the metering valve to its full open position, close the side-mounted choke valve, reduce air pressure to 40 or 50 psi, and pressurize the blast machine for a few seconds.

WARNING!

EMPTYING THE MACHINE AT HIGH PRESSURE WILL DAMAGE THE MACHINE COUPLING.

Any measurable wear on the coupling will affect the connecting efficiency and safety design of the coupling; consequently, it is vital to inspect it prior to reconnecting the hose, and immediately replace it when there is any sign of wear.

When blasting is interrupted for any reason, blast operators and all personnel in the blasting zone must remain in their air-fed helmets. Harmful dust lingers in the air long after blasting has ceased; therefore, all personnel must continue to wear respiratory protection at all times on the job site until the air has been tested and declared safe to breathe, personnel clothing has been vacuum cleaned, and all harmful dust avoidance procedures have been followed.

E. JOB SITE CLEANUP

At the end of the work day, or when the job is completed, follow the shut-down procedures described in the equipment owner's manuals. Carefully lay down the nozzle, and immediately open the blast machine safety petcock. Do not remove respiratory protection equipment. Turn off the air compressor supply valve leading to the blast machine. If pressure-hold remote controls are assembled on the blast machine, depressurize the blast machine. Disconnect and coil blast hose making sure the correct color-coded hose is stored with its corresponding blast machine.

Prior to shutting off the breathing-air supply, perform the abrasive clean-up duties before removing respiratory protection equipment. Used, pulverized abrasive in the blasting area has a high content of fine dust particles, which can be inhaled during the clean-up process. Everyone in the blasting zone during clean-up must wear NIOSH-approved, properly-rated, supplied-air respirators. Clean-up can be more hazardous than blasting because of the high concentration of pulverized abrasive. ALL personnel involved in clean-up MUST wear NIOSH-approved air-fed helmets. Any movement of pulverized abrasive, especially if it is swept or shoveled, creates vast amounts of airborne particles of which the majority may be respirable.

Use vacuum recovery methods to remove spent abrasive and debris in the blast area. Except for brief periods or in

hard to reach areas, do not use compressed air to blow abrasive and dust from the blast area. High powered air cleaning generates clouds of dust around the job site, adding more time for the air to clear. It also creates a breathing hazard to anyone not properly protected with a respirator in the vicinity.

On completion of abrasive clean-up, the safety engineer should test the blasting zone atmosphere with a dust monitor for the presence of dust. When the air is clear of dust, the blast operator and all personnel in the blasting zone should vacuum clean their clothing. Clothing becomes contaminated with fine dust which will dislodge during removal. Vacuuming ensures capturing the dust and sealing it until it can be disposed of properly.

IMPORTANT NOTE
OSHA has specific regulations on hygienic procedures to follow after blasting is completed, especially in applications which involve the removal of lead-based paints (ref: OSHA 29 CFR 1926). Employers are required to follow these procedures for the health and safety of their employees.

After removing vacuum-cleaned respiratory protection equipment, inspect it for wear or damage. Immediately replace all parts as necessary using the owner's manual as a guide to proper repair instructions. Place the respirator in a sealable plastic bag and store it in a clean, dust-free area.

Turn off the air compressor and bleed-off the air receiver tank. Wear hearing protection during the depressurizing process to avoid hearing injury from high-pitched air noise. Bleed accumulated water from moisture separators, air dryers and after-coolers according to the manufacturer's instructions. Disconnect the air hose and coil it for ease in handling. Keep hose ends clean to prevent entry of dirt and dust to avoid contaminating machine valves when hose is reconnected. Follow the same procedure for all air hoses. Perform the required maintenance on the compressor and air filtering system to maintain high quality production of compressed air. Drain and check the air filter. Refer to owner's manuals and comply with all inspection and maintenance instructions to keep the blast system components operating safely and efficiently.

SECTION THREE

COMPONENT SAFETY NOTES

This Section is a summary of safety notes for each major component of an abrasive blasting system. These safety notes are meant to supplement owner's manual instructions; therefore, these notes should not be considered as a replacement for equipment manuals. References to rules and regulations are made for the sole purpose of bringing attention to known requirements at the time of the printing of this booklet. Regulations and equipment requirements change based on specific applications, advancements in technical research, and new discoveries through health and safety studies. Always consult current regulations and requirements prior to undertaking abrasive blasting jobs.

