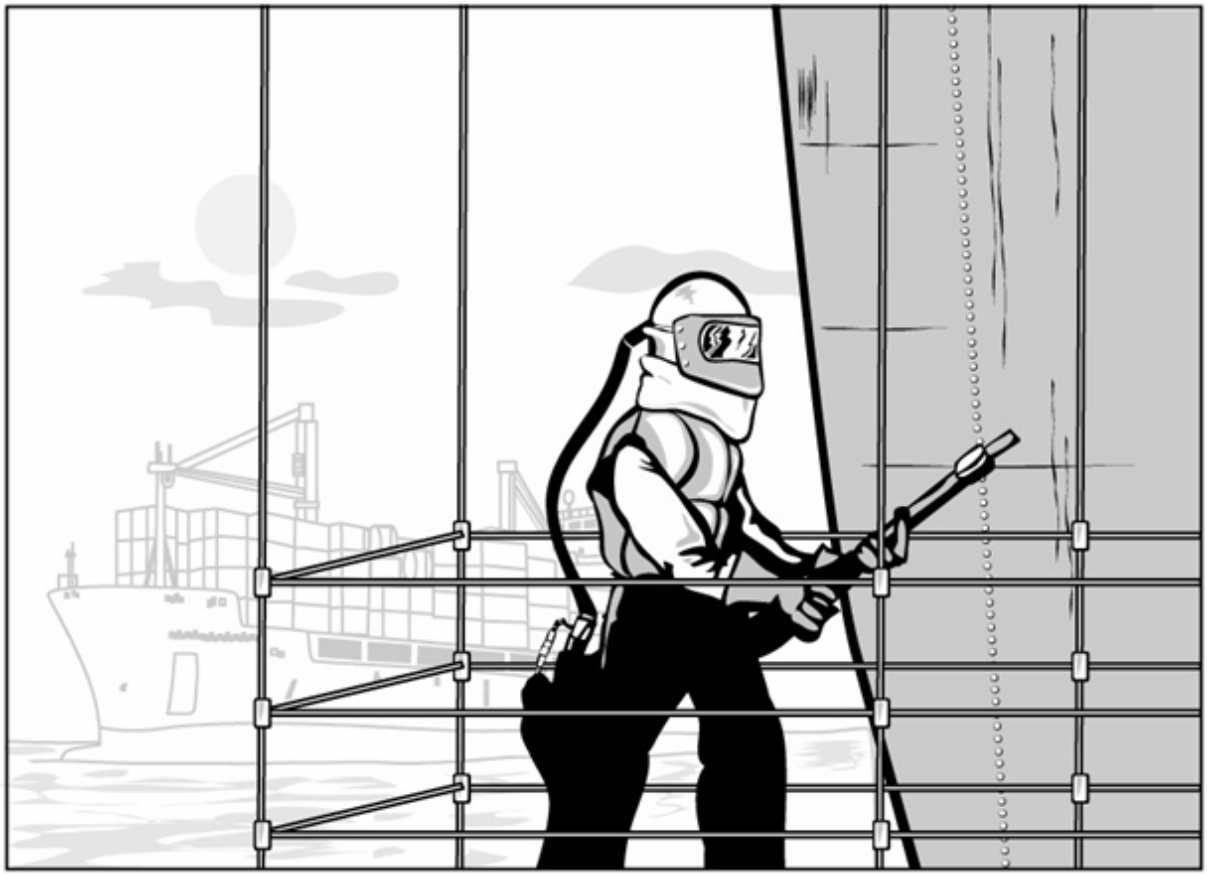
ABRASIVE BLASTING HAZARDS IN SHIPYARD EMPLOYMENT



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EXECUTIVE SUMMARY

OSHA developed this document to alert shipyard employers and their employees about abrasive blasting hazards and the controls that can be implemented to reduce, avoid or eliminate them. This document focuses on air contaminants because they are a major hazard during abrasive blasting. Other abrasive blasting safety and health hazards are discussed along with information regarding applicable regulations and control methods.

This guidance document provides employers with recommendations and information on how to protect their employees from the various hazards of abrasive blasting operations. These recommendations range from engineering controls, exposure monitoring and medical surveillance, to training on the OSHA Hazard Communication and PPE standards. In addition, OSHA recommends that employers perform an inspection of the worksite to identify additional hazards that may be present, such as excessive noise, static electricity, confined spaces, and heat and fall hazards. Where possible, OSHA has included the website address where employers may find additional information on specific topics. OSHA recommends that employers spend time evaluating each of the discussed hazards, the suggested preventative measures and the abatement steps that have been detailed.

Although this guidance document is designed specifically for shipyard employment, OSHA hopes that employers with similar work environments may also find this information useful.

Employers with limited expertise in this area can obtain services from (1) their state on-site safety and health consultation program; (2) industry associations, such as Shipbuilders Council of America, National Shipbuilders Research Program or National Institute for Occupational Safety and Health; (3) risk management services through their workers' compensation insurance provider; or (4) an industrial hygienist or other qualified health and safety consultant. A directory of free state safety and health consultation services is available electronically at OSHA's website or by contacting your local OSHA office. A listing of occupational and environmental health and safety consultants by state is available through the American Industrial Hygiene Association (AIHA) and may be accessed electronically or by calling AIHA Customer Service in Fairfax, Virginia at (703) 849-8888. Workplace health and safety consultants may also be located in the yellow pages of your telephone directory for safety and/or environmental engineers.

This guidance is not a standard or regulation, and it creates no new legal obligations. It is advisory in nature, informational in content, and is intended to assist employers in providing a safe and healthful workplace. The OSH Act requires employers to comply with hazard-specific safety and health standards. Under the OSH Act, the extent of an employer's obligation to address hazards related to scaffolding and fall protection is governed by 29 CFR Part 1915 Subpart E Scaffolds, Ladders and Other Working Surfaces, and 29 CFR Part 1915 Subpart I Personal Protective Equipment. Many of these requirements are referenced in this guidance and employers must comply with them. In addition, pursuant to Section 5(a)(1), the General Duty Clause of the OSH Act, employers must provide their employees with a workplace free from recognized hazards likely to cause death or serious physical harm. Employers can be cited for violating the General Duty Clause if there is a recognized hazard and they do not take reasonable steps to prevent or abate the hazard. However, failure to implement the recommendations in this guidance is not, in itself, a violation of the General Duty Clause. Citations can only be based on standards, regulations, and the General Duty Clause.

