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Surface Preparation and Coating Handbook

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

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Surface Preparation & Coatings Handbook

Prepared for the Naval Shipbuilding Research Program - Project 3-91-3

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1. SURFACE PREPARATION

1.1 Introduction - What is Surface Preparation?

Surface preparation is the most important factor in coating performance. It removes contaminants from, and provides a profile on a surface before painting.

Contaminants may range from oil and grease to oxide products like millscale or rust. Surface profile is needed to provide a mechanical "anchor" for the paint. The conditions of service for a ship are severe and require the best possible protection. This level of protection and coating performance is given by coatings applied over the best surface preparation.

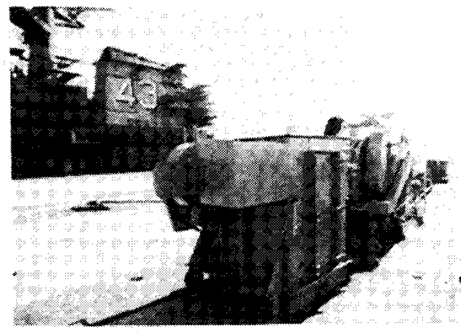


Figure 1•1:Typical Surface Preparation on Board a Vessel

This chapter covers many aspects of industrial applications of mechanical surface preparation. The chapter begins by describing the standards used for defining a surface finish. Surface preparation methods are then summarized allowing for environmental regulations.

1.2 Surface Preparation Standards

Many organizations from several countries have issued surface preparation standards. Standards can be written or visual. Sometimes a standard can have both written and visual parts. Standards will not tell you exactly how your finished surface will appear. Standards can tell you if you have met a specified level of cleaning. Two surfaces may be cleaned to the same level but appear very different from each other. The actual appearance of the finished surface depends on several factors. These include the original surface condition, the method of surface preparation and the quality of finish asked of you.

1.2.1 Written Surface Preparation Standards

In the United States both the U.S. military and various standards setting bodies issue written standards for surface preparation. Standards important to the U.S. shipbuilding industry include the following.

1.2.1.1 Steel Structures Painting Council

SSPC-SP 1, "Solvent Cleaning"
SSPC-SP 2, "Hand Tool Cleaning"
SSPC-SP 3, "Power Tool Cleaning"
SSPC-SP 11, "Power Tool Cleaning to Bare Metal"
SSPC-SP 7, "Brush-Off Blast Cleaning"
SSPC-SP 6, "Commercial Blast Cleaning"
SSPC-SP 10, "Near-White Metal Blast Cleaning"
SSPC-SP 5, "White Metal Blast Cleaning"

These standards are listed in approximate order of cleanliness, from worst to best in two categories, cleaning with tools and abrasive blast cleaning. All the listed specifications are available from:
Steel Structures Painting Council
4516 Henry Street, Suite 301
Pittsburgh, PA 15213-2786
(412)-687-1113

1.2.1.2 National Association of Corrosion Engineers
NACE Surface Preparation Grade 4 (Brush-Off)
NACE Surface Preparation Grade 3 (Commercial)
NACE Surface Preparation Grade 2 (Near-White)
NACE Surface Preparation Grade 1 (White)

These specifications are available from
NACE International
P.O. Box 218340
Houston, TX 77218-8340
(713) 492-0535

The SSPC and NACE are working to make joint abrasive blasting standards.

1.2.1.3 U.S. Government Specifications
STD ITEM 009-32
Federal Specification TT-490, "Cleaning Methods and Pretreatment of Ferrous Surfaces for Organic Coatings,"
U. S. Department of the Navy, Naval Sea Systems Command: Chapter 631, "Preservation of Ships in Service (Surface Preparation Painting) NAVSEA-S9086-VD-STM-000C/H-631, "

1.2.2 Visual Standards
Visual standards are reference documents. By agreement with the contractor and supplier they can be a part of the specification. Each of the visual standards is unique.

1.2.2.1 Steel Structures Painting Council
SSPC-Vis 1-89, "Visual Standard for Abrasive Blast Cleaned Steel"

1.2.2.2 National Association of Corrosion Engineers
NACE standards' TM-01-70 and TM-01-75

1.2.2.3 International Standards Organization
ISO 8501-1: l988/SIS SS 05 59 00

Figure 1•2: Visual Standards are used to Check Preparation Work - Shown is SSPC-VIS 1-89

The NACE standards use small pieces of blast cleaned steel to show normal finishes typical of NACE Grades of cleaning: 1 (White); 2 (Near White); 3 (Commercial), and; 4 (Brush-Off). The metal coupons show surfaces cleaned with mineral abrasives, (TM-01-70), and metallic abrasives, (TM-01-75). The coupons are part of the standards for the cleaning specifications. NACE visual comparators match the finish defined in both NACE and SSPC written standards for abrasive blast cleaning for new steel surfaces only.