WORK ENVIRONMENT

- Establish a hazardous blasting zone at the job site. The zone should include the entire area surrounding blasting operations where dust concentrations may exceed OSHA permissible exposure limits.
- To avoid respiratory disease from toxic contamination, investigate composition of materials to be blasted. Look for asbestos, lead, various heavy metals, and other types of toxins. Assign appropriate respiratory protection to blasters and other personnel in the blasting zone.
- Check for electrical power lines. Protect workers from exposed wires.
- Test work place air for hazardous fumes, especially in confined enclosures.
- Carefully inspect work surfaces. Remove obstacles, cover holes, remove water or other liquids, and dispose of loose, slippery materials.
- Provide clear visibility for blasters. Utilize air blowers, air movers, vacuum equipment and/or dust collectors to reduce dust.
- Test noise levels at job site and give blasters appropriate hearing protection if internal helmet noise exceeds 80 dBA.

BREATHING-AIR SUPPLY

- When an air compressor or an air pump is used for breathing air, the air intake must be positioned to prevent entry of engine exhaust and any other toxic gases.
- Install a carbon monoxide monitor/alarm on any source of breathing air or install a Clemco CMS-3 inside the Apollo respirator.
- If an oil-lubricated compressor is used for breathing air, it must be equipped with overheating shut-off device or carbon monoxide alarm or both. (ref: OSHA 29 CFR 1910.134).
- Do not use piston-type, oil bath air compressors for breathing air.
- Breathing air quality must meet the requirements described in ANSI/CGA G-7.1 for Grade D breathing air (ref: OSHA 29 CFR 1910.134 and 30 CFR 11.121).
- Do not use plant air for breathing air until the quality of air has been tested and approved for Grade D breathing air.
- Breathing air must contain at least 19.5% oxygen.
- Shut-off compressor and depressurize all air lines prior to performing maintenance.

AIR DRYERS AND AFTER COOLERS

- Filtering materials must be properly maintained to produce contamination-free air, especially if breathing air is processed through these units.

AIR LINES AND CONNECTORS

- Inspect air lines and connectors for wear and damage, and immediately replace or repair, as required.
- Check gaskets on each connector and immediately replace if worn, distorted or too soft.
- Lay out hoses where they will not obstruct workers.
- Install safety cables on air line connections, including attachment to compressor manifold and blast machine inlet piping.

ABRASIVE

- Use screened, non-contaminated and graded abrasive produced specifically for abrasive blasting.

- Check Material Safety Data Sheet (MSDS) for hazardous composition of abrasive.
- Use abrasive containing 1% or less of crystalline silica (quartz).
- Utilize mechanical lifting devices and/or vacuum loading equipment to handle abrasive.
- Wear NIOSH-approved, properly rated respirators when handling abrasive, especially during clean-up.

BLAST MACHINES

- Check fittings and valves for tightness and operating condition. Immediately replace broken or bent handles.
- Replace worn gaskets immediately.
- Use mechanical equipment to move machines. Never manually move machines containing abrasive.
- Inspect machine for dents and other damage. Repair work must be done by an ASME certified welder. If welding is done on the machine, it must be hydrostatically tested and documented according to ASME codes.
- Never replace steel air piping with hose.

ABRASIVE METERING VALVES

- Do not substitute Clemco metering valves with manual air valves or competitive metering valves.
- Valve handle or knob must move freely for accurate adjustment of abrasive flow.
- If using pressure-hold metering valve with rubber tube, thoroughly read owner's manual before disassembling. Valve must be caged (locked) before repair work begins.
- Do not perform maintenance on valves when blast machine or blast system is under pressure.

REMOTE CONTROLS

- All blast machines must be equipped with remote control systems (ref: OSHA regulations 29 CFR 1910.244).
- Never use substitute components or replacement parts on Clemco remote control systems.
- Never use Clemco components or replacement parts on competitive remote control systems.

- Never strap down remote control handle lever with tape, wire or any other material that will interfere with free movement of the lever.
- Clean abrasive trap at least twice daily to avoid restriction in air exhaust.
- Always use Clemco twinline remote control hose and fittings to ensure proper response time and adequate air flow. Never use welding hose or similar non-approved hoses.
- On pressure-hold remote controls, thoroughly read owner's manual before servicing, and use extreme caution during disassembly of the valves.
- Always maintain remote control systems in perfect working order.

PRESSURE REGULATORS WITH GAUGES

- Check manufacturer's metal identification plate on the blast machine to confirm its maximum working pressure rating. Set regulators accordingly.
- Use regulators specifically designed for nozzle air volume requirements.
- Replace damaged gauges immediately.

SCREENS AND COVERS

- Always use a blast machine screen to keep debris out of the machine.
- Cover top of blast machine when not in use to prevent entry of moisture.

BLAST HOSE AND COUPLINGS

- Inspect hose couplings for wear and damage prior to each use.
- On hose-to-hose connections, always check coupling fit and cam lock engagement. Do not mix different brands of couplings to prevent mismatching of locking lugs.
- Always use couplings screws provided by Clemco. If screws must be purchased locally, be sure the size and type are identical to those supplied by Clemco.
- Check coupling gaskets prior to each connection. Replace immediately if worn, distorted or too soft.
- Always wire couplings together to prevent

disengagement from accidental twisting.

