Introduction to Coatings and Paints

Course No: T04-003
Credit: 4 PDH

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1. SELECTION OF COATINGS

1.1 Selection Criteria. The best selection of a coating system for a particular service is determined by a variety of factors. These include desired properties, work requirements and limitations, safety and environmental restrictions, compatibilities, and costs.

1.1.1 Desired Film Properties. In selecting a coating system, the first consideration is the desired properties of the system for the particular service. Desired properties may include one or more of the following aspects:

- Resistance to exterior weathering (chalking; color and gloss retention)
- Water, fuel, or chemical resistance
- Abrasion, heat or mildew resistance
- Appearance (color, gloss, and texture)
- Drying time
- Ease of application and maintenance

1.1.2 Work Requirements or Limitations. The following work requirements or limitations may have to be considered:

- Type of surface preparation
- Access to work
- Drying times
- Necessary applicator skills
- Necessary equipment
- Scaffolding for access to work

1.1.3 Safety and Environmental Restrictions. It will be necessary to conform to all prevailing safety and environmental regulations concerning materials and processes to be used for surface preparation and for coating application.

1.1.4 Compatibilities. Coating systems must be compatible with the surfaces to which they are applied. Coating incompatibility can cause failures at or just after application or after a much longer time. Failures occurring just after application are due to solvent incompatibility or wetting problems. Failures associated with slow chemical reactions, such as those occurring between alkaline surfaces (e.g., concrete and galvanized steel) and oil-based paints or mechanical property mismatches (e.g., a rigid coating applied over a more flexible one) cause failure in a longer timeframe. The failure more often is peeling. For existing coatings being repainted, compatibility generally means that topcoats should be of the same generic type or curing mechanism as undercoats. One exception to this rule is inorganic zinc coatings. Since inorganic zinc coatings frequently do not bond well to themselves, it is safest to repair them with zinc-rich organic coatings. A simple test to classify coatings is to determine solvent sensitivity using an methylethyl ketone (MEK) or acetone rub test. To do this, soak a cloth in MEK or acetone, rub it against the existing paint, and visually check for pick up of paint. The paint is classified as "solvent soluble" if paint is picked up, and as "solvent insoluble" if not. Another practical method of ensuring topcoat solvent compatibility is to coat a small test area of the existing coating with the paint selected for the work. If situations permit, this test is preferred over the MEK rub test because it is specific for the surface to be repainted. The test area should be visually inspected the following day (or preferably after 3 or more days) for bleeding of undercoat, wrinkling, loss of adhesion, or other coating defects. Although most incompatibility problems are apparent in a couple of days, some types of incompatibility may not become apparent for several months or until after a change of seasons. These types are usually associated with mechanical film properties.

1.1.5 Costs. Life cycle cost has always been one of the most important considerations in selection of coating systems. Life cycle costs include original surface preparation, materials, and application and necessary maintenance throughout the life of the coating system. Today, the expense of containment of old paint during its removal and disposal of debris that is often considered to constitute hazardous waste must be included. This usually means that the system with the maximum maintainable life is the best choice.

1.2 Specifications for Lead- and Chromate-Free Coatings with VOC Limits. The coating specifications listed below in Table 1 are lead- and chromate-free and have limitations on their contents of VOC.

Table 1

Lead- and Chromate-Free Coating Specifications With VOC Limits

Latex Coatings	
Listed latex coatings are available with a VOC content of no more than 250 grams per liter unless otherwise specified	
TT-P-19	Exterior acrylic emulsion coating, available in a wide variety of colors and flat gloss finishes
TT-P-29	Interior latex paint, flat, available in white and tints
TT-P-650	Interior latex primer coating for gypsum board or plaster
TT-P-1510	Latex exterior flat finish coating, available in a variety of colors
TT-P-1511	Latex interior coating, available in gloss and semigloss in white and tints
TT-P-1728	Latex, interior, flat, deep-tone coating
TT-P-001984	Primer, latex, for wood
TT-P-002119	Latex high-traffic coating, available in flat and eggshell and a variety of colors
TT-E-2784	Acrylic emulsion exterior enamel, gloss and semigloss, available in a wide variety of colors
MIL-E-24763	Acrylic water-emulsion coating intended for shipboard use, available in 275 and 340 grams per liter VOC classes; high, medium, low, and flat glosses; and a limited number of colors
MIL-P-28577	Corrosion-resistant latex primer for metals
Stains	
MIL-P-28578	Waterborne acrylic semigloss finish, available in a wide variety of colors
TT-S-001992	Exterior latex stain, semi-transparent and opaque, available in a variety of colors
Clear Floor Finishes	
A variety of clear floor finishes are available from the Maple Flooring Manufacturers Association (MFMA) specifications, Heavy-Duty and Gymnasium Finishes for Maple, Beech, and Birch Floors. Suppliers must be contacted to determine VOC content.	
Oil and Alkyd Coatings	
SSPC PAINT-25	Corrosion-resistant raw linseed oil and alkyd primer, usually available at 300 grams per liter VOC but no requirement listed
TT-P-25	Oil-based primer for wood, normally available with a VOC content less than 350 grams per liter
TT-P-31	Red and brown oil ("roof and barn") paint, usually available with 250 grams per liter VOC content but no requirement specified
TT-E-489	Alkyd enamel, with 420 grams per liter VOC limitation, available only in gloss, but in a wide variety of colors
TT-P-645	Corrosion-resistant alkyd primer, with a 340 VOC limitation
TT-P-664	Corrosion-inhibiting alkyd quick-dry primer, with a 420 grams per liter VOC limitation
MIL-E-24635	Silicone alkyd enamel, available in limited colors, 275, 340, and 420 grams per liter VOC types, and high, medium, low, and flat gloss classes
MIL-P-28582	Alkyd primer normally available at less than 350 grams per liter

Table 1 (continued)

Lead- and Chromate-Free Coating Specifications With VOC Limits

Epoxy Coatings	
MIL-P-24441	Epoxy-polyamide, two- and three-coat systems, available in types with 340 VOC and limited colors
MIL-P-53022	Fast-dry epoxy primer with 420 grams per liter maximum VOC content
MIL-P-85582	Waterborne epoxy primer with 340 grams per liter maximum VOC content
Textured Coatings	
TT-C-555	Waterborne or oil- or rubber-based textured coating available at 250 grams per liter
Urethane Coatings	
MIL-C-85285	High-solids aliphatic urethane coating, with 340 and 420 grams per liter VOC types, available in a variety of colors and in glass and semigloss
Zinc-Rich Coatings	
MIL-P-24648	Zinc-rich coating, aqueous and organic solvent types, self-curing and post-curing classes, organic and inorganic

1.3 Recommendations for Different Substrates. This discussion provides general recommendations for wood, concrete and masonry, steel, galvanized steel, and aluminum surfaces. The recommended dry film thickness (dft) in mils is provided for coating specification recommended for a particular substrate. Referenced standards for coatings provide for lead- and chromate-free products that are low in VOCs. Although such requirements may not be necessary at all projects currently, such requirements may occur in the near future.

In making local repairs of damaged coatings, loose paint should be removed by scraping with a putty knife before lightly sanding or abrasive blasting any exposed substrate and feather-edging existing sound paint to obtain a smooth transition with the repaired area. Coats of repair material should be extended 1 inch onto the surrounding sound coating.

1.3.1 Recommendations for Wood. Oil-based and waterborne coatings and stains (frequently called latex) perform quite well on new wood. A two-coat system, paint or stain, is normally applied. However, as additional coats are applied to resurface or repair weathered paint, the film thickness may become sufficient to reduce the total flexibility to the point that results in disbonding of the total paint system from the surface. Thus, when topcoating or making localized repairs, no more coating should be applied than necessary to accomplish the desired goal.

Surface preparation of new wood normally consists of lightly hand sanding or power sanding, carefully controlled so that it does not damage the wood. Sanding is also appropriate for preparing weathered surfaces for refinishing and for spot repairing areas of localized damage.
1.3.1.1 Oil-Based Paints. Historically, wood has been successfully painted with oil-based products that penetrate the surface well. These coatings are very easy to apply.

Oil-Based Paint System for Wood		
Surface Preparation	Primer	Topcoat
Sand	one coat TT-P-25 or MIL-P-28582, 2 mils dft,	one-two coats MIL-E-24635 or TT-P-102, 2 mils dft per coat

1.3.1.2 Water-Emulsion Paints. More recently, latex coatings have been found to be very effective in providing attractive, protective finishes. They are also less affected by moisture than are oil-based finishes and are generally more flexible and thus less susceptible to cracking as the wood swells and contracts with moisture changes. A problem sometimes arises when repairing or topcoating existing smooth alkyd coatings with latex paints. To obtain good intercoat adhesion, it may be necessary to lightly sand the existing paint and/or apply a surface conditioner containing tung oil or some other oil that wets surfaces well before applying the first coat of latex paint.

Waterborne Paint System for Wood		
Surface Preparation	Primer	Topcoat
Sand	One coat TT-P-001984, 1.5 mils dft	One-two coats TT-E-2784 or other appropriate latex paint in Table 1, 1.5 mils dft per coat

1.3.1.3 Semi-Transparent Stains. Because oil-based and waterborne paints form continuous films, they may form blisters or disbond because of moisture in the wood attempting to escape. Semi-transparent stains do not form continuous films on wood and so do not have this problem. Thus, they are a good alternative on new wood. Additional coats applied over the years or heavybodied stains will, however, form continuous films.

Stains for Wood		
Surface Preparation	Primer	Topcoat
Sand	One coat TT-S-001992, 1.5 mils dft	One coat TT-S-001992, 1.5 mils dft

1.3.1.4 Clear Floor Finishes. A variety of clear floor finishes are available from MFMA Heavy-Duty and Gymnasium Finishes for Maple, Beech, and Birch Floors. Suppliers on the attached list must be contacted to determine VOC content. Surface preparation for hard wood floors is described in detail In the *Unified Facilities Guide Specifications* which are available for download without charge at www.wbdg.org.

