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ABRASIVE BLAST CLEANING

ABRASIVE BLAST CLEANING

Contents

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Introduction

This eBook features articles from the *Journal of Protective Coatings & Linings* (*JPCL*) about abrasive blast cleaning. All information about the articles is based on the original dates of publication of these materials in *JPCL*. Please visit www.paintsquare.com for more articles on these and other topics.

Fig. 1: Blast pot
Courtesy of Axxiom Manufacturing

Editor's Note: This Applicator Training Bulletin is an update of a previous article written by Joe Fishback of Custom Blast Services Inc. It was first published in the November 1989 JPCL and has been updated for this issue by Bill Corbett and Stan Liang of KTA-Tator, Inc.

Setting Up Air Abrasive Blast Equipment

An air abrasive blast equipment system is composed of several major components, including the following.

- Air Compressor
- Blast Pot (Pressure Blast Tank)
- Abrasive (Blast Media)
- Blast Nozzle
- Moisture Trap
- Deadman Switch
- Blast Hood
- Interconnect Hoses

Let's take a look at each to see how they work together to provide an efficient abrasive blast system.

Air Compressor

The air compressor provides high-pressure air for the blasting operation. This machine takes in atmospheric air at 14.7 psi and compresses it to a pressure several times higher, usually about 120 psi. The heat generated through compression is somewhat dissipated by an air intercooler. The air then passes through moisture and oil separators to make it dry and oil-free as it exits the compressor.

Air compressors are generally identified by output capacity, such as 250 CFM, 325 CFM or 750 CFM. CFM means cubic feet per minute, which is how the volume of pressurized air is measured. The power to run a compressor is usually provided by an internal combustion engine (gasoline or diesel) or by an electric motor. Selection of a power unit is generally dictated by the area where blasting is to be done or by the availability of utilities.

Fig. 2: Multi-colored deadman switches. Courtesy of SAFE Systems, Inc.

Before starting the compressor, remember to:
- check the engine oil level;
- check the coolant level; and
- check the belts and hoses for leaks or defects.

Blast Pot

The blast pot (Fig. 1, p. 17) is a coded pressure vessel generally referred to as a pressure blast tank (PBT). Because it is a pressure vessel, it must have a stamp on it showing that it has been pressure tested. The PBT is further identified by size. For example, it may be called a 6-ton PBT or a 6-sack pot (based on silica sand), referring to the amount of abrasive it can hold. During operation, the blast pot is pressurized and feeds abrasive into the air stream.

Abrasive (Blast Media)

While not usually thought of as abrasive blast equipment, not much happens to the surface without the abrasive. Abrasives are generally categorized as expendable (one-time use) or recyclable (multiple uses). The type, size, shape and hardness of the abrasive all affect productivity as well as the depth and shape of the surface profile or anchor pattern. The cleanliness of the abrasive is just as important as the cleanliness of the compressed air used to propel the abrasive. A vial test is performed on new or recycled abrasive prior to use. The abrasive is tested for oil according to ASTM D7393 and conductivity according to ASTM D4940. According to the SSPC standards, abrasives cannot contain any visible oil and cannot have a conductivity that exceeds 1,000 µS.

Blast Nozzle

The blast nozzle is a small but important piece of the blasting equipment. It is the last item to exert influence on the blast media. Nozzles are identified by their shell composition, their lining composition, the size of the orifice and length (for example, aluminum shell with tungsten lining, size #7, short). The orifice size number relates to the size in 1⁄16-inch units (#7 = 7⁄16-inch). The size of the nozzle has a bearing on the amount of air and abrasive used and on the amount of work completed. The larger the size of the nozzle, the greater the consumption of supplies. Nozzles are chosen for the work to be performed.

Moisture Trap

The moisture trap is a device that allows the compressed air to shed water. As the air is compressed, heat is generated. As this hot air passes through the heat exchanger to lower the air temperature, water in suspension (humidity) is condensed. Generally, a compressor is fitted with a moisture trap. This first trap catches most of the water. However, as the compressed air continues to cool, additional moisture condenses in the bull hose. This remaining moisture is trapped by the moisture separator just before it enters the PBT. This trapping is done either with a centrifuge-style separator or with a replaceable filter element-style separator. Generally, it is necessary to leave an air bleed valve open in the bottom of the moisture trap when blasting to allow the moisture to be expelled.

Deadman Switch

The deadman switch (Fig. 2), either pneumatic or electrical, allows the blaster to have remote control over the pressurization of the blast hose. With pneumatic operation, this is accomplished when pressure through the deadman switch closes the air control valve and opens an escape valve. This prevents air from entering the PBT and at the same time, it depressurizes the PBT. Electrically operated systems use pinch valves to stop the flow in the blast hose. With electrically controlled systems, the PBT is always pressurized when the bull hose is connected and pressurized.

The primary purpose of the deadman switch is safety. It provides a means to stop the discharge of abrasive from the nozzle when a safety hazard arises. The fact that it allows the blaster to start and stop work at his discretion is a secondary purpose.

Blast Hood

The blast hood (Fig. 3) is a piece of safety gear that provides a degree of comfort to the blaster as well. This hood is generally a reinforced plastic shell with a replaceable skirt that covers the torso of the blaster. It has a double-faced shield of clear plastic for eye protection and an air feed line to provide positive pressure under the hood. The positive air pressure under the hood prevents the entrance of harmful blasting dust and abrasive. Air coolers are also available. If the air is coming from a diesel compressor, an air purifier and carbon monoxide monitor are required.

Hoses

Hoses vary in size depending on the work to be performed, available air capacity, distance to work area and other considerations.

The first in the sequence is the bull hose. This is generally a short hose — less than 50 feet long, with an internal diameter (ID) of approximately 2.5 inches or less that provides passage of air from the compressor to the PBT.

The next hose is an air-line with an approximate ID of 0.75 inches or less that provides air first to a moisture trap and then to the blast hood. The section between the moisture trap and the hood is smaller, down to 0.25-inch ID.

Control hoses can be down to 0.20-inch ID and are generally duplex (dual-line) hoses. They run from the control valve on the PBT to the deadman switch and back to complete the circuit when the blaster is ready to commence work. Included here is the electrical wiring necessary if the deadman is electrically operated. It generally operates from a 12-volt DC source such as the compressor power unit's DC system.

The last hose in the circuit is the blast hose. It is a thick-wall, wire-reinforced hose designed and constructed to contain the high-pressure air (up to 120 psi) and abrasive mixture that moves from the PBT to the blast nozzle. The blast hose is constructed in three layers: an inner wearing lining, a conductive layer and an outer wrapping. Abrasive passing through a blast hose builds up static electricity. The conductive layer is needed so the whole system can be grounded. As a general rule, the hose should be three times the ID of the nozzle orifice; ideally, 1.25 inches to 1.5 inches for optimum production.

Fig 3: Blast hood
Courtesy of Bullard

Setting Up the System

With the major sub-assemblies identified, we can now set up our blasting equipment. Position the compressor upwind from the work area so that airborne grit does not enter the cooling or air intake systems. The compressor should be level so that the oil and moisture separators can function efficiently. The power unit's lubrication system also depends on the compressor being level. After fluid levels (oil, coolant and fuel) have been verified and topped off, the compressor is ready to start.

The bull hose should be laid out with no kinks and a minimum of bends. Prior to making connections at the compressor and PBT, the sealing gaskets should be examined for tears, cracks or other sealing problems. As soon as the connectors have interlocked, a safety pin or wire should be inserted to prevent accidental separation of the joint. If this separation should occur, there is great potential for personnel or property damage as the hose whips around. The hose should be examined for damaged locking lugs, missing gaskets, soft spots, torn covers or other damage.

If any defects are observed, consideration should be given to replacement of the worn or damaged part. If all appears in good condition, make the connections at the compressor and PBT moisture trap.

The next step is to lay out the blast hose utilizing the same inspection procedures used for the bull hose and fittings. If all is in good shape, connect the selected nozzle and pin all fittings.

When the blast hose connection is complete, you can run the hose for the deadman switch. The fittings on the ends of this hose are brass, male/female and threaded. It is necessary to use the proper-sized wrench to prevent damage to the brass hex surfaces. As the hose is installed, care should be taken to lay the hose parallel to the blast hose. The control line should also be secured to the blast hose by tape or other means to minimize possible damage to this less durable hose. This is important because air leaks in the control line will not allow the control valve to pressurize the PBT and thus no blasting takes place. The threaded fittings should be tightened securely but not over tightened.

Now, go back to the air source for connection of an air-line to feed the small moisture trap for hood atmosphere. These fittings are usually 0.75-inch crow's foot, quick-disconnect fittings. Inspection of hose gaskets and locking lugs is once again
necessary. Be certain to pin all quick-disconnect crow's feet.

The hood atmosphere line is the last hose to be hooked up. This hose has brass screwed fittings similar to those on the control line. The same care in hook-up should be exercised, with particular attention to preventing entry of debris.

Now, with all hoses connected to their respective fittings, you are ready for pressurized air. Close all air outlet valves on the compressor. Press the shutdown bypass button as well as the start button. The compressor should start and run. After the temperature moves up to the operating temperature, it is time to press the service air switch. At this time the air pressure gauge should register approximately 110–120 psi. If the reading is higher or lower, adjustments should be made before beginning the blasting operation. When the compressor stabilizes at working air pressure, slowly open the valve to furnish hood atmosphere air. After the quality (oil and contaminant-free) and quantity of this air are verified, slowly open the valve for the bull hose. There should be no air escape except at the moisture trap bleeds. If air leaks are present, they should be repaired. The PBT can now be filled with abrasive.

The blaster should be clothed with sturdy shoes or boots, heavy pants, a long-sleeved heavy shirt and leather gloves for protection from bounce-back of abrasive. When the blaster has been properly suited up, he or she can check operation of the blast equipment. He or she does this by opening the deadman valve to pressurize the PBT and thus force a quantity of abrasive to enter the air stream to the blast hose.