BACKGROUND

In the shipbuilding and ship repair industry, abrasive blasting is the most common surface preparation technique used to remove old paint and other surface materials such as rust, mill scale, dirt, and salts. Abrasive blasting might be conducted during vessel fabrication (e.g., on piping, steel plates and steel members used in structural assemblies, and other miscellaneous materials) and during maintenance and repair operations that include blasting and painting the ship's hull, and interior tanks and spaces. Surface preparation techniques, such as abrasive blasting, are also one of the most significant sources of shipyard wastes and pollution. (1)

In abrasive blasting, compressed air is used to propel abrasive material from a blast pot, through a blasting hose to a nozzle, where it is directed to the work area at high velocity by the operator. Air pressure is typically high, at 100 pounds per square inch, and nozzle velocities can approach 650 - 1,700 feet per second. (2) Abrasive blasting is usually conducted manually within a blast building, a dry dock, a floating dry dock, graving dock, shipways, vessel sections, on the ground, on board a vessel, and at the pier. (3) Automated abrasive blasting machines such as centrifugal blasting machines are also used in shipyards to prepare materials prior to priming or painting.

WARNING!

ABRASIVE BLASTING OPERATIONS CAN EXPOSE SHIPYARD EMPLOYEES TO TOXIC AIR CONTAMINANTS, HIGH NOISE LEVELS, AND OTHER SAFETY AND HEALTH HAZARDS.

HAZARDS

Shipyard employees who engage in abrasive blasting are at an increased risk of exposure to toxic dusts, high noise levels, and a range of other safety and health hazards. Helpers (e.g., the "pot tender" and cleanup personnel) and others may also be at risk if they work in the vicinity of areas where abrasive blasting is conducted.

Air Contaminants

Potential exposure to dust and air contaminants is the primary health hazard associated with abrasive blasting. Abrasive blasting can generate large quantities of dust that can contain high levels of toxic air contaminants. The source of the air contaminants includes the base material being blasted, the surface coating(s) being removed, the abrasive being used, and any abrasive contamination from previous blasting operations. (4) This means that employees can have exposures to multiple air contaminants from both the abrasive and the surface being blasted. Potential air contaminants that might be associated with abrasive blasting in shipyards and their sources are listed in Table 1.

Table 1. Potential Air Contaminants Associated with Abrasive Blasting in Shipyards

Source	Potential Air Contaminants
Base Material (e.g., steel, aluminum, stainless steel, galvanized steel, copper-nickel and other copper alloys)	Aluminum, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc
Surface Coatings (e.g., pre-construction primers, anticorrosive and antifouling paints)	Copper, barium, cadmium, chromium, lead, tributyl tin compounds, zinc
Abrasive Blasting Media (e.g., coal slag, copper slag, nickel slag, glass, steel grit, garnet, silica sand)	Arsenic, beryllium, amorphous silica, cadmium, chromium, cobalt, crystalline silica, lead, manganese, nickel, silver, titanium, and vanadium
Sources: EPA, 1997; EPA, 2000; NFESC, 1996; NIOSH, 1998.	

Base Materials

The base materials used to fabricate ships include iron-containing (e.g., carbon steel) and non-iron-containing metals. Various grades of mild and high strength steel are used for the structural framework of most ships while aluminum and other non-iron-containing materials are used for some superstructures and other areas with specific corrosion resistance and structural requirements. Other materials such as galvanized steel, stainless steel, and copper alloys are used to a much lesser extent. Depending on the base material being blasted, potential air contaminants might include aluminum, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc.

Surface Coatings

The interior and exterior surfaces of ships are protected with coatings that include zinc-based pre-construction primers (shop primers) and metal-based anticorrosive and antifouling paints. Antifouling paints are used on the hulls of ships to prevent the buildup of marine organisms (e.g., algae, bacteria, and barnacles) and typically include copper-based and tributyl tin-based paints. Metal-based paints are used to protect ship surfaces from corrosion and can contain up to 30 percent heavy metals. Lead compounds, such as lead chromate and red lead tetraoxide, have been used extensively in marine paint. Depending on the surface coating being blasted, potential air contaminants might include barium, cadmium, chromium, copper, lead, zinc, organotin compounds, and other types of air contaminants.

Abrasive Blasting Media

Common blasting abrasives used for paint removal and surface preparation in shipyard employment include coal slag, copper slag, and other metallic grit and shot. Traditionally, silica sand was used as a blasting abrasive; however, the majority of shipyards no longer use silica sand because of the health hazards associated with silica dust. Silica dust is generated by using blasting abrasives that contain crystalline silica (e.g., quartz rock, river sand, and beach sand) and when blasting crystalline silica-containing surfaces such as concrete or masonry. Employees who breathe in fine (respirable) particles of crystalline silica are at risk of developing silicosis, a stiffening and scarring of the lungs which can result in death.

The use of non-silica abrasives, such as coal and smelter slags, and metallic (e.g., steel shot, cast iron grit, cast iron shot) and mineral abrasives (e.g., garnet, olivine, and staurolite), results in nondetectable or lower levels of airborne crystalline silica; but levels of other hazardous air contaminants can be elevated, depending on the abrasive. For example, in a NIOSH-sponsored field study that evaluated silica sand alternatives for abrasive blasting, coal slag generated substantially lower airborne levels of crystalline silica than silica sand [(5)]. But, airborne levels of other air contaminants (arsenic, beryllium, cadmium, chromium, lead, manganese, nickel, titanium and vanadium) were two to four times higher than for silica sand. Other researchers have reported that abrasive blasting with copper slag can generate arsenic, chromium, and lead levels that exceed the OSHA Permissible Exposure Limits (PELs) for these substances.