1.3.2 Recommendations for Concrete and Masonry Surfaces. Concrete and masonry surfaces, as well as those of stucco, plaster, wallboard, and brick, can be coated with a variety of systems depending upon the desired purpose and appearance. Surface preparation is usually accomplished by power washing with aqueous detergent solution to remove dirt and other loose materials. Any oil or grease will have to be removed by solvent or steam cleaning; any mildew, by scrubbing with bleach; and any efflorescence or laitance, by brushing, followed by acid treatment.

1.3.2.1 Waterborne Coatings. A two-coat waterborne (latex) system provides an attractive breathing film that is normally less affected by moisture in the concrete than non-breathing systems. The latex material is a self-primer in this service, unless otherwise stated. Alkyd and other oil-based coatings should not be applied directly to concrete or masonry surfaces, because the alkalinity in the concrete will hydrolyze the oil in the binder and cause the coating to peel. However, they can be applied over concrete or masonry surfaces primed with waterborne coatings to produce a tougher, more washable finish.

1.3.2.2 Elastomeric Coatings. Elastomeric, waterborne acrylic coating systems also perform well to seal and protect concrete/masonry surfaces and are normally very low in VOCs. They can successfully bridge fine or larger caulked cracks. There are no federal specifications for them.

Elastomeric Waterborne Acrylic System for Concrete or Masonry		
Surface Preparation	Primer	Topcoat
Power wash	One coat primer recommended by supplier of elastomeric coating, dft varies with supplier	One coat elastomeric acrylic coating, 10 -20 mils dft

1.3.2.3 Textured Coatings. Textured coatings system can bridge fine cracks and waterproof from wind-driven rain. They are normally applied over a primer recommended by the supplier to insure good adhesion. They are available in a variety of textures and may be waterborne or oil or rubber-based products with a VOC limit of 250 grams per liter.

Textured Coating System for Concrete or Masonry		
Surface Preparation	Primer	Topcoat
Power wash	One coat primer recommended by supplier of textured coating, dft varies with supplier	One coat TT-C-555, 20 – 30 mils dft

1.3.2.4 Epoxy Coatings. A two-coat epoxy system will seal and protect concrete/masonry surfaces well. An aliphatic urethane finish coat should be used rather than the second epoxy coat on exterior surfaces to improve the weatherability.

Exterior Epoxy/Urethane System for Concrete or Masonry		
Surface Preparation	Primer	Topcoat
Power wash	One coat MIL-P-24441 Formula 15, 3 mils dft	MIL-C-85285, Type II, 2 mils dft

Interior Epoxy System for Concrete or Masonry		
Surface Preparation	Primer	Topcoat
Power wash	One coat MIL-P-24441, Formula 150, 3 mils dft	One coat MIL-P-24441, of another color, 2 mils dft

1.3.3 Recommendations for Steel. Presently, a high-performance coating system is recommended to prolong the service before it becomes necessary to remove and replace it. Costs in coating removal, especially where there are restrictions on abrasive blasting, are very high. Abrasive blasting is always preferred to alternative methods of preparing steel surfaces for painting. It cleans the steel and provides a textured surface to promote good primer adhesion. A commercial blast specified by the Steel Structures Painting Council [re-named the Society for Protective Coatings in 1997] (SSPC) is (SSPC SP 6) is normally adequate for alkyd and epoxy primers for a moderate environment. A near-white blast (SSPC SP 10) is required for epoxies, including zinc-rich epoxies, exposed to a severe environment such as marine atmospheric or water or fuel immersion. Some manufacturers may specify a white metal blast (SSPC SP 5) for particular coatings for special applications. It is important that a contract specification does not conflict with the coating manufacturer's written directions. A white metal blast (SSPC SP 5) is recommended for zinc-rich inorganic primers. If abrasive blasting cannot be done, then power tool cleaning to bare metal (SSPC SP 11) is recommended. It provides a surface cleanliness and texture comparable to those of a commercial blast (SSPC SP 6). Hand tool cleaning (SSPC SP 2) or power tool cleaning, however, may be adequate in making localized repairs.

1.3.3.1 Alkyd Systems. In the past, many steel structures with atmospheric exposures were coated with an alkyd or other oil-based system. Three-coat alkyd systems provided adequate protection in moderate atmospheric service. On new painting, they are being replaced in significant part by epoxy systems that provide longer protection. Alkyd systems, however, will still be used in large volume for repairing old deteriorated alkyd systems.

Alkyd Coating System for Steel		
Surface Preparation	Primer	Topcoat
SSPC SP 6	one coat TT-P-645 or SSPC PAINT 25, 2 mils dft	MIL-E-24635 or TT-E-489, 2 mils dft

1.3.3.2 Epoxy Coating Systems. A three-coat epoxy system provides good interior service in harsh as well as moderate environments. An aliphatic urethane finish system is used in place of the third epoxy coat in exterior service to provide greater resistance to deterioration by ultraviolet light. Several different epoxy mastic systems, some aluminum-filled,have been used successfully on steel structures. However, there is no specification for one at this time.

Epoxy System for Exterior Steel		
Surface Preparation	Primer/Mid Coat	Topcoat
SSPC SP 6 or 10	One coat each MIL-P-24441, Formulas 150 and 151, 3 mils dft	One coat MIL-C-85285, Type II, 2 mils dft

Epoxy System for Interior Steel		
Surface Preparation	Primer/Mid Coat	Topcoat
SSPC SP 6 or 10	One coat each MIL-P-24441, Formulas 150 and 151, 3 mils dft per coat	One coat MIL-P-24441 of desired color, 3 mils dft

1.3.3.3 Zinc-Rich Coatings. Good protection from corrosion and abrasion can be provided by zinc-rich inorganic coatings. They perform well un-topcoated in a variety of environments except acidic or alkaline. They may be topcoated with an acrylic latex finish coat to provide a variety of color finishes. Epoxy (for interior) or epoxy and aliphatic urethane (for exterior) topcoats may also be used. Localized repair of inorganic zinc systems is usually accomplished with a zinc-rich organic coating to permit good bonding to any exposed steel, inorganic coating, or organic topcoats.

Zinc-Rich System for Steel		
Surface Preparation	Primer	Topcoat
SSPC SP 1	MIL-P-2468, Composition B (inorganic), 3 mils dft. Composition A (organic) can be used when a more "forgiving" system is needed.	None, or one or more coats of acrylic or latex, epoxy, etc.

1.3.4 Recommendations for Galvanized Steel. Galvanized steel corrodes very slowly in moderate environments but may be painted with organic coating systems to provide color or additional corrosion protection, particularly in severe environments. It should never be coated directly with an alkyd paint, because the alkalinity on the surface of the galvanizing will hydrolyze the oil in the binder, degrading the binder, and cause paint peeling. New galvanizing should be solvent or steam cleaned (SSPC SP 1, Solvent Cleaning) to remove any grease or oil before coating. Older, un-topcoated galvanizing should be power washed to remove any dirt or loose zinc corrosion products. Any loose coatings should also be removed by power washing or scraping and sanding to produce a clean, sound surface. Rust should be removed by waterblasting or careful abrasive blasting to limit the removal of galvanizing.

1.3.4.1 Epoxy Systems. Two coats of epoxy will provide long-term protection to galvanizing in interior service, as will one coat of epoxy and one coat of aliphatic urethane to galvanizing in exterior service.

Epoxy Coating System for Exterior Galvanizing		
Surface Preparation	Primer	Topcoat
SSPC SP 1	One coat MIL-P-24441, Formula 150, 3 mils dft	One coat MIL-C-85285, Type II, 2 mils dft

Epoxy Coating System for Interior Galvanizing		
Surface Preparation	Primer	Topcoat
SSPC SP 1	One coat MIL-P-24441, Formula 150, 3 mils dft	One coat MIL-P-24441 of desired color, 3 mils ft

1.3.4.2 Waterborne System for Galvanizing. Two coats of latex paint will provide a pleasing appearance and good protection to galvanized steel in moderate environments. They are easy to apply.

Waterborne Coating System for Galvanizing in Moderate Environment		
Surface Preparation	Primer	Topcoat
SSPC SP 1	One coat TT-E-2784, 1,5 mils dft	One coat T-E-2784* (* other commercially available acrylic latex systems will also perform well)

1.3.5 Recommendations for Aluminum. Aluminum surfaces corrode very slowly in moderate environments. They may be coated to provide color or additional protection, particularly in severe environments. Epoxy and epoxy/urethane systems perform well in interior or exterior service, respectively. Alkyd systems usually require surface pretreatments containing toxic materials. Because aluminum surfaces are relatively soft, they should not be cleaned by blasting with conventional abrasives or grinding to avoid damage. Any grease or oil should be removed by solvent or steam cleaning (SSPC SP 1). Dirt and other loose contaminants should be removed by power washing. Existing coatings are best removed by careful blasting with a soft abrasive (e.g., plastic). Alkaline strippers should never be used, because they will attack the aluminum.

Coating System or Aluminum		
Surface Preparation	Primer	Topcoat
See above	MIL-P-24441, Formula 150, or MIL-P-53022, 3 mils dft	One-two coats MIL-C-85285, Type 2, 2 mils dft per coat

2. SURFACE PREPARATION

2.1 Introduction. Surface preparation is the single most important factor in determining coating durability. Available data and experience indicate that in most situations, money spent for a clean, well-prepared surface reduces life-cycle costs. A proper surface preparation:

- Removes surface contaminants (e.g., salts and chalk) and deteriorated substrate surface layers (e.g., rust and sunlight-degraded wood) which hinder coating adhesion and;

- Produces a surface profile (texture) that promotes tight adhesion of the primer to the substrate.

2.1.1 Selection Factors. Factors which should be considered in selecting the general type and degree of surface preparation are:

- Type of the substrate
- Condition of the surface to be painted
- Type of exposure
- Desired life of the structure, as some procedures are much more expensive than others
- Coating to be applied
- Environmental, time, and economical constraints

2.1.2 Specification Procedure. A performance-based requirement for surface preparation, rather than a prescriptive requirement, is recommended for contract use. That is, it is usually better to describe the characteristics of the cleaned surface (e.g., profile and degree of chalk removal) than to specify the specific materials and procedures to be used. Often the general type of surface preparation (washing, blasting, etc.) is specified, because of job or other constraints, along with requirements for characteristics of the cleaned surface. In this way, the specifier allows the contractor to select the specific equipment, materials and procedures to get the job done and avoids putting contradictory requirements into the job specification.