Adjustments in the amount of abrasive delivered to the nozzle can be made with an abrasive valve located close to the bottom of the PBT. Enough abrasive to do the work should be delivered, but not so much as to slow the impact or choke the blast hose or nozzle.

To assure the quality of cleaning, two important checks should be made. The first is a compressed air cleanliness test, also known as a white rag or blotter test. This test determines if the blast air is free of moisture and oil as it is delivered to the nozzle. The abrasive valve is closed to prevent abrasive from entering the air stream. A white rag or blotter (called an "absorbent collector") fastened to a rigid backing is then positioned in the air stream within 24 inches of the nozzle. A non-absorbent collector such as rigid transparent plastic may also be used. After a minimum of one minute, the collector is removed and examined for oil or moisture contamination. If evidence of oil is present on the collector, adjustments must be made to the system, possibly by service personnel from the supplier of the compressor.

The second test measures nozzle pressure. This measurement is taken with a needle pressure gauge. The needle is inserted into the blast hose in the direction of air and abrasive flow. This insertion takes place close to the nozzle with both the air and the abrasive flowing. Nozzle pressure is read directly on the face of the gauge. Optimum blast nozzle pressure should be approximately 100 psi for productive work. Pressures lower or higher than 100 psi may improve productivity depending on the abrasive being used.

With proper setup of equipment and a thorough knowledge of good safety practices, your job should be safe and trouble-free.

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Editor's Note: This Applicator Training Bulletin is an update of an original article written by Walter Shuler, certified safety professional and safety consultant; Jeff Theo, Service Painting Company; and Mike McGinness, Custom Process Systems. The article was originally published in the June 1998 issue of Protective Coatings Europe (PCE) and was updated for this issue by Dan O'Malley, Manager of the Environmental, Health, and Safety Group; and Stan Liang, Director of Health and Safety; KTA-Tator, Inc.

Safety Considerations for Abrasive Blasting Operations

The Occupational Safety and Health Administration (OSHA) writes and enforces regulations that govern safety and health practices in the work place, with many pertaining to cleaning and painting operations. Most of these regulations are very specific about how to do a job safely. Their purpose is not to make our job more difficult, but to make it safer. These regulations have been developed over many years through studies on how and why accidents happen, and following these written procedures and regulations should ensure that we don 't make the same mistakes that have injured others in the past.

This article will review some of the general requirements of regulations on abrasive blasting and explain how they can help increase job safety.

Hazards of Abrasive Blasting

When you blast clean surfaces with abrasive driven by air, you have to deal with several hazards to your health and safety. Some of these hazards can be lethal, so it is important that you understand what they are and observe the proper safety precautions. The hazards of abrasive blasting include, but are not limited to:

- dust,
- noise, and
- equipment. Dust

The dust produced by abrasive blasting is a very serious health hazard. Dust results from the breakdown of abrasives and the pulverizing of surface coatings, rust, millscale, and other materials on the steel surface being blasted. The individual dust particles vary in size from 1 micron (1⁄25,000-inch) to 1,000 microns (1⁄25-inch) in diameter. Dust larger than 10 microns may be visible and settles quickly. Dust smaller than 10 microns, called respirable dust, is invisible, remains suspended in the air for a longer period of time, and can pass through the respiratory system's defenses and settle in the small air sacs in the lung called alveoli.

Dust of this size cannot be dissolved by the lung fluids. Because the lung cannot break down or cast out the particles, it does the next best thing in its defense program, which is to isolate the intruder by building a thick, fibrous tissue around it. When too much of this tissue develops, the lung is said to be "fibrotic," or in a condition of fibrosis.

The routes of entry and the associated health effects depend on the chemical and physical properties of the dust. If the dust is soluble in water and respirable in size, it can enter the alveoli, pass through the walls of the alveoli in the lungs, and enter the bloodstream. Once in the bloodstream, dust can be transported rapidly throughout the body and damage various organ systems.

Other health hazards may be present in the dust produced by the abrasive blasting process. These hazards can result from the removal of coatings containing toxic metals such as lead, arsenic, cadmium, and hexavalent chromium. One of the most common toxic metal hazards encountered in the removal of a coatings system is lead, a toxic metal that can damage the body's blood-forming, nervous, urinary, and reproductive systems. Lead also accumulates in the body; thus, exposure to small doses over long periods of time can cause great harm.

Exposure to toxic metals can also directly affect the skin. Metals such as hexavalent chromium can irritate the skin or cause an allergic reaction. Other metals can have an irritant effect on the respiratory tract, such as pulmonary edema (fluid build-up in the lungs) caused by severe cadmium dust exposure. Entry can also occur via ingestion, typically caused by poor hygiene practices such as eating, drinking, and smoking in the work area.

To determine the specific toxic metals likely to be present in a coatings system, paint chip samples should be collected from representative areas of the structure. The metals that the samples should be analyzed for would depend on a number of considerations, such as the type of structure and the type of coatings system being evaluated. Sometimes, toxic metal content can be determined based on historical knowledge of the coatings system being evaluated.

Toxic metals can also be present in the virgin abrasive blast media, such as crystalline silica in silica sand abrasive. However, dust-containing crystalline silica also can be produced during other abrasive blasting activities, such as surface preparation of concrete. A study published in the September 2006 issue of the Journal of Occupational and Environmental Hygiene indicated that elevated exposure to crystalline silica exposure also can result when it is present in the coatings system being removed.1

The Safety Data Sheet should be consulted to determine what metals may be present in the abrasive blast media. Recently, OSHA has begun requiring abrasive manufacturers to list toxic metals in their products, even if they are present only in trace amounts. Arsenic is commonly found in steel grit and coal slag abrasives, while beryllium is commonly found in coal slag abrasives.

When there is exposure to toxic dust, the primary concern is to control respiratory exposure. Respiratory protection must comply with the OSHA Respiratory Protection Standard (29 CFR 1926.103). This standard requires feasible engineering and work practice controls to be employed before respiratory protection is used by workers. Engineering controls include ventilated abrasive blasting containments and considering alternatives to abrasive blasting, such as vacuum-shrouded power tools, water jetting, and chemical stripping. Job rotation is an example of a work practice control. Note that job rotation is not permitted by OSHA in all cases (if workers are exposed to hexavalent chromium, for instance). If such a control is used, a written schedule must be developed and followed.

Respiratory protection may only be used after engineering and work practice controls are employed and workers are still exposed above the OSHA Permissible Exposure Limit (PEL) for a given toxic dust. Employers must select, use, and maintain respirators in accordance with a written program (the elements of which are specified by OSHA in the Respiratory Protection Standard).

Blasters typically use a Type CE or helmet-type airline respirator. Workers in the vicinity of the blasting area, such as pot tenders and lookouts, are required to wear respiratory protection. Workers engaged in clean-up operations should also be equipped with respiratory protection. These workers are usually assigned a half-mask, air-purifying respirator with high-efficiency cartridges (labeled as N, R, or P 100). However, workers cleaning up abrasive blasting debris when blasting is still in progress (as is often the case when recyclable grit is used) may need a higher level of protection. Such workers may need to wear the same type of respirator as the blasters, as their exposure levels are likely to be similar.

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The National Institute of Occupational Safety and Health (NIOSH) conducts research on health issues in the work place, and one of its main functions is to test and certify industrial respiratory protection equipment. All respiratory protection equipment used in the workplace must be approved by NIOSH.

Respiratory protection should continue to be worn after blasting as long as dust-laden air remains. Respirable dust in an abrasive blasting booth or containment can remain suspended for long periods of time after blasting is finished. This time period is largely dependent on the effectiveness of the ventilation system, unless the work is performed outdoors.

A health and safety professional should review all projects that require abrasive blast cleaning to determine what precautions, if any, should be taken to eliminate the hazard of chemical exposure. Examples of these precautions include disposable clothing, boots, gloves, respiratory protective devices, and hygiene practices. Hygiene facilities that can be required by OSHA include hand wash stations and showers. OSHA requires provision of a hand wash station when workers may come into contact with toxic materials. Whether or not showers are mandatory depends on which OSHA standard is applicable. If workers are exposed to lead, showers are required when exposures exceed the PEL.

Noise

Most forms of abrasive blasting create the hazard of noise exposure, which will vary depending on the blasting conditions. Regardless of the nature, excessive amounts of noise may require personal hearing protection for blasters and other workers in the general area. Depending on the size of the equipment, the material being blasted, and the location of the blasting operation, noise levels can range from about 90 decibels to more than 110 decibels. OSHA's limit for noise depends on the duration of exposure. For an eight-hour shift of continuous exposure, the limit is 90 decibels. Personal hearing protection should then be recommended if the level and exposure time of the workers exceed the OSHA standard. Noise protection must reduce exposure to below the OSHA limit.

Note that some abrasive blasting hoods already provide some degree of noise protection, but the manufacturer's specifications should be checked to see if the degree of noise reduction will be adequate. When there is any question about the existing levels (meaning a noise survey is needed) or the adequacy of hearing protection, a health and safety professional should be consulted.

Equipment

The equipment used in abrasive blasting operations can create physical hazards that require certain precautions. The following are some examples of equipment commonly used during the abrasive blast cleaning process and the respective precautions that should be taken during their use.

