CLEMCO®

BLAST OFF 2

YOUR GUIDE TO SAFE AND EFFICIENT ABRASIVE BLASTING

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BLAST OFF

Second Edition

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FOREWORD

In 1963 Clemco first published a guide to efficient abrasive blasting titled *"Blast Off"*. This publication was part of Clemco's ongoing commitment to training, initiated in the mid 1950s. In the intervening years, thousands of seminars, training courses, articles, papers, and loans of films or videos, have been provided by Clemco throughout the world for the purpose of expanding the knowledge of safe, productive abrasive blast cleaning. To date, more than one million copies of the *"Blast Off"* booklet have been circulated, in several languages and in many countries.

The original *"Blast Off"* was produced following a series of tests that established the importance, to productivity, of some of the variables utilized in abrasive blast cleaning. This booklet was intended as an introduction to high production blasting and as a "readable" summary of the important elements of abrasive blasting.

This revised edition expands on the discussion of the elements of abrasive blasting that appeared in the original booklet and includes a number of new features. While more extensive than the original, it is still intensely practical and serves several purposes.

The updated description of efficient abrasive blasting provides an excellent introduction for the novice as well as a presentation of current practices for the more experienced user. The booklet provides pointers for obtaining optimum

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production rates in a number of applications. Also included are aids that may be used in making a selection of specific variables suitable for particular applications. This edition also provides reminders for safe practices and a large amount of reference information for blast equipment operators and supervisors. Numerous additional sources that should be contacted for further information on abrasive blasting have also been included.

There are a number of things that this booklet is not intended to accomplish.

This publication is not intended to provide a definitive education in abrasive blasting. This process has far too many possible combinations of applications, and variable elements, to be covered in a pocket-sized booklet. It is ultimately the user, usually through trial and testing, who must make the final decision on the combination of elements that is best suited for a particular application. The user must undergo appropriate training, access all available industry information, and gain firsthand experience with the process, before making operational decisions on a particular project.

This publication does not present all of the safe practice information necessary to engage in abrasive blasting. Safe practices must develop through a thorough study of all materials that relate to a particular blasting situation including, job specifications, local and national regulations, jobsite conditions, and especially the owners manuals for all of the equipment to be used on that particular job. Each manufacturer provides different features in their design. The particular manual for the equipment used,

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whether abrasive blast equipment, or related products such as a compressor or staging, must be studied and understood prior to use. The user should utilize all available training courses, videos, and materials that will help in the development of safe practices for abrasive blasting.

This booklet does not attempt to address the extensive body of regulations that exist at the federal, state, and local level that pertain to abrasive blasting. There are regulations with reference to air, water and ground pollution, operator safety, bystander safety, equipment design limitations, toxins, employee notification, and a number of other topics that may be important in a particular situation. These codes vary by region. Users must familiarize themselves with all appropriate regulations.

While safe practice information is provided throughout the booklet, the fourth section details the operator and employer educational responsibility for a safe, productive blasting system. The Appendix includes a reference section with additional data and resources.

The material in this booklet draws on the experience of Clemco's worldwide organization. We would like to express our thanks for the many suggestions and corrections provided by all those who contributed to this booklet.

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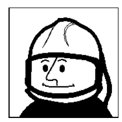
THE PROCESS AND APPLICATIONS

The Process

Abrasive blasting is the process of propelling abrasive particles from a blast machine, using the power of compressed air. Converting abrasive particles and compressed air into an effective cleaning treatment takes skill, properly engineered equipment, and good judgment. Each component contributes to the overall performance of the system.

Just one faulty element limits the performance of the entire system.



This booklet will emphasize the need to maintain correct pressure and volume through the entire setup.

Three fundamental components constitute a blasting setup: air compressor, blast machine system, and abrasive.

The compressor must produce sufficient air pressure and volume to convey abrasive from the blast machine to the surface. The blast machine must contain the abrasive and meter it into the air stream with as little restriction as possible. The abrasive utilizes the force of the compressed air to achieve the desired effect on the surface. Cleaning takes place as a direct result of how efficiently air moves from the compressor to the surface being blasted. A restriction in just one part reduces the entire system's production rate.

Contractors frequently overlook the blast machine system as a possible source of restrictions in air and abrasive flow. High-pressure air cannot flow through small fittings at the same volume as through large fittings.

A blast machine's role is to smoothly meter abrasive into the passing air stream. Sometimes, contractors install restrictive air fittings or metering valves that actually cut the air flow in half, then do not understand why their production rate is so slow. Avoid these self-imposed problems by selecting a blast machine system with large-diameter pipes, fittings, and valves, and by connecting it to large-diameter air and blast hoses.

The third major component in the blasting System is the abrasive. Ultimately, the abrasive produces the finish on the surface. Select an abrasive with the appropriate shape, size, hardness, density, and composition for the job. Contractors who choose the wrong abrasive risk cost overruns, paint failure, and expensive rework.

Match the abrasive material and size to the surface to be treated, to ensure the best possible finish, cleaning speed, and cost efficiency.

The finest air compressor and blast machine cannot compensate for an erroneous choice of abrasive. *See the Abrasive Section for selection guidelines.*

The expression "No chain is stronger than its weakest link" applies to abrasive blast equipment. Within each of the three major components of a blast system, the quality and performance of key elements affect that component's effectiveness and the effectiveness of the entire system.

Most blast system components are cylindrical. Even slight reductions in the diameters of those cylinders produce geometric reductions in the volume of air that can flow through them.

Even with a correctly sized compressor and blast machine and the right abrasive, it takes a trained and skillful operator behind the nozzle to make the system perform to its potential.

Applications

Abrasive blasting applications fall into three broad categories: surface preparation, surface cleaning and finishing, and shot peening.

Surface Preparation

Blasting for surface preparation removes unwanted material and leaves a surface ready for coating or bonding.

Blast cleaning existing steel structures removes old paint, rust, and other contaminants. Blasting removes the mill scale that forms on new steel.

The impact of angular abrasive roughens a surface to produce a profile or etch. Most paint manufacturers specify surface profiles that will ensure their products perform as intended. Profile is discussed in detail later.

Contractors blast masonry to accept sealers or paints. Blast cleaning stucco and brick removes loose paint, mildew, soot, stains, and even graffiti, and leaves an ideal surface for coating.

Contractors blast pre-stressed concrete panels, poured-in-place concrete walls and columns, and other concrete structures to remove latent cement, form marks, and discoloration; and to expose colored aggregate.

Beyond steel and masonry, blast cleaning under controlled circumstances can strip layers of paint from wooden houses and boats. On fiberglass, blasting removes the top layer of gelcoat to expose air bubbles. Blasting aluminum, titanium, magnesium and other sophisticated metals removes corrosion and, depending on the abrasive and pressure used, leaves a surface profile.

New, non-aggressive media (including plastic and wheat starch) and specialized low-pressure blast equipment have been developed to dry strip coatings from advanced composite materials. This allows companies to strip airplanes, helicopters, cars, trucks, and boats without using rotary sanding tools that might damage the surface. Also, switching to dry stripping eliminates worker exposure to toxic chemical strippers and the expense of properly disposing of this hazardous waste.

The list of blast cleaning possibilities seems endless. Every day, companies turn to abrasive blasting to solve longstanding cleaning and surface preparation problems. As industries create new materials and new surface preparation problems, manufacturers of blast equipment and media race to develop the technology and tools to meet these challenges.

Surface Cleaning and Finishing

Surface cleaning and finishing differ from surface preparation in that the desired result is to improve a product's appearance and usefulness, rather than condition it for coating or bonding. Surface cleaning includes removing production contaminants, heat scale, deflashing and deburring molded parts, and enhancing visual features.

Low-pressure blasting with glass or ceramic beads produces a blended matte appearance and a precise roughness average (Ra) finish on soft metals.

Most metal foundries blast cast parts to remove small burrs, for functional and aesthetic purposes.

In most cases, blasting exposes minute cracks and defects in metals. This is especially important to facilities that repair and recondition aircraft wheels.

Soft materials, such as rubber and plastic, usually emerge from molds with flashing left by tooling separation. Abrasive blasting quickly trims such flashing, leaving a smooth, uniform finish.

There is an enormous market for abrasive blasting in industries that use heat to harden metals. High temperatures can discolor parts. Blast finishing heat-treated parts removes the discoloration and the scale that sometimes forms.

Abrasive blasting can improve a product's appearance by removing stains, manufacturing compound residue, corrosion, and tool marks. Some blast media can blend surface variations, such as scratches and tooling marks, into an overall uniform appearance.

High operating temperatures build up carbon and burnt oil on many automotive parts. Electric motors become clogged with overheated insulation and melted stator lamination. In most cases, retaining original dimensions of these parts is critical. Blasting with plastic media, glass bead, or agricultural abrasive removes contaminants and provides an acceptable finish, without affecting tolerances.

Shot Peening

To make a metal product or component, manufacturers must cast, cut, bend, stamp, roll, or weld metal stock to produce the desired shape. Sometimes these processes leave residual stresses in the metal that, if not removed, can cause parts to fail when stressed.

Shot peening increases the strength and durability of high-stress components by bombarding the surface with high-velocity, spherical media — including steel shot, ceramic shot, glass beads, and other spherical media.

Shot peening produces an effect similar to that left by pounding a surface with a ball peen hammer, except that the dimples left by shot peening are much smaller and the impacts more consistent in intensity. This bombardment creates a uniformly compressed surface, diffusing the stress forces over a larger area and leaving the surface less likely to crack.

Shot peening is a precise science, requiring adherence to exacting specifications for media hardness, blast duration, nozzle angle, and pressure. Under- or over-peening a part may cause premature failure.

The automotive and aircraft industries use peening extensively. Gear manufacturers peen to eliminate burrs and sharp edges, and to strengthen gear teeth. Spring manufacturers peen their products to combat stress.

Shot peening metal castings and forgings cleans the surface, exposes defects, and improves appearances. Peening threaded parts removes sharp edges while increasing thread holding power. It is often used with airless machines to remove mill scale from new steel.

Surface Preparation Specifications

Paint manufacturers have long recognized the importance of surface preparation to the success of their coatings. Improperly cleaning a steel surface will cause premature coating failure; consequently, coating manufacturers specify surface preparation standards for their products. Failure to follow specifications may void a coating's guarantee.

Steel surface preparation standards measure two critical specifications — surface profile and degree of cleanliness.

Surface Profile

Coating manufacturers and professional organizations test paint systems by applying them over various surface profiles and subjecting them to a wide range of environmental conditions. They have found that coatings require specific profiles to ensure adhesion to and complete protection of the substrate. The profile provides a mechanical method of positive, uniform bonding between the coating and the surface.

Abrasive particles cut into the steel to form tiny peaks and valleys. The depth of this profile is controlled by the size, type, and hardness of the abrasive, by the air pressure, and by the distance and angle of the nozzle to the surface.

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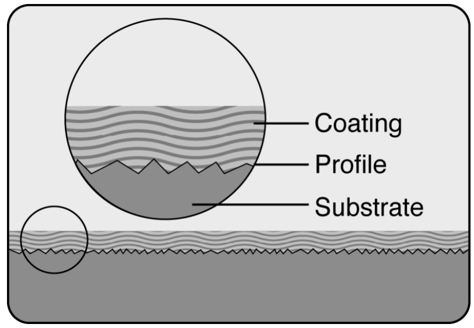
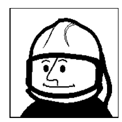


Surface Profile



When profiles exceed the maximum specifications, the peaks may protrude through the coating system, causing it to fail.

Applying heavier layers of paint to compensate for deep profiles adds substantially to the cost of the job. *See the Abrasive Section for details of the profiles created by different abrasives.*

Profiles are expressed in mils, microns or millimeters.

1 mil = 1/1000 inch
25 microns = 1 mil
25.4 millimeters = 1 inch
39 mils = millimeter

In the United States, a mil is used as a unit of measurement of paint thickness, as well as surface profile. Typically, specifications state a profile height average. For example, an average profile of 2 mils (50 microns) may include profiles as small as 1 mil (25 microns) and as large as 3 mils (75 microns). This range is acceptable, because there is no practical method to produce identical abrasive particle sizes.

Deviations in air pressure, or in the distance or angle of the nozzle to the surface also affect profile. Reduced air pressure or increased nozzle distance causes smaller profiles. Severe nozzle angles produce a skimmed blast pattern rather than definite peaks and valleys. For blasting structural steel, nozzles should be held at 80 to 90 degrees to the surface.

Use a profile measuring device to document profile conformance. Careful monitoring of the profiles can prevent expensive rework.

Degrees of Cleanliness

The Society for Protective Coatings (SSPC) has established five degrees of cleanliness for blasting, ranging from removal of all contaminants to removal of loose materials only. The five degrees are White Metal Blast, Near White Metal Blast, Commercial Blast, Industrial Blast, and Brush-Off Blast. These standards are subject to review and revision. The descriptions below are provided as a general guideline. For detailed descriptions of each, refer to the SSPC's Visual Standards for Abrasive Blast Cleaned Steel.

White Metal Blast — Viewed without magnification, a White Metal Blast cleaned surface is free of all visible rust, mill scale, paint, and foreign matter. This degree of cleanliness is usually required where sophisticated paints; such as, zinc-rich coatings, will be applied to surfaces exposed to highly corrosive environments. Chemical plants, offshore drilling rigs, and bridges over salt water are typical applications.

Near White Metal Blast — Viewed without magnification, a Near White Metal surface is free of all visible rust, mill scale, paint, and foreign matter. This is similar to White Metal but with some slight staining remaining on no more than 5 percent of the metal surface is allowed. This degree of cleaning is required where high-performance coatings will be applied to steel exposed to harsh elements and heavy usage.

Commercial Blast — Viewed without magnification, the surface is free of visible oil, grease, dust, dirt, mill scale, rust coating, oxides, corrosion products, and foreign matter. No more than 33 percent shadows, streaks, and discoloration from stains of rust, mill scale and old coatings may remain. For most applications applying standard coatings.

Industrial Blast — Viewed without magnification, the surface is free of all visible oil, grease, dust, and dirt. Traces of tightly adherent mill scale, rust, and coating residue may remain on up to 10 percent of the surface if they are evenly distributed. The remainder of the surface may contain shadows, streaks, and discoloration caused by stains of rust, mill scale and old coatings.

Brush-Off Blast — Viewed without magnification, a Brush-Off Blast cleaned surface may have only tightly adhering residues of mill scale, rust, or coating. Flecks of underlying metal need not be exposed whenever the original substrate consists of intact coating. This method is acceptable for surfaces not subject to severe environments or where long coating life is not expected.

Where commercial, Industrial or Brush-Off Blast is specified, make sure the new coating is compatible with the old. Incompatible coatings may blister and peel.

The SSPC offers sets of photographs that show four existing steel surface conditions and the degrees of cleanliness for each. The existing conditions include mill scale, mill scale and rust, total rusting, and rust with pitting.

The National Association of Corrosion Engineers (NACE) offers a set of encapsulated steel coupons that simulate the degrees of cleanliness.

The Swedish Standards Institute's (SIS) book of pictorial comparators is widely used in Europe. For reference, the degrees of cleanliness and the professional organization standards are shown in the following chart:

Degree of Cleanliness	SSPC Std.	NACE Std.	SIS Std.
White Metal Blast	SSPC-SP 5	NACE No. 1	SA-3
Near White Metal Blast	SSPC-SP 10	NACE No. 2	SA-2 1/2
Commercial Blast	SSPC-SP 6	NACE No. 3	SA-2
Industrial Blast	SSPC-SP 14	NACE No. 8	SA-1-1/2
Brush-off Blast	SSPC-SP 7	NACE No. 4	SA-1

The terms 'White Metal" and "Near White Metal" sometimes cause confusion between contractors and inspectors. A clean steel surface is gray, not white. When blasted with a light colored abrasive, a steel surface may appear to have a white tint. Black abrasives may leave a dark tint.

An inexperienced inspector may incorrectly fail a job because the surface is not "white." Before blasting, tell the inspector which abrasive you plan to use, and ask if this will affect his or her ability to judge the degree of cleanliness.

In addition to their safety training, blast operators must be schooled and experienced in surface preparation standards — not just to pass inspections, but to ensure that today's advanced coatings are applied over properly prepared surfaces. Use the information provided by the organizations listed in the Reference Section at the end of this booklet.

Abrasives

Abrasive — the air compressor powers it, the blast machine stores and meters it, the blast hose transports it, and the blast nozzle accelerates it. All are important, but the abrasive does the work.

Selecting the right abrasive is crucial to producing the desired finish, on time, and within budget. Selecting the wrong abrasive may produce a poor finish, impede production, require expensive rework, or cause all three.

Many coating failures can be traced to the use of the wrong abrasive. The best possible equipment cannot compensate for an abrasive that is not designed for the work.

Use high-quality abrasives intended for blasting. Material shoveled from river banks or rock quarries (unless it has been washed, screened, and properly graded) will produce unacceptable results. *See Appendix for Abrasive Comparison Chart.*

Properties

There are three sources for abrasives — natural, manufactured, and byproducts.

Natural abrasives are minerals, such as sand, flint, garnet, zirconium and other minerals found in deposits.

Manufactured abrasives are produced specifically for blasting. They include steel grit and shot, plastic, wheat starch, glass bead, aluminum oxide, silicon carbide, and others.

Byproduct blast media result from other manufacturing processes. These include the slag leftover from smelting or power generating stations and agricultural media from food sources.

Historically, open blasting called for cheap expendable abrasives, such as sand. Do not use any abrasive that contains more than 1 percent free silica. Silica dust can cause severe respiratory disease and death. Whenever recyclable abrasive can be used, do so. Recycleable abrasives tend to be lower in free silica, and produce less dust overall.

Choose a durable, recyclable material to reduce overall abrasive cost. Today's closed circuit blasters, vacuum recovery equipment, and portable containment, allow efficient recycling.

Size

The size of the particles of blast media is tremendously important for consistent blast pattern with the desired surface texture. Abrasive manufacturers use several distinctly different systems to express the sizes of their products.

Shot and some other spherical media are measured in thousandths of an inch, with their sizes expressed in whole numbers. Some media manufacturers use numbers to describe their products that may or may not refer to mesh size.

Usually, angular abrasives and glass bead are sized according to standard sieve measurements, expressed as either “mesh” or “microns.” Mesh refers to the number of openings per inch in a sieve; microns to the size of the particle sieved. Therefore, the higher the mesh number, the smaller the particle, and the higher the micron number, the larger the particle.

For example, the holes in a 20-mesh sieve allow particles 850 micron and smaller to pass, while a 40-mesh sieve allows 425 micron particles to pass. Therefore, most of the particles in a 20/40 mesh abrasive will measure between 850 and 425 microns, with a trace slightly larger and smaller. No abrasive sizing system is exact, but quality manufacturers furnish 95 percent of the particles within the designated range.

Consistent size becomes paramount when a coating’s manufacturer specifies a precise profile. Oversized particles cut too deep, leaving high peaks to protrude above the coating. This leads to rusting. Compensating for the high peaks, such as by applying thicker coatings, wastes time and money.

Undersized particles and dust reduce productivity and may neither clean the surface adequately nor create sufficient etch.

Choose a mesh size that will produce the finish desired. Large particles remove multiple layers of paint, heavy corrosion, or concrete splatter and leave deep profiles. Medium sized abrasives strip away light rust, loose paint, or thin mill scale. Small particles create shallow profiles and are ideal for blasting light-gauge metals, wood, plastic, and other semi-delicate surfaces.

Large particles do not always clean faster than small ones. While cutting deeper, large-mesh abrasives have fewer particles per square inch striking the surface, consequently, some surface areas will be left untouched. Prior to beginning a job, test blast small patches on the surface with different abrasives in different mesh sizes.

Measure the profiles to determine which complies with the specification.

When using recyclable media, replenish the abrasive regularly to maintain the proper finish and optimum productivity. Fresh abrasive produces a fairly uniform etch, but with each blast-and-recover cycle the particles get smaller and smaller. Left unchecked, this reduction in particle size produces a more shallow profile and may slow the cleaning rate.

To counteract this, the operator must monitor the quality of the surface finish, and periodically add measured amounts of fresh abrasive. The resulting "working mix" or "operating mix" is the average of particle sizes between new abrasive and old. Never try to reuse expendable abrasives. Expendable abrasive breaks down into dust after one pass.

Maintaining an accurate working mix ensures a consistent finish. This is critical in automotive and aircraft shot peening, and in preparing surfaces for sophisticated coatings.

Shape

Different abrasive shapes impart different surface profiles. In angular abrasives, individual particles have irregular shapes, with granular surfaces and sharp edges, to remove coatings and leave sharply defined peaks and valleys. Rounded particles produce dimples. Some rounded abrasives are actually oblong, and produce elongated dimples.

Angular abrasives have a variety of configurations — some being more angular than others. Sand, in particular, is available in round, oblong and various degrees of angularity. Beach and river sand tend to be rounded or oblong due to the erosive effect of water motion. Quarry sand is angular and has greater cutting action.

Angular abrasives work best for heavy layers of paint and corrosion. Rounded media are better at removing mill scale and light contamination. Rounded media are used in shot peening to relieve stress. Peening creates a uniform compressed surface that makes springs and other highly stressed metals less likely to fail.

Density

Density is the weight of abrasive by volume. For example, sand weighs about 100 pounds per cubic foot (1.5 kg/liter). By comparison, steel grit weighs about 250 pounds per cubic foot (3.8 kg/liter); walnut shell, just 44 pounds per cubic foot (0.7 kg/liter).

An abrasive's density is less important than other characteristics, unless the densities are vastly different between two otherwise similar materials. The more dense the material, the more energy each particle delivers to the surface. The difference in density between sand and slag is a negligible 10 pounds per cubic foot (.15 kg/liter), but between slag and steel grit, the difference can be as much as 150 pounds per cubic foot (2.4 kg/liter). All other things being equal, the denser particles will produce a deeper profile, which may not always be desirable. Denser particles are more effective in removing durable or hard coatings.

Hardness

The hardness of the abrasive determines its effect on the surface being blasted. If the abrasive is harder than the substrate, it will leave a surface profile. If it is softer than the surface, but harder than the coating, it will remove the coating. If it is softer than the coating, it will clean dirt from the surface without removing the coating.

Abrasive hardness is measured on the Mohs' Scale (steel abrasive excluded). The Mohs' Scale ranks hardness from 1 to 10, with 1 being as soft as talc and 10 being as hard as diamond. The most common abrasives range in hardness from soft agricultural to super-hard silicon carbide.

Steel grit and shot are measured on the Rockwell "C" scale (designated by "Rc"). Commonly used steel abrasives and shot range from soft Rc 35 to hard Rc 65.

Hard abrasives perform better on difficult jobs, removing rust and mill scale, and soft abrasives are more suited for cleaning or stripping coatings.

Friability

Friability refers to the abrasive's brittleness or its tendency to break into small particles upon impact. The more friable the abrasive, the fewer times it can be reused and the more dust it creates.

Sand is extremely friable, due to its quartz composition, and must never be reused. On the first use more than 70 percent of the sand turns to dust. Sand that contains silica will release hazardous silica particles. People exposed to silica dust may develop a painful, often fatal, disease called silicosis.

Most manufactured and byproduct abrasive can be recycled a limited number of times, as can a few natural abrasives, such as garnet and flint. Copper and nickel slag fracture into reusable smaller particles. Steel grit resists breaking and may be effectively recycled 200 times or more.

Many variables affect reuse factors, including air pressure, surface hardness, and media cleaning equipment efficiency. The friabilities shown on the Abrasive Comparison Chart in the Appendix are for comparison only. Check with the abrasive supplier for more accurate reuse factors.

Common Blasting Abrasives

Sand is widely used because of its availability, cleaning efficiency, and low cost. Sand's main drawback is dust.

After just one cycle, most of the sand turns to dust. Blasting with silica sand will generate fine crystalline silica dust, which remains airborne for long periods of time, and has been proven a serious health hazard if inhaled.

Do not blast with sand or any abrasive that contains more than 1 percent free silica.

The Occupational Safety & Health Administration (OSHA) enforces the federal regulations that limit an employee's exposure to crystalline silica. (Ref: OSHA 2206, General Industry Standards Part 1910, Subpart Z, Paragraph 1910.1000.)

OSHA requires that all blasting operators and other persons in the blasting vicinity wear properly maintained NIOSH approved, supplied-air respirators during blasting and after, until the surrounding atmosphere has been tested and cleared of lingering dust.

Mineral sand (staurolite, olivine, etc.), zircon and similar materials are found in deposits in various parts of the USA. They are usually produced in smaller mesh sizes — 70 to 100. Their high density, about 125 lbs per cubic ft (2 kg/liter), and durability make them ideal for cleaning new and lightly rusted steel. Most mineral sands contain free silica — that is the silica that can be freed from the sand particle during blasting. If free silica exceeds 1 percent, do not use the abrasive for blasting.

Garnet and flint are extremely hard and sharp blast media well suited for removing heavy surface materials and leaving high profiles. Both may be recovered, screened and reused. Garnet contains only a trace of free silica, however, flint is very high in free silica — 90 percent or more, and must never be used for blasting. Garnet has a bulk density of 140 pounds per cubic foot (2.1 kg/liter).

Byproduct abrasives such as slag and some agricultural media are generated from another process, but prove to be highly effective as blast cleaning agents.

Slag is derived from two main sources — metal smelting (copper and nickel) and electric power generating boilers (coal). Slag has come more in demand due to its cleaning ability, availability, low free silica content (less than 1 percent), wide array of mesh sizes, and relatively low cost.

Slag's hard, angular particles enhance speed and cutting ability, making it suitable for a wide spectrum of uses. In some applications, it may even be necessary to reduce nozzle air pressure to avoid embedding slag particles in steel.

The main drawback to using slag include its relatively high friability, which creates dust and limits reuse. Also, slag must be checked for contaminants prior to use.

There are several types of agricultural media. Walnut shell and corncob are among the most popular. Agricultural media are lightweight (40+ pounds per cubic foot [0.6 kg/liter]) and soft (3 on the Mohs' scale). Used with specialized equipment and careful attention to technique, agricultural media can remove paint from wood, plastics, light gauge metal, and other hard surfaces. These media are used to clean electric motors without damaging stator lamination and wire insulation.

The manufactured abrasives include steel grit and shot, aluminum oxide, silicon carbide, plastic, glass bead, and others.

There are three main metal abrasive types -steel, malleable iron, and chilled cast iron. Each comes in shot and grit. Steel is by far the most widely used manufactured abrasive because it can be recycled 200 times and more. Chilled cast iron may be recycled about 50 to 100 times; malleable iron, slightly more.

The hardness of metal abrasive is measured on the Rockwell "C" Scale (Rc), with the higher number being the hardest. Steel ranges from 35 Rc to 65 Rc; malleable iron from 28 Rc to 40 Rc; and chilled iron from 57 Rc to 68 Rc.

Chilled and malleable iron are less expensive than steel, and are used where much of the abrasive is lost in the process of loading and unloading parts. Additionally, iron is more brittle and tends to break down into angular particles making it more aggressive than steel.