The ISO standards use transparency photographs. The photographs accompany the written word. It is the written word that defines the finished condition. Currently the ISO standards do not match those of either SSPC or NACE for abrasive blast cleaned surfaces. The ISO standards have photographs depicting finishes achieved using hand or power tool cleaning and flame cleaning.

The SSPC visual standards are photographs that depict all the levels of abrasive blast cleaning defined in the SSPC specifications. SSPC visual standards accompany the SSPC specifications. SSPC-Vis 1-89 can help define the quality of all abrasive blasting surface preparation operations. The main photographs in SSPC-Vis 1-89 show steel cleaned by a mineral sand. Additional photographs show the different appearance of steel surfaces when cleaned with abrasives other than sand.

The SSPC and ISO visual standards depict finish conditions achieved by cleaning four original surface conditions. The four original surfaces are:

Rust Grade A - Defined as a steel surface completely covered with adherent mill scale, little or no visible rust.

Rust Grade B - Defined as a steel surface covered with both mill scale and rust.

Rust Grade C - Defined as a steel surface completely covered with rust, little or no visible pitting.

Rust Grade D - Defined as a steel surface completely covered with rust, visible pitting.

Only the SSPC standards follow the original surface through the various levels of blast cleaning. The ISO standard uses the same photographs for commercial, near-white and white metal cleaning whatever the original condition.

1.3 Surface Preparation Techniques

1.3.1 General Standards forAbrasive Cleaning Methods

1.3.1.1 Standards for Abrasives

Society of Automotive Engineers

SAE J1993 CAST STEEL GRIT: for information on composition and shape.

SAE J444a CAST SHOT AND GRIT SIZE SPECIFICATIONS FOR PEENING AND CLEANING - SAE Recommended Practice*

SAE J827-Cast Steel Shot: for information on Composition and Shapes.

SAE J445-Metallic Shot and Grit Mechanical Testing: for information on Shot Quality Determination.

Steel Structures Painting Council

SSPC-AB 1, "MINERAL AND SLAG ABRASIVES.": for information on abrasive quality,, size, and silica content.

Military Specifications

MIL- S -22262 Specification for Abrasives

ASTM Specifications

E 11 Specification for Wire-Cloth Sieves for Testing Purposes, for methods of deciding the size ranges of an abrasive working mix.

1.4 Methods for Getting to a Finished Condition

1.4.1 What is Solvent Cleaning?

When required, surface preparation begins with solvent cleaning. Solvent cleaning removes oil, grease, dirt, soil, drawing compounds, and other similar organic contaminants. This is the most common type of solvent cleaning and is briefly described in the SSPC-SP 1 "Solvent Cleaning" specification. Inorganic compounds such as chlorides, sulfates, weld flux, rust, and millscale are not removed by an organic solvent.

Solvent cleaning is also used to describe the process by which alkaline detergents are used to remove organic and inorganic soils

from a surface. This still leaves behind salts, rust and millscale. Alkaline cleaning compounds cover a very wide range in composition and method of use. Detailed discussion is given in Volume 1 of the Steel Structures Painting Manual along with suitable solvents. It is important that residues of alkaline compounds do not remain on the surface after cleaning. Use litmus paper or universal indicating paper to test the finished surface. The surface should be neutral or no more alkaline than the rinse water if used.
In a broader sense, solvent cleaning can include the use of solvent based paint removers or alkaline paint strippers.

The NSTM Chapter 631 has comprehensive details of solvent cleaning on Navy vessels. Cleaners to use on nonferrous metal surfaces receive special attention in the Ship Training Manual. Common nonferrous metals on ships include aluminum, bronze or galvanized metal. Many solvent or chemical cleaners used for steel surfaces will react with these alloys. Never use alkaline cleaners, chlorinated solvents and the like on nonferrous surfaces.

Many solvents used to degrease ferrous metals are hazardous. You must take care when using solvents for solvent cleaning. Follow safety precautions regarding ventilation, smoking, static electricity, respirators, eye protection, or skin contact. Also solvent waste may be hazardous and must be disposed of properly.

1.4.2 Grades of Abrasive Blast Cleaning

There are several grades of abrasive blast cleaning, these are briefly described below. The different grades are presented in order of increasing cleanliness. A simple rule-of-thumb is that cleaning should be at a minimum level of SSPC-SP 10 "Near White Metal Blast Cleaning" if the coating is to withstand immersion service. The level of cleaning for atmospheric service will depend on the original state of the coating. For total coating removal the minimum level will be SSPC-SP 6 "Commercial Blast Cleaning."