- Be sure that hose ends are properly seated against coupling shoulder. If hoses must be cut and re-coupled, be extremely careful to cut hose ends square and smooth to ensure a positive seal completely around hose end and coupling shoulder.
- Never use undersized blast hose or oversized couplings. Hose and couplings must fit tightly together.
- Never use blast hose that appears to have worn out areas on the internal rubber tube. Inspect hose daily for soft spots which indicate the need for replacement.
- Use only static-dissipating blast hose to prevent build-up of static electricity.

Important Note
Blasting near volatile fumes and gas will require additional grounding devices for static electricity. Consult with a safety engineer during equipment preparation.

- Replace blast hose showing damaged outer wrapping. Wrapping provides an added safety margin against blow-outs.
- Size of blast hose internal diameter should be 3 to 4 times the size of the nozzle orifice to prevent premature hose wear.
- Never use hoses or couplings that are not specifically designed for abrasive blasting.
- Never exceed pressure rating of blast machine or hose, whichever is lower.
- Lay out hoses in long curves. Sharp bends result in premature wear and blow-outs.
- Always install safety cables at all blast hose connections.

NOZZLES AND NOZZLE HOLDERS

- Never operate nozzle without a nozzle washer (gasket).
- Inspect nozzle washer before each use. Replace if worn, distorted or too soft.
- Do not drop, throw or otherwise abuse nozzle. Harsh treatment can cause fragile internal liner to crack and blow out.

- Inspect nozzle and nozzle holder threads before each use. Replace if worn or damaged.
- Select nozzles with large “contractor” (50 mm) threads for maximum attachment security.
- Always screw nozzles completely and tightly into nozzle holder. If there is any indication of looseness, replace nozzle or nozzle holder or both.
- Do not mix different brands of nozzles and nozzle holders to prevent mis-matching of different thread forms.
- Replace nozzle when orifice size wears to 1/16” (1.5 mm) larger than its original size.

OPERATOR SAFETY EQUIPMENT

- Blast operators must wear NIOSH-approved, properly-rated and properly maintained supplied-air respirators (Type CE air fed helmet). Respirator selection must comply with regulations matching the respirator’s assigned protection factor rating (APF) with the worker’s permissible exposure limit (PEL) of hazardous materials on the job site.
- Employer or safety engineer must check the composition of surface materials to be removed, and type of abrasive to be used to determine required type of respirators (helmets) for blasters and all personnel within the blasting zone.
- On lead and heavy-metal-based paint, and/or toxic materials removal jobs, blasters and all other personnel must wear NIOSH-approved, properly-rated respirators (helmets).
- On all jobs with any type of abrasive, all personnel within an established blasting zone must wear NIOSH-approved, properly-rated air-fed helmets.
- Respirators, safety glasses, hearing protection, and other appropriate safety equipment must be continuously worn in the blasting zone during all handling of abrasive, including the clean-up phase, and must not be removed until clothing has been cleaned, and zone air has been tested and declared safe for breathing without the aid of a respirator.
- Breathing air supply must be at least Grade D quality as defined in ANSI/CGA G-7.1.

- Breathing air must be filtered to remove moisture, oil mist and particulate matter.
- Breathing air hose must be NIOSH-approved and supplied by the same manufacturer as the respirator.
- Do not use oxygen bottles for breathing air.
- Check helmet for wear and damage before each use. Repair or replace parts immediately. Do not use tape for repairs.
- Do not replace air control valve, cool-air tube or climate control tube with other types or brands of valves.
- Replace lenses frequently. Do not use lenses from different sources other than the original manufacturer of the helmet.
- Never use substitute parts for replacement of any helmet assemblies.
- Do not abuse helmet breathing hose. Use carrying strap to handle helmet.
- Clean or replace cape inner collar when dirty or slightly stretched out of shape.
- Replace cape inner collar if it does not fit snugly around your neck.
- After blasting, thoroughly vacuum dust from helmet and clothing before removing them.
- Store helmet in clean, dust-free location away from blasting operation.
- Replace CPF filter cartridges every three months or sooner if pressure on regulator gauge decreases, odor is detected, or moisture enters helmet or hood.
- Set CPF filter regulator at required helmet pressure (check owner's manual for required pressure).
- Install carbon monoxide monitor and alarm system for helmet breathing air.
- Calibrate carbon monoxide monitor and alarm system as instructed in owner's manual.
- Wear heavy-duty blast suit; such as, Clemco's leather and cotton suits.
- Wear leather gloves and safety shoes.