2.1.3 Section Organization. This section is organized into: discussions of repair procedures usually done in conjunction with a painting contract and prior to painting; specific recommendations for surface preparation procedures and standards for specific substrates; recommendations for coating removal; and general background information on surface preparation methods.

2.2 Repair of Surfaces. All surfaces should be in good condition before recoating. If repairs are not made prior to painting, premature failure of the new paint is likely. Rotten wood, broken siding, and other deteriorated substrates must be replaced or repaired prior to maintenance painting. Water-associated problems, such as deteriorated roofs and nonfunctioning drainage systems, must be repaired prior to coating. Interior moist spaces, such as bathrooms and showers must be properly vented. Cracks, holes, and other defects should also be repaired. Areas in need of repair can sometimes be identified by their association with localized paint failures. For example, localized peeling paint confined to a wall external to a bathroom may be due to inadequate venting of the bathroom.

2.2.1 Joints, Cracks, Holes, or Other Surface Defects. Caulks and sealants are used to fill joints and cracks in wood, metal and, in some cases, in concrete and masonry. Putty is used to fill holes in wood. Glazing is used to cushion glass in window sashes. Specially formulated Portland cement materials are available for use in cracks and over spalled areas in concrete. Some of these contain organic polymers to improve adhesion and flexibility. Other materials are available to repair large areas of interior plaster (patching plaster), to repair cracks and small holes in wallboard (spackle), to fill joints between wallboards (joint cement), and to repair mortar. Before application of these repair materials, surfaces should be clean, dry, free of loose material, and primed according to the written instructions of the material manufacturer.

Caulking and sealant compounds are resin based viscous materials. These compounds tend to dry on the surface but stay soft and tacky underneath. Sealants have application properties similar to caulking materials but tend to be more flexible and have greater extendibility than caulks. Sealants are often considered to be more durable than caulks and may also be more expensive. Commonly available generic types of caulks and sealants include oil-based, butyl rubber, acrylic latex, silicone, polysulfide, and polyurethane. The oil-based and butyl-rubber types are continually oxidized by exposure to sunlight and become brittle on aging. Thus, their service life is limited. Acrylic-latex and silicone caulks tend to be more stable and have longer service lives. Applications are usually made with a caulking gun. However, some of these materials may also be available as putties or in preformed extruded beads that can be pressed in place. Putty and glazing compounds are supplied in bulk and applied with a putty knife. Putties are not flexible and thus should not be used for joints and crevices. Glazing compounds set firmly, but not hard, and thus retain some flexibility. Rigid paints, such as oil/alkyds, will crack when used over flexible caulking, sealing, and glazing compounds and should not be used. Acrylic-latex paints, such as TT-P-19, Paint, Latex (Acrylic Emulsion, Exterior Wood and Masonry) are a better choice.

2.2.2 Cementitious Surfaces. Epoxy resin systems for concrete repair are described in MIL-E-29245, Epoxy Resin Systems for Concrete Repair. This document describes epoxy repair materials for two types of application. They are: bonding hardened concrete to hardened concrete, and using as a binder in mortars and concrete. These types are further divided into classes based on working temperature. Thus, an appropriate material can be specified.

2.3 Recommendations by Substrate. Each different type of construction material may have a preferred surface preparation method. For substrates, grease and oil are usually removed by solvent or steam cleaning and mildew is killed and removed with a hypochlorite (bleach) solution.

2.3.1 Wood. Bare wood should not be exposed to direct sunlight for more than 2 weeks before priming. Sunlight causes photo-degradation of surface wood-cell walls. This results in a cohesively weak layer on the wood surface which, when painted, may fail. If exposed, this layer should be removed prior to painting by sanding. Failure of paint caused by a degraded-wood surface is suspected when wood fibers are detected on the backside of peeling paint chips. When the existing paint is intact, the surface should be cleaned with water, detergent, and bleach as needed to remove surface contaminants, such as soil, chalk, and mildew. When the existing paint is peeling and when leaded paint is not present, loose paint can be removed by hand scraping. Paint edges should be feathered by sanding. Power sanding may damage the wood if improperly done. Water and abrasive blasting are not recommended for wood, because these techniques can damage the wood. When leaded paint is present, special precautions, such as wet scraping, should be taken.

Table 2
Commonly Used Methods of Surface Preparation for Coatings
(IMPORTANT NOTE: Methods may require modification or special control when leaded paint is present.)

Cleaning Method	Equipment	Comments
Organic solvent	Solvent such as mineral spirits, sprayers, rags, etc.	Removes oil and grease not readily removed by other methods; precautions must be taken to avoid fires and environmental contamination; local VOC regulations may restrict use.
Detergent/power washing	Pumps, chemicals, sprayers, brushes	At pressures not exceeding 2000 psi, removes soil, chalk, mildew, grease, and oil, depending upon composition; good for smoke, stain, chalk and dirt removal.
Acid	Chemicals, sprayers, and brushes	Removes residual efflorescence and laitance from concrete after dry brushing. Thoroughly rinse afterwards.
Chemical paint strippers	Chemicals, sprayers, scrapers, washing equipment	Removes coatings from most substrates, but slow,messy, and expensive; may degrade surface of wood substrates.
Steam	Heating system pump, lines, and nozzles	Removes heavy oil, grease, and chalk; usually used prior to other methods.
Water blasting	High pressure water pumps, lines, and nozzles	At pressures of 2000 psi and above, removes loose paint from steel, concrete and wood; can damage wood or masonry unless care is taken; inhibitor generally added to water to prevent flash rusting of steel.
Hand tool	Wire brushes, chipping hammers, and scrapers	Removes only loosely adhering contaminants; used mostly for spot repair; slow and not thorough.
Power tool	Wire brushes, grinders, sanders, needle guns, rotary peeners, etc.	Faster and more thorough than hand tools because tightly adhering contaminants can be removed; some tools give a near-white condition on steel but not an angular profile; slower than abrasive blasting; some tools are fitted with vacuum collection devices.
Heat	Electric heat guns	Can be used to soften coatings on wood, masonry, or steel; softened coatings are scraped away, torches SHOULD NOT be used.
Abrasive blasting	Sand, metal shot, and metal or synthetic grit propelled onto metal by pressurized air, with or without water, or centrifugal force.	Typically used on metal and, with care on masonry; can use recyclable abrasives; special precautions are needed when removing lead containing paint. Water may be added to control dust and its addition may require use of inhibitors. Vacuum blasting reduces dust but is slower than open. Centrifugal blasting is a closed cycle system in which abrasive is thrown by a spinning vaned wheel.

Paint should be removed from wood when failure is by cross-grain cracking (that is, cracking perpendicular to the wood grain). This failure occurs when the total paint thickness is too thick and/or the paint is too inflexible. Painting over this condition almost always results in early failure of the maintenance paint layer. Paint removal from wood is difficult and may not always be feasible. Chemical strippers can be used, but the alkaline types may damage (chemically degrade) the surface of the wood and cause a future peeling-paint failure. Failure caused by a stripper-degraded wood surface is more likely for exterior exposures than for interior exposures. This is because the greater expansion and contraction of wood in exterior exposures requires that the surface wood have a greater mechanical strength.

2.3.2 Concrete/Masonry. Bare concrete and masonry surfaces, as well as painted surfaces, are usually best cleaned with water and detergent. Use low-pressure washing (less than 2000 psi) or steam cleaning (ASTM D 4258) to remove loose surface contaminants from surfaces. Use high-pressure water blasting (greater than 2000 psi and usually about 5000 psi) (ASTM D 4259, Abrading Concrete) to remove loose old coatings or other more tightly held contaminates or chalk. If existing paints are leaded, special worker safety and environmental controls will be needed. Abrasive blasting (ASTM D 4259 and D 4261, Surface Cleaning Concrete Unit Masonry for Coating) or acid etching of bare surfaces (ASTM D 4260, Acid Etching Concrete) may also be used to obtain a surface profile as well as clean surfaces for coating. Care must be taken to avoid damaging surfaces with high-pressure water or abrasives. Grease and oil must be removed with detergents or steam before abrasive blasting. Any efflorescence present should first be removed by dry wire brushing or acid washing. Special worker safety and environmental controls may be needed. Concrete surfaces must be completely dry prior to paint application for all types of paints except waterborne. The plastic sheet method (ASTM D 4263, Indicating Moisture in Concrete by the Plastic Sheet Method) can be used to detect the presence of water (i.e., tape a piece of plastic sheet to the surface, wait 24 hours and look for condensed moisture under the sheet - the inside of the sheet should be dry).

2.3.3 Steel. The first step in preparing steel for coating is solvent cleaning as described in SSPC SP 1. Cleaning methods described in SSPC SP 1 include organic solvents, vapor degreasing, immersion in appropriate solvent, use of emulsion or alkaline cleaners, and steam cleaning with or without detergents. SSPC SP 1 is specifically included as the first step in the SSPC surface preparation procedures. For large areas of uncoated steel and coated steel with badly deteriorated coatings, the preferred method of removing mill scale, rust and coatings is abrasive blasting (SSPC SP 7, SSPC SP 6, SSPC SP 10, SSPC SP 5). These methods can both clean the surface and produce a surface profile. The specific abrasive method selected depends upon the conditions of the steel, the desired coating life, the environment and the coating to be applied. If leaded paint is present, special precautions must be taken to protect workers and the environment. High-pressure water blasting, with or without injected abrasives, should be considered if dry abrasive blasting cannot be done because of environmental or worker safety restrictions. For small localized areas, other cleaning methods such as hand tool cleaning (SSPC SP 2) or power tool cleaning (SSPC SP 3 or SSPC SP 11) may be more practical.