Steel particles deform on impact, actually wearing away until eventually the particles become too small to use. New media must be periodically added to maintain a consistent blast pattern.

Metal abrasive sizing is standardized to the Society of Automotive Engineers (SAE) specifications. Grit sizes are designated G-10 (2.0/1.7mm) to G120 (0.125/0.075 mm) with G-10 being the largest. Shot sizes range from S-70 (0.125/0.180 mm) to S-780 (1.7/2.0 mm) with S-780 being the largest size.

Silicon carbide is the hardest, sharpest, most expensive abrasive on the market. It measures 8.5 on the Mohs' Scale, making it suitable where fine but deep cutting is required, as in removing heat-treat residue from hardened parts.

Aluminum oxide (alox) is second only to silicon carbide in sharpness. It is popular for super tough cleaning. Its high cost dictates that it be used in enclosed blasting systems that recycle abrasive. With a density of 120 pounds per cubic foot (1.8 kg/liter) and hardness of 8 on the Mohs' Scale, aluminum oxide is the most aggressive of the widely used abrasives.

Aerospace and aircraft industries use extremely pure grades of aluminum oxide for cleaning and deburring on titanium, magnesium and other sophisticated metals where ferrous contamination must be prevented. Standard grades are used on aluminum, brass, iron and steel castings to quickly remove flashing while cleaning the surface. Often, companies mix other abrasives with aluminum oxide to obtain deep cleaning while leaving a blended matte finish.

Aluminum oxide ranges from fine to extra coarse. It can be recycled several times, depending on whether it is used in suction or pressure blast systems. Aluminum oxide will accelerate wear on equipment components that come in contact with the high-velocity media. For longer equipment life when blasting with aluminum oxide, use boron carbide nozzles and line the blast enclosure with rubber curtains.

Glass bead removes most contaminants without affecting the surface's dimensional tolerances. It is used to provide a polished finish, and in some cases, to shot peen for stress relief.

Glass bead is manufactured from lead-free, silica-free, soda lime glass. Its spherical shape makes it ideal for shot peening. It measures 5.5 on the Mohs' Scale. Its high friability, however, requires blasting at lower nozzle air pressures to prolong the useful life of the media. Excessive blast pressure destroys the glass bead prematurely, without increasing productivity. Air pressure settings for glass bead in suction systems typically range from 60 to 80 psi (4.0 to 5.5 bar/415 to 552 kPa), and 40 to 60 psi (2.8 to 4.1 bar/276 to 414 kPa) in pressure systems.

Glass bead sizes range from U.S. Standard Mesh Screen 12/14 (1.68 to 1.41 mm) to 170/325 (0.088 to 0.044 mm) (MIL SPEC-G-9954A: Size 1 to Size 13). Consistent surface finish can be accomplished by maintaining an operating mix.

The automotive, aircraft and diecasting industries use glass bead to maintain the dimensional integrity of the pieces being processed. Glass bead's high purity prevents contamination on stainless steel, aluminum, and other soft metals. It is especially effective in deburring, deflashing, heat treat scale removal, blending of tooling marks, and producing an aesthetic appearance on all types of metal. Shot peening with glass bead reduces crack corrosion failure and relieves surface tension on products that are subject to high operational stress.

Plastic media is popular where paint and corrosion must be removed without disturbing the substrate. Plastic media, being angular and resilient, has proven effective in removing unwanted substances from light-gauge metals and some high-tech composite materials without causing damage. As an alternative to chemicals, hand sanding, and manual processes, plastic media has opened up new markets that would never have considered abrasive blasting.

Plastic media is made from different types of resins. The type of resin determines the hardness of the media — ranging from 3.0 to 4.0 on the Mohs' Scale. Mesh sizes range from 12/16 (1.70/1.18 mm) to 40/60 (0.425/0.250 mm). The U.S. military was first to research and approve plastic media for paint stripping from jet aircraft and components.

The U.S. Air Force has issued military specifications (MIL SPEC) for plastic media.

MIL SPEC Type I: 3.0 Mohs'
Polyester Resin
MIL SPEC Type II: 3.5 Mohs'
Urea Formaldehyde Resin
MIL SPEC Type III: 4.0 Mohs'
Melamine Resin
MIL SPEC Type IV: 3.5 Mohs'
Phenol Formaldehyde Resin
MIL SPEC Type V: 53 Barcol(*),
Acrylic Resin
MIL SPEC Type VI: 3.0 Mohs
Polycarbonate
MIL SPEC Type VII: 3.0 Mohs
Mixture - acrylic and wheatstarch
(*)Similar in hardness to 3.5 Mohs'

Stripping paint from thin metal requires operating pressure blast equipment at low pressures between 20 and 40 psi (1.4 to 2.8 bar/138 to 276 kPa). In suction blast systems, air pressures may be higher. The low pressures prolong media life, allowing 10 to 12 cycles.

Plastic media blasting requires special equipment. Plastic's low density of 57 pounds per cubic foot (0.9 kg/liter) and angular shape give it a steep angle of repose. Blast machines and storage hoppers must have cones sloped at least 60 degrees. The blast machine's conical bottom should be coated with an epoxy to ensure smooth media flow and, equally important, to prevent corrosion in the steel blast machine from contaminating the media. The compressed air must be as dry as possible because moisture severely interferes with media flow.

Potential uses for plastic include stripping paint from light-gauge metals, fiberglass, some composite materials, and even some wood products. Plastic is widely used on trucks, buses, automobiles, planes and boats, and in the electronics industry for deflashing circuit boards. Plastic is ideal for mold cleaning.

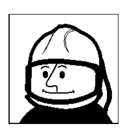
Foam media are open-celled, water-based polyurethane particles of sponge with or without encapsulated abrasives. The non-aggressive foam media can remove soot from wallpaper, and clean oil or grease from motors and hydraulic systems.

The abrasive-impregnated sponge flattens on impact, exposing the abrasive particle. As it rebounds from the surface, the sponge tends to capture some of the removed material, thereby reducing dust. These more aggressive foam media can remove coatings from steel and concrete.

Because foam media are often used slightly damp, they require specialized equipment to blast, recover, and refresh the particles, plus equipment to evaporate and concentrate the liquid waste.

Hazards Associated With Abrasives

No dust is safe to breathe - even when the blast abrasive is non-toxic.



No dust is safe to breathe. Even when the blast abrasive is non-toxic, dust from the coatings being removed may be toxic. 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.

Never blast with any media that contains more than 1 percent free silica.

The worst of the known respiratory diseases associated with abrasive blasting is silicosis. It results from prolonged inhalation of tiny, free-silica particles, which become permanently imbedded in the lungs. These particles cannot be removed by coughing. They build up and create scars that block the lungs' ability to take in sufficient oxygen. The afflicted person becomes short of breath and susceptible to infection or tuberculosis. Severe cases result in death.

In blasting, the most common source of free silica is pulverized crystalline silica sand. Other mineral and some byproduct abrasives contain free-silica. Some abrasives contain toxic materials, such as arsenic, cyanide, and heavy metals. Inhalation of these toxins will cause serious disease, resulting in death.

Read the manufacturer's material safety data sheets (MSDS) to determine health hazards (section VI of the MSDS) and reject any abrasive that contains silica or other toxic material.

PRIMARY ELEMENTS OF A BLASTING SYSTEM

Introduction

Each element of an abrasive blasting system plays an important part in the operational success. Success is defined as maximum productivity at the highest level of safety.

All elements of an abrasive blasting system are shown in the Set up Diagram in the Appendix.

Basic Elements:

- Air compressor — properly sized to produce sufficient volume
- Moisture separator & air drying equipment — to eliminate trouble-some stoppages caused by water
- Air line — large, with unrestrictive fittings
- Blast machine — with capacity, valves and piping for high production
- Abrasive metering valve — engineered for steady, uniform flow
- Remote controls — for safe and efficient operation
- Blast hose & couplings — sized to reduce friction loss
- Nozzle — matched to compressor output and necessary reserve
- Operator safety equipment — NIOSH approved and available for all person-nel
- Pressure regulator & gauge — for adjustment and monitoring
- Screen & cover — to keep equipment debris-free
- Operator — experienced, knowledge-able, and trained

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Blasting performance is the direct result of elements functioning in concert. Poor performance by one element will hamper the system's effectiveness.

Additional Elements:

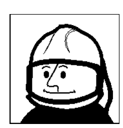
Other elements add versatility for different blasting applications. Such added elements include:

- Staging — to support and move blasters at elevated positions
- Field enclosures — to contain dust and abrasive
- Wetblast equipment — to control dust and wash surfaces
- Closed circuit equipment — for complete containment of abrasive
- Inspection equipment — to measure cleanliness and surface profile
- Training materials — to build operational skills
- Regulation education — for compliance with safety procedures
- Association support — to keep abreast of new processes

Compressed Air: An Energy Source

A standard pressure blast system uses compressed air to pressurize blast machines, convey abrasive to nozzles, provide breathing air, and operate valves and accessories.

Work will be done in direct proportion to the volume and pressure maintained at the nozzle.



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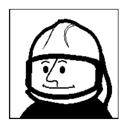
Pressure and Volume

A compressor's power output is measured in pressure and volume. Pressure is expressed in pounds per square inch (psi), or pounds per square inch gauge (psig). Volume is measured in cubic feet per minute (cfm). Metric systems use cubic meters per hour or minute to express volume and bar to express pressure. ***See Appendix for Nozzle Chart.***

Most air tools use air-driven pistons or diaphragms, which consume compressed air intermittently. Abrasive blast cleaning equipment demands more from a compressor than any other air-powered tool. High air pressure is not enough — blasting requires a steady supply of high-pressure, high-volume air.

High pressure is great, but it is only one half of the energy equation. Along with pressure, there has to be air volume.



Both a 1-hp (.75 kw) and a 100-hp (75 kw) compressor can produce 100 psi, but it takes the efficient, powerful 100-hp compressor to generate the great volume of air needed for blasting.

At 100 psi, the 1-hp compressor generates 4 to 4.5 cfm of air (0.11 to 0.12 m3/min), but the typical 100-hp (75 kw) compressor generates 400 to 450 cfm (11.3 to 12.7 m3/min) at 100 psi. This great volume of air must be sustained to maintain the 100 psi of pressure needed for blasting.

Increasing the air pressure increases the volume of air flowing out the nozzle. If the compressor does not produce the volume of air required by the nozzle, it will never achieve the required pressure.

For example, at 100 psi a 3/8-inch-orifice (9.5 mm) blast nozzle passes 200 cfm (5.6 m3/min at 7 bar/700 kPa). To maintain 100 psi, the compressor must produce at least 200 cfm of air. A compressor rated at 150 cfm (4.2 m3/ min) would never reach 100 psi, because the nozzle lets air out faster than the compressor can generate it.

Each one-pound drop in pressure reduces production by 1-1/2 percent. In the example above, the overtaxed compressor may reach just 70 psi (4.9 bar/490 kPa), which will cut the blasting production rate by 45 percent.

Most contractors blast clean structural steel at about 100 psi. In the U.S., standard blast machines and their related components are built to operate up to 125 psi (8.8 bar/880 kPa). While blast hose and other components may have higher pressure ratings, pressure to the system should not exceed the rating for the blast machine.

Many contractors have switched to steel grit and other recycleable abrasives. Manufacturers have responded by making 150 psi the standard for contractor-style blast machines. The higher pressure allows the system to maintain sufficient pressure at the nozzle while moving the dense steel grit through the blast hose.

Note: Some European blast machines are built for 175 psi (12 bar/1200 kPa); therefore, air compressors and ancillary equipment are rated accordingly.

For most blasting applications, 90 to 100 psi (6.3 to 7 bar/630 to 700 kPa), combined with hard, sharp abrasives in standard mesh sizes delivers good production and surface cleanliness. Higher pressures and durable steel grit push production rates (and compressor requirements) even higher.

Some fine-mesh mineral abrasives require pressures of 120 to 140 psi (8.4 to 9.8 bar/ 840 to 980 kPa) to produce acceptable cleaning rates. Extremely sharp abrasives, such as aluminum oxide, require pressures in the 70- to 80-psi (4.9 to 5.6 bar/490 to 560 kPa) range to reduce surface penetration by the sharp abrasive.

Proper pressure is based on the surface condition, the abrasive used, and the required surface finish.

Compressor Types and Selection

Generally, the high pressure and high volume of air required for blasting dictates the use of a rotary vane or rotary screw compressor.

For in-plant use, electric compressors cost less to operate and maintain. For field use, portable gasoline and diesel engine driven compressors are the norm.

Do not use old-style, piston compressors for blasting. A piston compressor kicks in when pressure drops 10 or 15 psi, then shuts off when pressure returns to normal. These pressure fluctuations vary blasting speed and affect surface finish. Also, piston compressors require a lot of lubrication, which can send oil through the air lines to contaminate the abrasive and the surface being blasted.

Some rotary screw compressors inject oil onto the screw to cool it. If the compressor is not functioning properly, some of this oil may be carried into the air lines.

⚠ WARNING

Oil-lubricated air compressors supplying breathing air to respirators (air-fed helmets and hoods) must be equipped with a high-temperature shut-off, carbon-monoxide alarm, or both. Ref: OSHA regulation 29 CFR 1910.134. See the Operator Safety Equipment section for details.

Oil-less compressors have sealed, lubricated bearings. The screws are not cooled by oiling, so they produce much hotter air.

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.

Select a compressor that will satisfy your current and anticipated demands, with enough reserve to compensate for nozzle wear. The compressor is the workhorse of a blasting system. Do not run it at maximum power for long periods as this will accelerate wear.

To determine the size compressor needed, add the air requirements of all equipment, plus a 50 percent reserve. If there is a possibility you might switch to a larger nozzle or add air-powered tools, choose a compressor to accommodate those potential demands. The compressor manufacturer can recommend the size and type of system best suited for your applications.

Compressors should be equipped with efficient air intake filters to trap the dust that might cause excessive engine wear.

Also, compressors must have shutdown devices to prevent overheating. Overheating can damage engine parts, but more important, it produces carbon monoxide (CO), an odorless, colorless, deadly gas. Where compressors supply helmet breathing air, CO can kill the blast operators.

Very important to the supply of air to blasting systems is the size and type of air outlets furnished with compressors.

To help regulate airflow, many compressor outlet valves have internal slotted plugs about half the size of the valve opening. A 1-inch (25 mm) valve actually has a 1/2-inch (12.5 mm) air passageway, far too small to supply a blast machine.

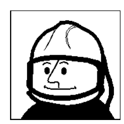
The quick-disconnect couplings fitted to air hose also cause restriction. Coupling size refers to the pipe thread — not the internal diameter. Most 3/4-inch (19 mm) couplings have 1/2-inch (12.5 mm) inner diameters (ID); 1-inch (25 mm) couplings have 3/4-inch (19 mm) IDs.

Do not use restrictive air valves or quick-disconnect couplings, except with small, low-production blast machines.

MINIMUM CONNECTOR ID				
Nozzle	Orifice		Connector ID	
Model No.	(inches)	(mm)	(inches)	(mm)
3	3/16"	5mm	3/4"	19mm
4	1/4"	6.5mm	1"	25mm
5	5/16"	8mm	1-1/4"	32mm
6	3/8"	9.5mm	1-1/2"	38mm
7	7/16"	11mm	2"	50mm
8	1/2"	12.5mm	2"	50mm
10	5/8"	16mm	2-1/2"	64mm
12	3/4"	19mm	3"	76mm

The smallest internal diameter of the compressor air outlet should be at least four times the size of the nozzle orifice or larger. For a 3/8-inch (9.5 mm) blast nozzle, the compressor air receiver fitting, air valve, and air couplings should all have IDs of at least 1-1/2-inches (38 mm). The chart above illustrates the minimum internal diameters for compressor air supply connectors used with standard nozzles.

Remember, the smallest opening in the air supply system controls the amount of air to be delivered to the blasting unit.



Moisture, Oil and Other Contaminants

Water and oil are the worst enemies of abrasive blast equipment. They cause abrasives to form clumps, which can clog metering valves, hoses, and nozzles. If moisture reaches the surface being cleaned, it can cause the steel to rust. If oil reaches the surface, it can cause the coating to blister and fail.

The air around us contains moisture. When this ambient air is heated by compression, then cooled by expansion in air receiver tanks, some of the moisture is released. Warm air holds more moisture than cold air and releases that moisture when it is compressed and cooled. Even cool, dry air releases moisture when compressed.

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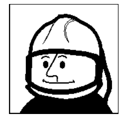
Naturally, all of the moisture produced in all receivers and air hose is pushed directly into blast machines, where it saturates stored abrasive.



A second cooling stage takes place in the air hose leading from the air receiver to the blast machine. This cooling causes condensation.

All compressors release moisture as a byproduct of compressed air. Some compressors produce moisture and oil. Depending on the relative humidity in the ambient air, the tools for removing this oil and moisture vary. Your compressor sales representative can help you select the air drying equipment you need, based on your application and the humidity normally encountered in your area.

An air filter, installed at the blast machine's air inlet, removes water and oil that has already condensed in the air lines.

Coalescing filters are often installed at the compressor outlet, but can be located at the blast machine inlet. They collect some of the water vapors that form small droplets.

After-coolers are radiators that cool the air to condense the moisture, then trap it before it can be carried to the blast machine. They are usually installed at the compressor outlet.

Air dryers (either chemical or refrigerated) are the most effective method for removing moisture and oil. They can be installed anywhere between the compressor outlet and the blast machine inlet. The ideal setup includes an after-cooler at the compressor outlet and an air dryer in the line leading to the blast machine.

Dry Ambient Air: If the ambient air is dry and the compressor is operating efficiently, a moisture separator alone — installed at the blast machine inlet — should remove any small amounts of oil and water from the compressed air. Select moisture separators that allow more than enough flow. Small units may restrict the air flow to the blast equipment.

Slight Humidity: If the ambient air is only slightly humid, install a coalescing filter in the air line just after the moisture separator.

Moderate Humidity: Install an after-cooler near the compressor outlet and a moisture separator near the blast machine.

High Humidity: Install a refrigerated or chemical air dryer. The refrigerated dryer cools the compressed air, then sends it through a series of coalescing, adsorbent, and desiccant filters which trap the moisture, oil, dust, and other contaminants. A moisture separator, installed at the blast machine inlet, removes any remaining water and oil.

Refrigerated or chemical air dryers are also required, no matter the humidity in the ambient air, for applications where moisture-control is critical. This includes use of plastic or agricultural media and blasting surfaces where no contamination is allowed.

`Climatic conditions at the blast site dictate the type of filtering system necessary. Even in a desert, moisture, oil, and other contaminants are present. Some efficient method of filtering compressed air must be installed to ensure only clean, dry air reaches the blasting system.

Air Receivers and Manifolds

Compressors have air receiver tanks, sized to compressor output, to store and cool newly compressed air. Most receiver tanks have compressor-industry fittings and air valves. Check the internal diameter of all fittings, air valves, and couplings to ensure they are adequate for the air volume required for the blast nozzle.

Standard receiver tank capacities are satisfactory if the distance between the compressor and the blast machine is up to 100 feet (30 meters). Beyond that, especially with large blast nozzles, use a secondary receiver tank.

Upon start-up, an initial surge of air pressurizes the blast machine and starts the flow of air to the nozzle. The compressor's small air receiver tank may not have the capacity to quickly pressurize the machine and a long air line. Install a secondary air receiver tank, properly sized and equipped with large diameter fittings and valves, close to the blast machine to ensure an immediate supply of compressed air.

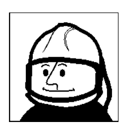
⚠ WARNING

All air receiver tanks must have drain valves, to release collected water, and pressure gauges and pressure relief valves which conform to OSHA regulations (Ref: 29 CFR 1910.169).

Air Manifolds

Manifolds allow multiple air hose connections. Many compressor manifolds come equipped with small fittings. These fittings can supply air to helmets and filters (if the air supply is Grade D breathing air) or other small air-operated equipment, but the fittings for blast machine connections must be sized to accommodate the air flow. Check the connections between the air receiver and manifold for proper size.

Always think big when it comes to air movement through hoses, couplings, and valves.



Manifolds can serve as "air banks" where two or more compressors feed air to a central point for distribution to several blast machines and other air tools. These manifolds are sometimes called "air receivers." The inner diameters of all manifold inlets and outlets must be sized for unrestricted air flow.

Note: On an air manifold with multiple inlets or outlets, install a check valve on each outlet to prevent air from flowing backward from the blast machine. This can occur when a sudden, heavy demand for air by some of the outlets creates a pressure drop in the manifold. Back flow can pull abrasive from a blast machine into the manifold and compressor, causing severe damage. Check valves should be installed on all compressor outlets to prevent air back flow when one compressor produces less pressure than others feeding the manifold.

Operation and Maintenance

Before buying or renting a compressor, tell the sales representative you intend to use the compressor for abrasive blasting. The sales representative should supply information on installing, operating, and maintaining the compressor. Read the manufacturer's instructions before operating the equipment and follow the instructions, warnings, and maintenance procedures.

Position the compressor upwind of dust generated by blasting. Dust, dirt, or other contaminants entering the compressor air inlets will cause premature wear.

⚠ WARNING

Exhaust fumes contain carbon monoxide (CO). If exhaust fumes enter the air inlet, blast operators connected to the compressor can be killed from inhaling carbon monoxide. See the Operator Safety Equipment section for measures to protect breathing air.

Locate the compressor where vehicle exhaust will not enter the air inlets. Do not allow vehicles to park near the compressor. Direct the compressor's own exhaust away from its air inlet by attaching metal pipe to its exhaust stack and running the pipe downwind from the inlet.

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Air Lines and Connections

Air flows best through straight, hard air lines. Directional changes and protrusions interfere with air flow. Metal piping and plastic tubing, properly sized, pressure rated, and assembled, can convey air without the friction loss common to rubber air lines.

Some contractors install rigid lines in fixed locations and at long-term field applications, such as bridges, where compressors are stationed at one end and blast equipment works its way along the length of the bridge.

In plants and other applications where blasting systems and the compressor are permanently placed use metal air lines.

As with any method of conveying air, condensation forms as hot compressed air expands and cools in the pipe lines. Install drain valves in the last vertical pipe, just before it connects to the blast system filters. As steel pipes age, rust and scale can be carried with the air to the blast machine. Use high-efficiency filters to remove moisture, oil mists, and particulate matter.

If the in-plant compressor is located several hundred feet from the blast equipment, install oversized pipes, with as few bends as possible, to reduce pressure loss. The 45- and 90-degree elbows in pipe can cause more friction than gradual bends. Where turns are unavoidable, minimize the amount of friction and turbulence by using two 45-degree elbows instead of one 90-degree elbow. These gradual bends are less detrimental to pressure.

Where hard piping is impractical, invest in high quality fabric-reinforced rubber airline. The inner tube should be neoprene or similar material to resist swelling caused by moisture and oil. Woven or braided fabric provides pressure strength and supports the round shape of the inner tube. The outer casing should be durable material to hold up to the rigors of field handling and climatic conditions.

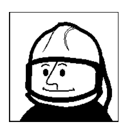
Keep hose as short as possible and avoid erratic bends. Even correctly sized air hose loses two to three pounds of air pressure for every 50 ft. (15 m) of length. Just one 90-degree bend increases the loss to about five or six pounds. When bends are unavoidable, make them gradual. Use only as much air line as needed. Excess hose tends to be coiled, twisted, and turned, which causes pressure loss.

Purchase air lines rated for a minimum working pressure equal to or greater than the blast machine's working pressure. Air hose has two ratings — working pressure and burst pressure. The difference between the two is a safety factor. Never exceed the working pressure rating of hose, pipe, or any component of the blasting system. Higher pressure air lines are available for use with blasting equipment designed for higher pressure.

Diameter to Length Ratios

Using the proper size air line is critical to getting the most from your compressor and blast system. The inner diameters of the air line sizes must be consistent with the inner diameters of all fittings to allow smooth air flow. Air line inner diameters should be at least four times the nozzle orifice size. This applies to air lines up to 100 feet (30 meters).

Sizing air lines is critical to fully utilizing compressor power, which ultimately affects blast equipment performance.



Use the Minimum Compressor Air Line Chart to ascertain the absolute minimum air line inner diameters to use. Use air lines larger than the minimum recommended whenever possible. No air line is too large.

Minimum Compressor Air Line Sizes

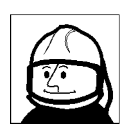
Nozzle No.	Nozzle Orifice	Minimum Air Line ID
3	3/16" (5.0mm)	1" (25.0mm)
4	1/4" (6.5mm)	1" (25.0mm)
5	5/16" (8.0mm)	1-1/4" (32.0mm)
6	3/8" (9.5mm)	1-1/2" (38.0mm)
7	7/16" (11.0mm)	2" (50.0mm)
8	1/2" (12.5mm)	2" (50.0mm)
10	5/8" (16.0mm)	2-1/2" (64.0mm)
12	3/4" (19.0mm)	3" (76.0mm)

When lengths exceed 100 feet (30 meters), use the next larger diameter air hose for all of the conveying distance except for the section that attaches to the blast machine. For example, at a distance of 200 feet (60 meters) a blast machine with a 3/4-inch (9.5 mm) nozzle requires 150 feet (45 meters) of 2-inch (50 mm) air hose from the compressor, reduced to 1-1/2-inch (38 mm) for the final 50 feet (15 meters) leading to the blast machine.

At some sites, compressors must be placed far from the blast equipment and air lines must be snaked over and around obstacles. In such cases, use one much larger hose or a series of hoses leading to a large manifold to maintain airflow. Test the air pressure to determine the best hose arrangement.

When air hoses exceed 200 feet (60 meters), check the air pressure at the blast machine to determine if air hose ID is sufficient. Check the pressure with the nozzle operating — not when the machine is shut down.

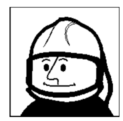
If choosing between long air hoses and long blast hoses, keep the blast hoses as short as possible.



Air Hose Connectors

Choose air hose connectors that offer the least resistance and greatest internal area. Do not confuse outer diameter with inner diameter. An air hose connector's size refers to pipe thread size or to the ID of hose it fits. A 1-1/2 inch (38 mm) threaded air hose connector has an O.D. of 1-1/2-inches (38mm), but an ID of 1-1/4-inches (32 mm) or less, which limits the volume of air.

The smallest ID determines air flow volume for the entire blast system.



Be especially wary of quick disconnect connectors and threaded swivel air hose fittings. While the couplings offer convenience and the swivel reduces kinking, internal passageways can be much smaller than their external openings.

⚠WARNING

Install safety cables at every air hose connection to prevent injury if fittings disengage. Use safety cables to support the weight of elevated hose. Do not rely on hose fittings.

Blast Machines

There are two types of blast equipment — suction blast and pressure blast. Suction blasting is less aggressive than pressure blasting. It is used in blast cabinets and for light-duty work, such as touch-up blasting. Pressure blasting is sometimes used with blast cabinets, but is more often used in blast rooms or outdoors to clean tough surfaces and large areas.

Types

Suction Blast

Suction blasting, sometimes called venturi blasting, draws abrasive from a non-pressurized container into a gun chamber, then propels the abrasive particles out a nozzle.