BLAST OPERATOR

- Operator must be thoroughly trained and qualified on equipment functions, blasting techniques, abrasives, maintenance requirements, and safety features.
- Operator must be educated to recognize the wide variety of surface contaminants, and to know when to consult with health and safety personnel for advice prior to blasting.
- Operator must attend safety meetings conducted by the employer, union or other professional organizations to ensure the operator's comprehension and compliance to safety rules and regulations.

STAGING

- Stationary staging must be safely constructed and maintained in accordance with manufacturer's instructions and job site requirements.
- Tubular scaffolding must be equipped with appropriate guard rails and work platforms.
- Blast operators and assistants must wear safety harnesses on elevated jobs.
- Blast operators and assistants must be properly trained on use of mechanical personnel lifts.
- Staging surface must be level, smooth and free of obstructions.
- Do not move mechanical lifts when operator platform is extended.

CONTAINMENT ENCLOSURES

- Containment enclosure must meet construction criteria (type) specified for each job.
- Properly-engineered ventilation equipment must be provided for field containment enclosures.
- Ventilation must be sufficient to reduce hazardous dust concentrations to permissible exposure limit or below.
- Extracted hazardous dust must be collected and stored in sealed containers to prevent contamination to surrounding environment.
- Employ the services of containment experts.

WETBLAST EQUIPMENT

- Whenever possible, use wetblast injection equipment to reduce airborne dust on the job site.
- Always wear NIOSH-approved, properly-rated respirators with wet blast equipment to eliminate the possibility of inhalation of wet dust.
- When using rust inhibitors with wet blasting, check to see if the inhibitor contains any chemicals which may be harmful to the blasters.
- Use rubberized tarps or similar membrane materials to capture water and abrasive so that the ground is not contaminated.

CLOSED CIRCUIT BLAST EQUIPMENT

- The advantages of containing abrasive and dust within a blast and vacuuming head should be explored to eliminate loose abrasive and dust in the job environment.
- Operator must wear NIOSH-approved, properly-rated respirator to prevent physical injury from accidental escape of abrasive, and respiratory injury from accidental escape of dust.
- Operator must be trained to seal the blast/vacuum head during movement across the surface.
- Do not strap down or, in any manner, circumvent the free movement of the remote control lever.
- Do not install a nozzle with an orifice larger than the manufacturer's recommended size. Larger nozzles will produce too much air volume for the vacuum to handle, and will permit abrasive and dust to escape from the blast/vacuum head.
- Entire system must be air-tight to work efficiently and prevent escape of dust. Check all seals, hoses and blast head brush before each use.
- Wear a NIOSH-approved, properly rated respirator when handling abrasive, especially when disposing of spent abrasive and dust.

RADIO COMMUNICATION EQUIPMENT

- When blasting inside tanks, ship hulls or other enclosed areas where blast operators are isolated from

other workers, communication equipment is highly recommended. Clemco's WiComm Communication System provides the blast operator with a head set, worn inside the Apollo helmet, and arm-actuated push-to-talk switch to activate the radio. Outside personnel are equipped with radios allowing them to stay in constant contact with blast operators inside confined spaces.

Important Note
Always provide observational personnel to watch over workers blasting in confined areas, even those using communication devices.

- Communication equipment is recommended where blast operators work in elevated places and supervisors are at ground level as instructions or problems can easily be communicated between parties with out work interruptions.
- Radio systems provide immediate contact between job site personnel, by allowing instant reporting and resolution of unexpected problems.

INTERNAL PIPE CLEANING TOOLS

- Pipe cleaning tools require special training to avoid injury from mishandling.
- High-velocity abrasive sprays out of these tools in a 360-degree blast pattern. Safe blasting zones must be established to keep other workers away.
- Abrasive exit end of pipe or tubing should be inserted into collection hoppers to capture abrasive, dust and contaminants. Hoppers should be furnished with dust collectors to prevent environmental contamination. Dust collectors pull air through pipe, controlling the escape of dust on the open pipe ends.
- Pipe cleaning tool parts wear out quickly due to their in-line exposure to high-velocity abrasive; consequently, frequent inspection and replacement is necessary. Failure to perform proper maintenance as described in owner's manuals may cause rapid damage to these tools, and endanger tool operators. Always follow manual instructions.
- Operators and all personnel in the pipe blasting vicinity must wear NIOSH-approved, properly-rated respirators.

EDUCT-O-MATIC TOOL

- Do not use sand or other rapid breakdown abrasives in this tool because of its abrasive recycling feature. For best and safest performance, use a steel grit abrasive.
- Rubber boot must be held firmly against surface at all times to prevent escape of abrasive and dust.
- Operators must wear, at least, full face shields, and NIOSH-approved, properly-rated nose-and-mouth respirators. Shields protect against possible facial injury, and respirators prevent harmful dust inhalation, both of which may occur from accidental separation of the rubber boot from the surface.
- Wear hearing protection if noise levels exceed 80 dBA.
- Replace worn dust bag to avoid escape of dust.
- To prevent leakage of high speed abrasive particles, replace worn or damaged rubber boots and/or its attachments.