- "Deadman" control: This is usually a spring-loaded control located near the nozzle end of the blast hose. When depressed, it starts the flow of high-pressure air and abrasive. When released, it stops the flow. Deadman controls can be either pneumatic (air-operated) or electric. In either case, the control must be kept depressed by the operator for the system to work. This prevents a nozzle from blasting the operator or nearby workers with abrasive if dropped. Always verify that there is a Deadman control and that it is operable before any work is performed.
- Hoses: Hoses are subject to severe abrasion from the high-pressure air and abrasive that moves from the pressure vessel to the nozzle. Ruptures can cause serious injury. Metal piping carrying abrasive also deteriorates rapidly. Hoses and piping should be inspected on a regular basis and repaired or replaced periodically as necessary. Hose and pipe couplings also should be inspected regularly. Blast hose couplings should be wired together and whip checks should be used. Whip checks are safety cables that restrain movement of the hose should the coupling connection become compromised.
- Pressure vessels: Pressure vessels for compressed air or abrasive under pressure should be checked regularly because they are also subject to abrasion and deterioration beyond that of normal pressure vessels. Pressurized abrasive tanks must have a removable plate for internal inspection. All vessels must conform to American Society of Mechanical Engineers (ASME) boiler and pressure vessel codes.
- Valves: All valves and rubber valve parts are subject to wear and should be inspected and replaced periodically.
- Fill ports: Pressure vessels for abrasive blasting should have a funnel-shaped input that is easily accessible to the operator so that strain caused by lifting bags of abrasive is avoided.
- Hoseline grounding: Nozzles should be grounded because the air and abrasive can create enough friction to develop a substantial charge of static electricity. This is most important while working inside tanks or in other areas where there is potential for explosion.
- Personal protective equipment: In addition to respiratory and noise protective equipment, blasters should wear apparel to prevent damage to their skin from abrasive blasting and ricochet. Such apparel includes safety footwear or toe guards, coveralls, leather or rubber capes, and gloves. Pant and sleeve cuffs should be secured with tape or other suitable fasteners. These clothing rules are most difficult to enforce during hot weather, but despite the discomfort, they still must be enforced. Protective equipment should be inspected daily and repaired or replaced as necessary. Clean storage areas should be provided for respiratory protection and protective apparel. It is most important that blasters receive proper training in the use of personal protective equipment.

Summary

When performing abrasive blasting, safety considerations must be given to hazards including dust, noise, and equipment. Once the hazards are determined, procedures for personnel protection can be developed. In addition to being provided with personal protection, workers must be properly trained in the use, inspection, and maintenance of equipment.

Procedures to control exposure to health and safety hazards must conform to the OSHA regulations that govern blasting operations. Additional regulations from state or local jurisdictions may be in force. Twenty-three states have their own version of OSHA, and their regulations are at least as strict and, in some cases, stricter than federal OSHA regulations.

This article should not be considered a comprehensive analysis of abrasive blasting health and safety. When there is any doubt about the nature of the hazard or how to protect workers, assistance should be obtained from a health and safety professional, typically someone who is a Certified Industrial Hygienist or a Certified Safety Professional or possesses a degree from a related field of study.

References:

1. Meeker, John D., Pellegrino, Anthony, and Susi, Pam, "Comparison of Occupational Exposures Among Painters Using Three Alternative Blasting Abrasives." Journal of Occupational and Environmental Hygiene, Volume 3, Issue 9 (September 2006): pp. D80–84.

On the Time between Blasting and Priming

How long can a blasted surface be left before priming under different temperatures/relative humidity environments?

Editor's Note: Problem Solving Forum questions are posted on the free daily electronic newsletter, PaintSquare News, on behalf of JPCL. Responses are selected and edited to conform to JPCL style. To subscribe to PaintSquare News, go to www.paintsquare.com/psn/.

From Lee Edelman
CW Technical Service

Always attempt to prime the prepared surfaces before the specified surface preparation starts degrading. Most specifications will address this practice. Humidity and dew point should be monitored throughout the process, so that when humidity or dew points exceed what the specification allows, there should not be any painting activities.

If the prepared surface has degraded, most specifications will require reblasting to the specified degree of surface preparation.

From Richard D. Souza
Stoncor Middle East LLC

How long a blast-cleaned surface can remain uncoated is not the issue; rather, the highest criterion is the steel temperature: It should always be at least 3 degrees C (5 F) higher than the calculated dew point temperature. This margin of safety is sufficient for all type of coatings.

A common scenario is that the contractor blasts all day long; experiences problems with the compressor or other piece of equipment; and as a result of the equipment problems, lets the newly blasted steel sit a long time before coating. But the standard requires that the surface to be painted must meet the cleanliness criteria set by the client or consultant. These criteria supersede every other judgment and vary from job to job. In Jordan, for example, oxidation or orange rust may not occur for several hours or days, but in UAE, you can probably expect to see rust break through in few hours, depending on the time of the day or night.

It is almost impossible to state the effect of time, temperature, and humidity on all blast-cleaned surfaces. On any given job, the answer must be the sole responsibility of the inspector, who conducts on-site checks of the conditions such as the following:

- Place of work
- Air temperature—minimum and maximum
- Relative humidity
- Dew point
- Steel temperature
- Necessary ventilation
- Type of weather, such as sunlight, rain, wind speed, and direction

These on-site checks must be done at least three times per shift. The inspector should have the sole right to determine the time without deviating from the specification.

From Remko Tas
Futuro SRL

As a curiosity, flash rust did not occur for 10 days in a dry climate at an altitude of 4,000 m (13,000 ft) in Bolivia, hundreds of kilometers away from the influence of saltwater and contamination from industry-generated air pollution. We could still safely paint the interior of the tank in one shot, achieving a high efficiency.

From Lubomir Jancovic
MSPLUB Inc.

You have to prime the blasted surface of steel within eight hours. Otherwise, blasting was for nothing. If the relative humidity is more like 60%, you have to prime the surface within four hours.

Shotblasting: Tips on the Operating Mix

In abrasive blasting, the phrases, "operating mix," "abrasive mix," and "work mix" all refer to the same thing: the mixture of metallic (or recyclable non-metallic) abrasive sizes that will provide the desired surface preparation. And, as noted in SSPC's *Protective Coatings Glossary*, "maintain- ing the appropriate abrasive mix requires periodic addition of new abra- sive to the recycled abrasive during the blasting operation" (p. 10). Here are a few tips from industry sources on main- taining the operating mix during shot blasting. (Please note that this article is just a starting point.)

First, there is "a golden rule" for the operating mix in shot blasting, to para- phrase technical literature posted on Wheelabrator-Allevard's web site, www.bestofblasting.com. The rule is that the mix should contain the smallest size abrasive needed for removing cont- amination and for cleaning the substrate at optimal productivity. Moreover, the company's literature points out, the greater the number of small abrasive particles is in a given volume, "the high- er the number of impacts [is] per minute and the more efficient the work [is]."

Second, as the Wheelabrator- Allevard literature indicates, the oper- ating mix is dynamic. It changes as blast- ing continues, with the particles eventu- ally wearing down to the point of rejec- tion—a point that is determined by the setting of the separator. The separator setting also helps to control the size dis- tribution in the operating mix. The size distribution of the abrasive particles is a key factor in the quality of the surface preparation achieved by the abrasive, and should be checked regularly and kept constant, as Wheelabrator- Allevard notes. The company adds that maintaining a constant operating mix means making sure the hopper is full. And while new abrasive must be added regularly to the mix, the amount of new material added at a time should be restricted to 10% or less of the blasting equipment's capacity. The hardness of an abrasive determines how long it will last and thus how soon it will be consumed. While the cleaning efficiency increases with hardness, so does the fri- ability of the abrasive, which makes it wear down faster.

Third, requirements for assuring the cleanliness of operating mixes of recy- clable abrasives are given in the SSPC's, Abrasive Specification No. 2, Cleanliness of Recycled Ferrous Metallic Abrasives. The specification includes acceptable levels of non-abra- sive residue, lead content, water-soluble contaminants, and oil content; and it gives procedures for determining whether or not the mix meets the requirements of AB 2. (SSPC members can download the standard for free at www.sspc.org.)

Remember: The tips above are intend- ed as a review or introduction to the subject of maintaining your operating mix. Consult your equipment manufac- turer or manual for all procedures required to maintain the mix. In addi- tion, read the entire SSPC-AB 5 stan- dard as well as the documents it refer- ences before you check the cleanliness of your abrasive mix.

Fig. 1: Monitor with 24-hour uplink to internet with secure access allows surface temperature, ambient conditions, and dew point spreads to be checked from a remote location. Courtesy of Munters Moisture Control Services

Sara Kennedy,
Coating Society of the Houston Area

Controlling Quality During Abrasive Blasting: Checking Environmental Conditions, the Steel, and Your Equipment

The performance of a coating depends in large part on the Checking Conditions before Blasting
Most coatings do not adherewell quality of surface preparation. This is because coatings have been formulated to perform properly under particular con- ditions, such as over a specified degree of surface cleanliness and a specified anchor profile, and under certain environmen- tal conditions. If theseand other conditions are not met, coatings may not achieve their expected performance.

When dry abrasive blasting is the specified method of surface preparation, you must take many conditions into consideration before you start blast cleaning. Some of these conditions will be addressed in future Bulletins, such as assuring the quality of abrasives, detecting and removing non-visible contaminants from steel, setting up abrasive blast equipment, techniques of air abrasive blasting, and assessing surfacecleanliness and profile.

This Bulletin will focus on field tests or checks that should be conducted to make sure that the blasting operation takes place under conditions favorableto successful coatings application and performance. Thesetestsinclude makingsurethat environmental conditions are suitable for blasting, that contaminants are not retained or introduced by the blasting process,and that equipment does not hamper productivity. While inspectors or owners representatives may perform many of these tests, the contractor is ultimately responsible for first-line quality control of the work and must conduct the field checks.

Checking Conditions before Blasting

Most coatings do not adherewell to surfaces contaminated with oil and grease. Blasting actually drives them further intothesteel rather than removingthesecont- aminants and thus contributes to premature coating failure. Therefore, you should always check for visual surfacecontami- nants before blasting. If oil and grease are present, they should be removed by solvent cleaning, as specified in SSPC-SP 1. All of the blast cleaning specifica- tions, SSPC-SP 5/ NACE No. 1 (White Metal) SSPC-SP 10/ NACE No. 2 (Near White), SSPC-SP 6/ NACE No. 3 (Commercial Blast), SSPC-SP 14/ NACE No. 8 (Industrial), and SSPC-SP 7/ NACE No. 4 (Brush-Off Blast), requirethis step.