A suction system consists of a blast gun, an air hose, a media hose, and an abrasive container. Compressed air flows through an air jet in the blast gun to create suction. This suction brings abrasive up through the media hose into the gun body where it is accelerated out the nozzle with the air.

The volume of compressed air required for suction blasting is determined by the ID of the air jet orifice in the back of the blast gun not the ID of the suction gun nozzle. A typical suction gun air jet is half the size of a typical nozzle orifice for pressure blasting. This means it will use about one-fourth the volume of air, and propels abrasive to about one-fourth the velocity created by pressure blasting.

This less-forceful blast is appropriate for light to moderate cleaning and touch-up applications. It is useful where the air supply or access to the work piece is limited.

Suction blasting is used on softer, delicate metals for mild deburring, light shot peening, and scale removal without penetrating the base metal. Such metals include aluminum, titanium, and magnesium used for automotive and aircraft parts.

Pressure Blast

Blast machines are known by a variety of names — pots, pressure generators, tanks, and so on. This booklet will refer to all systems that hold abrasive under pressure as blast machines.

In pressure blasting, abrasive feeds into a moving stream of compressed air via a metering valve mounted beneath a pressure vessel. Pressure blast systems are easily distinguishable from suction systems by the single hose feeding the nozzle. Air and abrasive travel through this blast hose at high pressure and speed, exiting the nozzle at about four times the velocity produced by suction blasting.

Pressure blast machines are used in structural steel blasting, for their high production rates, and in lightweight media blasting, for their precise regulation of media flow.

While it appears to be little more than a steel tank, a blast machine has integral parts that make sizable differences in safety, convenience, and efficiency. Poorly designed blast machines have restrictions that reduce air flow and pressure.

Blast Machine Construction

In the United States, blast machines and other pressurized containers must meet American Society of Mechanical Engineers (ASME) standards. ASME specifies the type of steel and welding methods, and an ASME-authorized inspector supervises the hydrostatic testing of each pressure vessel, then issues a National Board certificate of approval. A metal plate bearing the board approval number is permanently affixed to the blast machine. Most countries have similar requirements, though the specifications may differ. Clemco manufactures blast machines in the U.S. to meet ASME standards, and in Europe and Asia to meet standards in those regions.

In the U.S., most blast machines are rated for a working pressure of 125 to 150 psi (8.8 bar/880 kPa to 10 bar/1035kPa).

If a machine's working pressure is unknown, check the National Board approval plate.

WARNING

Never operate a blast machine that does not have a National Board approval stamped on a permanently affixed plate. Never exceed the rated working pressure. Serious injury or death can occur if a blast machine explodes under air pressure.

Concave Head and Conical Bottom

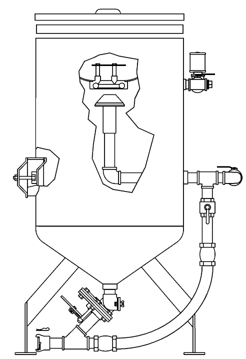
A well-engineered blast machine allows smooth air and abrasive flow throughout the system and is easy to operate and maintain.

The machine's semi-elliptical, concave head stores abrasive, which flows into the machine when it depressurizes.

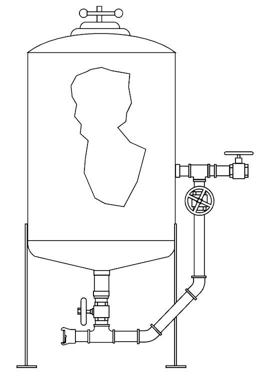
Most machines have a 35-degree conical bottom to allow abrasive to flow freely into the metering valve below. Steel grit and other common abrasives have a 32-degree angle of repose. This is the natural slope of the abrasive when it is poured to form a mound. Plastic and agricultural media have much steeper angles of repose. Blast machines for use with these lightweight media should have 60-degree cones to ensure free flow.

Flat-bottomed machines do not empty completely. The abrasive inside will eventually absorb moisture and harden against the machine wall and around the outlet, which leads to inconsistent abrasive flow.

All blast machines should have a hand hole big enough to allow reasonable access into the machine to replace parts and remove foreign matter. You should be able to easily reach the outlet at the bottom of the machine and pop-up valve at the top. A 6- by 8-inch (150 by 200 mm) hand hole usually is sufficient on small machines.



Well-designed blast machine.



Poorly-designed blast machine.

Features

Pop-Up Valve

A well-designed blast machine seals automatically with a pop-up valve — a cone-shaped aluminum casting coated with wear-resistant urethane or neoprene rubber. When air enters the machine, an external sleeve resting on internal piping guides the pop-up into the rubber sealed valve opening where the air pressure forces a tight seal.

Upon depressurization, the pop-up valve drops to allow abrasive stored in the concave head, or a storage hopper, to flow into the machine.

A small steel umbrella above the valve relieves pressure from abrasive stored in the concave head, so the pop-up valve can seal properly.

Exhaust Muffler

Clemco blast machines come equipped with self-cleaning exhaust mufflers. The muffler reduces the noise of the escaping air when the machine is depressurized, and traps any abrasive carried out with the exhaust. This prevents injury from abrasive spray. Exhaust air passes through the muffler and, after the machine is completely depressurized, the muffler releases the trapped abrasive to fall harmlessly to the ground.

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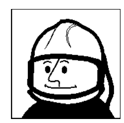
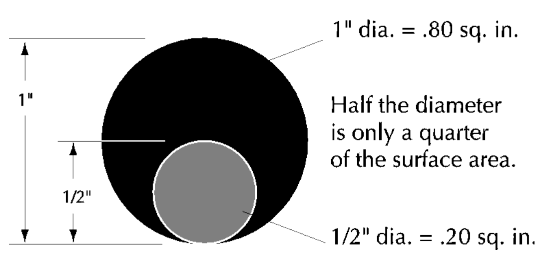
Piping and Fittings

Pay special attention to the blast machine's external plumbing, because this is where restrictions usually occur. In any size pipe, friction causes turbulence between the moving air and the wall of the pipe, which creates pressure loss. High-production blast machines use large-diameter pipe to minimize this loss. Light-duty, small-capacity machines can get by with small piping, because a high production rate is usually not a priority.

When working with air hose, blast hose, air piping, air valves, and for that matter, anything in the air line, think BIG...... VERY BIG!



In a blast machine system, air and media flow through pipes, valves, hoses, nozzles, and couplings, that are all cylindrical. Any reduction in the diameters of these cylinders dramatically reduces the rate of flow.



A 1 inch ID (25 mm) cylinder has an area of .80 square inches (51 cm2). A 1/2 inch ID (12.5 mm) cylinder has an area of .20 square inches (129 mm2). Reducing the diameter of the cylinder by half, reduces its area three-fourths.

The table is meant as a guideline and may not apply to applications where long blast hoses or other obstacles impede air flow.

The nozzle should be the smallest orifice between the compressor and the surface being blasted. From the blast machine to the nozzle, the internal diameters of the valves, pipes and fittings, blast hoses, and couplings must all be three to four times the ID of the nozzle. If the operator must work at distances greater than 100 feet from the blast machine, the ratio of hose ID to nozzle orifice is even greater.

Pipe or Valve ID		Area*	Nozzle Sizes**	
(inches)	(metric)	(sq. inches)	(inches)	(metric)
1/2	12.5mm	.20	1/8	4mm
3/4	19mm	.45	3/16	5mm
1	25mm	.80	1/4	6.5mm
1-1/4	32mm	1.2	5/16	8mm
1-1/2	38mm	1.8	3/8	9.5mm
2	50mm	3.2	7/16	11mm
2	50mm	3.2	1/2	12.5mm
2-1/2	64mm	4.9	5/8	16mm
3	76mm	7.1	3/4	19mm

* Area derived from $(\pi)r^2$ and rounded.
** Nozzle sizes supported at one hundred feet

On blast machines with capacities exceeding one cubic foot (30 liters), piping is typically 1-inch (25 mm) or 1-1/4-inch (32 mm) ID

Even with large internal diameters, the way in which the hoses and piping connect will affect air flow. Every twist and turn in the piping reduces the pressure and volume of air.

Adding up all these pressure loss points reveals the dramatic reduction in the amount of air reaching the nozzle.

Wherever possible, replace restrictive parts with full-flow fittings and valves. When check valves must be used, install valves with an ID slightly larger than the ID of the pipe. This prevents restrictions in the air flow.

Approximate Pressure Loss Caused by Common Fittings based on 100 psi (7 bar) in 1 inch (25 mm) pipe		
Fitting	**Pressure Loss**	
45° pipe elbow	1-1/2 psi	0.1 bar/10 kPa
90° pipe elbow	3 psi	0.2 bar/21 kPa
pipe tee	5 psi	0.3 bar/34 kPa
swing check valve	18 psi	1.2 bar/124 kPa

The blast machine's pusher line should be formed in one piece to eliminate interference from protrusions in the air stream. Install compression fittings in place of pipe unions to connect this formed piping.

For machines equipped with rubber pusher lines, make sure the line makes a gradual bend with no kinks. Replace worn or damaged pusher lines with hose and fittings identical to the originals.

There will always be some pressure loss due to the turns and bends inherent in piping. Follow the above recommendations to minimize those losses.

A single-operator blast machine should suffer no more than 8 to 10 pounds (0.5 to 0.7 bar/55 to 70 kPa) of pressure loss from the air inlet to the outlet coupling on the bottom of the machine.

Install a pressure gauge on the blast machine's air inlet. Test for pressure loss (without abrasive in the air stream) by inserting a hypodermic needle gauge into the blast hose near the point where it connects to the machine.

If the difference is more than 10 pounds (0.7 bar/70 kPa), investigate each piping component to find restrictions and replace restrictive components with appropriately sized parts.

Blast Operation

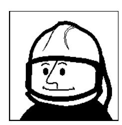
In operation, the blast machine's internal pressure should approximately equal the pressure in the external piping. Having equal pressure above and below the abrasive allows gravity to feed the abrasive through the metering valve and into the air stream. The blast machine's smooth walls and conical base complement gravity's power.

The secret to trouble-free abrasive feeding is to, upon pressurization, quickly balance the pressure between the inside of the machine and its external piping. If a balance is not quickly achieved, the higher-pressure air in the external piping will blow abrasive backward through the metering valve into the bottom of the blast machine. This blow-back damages the valves and fittings on the bottom of the machine. In time, blow-back from repeated starting and stopping wears out the metering valve and pipe connections.

In a well-designed machine, the vents in the pop-up valve sleeve prevent blow-back by rapidly dispersing the incoming air into the chamber, equalizing the pressure within 2 to 3 seconds.

A nearly empty bulk blast machine will take slightly longer to equalize due to the vast area to fill with air. Bulk machines and other multiple-operator machines are furnished with normally-closed metering valves which prevent blow-back.

A simple machine with properly sized components works best.



Blast Machine Selection

When you purchase or rent a blast machine, look for simple piping with properly sized components. Radical piping and complicated methods for metering abrasive into the air stream usually lead to premature wear and inconsistent abrasive flow.

Choose a blast machine that has the capacity, portability, and convenience features that best fit your needs and type of work.

Capacity

The diameter of the nozzle orifice determines the amount of work done and the amount of air and abrasive used per hour. *See U.S. and European Blast Machine Reference Tables in the Appendix.*

A 1/2-inch (12.5mm) nozzle cleans four times faster than a 1/4-inch (6.5mm) nozzle, and it uses four times the volume of air and abrasive.

Your compressor must be able to supply sufficient air for the nozzle, plus any accessories, plus a reserve amount to compensate for nozzle wear.

Based on the nozzle and compressor you plan to use, choose a blast machine with an abrasive capacity to supply 20 to 30 minutes of steady blasting.

Choose a nozzle size, then refer to the Abrasive Consumption Chart. Under the 100 psi (7 bar/ 700 kPa) column, find the amount of abrasive consumed in an hour by the chosen nozzle, then calculate the minimum size machine. The table provides comparison information only. Your actual consumption rate will vary based on metering, compressed air quality, hose layout and length, and blast machine efficiency.

For example, a 3/8-inch nozzle (9.5 mm) consumes approximately 11 cubic feet of abrasive (312 liters) per hour at 100 psi (7bar/700 kPa), so your blast machine should hold at least 5.5 cubic feet (156 liters) to last 30 minutes. For this example, choose a machine that holds at least 6 cubic feet (176 liters).

As the nozzle orifice wears to 7/16 inch (11 mm), abrasive consumption will increase to more than 14 cubic feet per hour (396 liters), or 7 cubic feet (198 liters) per half hour, which reduces the machine to about 20 minutes of blast time. When blasting times fall off substantially, check the nozzle orifice for excessive wear.

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Machines that are too small waste the blast operator's time reloading or waiting for others to reload abrasive. Machines that are too big are unnecessary, because the operator will have to stop after about 30 minutes to move to the next blasting area. For added efficiency, use non-pressurized storage hoppers to automatically refill the blast machine while the operator repositions.

The capacity by weight is based on abrasives weighing about 100 pounds per cubic foot (1.5kg/liter) — such as slag. Due to the increasing diversity in abrasive types and densities, it is now more accurate to size machines by their volume.

A six-cubic-foot (200 liter) machine, such as Clemco's 2452, holds approximately 600 pounds (273 kg) of slag. That same machine holds just 340 pounds (155 kg) of lightweight plastic media or 1500 pounds (682 kg) of steel grit. Despite the differences in the density of these abrasives, the blast machine will be emptied in about the same length of time.

See Appendix for the U.S. and European Blast Machine Reference Table.

⚠ WARNING

Never move a blast machine while it contains abrasive. The strongest operator is no match for the weight of the machine and abrasive once they are in motion. Use mechanical lifting equipment or a device such as Clemco's Mule to move an empty two-wheeled blast machine.

Portability

Blast machines are available in portable and stationary models with capacities from 1/2 to 800 cubic feet (European Models 20 to 25,000 liters). If the blast machine will never be moved, choose a stationary model. Portable machines are more versatile, in that they go where they're needed or can be used at a fixed site.

Blast machines can be classified in four categories: light duty, medium duty, high production, and bulk units.

Light-duty machines have a capacity of 1/2 to 1 cubic feet (15 to 30 liters), have small piping, short blast hose, and straight-barrel nozzles. These machines produce the same hard-hitting cleaning power as larger units but on a much smaller scale. Their light weight and portability make them ideal for spot cleaning on tough, contaminated surfaces.

Medium-duty machines offer pickup truck portability and high efficiency in capacities from 1-1/2 to 4 cubic feet (European Models 100 and 140 liters). They usually have 1-inch (25 mm) piping and blast hose, suitable for use with 3/16-inch, 1/4-inch, and 5/16-inch (5, 6.5, and 8 mm) venturi nozzles. Medium-duty machines are ideal for jobs that take an hour or two to complete.

High-production machines are the most versatile and popular, with capacities from 6 to 20 cubic feet (European models 200 liters and larger), standard 1-1/4-inch or 1-1/2-inch (32mm or 38mm) piping and blast hose feeding 3/8-inch to 1/2-inch (10 to 12.5mm) venturi nozzles. Popular among blasting contractors and industrial installations, high-production machines provide ample abrasive capacity for extended blasting. Stationary high-production machines are used with blast rooms and automated cabinets.

Portable machines are offered in two-wheel models, such as Clemco's popular 6-cubic-foot (200 liter) standard models and four-wheel models, such as Clemco's 6-cubic-foot (200 liter) Contractor Blast Machine models.

Bulk blast units, such as Clemco's Big Clems, offer the same results as the high-production machines, but with greater abrasive capacity. Bulk units range from 60 to 800 cubic feet capacity (1800 to 24,000 liters). Bulk units usually have outlets for multiple operators. The 120- to 160 cubic-feet (3600 to 4800 liters) portable units fitted with 2 to 4 outlets are most popular. The air inlet piping and air supply hoses for bulk blast machines must be large enough to serve all the outlets. On Big Clems, for example, the standard inlet pipe has a 4-inch (102 mm) ID.

Portable bulk blast units come fitted with wheels only, for movement within a work site, or can be ordered with brakes, lights, fenders, and other equipment that allows them to be towed on public highways. Most bulk machines can be towed while filled with abrasive that weighs approximately 100 pounds per cubic foot (1.5 kg/liter). Filling such a machine with steel grit may exceed its gross vehicle weight rating (GVW).

For large jobs, using bulk blast machines can save money. Bulk abrasive costs less than bagged abrasive, and the time spent loading bagged abrasive is non-productive.

To complement abrasive availability, storage hoppers can be stationed on the job site with enough abrasive to refill the blast machines several times. Blower trucks deliver abrasive to the storage hoppers as needed.

Bulk equipment is common in shipyards and large industrial facilities, and is preferred by some large blasting contractors.

There are some misconceptions about bulk blast machines. These machines do not blast harder or clean faster than other high-production machines. The size and number of nozzles used determines the production rate. Many times, the versatility of four smaller machines, in conjunction with storage hoppers and transfer equipment, is preferable, because the individual machines can be shut down for maintenance or positioned in different areas to reduce blast hose lengths.

Select a blast machine with sufficient capacity to meet your current and future needs. Larger machines, which may be necessary as your business grows, can be purchased for 5 to 10 percent more than smaller ones. A quality machine will last 15 to 20 years with proper care, so the initial cost difference is minimal; while the additional labor required to load a machine that's too small can become substantial.

Special Problems, Special Machines

Bulk blast machines offer convenience features including greater abrasive capacity, multiple outlets and continuous action. There are, however, drawbacks associated with these features.

Among the drawbacks are the enormous volume of air required to supply multiple nozzles, and the expense of removing moisture from such large volumes of air. These bulk machines demand high-efficiency air dryers and after-coolers, which increase operating expenses.

A four-operator bulk unit equipped with 3/4-inch (9.5 mm) nozzles uses 800 cfm at 100 psi (22 m3/min. at 7 bar/700 kPa). The piping and couplings on the bulk machine must be large enough to provide this 800 cfm (22m3/min.), plus accommodate normal nozzle wear, which significantly increases demand. If all four nozzle orifices wear to 7/16-inch (11.0mm), consumption increases to 1,040 cfm (28.4 m3/min).

Bulk machines are usually stationed in one centralized location, while the multiple blast hoses are strung out to blasting sites. Extremely long blast hoses suffer pressure loss due to friction. Pressure losses of 25 psi (1.7 bar/170 kPa) or more are common in long, twisted hose.

Continuous action machines have dual chambers. In operation, the bottom chamber remains pressurized while the top one is refilled with abrasive. When the top chamber is pressurized equal to the bottom, abrasive flows to the lower chamber — all without interrupting the blast. Non-stop blasting saves labor and time, and is more common in an automated blast system where parts are processed continuously.

The compromises inherent in continuous-action machines can cause temperamental air flow, especially in the popular multiple-outlet systems. Used to pressurize and depressurize the top chamber, while feeding high-volume air to multiple nozzles the air flow and pressure can fluctuate within the system. The resulting surges in abrasive flow are noticeable in the blast pattern. If the air supply is marginal or inadequately filtered, problems are compounded.

A few bulk machines are offered with dual chambers, which further compromise air flow.

For best results, keep it simple. Any added complexity usually produces adverse results that outweigh the benefits.

Accessories

Screens and Covers

A screen keeps out paper, candy wrappers, cigarette butts and other trash that somehow find ways into the blast machine.

The most common source of paper debris is from bagged abrasive. When the bags are opened on top of the machine, small pieces of paper fall inside and jam the outlets. Use a thick perforated metal screen with holes no larger than 1/4-inch (6.5mm). Do not use a wire-mesh screen, because it cannot support the weight of the bagged abrasive.

Cover the machine when it's not in use to keep out rain and condensation. Water in your blast machine will cause costly delays. Also, empty the machine at the end of each day, to prevent condensation from clogging the valves and hose with damp abrasive.

Use a durable metal lid, a heavy vinyl bag, or both. The metal lid keeps water out of the machine, while the bag covers the machine from top to bottom to keep water and dirt off.

Pressure Regulators and Gauges

Install a pressure regulator with a gauge on the blast machine to set and monitor the air pressure. Maintaining the correct operating pressure guarantees optimum performance and ensures the machine is working within its pressure limits; normally 125 psi to 150 psi (8.6 bar/862 kPa to 10 bar/1035kPa).

> *Note: Some European machines operate at 175 psi (12 bar/1240 kPa); some at lower pressure (110 psi [7.6 bar1758 kPa] in the U.K.). Many blasting tools have built-in pressure regulators.*

The compressor gauge shows air pressure at the compressor outlets, the beginning of the system.

The hypodermic needle gauge indicates pressure at the nozzle, the end of the system. The pressure at a 125-psi rated blast machine inlet should be 110 to 120 pounds (7.6 to 8.3 bar/758 to 827 kPa) at the air inlet. Never assume the pressure at the machine inlet is sufficient, because pressure loss due to friction in air hoses and fittings varies from one application to the other.

A pressure gauge at the blast machine inlet lets you quickly check for pressure loss, and a pressure regulator will prevent excess pressure from reaching the machine if the compressor is set too high.

If pressure at the nozzle falls below 90 to 100 psi (6.2 to 7 bar/620 to 689 kPa), yet the blast machine inlet gauge is reading 100 to 125 psi (7 to 8.6 bar/689 to 862 kPa), the pressure loss is in the machine, its plumbing, or most likely — the blast hose. Compare the pressure in the blast hose at the nozzle with the pressure in the blast hose near the blast machine outlet. If the pressures are about equal, you can rule out problems with the blast hose.

If the pressure at the blast machine inlet is lower than at the compressor, the pressure loss is in the air hose or manifolds.

Use regulators designed for high-pressure, high-volume air. You may have to buy regulators with larger pipe thread and bush them down to fit blast machine inlets. Never set the regulator higher than the certified working pressure of the blast machine and tools.

Abrasive Metering Valves

A metering valve uses gravity to feed abrasive into a fast-flowing stream of compressed air. Too little abrasive results in a wide-spread pattern, which slows production and leaves untouched surfaces. Too much abrasive causes particles to collide with each other, which wastes energy and disperses particles unequally within the blast pattern. Exorbitant abrasive usage also wastes material and labor.

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Metering valves that feed abrasive at 90 degrees, cause turbulence that leads to erratic abrasive flow, abnormal wear on piping, and inaccurate mixing of air and abrasive.

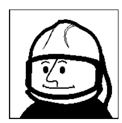
Feeding into the air stream at 45 degrees allows air and abrasive to blend smoothly. This minimizes turbulence and results in a more consistent blast pattern.

Properly adjusting the metering valve ensures that you get the maximum amount of cleaning power from each abrasive particle.

Start by closing the metering valve. Press the remote control handle to start air flowing out the nozzle, then slowly open the valve a little at a time.

Watch the air and abrasive mixture exiting the nozzle. A proper setting will show slight coloration of abrasive leaving the nozzle. Experienced blasters can hear a steady abrasive flow. Too little abrasive causes a high-pitched sound; too much abrasive, an erratic, pulsating sound.

Excessive abrasive flow actually slows production and wastes abrasive. It will not speed the job.



Metering Valve Features

A good abrasive metering valve permits precise adjustments. Air valves, and other valves not specifically designed for abrasive, will wear rapidly and adversely affect flow.

True metering valves have wear-resistant internal materials housed in sturdy bodies. The valve should have a simple, yet precise, adjustment feature. An inspection plate facilitates removal of foreign materials that clog the valve.

Design Concept

The most basic metering valves are designed for use with one type of abrasive.

Modern, state-of-the-art metering valves handle all types of abrasive, adding versatility to the blast machine.

The basic valve allows manual abrasive flow adjustment. With the addition of a controller, the basic valve becomes fail-to-safe, normally closed. Other options allow operators to remotely adjust abrasive flow and to remotely open and close the metering valve.

A metering valve must have wear-resistant, corrosion-resistant metering plates — usually with one fixed, the other adjustable. The adjustable plate precisely controls abrasive flow through the opening in the fixed plate — from closed to fully open.

Spring-loaded, normally closed metering valves require compressed air to open the valve to permit abrasive flow. The normally closed feature is safer, because it instantly stops abrasive flow if the air supply is interrupted.

As an abrasive cut-off feature, a normally closed valve works with pressure-release or pressure-hold remote controls to allow the operators to stop the abrasive and blast with compressed air only. Refer to the Remote Control Systems Section for more details.

Advanced metering valves allow remote metering adjustment from the nozzle. This is especially helpful if abrasive becomes damp and requires momentary flow adjustments.

Remote Controls

A blast machine must have remote controls which quickly stop blasting when the control handle is released. The Occupational Safety and Health Administration (Ref: OSHA 29 CFR 1910.244) requires remote controls on all blast machines. Failure to use remote controls can expose a blasting contractor to substantial fines and liabilities if someone is injured or killed.

The control handle must be located near the nozzle and must be used correctly by the blaster. Using a blast machine without remote controls is a dangerous practice that may result in serious injury or death to the blast operator or others.

In addition to their safety features, remote controls save substantial amounts of compressed air and abrasive. If the blast operator must wait for someone to shut off the machine, air and abrasive are squandered. Also, removing the need for a dedicated pot tender saves labor by allowing one person to load abrasive for several machines or do other work between refills.

Operating Principles

Two remote control operating principles are used in abrasive blasting. The popular pressure-release system allows the blast machine to depressurize each time the remote control handle is disengaged. The pressure-hold system shuts off air and abrasive flow to the nozzle without depressurizing the blast machine. Each has distinct advantages for particular applications.

Simple, pressure-release systems are widely used on single-operator machines. Pressing the remote control handle causes the machine to pressurize and blasting to start. Releasing the remote control handle stops the air supply to the blast machine, which depressurizes. Abrasive in the machine's concave head, or in an overhead storage hopper, automatically refills the machine.

Pressure-hold systems maintain air pressure in the machine even when blasting stops. On a multiple-operator machine, a pressure-hold system allows one operator to stop without affecting the other operator(s). Pressure-hold controls on a dual-chamber machine allow abrasive to transfer from the top to the bottom chamber without interrupting blasting.

Pressure-hold controls are sometimes installed on a single-operator blast machine if frequent on and off cycles might waste too much time in pressurizing and depressurizing.

The basic pressure-hold system does not allow automatic abrasive refilling. The blast machine must be manually depressurized to replenish the abrasive supply. There are, however, accessories that can automate the refilling process. These range from simple manually operated switches to electrically controlled timers and level indicators.

Major Components

Despite their different operating principles, pressure-release and pressure-hold systems share some components — including control handles and twin-line hose. Both pressure-release and pressure-hold systems can use either pneumatic or electric control handles.

Remote Control Handles

Most remote control valves operate pneumatically, but there is a choice between pneumatic or electric actuation. Pneumatic systems are suitable for most applications and usually cost less than electric systems.

Pneumatic remote control handles work well at distances up to 100 feet (30 meters). Electric remote control handles are recommended for distances of 150 feet (45 meters) or more.