VACUUM RECOVERY SYSTEMS

- Clemco offers vacuum recovery systems, which generate tremendous suction power. Special precautions must be taken to keep personnel and their clothing away from the inlet of suction tools. Severe injury can occur if hands, feet, or any body parts are caught in the operating suction tool.
- Vacuum system seals and filters must be maintained in perfect condition to contain dust and contaminants. Follow owner's manual instructions exactly.

LIGHTING

- Lighting fixtures and connections setup in abrasive blasting applications should be dust-tight, and may need to be explosion-proof.
- Fixture lens should be shatter-proof.

STATIONARY FIELD ENCLOSURES

- Stationary field enclosures must have properly-sized dust collection units.
- Air inlets must be designed to prevent escape of abrasive and dust, and supply sufficient volume of free air for required ventilation flow.

- Dust collectors must provide ventilation rates conforming to OSHA regulations for internal air flow (ref: OSHA 29 CFR 1910.94).
- Doors, ceiling and wall joints must be sealed to avoid abrasive and dust leakage.
- Blast operators and others working in the enclosure must wear NIOSH-approved, properly-rated, supplied-air respirators (air-fed helmets).

SECTION FOUR

SAFETY INFORMATION SOURCES

OSHA REGULATIONS

For the most part, regulations on the operation of abrasive blast equipment in the United States are governed by the Occupational Safety and Health Administration (OSHA). Clemco equipment is designed, fabricated, assembled and tested in compliance with OSHA and other applicable regulations. The following list contains current OSHA regulations on abrasive blasting equipment. These regulations must be known and implemented by employers, and practiced by blast operators and other personnel working in the vicinity of blasting operations. Other regulations may apply; such as those of the Environmental Protection Agency (EPA), relating to all job operations other than the ones listed in this section. Many states and some communities may have their own regulations. Employers have the responsibility to learn and implement all safety rules and regulations pertaining to abrasive blasting applications.

CODES OF FEDERAL REGULATIONS (OHSA)

GENERAL INDUSTRY

Reference	Title
29 CFR 1910.6	Incorporation by Reference
29 CFR 1910.94 (A)	Ventilation—Abrasive Blasting
29 CFR 1910.95	Occupational Noise Exposure
29 CFR 1910 Subpart I	Personal Protection Equipment (PPE)
29 CFR 1910.132	PPE—General Requirements
29 CFR 1910.133	PPE—Eye and Face Protection
29 CFR 1910.134	PPE—Respiratory Protection
29 CFR 1910.135	PPE—Head Protection
29 CFR 1910.136	PPE—Occupational Foot Protection
29 CFR 1910.138	PPE—Hand Protection
29 CFR Subpart M	Compressed Gas and Compressed Air Equipment
29 CFR 1910.169	Air Receivers
29 CFR 1910.307	Hazardous (Classified) Locations
29 CFR 1910 Subpart Z	Toxic and Hazardous Substances
29 CFR 1910.1024	Beryllium
29 CFR 1910.1025	Lead
29 CFR 1910.1026	Hexavalent Chromium
29 CFR 1910.1053	Crystalline Silica
29 CFR 1910.1200	Hazard Communication

CODES OF FEDERAL REGULATIONS (OHSA)

MARITIME

Reference	Title
29 CFR 1915.5	Incorporation by Reference
29 CFR 1915 Subpart C	Surface Preparation and Preservation
29 CFR 1915.34	Mechanical Paint Removers
29 CFR Subpart I	Personal Protection Equipment (PPE)
29 CFR 1915.152	PPE—General Requirements
29 CFR 1915.153	PPE—Eye and Face Protection
29 CFR 1915.154	PPE—Respiratory Protection
29 CFR 1915.155	PPE—Head Protection
29 CFR 1915.157	PPE—Hand and Body Protection
29 CFR 1915 Subpart K	Portable, Unfired Pressure Vessels, Drums and Containters, Other than Ship's Equipment
29 CFR 1915.172	Portable Air Receivers and Other Unfired Pressure Vessels
29 CFR 1915 Subpart Z	Toxic and Hazardous Substances
29 CFR 1915.1024	Beryllium
29 CFR 1915.1025	Lead
29 CFR 1915.1026	Hexavalent Chromium
29 CFR 1915.1053	Crystalline Silica
29 CFR 1915.1200	Hazard Communication

CODES OF FEDERAL REGULATIONS (OHSA)