2.3.3.1 Specific Surface Preparation Requirements for Coatings for Steel. Different types of coatings may require different levels of cleaning. Commonly agreed upon minimum requirements are listed below. However, manufacturers of some specific coatings may require or recommend a cleaner surface. Conflicts between manufacturer's written instructions (tech data sheets) and contract specifications should be avoided.

Coating	Minimum Surface Preparation
Drying Oil	SSPC SP 2 or SSPC SP 3
Alkyd	SSPC SP 6 or SSPC-SP 11
	SSPC SP 3 for limited localized areas
Asphaltic	SSPC SP 6 or SSPC SP 11
Latex	SSPC SP 6 or SSPC SP 11
Vinyl Lacquer	SSPC SP 10
Chlorinated Rubber	SSPC SP 10
Epoxy	SSPC SP 6 or SSPC SP 10
Polyurethane	SSPC SP 10
Organic Zinc	SSPC SP 6 or SSPC SP 10
Inorganic Zinc	SSPC SP 10 or SSPC SP 5

For immersion or other severe environments, the higher level of the two options should be used. Higher levels may also be used to ensure the maximum lives from coating systems.

2.3.4 Galvanized and Inorganic-Zinc Primed Steel. The recommended method of cleaning uncoated galvanized steel varies with the condition of its surface. Simple solvent (organic or detergent-based) cleaning (SSPC SP 1) is usually adequate for new galvanizing. This will remove oil applied to the galvanizing to protect it during exterior storage. If loose zinc corrosion products or coating are present on either galvanized or inorganic-zinc primed steel, they should be removed by bristle or wire brushing (SSPC SP 2 or SSPC SP 3) or water blasting. The method chosen must successfully remove the contaminants. Uniform corrosion of unpainted galvanizing may expose the brownish iron-zinc alloy. If this occurs, the surface should be painted as soon as possible. If rusting is present on older galvanized or on inorganic-zinc primed steel, remove the rust by sweep abrasive blasting (SSPC SP 7) or using power tools, such as wire brushing (SSPC SP 2, SSPC SP 3). Abrasive blasting is usually more appropriate when large areas are corroded, while the use of hand or power tools may be more appropriate when rusting is localized. For either method, the procedure should be done to minimize removal of intact galvanizing or of the inorganic zinc primer. Deteriorated coatings should also be removed using abrasive blasting or hand or power tools. When leaded-coatings are present, special worker safety and environmental precautions must be taken.

2.3.5 Aluminum and Other Soft Metals. New, clean aluminum and other soft metals may be adequately cleaned for coating by solvent cleaning (SSPC SP 1). The use of detergents may be required for removal of dirt or loose corrosion products. Abrasive blasting with plastic beads or other soft abrasives may be necessary to remove old coatings. Leaded coatings will require special worker safety and environmental precautions.

2.4 Standards for Condition of Substrates

2.4.1 Unpainted Steel. Verbal descriptions and photographic standards have been developed for stating the condition of existing steel substrates. SSPC VIS 1, Abrasive Blast Cleaned Steel (Standard Reference Photographs) illustrates and describes four conditions of uncoated structural steel. They are:

Title	Grade
Adherent mill scale	A
Rusting mill scale	B
Rusted	C
Pitted and rusted	D

Since the condition of the surface to be cleaned affects the appearance of steel after cleaning, these conditions are used in the SSPC VIS 1 cleanliness standards described below.

2.4.2 Nonferrous Unpainted Substrates. There are no standards describing the condition of other building material substrates.

2.5 Standards for Cleanliness of Substrates

2.5.1 Standards for Cleaned Steel Surfaces

2.5.1.1 SSPC and NACE Definitions and Standards. The SSPC and the NACE Standards are used most frequently for specifying degree of cleanliness of steel surfaces. SSPC has standard definitions and photographs for common methods of cleaning (SSPC VIS 1 and SSPC VIS 3, Power- and Hand-Tool Cleaned Steel). NACE TM0170, Surfaces of New Steel Air Blast Cleaned With Sand Abrasive; definitions and metal coupons) covers only abrasive blasting. Volume 2 of SSPC Steel Structures Painting Manual contains all the SSPC standards, as well as other useful information. For both types of standards, the definition, rather than the photograph or coupon, is legally binding. To use the SSPC or NACE standards, first determine the condition of steel that is to be blasted (e.g., Grade A, B, C, or D), since different grades of steel blasted to the same level do not look the same. After determining the condition of steel, compare the cleaned steel with the pictorial standards for that condition. The appearance of blasted steel may also depend upon the type of abrasive that is used. NACE metal coupons represent four degrees of cleanliness obtained using one of three types of abrasives - grit, sand, or shot.

2.5.1.2 Job-Prepared Standard. A job-specific standard can be prepared by blasting or otherwise cleaning a portion of the structure to a level acceptable to both contractor and contracting officer, and covering it with a clear lacquer material to protect it for the duration of the blasting. A 12-inch steel test plate can also be cleaned to an acceptable level and sealed in a water- and grease-proof bag or wrapper conforming to MIL-B-131, Barrier Materials, Water Vaporproof, Greaseproof, Flexible, Heat-Sealable.

2.5.1.3 Pictorial Standards for Previously Painted Steel. Photographic standards for painted steel are available in the Society for Naval Architects and Engineers Abrasive Blasting Guide for Aged or Coated Steel Surfaces. Pictures representing paint in an original condition and after each degree of blasting are included.

Table 3

SSPC and NACE Standards for Cleaned Steel Surfaces

Method	SSPC No.	NACE No.	Intended Use
Solvent Cleaning	SP 1		Removal of oil and grease prior to further cleaning by another method
Hand Tool	SP 2		Removal of loose mill scale, rust, and paint
Power Tool	SP 3		Faster removal of loose mill scale, rust, and coatings than hand tool cleaning
White Metal Blast	SP 5	1	Removal of visible contaminants on steel surfaces; highest level of cleaning for steel
Commercial Blast	SP 6	3	Removal of all visible contaminants except that one third of a steel surface may have shadows, streaks, or stains
Brush-off Blast	SP 7	4	Removal of loose mill scale, rust, and paint (loose paint can be removed with dull putty knife)
Pickling	SP 8		Removal of mill scale and rust from steel
Near-white Blast	SP 10	2	Removal of visible contaminants except that 5 percent of steel surfaces may have shadows, streaks, or stains
Power Tool Cleaning	SP 11		Removal of visible contaminants (surface is comparable to SSPC SP 6, also provides profile)

2.6 Recommendations for Paint Removal. It is often necessary to remove old coatings that are peeling, checking, cracking, or the like. General recommendations for removal of paint from a variety of substrates are made in Table 4.

Table 4 Procedures for Coating Removal (IMPORTANT NOTE - Presence of Leaded Paint Will Require Environmental and Worker Safety Controls)	
Substrate	Methods
Wood	Chemical removers; heat guns or hot plates along with scraping; power sanding (must be done with caution to avoid damaging wood).
Masonry	Careful water blasting to avoid substrate damage; brush-off blasting and power tools, used with caution.
Steel	Abrasive blasting; water blasting.
Miscellaneous metals	Chemicals; brush-off blast; water blast

2.7 Methods of Surface Preparation. Information on surface preparation methods and procedures are presented to help select appropriate general procedures and to inspect surface preparation jobs. It is not intended to be a complete source of information for those doing the work.

2.7.1 Abrasive Blasting. Abrasive blast cleaning is most often associated with cleaning painted and unpainted steel. It may also be used with care to prepare concrete and masonry surfaces and to clean and roughen existing coatings for painting. Abrasive blasting is an impact cleaning method. High-velocity abrasive particles driven by air, water, or centrifugal force impact the surface to remove rust, mill scale, and old paint from the surfaces. Abrasive cleaning does not remove oil or grease. If the surface to be abrasive blasted is painted with leaded paint, additional controls must be employed to minimize hazards to workers and the surrounding environment. There are four degrees of cleanliness of blast cleaning designated by the SSPC and the NACE for steel substrates. These designations are white metal, near-white metal, commercial, and brush-off. The degree of cleanliness obtained in abrasive blasting depends on the type of abrasive, the force with which the abrasive particles hits the surface, and the dwell time.

2.7.1.1 Types of Abrasive Blasting

a) Air (Conventional). In conventional abrasive blasting, dry abrasive is propelled against the surface to be cleaned so that rust, contaminates, and old paint are removed by the impact of the abrasive particles. The surface must be cleaned of blasting residue before painting. This is usually done by blowing clean air across the surfaces. Special care must be taken to ensure that horizontal or other obstructed areas are thoroughly cleaned. Uncontrolled abrasive blasting is restricted in most locations because of environmental regulations. Consult the local industrial hygiene or environmental office for regulations governing local actions. Procedures for containment of blasting debris are being used for paint removal from industrial and other structures. The SSPC has developed a guide (SSPC Guide 6I) for selecting containment procedures depending upon the degree of containment desired. The amount of debris generated can be reduced by recycling the abrasive. Recycling systems separate the paint waste from the abrasive.

b) Wet. Wet-abrasive blasting is used to control the amount of airborne dust. There are two general types of wet abrasive blasting. In one, water is injected near the nozzle exit into the stream of abrasive. In the other, water is added to the abrasive at the control unit upstream of the nozzle and the mixture of air, water, and sand is propelled through the hose to the nozzle. For both types of wet-blasting, the water may contain a corrosion inhibitor. Inhibitors are generally sodium, potassium, or ammonium nitrites, phosphates or dichromates. Inhibitors must be chosen to be compatible with the primer that will be used. After wet blasting, the surface must be rinsed free of spent abrasive. (The rinse water should also contain a rust inhibitor when the blasting water does.) Rinsing can be a problem if the structure contains a large number of ledges formed by upturned angles or horizontal girders since water, abrasives, and debris tend to collect in these areas. The surface must be completely dry before coating. When leaded paint is present, the water and other debris must be contained and disposed of properly. This waste may be classified as a hazardous waste under Federal and local regulations, and must be handled properly.

c) Vacuum. Vacuum blasting systems collect the spent abrasives and removed material, immediately adjacent to the point of impact by means of a vacuum line and shroud surrounding the blasting nozzle. Abrasives are usually recycled. Production is slower than open blasting and may be difficult on irregularly shaped surfaces, although shrouds are available for non-flat surfaces. The amount of debris entering the air and the amount of cleanup is kept to a minimum if the work is done properly (e.g., the shroud is kept against the surface). This procedure is often used in areas where debris from open air blasting or wet blasting cannot be tolerated.