The levels of heavy metals in non-silica abrasives are highly variable depending on the type of raw material sources and/or the manufacturing processes used to make the abrasives. [(5)] Abrasive blasting media from coal slag will typically contain nickel and vanadium and a variety of other metals depending on the source of the coal used to make the slag. Copper slag from primary smelters contains significant levels of barium, cobalt, copper, chromium (trivalent), and nickel; whereas copper slag from secondary smelters might contain significant levels of arsenic and lead. Nickel slag typically contains elevated levels of copper, chromium (trivalent), and nickel and lower levels of cobalt and vanadium. [(6)]

Health Hazards

A summary of the potential health hazards associated with abrasive blasting air contaminants and their corresponding OSHA PELs are listed in Table 2.

Table 2. Hazards of Air Contaminants Associated with Abrasive Blasting in Shipyards		
Contaminant	**Potential Health Hazards**	**OSHA PEL[a] (mg/m^3)**

Aluminum	Occupational overexposure to aluminum can lead to respiratory irritation.	15 (total dust) 5 (respirable dust)
Arsenic (metal)	Occupational overexposure to arsenic can increase the risk of skin, lung and possibly lymphatic cancers and lead to peripheral neuropathy and vascular disease [Reynaud's phenomenon].	0.01
Barium (insoluble dust)	Occupational overexposure to barium dust can lead to respiratory irritation.	15 (total dust) 5 (respirable dust)
Beryllium	Occupational overexposure to beryllium can lead to the immune-mediated lung disorder known as chronic beryllium disease, increase the risk of lung cancer, and can cause allergic skin reactions upon dermal contact.	0.002
Cadmium	Occupational overexposure to cadmium can lead to degeneration of the renal tubules [kidney damage] manifested by increased protein in the urine [proteinuria]; increased blood pressure contributing to hypertension; obstructive lung diseases like chronic bronchitis, pulmonary fibrosis and emphysema; and increase the risk of lung and prostate cancer.	0.005
Chromium (metal)	Occupational overexposure to chromium may lead to skin irritation and increase the risk of lung fibrosis.	1
Chromium (III) (trivalent)	Occupational overexposure to trivalent chromium may lead to respiratory irritation and allergic dermatitis upon skin contact.	0.5
Chromium (VI) (hexavalent)	Occupational overexposure to hexavalent chromium can increase the risk of lung cancer and occupational asthma, damage nasal tissue and cause allergic dermatitis with skin contact.	0.005
Cobalt	Occupational overexposure to cobalt can lead to chronic lung inflammation and pulmonary fibrosis, increase the risk of lung cancer, and cause allergic contact dermatitis with skin contact.	0.1
Copper	Occupational overexposure to copper can lead to respiratory irritation.	1
Iron	Occupational overexposure to iron oxide can lead to siderosis [mildly fibrotic lung disease].	10
Lead	Occupational overexposure to lead can cause subclinical and clinical peripheral neuropathy [muscle weakness, pain, and paralysis of extremities], disruption of hemesynthesis and anemia, loss of kidney function, increased blood pressure, nephropathy, reduced sperm count and male sterility, and increase the risk of cancer.	0.05
Manganese	Occupational overexposure to manganese can lead to subclinical/clinical manganism, a 'Parkinson's -like' movement disorder manifested by reduced reaction time, loss of steadiness, walking difficulties, and emotional instability.	5 (Ceiling Limit)[b]
Nickel	Occupational overexposure to nickel compounds can increase the risk of lung and nasal cancers, and cause occupational asthma and allergic dermatitis with skin contact.	1
Crystalline Silica	Occupational overexposure to crystalline silica can lead to the chronic lung disease, silicosis, and increase the risk of lung cancer.	10 (% SiO_2 + 2) (respirable quartz)
Silver	Occupational overexposure to silver can lead to argyria, a gray pigmentation disorder of the skin and eye.	0.01
Tin (organic)	Occupational overexposure to certain organotins may lead to headaches and subclinical neurological disturbances.	0.1

Titanium	Occupational overexposure to titanium dioxide can lead to lung inflammation and pulmonary fibrosis.	15
Vanadium (Ceiling Limit)b	Occupational overexposure to vanadium can lead to lung inflammation, chronic bronchitis, and pulmonary fibrosis.	0.5
Zinc and Copper	Occupational overexposure to zinc or copper can lead to metal fume fever [acute 'pneumonia-like' symptoms].	15 (total dust) 5 (respirable dust)

[a] OSHA PEL refers to the eight-hour time-weighted average (TWA) concentration unless otherwise noted.

[b] Ceiling limit refers to that concentration that must not be exceeded during any part of the working exposure.

Sources: NIOSH, 1986; NIOSH, 2003; 29 CFR 1915.1000; 29 CFR 1915.1018; 29 CFR 1915.1025; 29 CFR 1915.1026; 29 CFR 1915.1027.

CONTROL MEASURES

Exposure to hazardous air contaminants during abrasive blasting can be controlled through the combined use of the following control measures: engineering controls; work practices; personal hygiene; waste management and prevention programs; and personal protective equipment (PPE);

A. ENGINEERING CONTROLS:

1. Substitution -- The easiest way to eliminate hazardous air contaminants associated with abrasive media is to select a safer abrasive blasting agent. If silica sand is used as a blasting abrasive, OSHA recommends that employers evaluate the available blasting agents and select the safest blasting agent that is appropriate for the work being performed. Several guides are available to help employers select abrasive blasting agents. For example, Michigan State University offers a substitutes list in its user's manual for preventing silicosis. (7) There are important things to keep in mind when selecting an alternative blasting agent:

- depending on the abrasive, alternative abrasive agents can result in elevated levels of other hazardous air contaminants such as heavy metals;
- alternative abrasive agents containing small amounts of crystalline silica (one percent or less) might result in elevated levels of airborne crystalline silica if used in confined or enclosed spaces, such as cargo holds, tanks and coffer dams;
- the use of alternative abrasive agents for abrasive blasting can reduce but might not eliminate silica exposures if silica-containing substrates are blasted, such as silica-containing coatings; and
- the use of appropriate procedures for the cleanup and disposal of waste material.