CONSTRUCTION

Reference	Title
29 CFR 1926.28	Personal Protection Equipment (PPE)
29 CFR 1926.52	Occupational Noise Exposure
29 CFR 1926.57(F)	Ventilation—Abrasive Blasting
29 CFR 1926.59	Hazard Communication
29 CFR 1926 Subpart E	Criteria for Personal Protective Equipment
29 CFR 1926.96	PPE—Occupational Foot Protection
29 CFR 1926.100	PPE—Head Protection
29 CFR 1926.101	PPE—Hearing Protection
29 CFR 1926.102	PPE—Eye and Face Protection
29 CFR 1926.103	PPE—Respiratory Protection
29 CFR 1926.306	Air Receivers
29 CFR 1926 Subpart Z	Toxic and Hazardous Substances
29 CFR 1926.1124	Beryllium
29 CFR 1926.62	Lead
29 CFR 1926.1126	Crystalline Silica
29 CFR 1926.1153	Hazard Communication

FEDERAL AGENCIES

- **OSHA**
  US Department of Labor
  200 Constitution Avenue NW, Room N3647
  Washington, DC 20210
  Phone (800) 321 OSHA (6742)
  website:www.osha.gov

- **NIOSH**
  National Personal Protective Technology Laboratory
  1600 Clifton Road
  Atlanta, GA 30329
  Phone: (800) 232-4636
  Website: www.cdc.gov/niosh

PROFESSIONAL ASSOCIATIONS

Membership in professional organizations and trade associations is definitely necessary in today's world to keep up with continual product innovations, application techniques, and the latest regulations affecting our industry. Some of the most prominent associations, who are especially active in abrasive blasting industry specifications, standards, safety, and other technical information are listed on the following pages.

- **National Safety Council**
  1121 Spring Lake Drive
  Itasca, IL 60143
  Phone: (630) 285-1121
  email: customerservice@nsc.org
  www.nsc.org
  — Reference material and publications, and counseling on safety issues.

- **The Society For Protective Coatings (SSPC)**
  800 Trumbull Drive
  Pittsburgh, PA 15205
  Phone: (877) 281-7772
  Fax: (412) 281-9992
  email: info@sspc.org
  Website: www.sspc.org
  — Research and testing committees, conducts seminars and establishes industry standards on surface preparation methods, abrasive and coatings.

- **National Association of Corrosion Engineers (NACE)**
  15835 Park Ten Place
  Houston, TX 77084-4906
  Phone: (281) 228-6200
  email: firstservice@nace.org
  Website: www.nace.org
  — Through committee work, develops test methods and recommended practices on surface preparation techniques and coatings.

- **Painting & Decorating Contractors of America (PDCA)**
  2316 Millpark Drive
  Maryland Heights, MO 63043
  Phone: (800) 332-PDCA (7322)
  Website: www.pdca.org
  — Publishes current technical and regulatory information on surface preparation, painting and wallcovering.

- **American National Standards Institute (ANSI)**
  25 West 43rd street
  New York, NY 10036
  Phone: (212) 642-4900
  Fax: (212) 398-0023
  Website: www.ansi.org
  — Develops and recommends safety standards for all industries.

- **American Society for Testing and Materials (ASTM)**
  100 Barr Harbor Drive
  West Conshohocken, PA 19428
  Phone: (610) 832-9500
  FAX: (610) 832-9555
  Toll-Free (877) 909-2786
  email: service@astm.org
  Website: www.astm.org
  — Development and delivery of international voluntary consensus standards

- **American Society of Safety Engineers (ASSE)**
  520 N. Northwest Hwy
  Park Ridge, IL 60068
  Phone: (847) 699-2929
  Email:customerservice@asse.org
  Website: www.asse.org
  — Professional safety organization provides current safety regulations and standards to its membership.

- **Compressed Gas Association**
  14501 George Carter Way
  Suite 103
  Chantilly, VA 20151-1788
  Phone: (703) 788-2700
  Fax: (703) 961-1831
  email: cga@cganet.com
  www.cganet.com
  — Develops specifications on breathing air and other gases used in all industries.

Compressed-Air and Abrasive Consumption

Nozzle Orifice	PRESSURE AT THE NOZZLE (PSI)			
	50	60	70	80
No. 2 (1/8")	11	13	15	17
	.67	.77	.88	1.01
	67	77	88	101
	2.5	3	3.5	4
No. 3 (3/16")	26	30	33	38
	1.50	1.71	1.96	2.16
	150	171	196	216
	6	7	8	9
No. 4 (1/4")	47	54	61	68
	2.68	3.12	3.54	4.08
	268	312	354	408
	11	12	14	16
No. 5 (5/16")	77	89	101	113
	4.68	5.34	6.04	6.72
	468	534	604	672
	18	20	23	26
No. 6 (3/8")	108	126	143	161
	6.68	7.64	8.64	9.60
	668	764	864	960
	24	28	32	36
No. 7 (7/16")	147	170	194	217
	8.96	10.32	11.76	13.12
	896	1032	1176	1312
	33	38	44	49
No. 8 (1/2")	195	224	252	280
	11.60	13.36	15.12	16.80
	1160	1336	1512	1680
	44	50	56	63