Table 5
Procedures for Coating Removal
(IMPORTANT NOTE - Presence of Leaded Paint Will Require Environmental and Worker Safety Controls)

Substrate	Methods
Wood	Chemical removers; heat guns or hot plates along with scraping; power sanding (must be done with caution to avoid damaging wood).
Masonry	Careful water blasting to avoid substrate damage; brush-off blasting and power tools, used with caution.
Steel	Abrasive blasting; water blasting.
Miscellaneous metals	Chemicals; brush-off blast; water blast

d) Centrifugal. Cleaning by centrifugal blasting is achieved by using machines with motor-driven bladed wheels to hurl abrasives at a high speed against the surface to be cleaned. Advantages over conventional blasting include savings in time, labor, energy, and abrasive; achieving a cleaner, more uniform surface; and better environmental control. Disadvantages of centrifugal blasting include the difficulty of using it in the field, especially over uneven surfaces, although portable systems have been developed for cleaning structures such as ship hulls and storage tanks. Robots may be used to guide the equipment. In many cases, the abrasive used is reclaimed and used again.

2.7.1.2 Conventional Abrasive Blasting Equipment. Components of dry abrasive blasting equipment are air supply, air hose and couplings, abrasive blast machines, abrasive blast hose and couplings, nozzles, operator equipment, and oil and moisture separators. A brief description of each component follows:

a) Air Supply. The continuous and constant supply of an airstream of high pressure and volume is one of the most critical parts of efficient blasting operations. Thus, the air supply (compressor) must be of sufficient capacity. Insufficient air supply results in excessive abrasive use and slower cleaning rates. The compressor works by taking in, filtering, and compressing a large volume of air by rotary or piston action and then releasing it via the air hose into the blasting machine. The capacity of a compressor is expressed in volume of air moved per unit time (e.g., cubic feet per minute (cfm)) and is directly related to its horsepower. The capacity required depends upon the size of the nozzle orifice and the air pressure at the nozzle. For example, a flow of 170 to 250 cfm at a nozzle pressure of 90 to 100 psi is necessary when using a nozzle with a 3/8 to 7/16 inch orifice. This typically can be achieved with a 45 to 60 horsepower engine.

b) Air-Supply Hose. The air-supply hose delivers air from the compressor to the blasting machine. Usually the internal diameter should be three to four times the size of the nozzle orifice. The length of the hose should be as short as practical because airflow through a hose creates friction and causes a pressure drop. For this reason, lines over 100 feet long generally have internal diameters four times that of the nozzle orifice.

c) Blasting Machine. Blasting machines or "sand pots" are the containers which hold the abrasives. The capacity of blasting machines varies from 50 pounds to several tons of abrasive material. The blasting machine should be sized to maintain an adequate volume of abrasive for the nozzles.

d) Abrasive Blasting Hose. The abrasive blasting hose carries the air and abrasive from the pot to the nozzle. It must be sturdy, flexible, and constructed or treated to prevent electrical shock. It should also be three to four times the size of the nozzle orifice, except near the nozzle end where a smaller diameter hose is attached.

e) Nozzles. Nozzles are available in a great variety of shapes, sizes, and designs. The choice is made on the basis of the surface to be cleaned and the size of the compressor. The Venturi design (that is, large throat converging to the orifice and then diverging to the outlet, Figure 3) provides increased speed of abrasive particles through the nozzle as compared with a straight bore nozzle. Thus, the rate of cleaning is also increased. Nozzles are available with a variety of lengths, orifice sizes, and lining materials. The life of a nozzle depends on factors such as the lining material and the abrasives and varies from 2 to 1500 hours. Nozzles should be inspected regularly for orifice size and wear. Worn nozzles result in poor cleaning patterns and efficiency.

f) Oil/Moisture Separators. Oils used in the compressor could contaminate the air supply to the nozzles. To combat this, oil/moisture separators are installed at the blast machine. The separators require periodic draining and routine replacement of filters. Contamination of the air supply can be detected by a simple blotter test. In this test, a plain, white blotter is held 24 inches in front of the nozzle with only the air flowing (i.e., the abrasive flow is turned off) for 1 to 2 minutes. If stains appear on the blotter, the air supply is contaminated and corrective action is required. ASTM D 4285, Indicating Oil or Water in Compressed Air describes the testing procedure in more detail.

g) Operators Equipment. The operator's equipment includes a protective helmet and suit. The helmet must be air-fed when blasting is done in confined or congested areas. To be effective it must furnish respirable air to the operator at a low noise level, protect the operator from rebounding abrasive particles, provide clear vision to the operator, and be comfortable and not restrictive. Air-fed helmets must have National Institute of Safety and Hygiene (NIOSH) approval.

h) Wet Blasting. In addition to equipment needed for dry abrasive blasting, metering, delivery, and monitoring devices for water are needed.

i) Vacuum Blasting. Although there are many designs for vacuum blasting equipment, all systems have a head containing a blast nozzle, surrounded by a shroud connected to a vacuum system, and a collection chamber for debris.

j) Centrifugal Blasting. In centrifugal blasting, abrasive is hurled by wheels instead of being air-driven. This type of blasting is often used in shop work. Portable devices have been developed for use on flat surfaces. Abrasive is contained and usually recycled.

2.7.1.3 Abrasive Properties. The SSPC has a specification for mineral and slag abrasive, SSPC AB 1, Mineral and Slag Abrasives. Abrasives covered by the specification are intended primarily for one-time use without recycling. The specification has requirements for specific gravity, hardness, weight change on ignition, water soluble contaminant, moisture content and oil content. These and other properties of abrasives are discussed below:

a) Size. Abrasive size is a dominant factor in determining the rate of cleaning and the profile obtained. A large abrasive particle will cut deeper than a small one of the same shape and composition, however, a greater cleaning rate is generally achieved with smaller-sized particles. Thus, a mix is generally used.

b) Shape. The shape and size of abrasive particles determine the surface profile obtained from blasting. Round particles, such as shot, produce a shallow, wavy profile. Grit, which is angular, produces a jagged finish. Usually a jagged finish is preferred for coating adhesion. Round particles are well suited for removal of brittle contaminants like mill scale and are also used when little or no change in surface configuration is permitted. Sand and slag, which are semi-angular, produce a profile that is somewhere between that of shot and grit. Currently, sand is used much less than other abrasives because of health and breakdown factors.

c) Hardness. Hard abrasives usually cut deeper and faster than soft abrasives. Hence, hard abrasives are best suited for blast cleaning jobs where the objective is to remove surface coatings. Soft abrasives, such as walnut hulls, can remove light contaminants without disturbing a metal substrate or, in some cases, the existing coating system.

d) Specific Gravity. Generally the more dense a particle, the more effective it is as an abrasive. This is because it takes a certain amount of kinetic energy to remove contaminants from the surface and the kinetic energy of an abrasive particle is directly related to its density (specific gravity).

e) Breakdown Characteristics. Abrasive particles striking the surface at high speeds are themselves damaged. The way in which they fracture (breakdown) and/or in which they change their shape and size is called their breakdown characteristic. An excessive breakdown rate results in a significant increase in dusting, requires extra surface cleaning for removal of breakdown deposits, and limits the number of times the abrasive can be reused.

f) Water-Soluble Contaminants. ASTM D 4940, Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives describes a conductivity test for determining the level of contamination of metallic, oxide, slags, and synthetic abrasives by water-soluble salts. SSPC AB 1 requires that the conductivity of the test solution be below 100 microsiemens.

2.7.1.4 Abrasive Types. Abrasives fall into seven general categories: metallic, natural oxides, synthetic, slags, cellulose (such as walnut hulls), dry ice pellets (carbon dioxide), sodium bicarbonate, and sponge.

a) Metallic. Steel shot and grit are the most commonly used metallic abrasives. Metallic abrasives are used to remove mill scale, rust, and old paint and provide a suitable anchor pattern. The advantages of metallic abrasives include longer useful life (can be recycled many times), greater impact energy for given particle size, reduced dust formation during blasting, and minimal embedment of abrasive particles. The disadvantages include blast cleaning equipment must be capable of recycling, abrasives must be kept dry to prevent corrosion, and the impact of steel shot on metal surfaces may cause formation of hackles on the surface. These hackles are relatively long slivers of metal and must be removed mechanically by sanding or grinding before coating to prevent pinpoint corrosion through the paint film.

b) Natural Oxides. Silica is the most widely used natural oxide because it is readily available, low in cost, and effective. Sand particles range from sharply angular to almost spherical, depending on the source. OSHA and EPA regulations have restricted the use of sand in many areas. Non-silica sands (generally termed "heavy mineral" sands) are also being used for blast cleaning. However, they are generally of finer particle size than silica sand and are usually more effectively used for cleaning new steel than for maintenance applications.

c) Synthetics. Aluminum oxide and silicon carbide are nonmetallic abrasives with cleaning properties similar to the metallics and without the problem of rusting. They are very hard, fast-cutting and low-dusting, but they are costly and must be recycled for economical use. They are often used to clean hard, high tensile strength metals.

d) Slags. The most commonly used slags for abrasives are by-products from metal smelting (metal slags) and electric power generation (boiler slags). Slags are generally hard, glassy, homogeneous mixtures of various oxides. They usually have an angular shape, a high breakdown rate, and are not suitable for recycling.

e) Cellulose Type. Cellulose type abrasives, such as walnut shells and corncobs, are soft, low density materials used for cleaning of complex shaped parts and removing dirt, loose paint, or other deposits on paint films. Cellulose type abrasives will not produce a profile on a metal surface.

f) Dry Ice. Special equipment is used to convert liquid carbon dioxide into small pellets which are propelled against the surface. Since the dry ice sublimes, the abrasive leaves no residue. The method can be used to remove paint from some substrates, but not mill scale and will not produce a profile. Paint removal is slow (and very difficult from wood) and the equipment needed to carry out the blasting is expensive.

g) Sponge. Specially manufactured sponge particles, with or without impregnated hard abrasive, are propelled against the surface. Less dust is created when sponge abrasive is used as compared to expendable or recyclable abrasives. The sponge is typically recycled several times. If sponge particles with impregnated hard abrasive are used, a profile on a metal can be produced. Sponge blasting is typically slower than with conventional mineral or steel abrasives.

h) Sodium Bicarbonate. Sodium bicarbonate particles are propelled against the surface, often in conjunction with high-pressure water. This method provides a way to reduce waste if the paint chips can be separated from the water after cleaning since sodium bicarbonate is soluble in water. These particles can be used to remove paint, but not mill scale or heavy corrosion.