Pneumatic Handle

Clemco's most popular pneumatic control design is simple and easy to maintain. Compressed air travels out one side of the twin-line hose and, when the control lever is pressed, travels back along the other line to activate the valves on the blast machine. When the lever is released, a safety lock prevents unintentional blasting. Either side of the twin-line hose can be connected to either fitting on the control handle because the air volume control orifice is located on the blast machine air inlet valve. This important feature reduces the risk of accident from crossed lines.

Pneumatic remote controls respond in about 5 seconds under normal circumstances and response time increases with distance, because there is more area to pressurize. At distances greater than 100 feet (30 meters), the response time can double.

Electric Handles

Electric controls respond almost instantly, and response times do not increase with distance. Use heavier electric cord at extreme distances, beyond 300 feet (90 meters), to ensure that the remote controls function properly. Operating at distances beyond 500 feet (1500 meters) is impractical.

Electric control handles function similar to the pneumatic type except that an encapsulated micro-switch replaces the pneumatic parts and electric cord replaces the twin-line hose. Electric control handles operate on 12-volt power for safety reasons. Control panels may be furnished for higher voltage service, but they will be equipped with reduction transformers so that only 12-volt power is supplied to the electric handles and cords. This prevents electric shock to the operator, which is especially important when working around water and during inclement weather. Low-voltage service also offers the convenience of using the air compressor battery as a power source.

Special care must be taken with control handles because they are the activating device for remote controls. Being installed at the nozzle subjects the handles to rough treatment, which results in damage and rapid wear. Inspect and test the handle function several times each work day. Be especially sure the lever and lever lock work properly. Clean the moving parts to prevent jamming, and replace rubber buttons and seals often to prevent air from escaping and abrasive from entering.

Remote Control Systems

Two types of remote control systems are commonly used on blast machines — pressure-hold and pressure-release.

Pressure-Release Systems

A pressure-release system uses two valves on the blast machine to start and stop blasting. The inlet valve controls air flow into the blast machine and pusher line, the outlet valve controls exhaust air. Both require compressed air to operate.

The air inlet valve is normally closed, meaning its internal mechanism is physically held closed by a spring. The air outlet valve is normally open. These valves are interconnected by moisture-resistant hose.

In Clemco systems, air to a pneumatic remote control system flows through a precisely sized orifice that regulates the volume of air to the control handle. This orifice ensures the controls receive the proper amount of air for optimum response times.

WARNING

Never substitute a different size orifice anywhere in a remote control system. An orifice that is too large or too small may cause unintentional blasting.

Air traveling back from the control handle pressurizes the chamber above the inlet and outlet valve pistons, overcoming the spring tension. This opens the inlet valve and closes the outlet valve, which pressurizes the machine and begins blasting.

Releasing the control handle releases the compressed air over the valve pistons to depressurize the blast machine.

Air turbulence during depressurization sometimes carries abrasive particles out of the blast machine through the outlet valve. An abrasive trap, usually installed just before the outlet valve, captures these particles to prevent damage to the outlet valve. Most abrasive traps have a replaceable screen which must be inspected and cleaned several times a day.

Pressure-Hold Systems

In a pressure-hold system the inlet valve is manually opened to pressurize the blast machine. Two valves, one in the external piping and one in the metering valve, are held closed by springs until compressed air from the remote control handle opens them. These normally-closed valves maintain pressure in the blast machine even when blasting has stopped.

Pressing the remote control handle opens both valves, almost simultaneously, to allow air and abrasive to flow to the nozzle.

Variations of the pressure-hold and pressure-release systems abound, but beware of systems that trade safety for convenience or low cost.

Abrasive Cut-Off Systems

An abrasive cut-off accessory lets the operator flip a switch on the remote control handle to close the abrasive metering valve but continue to use high-pressure air. Cut-off systems adapt to pressure-release and pressure-hold remote controls.

The cut-off accessory lets the operator air-clean the surface and remove spent abrasive from nooks and crannies. Used with a Wetblast injector, the cut-off switch lets the operator rinse away abrasive residue then dry the surface. It is also useful for clearing abrasive from inside the blast hose.

Note: Because some residual abrasive may remain in the blast hose, all the blasting safety requirements apply to air-only blasting. Wear a NIOSH approved respirator and protective clothing.

Control Lines

Different types of hose are used with different remote controls. When replacing control lines, use the hose specified by the manufacturer and connect it according to the instructions in the owner's manual.

Most remote controls use two hoses bonded together to form what is commonly called twin-line hose. Good twin-line hose is manufactured of high-grade neoprene rubber to resist deterioration and swelling from moisture and oil. The internal diameter is held to a uniform dimension through its entire length to ensure unrestricted air flow.

With Clemco's 3/16-inch (5 mm) ID twin-line hose remote systems, either side may be connected to fittings on the remote control inlet valve or control handle. This feature eliminates the danger of misconnection which could cause unintentional blasting.

Some systems use welding hose, which has two different-size hoses bonded together and requires two sizes of fittings. On some systems, the fittings must be connected in the exact manner specified by the equipment manufacturer or the remotes may not operate properly. Also, most welding hose is designed for use with clean, dry bottled gases. It may not have the moisture and oil resistant properties needed to stand up to compressed air, and may not have consistent ID throughout its length. Welding hose can be distinguished by the colors — one side red and the other side green.

Note: The European one-piece, twin-line hose has one side brown and the other side yellow. Some U.S. remote control systems, and the European version mentioned here, have specific connection requirements. To prevent injury from unintentional blasting always refer to manufacturer's instructions before connecting control hoses.

In both electric and pneumatic remote control handles the power source (electric current or air pressure) must complete a circuit to activate the remote control valves.

Electric

Most electrically operated remote control systems use cord rated for 12-volt service. A weatherproof outer cover protects the wiring from water and dirt to prevent short circuits. Short circuits are not a safety hazard, because terminal boxes signal remote control valves to stop blasting if power is interrupted. Tracing a short circuit can be inconvenient and time consuming, however, so install cords specifically constructed for the rigors of field use.

Safety Practices For Remote Controls

A blast machine propels abrasive particles to speeds in excess of 660 feet per second (200 meters per second). This high-speed abrasive can cause serious injury or death.

The following list includes general guidelines for using remote controls. Read the instruction manuals for each component before setting up or operating the system.

- Never modify, remove, or substitute parts in place of the original manufacturers' parts for any component of the system. This rule applies to even the simplest replacement pieces.
- Follow the instruction manual's recommendation for inspection, maintenance, and cleaning for each component.
- Never tape down or prevent free movement of the lever on the remote control handle. This defeats the safety purpose of the remote control system, and may cause serious injury if a nozzle is dropped.

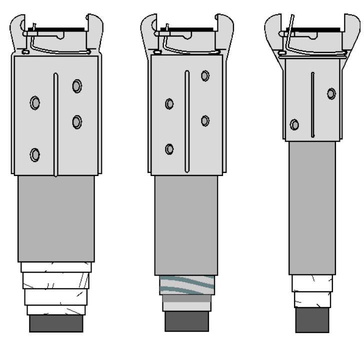
• Inspect and clean control hose line fittings before connecting them. Dust and dirt in the fittings will clog air passageways throughout the system and scar control valve cylinder walls. Use care when attaching the fittings to prevent cross threading. Always use a wrench to snugly tighten fittings.

Blast Hose and Couplings

Blast hose and couplings are vulnerable to rapid wear and tear due to the cutting action of high velocity abrasive on the inside, and harsh treatment and weathering on the outside.

Couplings rarely wear out. They do, however, break from rough handling or become crushed by vehicles.

The best way to keep costs in line and production high is to use appropriately sized, top-quality blast hose, specifically manufactured for abrasive blasting, and rated at the appropriate working pressure. Install top-quality couplings, made specifically for use with blast hose.



Types of hose, with couplings

Blast Hose

Blast hose has a thick, fabric-supported natural rubber and SBR tube, protected by a durable outer cover. Avoid hoses made from recycled rubber, because their mixed composition wears quickly and unevenly.

The inner tube in most blast hose is 1/4-inch thick (6.3 mm). Super-flexible blast hose, such as Clemco's Supa Hose, has an inner tube wall measuring just 3/16-inch (5 mm). Many blast operators install a whip hose, a 10-to-15-foot (3 to 4.5 m) length of this flexible hose, as the last section of their blast hose because it weighs less and bends easier.

Design Characteristics

Abrasive particles skimming along the inside of the blast hose can create static electricity. Static arcs flashing from the nozzle will not harm the blast operators but may startle them, possibly causing them to lose their footing. To prevent static electric sparks, manufacturers of quality blast hose treat the rubber inner tube with a static-dissipating compound.

For blast operators working in or near volatile fumes, such as in an oil storage tank, a spark can be deadly. In applications where fumes might be present, use static-dissipating hose and install grounding cables on the blast machine and nozzles.

Blast hose casing is made from tightly wrapped polyester, which withstands the air pressure inside and the rough handling outside. During manufacturing, the casing is pricked by thousands of tiny pins. The pin pricks prevent any air that escapes from the inner tube from forming air bubbles between the casing and tube. Such air bubbles, which usually occur where hose ends are improperly cut, could swell and burst the casing. If air bubbles appear, remove the coupling and recut the hose.

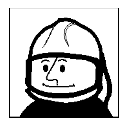
When installing couplings, cut the blast hose squarely to ensure a firm, uniform seal against the coupling shoulder. Abrasive that escapes around the end of a poorly cut hose will wear away the coupling wall. Place the hose in a miter box and use a fine-tooth saw to cut it as smoothly as possible. Pocket knives or similar devices will not produce a clean, square cut.

Like all hose, blast hose is pressure rated. Ratings differ among the three types of reinforcement specifications and by manufacturer. If, however, blast pressures exceed normal ratings, use hose and fittings specially manufactured for higher pressures to prevent rupturing. See Appendix for Blast Hose Rating Table.

Blast Hose Sizing

To efficiently convey air-driven abrasive from the blast machine to the nozzle, blast hose should have sufficient inner diameter and be kept as short as possible.

Blast hose inner diameter should be 3 to 4 times the size of the nozzle orifice.



Using a blast hose with an inner diameter that's smaller than the blast machine outlet diameter greatly reduces the amount of air and abrasive flowing to the nozzle. A blast machine with 1-1/4-inch piping (32 mm) feeding a 3/4-inch (19 mm) blast hose must overcome a 64-percent reduction in capacity. Air and abrasive are now being forced into an area that has one-third the capacity of the blast machine's external piping. This is not a problem if you also switch to a smaller nozzle — appropriate for the size of the hose. If you switch to a smaller hose and still try to use a nozzle that has a large orifice, nozzle pressure will drop dramatically.

For use with most abrasives, the blast hose inner diameter should be at least 3 times (preferably 4 times) the size of the nozzle orifice. For example, a 3/8-inch (9.5 mm) nozzle demands a minimum hose ID of 1-1/8-inch (28.5 mm). There is no 1-1/8-inch blast hose, so use the next larger size: 1-1/4-inch (32 mm).

Note: Metallic abrasives, such as steel or iron grit, provide the exception to the 3 to 4 times rule. Steel grit is two and half times heavier than common non-metallic abrasive. When blast hoses exceed 50 feet (15 m) some contractors use hose with a slightly smaller inner diameter to keep the heavy abrasive particles moving at a steady speed. To maintain pressure at the nozzle with the same size orifice and a smaller hose, the contractor must also switch to a compressor with a greater volume capacity. With metallic abrasive, the correct hose diameter is determined by volume and pressure of air, abrasive weight, hose length and severity of hose bends.

Because the hose ID will be 1-1/4-inch (32 mm), piping on the blast machine should also be at least 1-1/4-inch (32 mm).

With a larger nozzle orifice, maintaining the hose-to-nozzle ratio becomes more difficult. A 1/2-inch (12.5 mm) nozzle dictates use of a minimum hose ID of 1-1/2-inch (38 mm). An operator would find it hard to work all day with the bulk and weight of such a large hose. A short length of one-size-smaller hose, called a whip, can be used near the nozzle. Two-ply hose, such as Clemco's Supa Hose, is often used for whips.

Keep whip hoses as short as possible, preferably 10 to 15 feet (3 to 4.5 m) but no longer than 25 feet (7.6 m) Whip hose inner diameters should not be more than one size smaller than the main hose.

When using whip hose with long runs of blast hose, install the smaller ID hose in increments, keeping the smallest hose closest to the nozzle. Using an example of a 1/2-inch (12.5 mm) nozzle and hose distance of 125 feet (38 m), 100 feet (30 m) of hose from the blast machine should be 1-1/2-inch (38 mm) ID and 25 feet (7.6 m) should be 1-1/4-inch (32 mm) ID of whip hose prior to the nozzle. In cases where hose distance is unusually long and/or where 5/8 or 3/4-inch (16 or 19 mm)

Internal Area Loss Due to Hose Size Reduction

Main Hose Size		Whip Hose Size		Percent of
inches	metric	inches	metric	reduction
2	50mm	1-1/2	38mm	44%
2	50mm	1-1/4	32mm	61%
1-1/2	38mm	1-1/4	32mm	31%
1-1/2	38mm	1	25mm	56%
1-1/4	32mm	1	25mm	36%
1-1/4	32mm	3/4	19mm	64%
1	25mm	3/4	19mm	44%

nozzles are used, the majority of hose should be 2-inch (50mm) reduced to a transition section of 25 feet (7.6m) of 1-1/2-inch (38 mm), then coupled to 25 feet (7.6m) of 1-1/4-inch (32 mm) whip hose.

Note: Use of 5/8 or 3/4-inch (16 or 19 mm) nozzles and/or abnormally long hose lengths will require larger blast machine piping, valves and other components. Consult Clemco for requirements.

There is no reason to go below 1-1/4-inch (32 mm) on whip hoses because of the availability of Clemco's super flexible, 1-1/4 -inch (32 mm) Supa Hose. Many contractors accept quicker wear because the benefits of a large ID, light weight, and handling flexibility outweigh the reduced life of the hose. Supa hose is typically cut into 15 or 25 feet (4.5 or 7.6 m) sections to save cost of replacing an entire 50 feet (15 m) section. Always cut hose square and smooth.

Note: U.S. blast hoses are manufactured in 50-feet lengths (15 meters). Metric hose comes in standard lengths of 20 and 40 meters. Conversions in this booklet from feet to meters are for comparison only.

A blast hose's outer diameter is critical to the proper fit of the couplings.

The standard tolerance on outer diameters is plus or minus 1/16-inch (1.6 mm) over the entire length. High quality hose maintains a tolerance of plus or minus 1/32-inch (0.8 mm) on the first 18-inch (460 mm) section of each hose end with the balance of the hose within the standard tolerance. The tighter tolerance ensures a snug fit in couplings and nozzle holders, which also have a 1/16-inch (1.5mm) tolerance.

If a length of hose is produced on the low side of the tolerance and it is matched with a coupling that is cast or molded on the high side, the fit between the two parts may be too sloppy for a proper seal. Any leaks will cause nozzle pressure loss. If the leaks are substantial, there may be abnormal abrasive wear on hose and couplings.

Typical ID to OD Relationship in Common Blast Hose			
Standard Hose (2 Braid & 4 Ply) inches		**SUPA Hose** (Lightweight 2 Ply) inches	
ID	**OD**	**ID**	**OD**
1/2	1-3/16		
3/4	1-1/2	3/4	1-5/16
1	1-7/8	1	1-1/2
1-1/4	2-5/32	1-1/4	1-7/8
1-1/2	2-3/8		

Most important is the safety aspect. Excessive leakage of air and abrasive may cause unexpected failure of hose ends and couplings.

Always specify blast hose that meets U.S. industry standards for size and construction. Imported hose made to other standards may not fit U.S. standard couplings properly.

Friction Loss

Pressure loss is not the only problem with undersized hose. The smaller the internal area, the greater the wear. Abrasive particles want to flow in a straight path. When the path narrows, particles dig into the rubber wall at the point of reduction and begin to bounce and skim through the entire hose. This causes pressure drop called friction loss.

Pressure loss results from a combination of reduced hose size, bends and turns, and excessive length. Once hose length exceeds 100 ft. (30 m), use the next larger size hose.

Bends in the blast hose also cause friction loss. Air and abrasive flow better through a straight line. Even a gradual turn increases friction slightly, but having many sharp turns and bends will cause a noticeable drop in pressure and cause the hose to wear more rapidly at the bends.

Most job sites require bends and turns in the blast hose, but by making those turns as wide as possible you can increase hose life and reduce pressure loss.

Never blast with coiled hose as it will accelerate wear tremendously. Blast hose is the most frequently replaced component of a blast system. It represents a significant expense, making it well worth the time spent checking for proper size, length, layout, and connections.

Inspection and Care

Blast hose should be inspected daily. Damage may not be visible. Squeeze the hose every six inches (150 mm), feeling for places where the inner walls can touch. This indicates that most, if not all, of the rubber tube is worn away. Replace worn hose immediately. If the tube appears worn in an isolated area, cut out that area and re-couple the remaining hose.

If you discover a pin hole in the blast hose, stop blasting immediately and repair or replace the hose. Do not tape holes in blast hose. Tape is not an effective repair method. The hole will enlarge quickly and could cause a dangerous blow-out.

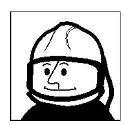
Weather, age, chemicals, and handling affect the outer casing. When you find evidence of cracking, peeling, or other disintegration, replace the entire hose section. The cover provides reinforcement against blow-outs and preserves the round shape of the rubber tube.

Check the end of the blast hose daily for wear. If the end is not square and smooth, remove the coupling and cut the hose. Worn ends allow abrasive leakage, which will destroy the hose and couplings.

At the end of each work day, turn off the abrasive at the metering valve and, while holding the nozzle firmly, remove residual abrasive from the hose by blowing compressed air through it. Abrasive can harden from moisture and clog the hose.

Blast hoses should be coiled and stored away from water, oil, and chemicals to prevent rotting.

If there is one element in a blast system that has a pay back for top quality, it is blast hose.



Buy top-quality blast hose and take proper care of it. It takes the brunt of destructive forces in the abrasive blasting process. Bargain-priced, inferior-quality blast hose offers false economy. It costs less to purchase, but wears quickly. Failure to inspect and care for blast hose can be extremely detrimental to production rates and budgets.

Couplings

Blast hose couplings and nozzle holders are available in brass alloy, aluminum alloy, and reinforced nylon in a variety of configurations. Much like blast hose, couplings and nozzle holders must withstand the rigors of field service.

Coupling Material

Choose couplings and holders based on their safety and suitability for job site conditions — not on their purchase price. Couplings and holders can become a major replacement expense if you choose the wrong type.

Brass is bulky, heavy and expensive, but is ideal for rough and tough usage. However, brass is soft and, therefore, can become crushed under heavy loads, such as trucks and forklifts.

Aluminum is lightweight but less durable and more brittle than brass and nylon. It should be used where vehicle traffic is absent.

Nylon offers the light weight of aluminum and the durability of brass, in addition to precise dimensional tolerances made possible through injection molding. Nylon's tight tolerances ensure that each piece will match precisely.

Nylon couplings are injection molded, a process which ensures consistent, precision crafted parts every time. All nylon dimensions are kept within tight tolerances so that each piece will match as precisely as possible. Nylon has "shape memory," which allows for heavy load deflection but rebounds to its original shape.

Brass and aluminum are sand cast. Sand castings require periodic tooling maintenance to preserve tolerances. Extra care must be taken when connecting two sand cast couplings due to variances in tooling wear.

Design Characteristics

Blast hose couplings have two locking lugs, identically formed to allow any two sizes of couplings to be firmly connected. Some couplings designed for 1-1/2-inch and 2-inch (38 and 50 mm) blast hose are specially cast with larger locking lugs to offer inner openings to match the large ID of the blast hose.

The compatible interlocking lugs are found on couplings for blast hoses ranging from 1/2-inch to 1-1/2-inch ID (12.5 to 38 mm). Do not, however, connect different brands of coupling, because each manufacturer's molds produce couplings with slightly different dimensions.

Manufacturers use threaded couplings to connect hose couplings to machines and specialty tool piping. These couplings are available in the same three materials and with the same type of locking lugs. In the United States, the tapered thread type conforms to the U. S. National Pipe Thread Standard (NPT) and are available from 1/2 to 2 inches (12.5 to 50 mm).

When two couplings are placed together for connection, gaskets in each coupling align and compress as the couplings are twisted into the locked position. It is important to maintain the compression between the gaskets. Worn gaskets can cause serious air pressure loss. Couplings can be worn to the point where the locking lugs no longer have the material and strength to hold together, ruining the coupling and disconnecting the blast hose.

Most blast hose coupling gaskets have a 1-1/4-inch (32 mm) ID to eliminate restrictions in the flow from one hose to another. Most gaskets have a lip that snaps into a recessed cavity in the coupling.

Coupling sleeves have molded internal protrusions — usually circular in brass and aluminum, spiral in nylon. Under pressure, the blast hose expands against these protrusions to create an airtight seal.

Installing Couplings

When installing couplings, use the size and type of screws recommended by the coupling manufacturer. Most use wood screws, which have the proper thread pitch and width to hold the rubber without ripping or tearing it. The length of the screws is calculated to provide sufficient holding power without penetrating the inner tube. Screws that pierce the inner tube will interfere with air flow and provide a means for abrasive to escape.

To ensure that the coupling screws fully engage the blast hose, insert a snug-fitting wooden dowel into the hose while tightening the screws. The dowel will prevent the hose wall from collapsing as the screws tighten.

As a safety feature, blast hose couplings have two holes on each flange. When couplings are connected, these holes line up to permit insertion of safety pins. These pins prevent accidental uncoupling. Nylon couplings have built-in, spring-assisted, steel safety pins. When nylon couplings are connected, the safety pins automatically snap into place. The built-in pins can never be lost or misplaced.

On metal couplings, safety pins must be installed manually.

Safety Cables

Blast hose safety cables prevent injury in the event the couplings disengage. The cables are braided, corrosion resistant steel, with spring loaded end loops. The loops are installed across the couplings, allowing just enough tension to keep from interfering with hose alignment yet keeping the weight off the coupling when the hose is run vertically.

As the interior of a blast hose wears, the screws in the couplings have less material to grip. The couplings themselves are subjected to abuse that can weaken locking lugs. Should a coupling fail or safety pins fall out, the safety cables prevent the blast hose from whipping wildly and possibly hurting someone.

Do not rely on rope to support vertical hoses. Rope will not hold hoses in straight lines, which hampers air and abrasive flow.

Safety Practices

Blast hose and couplings take a beating in normal use. They must withstand all types of weather, high pressure, high-speed abrasive, stretching, dragging, dropping, and vehicle and people traffic.

Listed below are some of the general inspections and actions that must be followed for safe and productive usage. Other federal, state, and local rules may also apply.

- Inspect hose couplings for wear and damage prior to each use.
- Check coupling fit. Avoid mixing different brands of couplings to prevent mismatching of locking lugs.
- Use the screws furnished by the coupling manufacturer.
- Check nozzle and coupling gaskets before each use. Replace frequently.
- Cut the hose square and smooth. Re-cut when any sign of wear appears.
- Ensure that hose end fits uniformly flush with coupling shoulder.
- Be sure nozzle holders and couplings fit snugly on blast hose. Reject those that are loose.
- Test entire length of hose daily. Remove soft spots.
- Replace hose that has damaged outer cover.
- Never use hose or couplings not specifically manufactured for abrasive blasting.
- Use only static-dissipating hose.
- Use hose that is 3 to 4 times the ID of the nozzle.

- Never exceed the blast hose's rated working pressure.
- Install safety pins on all couplings.
- Install safety cables at all coupling connections.
- Wear protective clothing to prevent injury in the event of a hose or coupling failure.

Blast Nozzles

The objective of everything up to this point is to convey a steady supply of abrasive at adequate pressure to the nozzle. Performance at the blast nozzle reveals whether or not all of the previous requirements for air and abrasive flow have been correctly followed.

Nozzles accelerate air-driven abrasive into a highly effective cutting force that can tackle the toughest application. The size, type and shape of the nozzle helps determine the production speed and the appearance of the end product. Investing in the appropriate nozzle for the application yields a substantial payback in productivity.

Nozzle Material

Nozzle material primarily affects wear life, which is more than just how long a nozzle will last; it is critical to air usage.

As the nozzle orifice wears, it uses more air volume to maintain a given air pressure. A nozzle with a 3/8-inch (9.5 mm) orifice operating at 100 psi (7 bar/689 kPa) requires about 200 cfm (5.5 m3/min). When the orifice enlarges by 1/16-inch (1.5 mm), the air requirement increases to more than 250 cfm (7.2 m3/min) — a 25-percent increase.

For this reason, replace a nozzle when its orifice is worn to 1/16-inch (1.5 mm) larger than its original size.

More importantly, in addition to wasting air, a nozzle worn beyond 1/16-inch (1.5 mm) could cause injury if the liner fails.

Common nozzle liner materials include ceramic, tungsten carbide, silicon carbide, silicon nitride and boron carbide.

Cast iron nozzles are rare, because they wear out after just 6 to 8 hours.

Ceramic nozzles are used with non-aggressive abrasive in light-duty equipment and in blast cabinets.

Carbide nozzles — tungsten, silicon, and boron — are most popular for the majority of blasting applications, due to their long life. The nozzle wear comparisons below are based on expendable abrasive. The type of abrasive and the pressure used, will affect your actual nozzle life.

Tungsten carbide is a hard, heavy material used in many industries for wear resistance. Tungsten carbide is sintered, a process that uses extreme heat and pressure to produce one-piece liners in a mold. Sintering, however, contributes to the nozzle liner's brittleness. Tungsten carbide nozzles last about 300 hours when used with expendable abrasive.

Silicon carbide grew from research on lightweight and durable materials for aircraft and aerospace industries. A silicon carbide nozzle weighs 42 percent less than a comparable tungsten carbide nozzle, making it easier to hold for a long time. With expendable abrasive, silicon carbide lasts up to 500 hours, which is 50 to 65 percent longer than tungsten carbide.

Boron carbide is the longest wearing nozzle liner material. It is especially effective when using extremely sharp abrasive such as aluminum oxide and silicon carbide. With expendable abrasive, boron carbide lasts up to 1000 hours. The purchase price for boron carbide is 2 to 3 times that for silicon and tungsten, however, the cost per operating hour may be less compared to tungsten, or more compared to silicon.

Some liner materials are better suited for specific abrasives. Choose a boron carbide nozzle when using aluminum oxide or silicon carbide abrasive. Boron tolerates extremely sharp particles better.

For steel grit, steel shot, or any iron abrasive, use a tungsten carbide nozzle. The high density of steel abrasive causes chipping on other carbide liner materials.

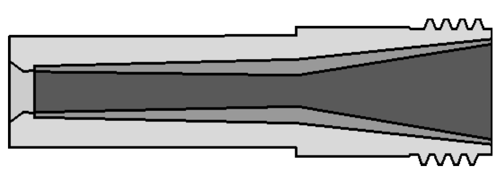
All carbide nozzle liners are brittle. For protection, all nozzle liners are encased in a jacket, usually made from metal, urethane, or rubber.