Metric Compressed-Air & Abrasive Consumption

Nozzle Orifice	PRESSURE AT THE NOZZLE (bar & kPa)			
	3.5 350	4.2 420	4.9 490	5.6 560
5mm (3/16")	0.73	0.84	0.92	1.06
	68	78	89	98
	4.5	5.3	5.6	6.4
6.5mm (1/4")	1.31	1.51	1.71	1.90
	122	142	161	185
	7.9	9.0	10.1	11.6
8mm (5/16")	2.16	2.50	2.83	3.16
	212	242	274	305
	13.1	15.0	19.1	20.2
9.5mm (5/16")	3.02	3.53	4.00	4.50
	303	347	392	435
	18.0	21.0	24.0	27.0
11mm (7/16")	4.12	4.76	5.44	6.09
	406	468	533	595
	24.8	28.5	32.6	36.4
12.5mm (1/2")	5.46	6.28	7.06	7.85
	526	606	686	762
	32.6	37.5	42.0	46.9

PRESSURE AT THE NOZZLE (PSI)				Air (cfm) Abrasive Use Compressor HP
90	100	125	140	
18.5	20	25	28	Air (cfm)
1.12	1.23	1.52	1.70	Abrasive (cuft/hr.)
112	123	152	170	Abrasive (lbs./hr.)
4.5	5	5.5	6.2	Compressor hp
41	45	55	62	Air (cfm)
2.38	2.64	3.19	3.57	Abrasive (cuft/hr.)
238	264	319	357	Abrasive (lbs./hr.)
10	10	12	13	Compressor hp
74	81	98	110	Air (cfm)
4.48	4.94	6.08	6.81	Abrasive (cuft/hr.)
448	494	608	681	Abrasive (lbs./hr.)
17	18	22	25	Compressor hp
126	137	168	188	Air (cfm)
7.40	8.12	9.82	11.0	Abrasive (cuft/hr.)
740	812	982	1100	Abrasive (lbs./hr.)
28	31	37	41	Compressor hp
173	196	237	265	Air (cfm)
10.52	11.52	13.93	15.60	Abrasive (cuft/hr.)
1052	1152	1393	1560	Abrasive (lbs./hr.)
39	44	52	58	Compressor hp
240	254	314	352	Air (cfm)
14.48	15.84	19.31	21.63	Abrasive (cuft/hr.)
1448	1584	1931	2163	Abrasive (lbs./hr.)
54	57	69	77	Compressor hp
309	338	409	458	Air (cfm)
18.56	20.24	24.59	27.54	Abrasive (cuft/hr.)
1856	2024	2459	2754	Abrasive (lbs./hr.)
69	75	90	101	Compressor hp

The above chart provides calculated consumption rates of air and abrasive for new nozzles. When selecting a compressor add 50% to above figures to allow for normal nozzle wear and friction loss.

PRESSURE AT THE NOZZLE (bar & kPa)				Requirements: Air (m^3/min) Abrasive (kg/h)* & kW
6.3 630	7.0 700	8.6 860	10.3 1035	
1.15	1.26	1.54	1.82	Air (m^3/min)
108	120	145	174	Abrasive (kg/h)
7.1	7.5	9.0	10.8	kW
2.08	2.27	2.75	3.22	Air (m^3/min)
203	224	276	325	Abrasive (kg/h)
12.4	13.5	16.2	19.4	kW
3.53	3.84	4.71	5.57	Air (m^3/min)
336	368	445	534	Abrasive (kg/h)
21.0	22.9	27.5	33.0	kW
4.85	5.50	6.64	7.79	Air (m^3/min)
477	573	632	758	Abrasive (kg/h)
28.9	33.0	39.6	47.5	kW
6.73	7.11	8.80	10.48	Air (m^3/min)
657	719	876	1040	Abrasive (kg/h)
40.1	42.4	50.9	61.1	kW
8.65	9.46	11.46	13.45	Air (m^3/min)
842	918	1115	1333	Abrasive (kg/h)
51.8	56.3	67.6	81.1	kW