Fig. 2: A handheld digital gage for measuring air temperature, surface temperature, and relative humidity. It uses the values to calculate dew point and the difference between the dew point and the surface temperature.
Courtesy of Defelsko

One piece of equipment for checking for the pr esence of contaminants is a black light, available from blasting equipment manufacturers and inspection instrument supply com- panies.It operates on the same principle asblack lights in dis- cos. When you shinethelight on thesubstrate, theclean part of the surface will appear to be dark, while areas with oil or grease typically will be shiny, although not all oils will fluo- resce under theblack light.

Ambient conditions should bemeasured beforeblasting. If blasting is not to be followed immediately by coating appli- ca- tion, then it may beall right to proceed first with rough blast- ing to remove the existing coating, rust, and mill scale, and only verify that the ambient conditions are satisfactory before the final blast begins. If blasting is to be followed immediately by coating, then ambient conditions should be checked before blasting begins.

Among the ambient conditions you must check are the dew point, air tem- perature, relative humidity, and surface temperature, to be sure conditions are suitable for blasting. Otherwise, conden- sation will form on the steel during or af ter blasting and cause f lash rust, which can be detrimental to the overall quality of the coating performance.

To measure ambient conditions, you can use electron- ic gages that measure dew point, relative humidity, and sur- face temperature(Figs. 1 and 2). Or you can determine ambient conditions the old-fashioned way with the following tools:

- a surface temperaturegage,
- a sling psychrometer for measuring dry bulb (air) and wet bulb temperature (Fig. 3), and
- a psychrometric charts to calculate relative humidity and dew point.

Dew point is the temperature at which moisture condens- es on a surface. For example, if the dew point is 70 F (21 C), condensation will occur if the steel is at or below 70 F (21 C). A s a general r ule, final blast cleaning should take place only when the sur- faceis at least 5 degrees F (3 degrees C) above the dew point. For example, if the dew point is 70 F (21 C), the steel temperature should be at least 75 F (24 C). This rule provides a margin of error in case of instrument inaccura- cies, quickly changing weather condi- tions, or human error.

Dew point can becalculated using the psychrometer and psychr ometric tables from the U.S. Weather Bureau Service. The psychrometer is a hand- operated or motorized instru- ment that has two glass thermometers. One glass thermom- eter has on its bulb a clean sock or wick made of cloth. This is called the wet bulb. The uncovered thermometer is called the dry bulb. To usethepsychrometer, first wet thesock thor- oughly. Then, whirl thepsychrome- ter if it is hand-operated, so that the instrument spins at a steady, medium speed for about two minutes. Observe the temperatures at 20 to 30 second intervals.

When you obtain three consecutive readings of the same temperature on the wet bulb thermometer, record the readings from both thermometers. In thecase of the fan-op- erated psychrome- ters, turn on the fan and allow it to run for approximately two minutes, then record the readings. On the psychro- metric chart labeled "dew point," you will find instructions for calculating that value.

Then, measure the surface tempera- ture. The easiest in- strument to use for this task is a magnetic temperaturegage that attaches to the steel. Place the gage on the steel and allow it about two min- utes to stabilize. If the surface tem- pera- ture is 5 degrees F (3 degrees C) above the dew point, then conditions are suit- able for final blasting.

The readings should be taken where the work is being performed, because conditions can vary across a struc- tur e. If the work is taking place in many locations at the same time, note that dew point problems will occur in the coldest (shaded) portions of the structure first.

Relative humidity can be calculated using the values ob- tained from thepsy- chrometer and the psychrometric charts labeled "relative humidity." As a general rule, final blasting should not be done if relative humidity is at or above the maximum relative humidity for coating application. Note that for some coatings, being above a minimum rela- tive humidity may also be an issue.

Checking Blasting Abrasives and Equipment

Abrasives and equipment should also be checked for cleanli- ness before blast- ing, and the equipment should be checked for efficiency.

Abrasives can beeasily and economi- cally checked for oil, dirt, and salts in the field with the following equipment: clean jars with tight lids, distilled water, and chemical test papers. A small amount of the abrasive is placed in the jars, covered with distilled water, and shaken. The abrasive will settle to the bottom of the jar. If an oily film appears on the top of the water after the abra- sive settles, the abrasive is contaminat- ed and should not be used. If the water be- comes very cloudy, theremay also be an issue with theabra- sive that requires further investigation.

> "If you are using recyclable abrasive, you should test it for cleanliness before and during the project."

Test papers and portable meters will indicate the presence of some soluble salts,and litmus papers will indicate the presence of some acids or bases.

If you are using recyclable abrasive, the abrasive should be tested during the job (using the jar and water) to make sure the reused abrasive is clean. SSPC-A B 2 provides an additional bat- tery of tests that can be conducted to check the cleanliness of recyclable steel abrasives.

A STM D 4940 is another method for evaluating thepres- enceof solublesaltson abrasives. It involves measuring the con- ductivity of a water / abrasivemixture.

The blasting equipment should also be examined. You will have to depressurizetheblastingequipment and take it apart to check some of its components. The compressor and the moisture trap or moisture separator must be checked for contaminants, and the nozzle lining must bechecked for wear.

The compressor has oil and moisture separators that remove oils and mois- ture from the air passing through the compressor. Make sure the compressor is level. Otherwise, the separators will not work properly, and oil and moisture will get into the hoses (and onto the steel).

A second moisture trap or moisture separator, not part of the compressor, should be used to catch any remaining moisture that might be trapped in the hose that connects the compressor to theblast pot. Besure that this separator is as close to the blast pot as possible to catch any moisture that has condensed in the hose. A lso be sure that the mois- ture trap is set on automatic bleed so that moisture drains out of the trap to the ground and does not remain in the blasting system. These measures will help keep the abrasive and substrate dry during blasting so that rust bloom does not appear.

The nozzle lining should also be checked for wear before blasting operations begin and during blasting if your produc- tion rate drops. An orifice nozzle or throat gage can be used to check the inside diameter of the nozzle lining. The gage consists of a china marking chalk and a tapered rod that is marked to indicatedifferent diameter readings.

Using the china marker, "color" the gagearound thediam- eter mark that rep- resents the nozzle that you are using. Put the gage in the back side of the noz- zle, twist it, and pull it out. The china markings will be scored by the nozzle orifice, and you can determine the ori- fice diameter by reading the gage. If the diameter is larger than required (gener - ally one nozzle size larger than a new nozzle), then the lining of the nozzle has worn out and needs to be replaced.

Otherwise, your production rate may be lower than de- sired.

You will have to put the equipment back together and carefully re-pressur- ize the system to check the air that comes from the blasting equipment for moisture and oil. This can be done with a blotter test.

Clean white rags, blotters, or even coffee filters can be used to test the blast air. To conduct the blotter test, close off the abrasive valve so that no abrasive gets into the air stream. One way is to place the rag or blotter in front of the nozzle or other air outlet, and turn on the air for one minute. If the rag is wet, then moisture is escap- ing, so you should adjust the moisture separators.If theragisdirty, oil is in the air stream, and theoil separator should be checked. ASTM D 4285 describes another method that involves blowing theair onto blotter paper and rigid plas- tic for a minimum of oneminute.

Before beginning blasting operations, you should also check for proper pres- sure at the nozzle. Generally, 90–100 psi at the nozzle is the pressure range suitable for efficient production. The pressure reading should be obtained at the nozzle, not at the compressor. Pressure at the nozzle can be checked with a needle pressure gage. This device

Fig. 3: A sling psychrometer (above) along with a surface temperature gage and psychrometric charts can be used to determine dew point and relative humidity.
Courtesy of Bacharach

consists of a hypodermic needle attached to a pressure gage with pres- sure increments marked on its face.

The hose should be directed toward the substrate and turned on, with air and abrasive flowing. The needle should be inserted into the hose right behind the nozzle in thedirec- tion of the flow of theair and abrasive. Thefaceof thegage can then be read. The compressor pres- surecan bead- justed if pressure isbelow 90– 100 psi or the source of the pres- sure drop is determined and corr ected. A lternatively, changes to the hoses (diameter or length) or nozzle sizes can bemade.

Checking the Steel after Blasting

A f ter blasting, make sure you have removed all dust from the blast-cleaned surface, either by blowingdown thesur- face with clean compressed air or vacu- uming the dust with a vacuum available from equipment manufacturers. Dust on the surface can interfere with the coating's ability to bond to thesurface. If you blow down the surface, first check the cleanliness of the air again with the blotter test descr ibed earlier. A f ter blowing or vacuuming the surface, you can brush a clean whitecloth across the surface. Be sure not to touch the steel with your bare hand. Oils or salt from your hand can be transferred easily to the surface and contami- nate it. If dust appears on the cloth, you need to blow down or vacuum the surface again.

You can also check for non-visible contaminants, espe- cially soluble salts, which aredetrimental to coating per- for- mance. Portable test kits, available from test equipment manufacturers and from testingand inspection firms,are to beused to analyzethesurface. SSPC TU 4 describes the vari- ous test methods. The test kits help you quantify the amount of chloride and other salts remaining on the steel surface af ter blast cleaning. You will have to get the opinion of your supervisor or the coat - ing manufacturer to determine if the level of contaminants measured isdetri- mental to coating performance. These kits are available from test equipment manufacturers and from testing and inspection firms. Their use will be described in an upcoming Bulletin on non-visible contaminants.

Once the blast-cleaned surface is free of dust (and other contaminants), you should check surfaceprofileand degree of cleanliness to see that you have met the specifications, procedures that will bedetailed in another Bulletin.