2. Isolation or enclosure -- OSHA recommends that abrasive blasting operations be isolated to minimize exposure to employees and prevent exposure to others in the work area and the environment.

Blasting Cabinets
For small objects, a properly designed, sealed, and ventilated blasting cabinet can be used to eliminate operator and bystander exposure to hazardous air contaminants.

Blasting Rooms
For transportable objects too large for blasting cabinets, a blasting room where blasting is done manually by one or more operators working inside the room should be considered. Blasting rooms should have sufficient ventilation to: (1) provide good operator visibility, (2) prevent dust from settling and accumulating in the room, (3) reduce dust concentrations so that PPE provides adequate protection, and (4) prevent the escape of contaminants into adjacent work areas or the environment. Operators working inside abrasive blasting rooms must be protected by hoods and Type CE NIOSH certified abrasive blasting airline respirators, or by positive-pressure blasting helmets. (29 CFR 1915.34(c)(3))

Temporary Enclosures
For large objects or structures that cannot be transported, or for fixed structures, temporary enclosures should be used. Where possible, objects or structures should be fully enclosed. When full enclosure is not possible, extend screening above the object or structure, and blast downwards. Air monitoring should be used to ensure that employees outside the enclosure are not exposed to elevated levels of air contaminants. If high levels of air contaminants are detected outside the enclosure; (1) employees should be excluded from these areas through the use of warnings signs and barricades or provided with appropriate PPE and (2) better control measures should be investigated and implemented.

Exclusion Zones
When open air blasting must be conducted, exclusion zones can be used to protect employees and others in the vicinity from exposure to elevated levels of hazardous air contaminants. Exclusion zones can also be used in conjunction with

blasting rooms and temporary enclosures. The extent of the zone should be based on the risk to all unprotected people and the weather conditions at the time of the blasting. Exclusion zones should be posted with appropriate warning signs and restricted to those employees wearing respiratory protection.

3. Process or Equipment Change -- OSHA recommends that alternative techniques to dry abrasive blasting be used to reduce or eliminate the amount of dust generated during surface preparation. These techniques are summarized in Table 3 and include wet abrasive blasting, hydroblasting, and blasting with dry ice pellets. Cleaning techniques that do not use abrasive blasting and are suitable for smaller jobs include thermal, chemical, and mechanical stripping methods. Other removal techniques that may reduce or eliminate toxic dust levels during surface preparation include blast cleaning with baking soda (sodium bicarbonate), reusable sponge abrasives, or plastic media (PMB); cryogenic stripping (immersing small parts into liquid nitrogen, followed by gentle abrasion or PMB); and laser paint stripping (generates no waste and uses a pulsed carbon dioxide laser as the stripping agent).

Table 3. Alternative Methods for Abrasive Blasting in Shipyard Employment

Name	Description	Advantages/Limitations
Wet Abrasive Blasting	Includes systems where a mixture of abrasive and water is propelled by compressed air and an alternative method where water is added to conventional abrasive blasting nozzles via an adapter (retrofit water curtain device). Inhibitors may need to be added to the water to minimize "flash rusting" surface areas that rust when bare metal is exposed to the elements between removal of old coating and application of new coating. Additives (such as Blastox) can be added to wetted grit to bind heavy metals and form silicates (limiting employee and environmental exposure to heavy metals).	■ Can be used in most instances where dry abrasive blasting is used. ■ Produces substantially lower dust emissions and lessens the amount of containment required (compared to dry blasting). For example, airborne dust can be reduced 50-75% by a simple water curtain device that fits around the blasting hose nozzle. (Device has a minimal effect on cleaning rate). ■ Surface cleaning rate can be lower compared to dry abrasive blasting because most wet abrasive blasters mix water with the abrasive prior to impact on the surface. To address this problem a retrofit (water curtain) device that minimizes premixing of the water with the abrasive blast was developed to fit over the end of conventional abrasive blast nozzles. ■ Can generate wastewater contaminated with paint chips and surface contamination.
Hydroblasting (water jet stripping)	A cavitating high-pressure water jet stripping system that uses an engine-driven high-pressure pump, a large volume of water, high-pressure hose, and a gun equipped with a spray nozzle. Abrasives may also be introduced into this type of system. Systems may use pressures as high as 50,000 psig* (ultra high pressure washing). Some systems (e.g., robotically driven) reuse (recirculate) the water for additional blasting by automatically removing the paint chips or stripped materials from the water. Inhibitors may need to be used to prevent flash rusting.	■ Can be used in most instances where abrasive blasting is used. ■ Removes most paints. Excellent method for removing hard coatings from metal substrates. Primary application is for older, (saline) rusted surfaces; not new steel. Can be used for stripping hulls, removing deposits and scale from heat exchangers, and removing rubber liners. ■ Does not require complex containment necessary for dry grit blasting and produces substantially lower dust emissions. Permits more flexible scheduling of maintenance projects on dust-sensitive components. ■ Avoids need to dispose of large quantities of contaminated spent grit. Paint chips can be gathered with a wet vacuum. ■ Recirculating water systems produce very little waste. Wastewater is