Nozzle Shape

Most contractors use blast nozzles with wide cone-shaped entrances and more gradually tapered exits, which together form a venturi. The venturi's length, angles of entrance and exit, and orifice size are precisely calculated to provide maximum acceleration of the abrasive and air.

Abrasive enters the converging end of the nozzle, funnels through the orifice, then rapidly expands into a high-powered stream through the diverging exit end. At 100 psi (7 bar/689 kPa), the velocity at the end of the nozzle reaches 660 feet per second (200 meters per second) — nearly the speed of sound. By comparison, abrasive exits a straight barrel nozzle at 318 feet per second (97 meters per second).

As a venturi nozzle wears beyond 1/16-inch (1.5mm) over its original size, it loses its venturi shape and much of the accelerating force that shape provided. An extremely worn venturi nozzle wastes air, and delivers a blast velocity and pattern comparable to a straight-barrel nozzle.



Cutaway illustration: venturi nozzle

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A well-designed venturi nozzle has precise inlet, orifice and outlet dimensions to accelerate the abrasive and disperse it uniformly within the blast pattern — with no scatter and no "hot spots." This provides consistent cleaning results over the entire surface.

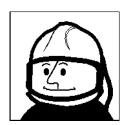
Poorly designed venturi nozzles, where the inlet and outlet angles have not been accurately calculated, allow the abrasive particles to fan out in a "shotgun" spray that leaves many areas untouched. These wide, sparse blast patterns often require that you over-blast the edges of the pattern, which wastes time and abrasive.

The "super colossal" nozzles, with unusually large blast patterns, often produce disappointing results.

Nozzle Orifice and Length

The nozzle orifice dictates the amount of compressed air required for blasting. The larger the orifice; the higher the production and the more air consumed. Use the largest nozzle the air compressor can support.

Abrasive blasting requires a constant, steady flow of air at high pressure; no other air tool demands as much from a compressor.



The compressor must supply the blast nozzles, helmets, and other accessories, plus have enough reserve to compensate for nozzle wear and for friction and pressure loss throughout the system.

The following chart shows the effect of nozzle wear on air consumption.

See Appendix for the Minimum Air Volume Requirements Table.

Effect of Nozzle Wear on Air Consumption

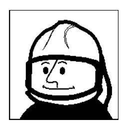
Nozzle Size.	Orifice size inches	Orifice size metric	Air Flow in cfm	Increase in Air Consumption
4	1/4	6.5mm	81 cfm	
5	5/16	8.0mm	137 cfm	**69%** more than No. 4
6	3/8	9.5mm	196 cfm	**43%** more than No. 5
7	7/16	11.0mm	254 cfm	**29%** more than No. 6
8	1/2	12.5mm	338 cfm	**33%** more than No. 7

Information shown is based upon air consumption at 100 psi (7 bar/700kPa)

Air compressors are not sized in the exact increments shown, so use the next larger compressor.

Pressure loss — whether from nozzle wear, hose restrictions, or compressor problems — will decrease productivity.

Most contractors use a rule of thumb that each one-pound drop in nozzle pressure causes a 1-1/2 percent reduction in productivity.



At 100 psi (7 bar/700 kPa), a one-pound drop in nozzle pressure reduces productivity by 1-1/2 percent. At lower blasting pressures, the productivity loss is less dramatic, but still costly.

Therefore a 10-pound (.7 bar/70 kPa) loss in pressure reduces productivity by about 15 percent. This loss in productivity can add more than an hour of overtime to a typical 8-hour day. Compressed air is expensive, but the added labor, scheduling delays, and cost overruns caused by falling productivity will quickly outweigh the cost of the larger compressor. When compressor capacity is limited, the pressure drop is dramatic.

While nozzle wear can decrease pressure and hinder productivity, the ability to maintain pressure while using a larger nozzle will increase production and efficiency remarkably. Of course, all the blast system components must be sized to handle the higher volume of air and abrasive.

Emphasizing the pressure loss rule of thumb, refer to the Nozzle Chart at the end of this booklet.

A 5/16-inch (8 mm) nozzle requires 137 cfm of air at 100 psi (3.9 m3/min at 7 bar/700 kPa). When the nozzle wears by 1/16-inch (1.5 mm), it becomes equivalent to a 3/4-inch (9.5mm) nozzle 196 cfm at 100 psi (5.5 m3/min at 7 bar/700 kPa). If your compressor is only able to supply 137 cfm (3.9 m3/min), the nozzle pressure will drop to between 60 and 70 psi (4.1 and 4.8 bar [414 and 483 kPa]), reducing the production rate by as much as 50 percent. Nozzles will wear, therefore, it is vital to have an adequate reserve of compressed air to maintain high pressure.

Nozzle lengths vary by application. Short, straight-barrel nozzles, from 1-1/2 to 2-inches (38 to 50 mm), are used with blast cabinets and small blast machines, or wherever the distance between the nozzle and the surface is short.

Short venturi nozzles, about 3-inches (76 mm) long, are appropriate for high-production blasting at close distances — 12 inches (300 mm) on steel, 18 inches (460 mm) on concrete and other soft surfaces.

Long venturi nozzles, range from 4 to 9 inches (100 to 230 mm). The longer the nozzle; the larger the orifice. Long venturi nozzles allow high-production blasting on any surface at distances of 18 to 24 inches (460 to 610 mm) for hard-to-clean surfaces, and 30 to 36 inches (760 to 915 mm) for loose paint and soft surface.

Nozzle Pressure

Maintaining adequate nozzle pressure is essential to high-production blasting. The gauge on the compressor shows the air pressure at the compressor only. It does not indicate blasting pressure.

Hoses, air filters, blast machines, and other components between the compressor and the nozzle all contribute to friction and pressure losses.

To accurately determine nozzle pressure, use a hypodermic needle gauge. This simple tool consists of a needle mounted on a pressure gauge.

Insert the needle into the blast hose at a 45 degree angle, about six inches (150 mm) behind the nozzle holder, with the tip of the needle pointing toward the nozzle. The needle should penetrate enough to position the tip into the center of the air stream. The gauge will register the actual pressure at the nozzle.

For example, blasting on structural steel usually demands nozzle pressures of 100 to 110 psi (7 bar/700 kPa to 7.6 bar/758 kPa). In normal field practice, however, contractors accept anything between 90 and 100 psi (6.2 and 7 bar/620 and 689 kPa). In a blast system with 50 feet (15 m) each of blast hose and air hose, a pressure drop of 10 to 15 psi (0.7 to I bar/7 to 100 kPa) is expected.

Nozzle pressure below 85 psi (5.9 bar/585 kPa) indicates something wrong in the system. Check the air compressor pressure setting, then check for restrictions at all hoses and fittings, moisture separators, and any system components. Also check the nozzle orifice for excessive wear.

Attachment and Inlets

Nozzles come with contractor threads, standard fine threads, or flanges.

Contractor threads allow the nozzle to be installed or removed without tools. Their wide, deep pitched threads prevent galling by trapped dust, dirt and abrasive particles and provide more "meat" to firmly hold the nozzle.

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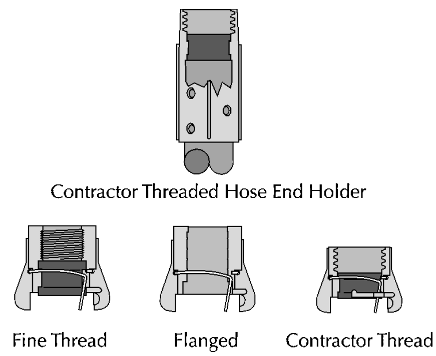
Holders

Two types of nozzle holders are commonly used for blasting — threaded hose-end holders and quick coupling holders.



Typical Nozzle Holders

The most popular, threaded hose-end nozzle holders, fasten to the end of blast hose the same way couplings do and the nozzles thread directly into them.

The second type, quick coupling holders, connects to already coupled hose.

Threaded nozzle holders, available in contractor thread and fine thread, are lightweight and easy to handle.

Quick-coupling nozzle holders attach to any blast hose fitted with compatible interlocking couplings. They are available to fit nozzles with contractor threads, standard threads, or flanges.

Quick-coupling nozzle holders are used by contractors who have all their blast hoses assembled with couplings at both ends, because it is easier to add and remove hose as needed.

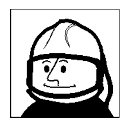
Whatever the method of attaching the nozzle, the nozzle inlet must be sized to allow a smooth transition from the blast hosae to the nozzle. Most contractors use nozzles with either a 1-inch or 1-1/4-inch (25mm or 32mm) entry. A 1-1/4-inch (32mm) entry nozzle actually cleans faster than a 1-inch (25mm) nozzle of the same orifice size. Whatever the nozzle inlet size, the blast hose leading up to it should be the same size.

Gaskets

Nozzles are expensive; nozzle gaskets are cheap. Using a worn gasket or worse yet, no gasket, allows the air-driven abrasive to destroy the nozzle jacket and the nozzle holder.

Check all gaskets daily and replace only with gaskets of the proper diameter to maintain a smooth flow from the hose to the nozzle.

It is amazing what costly problems are generated by the lack of a good rubber gasket.



Most nozzles are destroyed before they reach the end of their useful life, primarily due to careless handling. The same extreme hardness that helps nozzle liners withstand abrasive flow makes them brittle. Nozzles cannot survive being thrown about on job sites. With proper care, a nozzle can fulfill its expected productive existence.

Safety Practices For Nozzles

- When blasting, point the nozzle only at the structure being blasted. High-velocity abrasive can inflict serious injury.
- Measure the nozzle orifice each day. Replace any nozzle worn 1/16-inch (1.5mm) beyond its original size.
- Inspect the nozzle and liner daily. Replace any that show cracks on the jacket or liner or that have deep gouges in the liner.
- Check the nozzle threads for wear.
- Use nozzle washers, and replace them when they show signs of wear.

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Operator Safety Equipment

Blasting can be dangerous for a poorly trained, poorly equipped operator. A blast machine produces a powerful stream of sharp particles that, in addition to cleaning a surface, creates clouds of potentially toxic dust. To prevent a variety of injuries and illness, personal safety equipment is absolutely necessary for blast operators and anyone in the work area.

Regulations

Throughout the world, laws govern abrasive blasting safety. Most countries use safety standards similar to U.S. standards.

In the U.S., the Occupational Safety and Health Administration (OSHA) enforces the regulations pertaining to the safe operation of abrasive blast equipment.

Respirators, such as air-fed helmets and hoods and pressure-demand full-face models, must be tested and approved by the OSHA departments of the National Institute of Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA).

Always, consult with local safety agencies for current regulations.

Blast operators who are properly trained and fitted with the best safety and comfort equipment will be much more confident and efficient.

Hazards of Blasting

Potential hazards of abrasive blasting include high-pressure compressed air throughout the system, air-propelled abrasive from the nozzle, impurities in the breathing air, toxic dust from pulverized abrasive and coatings, loud noises from blast nozzles and compressor motors, head impact injuries from beams and equipment, plus all the other hazards normally associated with construction sites.

Do not rely solely on the safety information in this booklet. Technology changes, so use state-of the-art safety equipment and heed the instructions in the manuals.

Dust from coatings being removed may contain lead, which is extremely dangerous to the operator and anyone else in the vicinity. Often, structures have several layers of unidentified, potentially toxic coatings; therefore, everyone in and around the blast site must wear approved respirators.

Lead dust on skin and clothing must be removed prior to meals or smoking breaks and before employees leave the blast site. When inhaled or ingested, lead dust can cause brain disorders, infertility, high blood pressure, and other diseases.

Most dangerous to the respiratory system are tiny, easily inhaled dust particles. They linger in the air until they settle to the ground or are drawn out of the blast site by exhaust fans. Airborne dust results from loading and recovering abrasive, removing clothing, and other activities before or after blasting. Though workers are protected while wearing air-fed helmets, they can be exposed to dangerous levels of invisible dust once the helmets come off.

Safety Practices

Block off the blasting site and surrounding area to prevent unprotected personnel from entering. Safety personnel should monitor atmospheric dust to determine the size of the blasting zone. Weather, humidity, wind direction and velocity, abrasive composition, type of material being removed and other factors determine the extent of the zone. Periodically test the atmosphere and adjust the size of the zone.

In enclosures such as tanks and blast rooms, all personnel must wear approved respirators 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 (Ref: OSHA 29 CFR 1910.1000).

Do not use silica sand for abrasive blasting, especially in enclosed areas, because it generates harmful dust.

OSHA enforces stringent regulations on supplied-air respirators and pressure-demand respirators for abrasive blasting. All manufacturers must submit their respirators to NIOSH, OSHA's agency for testing, to obtain approval. Manufacturers must display a copy of the approval certificate in their instruction manual. Using, a non-approved respirator violates OSHA regulations, and subjects the respirator's owner to stiff penalties.

Employers must supply all required safety clothing and decontamination equipment, and enforce their use. Also, employers must train their employees — even when that means reading the instructions to the illiterate and translating instructions into foreign languages.

For additional information on abrasive blasting and regulations contact the professional organizations and agencies listed in the reference section.

Air-Fed Helmets

OSHA defines an air-fed helmet for abrasive blasting as a continuous-flow, supplied-air respirator. On job sites where concentrations of toxic dust exceed the level of protection provided by a continuous-flow respirator, OSHA requires that each operator use a pressure-demand respirator — which is worn over the operator's face inside a special supplied-air respirator. To avoid confusion, we will refer to all respirators as air-fed helmets or, sometimes, simply as helmets.

An air-fed helmet should furnish the operator with breathing air, protect his or her head and face from rebounding abrasive and from impacts, muffle noise, and allow an unobstructed field of vision.

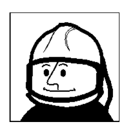
OSHA regulations dictate that noise levels generated by the respirator at maximum air flow and measured inside an air-fed helmet not exceed 80 dBA (decibels on the "A" scale). Approved helmets conform to the OSHA regulations, but job site noise, primarily from blast nozzles, usually exceeds the permissible level, therefore, operators must wear hearing protection appropriate to the surrounding environment.

The helmet window lens protects the operator's face from rebounding abrasive. NIOSH requires a single lens of at least .040 inch (.01 mm) thick.

Most helmets have a frame to hold several thin, sacrificial lens covers, which protect the thick inner lens. Clemco's thin lenses have tabs and perforated borders that permit the operator to tear away the outermost lens, when it becomes frosted, to expose another lens.

High-quality lenses are essential for clear visibility and comfort. NIOSH requires that all replacement helmet components, including lenses, be identical to the originals specified by the manufacturer. Lenses cut from locally purchased sheets of clear plastic may have poor optical quality. This can cause headaches and eye strain, which can seriously affect the operator's performance.

There is no logical justification to save a few pennies by using cheap plastic lenses. They cause operator discomfort, reduce operator performance, affect surface finish, violate NIOSH approval, and void the manufacturer's warranty on the complete helmet system.



Using any helmet component not specified by the manufacturer voids the NIOSH approval and the manufacturer's warranty. (Ref: OSHA 29 CFR 1910.134.)

A helmet with a wide, tall window provides the operator with a great field of vision. This makes the operator more likely to see obstacles which may hinder his movement. Helmets equipped with pressure-demand respirators usually have a smaller view area.

A properly adjusted helmet chin strap holds the helmet securely on and ensures that it turns with the operator's head. Without a chin strap, you may turn your head and find yourself looking at the side wall of the helmet.

The helmet cape protects the operator's upper body from rebounding abrasive. The cape requires periodic cleaning, frequent inspection, and immediate replacement if damaged.

Most capes have an inner collar made from porous elastic cloth that fits snugly around the operator's neck. It allows air to escape at about the rate it enters from the air line, maintaining positive pressure in the helmet. This continuous air flow helps block dust and abrasive from entering. In Clemco's Apollo 60 helmets, the inner collars can be removed for laundering or replacement.

The wear-resistant cape protects the operator from rebounding abrasive and helps keep dust and abrasive out of the helmet and blast suit. Replace the cape when it shows wear, especially when holes appear near the point where it connects to the helmet. Holes in this area can allow dust to enter the helmet. When purchasing a replacement cape, make sure the method of attachment matches your helmet.

Air Supply Hose

An air supply hose connects the air control valve or orifice to the helmet air inlet. This hose is flexible so it will not interfere with head movement. Never carry the helmet by the air hose. This results in leaks that waste compressed air and reduce the amount of air reaching the operator. Clemco helmets come with a carrying handle or strap. If the air supply hose becomes damaged or starts to leak, replace it with the exact same type of hose from the same manufacturer. Air supply hose for blast helmets contains baffles and muffling material that reduce compressed air noise inside the helmet.

Breathing Air Hose

Breathing air hose, which carries air from the air filter to the air control valve, must meet NIOSH specifications for size, strength, composition, and manufacturing techniques. Such hose carries a NIOSH-approval stamp.

Note: Breathing air hose in Europe must be green to distinguish it from standard air hose.

Most air-fed helmets have control valves set to supply a minimum of 6 cfm to a maximum of 15 cfm (0.2 to 0.4m3/min) of air, as required by NIOSH. This air flow will maintain positive pressure inside the helmet, which prevents dust from entering. An operator may adjust the helmet air flow within these ranges but can neither shut off the air completely, nor exceed 15 cfm (0.4m3/min). Some helmets have a fixed orifice that ensures proper airflow, but does not allow adjustment

Never modify an air valve or substitute any other type of valve. Doing so will violate the NIOSH approval and void the manufacturer's warranty.

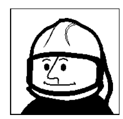
Some helmets have a fixed orifice that ensures proper airflow, but does not allow adjustment.

Special Helmets

For blast environments where high concentrations of lead dust are anticipated, choose a type-CE respirator that can operate in pressure demand mode. This respirator includes a separate face mask which is worn inside the respirator hood. The mask seals tightly to the blast operator's face. Air, which is fed from the same breathing air source supplying the hood, enters the mask and is discharged through an exhalation valve. The mask is kept under positive pressure, relative to the outside air. The positive pressure inside the mask prevents lead dust from entering.

Even with this added protection, blast operators should not be exposed unnecessarily to high concentrations of dust. Where possible, set up field enclosure ventilation to quickly move dust away from the operators.

To ensure the respirator functions as designed and provides the highest level of safety and comfort, you must follow the maintenance schedule in the owner's manual.



Severe applications may call for even more frequent maintenance than called for by the manufacturer.

No one should use a respirator without being trained on its operation, upkeep, and care. Untrained personnel can injure themselves and damage equipment.

Helmet Air Temperature Valves

Two types of optional air control valves may be used in place of the standard air control valve. One valve cools the air; the other cools or warms it.

When the air outside is warm and the compressed air is hot, a valve such as Clemco's Cool Air Tube, can reduce the temperature of the air entering the helmet by approximately 30 degrees. A heat/cool valve, such as Clemco's Climate Control Tube, can direct either cool or warm air into the helmet. These valves allow temperature adjustment, but may or may not allow volume adjustment.

Temperature control valves do not heat or cool air. They take the incoming compressed air, and separate the hot air from the cold air by means of a vortex. The cold valves discharge the hot air and send the cold air to the helmet. The hot/cold valves can be adjusted to send hot or cold air to the helmet.

Blast operators work more efficiently when they are supplied with air at a comfortable temperature.

Air temperature valves are also tested and approved by NIOSH with the original manufacturer's helmet. Do not mix different brands of valves and helmets, because substitution voids the NIOSH approval.

Clemco's air temperature valves increase the amount of air consumed per helmet to 20 cfm (0.6 m3/min) at 90 to 100 psi (6.2 to 7 bar/620 to 689 kPa). As with standard air control valves, temperature control valves must furnish at least 6 cfm (0.2m3/min.) and not more than 15 cfm (0.4m3/min.) to the helmet, and must not allow the operator to shut off the air completely.

Ambient Air Pumps

Ambient air pumps are electrically driven systems that do not use oil, so they will not produce carbon monoxide or put oil in air lines. They are used with helmets specifically designed for low-pressure air supplies. As with compressors, air pumps must be placed where engine exhaust or other contamination will not enter the air inlet. Air pumps have integral air filters on the inlet and outlet, so no additional filters are necessary. Most ambient air pumps produce heat, so they may not be suitable for warm climates.

Helmet Air Supply

Air furnished to helmets must be clean, dry, contamination-free and at NIOSH prescribed pressure and volume. Pay special attention to the source, filtration, and composition of the air. Read all instructions for the equipment used to produce and convey breathing air.

WARNING

Read and follow the instructions supplied with your respirator. Failure to comply with all installation, operation, and maintenance instructions will result in serious injury or death.

Sources for breathing air range from personal air cylinders to large air compressors. No matter the source, breathing air must meet strict standards.

Never attach a breathing air hose to any source without first testing the quality of air.

Breathing air must meet the minimum requirements, Grade D or higher, described in the Compressed Gas Association Commodity specifications G 7.1.

See the Reference Section for more details and Ref. OSHA 42 CFR 84.14,1. Requirements for Grade D breathing air include:

Oxygen Content . . . . *19.5% min. to 23.5% max.*
Oil (condensed). . . . . *5mg/m3max.*
Carbon Monoxide . . . . . *10 parts per million max.*
Carbon Dioxide . . . . *1000 parts per million* ***max.***

Breathing air must contain no toxic contaminants at levels which would make the air unsafe to breathe.

Air Cylinders

An air cylinder, fitted with a pressure regulator, can supply breathing air in remote areas, or when a contractor prefers the extra insurance of contamination-free air. These cylinders must be obtained from qualified suppliers who certify that they meet or exceed Grade D specifications.

Never use oxygen tanks to supply breathing air. Breathing air contains about 20 percent oxygen, but is predominantly nitrogen with other gases. Prolonged exposure to high concentrations of oxygen damages the tissue in the lungs and eyes.

Air Pumps

Electric, oil-free air pumps supply breathing air to low-pressure (up to 15 psi [1 bar/103 Val]) helmets. Air pumps are small and lightweight and can be moved easily.

Air pumps do not compress air; they merely draw in ambient air, normally 14.7 psi (1 bar/100 kPa), and push it through the hose, therefore, they cannot exceed 15 psi.

Air pumps will not produce carbon monoxide. The insides of an air pump are coated with friction-resistant materials, so they require no lubricants. Lubricants in compressors are the primary source of carbon monoxide. Because they have built-in filters, air pumps do not need overheating shutdown devices or in-line filters. Clemco air pumps are available in single- and multi-operator models.

Lubricated Air Compressors

Some contractors use one compressor to supply breathing air and blast air. The most common compressors use oil to lubricate the air-generating component. Air compressors for blasting are covered earlier in this booklet. This section will discuss breathing air requirements.

Take extra precautions when lubricated compressors supply your breathing air.

Many lubricated compressors now carry a warning label stating that they must not be used to supply breathing air.

OSHA regulations require a high-temperature alarm, carbon monoxide alarm, or both. If only a high-temperature alarm is installed, test the air frequently to ensure it meets Grade D specifications and is free of carbon monoxide. Install appropriate filters to capture particulate matter, oil mist, and moisture.

Position the compressor's air inlet away from all sources of toxic gases and smoke, including engine exhaust and burn barrels. Service compressors and related components according to the manufacturer's recommended schedule.

⚠ WARNING

Do not use piston-type, oil-bath, compressors for breathing air. They can produce unacceptable levels of carbon monoxide which will kill.

Oil-less Air Compressors

The best compressors for high-pressure breathing air do not require lubricants. They do not create carbon monoxide or contaminate the air with oil.

Oil-less compressors are available in portable and stationary models, in capacities to support different operator and equipment needs. They usually have pre- and after-filters to remove particulate matter and moisture.

Stationary compressors often incorporate air dryers, aftercoolers or both, to ensure clean, dry air.

Oil-less air compressors cost more than other compressors but their advantages far outweigh the added cost.

Air Filters

OSHA requires that compressors used to supply air to respirators be of the breathing air type and supply Grade D air. OSHA also requires inline filters to further assure breathing air quality. (Ref: OSHA 29 CFR 1910.134.) The filter removes oil mists, water vapor and particles larger than 0.5 micron. Filters that do not meet these specifications should not be used for breathing air.

Use high-capacity, super-efficient filters specifically designed for breathing air systems. These filters should have easily replaceable cartridges.

The filter has to be able to pass sufficient air volume (cfm) to supply all the respirators connected to it.

The filter must have a pressure regulator and gauge, not only to regulate the air pressure, but also to indicate when the cartridge needs replacement, The gauge will show declining pressure as the cartridge becomes saturated with liquid and solid matter.

A pressure relief valve on the filter exhausts air if excess pressure is fed to the filter.

Choosing a small, inefficient filter is false economy. Such filters allow dirt, oil, and water to clog the air passages and ruin the sound-deadening materials in respirators. This reduces air flow and introduces unpleasant odors.

There are limits to the cleaning capacities of any air filter. An old, worn, poorly maintained compressor will discharge abnormal amounts of contaminants. In extreme heat and humidity, compressed air can contain a lot of water vapor that quickly condenses in the lines and filter. Small filters cannot handle large volumes of oil and water for very long. Install pre-filters and expansion tanks to remove excess liquid to preserve the effectiveness of the filter cartridge.

Install air dryers or after coolers where environmental conditions produce large quantities of water in compressed air. Typically, fixed blasting installations employ breathing air stations consisting of an air dryer, after-cooler, air receiver tank, carbon monoxide alarm, and cartridge filters. These components, when properly maintained, eliminate the possibility of contaminated breathing air.

Carbon Monoxide Alarms and Converters

Oil-lubricated air compressors sometimes produce carbon monoxide (CO), a colorless, odorless, deadly gas. To help prevent operator exposure to carbon monoxide, service the compressor at the manufacturer's recommended intervals, and install overheating shut-off devices and/or carbon monoxide alarms.

If only an overheating alarm is used, OSHA regulations require that the air be frequently tested for carbon monoxide. (Ref: OSHA 29 CFR 1910.134.) Because even brief exposure to high concentrations of CO can kill, Clemco recommends that you install equipment to alert the operator if the amount of CO exceeds safe levels.

There are two different approaches to protecting workers from carbon monoxide — each using vastly different technology. One monitors the air supply and triggers an alarm if carbon monoxide reaches an unacceptable level. The other converts carbon monoxide to carbon dioxide.

Alarms

A carbon monoxide monitor/alarm continuously tests air samples for carbon monoxide (CO). These electrically-or battery-operated systems measure the amount of carbon monoxide (CO) in the air line and trigger alarms if the gas exceeds the permissible level of 10 parts per million (ppm). Ten ppm is the maximum exposure limit in the USA; exposure limits may differ in other countries. Most systems activate some combination of visible, audible, and vibratory alarm when concentrations exceed the permissible limit.

Converters

Carbon monoxide converters use chemicals to change carbon monoxide to carbon dioxide (CO2). The human respiratory system can tolerate much more CO2 than CO. The permissible level of CO2 is 1000 ppm whereas CO is only 10 ppm. These electrically operated units include elaborate air drying and moisture-purging equipment to keep the reactive conversion chemicals dry.

CO converters incorporate alarms similar to CO monitors. If the alarm sounds, check the source of the compressed air for high concentrations of CO.