Record Keeping

The quality control checks that you make should be docu- mented and kept as part of your quality control records for the job. This way, you have histori- cal information for verify- ing compli- ance with specifications. Record keep- ing will be detailed in a future Bulletin.

Conclusion

Remember that the quality control measures you take will help you ensure that abrasive blasting opera- tions create a surface suitable for coat- ing application. Moreover, while inspector s may be on the job conduct- ing similar tests, you should not be intimidated by the inspectors and should conduct your own quality con- trol checks. Their efforts and your own will help you provide the high-quality work needed for successful coating application and performance.

Keeping Workers Safe During Abrasive Blasting

This article reviews the use of personal protective equipment, regulations, & standards affecting safe abrasive blasting.

By Thomas E. Enger, MS, CSP, CHMM,
Clemco Industries Corp.

Editor's Note: This article, from Clemco's publication, "The Use of Personal Protective Equipment and Regulations & Standards Affecting Safe Abrasive Blasting," appears here with the permission of Clemco (www.clemcoindustries.com).

Employers understand that safety is one of the most important ingredients to a successful business. However, providing a safe workplace and ensuring a safe and environmentally-sound environment is complex. Navigating the course to fool-proof safety can be mind-boggling.

Since 1970, the primary references for determining the minimum safety and environmental standards in the workplace have been the Occupational Safety & Health Administration (OSHA) and the Environmental Protection Agency (EPA) mandated by Titles 29 and 40 of the Code of Federal Regulations. These regulations incorporate thousands of standards from hundreds of agencies and organizations. The purpose of this article is to attempt to provide the reader a basic understanding of the minimum standard to provide safe work conditions for their employees when using open air abrasive blasting equipment. (The phrase "open air abrasive blasting" in this article refers to unrestricted abrasive blasting, as opposed to enclosed abrasive blasting that is done in blast booths or permit-required confined spaces, where additional safety regulations would apply and are beyond the scope of this article.) This article addresses many federal worker safety regulations from 29 CFR as well as from other agencies or organizations, but does not purport to be comprehensive or a substitute for reading and complying with any regulation. Moreover, this article does not address in any detail the federal regulations (40 CFR) or other regulations and standards for protecting the environment (ground, air, water, and the public) during and after abrasive blasting, such as allowable emissions or contaiment of abrasive blasting debris.

Worker Protection Standards Associated with Abrasive Blasting

There are three primary industries that perform abrasive blasting: General Industry (29 CFR 1910), Maritime (29 CFR 1915), and Construction (29 CFR 1926). OSHA has developed regulations for these industries. The most basic elements of these standards include the sections shown in Table 1 (p. 22) and can be found on OSHA's website, www.osha.gov.

There are more than 40 references in 29 CFR that address the basic hazards associated with open air abrasive blasting. The regulations governing these three industries address the requirement for Job Hazard Analysis (JHA) when the operator wears Personal Protective Equipment. Because a JHA is required by all the OSHA-covered industries, I will use a JHA to identify not only the proper PPE but also to identify other hazards and relevant regulations as they apply to open air abrasive blasting. Table 2 (pp. 29–33) contains a Job Hazard Analysis. This Job Hazard Analysis is modeled after OSHA publication #3071 and can be downloaded from www.osha.gov/Publications/osha3071.pdf.

In Tables 1 and 2, we have identified all the basic regulatory references that address the process for safely blasting a surface that is not in a permit-required confined space or blast room. Figure 1 better illustrates these basic regulatory requirements and standards by component.

Basic Elements of Abrasive Blasting and Their Hazards

It should be emphasized that this article reviews only the basic safety regulations and standards that directly affect how abrasive blasting is performed in an ambient environment. The analysis does not delve into the multitude of referenced standards incorporated by the basic regulations and standards that this article lists; but it has established that there are standards to support the following layman discussion on what an operator must have to safely work and be fully compliant when operating abrasive blast equipment. There are three basic elements of abrasive blasting: the abrasive, the personal protection equipment the operator uses, and the abrasive-delivery system. Each could pose safety hazards and call for protective measures.

The Abrasive

The first element, the abrasive, brings into consideration the surface being cleaned or prepared for coating operations. There are a multitude of abrasives the operators may use, and they must be aware of the hazards (and other regulations) associated with not only the abrasive but also the surface they are blasting. The most common abrasives used in open air blasting include, but are not limited to, sand and slags.

There are numerous hazards associated with these and other abrasives and the surface contamination that is being removed. The government is aware of these hazards and has placed the responsibility of protecting and educating the worker squarely on the shoulders of the employer. Most employers specialize in very specific surface preparation and coating operations. The best way to determine the hazards generated by these abrasives and coatings is to have a local Certified Safety Professional or Certified Industrial Hygienist perform a workplace environmental audit and determine the appropriate worker protection. Safety professionals and industrial hygienists are listed in local directories available to employers on these web sites:

- Safety Professionals: http://www.asse.org; and
- Industrial Hygienists: http://www.aiha.org.

Personal Protective Equipment

The second element of abrasive blasting is personal protective equipment. Once the professional performs the environmental audit, the employer can determine the proper protection for the operator. In the vast majority of applications, the personal protective equipment shown in Figs. 2, 3, 4, and 5 (pp. 24–25) will be required when performing abrasive blasting.

Leather gloves and steel-toed boots are commonly acknowledged to be necessary and are commercially available from safety supply stores (Fig. 2, p. 17). There are several different types of fall protection available. The most common type for scaffolding is handrails and toe boards. When handrails and toe boards are not used or available, the most common fall protection involves a harness and a shock-absorbing lanyard (Fig. 3, p. 17).

Blast suits are not normally provided by safety supply houses but are readily available through an abrasive blasting equipment distributor. The two basic types of blast suits are "lightweight" and "leather" (Fig. 4). Because they seal out the abrasive material from entering the operator's clothing and irritating the skin, blast suits are preferable over heavy jeans and a shirt. The use of blast suits also provides the operator outer clothing that can be removed and cleaned.

The most common respirator used in the surface preparation operation is the Supplied Air Respirator (SAR). This respirator is the most complex piece of Personal Protection Equipment the operator uses and is also the most controlled by federal safety regulations. Every major manufacturer of supplied air respirators provides an owner's manual with every respirator. These manuals provide all the operation, maintenance, and cleaning instructions required for the use of the respirator. OSHA requires every respirator user to understand not only the hazards the respirator protects him or her from, but also how to maintain the respirator. Conscientious manufacturers have web sites where owners can download these manuals if the originals get lost. Three examples of these web sites and brands or series include the following.

- http://clemcoindustries.com (Apollo Respirators)
- http://www.bullard.com (88VX Series)

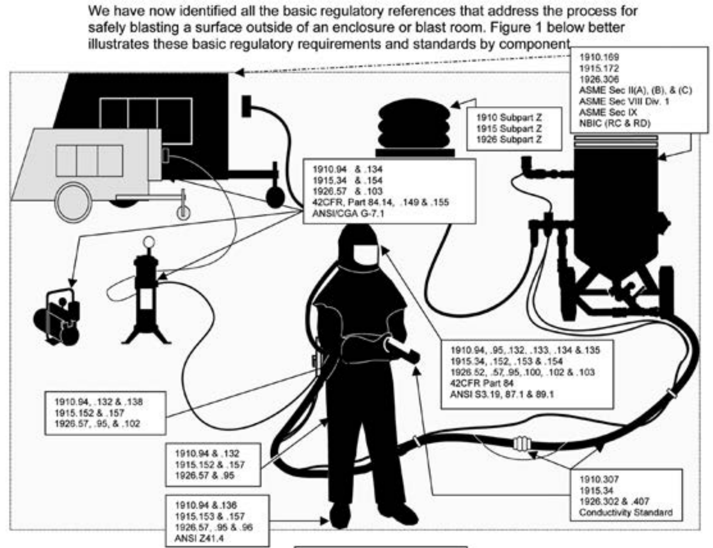

Figure 1

a. air compressor
b. breathing air compressor
c. ambient air pump
d. breathing air filter
e. eather/canvas gloves
f. blast suit
g. safety shoes
h. NIOSH-approved type CE respirator
i. blast nozzle
j. coupling
k. blast hose
l. ASME-code blast machine
m. abrasive

- http://www.3m.com (Helmet Systems Headgear W-Series)

OSHA's respiratory standard requires more than just reading these manuals. The manual should be the cornerstone of an effective respiratory safety program.

A common mistake made by employers in the surface preparation industry is issuing a SAR only to the operator of the blast equipment. The use of SARs should be based on the industrial environmental survey the safety professional performs.

Another common mistake operators and employers make is using non-original replacement parts for these respirators. All manufacturers must get their respirators approved by the National Institute of Occupational Safety and Health (NIOSH). NIOSH approval is valid only when all the manufacturer's parts are used. There is no acceptable or approved non-original aftermarket replacement part, PERIOD! Everything that comes in the original respirator box must be replaced by the same item from the original manufacturer.

While there are low-pressure SARs available for use with an ambient air pump, the vast majority of SARs are high-pressure respirators, which use air compressors for the air supply. There are air compressors that are oil-less and do not present a carbon monoxide hazard; however, the majority of compressors employers use are oil-lubricated and require a carbon monoxide alarm as well as a high-temperature alarm.

It is also common for employers to use the same compressor for providing breathing air as they use for operating the blast machine. It is important to remember to place the intake of the compressor away from sources of carbon monoxide, e.g., cars and trucks.