		usually suitable for sewer disposal after paint particles are removed. ■ Not always as efficient as abrasive grit blasting and has high capital and maintenance costs. Production rate is lower with ultra-high pressure blasting; but containment and cleanup costs are lower. For viscous coatings, production rate exceeds that of dry grit blasting. ■ Water blasted at ultra-high pressures can sever operators' limbs. Work is also very strenuous. Frequent rotation of employees is necessary to prevent fatigue. ■ Major problem with hydroblasting is flash rusting.
Centrifugal Wheel Blasting	Uses high-speed rotating blades inside an enclosure equipped with a dust collector to propel abrasive against the surface to be cleaned. Removes rust, paint, and mill scale. Abrasives include steel shot, steel grit, cut wire, and chilled iron grit. Surface to be cleaned is usually passed through the enclosure while rotating blade assembly remains fixed. Can also be used in the field with special adaptors where rotating blade assembly moves across a stationary work surface.	■ Enclosed systems typically used for uniform-sized parts (e.g., valves, pipes, or steel sections). Small hand-held units developed for use on bridges and similar structures. Field versions used for large, flat, horizontal surfaces (e.g., ship decks). Some designed for use on large vertical surfaces (ship hulls and storage tanks). ■ Abrasives are retrieved and recycled (continuously recovered, cleaned, and reused). ■ Very limited to no contact with airborne dust or high velocity particles (little abrasive or paint debris escapes).
Vacuum Blasting	Removes paint and surface coatings by abrasive blasting and simultaneously collects and recovers spent abrasive and paint debris with a vacuum capture and collection system surrounding the blast nozzle. Uses a standard blast nozzle inside a vacuum recovery head that forms a tight seal with the work surface. A variety of heads (different sizes) are available for different work surfaces (e.g., flat surfaces, inside corners, outside corners). Abrasives typically include aluminum oxide, garnet, steel shot, steel grit, and chilled iron grit.	■ Abrasive is automatically reclaimed and reused as work progresses. ■ When used properly, cleans effectively with minimal dust. However, operators do not always use the appropriate head and break the vacuum seal by lifting the apparatus to clean inaccessible surfaces and odd shapes. This work practice defeats the purpose of the vacuum exhaust system and exposes employees to blasting dust and debris. ■ Heavy and awkward to use. ■ Small units have low production rates and relatively high costs.
Dry Ice Pellets	Abrasive blasting with dry ice pellets (solid carbon dioxide). After use, the dry ice evaporates leaving only paint chips/scales and rust that can be vacuumed or swept up and placed in containers for disposal. Applications include cleaning aircraft parts and exotic metals.	■ Waste is minimized and includes paint chips/scales and rust; no media waste. ■ Capital costs can be high (i.e., dry ice, handling, and storage equipment costs). ■ Can provide excellent surface preparation. ■ Multiple passes may be needed to fully remove paint. (Lack of "bounce back" effect that helps remove surface

		contaminants from the back and sides of the object being blasted). ■ May be an asphyxiant hazard ■ System may cause employee fatigue.
Thermal Stripping	Uses a flame or stream of superheated air to heat and soften paint, allowing for easy removal.	■ Generates one waste stream (i.e., waste paint). ■ Limited in its application. Effective for small parts; not suitable for heat-sensitive surfaces. ■ More labor intensive than other stripping methods.
Chemical Stripping	Immersing small parts in dip tanks containing a stripping solution. Chemical stripping solutions include organic (e.g., methylene chloride-based solutions) and inorganic (e.g., caustic soda solutions) strippers. Parts must be rinsed to remove stripping solution residue.	■ Effective for small fiberglass, aluminum, and delicate steel parts. ■ Requires adequate ventilation and other safety measures. ■ Generates multiple waste streams including contaminated rinse water and hazardous waste strippers. ■ Organic strippers typically used for coated parts; inorganic strippers typically used for non-coated parts. ■ Key problems with inorganic strippers: flash rusting of non-coated parts and waste stripper that must be discarded as hazardous waste. ■ Chemicals, such as methylene chloride, may cause adverse health effects.
Mechanical Stripping	Chipping, grinding, sanding, or scraping the coating off small parts or surfaces through the use of needle guns, chipping hammers, sanders, and grinders. Some power tools may be equipped with dust collection systems.	■ Generates paint waste and airborne particulate emissions. ■ May be less costly for small areas aboard vessels.
* psig: pounds per square inch (gauge). Sources: EPA, 1991, 1995, and 1997; Kura, B. et al., (no date); MSU, 1999; PPRC, 1997a and b; Queensland Government, 1999.		

4. Ventilation -- All blast-cleaning enclosures must be adequately ventilated. Abrasive blasting rooms, portable blast-cleaning equipment, and temporary containment structures must have sufficient exhaust ventilation to: (1) prevent a buildup of dust-laden air and reduce the concentrations of hazardous air contaminants; (2) increase operator visibility; and (3) prevent any leakage of dust to the outside. Exhaust ventilation systems must be constructed, installed, inspected, and maintained according to the OSHA Ventilation standard for abrasive blasting. (29 CFR 1910.94(a)) The exhaust air from blast-cleaning equipment must be discharged to the outside through an appropriate dust collector to protect the workplace, the environment and the surrounding community from hazardous air contaminants. The dust collector should be set up so that the accumulated dust can be emptied and removed without contaminating work areas. (8)

5. Wet Methods -- OSHA recommends that wet methods be used to reduce or eliminate the amount of dust generated during surface preparation. All wet blasting techniques (such as wet abrasive blasting and hydroblasting) produce substantially lower dust emissions compared to dry abrasive blasting. (9) If a wet blasting technique is not feasible, consider installing a water hose to wet down the dust at the point of generation.

B. WORK PRACTICES

OSHA believes that by using good work practices, the risk of exposure to toxic air contaminants and other safety and health hazards associated with abrasive blasting can be minimized. Such practices might include:

- using vacuums equipped with High Efficiency Particulate Air (HEPA) filters or wet methods when removing accumulated dust.
- scheduling blasting when the least number of people would be exposed;
- blasting in a specified location that is as far away as possible from other employees;
- stopping other work and clearing people away while blasting is taking place;

- cleaning up paint chips, dust, and used abrasive daily or as soon as possible after blasting has finished;
- avoiding blasting in windy conditions; and
- posting warning signs to mark the boundaries of work areas contaminated with blasting dust and alerting employees to the hazard and any required PPE.