2.7.1.5 Selection. Selection of the proper abrasive is a critical part of achieving the desired surface preparation. Factors that influence the selection include: desired degree of cleanliness; desired profile; degree of rusting; deep pits; and kind and amount of coating present. Since obtaining the desired degree of cleanliness and profile are the main reasons for impact cleaning, they must be given priority over all other factors except environmental ones in abrasive selection.

2.7.1.6 Inspection. Abrasives must be dry and clean. It is most important that they are free of inorganic salts, oils, and other contaminants. There are only limited standard procedures for inspecting abrasives. The following general procedure is suggested:

a) Visually inspect the abrasive to ensure that it is dry,

b) Test for presence of water soluble salts by following ASTM D 4940 in which equal volumes of water and abrasive are mixed and allowed to stand for several minutes and the conductivity of the supernatant is measured using a conductivity cell and bridge,

c) Examine the supernatant of the ASTM D 4940 test for presence of an oil film.

2.7.1.7 Procedures/General Information. Good blasting procedures result in efficient and proper surface preparation. Adequate pressure at the nozzle is required for effective blasting. Other factors, such as flow of abrasive, nozzle wear, position of the nozzle with respect to the surface, and comfort of operator are also important. A well trained operator is essential to obtaining an acceptable job.

a) Handling the Nozzle. The angle between the nozzle and the surface and the distance between the nozzle and surface are important factors in determining the degree and rate of cleaning. The working angle will vary from 45 to 90 degrees depending upon the job. To remove rust and mill scale, the nozzle is usually held at an angle of between 80 and 90 degrees to the surface. This is also the preferred configuration for cleaning pitted surfaces. A slight downward angle will direct the dust away from the operator and ensure better visibility. A larger angle between nozzle and surface allows the operator to peel away heavy coats of old paint and layers of rust by forcing the blast under them. Other surface contaminants may be better removed with a cleaning angle of from 60 to 70 degrees. By varying the distance between the nozzle and the surface, the type and rate of cleaning can also be varied. The closer the nozzle is to the surface, the smaller the blast pattern and the more abrasive strikes it. Thus, a greater amount of energy impacts the surface per unit area than if the nozzle were held further away. A close distance may be required when removing tight scale, for example. However, a greater distance may more effectively remove old paint. Once an effective angle and distance have been determined, each pass of the nozzle should occur in a straight line to keep the angle and distance between the nozzle and the surface the same. Arcing or varying the distance from the surface will result in a nonuniform surface.

b) Rates. The rate of cleaning depends on all of the factors discussed above. Abrasive blasting of steel to a commercial degree of cleanliness (SSPC SP 6 or better) is much slower than painting. No more steel surface area should be blast cleaned at one time than can be primed the same day, since significant rusting can occur overnight. If rusting does occur, the surface must be reblasted before painting.

2.7.2 Acid Cleaning. Acid cleaning is used for cleaning efflorescence and laitance from concrete.

2.7.2.1 Concrete. Heavy efflorescence and laitance should be removed from concrete surfaces by dry brushing or cleaning prior to acid cleaning. This is to prevent dissolution of the efflorescence and subsequent movement of the salts into the concrete. Prior to application of an acid solution, heavy oil, grease, and soil deposits must also be removed. Oily dirty deposits can be removed by solvent or detergent washing. The commonly used procedure to acid clean these surfaces is to thoroughly wet the surface with clean water; uniformly apply acid solution (often a 5 to 10 percent solution of hydrochloric (muriatic) acid solution or a solution of phosphoric acid); scrub the surface with a stiff bristle brush; and immediately rinse the surface thoroughly with clean water. Measure the pH of the surface and rinse water using pH paper (ASTM D 4262, pH of Chemically Cleaned or Etched Concrete Surfaces). In general, the pH should be within one pH unit of fresh rinse water. It is essential for good paint performance that the acid be neutralized before painting. Work should be done on small areas, not greater than 4 square feet in size. This procedure or light abrasive blasting can also be used to etch the surface of very smooth concrete prior to coating. Coating adhesion on slightly rough concrete surfaces is usually much better than on smooth and (e.g., troweled) surfaces. An acid etched surface is usually roughened to a degree similar in appearance to a medium grade sandpaper. This cleaning method is described in detail in ASTM D 4260.

2.7.3 Chemical Removal of Paint. Paint strippers can be used when complete paint removal is necessary and other methods, such as abrasive blasting, cannot be used due to environmental restraints or potential damage to the substrate. Removers are selected according to the type and condition of the old coating as well as the nature of the substrate. They are available as flammable or nonflammable types and in liquid or semi-paste types. While most paint removers require scraping or other mechanical means to physically remove the softened paint, types are available that allow the loosened coating to be flushed away with steam or hot water. If paint being removed contains lead, additional environmental and worker safety precautions will be needed. Many removers contain paraffin wax to retard evaporation and this residue must be removed prior to recoating. Always follow manufacturer's recommendations. In addition, surrounding areas (including shrubs, grass, etc.) should be protected from exposure to the remover, collection of the residue will probably be required by environmental regulations. Removers are usually toxic and may cause fire hazards. Management of the waste associated with the procedure will also be necessary. Consult the local environmental and safety offices for further information.

2.7.4 Detergent Washing. Detergent washing or scrubbing is an effective way to remove soil, chalk and mildew. Detergent cleaning solutions may be applied by brush, rags, or spray. An effective solution for removal of soil and chalk is 4 ounces of trisodium phosphate, 1 ounce household detergent, and 4 quarts of water. For mildew removal, 1 part of 5 percent sodium hypochlorite solution (household bleach) is added to 3 parts of the cleaning solution used for chalk and soil removal. Of course, if there is little or no existing chalk on the surface, the cleaning solution should not contain the trisodium phosphate. Note, that sodium hypochlorite solution (household bleach) must not be added to cleaning solutions containing ammonia or other similar chemicals. Toxic fumes will be produced. Thorough rinsing with water is absolutely necessary to remove the soapy alkaline residues before recoating. To test the effectiveness of the rinse, place pH paper against the wet substrate and in the rinse water and compare the pH of the two. (Refer to ASTM D 4262 for complete description of the procedure.) The pH of the substrate should be no more than one pH unit greater than that of the rinse water.

2.7.5 Hand Tool Cleaning. Hand cleaning is usually used only for removing loosely adhering paint or rust. Any grease or oil must be removed prior to hand cleaning by solvent washing. Hand cleaning is not considered an appropriate procedure for removing tight mill scale or all traces of rust and paint. It is slow and, as such, is primarily recommended for spot cleaning in areas where deterioration is not a serious factor or in areas inaccessible to power tools. Hand tools include wire brushes, scrapers, abrasive pads, chisels, knives, and chipping hammers. SSPC SP 2 describes standard industrial hand-tool cleaning practices for steel. Since hand cleaning removes only the loosest contaminants, primers applied over hand-tool cleaned surfaces must be chosen that are capable of thoroughly wetting the surface. Paint performance applied to hand-cleaned steel surfaces is not as good as that applied over blast cleaned surfaces.

2.7.6 Heat. Electric heat guns and heat plates are used to remove heavy deposits of coatings on wood and other substrates. The gun or plate is positioned so that the coating is softened and can be removed by scraping. Production rates depend upon the thickness of the old coating and the smoothness of the substrate. There is a possibility of creating toxic fumes, or conditions in which burns are possible. The use of torches is not recommended, although they have been used to remove greasy contaminates and paints from surfaces prior to painting. This is an extremely dangerous procedure. The SSPC no longer has a surface preparation standard for flame cleaning because of the danger involved.

2.7.7 Organic Solvent Washing. Solvent cleaning is used for removing oil, grease, waxes, and other solvent-soluble matter from surfaces. VOC rules may prohibit or limit the use of solvent cleaning. The local environmental and safety office should be consulted before using or specifying solvent cleaning. Inorganic compounds, such as chlorides, sulfates, rust, and mill scale are not removed by solvent cleaning. Solvent cleaning or detergent or steam washing must precede mechanical cleaning when oil and grease are present on the surface because mechanical and blast cleaning methods do not adequately remove organic contaminants and may spread them over the surface. Before solvent washing, any soil, cement splatter, or other dry contaminants must first be removed. The procedure for solvent washing is to: wet the surface with solvent by spraying or wiping with rags wet with solvent; wipe the surface with rags; and make a final rinse with fresh solvent. Fresh solvent must be used continuously and the rags must be turned and replaced continuously. Solvents rapidly become contaminated with oils and grease since they clean by dissolving and diluting contaminants. Mineral spirits is effective in most solvent cleaning operations. SSPC SP 1 describes recommended industry practices for cleaning steel using solvents. Organic solvents pose health and safety threats and should not come into contact with the eyes or skin or be used near sparks or open flames. Disposal of solvent must be done in accordance with governing regulations. Rags must be placed in fireproof containers after use.