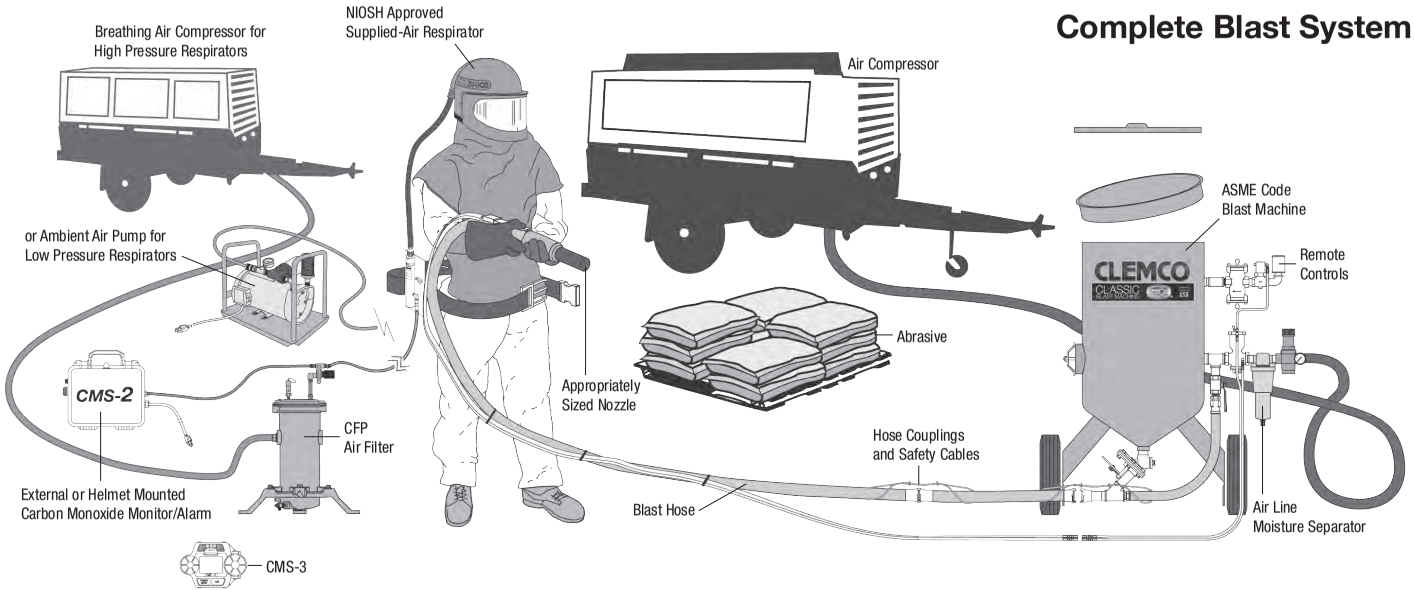
The above chart provides calculated consumption rates of air and abrasive for new nozzles. When selecting a compressor add 50% to above figures to allow for normal nozzle wear and friction loss.

Blast Hose Rating

Types of Blast Hose	Construction	Working Pressure Rating	Features & Applications
Two-Braid	Two layers of cross-woven fabric	175 psi (12 bar, 1206 kPa)	Moderate flex with enough outer support to keep hose round. Common among contractors and at fixed sites and blast room.
Two-Ply	Two layers of semi cross-woven fabric	175 psi (12 bar, 1206 kPa)	Smaller overall wall dimension for optimum flexibility with maximum internal diameter. Sometimes used as whip hose.
Four-Ply	Four layers of straight-woven fabric	175 psi (12 bar, 1206 kPa)	Stiff, with greater exterior endurance, rebounds to a fully round shape. Used in shipyards, high traffic areas to withstand weight of motor vehicles.

System-Air Volume Requirements at 100 psi for a Complete Blast System

Nozzle	Size of Orifice	Volume of Air	Plus HP Helmet	Plus 50% (reserve)	Min. Air Required
No. 4	1/4” 6.5mm	81 2.3	20 0.5	50 1.4	151 cfm 4.2 m^3/min
No. 5	5/16” 8.0mm	137 3.9	20 0.5	79 2.2	236 cfm 6.6 m^3/min
No. 6	3/8” 9.5mm	196 5.5	20 0.5	108 3.0	324 cfm 9.0 m^3/min
No. 7	7/16” 11.0mm	254 7.2	20 0.5	137 3.9	411 cfm 11.6 m^3/min
No. 8	1/2” 12.5mm	338 9.6	20 0.5	179 5.0	537 cfm 16.1 m^3/min


Complete Blast System
Breathing Air Compressor for High Pressure Respirators
NIOSH Approved Supplied-Air Respirator
Air Compressor
ASME Code Blast Machine
or Ambient Air Pump for Low Pressure Respirators
Remote Controls
CLEMCO
CMS-2
Abrasive
Appropriately Sized Nozzle
CFP Air Filter
Hose Couplings and Safety Cables
External or Helmet Mounted Carbon Monoxide Monitor/Alarm
Blast Hose
Air Line Moisture Separator
CMS-3

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