C. PERSONAL HYGIENE

OSHA recommends that employers require employees to use proper personal hygiene practices. These practices are an important control measure for protecting employees from exposure to hazardous contaminants generated during abrasive blasting. Some contaminants, such as lead, are hazardous when inhaled or ingested. Others, such as beryllium, may be hazardous through inhalation and skin contact. Good personal hygiene practices to limit exposure to abrasive blasting dust include the following:

- Prohibiting eating, drinking, using tobacco products, or applying cosmetics in abrasive blasting areas;
- Washing hands and face before eating, drinking, smoking, or applying cosmetics;
- Showering before leaving the worksite;
- Changing into clean clothing before leaving the worksite; and
- Parking cars where they will not be contaminated with abrasive blasting dust.

WARNING!

Employees who do not shower and change into clean clothing before leaving the worksite may contaminate their automobiles and homes with toxic dust.

Other members of the household may then be exposed to harmful levels of toxic substances.

D. PERSONAL PROTECTIVE EQUIPMENT (PPE)

Respiratory Protection
OSHA requires controls, such as substitution, isolation, and ventilation, as the primary means of preventing or minimizing exposures to airborne contaminants during activities such as abrasive blasting in 29 CFR 1910.134(a). However, when such controls cannot keep exposures below the OSHA PELs, employees must use NIOSH-certified respirators appropriate for the types and concentrations of airborne contaminants present during abrasive blasting (1910.134(d)(1)(i)). In all cases, respirators should be donned before entering contaminated work areas and removed only after leaving.

Abrasive blasting operators must wear NIOSH-certified Type CE abrasive blasting respirators when:

- working in enclosed or confined spaces; or
- using abrasive media that contains more than one percent crystalline silica.

When not working in enclosed and confined spaces, or where abrasives containing less than one percent crystalline silica are used, abrasive blasters must be protected with Type CE abrasive blasting respirators or air-purifying respirators with HEPA filters. The respirator selected should be based on the highest anticipated exposures as determined by an evaluation of the hazards to which employees will be exposed. As a minimum, respiratory protection for heavy metals and silica dusts require an air-purifying respirator with HEPA filters. However, if workplace conditions for airborne contaminants, or their concentrations are highly variable or are not well understood, respiratory protection with a higher level of protection may be needed.

Appropriate respiratory protection must also be provided for other employees working in areas where concentrations of abrasive materials and dusts are present; and for short, intermittent or occasional dust exposures such as cleanup, dumping of dust collectors, or unloading shipments of abrasives.

When respirators are used, employers must establish a comprehensive respiratory protection program as required by the OSHA Respiratory Protection standard. (29 CFR 1910.134) Important elements of this standard include: (1) designating a program administrator; (2) evaluating workplace exposures; (3) selecting NIOSH-certified respirators; (4) medically evaluating employees to determine their ability to perform the work while wearing a respirator; (5) conducting respirator fit testing; (6) developing procedures for cleaning, inspecting, maintaining, and storing respirators; (7) training employees at least annually; and (8) evaluating the effectiveness of the respirator program on a regular basis.

Other PPE
In addition to respiratory protection, additional PPE is required for abrasive blasting operators for specific operations. This additional PPE may include:

- eye and face protection (if the respirator design does not provide this protection); (1915.153)
- a protective helmet (if the respirator design does not provide this protection and there is potential for head injury); (1915.155)
- heavy canvas or leather gloves and aprons (or equivalent protection) to protect from the impact of abrasives; (1915.34(c)(3)(iv))
- safety shoes or boots; (1915.156)
- hearing protectors to reduce noise levels below the OSHA PELs; (1910.95)
- fall protection (if protection from falling cannot be provided by railings). (1915.34(c)(3)(v))

OSHA also requires that other employees, such as the pot tender and abrasive recovery men, working in abrasive blasting areas where there is an unsafe concentration of abrasive materials and dusts be protected with appropriate eye and respiratory protection. (1915.34(c)(3)(iii)) However, employers are required to perform a hazard assessment of the worksite to determine the hazards employees are exposed to, or are likely to be exposed to, that will necessitate issuing PPE. From this assessment, employers must identify any and all pieces of PPE that each employee will need in order to complete the task in a safe and healthful manner. (1915.152(b)) and Subpart I - Personal Protective Equipment).

WARNING!

Abrasive blasters' dusty clothes can contaminate their cars, homes and other worksites with hazardous air contaminants. To ensure that this does not happen, OSHA recommends that employees:

- **Before beginning work, change into disposable or washable work clothes at the worksite;**
- **Store street clothes separately from work clothes in a clean area;**
- **Change into clean clothing before leaving the worksite.**

E. WASTE MANAGEMENT AND PREVENTION

Shipbuilding and repair activities present public health and environmental concerns because of the processes and materials that are used, as well as the close proximity of shipyards to large bodies of water. Pollutants and wastes typically generated by dry abrasive blasting include: (1) particulate air emissions of blasting abrasives and paint chips; and (2) large quantities of spent abrasives mixed with paint chips that can enter waterways through shipyards' stormwater, or when a marine railway is flooded. Both of these waste streams can be hazardous to people and the environment because they might contain toxic metals. In addition, cleanup and disposal costs of spent abrasive can be high, especially if it is contaminated with hazardous paints. This information needs to be verified with the applicable Environmental Protection Agency laws in your area.

EXPOSURE MONITORING

OSHA recommends that air sampling be conducted by trained personnel in all abrasive blasting applications. This sampling is necessary to: (1) measure employee exposure to airborne contaminants (e.g., total dust, respirable crystalline silica and heavy metals); (2) select the proper PPE; and (3) evaluate the effectiveness of engineering controls. Exposure monitoring must be performed when abrasive blasting applications may expose employees to arsenic (29 CFR 1915.1018), cadmium (29 CFR 1915.1027), hexavalent chromium (29 CFR 1915.1026) or lead (29 CFR 1915.1025). If concentrations of airborne contaminants are high, corrective measures should be taken to reduce exposures and sampling should be repeated to confirm reduced exposures. Air samples should to be collected and analyzed according to OSHA methods or their equivalent.