Table 1: Basic OSHA Regulations for Abrasive Blasting

General Industry		Maritime		Construction	
Reference	Title	Reference	Title	Reference	Title
29 CFR 1910.6	Incorporation By Reference	29 CFR 1915.5	Incorporation By Reference	29 CFR 1926.28	Personal Protective Equipment (PPE)
29 CFR 1910.94(A)	Ventilation–Abrasive Blasting	29 CFR 1915 Subpart C	Surface Preparation & Preservation	29 CFR 1926.52	Occupational Noise Exposure
29 CFR 1910.95	Occupational Noise Exposure	29 CFR 1915.34	Mechanical Paint Removers	29 CFR 1926.57(F)	Ventilation–Abrasive Blasting
29 CFR 1910 Subpart I	Personal Protective Equipment (PPE)	29 CFR 1915 Subpart I	Personal Protective Equipment	29 CFR 1926.59	Hazard Communication
29 CFR 1910.132	PPE–General Requirements	29 CFR 1915.152	PPE–General Requirements	29 CFR 1926 Subpart E	Criteria For Personal Protective Equipment
29 CFR 1910.133	PPE–Eye & Face Protection	29 CFR 1915.153	PPE–Eye & Face Protection	29 CFR 1926.96	PPE–Occupational Foot Protection
29 CFR 1910.134	PPE–Respiratory Protection	29 CFR 1915.154	PPE–Respiratory Protection	29 CFR 1926.100	PPE–Head Protection
29 CFR 1910.135	PPE–Head Protection	29 CFR 1915.155	PPE–Head Protection	29 CFR 1926.101	PPE–Hearing Protection
29 CFR 1910.136	PPE–Occupational Foot Protection	29 CFR 1915.157	PPE–Hand & Body Protection	29 CFR 1926.102	PPE–Eye & Face Protection
29 CFR 1910.138	PPE–Hand Protection	29 CFR 1915 Subpart K	Portable, Unfired Pressure Vessels, Drums & Containers, Other Than Ship's Equipment	29 CFR 1926.103	Respiratory Protection
29 CFR Subpart M	Compressed Gas & Compressed Air Equipment	29 CFR 1915.172	Portable Air Receivers & Other Unfired Pressure Vessels	29 CFR 1926.306	Air Receivers
29 CFR 1910.169	Air Receivers	29 CFR 1915 Subpart Z	Toxic And Hazardous Substances	29 CFR 1926 Subpart Z	Toxic And Hazardous Substances
29 CFR 1910.307	Hazardous (Classified) Locations	29 CFR 1915.1200	Hazard Communication		
29 CFR 1910 Subpart Z	Toxic And Hazardous Substances				
29 CFR 1910.1200	Hazard Communication				

Figure 5 p.18 shows one of the most commonly used SARs. It is composed of a

- helmet,
- removable knitted collar,
- breathing air hose,
- air control valve,
- cape,
- air supply line, and
- helmet lenses.

The only acceptable replacement parts for any of these items are those made by the original manufacturer.

This SAR must be supplied by what is termed as Grade D breathing air, as well as having oil, mist, and odors removed (Fig. 5). The sorbent bed filter shown in Fig. 5 removes oil, mist, and odors, but does not create Grade D air. The air entering this filter already must be Grade D.

Most compressors can provide Grade D air; however, several precautions must be taken. The air must be mon-

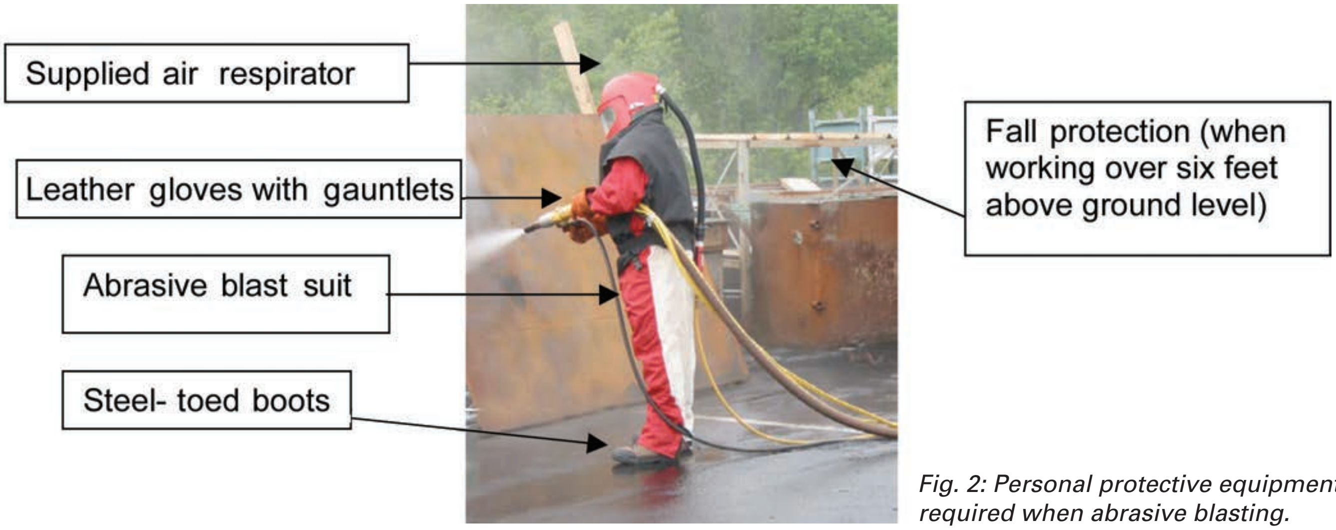

Fig. 2: Personal protective equipment required when abrasive blasting.

itored for carbon monoxide. There are exceptions to the requirement for using CO monitors; but they are few, and the alternative is restrictive. The alternative is that all breathing systems include a CO monitor. The air coming from most compressors is also extremely hot. OSHA requires a high-temperature alarm or switch on the compressor.

It is recommended the employer supply the user with an air-temperature control valve as shown in Fig. 5. There are air control valves, which do not provide cooling; however, for a minimal investment, the employer can provide an air supply that makes this very demanding operation comfortable. Every SAR requires a defined airflow. This airflow is mandated by NIOSH and is controlled by the regulator. Lastly, the manufacturer of the respirator must supply the airline

Fig. 3: Harness and shock-absorbing lanyard.

from the sorbent bed to the air control valve. These air lines are commonly color-coded for easy recognition.

This type of SAR has an Assigned Protection Factor (APF) of 25. This NIOSH rating means that the operator can work in an environment with contaminants defined by OSHA that are present at 25 times the permissible exposure limit. The safety professional who performs the original environmental audit will determine the concentration of OSHA-defined contaminants. All three manufacturers listed on p. 22 also obtained an OSHA exception to NIOSH's APF of 25 rating for lead. The OSHA exception rates these respirators as having an APF of 1000 for lead.

The Abrasive Delivery System

The third element, the abrasive delivery system, is the surface preparation equipment itself. The most common piece of equipment is the six-cubic foot capacity blast machine, commonly called a "six-sack pot." This slang is used to describe the number of bags of abrasive material loaded into the pot at one time. Figure 6, p. 18 shows a six-cubic foot capacity blast machine and related equipment for abrasive blasting.

Fig. 4: Lightweight blast suit for hot environments (left); leather blast suit for cooler environments (right)

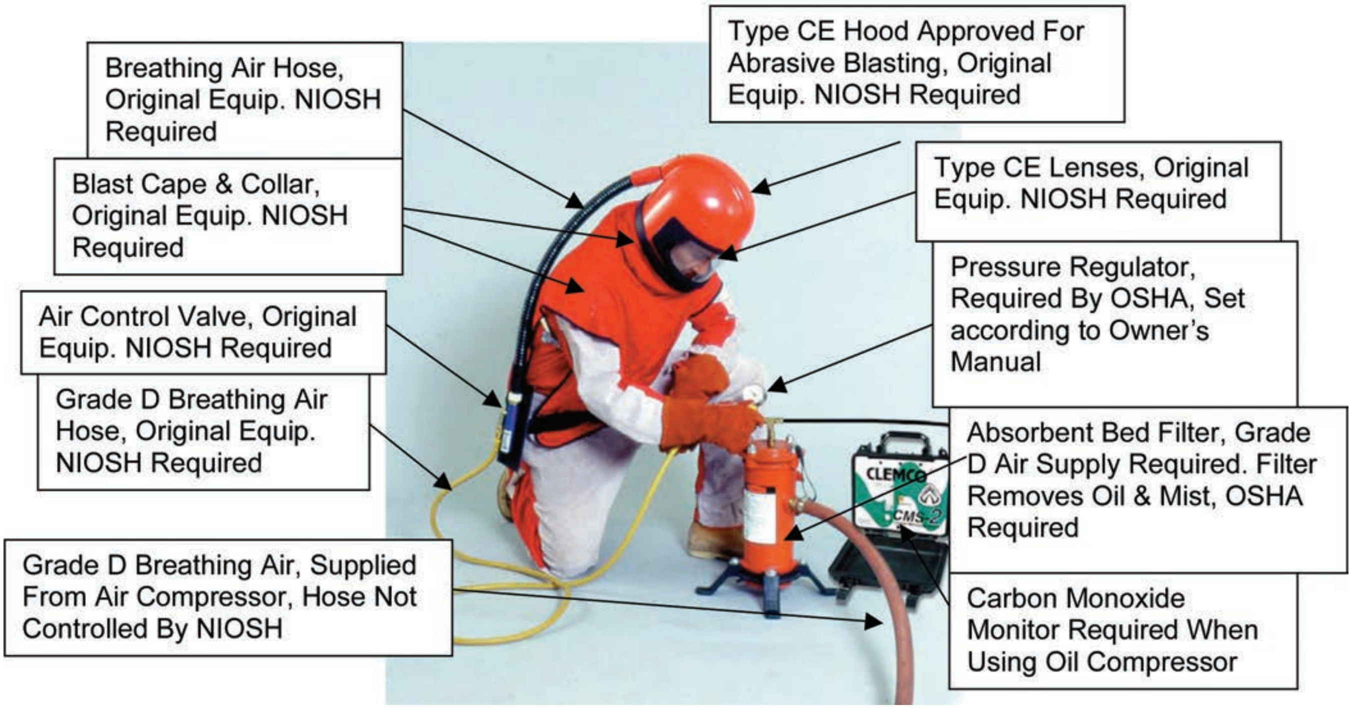

Fig. 5: One of the most commonly used supplied air respirator (SAR) setups.