2.7.8 Power Tool Cleaning. Power tool cleaning can be used to remove more tightly adhering contaminants and existing paint than hand tool cleaning. Either electrical or pneumatic power is used as the energy source. Power tool cleaning is recommended when deterioration is localized, deterioration is not a serious problem, or when abrasive blasting is not possible. SSPC SP 3 and SSPC SP 11 describe the use of some of these tools for steel. In general, power tool cleaning is less economical and more time consuming than blasting for cleaning large areas. However, power tools do not leave as much residue or produce as much dust as abrasive blasting. Also, some power tools are equipped with vacuum collection devices. Power tools include sanders, grinders, wire brushes, chipping hammers, scalers, needle guns, and rotary peeners. Power tools clean by impact or abrasion or both. Near-white (i.e., rust and paint removed) steel surfaces with anchor patterns (although different than those achieved in blast cleaning) can be obtained with some power tools, as described in SSPC SP 11. Care must be taken when using wire brushes to avoid burnishing the surface and thus causing a reduced adhesion level of the primer coating. Grease and oil must be removed prior to power tool cleaning. Danger from sparks and flying particles must always be anticipated. The operator and adjacent workers must wear goggles or helmets and wear protective clothing. No flammable solvents should be used or stored in the area.

2.7.9 Steam Cleaning. A high-pressure jet of steam (about 300 degrees F, 150 psi), usually with an added alkaline cleaning compound, will remove grease, oil, and heavy dirt from surfaces by a combination of detergent action, water, heat and impact (refer to SSPC SP 1). The steam is directed through a cleaning gun against the surface to be cleaned. The pressure is adjusted to minimize spraying time. Any alkaline residue remaining on the surface after the cleaning operation must be removed by thorough rinsing with fresh water. Alkali cleaners used in steam cleaning may attack aluminum and zinc alloys and should not be used on these substrates. Steam cleaning may cause old paints to swell and blister. Thus, when steam cleaning previously painted surfaces, the cleaning procedure should first be tested in a small area to assess the effect on the old paint. Steam cleaning equipment is usually portable and is one of two designs. With one type of equipment, concentrated cleaning solution is mixed with water, fed through a heating unit so that it is partially vaporized, pressurized, and forced through a nozzle. With another type of equipment, sometimes called a hydro-steam unit, steam from an external source is mixed with the cleaning solution in the equipment or in the nozzle of the cleaning gun. The shape of the nozzle is chosen according to the contour of the surface being cleaned. Steam cleaning is dangerous and extreme caution should be exercised with the equipment. A dead man valve must be included in the equipment and the operator must have sound, safe footing. Workers engaged in steam cleaning operations must be protected from possible burns and chemical injury to the eyes and skin by protective clothing, face shields, and the like.

2.7.10 Water Blast Cleaning. Water blast cleaning uses a high-pressure water stream to remove lightly adhering surface contaminants. Selection of water pressure and temperature and addition of a detergent depend on the type of cleaning desired. Low pressure - up to 2000 psi - (sometimes called "power washing") is effective in removing dirt, mildew, loose paint, and chalk from surfaces. It is commonly used on metal substrates and generally does little or no damage to wood, masonry, or concrete substrates. For removing loose flaky rust and mill scale from steel, water pressures as high as 10,000 psi or more and volumes of water to 10 gallons per minute are used. However, water blasting without an added abrasive does not provide a profile. By introducing abrasives into the water stream, the cleaning process becomes faster and an anchor pattern is produced. Hydroblasting at high pressures can be dangerous and extreme caution should be exercised with the equipment. A dead man valve must be included in the equipment and the operator must have sound, safe footing. He should wear a rain suit, face shield, hearing protection, and gloves. Additional safety equipment may be needed.

2.7.10.1 Equipment. The basic water blasting unit (without injection of an abrasive) consists of an engine-driven pump, inlet water filter, pressure gauge, hydraulic hose, gun, and nozzle combination. As with the equipment for abrasive blasting, the gun must be equipped with a "fail-safe" valve so that the pressure is relieved when the operator releases the trigger. Nozzle orifices are either round or flat. The selection depends on the shape of the surface to be cleaned. Flat orifices are usually used on large flat surfaces. Nozzles should be held about 3 inches from the surface for most effective cleaning.

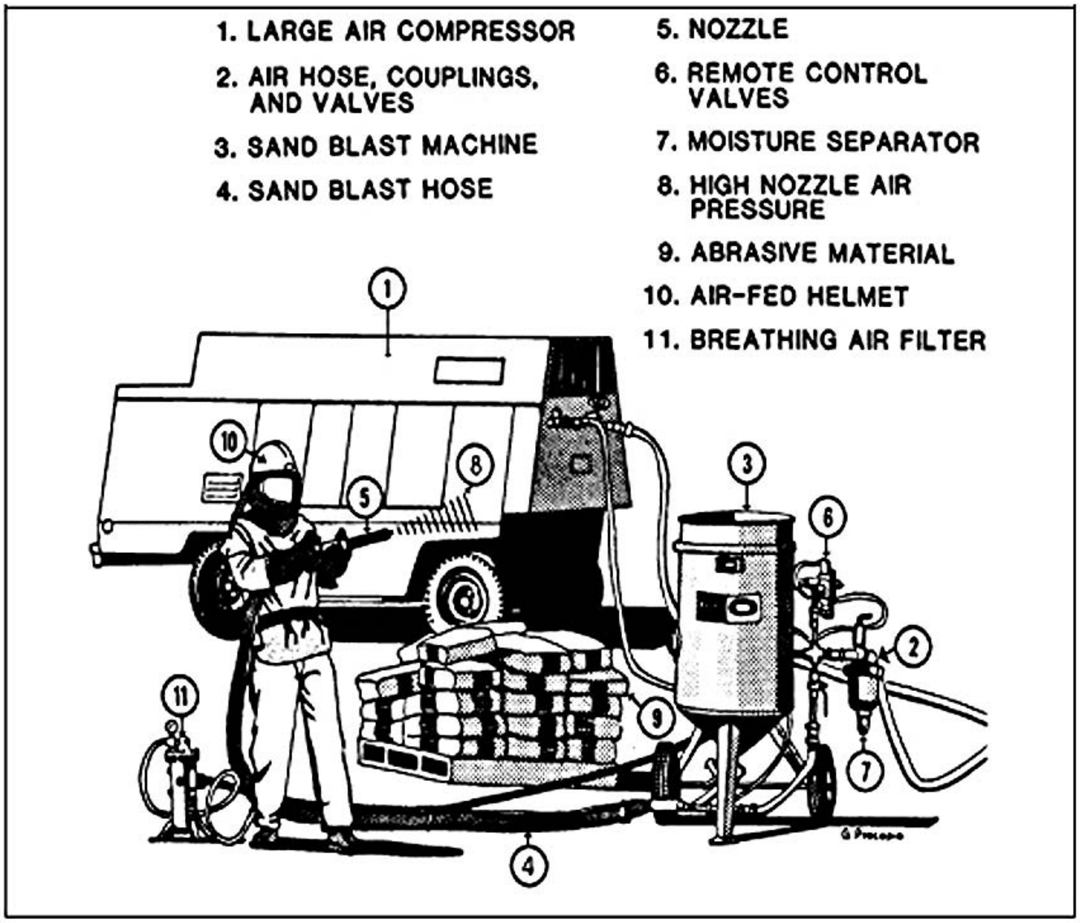

Figure 1
Schematic Drawing Illustrating Components of Conventional Abrasive Blasting Equipment

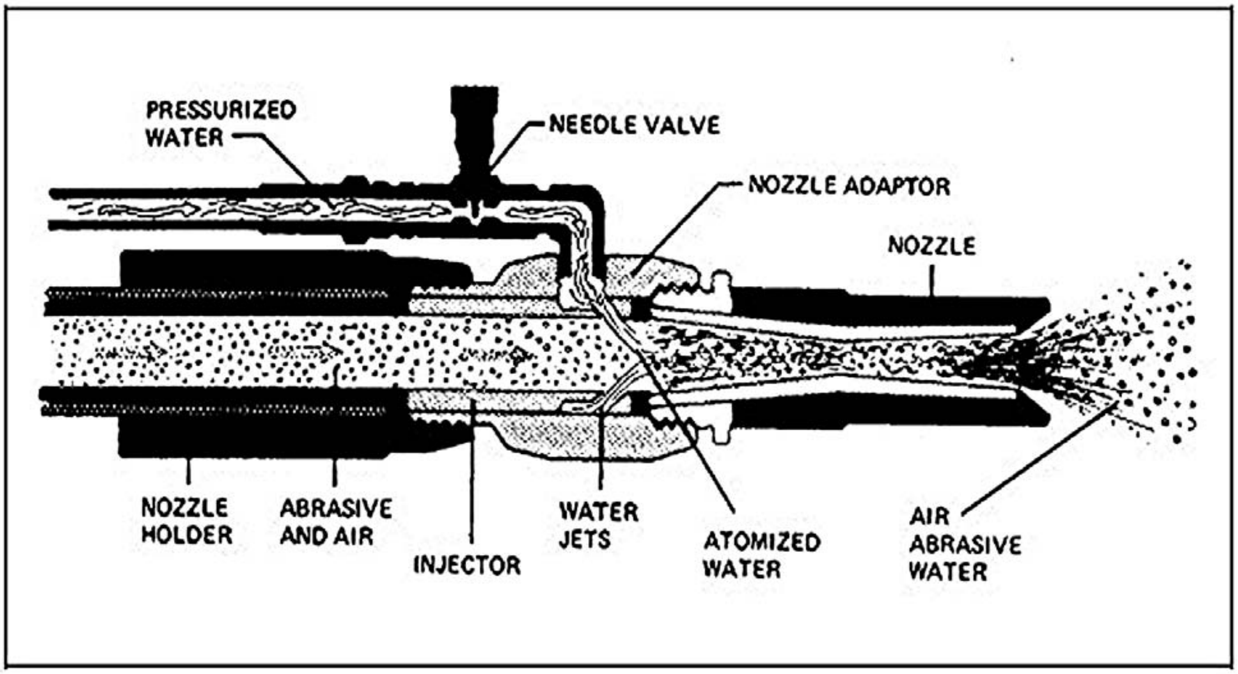

Figure 2
Schematic Drawing of Cross Section of Typical Water-Injected Wet Abrasive Blasting Nozzle