Protective Clothing

High-velocity abrasive can inflict serious injury upon an unprotected operator. OSHA regulation 29

CFR 1910.94 and 1910.134 require that operators wear canvas or leather gloves and aprons or the equivalent. If the operator will be around heavy pieces of work, safety shoes are required as well.

Lightweight clothing does not provide sufficient protection for blast operators. Heavy-duty clothing protects against ricocheting abrasive and against momentary direct blasts from the nozzle.

High-quality blast suits have leather over the areas exposed to rebounding abrasive, usually including the sleeves and the front area from the waist to the ankles.

The blast operator's chest usually is shielded by the helmet cape. The back of the suit, which needs less protection, usually is made from lighter weight material, such as woven cotton. To keep out dust and abrasive, a suit should have leather or elastic straps at the wrist and ankles, and overlapping flaps at all suit closures.

The best blast suits combine light weight, durability, and protection. Usually all-leather or all-rubber suits are too hot and heavy to allow the operator to work for long.

For rentals and other applications, where long blast suit life is not critical, some contractors opt for lighter-weight suits without the leather reinforced panels.

Communication Equipment

An age-old method of getting a blaster's attention is to shut down the blast machine. The blaster then has to remove the air-fed helmet to hear and respond to what is being said — possibly exposing the operator to toxic dust. Communication problems are compounded when the blast operator is in a tank or other enclosure.

To overcome these problems, use battery-operated radio sets, specifically designed for blasting. Standard walkie-talkies will not work. Blasting often takes place in noisy, enclosed steel structures, sometimes surrounded by electrically operated equipment that can interfere with radio signals.

Radio sets allow a supervisor to communicate with several blasters under noise conditions as high as 130 decibels (dBA) and at varying distances.

Helmet communicators can speed training of new operators and increase the productivity of experienced operators. One person can communicate with several operators, coordinating movement through the work area, pointing out missed areas, and announcing breaks, shift changes, or impending bad weather.

Communication is more than a convenience. It is a valuable safety feature when blasters work outside visual range. Blasters can alert their supervisors to any trouble. The time-saving and safety benefits make communication equipment a wise investment.

Regulations for Operator Safety Equipment

Everyone involved in abrasive blasting must learn and apply safety practices and use proper safety equipment.

The Occupational Safety & Health Administration (OSHA) not only specifies equipment and operating procedures, but they also require that you adhere to manufacturers' recommended maintenance schedules and carefully document all maintenance procedures.

⚠ WARNING

Failure to use required safety equipment, misuse of safety equipment, or use of poorly maintained safety equipment will cause serious injury or death.

Safety equipment is only as effective as the quality of service it receives. For example, tape is not an adequate repair for a worn or leaking air-fed helmet.

Federal law requires that respirators for abrasive blasting be approved by NIOSH. This includes helmets, air control valves, air temperature valves, breathing-air supply hoses, and each part of the components listed. OSHA Ref: 30 CFR 11.2(a) and NIOSH do not permit substitution or modification of any parts on respirators.

OSHA Ref: 29 CFR 1910.94 and 1910.132 - 1910.140 also specify breathing air quality, air filters, gas detection equipment, air valves, air fittings and related parts.

Most helmets for abrasive blasting are classified by NIOSH as Type C and CE, continuous flow or pressure demand, supplied-air respirators. These respirators are also approved by the Mine Safety and Health Administration (MSHA).

Air-fed helmets are approved for respiratory protection in any atmosphere not immediately dangerous to life or health with at least 19.5 percent oxygen, and from which the wearer can escape without the aid of the respirator.

A supplied-air respirator alone may not be suitable in every blasting application. Depending on the ventilation, dust concentrations from lead-based paints and other toxic materials can exceed the protection factor of a standard air-fed helmet. When this occurs, use an air-fed respirator that allows room to wear a pressure-demand, full-face respirator. The regulations regarding permissible exposure limits (PEL) to toxic materials change often. For up-to-date information, check the current edition of the Code of Federal Regulations (CFR), or consult a reputable expert on industrial safety and hygiene.

Investigate and identify all materials to be removed from surfaces and any ambient contamination in the work area, then provide appropriate protection for everyone entering the blast site.

In addition to federal regulations, state, local, and job site directives must be followed. The employer is responsible for complying with all job safety requirements prior to initiating any work. While OSHA cannot enforce regulations outside of this country, most nations have similar rules. Irrespective of regulations, employers have a moral duty to protect their employees with the best possible safety equipment.

Safety Practices for Operator Safety Equipment

Helmets

- Always wear NIOSH-approved, supplied-air respirators and keep them properly maintained.
- Before connecting the respirator to any air source test the source to ensure it provides clean, dry, Grade D Breathing Air.
- Never drop a helmet or leave it in areas where it might be exposed to dust and dirt. Before removing the helmet, vacuum dust from the helmet and cape.
- Place the cleaned helmet in a plastic bag and store in a dust-free area.
- Inspect all components for wear at least once a day. Replace outer capes when worn sections are noticed. NEVER use tape to repair holes or worn areas.
- Replace the inner collar when the elastic becomes stretched out of shape.
- Replace the breathing air hose if any damage is found.
- Check the tightness of all connections and the condition of the face piece, headbands, and valves.
- At least once a week, wipe the inside of helmet with warm water and mild detergent. Detach the cape and inner collar from the helmet and wash in warm water and mild detergent.

- Replace window frames and window seals immediately if there is any leakage.
- Maintain a ready supply of outer lenses, and replace outer lenses when they become frosted.

Filters & Air Lines

- Follow the manufacturer's schedule for replacing filter cartridges. Use the cartridges recom mended by the manufacturer and install them right-side-up.
- Each day, inspect air lines and fittings for worn areas and leaks.
- Route lines as straight as possible.
- Do not place breathing air lines where vehicles can run over them.
- If the air supply contains high concentrations of moisture or oil, install air drying equipment in the line to prevent moisture and oil from reaching the fil ter.

Monitors and Converters

- Calibrate monitors and converters according to the manufacturer's instructions and schedule. Only qualified, trained personnel should be allowed access to monitors and converters.
- When alarms sound, stop blasting, exit the blast area, and check the source of compressed air for problems. Do not resume blasting until the cause of the alarm has been found and remedied.
- Never disable alarms or other safety devices. Do not use any equipment unless all alarms have been tested and shown to function properly.

Air Sources

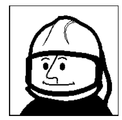
- Maintain the compressor or air pump according to the manufacturer's instructions and schedule.

- Drain air drying systems frequently.
- Position compressors and air pumps upwind of vehicles, generators, burn barrels, and other sources of toxic gases and smoke.
- When using bottled air, ensure that the supplier has tested and certified the air and its source.

SPECIALTY EQUIPMENT FOR BLAST CLEANING

Wetblasting vs Waterblasting

Wetblasting is often confused with water blasting (also called hydroblasting or liquidblasting).



Waterblasting and related systems use water pumps as their power sources, and may or may not use abrasive for more aggressive cleaning.

Simple water washers work at relatively low pressures and usually clean with detergent additives. High-pressure waterblasters operate at up to 20,000 psi (1370 bar/137,000 kPa); ultra-high pressure waterblasters operate at pressures as high as 50,000 psi (3447 bar/344,700 kPa).

Waterblasting cleans concrete, stucco, brick and other masonry surfaces. It strips paint and mold from wood, and marine growth from ships. At higher pressures it can even remove paint and corrosion from structural steel, though the production rate may be slow. But no matter how high the pressure, water will not produce a surface profile on steel.

Waterblasting with abrasive injected into the water stream produces a very small blast pattern, because only meager amounts of abrasive can be injected into the high-pressure water stream.

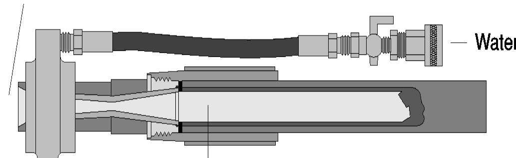
Wetblasting uses compressed air and a standard blast machine to propel abrasive, with just enough water added at the nozzle to suppress dust. It produces the same hard-hitting force of dry abrasive blasting.

State-of-the-art wetblasting systems have a control at the nozzle to adjust water pressure and volume from a fine mist to a full water wash. The volume of water can be regulated to match the amount of dust being produced.

When blasting steel structures, the addition of water has the added benefit of washing away water-soluble salts, chlorides, and other chemicals — contamination that might cause coating failure and that dry blasting alone will not always remove.

Wetblast Attachment

The simplest form of wetblasting uses a circular ring that fastens to the end of a blast nozzle. It directs streams of water into the air and abrasive as it leaves the nozzle. Typically, water is supplied from the nearest faucet or pumped from storage drums. The operator adjusts water volume by turning a petcock lever at the nozzle.

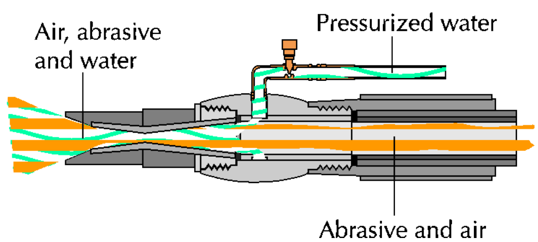


Simple Wetblasting Attachment

Wetblast attachments spray water on the outside of the air and abrasive stream, leaving the center of the blast pattern dry. They work well where the local water supply has sufficient pressure for light dust suppression, but they have limitations.

Wetblast Injection Systems

For extremely dusty applications, such as stripping old painted concrete, a Clemco wetblast injector is more effective than a water ring attachment. An injector adapter, inserted between the nozzle holder and the nozzle, introduces water through angled jets just before the abrasive flows through the nozzle. This thoroughly wets the abrasive particles before they leave the nozzle to provide more effective dust control.



Cut-away — Clemco Wetblast Injector

The Clemco injector has a needle valve to precisely adjust water flow from a very fine mist to wide open.

The wetblast injector uses a water pump to overcome the pressure in the blast hose. Because the Clemco system supplies its own water pressure, the water can come from a faucet or storage drum.

Typically, the injector pump converts compressed air power to water pressure at a 10-to-1 ratio. An air pressure setting of 100 psi (7 bar/700 kPa) produces 1000 psi (70 bar/7000 kPa) of water pressure — more than enough to overcome nozzle air pressure and generate a steady flow of water.

The Clemco injector pump will not propel water out the nozzle at high pressure. The water pressure dissipates instantly as it exits the needle-point injectors in the nozzle. As the water enters the air and abrasive stream, it does not interfere with nozzle acceleration.

Injector flow rates of 2 to 2.5 U.S. gallons per minute (7.5 to 9.5 liters per minute) safely remove sulfides and chlorides from steel. At maximum setting, an injector uses about 4 gallons per minute (15 liters per minute).

Clemco offers an optional abrasive cut-off switch which enhances the versatility and effectiveness of an injector system. The operator can stop the flow of abrasive and use compressed air and water to rinse a cleaned surface. Then, by turning off the water, the operator can dry the surface with compressed air only. For extended dry blasting, remove the injector adaptor to prevent unnecessary wear to it.

⚠ WARNING

Wear approved supplied-air respirators when wetblast equipment is in operation. Inhaling contaminants, wet or dry, will harm the respiratory system.

Abrasive Vacuum Recovery Equipment

Recovering abrasives after blasting can be the most labor intensive part of any job. Using shovels and brooms is far too costly in labor and time. Most contractors consider vacuum recovery equipment essential to their blasting operation.

Vacuum recovery equipment is more efficient and cost effective than manual recovery, especially when abrasive is being re-used. Also, most vacuum recovery systems capture dust, to help protect workers and keep the surrounding atmosphere relatively clean. Vacuum systems pick up the abrasive and dust, then rapidly convey them to separate storage containers.

Most field recovery systems employing screw conveyors, belt conveyors, and bucket elevators must be manually loaded with the abrasive and may still require manual clean-up of residual abrasive and dust. Vacuum recovery is more efficient for most field applications.

Air-Powered Systems

Compressed-air-powered recovery systems, such as Clemco's Easy Load, accelerate air through a venturi tube (also called a vacuum producer) to generate a strong vacuum.

Engineers classify these venturi vacuum systems as "high vacuum - low volume," because they convey a relatively small amount of air. Consequently, venturi vacuum systems can efficiently convey abrasive over short distances — usually 25 to 150 feet (8m to 45m). Beyond 150 feet (46m), conveying rates taper off drastically.

Most air-powered systems include a vacuum producer, storage hoppers, dust collector, hoses, and an assortment of pick-up tools. These storage hoppers are usually specially designed drums that collect spent abrasive for disposal or mount atop the blast machines to automatically recycle the abrasive.

Large-capacity, free-standing storage hoppers collect abrasive for re-use or disposal.

Clemco's air-powered systems have efficient reverse-pulse cartridge dust collectors or economical wet units where dust-laden air is pulled through a water reservoir. Wet units are best reserved for loading relatively clean abrasive, because they quickly become overtaxed if the abrasive is extremely dusty.

Clemco's reverse-pulse cartridge collectors can drop the dust into sealed bags that can be disposed of without requiring the operator to handle dust. Where dust control is critical, Clemco offers an optional High Efficiency Particulate Air (HEPA) filter.

Clemco's pick-up tools include the bulk loading tool for vacuuming mounds of abrasive, plus wall brushes for flat surfaces, crevice tools for hard to-reach areas, and flared tools for thin layers of fine dust.

Clemco's abrasive loading hopper is a convenient, back-saving accessory. A standard pick-up tool is inserted into the bottom of the loading hopper to convey new abrasive to the storage hopper located on top of a blast machine. Bagged abrasive is placed on the hopper screen and cut open to fill the hopper. The vacuum producer draws abrasive into the storage hopper. This accessory saves time and greatly relieves the strain of lifting heavy bags of abrasive to the tops of blast machines.

Air-powered vacuum systems offer many advantages. They use the same compressed air supply as the blast machine, so no additional power source is required. They eliminate the need for employees to handle dust. Abrasive, dust, and residue can be rapidly reclaimed from the entire job site area, including difficult places where manual cleaning may not be possible. Re-usable abrasive can be recaptured, screened, and loaded into storage hoppers. Unwanted abrasive and contaminants can be removed and collected in disposal containers. Potentially harmful dust from manual clean-up is captured for disposal. Stress and strain from loading abrasive can be minimized. It is well worth the effort to investigate adding air-powered vacuum systems to any blast machine set-up.

Blower-Powered Recovery Systems

Blower-powered vacuum systems do not rely on compressed air. They use positive displacement blowers driven by electric motors or diesel engines. The blowers maintain stable static pressures to pull large volumes of air over long distances.

Typically, the blowers produce 1,000 to 3,500 cfm at 14 inches Hg (32 to 81 m3/min at 0.5 bar/ 50 kPa Hg), which is normal vacuum under abrasive load. Abrasive recovery rates range from 15 tons per hour with 50 feet of vacuum hose to 3 tons per hour with 500 feet of hose (13.6 metric tonnes; per hour with 15 meters of hose to 2.7 metric tonnes per hour with 150 meters of hose).

Blower-powered systems such as Clemco's MB models are preferred in shipyards, oil tank farms, and other applications where abrasive recovery extends over large areas. They are remarkably effective where vacuum hose traverses long vertical and horizontal distances. Vertical hose actually relieves the one-sided gravitational force imposed on horizontal hose. In other words, 400 feet (120+ meters) of intermittently vertical and horizontal hose will recover abrasive faster than a comparable length of all horizontal hose. As with all hoses, sharp bends and erratic turns will reduce conveying rates.

Clemco's MB systems produce vacuum with a positive-displacement rotary blower, powered by an electric motor. A cyclone separator and dust collector protect the blower from exposure to abrasive and dust, which can damage its rotors.

Hoppers fitted with transfer airlocks allow the blower-powered system to discharge abrasive into trucks, drums, or back into the blast machines while feeding dust into disposal containers — all without interrupting vacuum recovery. This is especially beneficial with steel grit abrasive, due to its high re-use factor.

This arrangement allows recycling of steel grit hundreds of times. In the final analysis, abrasive vacuum systems are invaluable for reducing labor costs, recovering abrasive and debris, and preventing pollution.

Closed-Circuit Equipment (Suction and Pressure Systems)

In areas that restrict open blasting, closed-circuit equipment is used to confine the abrasive and the dust and foreign materials removed during blasting. In a closed-circuit system, the abrasive never leaves the equipment. It is propelled against a surface, then the dust and abrasive are immediately captured. This controlled, dust-free blasting still achieves reasonable production rates.

Use closed circuit systems with recyclable abrasives, such as steel, plastic, and glass bead. Expendable abrasives produce too much dust, which can overload the dust collector.

Suction Systems

With lower-production suction-blast tools, such as Clemco's Educt-O-Matic (hand-held tool), and Comet (small portable tool), the operator holds the blast head firmly against the surface and moves along as fast as the surface is cleaned. The operator should wear safety goggles or a face shield to guard against injury from accidental escape of abrasive. If the coatings being removed contain hazardous materials, the operator must wear approved respiratory protection.

Tools such as the Educt-O-Matic, and Comet, offer the convenience of light-duty, touch-up blasting without contaminating nearby machinery or annoying nearby personnel, and are especially useful in dust sensitive areas. The basic tool cleans flat, smooth surfaces. Different heads adapt the tool to different shaped surfaces, such as inside corners, outside corners, and curves.

Compressed air powers a venturi blast head and venturi vacuum. The vacuum draws the abrasive and dust through a miniature cyclone separator. The abrasive falls into the small storage hopper for re-use, while the dust is blown into a bag or canister.

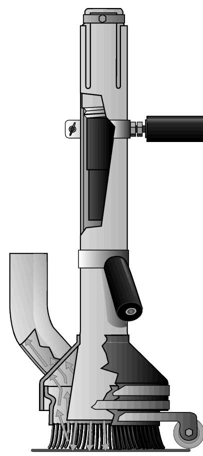
Clemco's Educt-O-Matic has a two-stage trigger that activates the vacuum recovery only or blast and recovery together.

Most closed-circuit, suction blast units use less than 100 cfm (2.8m3/min) of compressed air at 100 psi (7 bar/700 kPa), and produce a blast pattern of 1 inch (25 mm) or less. Cleaning rates vary widely depending on surface condition and abrasive used.

Pressure Systems

Clemco's Super Comet is a portable pressure blaster on a 4-wheeled cart. It includes a closed circuit head, integral media reclamation and dust collection. The Super Comet is used with most recyclable media and cleans a one-inch wide strip at a rate of up to 6 feet per minute depending upon surface conditions.

CCB Closed Circuit Blaster
Blasting, containment and recovery tool.



The higher-production, closed-circuit blast tool, such as Clemco's CCB, attaches to a standard pressure blast machine and vacuum recovery system.

A typical Clemco system uses a 1/4-inch (6.5 mm) nozzle and 1-1/4-inch (32 mm) ID thin-walled blast hose to provide high-production cleaning, and a larger diameter vacuum hose for recovery.

Wheels hold the closed-circuit tool at the proper distance and allow it to move easily along the surface. A thick, nylon brush ring around the head prevents abrasive and dust from escaping, but allows free air to be drawn in through the bristles for the vacuum process. The wheels and brush are mounted on a flexible rubber boot that helps keep them flat against the surface as the operator moves.

Clemco's CCB allows room for mounting a standard blast machine remote control handle.

Most high-production closed-circuit tools use a standard blast machine and an air-powered vacuum system. The recovered abrasive is either reused or captured in a disposal container.

See the section on Abrasive Recovery Equipment for details on air-powered vacuums.

The operator starts the vacuum system, presses the tool against the surface, then starts blasting in a smooth and even motion, keeping the brush firmly in contact with the surface. The operator watches the blast pattern and adjusts the speed across the surface to achieve optimum cleaning. The blast pattern is about 3 inches (76 mm) in diameter. The 1/4-inch nozzle consumes 81 cfm (2.3 m3/min) at 100 psi (7bar/689/kPa), while the vacuum uses about 290 cfm (8.2 m3/min).

Used with recyclable abrasive, the closed-circuit system allows environmentally safe, high-production blasting with substantial cost savings in labor and abrasive. Abrasive clean-up, dust pollution, exposure to toxic materials are all eliminated.

Operators must wear operator safety equipment. A NIOSH-approved, air-fed respirator protects against the inhalation of dust. Heavy gloves and clothing will help prevent serious injury from the abrasive blast if the closed-circuit tool is accidentally lifted off the surface.

Portable Steel Grit Recycling Systems

Many older bridges, water towers and other outdoor steel structures were protected by coatings that contained lead, a low cost corrosion inhibitor.

Lead has been proven toxic, and now businesses, as well as federal, state, and local governments want the lead-based coatings removed from the structures they own. Abrasive blast cleaning can efficiently remove lead-based coatings and leave behind the uniform etch required by today's coatings. But the lead dust created by blasting and any expendable abrasive that comes into contact with the lead dust must be disposed of as a hazardous waste. With expendable abrasive, the great volume of material for disposal can drive the cost of the project prohibitively high.

Steel grit recycling systems let the contractor blast, recover, and re-use their abrasive, while minimizing employee contact with lead dust. Complete systems use one or more blast machines, storage hoppers, vacuum recovery equipment, multi-stage abrasive cleaners, and super-efficient dust collectors.

The dust collectors on a steel grit recycling system trap the dust generated during vacuum recovery and the dust removed during abrasive cleaning. Usually, these dust collectors do not have the capacity to ventilate the enclosure.

Recycling systems often use reverse-pulse cartridge dust collectors, which virtually eliminate the need to handle toxic dust, and abrasive cleaners to separate the dust from the abrasive.

Cleaned steel grit is carried to a storage hopper above the blast machines, where it is held for reuse or discharged for transportation or disposal.

Because most systems will recycle steel grit exclusively, the compressed air supply must be extremely dry. Most mid-size and large systems offer built-in air drying equipment sized to meet the system's requirements.

Pay special attention to the manufacturer's instructions for transporting the recycling system while it contains steel grit. The position of large quantities of steel grit can dramatically affect the stability of the trailer on the highway. Also, steel grit tends to pack together during transportation. It may clog metering valves and plumbing or not flow freely during initial blasting.

When considering any steel grit recycling system, weigh the purchase price against the daily operating cost. Recycling systems represent a sizable capital expenditure. The cost of purchasing or leasing the equipment becomes a known, fixed monthly expense, but the cost to operate that equipment will vary widely with the number of hours in use.

Secondary Elements of a Blasting System

Staging

To blast clean large steel structures, contractors must use staging to support the blast operators and their equipment in elevated positions. The information in this section describes the general use and care of staging. Refer to the instructions and safety precautions provided by the staging manufacturers and their suppliers before using any staging.

Choose staging that is appropriate for blasting and that provides safety and freedom of movement. A few general rules apply no matter what staging you use.

No one should work below blast operators. A nozzle or hose dropped from even a slight elevation can kill or severely injure a person.

Wear approved safety belts or harnesses connected to a fall-arrest system. Discard all such devices, including ropes, once they have arrested one fall, unless a qualified person has inspected and repaired them.

Stop frequently to sweep or blow the abrasive from all horizontal surfaces on the staging. Footing is treacherous on loose abrasive.

Use safety cables, or other strong attachment methods to secure the blast hose to the staging. This relieves the operator from the weight of the hose and prevents a dropped hose from falling onto someone below.

Scaffolding

Many blasting and painting contractors rely on steel-tube scaffolding with wood or aluminum planks. It allows the worker to move horizontally along a surface, blasting or painting a large area.

Take extra safety precautions when blasting from a scaffold. An air-fed helmet does not allow a full field of vision, so planks should be wide and tightly secured for maximum footing. Install guard rails at the proper height as required by OSHA Ref: 29 CFR 1910.28 and according to the scaffolding manufacturer's instructions.

Mechanical Lift Equipment

Most mechanical lifts consist of platforms or personnel buckets elevated by hydraulic cylinders. Some are quite versatile in their ability to quickly move personnel around the structure being blasted.

Mechanical lifts include manlifts, scissors lifts and telescopic cranes. Generally, mechanical lifts are equipped with guard rails.

Most mechanical lifts are not intended to be moved while personnel are elevated.

Choose mechanical lift equipment carefully. Some are not designed to withstand dust and abrasive on hydraulic shafts or lubricated retractable booms. Check the equipment manufacturer's limitations on applications and read and follow all safety and operating instructions.

Blast Machine Positioning

Most elevated platforms and personnel buckets will not support the combined weight of a blast machine, hoses, abrasive, and operator. Position the blast machine on the ground, as close to the blasting area as possible.

Running blast hose vertically, even in straight lines, can reduce nozzle pressure, especially when the length exceeds 100 feet (30 meters). Friction loss is compounded by gravity.

To overcome this gravitational pressure loss, first, if the capacity of the air compressor being used is marginal, switch to a larger capacity unit. Connect this larger compressor to the blast machine using correspondingly larger air hose and fittings. Under normal conditions, air hose to suport a 7/16-inch (11 mm) nozzle is 1-1/2-inches (38 mm) in diameter, but to support a long vertical run of blast hose, use 2-inch (50 mm) air hose.

Next, switch to larger diameter blast hose and couplings. With a 7/16-inch (11 mm) nozzle 1-1/4-inch (32 mm) blast hose is usually suitable, but vertical applications demand 1-1/2-inch (38 mm) or larger hoses. The larger ID blast hose provides more area for air and abrasive and makes it easier to transport them uphill.

The last hose before the nozzle can be reduced to a 1-1/4-inch (32 mm) whip for easier handling.

For heights beyond 200 feet (60 meters), consider higher pressure equipment. These applications are well out of the range of most mechanical lifts. They require special evaluation of equipment and staging requirements.

On elevated blasting applications, start and stop the blasting with air only. This prevents abrasive from falling back and collecting in the blast hose. This abrasive is difficult to clear out and, when it is cleared, usually will be wasted.

Field Enclosures

There are several reasons for enclosing abrasive blasting operations — from protecting the environment to increasing productivity. Whatever the motivation for using one, choose a field enclosure that conforms to safety and environmental regulations.

Enclosing a blasting operation stops dust and abrasive from polluting the surrounding area. The main sources of hazardous dust are coatings that contain lead or other heavy metals and insulation that contains asbestos. Also, dust from sand and other abrasives high in crystalline quartz are hazardous.

In open blasting dust can travel over wide areas, contaminating soil and water, and settling on cars, homes and other structures. Even in small amounts, dust can be a nuisance to those affected.

Tents

In many field applications, blasting is contained within enclosures of heavy vinyl or fabric. These tent-like enclosures allow operators to blast and paint parts just prior to installation on the job site. They contain the pollutants, reduce the health hazards and annoyance to others in the area, and protect the part from rain.

Military surplus tents are not suitable for blasting. Lighting, dust permeability, ventilation, and abrasive recovery must be considered. Specially designed field enclosures have clear vinyl ceilings and windows to let in sunlight and illumination from light modules positioned outside.

The enclosure must have properly designed air inlets and dust collector outlets for ventilation. The OSHA requirements for field-enclosure ventilation are similar to those for blast rooms.