SSPC-SP 7, "BRUSH-OFF BLAST CLEANING": Brush-Off Blast Cleaning is suitable for mild surroundings. Brush-Off Blast Cleaning permits tight mill scale, paint, and minor amounts of tight rust and other foreign matter to remain on the surface. The surface resulting from this method of surface preparation should be free of all loose mill scale and loose rust. The small amount of rust remaining should be an integral part of the surface. All remaining paint and mill scale should be tight and the surface sufficiently abraded to provide a good anchor for paint. The low cost of this method may result in economical protection in mild environments.

SSPC-SP 6, "COMMERCIAL BLAST CLEANING": Commercial Blast Cleaning should be employed for all general purposes where a cleaner surface is required. Commercial Blast Cleaning is often sufficient in milder shipboard environments. It will remove all rust, mill scale, and other detrimental matter from the surface, but will allow a great deal of staining from rust or mill scale to remain. The amount of staining should be less than one-third of each square inch of prepared surface. The surface will not necessarily be uniform in color, nor will it be uniformly clean. An advantage of Commercial Blast Cleaning lies in its lower cost while still providing satisfactory surface preparation.

In maintenance painting define the surface areas to be blast cleaned and quantity of spot cleaning required. Do no remove sound, adherent, old paint unless it is excessively thick, inflexible, or incompatible with the new paint system. SSPC-PA 1, "Shop, Field, and Maintenance Painting," and SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," cover surface preparation for maintenance painting.

SSPC-SP 10, "NEAR-WHITE BLAST CLEANING":

Near-White Blast Cleaning should be employed for all general purposes where a high degree of blast cleaning is required. It will remove all rust, mill scale, and other detrimental matter from the surface but permits streaks and stains to remain. The surface will not necessarily be completely uniform in color, nor uniformly clean. However, shadows, streaks, or discolorations, should be slight and distributed uniformly over the surface--not concentrated in spots or areas. Stains should not cover more than 5 % of each square inch of the surface.

The advantage of Near-White Blast Cleaning lies in the lower cost for surface preparation that is satisfactory for all but the most severe conditions. In exposures involving a combination of high humidity, chemical atmosphere, marine, or other corrosive environment, the use of White Metal Blast Cleaning is too expensive. Removing the last vestiges of streaks and shadows in White Metal Blast Cleaning entails a lot of work. But there are many applications in which some stains are tolerable without appreciable loss in coating life. This showed the need for a grade of blast cleaning better than Commercial but less than White Metal Blast Cleaning. The Near-White Blast Cleaning specification fills this need.

SSPC-SP 5, "WHITE METAL BLAST CLEANING": White Metal Blast Cleaning is generally used for exposures in very corrosive atmospheres and for immersion service. These cases require the highest degree of cleaning and justify a high surface preparation cost.

Blast cleaning to white metal removes all rust, mill scale, and foreign matter or contaminants from the surface. White Metal Blast Cleaning is too high a quality for ordinary atmospheres and general use.

Achieving this grade of blast cleaning without rust-back can be difficult. This is the case in the environments where it is most needed, for example in humid chemical environments. White Metal Blast Cleaning needs conditions when no contamination or rusting can occur, and when prompt painting is possible. A good rule is that no more metal should be prepared for painting than one can coat in the same day.

1.5 Abrasive Blasting with Recyclable Abrasives

Abrasive blasting is the most common method for removing existing paint, rust or millscale. The way in which you do abrasive blasting has changed in recent years. In the past abrasive blasting was

often done without trying to limit waste or debris. Abrasives were disposable and were typically mineral sands or by-products such as coal slag or copper or nickel slag. The most important thing was getting to the correct surface finish and getting there quickly.
The situation is very different today. Generating large amounts of debris is not a good idea. Shipyards have been looking at ways to reduce the volume of debris made by surface preparation. This is called waste minimization.

1.6 Waste Minimization & Recyclable Abrasives

1.6.1 What is a Recyclable Abrasive ?

Waste volumes can be reduced by using recyclable abrasives. A recyclable abrasive is one that does not break down with limited use. It can be recovered and good abrasive separated fromthe dust and other products from the blasting process. Not all abrasives are easy to recycle. Traditional abrasive choices like copper slag will probably only be usable twice before breaking down to dust. The most widely used recyclable abrasive is steel. While some slags, sands, almondite garnet and aluminum oxide can be reused several times you can recycle steel fifty times or more.

1.6.2 Using Recyclable Abrasives

There are some important factors to be aware with recycled abrasives. Some factors to note are: the abrasive working mix, shape, dryness and purity. Check the recyled abrasive for these factors, they can help make recycled abrasive use more effective.