MEDICAL SURVEILLANCE

Specific substances requiring medical surveillance that might be encountered in shipyards during abrasive blasting include arsenic (29 CFR 1915.1018), cadmium (29 CFR 1915.1027), hexavalent chromium (29 CFR 1915.1026) and lead (29 CFR 1915.1025). Depending on the levels of these air contaminants, employers may need to comply with the requirements of one or more substance-specific standards, including the provision of medical surveillance. Medical surveillance requirements vary depending on the substance and may include: work and medical histories, smoking histories, chest X-rays, blood and urine testing, medical examinations, and other tests or procedures.

Some air contaminants, such as crystalline silica, do not have OSHA medical surveillance requirements. However, NIOSH recommends that medical examinations be available to all employees who may be exposed to crystalline silica. Examination should at least include: (1) a medical and occupational history to collect data on employee exposure to crystalline silica and signs and symptoms of respiratory disease; (2) a chest X-ray; (3) pulmonary function testing; and (4) an annual evaluation for tuberculosis. (8)

OSHA recommends that all employers engaged in abrasive blasting evaluate the risks abrasive blasting dusts present to exposed employees and determine what medical surveillance, if any, is required. The need for medical surveillance can usually be determined by conducting air sampling to measure and evaluate the levels of regulated air contaminants.

TRAINING AND INFORMATION

OSHA recommends that employers provide information and training to employees who engage in abrasive blasting activities. This information should incorporate the training requirements of the OSHA Hazard Communication (29 CFR 1915.1200) and Personal Protective Equipment (29 CFR 1915.152) standards. If necessary, the training requirements of applicable substance-specific standards (arsenic, cadmium, hexavalent chromium, and lead) must also be addressed. Typical information and training includes:

- The location and availability of the written hazard communication program and material safety data sheets (MSDSs) for abrasives;
- Instruction about the purpose and set-up of regulated areas marking the boundaries of blasting areas containing hazardous materials, sand, and dusts;
- Methods and observations that may be used to detect the presence or release of hazardous air contaminants, such as workplace air sampling outside of the blasting area;
- Results of any air sampling the employer or others have conducted for levels of hazardous air contaminants in the workplace;
- The physical and health hazards of the air contaminants employees are exposed to. Employees should be made aware of the importance of recognizing relevant symptoms and encouraged to report such symptoms to their employer for further evaluation and advice;
- Discussion about the importance of engineering controls, work practices, and personal hygiene in reducing exposure to hazardous air contaminants;
- Instruction about the need, use, limitations, and care of appropriate PPE (including protective clothing, and respiratory, hearing, and fall protection);
- Other controls the employer has implemented to protect employees from exposure to hazardous air contaminants, such as medical surveillance programs;
- Information regarding applicable OSHA standards, other relevant safety and health hazards and the control measures implemented to protect employees; and
- A copy of this guidance document.

Employers engaging in abrasive blasting should research the relevant training requirements to ensure that their employees are protected. The above listing may not be all-inclusive.

OTHER SAFETY AND HEALTH HAZARDS

Although this guidance document focuses on the hazards of air contaminants associated with abrasive blasting, employers must be aware of other safety and health hazards that are present in the workplace. OSHA recommends that employers perform an inspection of the worksite, prior to work taking place, to determine what hazards exist and what precautions need to be taken. Some of these hazards are discussed below.

Exposure to Noise

Abrasive blasting produces noise levels that can cause permanent hearing loss in unprotected employees and others close to the blasting process. The main source of noise is the discharge of compressed air at the blast nozzle. Other noise sources during manual blasting include: (1) the supply air inside the operator's helmet; (2) the impact of the abrasive on the surface being blasted; (3) air compressors; (4) exhaust ventilation systems; and (5) air releases during grit pot blow-down. Small abrasive blasting cabinets are also significant sources of noise exposure for operators.

Typical Noise Levels Associated with Abrasive Blasting

- Air discharge from blast nozzle: 112 to 119 dB(A)
- Supply air inside operator's helmet: 94 to 102 dB(A)
- Abrasive blasting cabinets: 90 to 101 dB(A)
- Air compressors: 85 to 88 dB(A)

Maximum noise levels up to 145 dB(A) have been measured at the operator when the grit pot runs out of abrasive. (10)

OSHA regulates occupational noise exposure in shipyards under 29 CFR 1910.95. The current PEL is 90 dB(A) with employers taking action at 85 dB(A), both measured as eight-hour time-weighted averages. For those employees exposed to elevated levels of noise,

employers must implement the requirements of the noise standard which include provisions for engineering and administrative controls, employee noise monitoring, audiometric testing, hearing protectors, training, and recordkeeping.

Additional information can be found on OSHA's Noise and Hearing Conservation Health Topics Page, including information on recognition, evaluation, control, compliance, and training.

High-Speed Particles
Employees engaged in abrasive blasting can be struck by high-speed particles from the blasting media or the surface being blasted (substrate). Potential injuries can include particles becoming embedded in the skin, eye damage, severe cuts, and burns. Control measures to prevent these injuries include: (1) never pointing a blast nozzle at a person; (2) using a dead-man control device at the nozzle end of the blasting hose; (3) ensuring, where possible, that only one employee operates each blast nozzle; (4) installing guards to protect the operator from high-speed particles; (5) conducting abrasive blasting in a blasting enclosure or an area isolated from the workplace to reduce the possibility of employees and others being struck by high-speed particles; and (6) using appropriate personal protective equipment (PPE) when blowing off with 30 psi (pounds per square inch) air.

High-pressure Hazards
Abrasive blasting operators and other employees in the blasting area can be exposed to high-pressure hazards through contact with high-pressure air or water streams, uncontrolled high-pressure hoses, and air or water leaks in the equipment. Injuries can be very serious and include loss of sight and body parts (e.g., fingers and hands). Preventive measures include the following:

- Controlled access to the blasting area;
- Use of a dead-man control on the blast nozzle;
- Use of metal nozzle and hose couplings;
- Use of hose-coupling safety locks and hose whip checks;
- Inspection of all hoses and connections prior to use; and
- Use of appropriate PPE.

Additional information can be found on the Shipyard eTool, under cleaning operations.