Choose abrasive recovery and disposal systems carefully. Long-term jobs may require automatic abrasive recovery systems to reduce the labor expense associated with loading, unloading, and disposing abrasive. For short-term jobs, vacuum recovery equipment permits abrasive recycling. This dramatically reduces operating expenses of field blasting operations.

Containment Tarps

Several companies market and install special containment tarps to incrementally surround large structures. These tarps prevent abrasive and dust from becoming environmental contamination. The tarps are used extensively on bridges, buildings, storage tanks, ships, and other large structures.

The companies that market these containment systems have become expert at rigging them on structures to ensure effectiveness. These tarps are particularly beneficial when lead-based paint and other toxic coatings are removed by blasting. Enclosing the blast area allows dust collectors to capture toxic dust for disposal.

New containment technology allows contractors to remove toxic paint from almost any structure without posing serious health and environmental hazards.

Ventilation

Dust collectors ventilate the enclosure to keep dust concentrations at safe levels for workers inside. OSHA 29 CFR 1910.94 requires that any blast enclosure be equipped with dust collecting ventilation equipment. Personnel inside blast enclosures must not be subjected to heavy concentrations of harmful dust.

The exhaust fans that ventilate the enclosure must retain the dust and must conform to local air quality regulations on atmospheric emissions.

The enclosure size and shape, and the type of abrasive used, help determine the rate of ventilation and the amount of filtering material needed. The dimensions and locations of air inlets and outlets must create adequate internal air flow through the enclosure — especially in the area immediately surrounding the blast operators.

A properly installed dust collector draws sufficient air through the enclosure to maintain visibility and minimize operator exposure to dust, and has sufficient filtering capacity to handle the amount of dust generated by blasting.

Dehumidification

Heat and humidity can cause condensation and oxidation on bare steel, and allow dust to stick more readily. All are detrimental to paint adhesion.

Dehumidifiers replace the enclosure's wet, hot ambient air with cool, dry air. In addition to helping the blast cleaned surface stay dry, dehumidifiers let you recycle steel grit more times without becoming moisture contaminated.

Dehumidifiers may seem expensive to purchase or rent, but the savings from using steel grit, rather

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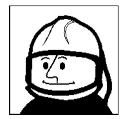
than an expendable abrasive, can usually justify the added cost.

Surface Inspection Equipment

Coatings will not adhere for long to an improperly prepared foundation.



Several test and inspection aids are available to check the blast quality on steel substrates. Periodic inspection is vital, because several variables make blasting an imperfect process. These variables include the abrasive's quality and cleanliness, the blast system's efficiency, the blaster's experience and expertise, and the surface's existing condition. Other variables include temperature, humidity, wind, and lighting.

Many job specifications require inspection and testing at regular intervals to document the quality of the surface preparation.

To document specification compliance, use one or more of the test and inspection products below.

Measuring Surface Cleanliness

The Society for Protective Coatings (SSPC) and the National Association of Corrosion Engineers (NACE) produce visual comparators for checking surface cleanliness.

The SSPC sells a pocket-sized booklet, "Visual Standard for Abrasive Blast Cleaned Steel," that contains color photographs of grades of rust, and the degrees of cleanliness for each. It also has photographs of white metal produced by various metallic and non-metallic abrasives.

See the Surface Preparation Section in this booklet for details.

NACE sells a set of encapsulated steel coupons for visual comparison to the surface. Order the

"Visual Standard for Surfaces of New Steel Airblast Cleaned With Sand Abrasive."

In Europe, the Swedish Standards Institute (SIS) sells a book of color photographs showing four grades of rust and the degrees of cleanliness for each. This is also published as a British Standard.

Standards are constantly reviewed and updated. For the latest information, contact SSPC, NACE, SIS, or your national standards agency for current information. The addresses for many of these agencies are listed in the reference section.

Measuring Surface Profile

Exact surface profile measurement requires a microscope and a laboratory setting. Generally accepted methods of field inspection, however, provide reasonable accuracy in documenting compliance with surface preparation specifications.

The following information covers general methods for measuring surface profile. To ensure accurate results, read and follow the instructions provided by the equipment manufacturer.

Replica tape is pressed against the blasted surface to form a reverse image of the profile. The inspector then uses a spring micrometer to measure the peaks and valleys.

Two types of tapes are available — Coarse for 0.8 to 2 mils (20 to 51 microns) and X-Coarse for 1.5 to 4.5 mils (38 to 114 microns). The National Association of Corrosion Engineers sells a publication describing in detail — ask for the current edition of "Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using A Replica Tape. "

Stylus measurement devices consist of a dial gauge on a flat base with a spring-loaded probe. The inspector moves the gauge across the surface, while the probe indicates peak and valley measurements on the dial. The inspector records the measurements and calculates the average profile.

Visual comparators provide the simplest and most popular method for checking profile. One of the most common instruments uses a reference disc and an illuminated magnifier. The reference disc shows five increments of profiles to compare to the blasted surface. Three available discs conform to the profiles produced by sand — .5 to 4 mils (12 to 100 microns), steel grit — 1.5 to 5.5 mils (37 to 138 microns), and steel shot — 2 to 5.5 mils (50 to 138 microns). A magnet holds the disc in place in the magnifier. The inspector can view the magnified disc and surface, side-by-side, to compare profiles.

The International Standards Organization's visual comparator (ISO 8503) uses a four-segment coupon covering a range of profiles. The ISO starts with the premise that there can be no precise profile values because there is no practical method of producing precise surface etch. Consequently, they specify only three profile grades — fine, medium, and coarse — which will fall within four segments on the comparator.

Segment 1 shows a profile of 23 to 28 microns (1 ± mil); segment 2 is 35 to 45 microns (1.4 to 1.8 mils); segment 3 is 60 to 80 microns (2.4 to 3.2 mils); and segment 4 is 85 to 115 microns (3.4 to 4.6 mils).

Fine profile falls between segments I and 2; Medium between 2 and 3; and Coarse between 3 and 4. This simple method of inspecting profiles is slowly being adopted throughout the world.

Multipurpose Measuring Devices

Sophisticated surface measuring instruments are available using advanced microprocessor electro-optical technologies. These instruments accurately detect the presence of oil, grease, and corrosive properties. They also have the ability to precisely measure surface profile and degrees of surface cleanliness. Most hand battery-operated instruments show instant readings on LCD displays. Some of the instruments are designed to download their data into compatible computers for extensive surface analysis.

PROCESS EDUCATION

What You Need to Know Before Blasting

Without question, the most important element of a manually operated blasting system is the blast operator. The finest equipment will not perform to its potential without trained, knowledgeable, careful, safe operators. Spending the time and money up front to train operators, pays off quickly in productivity, and reduces the risk of accidents and injuries.

While most abrasive blasting is not considered highly technical, operator skill is essential. Many painting jobs have had to be redone, at great expense to the contractor, due to poor blasting work.

Blast operators will not produce satisfactory cleaning rates or the desired surface finish without proper training. More important, they may seriously injure themselves or others.

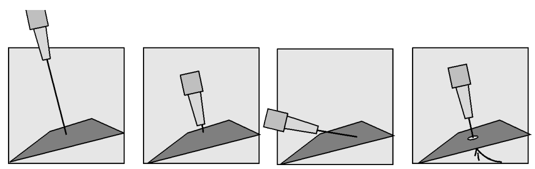
Training and experience will help produce predictable and profitable results. The blast operators' success contributes, ultimately, to the overall success of the company.

To become truly skillful, blast operators must know what surfaces they will be blasting, the desired results, their productivity objectives, and how their performance will be measured. They must learn about abrasive, air pressure, air volume, and how these relate to the specifications for surface cleanliness and profile. Above all, they must know how to use the equipment safely and maintain it in top condition.

Contact manufacturers and professional organizations (listed in the reference section) for technical training programs on specific blasting equipment and techniques.

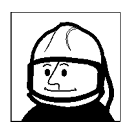
Technique has a tremendous effect on productivity and surface finish. Some inexperienced operators hold onto the blast hose about a foot back from the nozzle and whip the nozzle back and forth. Others move the nozzle in a wide arc. Neither method produces uniform surface finish.

Just as a skilled painter moves the spray gun perpendicular to the surface in smooth, steady strokes, the same technique holds true for abrasive blasting. Hold the nozzle at a distance appropriate for its orifice and length, at an angle appropriate for the material being removed, and move it in smooth, steady strokes with little overlap of the blast pattern. This results in complete cleaning with acceptable profiles on most surfaces, including steel, concrete, wood, plastic, aluminum, and some composite material.



Determining correct distance.....angle....and dwell time is crucial to developing proper blasting technique.

Blast operators must know what contaminants and coatings they are removing, and how the surface should appear after blasting.



To clean structural steel and leave a good profile, hold the nozzle at 80 to 90 degrees. To dislodge thick layers of paint, resilient coatings, and heavy laminated corrosion use 35- to 45-degree blast angles. Remove thin paint, flaking paint, and light rust with 70- to 90-degree blast angles.

Clean oil and grease from the surface with solvent prior to blasting, so that the solvent will not interfere with paint adhesion. Follow the solvent manufacturer's instructions for use and safety precautions.

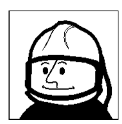
Learn to properly blast clean corrosion pits, bolt holes, rivet heads, welds, corners, edges, and angles. On flat surfaces, maintain consistent angle, distance, and nozzle speed to produce uniform cleanliness and anchor pattern, while sustaining a high production rate. Experience and practice will help you develop the proper technique for each surface.

Blast operators must understand abrasive qualities and the performance properties of each type. An experienced blast operator learns to determine if abrasive is clean or dusty, too coarse or fine, or too sharp or dull. As the person doing the blasting, the operator usually has a better perspective on cleaning and cutting speed. Their input on abrasive efficiency can be valuable in analyzing production rates.

Blast Equipment Knowledge

Blast operators must develop a thorough understanding of what the blast equipment will do and what happens when the source of compressed air is altered. Once they comprehend the value of air pressure and volume, they will be better prepared to evaluate the blasting system.

Abrasive blast equipment is an air powered tool, a big, air consuming tool.



The employer or supervisor is responsible for making sure all employees read and understand the manuals for each piece of equipment, and for providing oral instruction for those operators who cannot read the manuals.

In essence, blast operators must be completely familiar with the form, fit, function, and maintenance of everything from the compressor to the nozzle. The hazards inherent to blasting pose little danger, if operators are properly attired and use safe work practices.

All of the manuals and warning labels are meaningless if you do not comply with the warnings and instructions given.

Operator Safety Equipment Knowledge

Blast operators must maintain their personal protective equipment for peak performance. Failure to do so, can cost them their lives. Operators must have in-depth training on care and maintenance of all components in the breathing air system. These instructions include:

- Never inhale dust — ANY dust. This includes dust generated from coatings removed, as well as from pulverized abrasive. It includes the dust created when you handle and load abrasive. It especially means dust kicked up during clean-up.
- Remember — the invisible dust particles cause the most harm to your respiratory system.
- To avoid respiratory injury, wear a NIOSH-approved air-fed helmet before, during, and after blasting, until the clean-up is completed and the air has been tested and found clear of dust.
- Clean and maintain your helmet regularly.
- Drain air filters and replace cartridges according to the instructions.
- Check your breathing air hose for leaks.
- Calibrate CO monitors according to the manufacturer's instructions and schedule. Usually, monitors used in the field require more frequent calibration.
- Wear heavy-duty clothing, or a blast suit, as well as safety shoes, and leather gloves — even when it's hot and humid. Soft human skin is no match for sharp, high-speed abrasive.
- Do not allow anyone who is not fully protected into the blasting zone.

Skills and Information

The following list shows some of the skills and information blast operators must have, and steps they must take before blasting:

- Inspect all equipment during set-up, looking for correctly sized fittings and components that will not hamper air flow. Be aware that a 1-pound loss of pressure causes a 1-1/2 percent loss in productivity. The internal diameters of the blast hose and fittings should be 3 to 4 times the diameter of the nozzle orifice.
- Read and understand all instructional materials prior to touching the equipment. You must be able to install, operate and maintain the equipment in a safe and productive manner.
- Inspect and test the remote controls without turning on abrasive metering valves, checking for precise start and stop response time.
- Learn to adjust the abrasive metering valve, lay out the blast hose, drain the moisture separator, and operate all the accessories furnished with the blast machines.
- Don't overlook simple items that affect performance. Worn coupling gaskets, for example, waste enormous amounts of valuable air pressure. Also, leaking fittings rob the system of precious air volume. Identify and correct these problems as quickly as possible.

Training Materials

Employer Responsibility

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.

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 may wrap rags around their noses and mouths because they find air-fed helmets too bulky. Employers have a duty to create effective safety programs and enforce them through training and strict disciplinary action for violators.

Prior to starting blasting, employers should investigate potential 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 material safety data sheet (MSDS) provides this information.

Avoid unnecessary risks, by adhering to the equipment and material manufacturers' warnings and safety recommendations.

Never modify or substitute original equipment components and parts. Employers who perform or allow unauthorized modifications and substitutions assume full liability of the equipment. No manufacturer will guarantee or warrant equipment that has been altered or misused.

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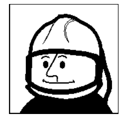
Employers should be particularly sensitive to the ability of employees to understand instructions, warnings, and all potential hazards associated with their jobs.

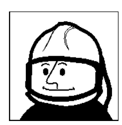


If an employee cannot read or is a poor reader, the employer should have a qualified person meticulously explain each equipment manual and all warning labels and tags, making absolutely sure that the employee comprehends how to safely use and maintain the equipment.

Employers take on a tremendous amount of work to train and equip employees, but in reality, everyone wins. The properly trained employees become craftsmen, taking pride in their work, and becoming valuable assets to their employer. Employers benefit from the increased employee productivity which provides increased profit.

Owner's Manuals

When it comes to abrasive blast equipment, everyone involved in its operation and maintenance must read and follow all the instructions. Incomplete understanding or improper training can lead to serious injury or death.



Equally important, following the instructions allows you to get the full benefit of the equipment without being subjected to aggravating downtime.

Since 1993, all Clemco manuals have a bright orange cover with general warnings and safety instructions that apply to all equipment using compressed air and requiring air-fed helmets (supplied-air respirators). The cover ensures that this vital

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safety information is provided with every piece of Clemco equipment.

The back of the cover has an illustration of a general set-up and a convenient daily checklist. (A copy of this checklist is in the reference section.) Read the cover and insist that employees who will set-up, maintain, or operate the blast system read and fully understand the information before touching any equipment.

Clemco owner's manuals generally follow this format: Introduction, Installation, Operation, Maintenance, Troubleshooting, and Replacement Parts. The common format helps the reader quickly locate specific information.

Pay special attention to warnings and other highlighted text. Clemco uses the warning system specified by the American National Standards Institute (ANSI Z535).

Clemco uses safety alert signal words, based on ANSI Z535.4-1998, to alert the user of a potentially hazardous situation that may be encountered while operating this equipment. ANSI's definitions of the signal words are as follows:

⚠ This is the safety alert symbol. It is used to alert the user of this equipment of potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

CAUTION

"Caution" used without the safety alert symbol indicates a potentially hazardous situation which, if not avoided, may result in property damage.

⚠ CAUTION

"!Caution" with Safety Alert Symbol, is used to indicate a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

⚠ WARNING

"Warning" is used to indicate a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ DANGER

"Danger" is used to indicate an imminently hazardous situation which, if not avoided, will result in death or serious injury.

Keep the manuals with the equipment to allow ready access for reference by operators and supervisors. For rental equipment, complete instructions must be made available by the company supplying the equipment.

Many standard manuals are available free from Clemco distributors or on our website, www.clemcoindustries.com, or directly from Clemco. Refer to manual stock number, including revision number if applicable, when ordering.

Other Training Materials

Clemco Distributors and some trade organizations offer training programs on abrasive blasting equipment and techniques. If you cannot attend a training school, take advantage of the training materials offered by SSPC and other groups to assist in conducting in-house training programs.

First, use this booklet as an outline for your training program. It includes charts and tables illustrating air and media consumption, effects of nozzle wear, hose and fitting sizes, safety requirements, and so on.

The illustration on the back of any current Clemco owner's manual cover can help you identify major parts of the blast system. Individual manuals show exploded views of the component parts, which can enhance understanding the equipment's function and maintenance requirements.

For more effective in-house training programs, display the actual components and allow the attendees to handle them as they are being discussed. Cut-aways show the internal workings or configurations of the parts. For example, make cut-aways of couplings and blast hose to show how proper installation prevents turbulence and leakage. Supervised assembly and disassembly of components gives hands-on training on what to do in the field. Hands-on demonstrations of equipment teach proficiency.

Clemco, in cooperation with its Sales Representatives and Distributors, can assist you in planning a complete abrasive blast equipment training program or in tailoring your program to a particular product or application.

Regulations

As a responsible manufacturer, Clemco complies with many rules and regulations to produce safe, high-quality products. Regulations also apply to companies and their employees who make use of blast equipment.

OSHA enforces the regulations pertaining to the safe operation of abrasive blast equipment.

The following is a partial summary of key federal regulations pertaining to abrasive blasting. Other federal, state and local regulations may apply. It is the responsibility of the employer to investigate and comply with all regulations.

See OSHA regulations pertaining to abrasive blasting in the Reference Section.

Supplied-air respirators must be tested and approved by the OSHA departments of the National Institute of Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA).

Supplied-air respirators for abrasive blasting are classified as Type C and CE Continuous Flow. NIOSH and MSHA tests ensure adequate air pressure and volume, head and face protection, acceptable noise level, and safeguards against dust ingress. NIOSH and MSHA approval covers the breathing air supply hose, air control valve, and replacement face lenses, as well as the helmet.

It is a serious violation of OSHA regulations to use non-approved supplied-air respirators, non-approved accessories or other manufacturers' parts, approved or not. Violators are subject to stiff penalties.

OSHA, NIOSH, and MSHA emphasize the necessity of supplying Grade D breathing air to an operator's supplied-air respirator. Employers must pay close attention to the source of breathing air. If an air compressor supplies the breathing air, it must be maintained in excellent operating condition. This subject has been covered extensively in the Operator Safety Equipment section.

OSHA requires remote controls on every blast machine — no matter what size — to allow operators to start and stop blasting from their working position, and to ensure automatic blast shut-off when the control handle is released. Remote controls are absolutely necessary to prevent accidents. OSHA firmly places the responsibility on employers to install and maintain remote controls. Again, stiff penalties apply.

Blast machines must be built to American Society of Mechanical Engineers (ASME) standards. Blast machines approved by ASME display a metal National Board approval plate on the pressure vessel. The manufacturer must comply with these specifications, but restrictions apply to blast machine owners as well. Never weld, drill, grind or otherwise modify the pressure vessel. Doing so will weaken the pressure vessel and void the board approval.

ASME-coded pressure blast machines are not necessarily accepted in every country. The European union has pressure vessel specifications which are not consistent with U.S. standards. Check with the regulatory agencies in the country in which the machines are to be used before sending U.S.-built machines there.

Clemco manufactures machines in several countries for operation in many other countries; contact Clemco for information on overseas requirements.

Reference Section

Organizations

Membership in professional organizations and trade associations can help you keep up with regulations, product innovations, and application techniques. A few of the more prominent organizations are listed below.

The Society for Protective Coatings (SSPC)
40 24th Street
Pittsburgh, PA 15222-4656
Phone: (412) 281-2331
US Toll-Free: (877) 281-7772
Fax: (412) 281-9992
Website: www.sspc.org

Maintains research and testing committees, conducts seminars, and establishes industry standards on surface preparation methods, abrasives, and coatings.

National Association of Corrosion Engineers (NACE)
1440 South Creek Drive
Houston, TX 77084-4906
Phone: (281) 228-6200
Toll Free: (800) 797-6223
Fax: (281) 228-6300
Website: www.nace.org

Develops test methods and recommends practices on surface preparation techniques and coatings.

Painting & Decorating Contractors of America (PDCA)
11960 Westline Industrial Drive, Suite 201
St. Louis, MO 63146
Phone: (314) 514-7322
Toll Free: (800) 332-7322
Fax: (314) 514-9417
Website: www.pdca.org

Publishes current technical and regulatory information on surface preparation, painting and wall covering.

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 safety standards for all industries.

ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959
Phone: (610) 832-9500
Fax: (610) 832-9555
Email: service@astm.org
Website: www.astm.org
Voluntary standards development organization; develops technical standards that guide design, manufacturing and trade in the global economy.

Swedish Institute for Standards (SIS)
11880 Stockholm, Sweden
Phone: (46) 08-555 520 00
E-post: info@sis.se
Website: www.sis.se
Provides pictorial surface cleanliness standards. Establishes standards adopted in Europe and various other countries.

Compressed Gas Association
4221 Walney Road, 5th Floor
Chantilly, VA 20151-2923
Phone: (703) 788-2700
Fax: (703) 961-1831
www.cganet.com
Develops and publishes technical information and standards for safe use of industrial gases.

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Federal Regulations Pertaining to Abrasive Blasting

Regulations pertaining to abrasive blasting change from time to time. Contact your regional OSHA office for all current regulations.

CODE OF FEDERAL REGULATIONS CFR TITLE 29, PART 1910 Labor, Occupational Safety and Health Standards

1. Subpart G Occupational Health & Environmental Control

   1910.94 - Ventilation

2. Subpart I Personal Protection Equipment

   1910.132 -General requirement for personal protection equipment

   1910.133 - Eye and face protection

   1910.134 - Respiratory protection

   1910.135 - Occupational head protection

   1910.136 - Occupational foot protection

   1910.137 - Electrical protective devices

   1910.138 - Hand Protection

   1910.139 - Respiratory protection for tuberculosis

3. Subpart J -General Environmental Controls

   1910.144 - Safety color code for marking physical hazards

   1910.145 -Specifications for accident pre vention signs and tags

4. Subpart M Compressed Gas & Compressed Air Equipment

   1910.169 - Air Receivers

5. Subpart P Hand and Portable Powered Tools

   1910.244 - Other portable tools and equipment

6. Subpart Z - Toxic and Hazardous Substances

   1910.1000 - Air contaminants

Glossary of Abrasive Blasting Terms

This glossary is intended to streamline discussion through a common understanding of abrasive blasting terms. While many of these terms have meanings outside our industry, only the definition relating to abrasive blasting is included.

A

ASME ***American Society of Mechanical Engineers.*** The agency that, among other things, dictates standards concerning the manufacture of pressure vessels (blast machines).

abrasive The agent used for abrasive blast cleaning; such as, sand, slag, steel grit, etc. (See "media".)

abrasive control valve (See "metering valve".)

air consumption Quantity of compressed air utilized by compressed-air-powered equipment, expressed as cubic feet per minute (cfm) and m3/min. in the metric system.

air hose Rubber hose of air-supply quality, available in various inside diameters.

air jet The orifice in a suction type blast gun which controls the compressed air flow in relation to the nozzle orifice and ensures a proper air-to-abrasive mixture. The size of the jet determines air consumption. The nozzle must be twice the diameter of the jet.

air lock A device that allows a hopper or pressure vessel to maintain vacuum or pressure while transferring media. Usually made of a pair of valves or doors that open and close in sequence so that both are never open at the same time.

air manifold A device, usually made of steel, that converts one large air line into a common supply for several air lines. It has a large inlet and two or more smaller outlets.

air pollution In more and more states, blast cleaning is strictly regulated by the air pollution controls established by statute. Consult local authorities to ensure compliance with regulations.

air pressure The kinetic force generated by an air compressor, usually measured in pounds per square inch (psi), or in the metric system in bar or kilopascals (kPa).

air supply Furnished by a compressor. In abrasive operations, results achieved are in direct proportion to the amount of air and pressure passing through the nozzle.

air valve A control valve in an air line system.

air volume The quantity of air in cubic feet per minute (cfm), at a stated pressure (psi); or in cubic meters per minute (m3/min) at a stated pressure (bar or kilopascals).

anchor pattern Sometimes referred to as the "etch" or "tooth" and is different for each type of material being blasted and each type of abrasive used. The anchor pattern has tremendous importance as it is in most cases the end result of the abrasive blast operation. (See "surface profile".)

angle blasting Blast cleaning at angles to a surface which are less than 90 degrees.

angle of repose The angle at which dry abrasive "rests," or can be piled. This angle varies from one type or size of media to another. For example, the angle of repose of sand is 32 degrees. The cone at bottom of most blast machines is 35 degrees, suitable for most media. Plastic media has a higher angle of repose and requires a cone of 60 degrees for proper flow.

atmospheres Metric expression of pressure. 1 atmosphere (atm) equals 14.696 psi.

B

bar Expression of pressure in the metric system. 1 bar equals 14.504 psi (see kilopascals).

blast angleÊThe angle of the blast nozzle with reference to the surface.

blast cabinet A controlled work environment. Defined by size, work in a cabinet is done with the operator outside the enclosure (with the exception of the operator's glove-protected hands), as opposed to a blast room where the operator (wearing respirators and other protective clothing) works inside the enclosure. A small cabinet is sometimes called a glovebox.

blast cleaning 1. The standard and accepted nomenclature to describe the action of equipment listed under SIC-3569. Blast cleaning has nothing to do with explosives and is not necessarily confined to "cleaning". The application involves the propelling by air of abrasives to the surface of an object with sufficient force to clean, prepare or improve it. Also called abrasive blast cleaning or abrasive media blasting or sandblasting. 2. To clean a surface with abrasives; air propelled or mechanically propelled.

blast room Structural enclosure used for blasting.

blast suit Protective clothing used to protect the operator from ricochetting media.

blasting pressure The air pressure at the nozzle, as measured by a hypodermic needle gauge inserted into the blast hose just behind the nozzle.

boron carbide Long-lasting nozzle liner material. Recommended when aluminum oxide or silicon carbide abrasives are used.

bright blast (See "white metal blast".)

brush-off blast One of five accepted "grades" of blast cleaning. Also known by the following: SSPC-SP7 (The Society for Protective Coatings), NACE No. 4 (National Association of Corrosion Engineers), and SA-1 (Swedish Standards Institute).

C

CCB - Closed Circuit Blaster A device, combining a blast head and vacuum, that contains the media and dust at the nozzle, carrying the dust to a collector and the media to hopper or the blast machine. Examples include the Clemco CCB, Comet, and Educt-O-Matic.

cfm - cubic feet per minute The rate of air movement through a system or an orifice at a given pressure. A 3/8-inch nozzle allows 196 cfm of air to pass through it at 100 psi. In the metric system air volume is expressed in cubic meters per minute (m3/min).

choke valve A valve, located in the pusher line, which when closed directs air into the blast machine to force abrasive blockages through the metering valve.

CO - Carbon Monoxide A colorless, odorless, deadly gas produced by combustion. Some compressors produce CO as a byproduct of lubricants. All compressors have the potential to pull in CO from outside sources and send concentrated CO through the air lines. All breathing air sources must be monitored for CO.

coatings Surface coverings such as paints, varnishes, platings, powders, or other materials applied to protect or enhance the appearance of a surface. Abrasive blasting is an effective way to remove coatings or to prepare surfaces for coatings. A coating's specifications often dictate how a surface is to be blasted.

commercial blast One of five accepted "grades" of blast cleaning. Also known by the following: SSPC-SP6 (The Society for Protective Coatings), NACE No. 3 (National Association of Corrosion Engineers) and SA-2 (Swedish Standards Institute).

corrosion Deterioration due to interaction with the environment, usually through oxidation. Abrasive blasting removes existing corrosion, while coatings reduce the rate at which a material corrodes.

coupling A device mounted to each end of the blast hose to allow connection to the blast machine or other hoses. Usually made of nylon, brass, or aluminum.