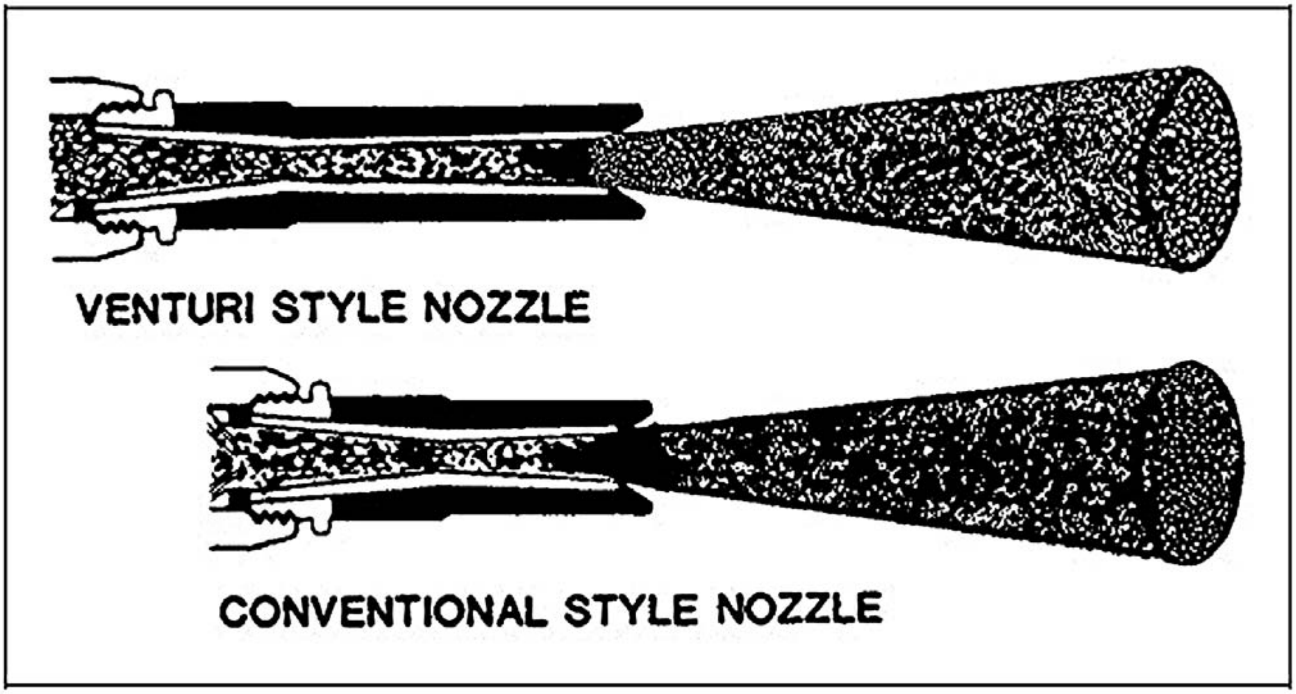

Figure 3
Cross-Sectional Drawing of Nozzles

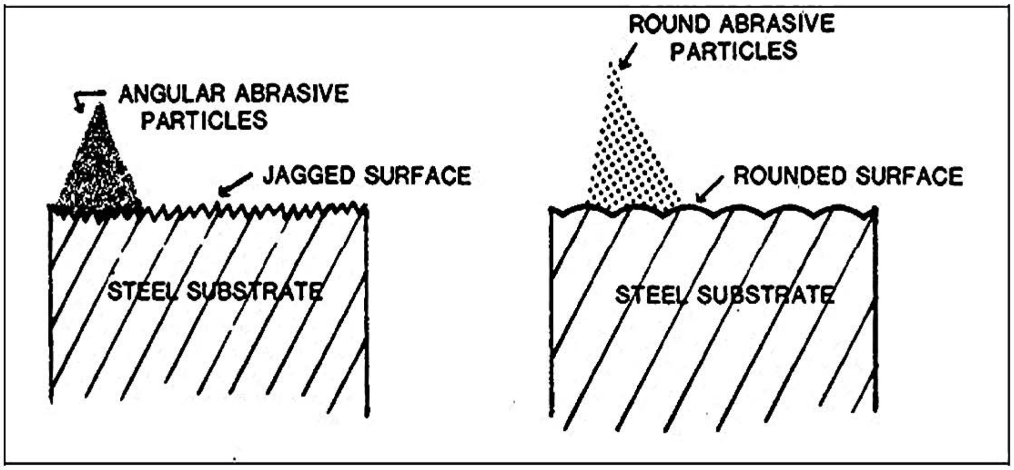

Figure 4
Drawing Illustrating Effect of Shape of Abrasive Particle on Contour of Blast-Cleaned Metallic Substrate

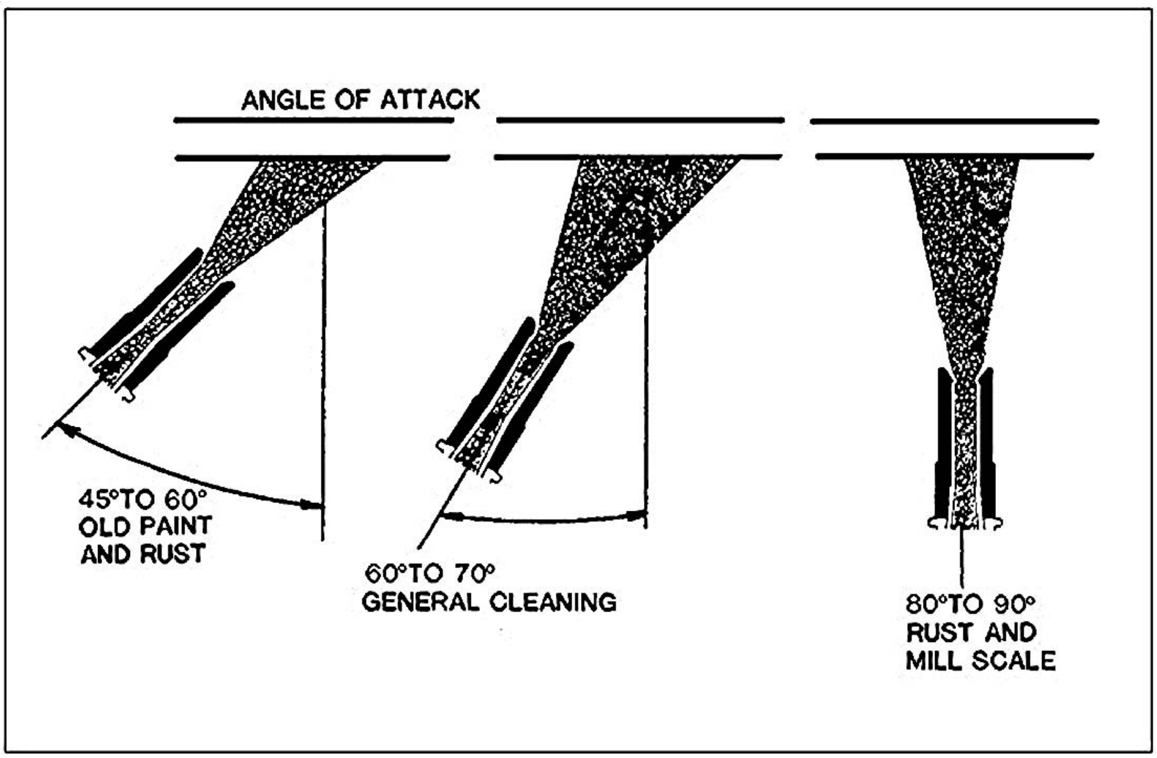

Figure 5
Schematic Illustrating Typical Cleaning Angles for Various Surface Conditions

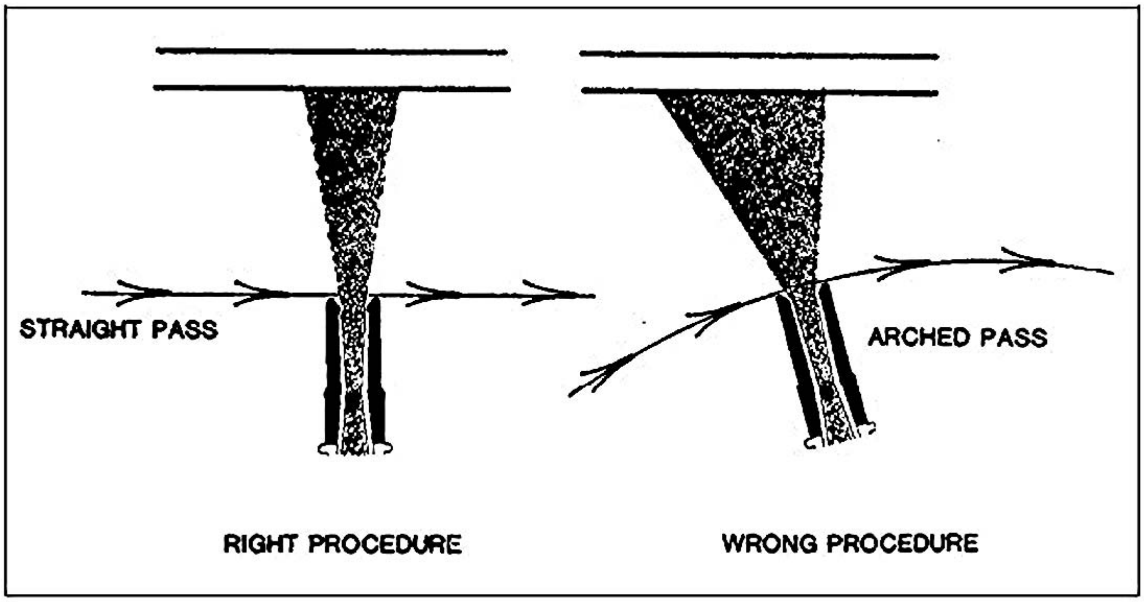

Figure 6
Illustration of Proper Stroke Pattern for Blast Cleaning