Static Electricity
Static electricity can be generated by abrasive blasting equipment, the surfaces being blasted, and exhaust ventilation systems (fans and ductwork). Static electricity can shock employees and cause fires and explosions by igniting flammable/combustible atmospheres or materials. The buildup of static electricity can be prevented through the proper use of bonding and grounding. Additionally, blast hoses can be constructed with anti-static rubber linings or fitted with a ground wire or similar mechanism to dissipate static electrical charges. Additional information can be found on the Shipyard Employment e-Tool.

Vibration and Other Ergonomic Hazards
Abrasive blasting operators are exposed to hand-arm vibration from the force of the abrasive moving through the blast hose. Prolonged use of abrasive blasting equipment can damage the nerves and blood vessels in the fingers and result in a condition known as vibration syndrome (also known as vibration white finger and Raynaud's disease). The signs and symptoms of vibration syndrome include numbness, tingling, blanching (fingers turning pale and ashen), pain, and flushing. In advanced cases, individuals lose their manipulative skills (dexterity) and the ability to distinguish between hot and cold objects. If exposure to vibration continues, skin necrosis and gangrene can occur.

Preventive measures for vibration syndrome include: (1) the use of vibration-reduced equipment such as vibration-isolating handles incorporated into blasting nozzles; (2) reducing the extent and duration of continuous exposure to vibration through job rotation or more frequent breaks (e.g., a 10-minute break after each hour of continuous blasting); (3) frequent and careful maintenance of blasting equipment according to manufacturers' recommendations; and (4) the use of protective gloves to keep hands warm and dry while on the job. Certain glove designs also reduce vibration.

Additional information on vibration and ergonomic hazards can be found on OSHA's Ergonomics Safety and Health Page.

Confined Spaces
Confined and enclosed spaces in vessels or vessel sections (such as cargo tanks or holds, pump or engine rooms, storage lockers, and tanks containing or having last contained hazardous substances) can contain dangerous atmospheres resulting from oxygen deficiency or enrichment and flammable, combustible, toxic, corrosive or irritating substances. Abrasive blasting is a spark-producing operation that is considered "hot" work unless it is physically isolated from a flammable or combustible atmosphere. Abrasive blasting in confined and enclosed spaces can also introduce additional air contaminants such as heavy metals from the abrasive media and/or the surfaces blasted. Shipyard employers engaged in abrasive blasting in confined and enclosed spaces must meet OSHA requirements for confined space work (29 CFR 1915 Subpart B), surface preparation and preservation (29 CFR 1915 Subpart C) (not limited to confined/enclosed spaces), and ventilation. (29 CFR 1910.94).

In addition, other hazards inherent in the work performed in confined and enclosed spaces may include limited access, ladders, scaffolds, electrical circuits, unguarded openings and others. Such hazards must be addressed and specific safety practices followed to

ensure that spaces are entered and worked in safely. Additional information on confined spaces can be found on the OSHA Confined Spaces Safety and Health Topics Page, or in the Shipyard e-tools.

Working at Heights
Falls are a leading cause of fatalities in shipyards. Fall hazards for abrasive blasters include: (1) surges from drops in pressure in the hose line that can be sufficient enough to throw the blaster from the work surface; (2) shocks from static electricity that might cause the blaster to lose balance and fall when working at heights; and (3) blasting hoods that visually restrict the vision of the blaster.

Preventive measures include: (1) protecting the blaster with proper fall protection when adequate protection against falling cannot be provided by guard railings; (2) bonding and grounding blasting equipment and wearing appropriate gloves and boots to insulate from static electricity; and (3) working from scaffolds, not from ladders. Other preventive measures include covering or guarding holes and deck openings, providing adequate lighting so that blasters can see the physical limits of the work surface, and all control devices, and frequently removing abrasive media from all horizontal surfaces on staging or other elevated work surfaces.
Additional information on fall protection can be found in OSHA's Shipyard e-Tool, under Working Surfaces.

Slips and Trips
Abrasive blasting operators are exposed to tripping hazards and slippery work surfaces. High levels of airborne dust can also obstruct the blaster's vision. Preventive measures for slips and trips can be found in OSHA's Shipyard Employment e-Tool under Housekeeping and Illumination.

Heat
Abrasive blasting operators are at risk of heat-related illnesses due to the PPE that is worn (blast helmets and protective suits, sometimes for long periods of time), the work activity or physical demands of the job, and environmental conditions (i.e., temperature, humidity, and air movement). Additional information on reducing the risk of heat-related illnesses can be found on the OSHA Heat Stress Safety and Health Topics Page.

APPLICABLE STANDARDS

29 CFR 1910.94	General Industry - Ventilation
29 CFR 1910.95	General Industry - Occupational Noise Exposure
29 CFR 1910.134	General Industry - Respiratory Protection
29 CFR 1915 Subpart B	Shipyard Employment - Confined and Enclosed Spaces and Other Dangerous Atmospheres in Shipyard Employment
29 CFR 1915 Subpart C	Shipyard Employment - Surface Preparation and Preservation
29 CFR 1915.34	Shipyard Employment - Mechanical Paint Removers
29 CFR 1915.77	Shipyard Employment - Working Surfaces
29 CFR 1915.91	Shipyard Employment - Housekeeping
29 CFR 1915.92	Shipyard Employment - Illumination
29 CFR 1915.151	Shipyard Employment - Personal Protective Equipment: Scope, Application and Definitions
29 CFR 1915.152	Shipyard Employment - Personal Protective Equipment: General Requirements
29 CFR 1915.153	Shipyard Employment - Eye and Face Protection
29 CFR 1915.154	Shipyard Employment - Respiratory Protection
29 CFR 1915.155	Shipyard Employment - Head Protection
29 CFR 1915.156	Shipyard Employment - Foot Protection
29 CFR 1915.1018	Shipyard Employment - Inorganic Arsenic
29 CFR 1915.1025	Shipyard Employment - Lead
29 CFR 1915.1026	Shipyard Employment - Hexavalent Chromium
29 CFR 1915.1027	Shipyard Employment - Cadmium
29 CFR 1915.1200	Shipyard Employment - Hazard Communication

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