D

deadman handle An on-off control, which operates pneumatically or electrically, to default to off when released by the operator (i.e., the Clemco RLX handle, also known as a "deadman valve").

deburr To remove any protruding ragged edge raised during drilling, shearing, punching or engraving. One of the major uses of abrasive blasting.

decibel A numerical expression of the relative loudness of a sound. Over an eight-hour work period, 85 dBA is the highest OSHA acceptable average level of sound in the work environment.

dew point The temperature at which dew starts to condense into liquid. A high dew point can increase the probability of flash rust on blasted surfaces.

dust collector A component of the blast system that filters dust from air exhausted from an enclosed blasting system.

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E

EPA - Environmental Protection Agency Federal agency that monitors compliance with laws governing contamination of air, water, and soil. Many states have their own EPAs.

Educt-O-Matic Clemco's unique closed-circuit blast tool that operates by suction blasting and includes a built-in, air-powered vacuum for dust collection.

F

fatigue life The length of time metal can withstand repeated stress before cracking occurs. Fatigue life can be increased through shot peening.

fine mesh Abrasive particles from 100 to 600 mesh.

fully automated A blast system in which materials are loaded, blasted, and removed without human operators. Usually a component of an automated manufacturing or assembly line.

G

Grade D Breathing Air An OSHA requirement for all supplied-air respirators, such as a Clemco Apollo Helmet. A partial specification for Grade D air includes:

Oxygen content	Atm19.5% to 23.5%
Carbon monoxide	Maximum 10 ppm
Carbon dioxide	Maximum 1,000 ppm
Hydrocarbons (condensed) in mg/m3 of gas at NTP	Maximum 5 mg/m3

Consult Compressed Gas Association for complete details. (See "Reference Section".)

H

HEPA A high efficiency particulate air filter. HEPA filters trap very fine particles. Used where hazardous coatings are being removed or for applications where dust emissions are strictly controlled.

I

ID - Inside Diameter A measurement of the inside of blast hose or the piping on the blast machine, or the orifice of a nozzle.

industrial blast One of five accepted grades of blast cleaning. Also known by the following: SSPC-SP14 (The Society for Protective Coatings), NACE No. 8 (National Association of Corrosion Engineers).

intermittent use A term of contrast with "High Production," referring to normal use of abrasive blasting 1 to 2 hours each work day, or on an unscheduled basis as required.

K

kilopascals Metric expression of pressure. 1 bar equals 100 kilopascals (kPa).

L

lead-based coating Protective coating made with lead or lead chromate, usually applied to bridges and other steel structures to prevent rust. Lead is a hazardous material that requires special equipment, special removal techniques, and special disposal methods.

M

MSHA ***Mine Safety and Health Administration.*** This organization does testing and approvals, much like NIOSH.

matte finish A dull uniform satin finish which has a minimum of surface reflection.

media A substance that transmits a force or effect. In abrasive blasting, air is the force, media is the means to transmit that force to a surface. The term abrasive is not the same as media, though it often used so. Media can be abrasive, nonabrasive, or peening. Abrasive media are usually capable of removing part of the substrate. Nonabrasive media will usually not remove substrate, because it is softer than the substrate. Peening media, is always spherical. It is used to stress-relieve a surface to increase its strength. This subject is so broad and selection of the proper type is so vital that firms specializing in abrasive supplies should be consulted. Media are divided into two categories, reusable and disposable. Within those broad categories, abrasives are classified by hardness, size, shape, source. 1) By hardness — the harder the abrasive, the faster and deeper the cutting action. 2) By size — the larger the particle, the greater the impact on the surface and the larger the anchor pattern. 3) By shape — spherical particles (shot) clean by impact, angular particles (grit), clean by gouging or cutting into the surface. 4) By source — media can be manufactured, byproducts or naturally occurring minerals.

media cleaner An air wash and mechanical unit designed to clean the media for re-use. Dirty media particles are dropped through a series of baffles, oversized contaminants are screened out, then a controlled flow of air draws dust and fine particles into the dust collector, leaving only clean reusable media which is returned to the storage hopper.

media reclaimer (also see media cleaner) A component of a blast system that returns reusable media to the hopper after removing dust, debris and fines. During blasting, the used media passes through a cyclone unit which removes contaminants by centrifugal force.

Cleaned media is returned for reuse, and dust and fines are trapped in the dust collector; debris is removed by screening.

media hopper A storage receptacle for blast media.

mesh size A term that relates to the particle size of abrasives. To assure uniformity of cutting action, abrasive grains are graded into various sizes. The sizes are measured by the standard screen mesh through which grains will pass. Thus a 24-grit will just pass through a standard screen which has 24 openings per linear inch, but will not pass through a screen which has 30 openings per inch.

metering valve The valve on the bottom of the abrasive blast machine that controls the flow of abrasive entering the compressed air stream.

milÊUnit of measure; one one-thousandth of an inch. A coating's thickness is measured in mils. 1 mil equals 25 microns.

mild steel "Common" steel; SAE 1020.

mill scale Oxide layer that is formed on steel by the hot rolling process.

Mohs' scale A method of measuring relative hardness in media.

N

NACE ***National Association of Corrosion Engineers.*** An organization comprised of companies and individuals with the common interest of corrosion control.

near-white metal blast One of five accepted "grades" of blast cleaning. Also known by the following: SSPC-SP10 (The Society for Protective Coatings), NACE No. 2 (National Association of Corrosion Engineers) and SA-2-1/2 (Swedish Standards Institute).

needle gauge An air pressure gauge, fitted with a hypodermic needle, inserted into the blast hose to measure blasting pressure at the nozzle.

nozzle holder A special fitting for the end of a blast hose that allows a nozzle to be attached.

NIOSH ***National Institute of Occupational Safety and Health.*** NIOSH is the testing and approval agency of OSHA.

normally open and normally closed The valves on a blast machine that are designed to return to a non-blast position if power to the remotes is interrupted. To achieve this fail-safe feature, a normally open outlet valve is held open by a spring until a signal from the remote control handle closes it, which pressurizes the blast machine. A normally closed valve is held closed by a spring until the signal from the remote control handle opens it. Normally closed designs are used for metering valve actuators and air inlet valves.

nozzle An orifice through which air and media are accelerated and aimed.

O

O.D. - ***Outside Diameter*** A measure of the outside of blast hose, and pipe.

orifice When used in reference to a blasting nozzle or air jet, that point inside the nozzle (its smallest diameter) at which it is measured for size.

orifice gauge A device for measuring the orifice of a nozzle.

OSHA ***Occupational Safety and Health Administration.*** OSHA develops industry regulations and enforces compliance to same.

P

particle size distribution Percentages of particles of differing screen mesh sizes.

PEL - *Permissible Exposure Limit* Mandated limit of a toxic material over an 8-hour period. For example, the current PEL for lead dust is 50 micrograms per cubic meter (50 µg/m3). Exceeding the PEL requires repeated monitoring of conditions at that site.

pH value The measurement of acidity or alkalinity, with pH being neutral. The pH value of acids ranges from 1 to 7 and of alkalis (bases) from 7 to 14. The specifications for plastic media blasting usually ask for a pH that's compatible with the substrate and the coating to be applied.

plastic media One of the newer types of nonabrasive media, made from plastic or resin, generally used for paint or coatings removal from delicate surfaces; such as aircraft skins.

pot Blast machine.

pot tender A person who loads abrasive into a blast machine and operates any manual valves, such as those found on pressure-hold systems.

ppm - ***Parts per million.*** In blasting, ppm is used to measure the amount of contaminants, such as CO, in the air supply. The amount of dust released from a dust collector is also measured in ppm.

pressure blast Media in a pressure vessel is gravity fed directly into the compressed air flow. Both air and media then travel through a single hose to the nozzle. Pressure blasting is the most forceful form of abrasive blasting and is generally used where a deep etch is required. It is three to four times faster than suction blasting.

pressure drop A loss in air or air/media pressure usually due to excessive length and/or restrictions in the size of hose.

pressure-hold and pressure-release remote controls A pressure-hold system keeps the blast machine pressurized until it is manually depressurized. This type of system is used on multiple outlet machines and dual chamber machines. A pressure-release system allows the blast machine to depressurize each time the remote control handle is released.

production rate The measurement (usually in square feet or square meters) of surface area cleaned during a given time. Many variables can affect production rates, including, but not limited to air pressure, nozzle size, type and size of abrasive.

profile The contour of a surface when viewed from the edge.

profile depth The average distance (usually measured in mils) between the tops of the "peaks" and the bottoms of the "valleys" on a blasted surface.

psi Pounds per square inch. Most outdoor blasting is done at 100 to 125 psi. Cabinet and blast facility blasting pressures are varied to match the material being blasted. Pressure is an important factor in determining production rates.

pulsation A surging sensation at the blast nozzle caused by a too-rich flow of media or by damp media.

pusher line The blast machine's exterior piping carrying compressed air to the media control valve where it joins the media flow from the blast machine, and continues to the blast nozzle. Clemco pusher lines are designed for nearly unrestricted airflow, an advantage over machines using restrictive couplings in the pusher line.

R

remote controls A safety feature composed of a set of valves, connected to the compressed air inlet and blast machine outlet and interconnected to the operator's "deadman" handle. A remote control system allows the blast operator to control the on/off cycle of the blast machine. Remote controls are required by OSHA on all blast machines. (See "deadman handle".)

S

sandblast Generic term commonly used when referring to media blasting or abrasive blasting.

semi-automated Involving the human element for a minimum amount of the work cycle. i.e. loading or unloading parts in a automated cabinet.

shot Spherical media usually manufactured from steel, iron, or ceramic.

shot blasting A method of blasting, using steel or iron shot.

shot peening A precisely controlled cold-working process in which the surface of a metal is struck repeated blows by shot. This produces a surface which resists cracking and improves tensile strength. For this reason aircraft and automotive parts such as crankshafts, gear teeth, etc., are peened.

silicon carbide A lightweight nozzle liner material recommended for use with glass bead and aluminum oxide.

SSPC ***Society for Protective Coatings.*** The organization of blasting and painting contractors, coatings manufacturers, blast equipment manufacturers, painting equipment manufacturers, inspection companies and other organizations and individuals with a common interest in the fabrication and maintenance of structures.

static wire A wire used to ground a piece of equipment to prevent a static electricity discharge.

substrate The surface material beneath the protective coating being removed. The type of substrate will determine what media, pressure, and technique to use.

suction blast Blast equipment that uses suction, or venturi principle, to move the media from its source to the blast nozzle. The blast media is held in a container at atmospheric pressure. Media and air travel through separate hoses and are mixed just prior to passage through the nozzle. Media is carried to the nozzle under a partial vacuum caused by the air passing by the media source. The recommended blasting pressure for this method is 80 psi(5.5 bar/55 kPa). Suction blasting is used when a shallow anchor pattern is required.

surface improvement A cosmetic effect achieved by blasting to improve the appearance of the product.

surface preparation For metal surfaces, there are five approved grades or degrees of cleaning the surface: "White Metal Blast"; "Near White Metal Blast"; "Commercial Blast; "Industrial Blast" and "Brush-Off Blast". Surface cleanliness is a highly important consideration where the surface is being prepared for the application of a coating. Detailed information on proper specifications should be obtained from SSPC.

surface profile The profile, surface roughness or anchor pattern. Substrate texture to which a coating can adhere, or to which a coating can anchor. Normally measured in microinches, using a profilometer.

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T

tool mark removal Elimination of any surface blemishes or marks which occur as a result of machining or other tooling during the manufacturing process.

tooth (See "surface profile".)

tungsten carbide The lining of nozzles recommended for use with all common media except aluminum oxide and silicon carbide.

V

venturi A short size restriction in the inside diameter of the center portion of the nozzle which results in a velocity increase of air and media.

venturi blasting (See "suction blasting".)

W

wet honing A method of blasting, usually in a cabinet, using a suction type blast head and a slurry of liquid and media. It provides a smoother finish than dry blasting.

white metal blast One of five accepted "grades" of blast cleaning. Also known by the following: SSPC-SP5 (The Society for Protective Coatings), NACE No. 1 (National Association of Corrosion Engineers) and SA-3 (Swedish Standards Institute) and 1st Quality (United Kingdom Standards).

Appendix

Abrasive Comparison Table

Abrasive Characteristic Comparison

Material	Mesh Size	Shape	Density lbs/ft^3	Mohs	Friability	Initial Cost	No. of Cycles	Per Use Cost	Source	Typical Applications
Sil. Sand	6-270	✷	100	5.0-6.0	high	low	1	med.	nat.	Outdoor blast cleaning
Min. Slag	8-80	✷	85-112	7.0-7.5	high	med.	1-2	med.	b-p	Outdoor blast cleaning
Steel Grit	10-325	✷	230	8.0	low	high	200$^+$	med.	mfg.	Removing heavy scale
Steel Shot	8-200	●	280	8.0		high	200$^+$	low	mfg.	Cleaning, peening
Al. Oxide	12-325	✷	125	8.0-9.0+	med.	high	6-8	med.	mfg.	Cleaning, finishing, deburring, etching
Glass Bead	10-400	●	85-90	5.5	med.	med.	8-10	low	mfg.	Cleaning, finishing
Plastic	12-80	✷	45-60	3.0-4.0	low/med.	high	8-10	med.	mfg.	Paint stripping, deflashing, cleaning
Wheat Starch	12-50	✷	45	3.0	med.	med.	12-15	high	mfg.	Paint, adhesive removal; composites
XL-Corn Hybrid Polymer	16-60	✷	45	3.0	low	high	14-17	med.	mfg.	Composite paint removal, adhesive deflash
Corn Cob	8-40	✷	35-45	2.0-4.5	med.	low	4-5	low	b-p	Removing paint from delicate surfaces

✷ = Angular ● = Spherical nat. = Natural b-p = By-product mfg. = Manufactured

Note: Do not use silica sand or any abrasive containing more than 1 percent free silica.

Air/Abrasive Consumption Guide (U.S. Standard)

U.S. Standard Compressed Air and Abrasive Consumption

Nozzle Orifice	Pressure at the Nozzle (psi) 50	60	70	80	90	100	125	140	Air (in cfm) Abrasive & HP requirements
No. 2 (1/8")	11	13	15	17	18.5	20	25	28	Air (cfm)
	.67	.77	.88	1.01	1.12	1.23	1.52	1.70	Abrasive (cu.ft./hr
	67	77	88	101	112	123	152	170	& Lbs/hr)
	2.5	3	3.5	4	4.5	5	5.5	6.2	Compressor hp
No. 3 (3/16")	26	30	33	38	41	45	55	62	Air (cfm)
	1.50	1.71	1.96	2.16	2.38	2.64	3.19	3.57	Abrasive (cu.ft./hr
	150	171	196	216	238	264	319	357	& Lbs/hr)
	6	7	8	9	10	10	12	13	Compressor hp
No. 4 (1/4")	47	54	61	68	74	81	98	110	Air (cfm)
	2.68	3.12	3.54	4.08	4.48	4.94	6.08	6.81	Abrasive (cu.ft./hr
	268	312	354	408	448	494	608	681	& Lbs/hr)
	11	12	14	16	17	18	22	25	Compressor hp
No. 5 (5/16")	77	89	101	113	126	137	168	188	Air (cfm)
	4.68	5.34	6.04	6.72	7.40	8.12	9.82	11.0	Abrasive (cu.ft./hr
	468	534	604	672	740	812	982	1100	& Lbs/hr)
	18	20	23	26	28	31	37	41	Compressor hp
No. 6 (3/8")	108	126	143	161	173	196	237	265	Air (cfm)
	6.68	7.64	8.64	9.60	10.52	11.52	13.93	15.60	Abrasive (cu.ft./hr
	668	764	864	960	1052	1152	1393	1560	& Lbs/hr)
	24	28	32	36	39	44	52	58	Compressor hp
No. 7 (7/16")	147	170	194	217	240	254	314	352	Air (cfm)
	8.96	10.32	11.76	13.12	14.48	15,84	19.31	21.63	Abrasive (cu.ft./hr
	896	1032	1176	1312	1448	1584	1931	2163	& Lbs/hr)
	33	38	44	49	54	57	69	77	Compressor hp
No. 8 (1/2")	195	224	252	280	309	338	409	458	Air (cfm)
	11.60	13.36	15.12	16.80	18.56	20.24	24.59	27.54	Abrasive (cu.ft./hr
	1160	1336	1512	1680	1856	2024	2459	2754	& Lbs/hr)
	44	50	56	63	69	75	90	101	Compressor hp

(Based on abrasive with a density of 100 pounds per cubic foot.)

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

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Air/Abrasive Consumption Guide (Metric)

Metric Compressed Air and Abrasive Consumption

Nozzle Orifice	Pressure at the Nozzle (bar & kPa) 3.5 / 350	4.2 / 420	4.9 / 490	5.6 / 560	6.3 / 630	7.0 / 700	8.6 / 860	10.3 / 1035	Requirements: Air (m^3/min) Abrasive (kg/h) * & kW
5mm (3/16")	0.73	0.84	0.92	1.06	1.15	1.26	1.54	1.82	Air (m^3/min)
	68	78	89	98	108	120	145	174	Abrasive (kg/h)
	4.5	5.3	5.6	6.4	7.1	7.5	9.0	10.8	kW
6.5mm (1/4")	1.31	1.51	1.71	1.90	2.08	2.27	2.75	3.22	Air (m^3/min)
	122	142	161	185	203	224	276	325	Abrasive (kg/h)
	7.9	9.0	10.1	11.6	12.4	13.5	16.2	19.4	kW
8mm (5/16")	2.16	2.50	2.83	3.16	3.53	3.84	4.71	5.57	Air (m^3/min)
	212	242	274	305	336	368	445	534	Abrasive (kg/h)
	13.1	15.0	19.1	20.2	21.0	22.9	27.5	33.0	kW
9.5mm (3/8")	3.02	3.53	4.00	4.50	4.85	5.50	6.64	7.79	Air (m^3/min)
	303	347	392	435	477	573	632	758	Abrasive (kg/h)
	18.0	21.0	24.0	27.0	28.9	33.0	39.6	47.5	kW
11mm (7/16")	4.12	4.76	5.44	6.09	6.73	7.11	8.80	10.48	Air (m^3/min)
	406	468	533	595	657	719	876	1040	Abrasive (kg/h)
	24.8	28.5	32.6	36.4	40.1	42.4	50.9	61.1	kW
12.5mm (1/2")	5.46	6.28	7.06	7.85	8.65	9.46	11.46	13.45	Air (m^3/min)
	526	606	686	762	842	918	1115	1333	Abrasive (kg/h)
	32.6	37.5	42.0	46.9	51.8	56.3	67.6	81.1	kW

* Based on abrasive with a density of 1.5 kg per liter.

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

10 bar or 1035 kPa (150 psi) working pressure in last column relates to blast machines and components specifically built for higher pressures. Never exceed approved working pressures.

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Blast Hose Rating Table

Blast Hose Rating

Types of Blast Hose	Construction	Working Pressure Rating	Features and 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 rooms.
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.

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Minimum Air Volume Table

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)	Minimum 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

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Blast Machine Reference Table (U.S.)

United States Blast Machine Reference Table

Clemco U.S. Models	Dimensions		Capacity (Vol.) *	Capacity (Wt.) **
	Diameter	Height	Cu Ft	Lbs
1028	10"	28"	.5	50
1042	10"	42"	1	100
1440	14"	40"	1.5	150
1642	16"	42"	2	200
1648	16"	48"	3	300
2002	16"	42"	2	200
2004	24"	42"	4	400
2006	24"	52"	6	600
2452	24"	52"	6	600
3054	30"	54"	7	700
3658	36"	58"	10	1000
3676	36"	76"	20	2000

* Actual volume may vary based on head and cone sizes.
** Based on abrasives with a density of 100 pounds per cubic foot.

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Blast Machine Reference Table (European)

Clemco International Blast Machine Reference Table

European Models	Capacity (Vol.) * Liters	Capacity (Wt.) ** Kg
1028	20	25
1440	50	76
1628	40	60
1638	60	90
1648	100	150
2040	100	150
2048	140	210
2452	200	300

*** Actual volume may vary based on head and cone sizes. European machines are built to slightly larger dimensions and may have greater volumes.**

**** Based on abrasives with a density of 1.5 kg per liter.**

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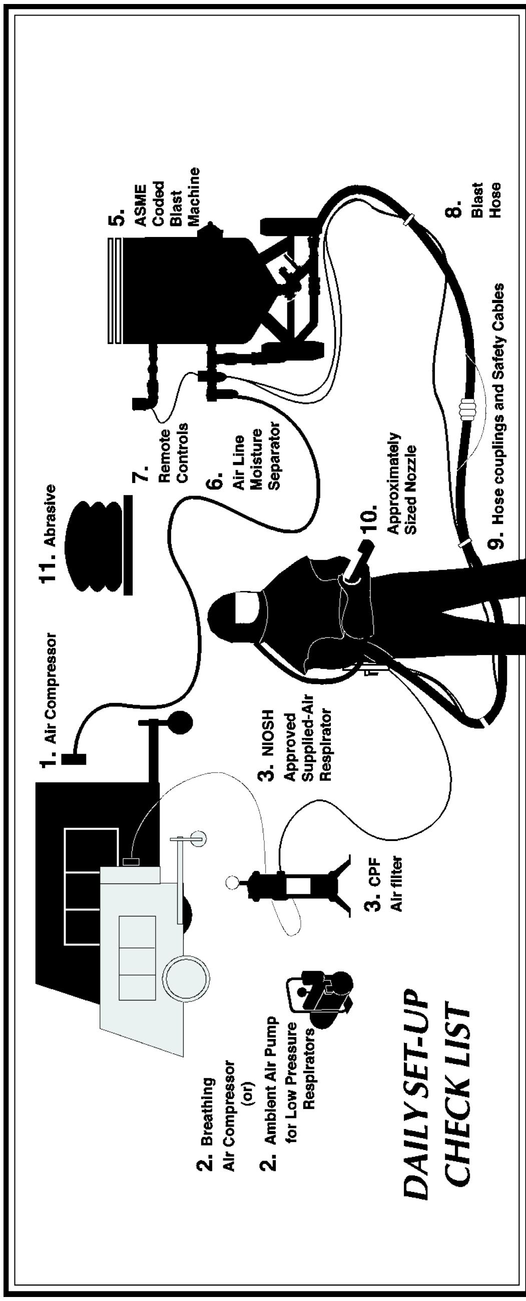
Set-Up Diagram



Daily Checklist

WARNING

- **ALL piping, fittings and hoses MUST be checked DAILY for tightness and leakage.**
- **ALL equipment and components MUST be thoroughly checked for wear.**
- **ALL worn or suspicious parts MUST be replaced.**
- **ALL blast operators MUST be properly trained to operate equipment.**
- **ALL blast operators MUST be properly outfitted with abrasive resistant clothing, safety shoes, leather gloves and ear protection.**
- **BEFORE blasting ALWAYS use the following check list.**

☐ **1. PROPERLY MAINTAINED AIR COMPRESSOR** sized to provide sufficient volume (cfm) for nozzle and other tools PLUS a 50% reserve to allow for nozzle wear. Use large compressor outlet and large air hose (4 times the nozzle orifice size). FOLLOW MANUFACTURER'S MAINTENANCE INSTRUCTIONS.

☐ **2. BREATHING AIR COMPRESSOR — or AMBIENT AIR PUMP** (oil-less air pump) capable of providing Grade D Quality air located in a dust-free, contaminant-free area. If oil-lubricated air compressor is used to supply respirator, it should have high temperature monitor and CO monitor or both. If CO monitor is not used, air MUST be tested FREQUENTLY to ensure proper air quality.

☐ **3. CARBON MONOXIDE ALARM** to detect the presence of carbon monoxide in the breathing air line, up-stream of the in-line breathing air filter. (For compressed air systems only.) THIS DEVICE DOES NOT REMOVE CARBON MONOXIDE (CO).

☐ **4. BREATHING AIR FILTER** for removal of moisture and particulate matter from breathing air supply. THIS DEVICE DOES NOT REMOVE OR DETECT CARBON MONOXIDE (CO). ALWAYS USE CO MONITOR ALARM. (For compressed air systems only.)

☐ **5. CLEAN, PROPERLY MAINTAINED NIOSH APPROVED SUPPLIED-AIR RESPIRATOR.** ALL components should ALWAYS be present. NEVER operate without inner lens in place. Thoroughly inspect ALL components DAILY for cleanliness and wear. ANY substitution of parts voids NIOSH approval i.e. cape, lenses, breathing hose, breathing air supply hose, air control valve, and cool air or climate control devices.

☐ **6. ASME CODE BLAST MACHINE** sized to hold 1/2 hour abrasive supply. ALWAYS ground machine to eliminate static electricity hazard. Examine pop-up valve for alignment. Blast machine MUST be fitted with a screen to keep out foreign objects and a cover to prevent entry of moisture overnight.

☐ **7. AIR FILTER/MOISTURE SEPARATOR** installed AS CLOSE AS POSSIBLE to machine inlet. Sized to match inlet piping or larger air supply line. Clean DAILY. Drain OFTEN.

☐ **8. REMOTE CONTROLS** MUST be in PERFECT operating condition. Use ONLY APPROVED spare parts, including twin-line hose. DAILY: test system operation and check button bumper and spring action of lever and lever lock. DO NOT USE WELDING HOSE.

☐ **9. BLAST HOSE** with ID 3 to 4 times the nozzle orifice. Lines MUST be run AS STRAIGHT AS POSSIBLE from machine to work area with NO sharp bends. Check DAILY for internal wear and external damage.

☐ **10. HOSE COUPLINGS, NOZZLE HOLDERS** fitted SNUGLY to hose end and installed using PROPER coupling screws. Coupling lugs MUST be snapped FIRMLY into locking position. Gasket MUST form positive seal with safety pins inserted through pin holes. Check gaskets and replace if ANY sign of wear, softness, or distortion. ALWAYS install safety cables at every connection to prevent disengagement. Check nozzle holder for worn threads. NEVER MIX DIFFERENT BRANDS OF COMPONENTS. Check each of these components DAILY.

☐ **11. INSPECT NOZZLE and GASKET DAILY** for wear. Replace nozzle when 1/16-inch larger than original size or if liner appears cracked. Check nozzle threads for wear.

☐ **12. USE ABRASIVE THAT IS PROPERLY SIZED** and free of harmful substances such as: free silica, cyanide, arsenic or lead. Check material data sheet for presence of toxic or harmful substances.

☐ **13. TEST SURFACE TO BE BLASTED** for toxic substances. Take appropriate protective measures for operator and bystanders which pertain to substances found on the surface to be blasted.

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