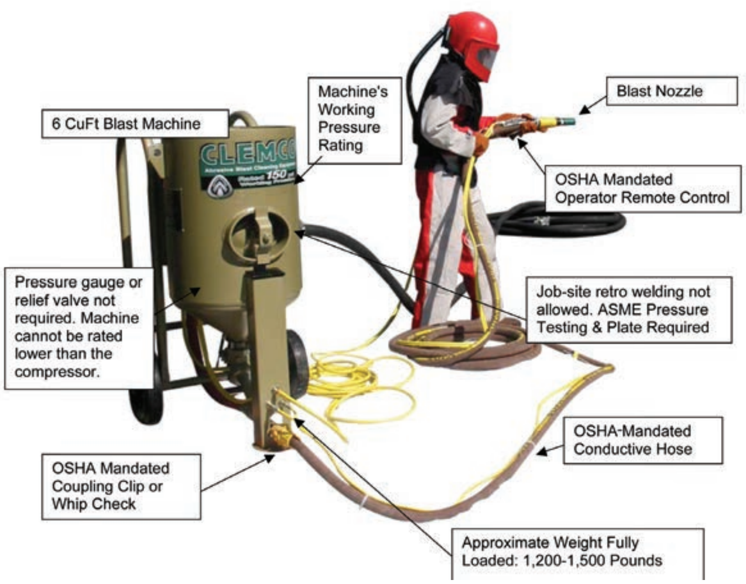

Fig. 6: Six cubic foot capacity blast machine and related equipment for abrasive blasting.

Misuse and abuse of surface preparation equipment is the major cause of all acute injuries when performing surface preparation. The following are common causes of injury.

- Moving machine while loaded with abrasive
- Placing fully loaded machine on scaffolding not rated for heavy loads
- Operator remote being bypassed, taped, or tied down
- Hose or nozzle being worn out and rupturing while under high pressure
- Coupling not being fully engaged and screwed tightly onto conductive hose causing a break in the conductive hose system and static discharge
- Coupling screws missing or not fully screwed into the hose
- Deflated tires

Abrasive blasting remains the predominant method to efficiently prepare a surface for coatings. However, abrasive blasting poses specific hazards, which must be addressed before beginning operation. The Federal or State Occupational Safety & Health Administration mandates all the above minimal monitoring and training requirements. The very best way to assure a safe and compliant workplace is to implement a Safety Audit and Training program developed by a Certified Safety Professional that is tailored to a specific operation.

Safety Compliance Is Not the End of the Story

As noted earlier, several environmental standards also apply to air abrasive blasting. These standards are predominantly promulgated by Title 40 of the Code of Federal Regulations. These regulations can be found on the web site, http://www.epa.gov/epahome/cfr40.htm. ***Continued on page 24***

Table 2: Job Hazard Analysis Model (table continues over 5 pages)

Job Description: Blasting Setup	Analyst: Tom Enger		Date: April 1, 2009
Task/Activity	**Hazard Description**	**Hazard Control**	**Regulation-Standard**
Move pot to work area Tilt pot onto back wheels and push to work area. Upright pot	Pot tips, crush hand/fingers & toes; back injury; collateral damage	Move pot empty, use mule, inspect wheels prior to moving, inspect work surface for tipping hazards. Use gloves & steel-toe shoes	General Duty Clause, Section 5(a)(1) OSH Act 29CFR1910.136 & .138 29CFR1926.96 & Subpart E 29CFR1915.152 & .157
	Back injury, sprain/strain (pot weight ≥ 600 lbs, abrasive weight ≥ 600 lbs)	Move pot empty, remove all abrasive prior to moving. Inspect wheels, inspect work surface	General Duty Clause, Section 5(a)(1) OSH Act NIOSH "Work Practices Guide for Manual Lifting" PB94-176930LJM
	Floor/scaffold failure under load	Assure scaffold/floor is designed to handle load of pot & abrasive @ ≥ 1,200 lbs	29CFR1926 Subpart L - Scaffold Specifications 29CFR1910.28 - Safety Requirements for Scaffolding 29CFR1915.71 - Scaffolds or Staging ANSI/ASSE-A10.8-2001 Scaffolding Safety Requirements
Set up pot	Hand injury from sharp/rough equipment edges	Heavy cotton/leather gloves	29CFR1910.138 29CFR1915.157 29CFR1926 Subpart E
Add abrasive	Inhalation hazard, when adding abrasive	Type CE abrasive-blast respirator. Industrial environmental audit to determine PELs	29CFR1910.94(a) 29CFR1910.134 29CFR1915.154 29CFR1926.103 29CFR1910 Subpart Z 29CFR1915 Subpart Z 29CFR1926 Subpart Z 42CFR Part 84
Hook up blast hose & nozzle	Regulatory violation ESD, explosion/fire (Hazards associated with these violations occur during operation of equipment)	ESD/Conductive blast hose, metal couplings, conductive washers/blast hose system	29CFR1910.307(b)(2)(i) 29CFR1915.34(c)(1)(i) 29CFR1915.34(c)(1)(ii) 29CFR1915.34(c)(1)(iii) 29CFR1926.407(b)(2)(i)
	Regulatory violation (Hazards associated with these violations occur during operation of equipment)	Inspection/quality of hose, coupling, deadman, whip check/clips, nozzle & nozzle support is a regulatory requirement	29CFR1915.34(c)(2) 29CFR1915.34(c)(1)(iii) 29CFR1915.34(c)(1)(iv) 29CFR1926.302(b)(1) 29CFR1926.302(b)(5) 29CFR1926.302(b)(7) 29CFR1926.302(b)(10)
Hook up air supply hose to pot	Regulatory violation (Hazards associated with these violations occur during operation of equipment)	Inspection/quality of hose, coupling, whip checks/clips pressure reducing valve on air supply line	29CFR1915.34(c)(2) 29CFR1915.34(c)(1)(iii) 29CFR1915.34(c)(1)(iv) 29CFR1926.302(b)(1) 29CFR1926.302(b)(5) 29CFR1926.302(b)(7) conductivity standard

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Task/Activity	**Hazard Description**	**Hazard Control**	**Regulation-Standard**
Inspect pot for damage	Regulatory violation (Hazards associated with these violations occur during operation of equipment)	Inspect compressor to assure relief valve is operable & compressor does not exceed pot rating. Inspect for nonapproved ASME welds/modification	29CFR1910.169(b)(3) 29CFR1915.172(c) 29CFR1926.306(b)(3) ASME-VIII, Div.1,UG-125(g)(1) ASME-VIII, Div. 1, Sec. 9
Inspect pot piping	Possible failure when pressure is turned on	Inspect piping, especially piping in abrasive stream for wear and excessive rust	General Duty Clause, Section 5(a)(1) OSH Act
Set up respirator & put on respirator			
Select respirator	Unapproved respirator, regulatory violation (Hazards associated with these violations occur during operation of equipment)	Assure you have NIOSH respirator approved for abrasive blasting & toxins associated with surface and abrasive	29CFR1910.94(a)(5) 29CFR1915.34(c)(3) 29CFR1926.57(f)(5) 42CFR Part 84 OSHA 3142 – Lead In Construction NIOSH - Respirator User Notice: All Users of Type CE, Abrasive-Blast Supplied-Air Respirators NIOSH Respirator Selection Logic 2004
Inspect respirator	Unapproved respirator assemblies, damaged parts (Hazards associated with these violations occur during operation of equipment)	Inspect breathing hose, helmet, air hose, air control valve, & cape. All parts should be from same manufacturer. Check for cleanliness	29CFR1910.94(a)(5) 29CFR1915.34(c)(3) 29CFR1926.57(f)(5) 29 CFR1910.134(h)(3) 42CFR Part 84
Inspect absorbent bed filter	Regulatory violation (Hazards associated with these violations occur during operation of equipment)	Absorbent bed filter is normally cartridge type & is replaceable. Check housing & regulator for damage	29CFR1910.134(l)(5)(iii)&(iv) 29CFR1915.154 29CFR1926.103 29CFR1910.94(a)(6)
Inspect gage/regulator at respirator connection	Regulatory violation (Hazards associated with these violations occur during operation of equipment)	29 CFR 1910.134(l)(5) requires respirator to meet 42 CFR Part 84. This reg. requires use of gage/regulator	42CFR Part 84.82 (Gages) 42CFR Part 84.148 & .149 42CFR Part 84.155
Connect breathing air	Regulatory violation, improper fittings or tanks (Hazards associated with these violations occur during operation of equipment)	Ensure breathing air couplings are incompatible with outlets for nonrespirable worksite air. Ensure breathing gas containers are marked for breathing	29CFR1910.134(l)(8) 29CFR1910.134(l)(9)
	Regulatory violation, noncompliant breathing air from compressor (Hazards associated with these violations occur during operation of equipment)	Use, calibrate high temperature & carbon monoxide alarm. Place compressor intake away from contaminated air (car exhaust)	29CFR1910.94(a)(6) 29CFR1910.134(l) ANSI/CGA G-7.1
Put on blast suit	Regulatory violation, blast suit mandated by OSHA (Hazards associated with these violations occur during operation of equipment)	Put on "blast suit" coveralls or appropriate alternative	29CFR1910.94(a)(5)(v) 29CFR1910.132 29CFR1915.152 29CFR1915.157 29CFR1926.57(f)(5)(v) 29CFR1926.95

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Task/Activity	**Hazard Description**	**Hazard Control**	**Regulation-Standard**
Put on safety shoes	Regulatory violation, safety shoes mandated by OSHA (Hazards associated with these violations occur during operation of equipment)	Put on safety shoes	29CFR1910.94(a)(5)(v)&(v)(a) 29CFR1910.136 29CFR1915.153 29CFR1915.157 29CFR1926.57(f)(5)(v)& (v)(a) 29CFR1926.95 29CFR1926.96 ANSI Z41.1
Put on proper hearing protection	Regulatory violation, hearing protection mandated by OSHA (Hazards associated with these violations occur during operation of equipment)	Properly use hearing protection based on noise survey	29CFR1910.95 29CFR1910.95 App B 29CFR1910.132 29CFR1926.52 29CFR1926.101 ANSI S3.19 for NRR
Put on face protection	Regulatory violation, face protection mandated by OSHA (Hazards associated with these violations occur during operation of equipment)	Inspect inner respirator lens for ANSI Z87.1 stamp or put on safety glasses/shield compliant with ANSI Z87.1	29CFR1910.94(a)(5)(v)(b) 29CFR1910.133 29CFR1915.152 29CFR1915.153 29CFR1926.57(f)(5)(v)(b) 29CFR1926.95 29CFR1926.102 ANSI Z87.1
Put on head protection	Regulatory violation, head protection mandated by OSHA (Hazards associated with these violations occur during operation of equipment)	Inspect inner respirator for ANSI Z89.1 stamp/label or put on protection compliant with standards	29CFR1910.133 29CFR1910.135 29CFR1915.152 29CFR1926.57(f)(1)(ii) 29CFR1926.95 29CFR1926.100 ANSI Z89.1
Put on leather/canvas gloves	Regulatory violation, hand protection mandated by OSHA (Hazards associated with these violations occur during operation of equipment)	Put on gloves that have adequate coverage and durability to resist abrasive rebound and misdirected blast stream (i.e., leather/canvas gloves with gauntlets)	29CFR1910.94(a)(5)(v) 29CFR1910.132 29CFR1910.138 29CFR1915.152 29CFR1915.157 29CFR1926.57(f)(5)(v)(b) 29CFR1926.95 29CFR1926.102
Turn on breathing air line	Operator receives toxic or degraded air	Assure compressor, monitors, absorbent bed, gages/regulators and alarms are all working properly	29CFR1910.94(a)(5) 29CFR1915.34(c)(3) 29CFR1926.57(f)(5) 29 CFR1910.134(h)(3) 29CFR1910.134(I)(5)(iii)&(iv) 29CFR1915.154 29CFR1926.103 29CFR1910.94(a)(6) 29CFR1910.134(I)(8) 29CFR1910.134(I)(9) 29CFR1910.94(a)(6) 29CFR1910.134(I) 42CFR Part 84 42CFR Part 84.82 (Gages) 42CFR Part 84.148 & .149 42CFR Part 84.155 ANSI/CGA G-7.1
	Operator is not physically fit and suffers harm by the use of respirator	Assure each operator has annual pulmonary fitness test	29CFR1910.94(a)(5)(iv) 29CFR1910.134(e) 29CFR1915.134 29CFR1926.103

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Task/Activity	**Hazard Description**	**Hazard Control**	**Regulation-Standard**
Turn on blast air	Inadvertent operation of blast nozzle, damaged surrounding equipment, injury of operator/ bystanders Pot failure, piping failure, air & blast hose failure	Inspect operator's remote to assure proper operation and condition Inspect pot for wear and non-ASME approved welding. Inspect fittings & hoses for wear. Check to make sure pressure on compressor does not exceed blast equipment ratings	29CFR1915.34(c)(1)(iv) 29CFR1926.302(b)(10) 29CFR1910.169(b)(3) 29CFR1915.34(c)(2) 29CFR1915.172(c)(2) 29CFR1926.306(b)(3) ASME-VIII, Div.1,UG-125(g)(1) ASME-VIII, Div. 1, Sec. 9 ASME Standards
	Blast & air hoses disconnect at couplings	Inspect and install whip checks and safety clips onto couplings	29CFR1915.34(c)(1)(iii) 29CFR1926.302(b)(1) 29CFR1926.302(b)(2)
Actuate blast machine	Initial pressure pushes operator off platform–injury	Install handrails or require fall protection use Proper blast hose grip and operator position for blasting	29CFR 1926 Subpart L - Scaffold Specifications 29CFR 1910.28 - Safety Requirements for Scaffolding 29CFR 1915.34(c)(3)(v) 29CFR 1926.500 29CFR 1915.71 - Scaffolds or Staging A10.8-2001-ANSI/ASSE Scaffolding Safety Requirements
Blast surface	Body/bystander injury from rebound	Wear proper PPE: helmet/respirator, shoes, gloves, clothing, face/eye protection	Blast Suit: 29CFR1910.94(a)(5)(v) 29CFR1910.132 29CFR1915.152 29CFR1915.157 29CFR1926.57(f)(5)(v) 29CFR1926.95 Safety Shoes: 29CFR1910.94(a)(5)(v)&(v)(a) 29CFR1910.136 29CFR1915.153 29CFR1915.157 29CFR1926.57(f)(5)(v)& (v)(a) 29CFR1926.95 29CFR1926.96 ANSI Z41.1 Face/Eye Protection: 29CFR1910.94(a)(5)(v)(b) 29CFR1910.133 29CFR1915.152 29CFR1915.153 29CFR1926.57(f)(5)(v)(b) 29CFR1926.95 29CFR1926.102 ANSI Z87.1 Head Protection: 29CFR1910.133 29CFR1910.135 29CFR1915.152 29CFR1926.57(f)(1)(ii) 29CFR1926.95 29CFR1926.100 ANSI Z89.1 Leather/Canvas Gloves: 29CFR1910.94(a)(5)(v) 29CFR1910.132 29CFR1910.138 29CFR1915.152 29CFR1915.157 29CFR1926.57(f)(5)(v)(b) 29CFR1926.95 29CFR1926.102

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Task/Activity	**Hazard Description**	**Hazard Control**	**Regulation-Standard**
	Noise level exceeds 85 TWA & 130 dBA OSHA Max. Hearing damage	Wear proper hearing protection using Hearing Conservation Program and NIOSH recommendations	29CFR1910.95 29CFR1910.95 App B 29CFR1910.132 29CFR1926.52 29CFR1926.101 ANSI S3.19 for NRR Compendium of Hearing Protection Devices - Online Version NIOSH Publication No. 98-126 NIOSH Publication No. 96-110
	Inhalation hazards from abrasive and blasted surface	Perform industrial environmental audit to determine toxins generated by blasting operations	29CFR1910.94(a)(2)(ii) 29CFR1910.94(a)(5)(ii)(c) 29CFR1910.94(a)(5)(iv) 29CFR1910.94(a)(6) 29CFR1910.132(d)(1) 29CFR1910.134(a)(2) 29CFR1910.134(d)(1)(ii) 29CFR1910.134(d)(1)(iii) 29CFR1910.134(d)(3)(I) 29CFR1910.134(I)(1)(ii) thru (j) 29CFR1910 Subpart Z 29CFR1915.34(a)(4) 29CFR1915.34(c)(3)(I) thru (iii) 29CFR1915.152(b) 29CFR1915.154 29CFR1915 Subpart Z 29CFR1926.55(a) 29CFR1926.57(d)(2) 29CFR1926.57(f)(1)(vi) 29CFR1926.57(f)(2)(I)thru(iii) 29CFR1926.57(f)(5)(I)thru(iv) 29CFR1926.57(f)(6) 29CFR1926.103 29CFR1926 Subpart Z
		Proper respirator selection & use	29CFR1910.94(a)(1)(ii) 29CFR1910.94(a)(5) 29CFR1910.94(a)(6) 29CFR1910.134 29CFR1915.154 29CFR1926.57(f)(5)&(6) 29CFR1926.103 NIOSH Pub. #2005-100
	Tripping hazards	Maintain clean work area, remove spent abrasive	29CFR1910.22 29CFR1915.77 29CFR1926.25 29CFR1926.57(f)(7)
	ESD – Explosion, shock	Use conductive blasting system, i.e., hoses & couplings	29CFR1910.307(b)(2)(i) 29CFR1915.13(b)(11) 29CFR1915.34(c)(1)(i) 29CFR1915.34(c)(1)(ii) 29CFR1915.34(c)(1)(iii) 29CFR1926.407(b)(2)(i)
Stop blasting operation	Inadvertent operation of nozzle	Hang nozzle on appropriate hook, assure safety latch operates properly	29CFR1915.34(c)(1)(iii) 29CFR1926.302(b)(10)

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These federal regulations for environmental protection are based primarily on the Clean Air Act. They normally control the dust (PM10, or PM5) generated by open air blasting. The degree of dust abatement is predominantly controlled by a local governmental authority, which may be the State, County, or Air Pollution Control District. The Clean Water Act, and the Resource Conservation and Recovery Act, as well as related state and local enviromental laws, also figure prominently in the environmental regulations to protect water bodies, soil, groundwater, and the general public from contamination and exposure to hazardous materials.

It is the contractor's responsibility to obtain the proper environmental permits, such as a dust abatement permit, and comply with their standards. The primary document the surface preparation industry uses to comply with these regulations is the SSPC Guide #6, titled "Guide for Containing Debris Generated During Paint Removal Operations" (Publication No. 97-21, ISBN #1-889060-22-4). This document can be purchased and downloaded from the Internet by going to http://www.sspc.org/standards/guidescopes.html#g6.

This article quickly touches on the environmental requirements for using dust containment systems while preparing a surface to be painted; however, what controls containment more often is owner-mandated protection of the area surrounding the surface preparation work. Always take the time to investigate the surrounding area and the customer requirements for protection of non-work-site property.

Summary

Surface preparation, using open air abrasive blasting, is a very effective and economical way to provide high-quality surfaces ready to receive state-of-the-art coatings. Costs associated with employee accidents, regulatory actions, or damage to surrounding property add unnecessary expenses to a job. A well-planned job, which provides a safe environment for both the contractor's employees and the nearby public, always pays off in large cost savings and customer satisfaction.