1.6.2.1 Recycled Abrasive & Working Mix

All abrasives are supplied as, or develop through use, a working mix. A woking mix is a distribution of particle sizes that maximizes the production rate and gives a correct surface profile. As the abrasive is used it breaks down to finer particles. Any recycled abrasive can becomes too fine to be effective. If this happens add enough make-up abrasive to maintain the working mix sizes and total volume. You can estimate the number of cycles a pot of abrasive can be put through from the amount of make-up abrasive added.

1.6.2.2 Recycled Abrasive & Particle Shape

With the exception of steel shot, most recycled abrasives will have a sharp cutting edge. Steel grit changes shape with reuse, it can become more rounded. This can reduce the "cutting edge" of the working mix. Normal make-up additions will maintain the cutting power of the abrasive work mix. Even so, at some point the entire mix will need to be changed. For steel grit, guidance on work mix and shape maintenance can be found in standard SAE J1993. For shop cleaning of steel a typical work mix ratio for a shot grit mix is 9:1.

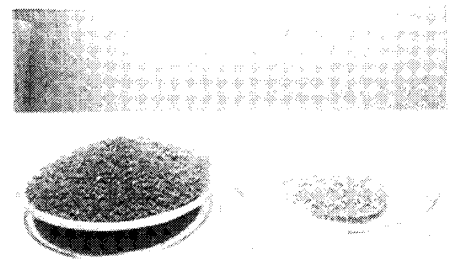


Figure 1•3:Typical 9:1 Ratio Between Shot & Grit in Recyclable Metallic Grit Work Mix

1.6.2.3 Recycled Abrasive & Condition

The physical condition of the recycled abrasive is important. The abrasive mix must be clean, dry, and free of dust and fines. Moisture in the abrasive can cause problems. Moist steel abrasive can become one solid piece. If the reused abrasive has too large an amount of dust or fines in it then reduced visibility can result during blasting work. For Navy work you may have to keep the recycled abrasive in a condition equally clean as the new abrasive. Normally cleaning abrasive before reuse depends on specialized recycling equipment. To correct any observed problems with abrasive condition requires more than adding new abrasive to a work mix. It deamnds that recycling units are kept in good operating condition.

1.6.3 Recovery & Recycling

One must capture or recover the abrasive before it can be recycled. There are three general classes of recovery process equipment. Fixed recovery equipment is used in blast and paint rooms, or with centrifugal wheel blast plate descaling lines. Portable recovery equipment has use in dry dock or hull blasting. Finally, immediate vacuum recovery of abbrasive is also available.

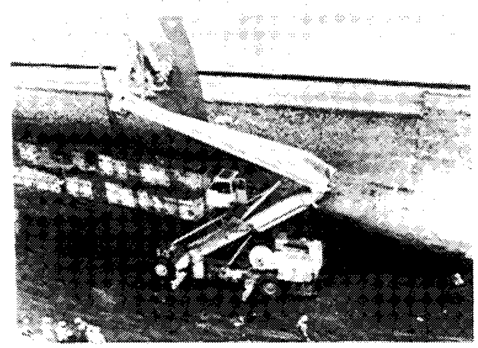


Figure 1•4:Portable Hull Wheel Blast System -an Example of Abrasive Recovery

1.6.3.1 Recovery with Fixed Facilities

Recovery of abrasive in fixed facilities is done automatically. Feed of the abrasive to the cleaning and recyling unit is continuous.

1.6.3.2 Recovery in Dry Dock

In dry dock, or out of a blast and paint room, recovery of abrasive may only happen once per work shift. Typically the abrasive is vacuumed up intoa portable cleaning and recycling unit. Some portable equipment comes fitted with continuous abrasive recovery.

1.6.3.3 Recovery with Vacuum Blasting Equipment

Some blasting equipment can instantly vacuum the abrasive away from the surface. Vacuum blasting will do a good job recovering grit from flat surfaces. On complex surfaces, like channels or beams, vacuum blasting can lead to loss of abrasive. Because vacuum blasting nozzles have a heavy shroud around them, working with a vacuum blasting nozzle can be tiring. As a result, cleaning rates are often much lower than regular abrasive blasting.

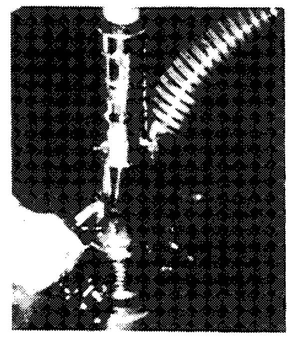


Figure 1•5: Vacuum Blasting Equipment an Example of Abrasive Recovery Methods

1.6.4 On-Site Recycling Equipment Needs

Recycling on-site requires use of a new class of equipment. The equipment screens the incoming abrasive to remove large paint

particles. It also removes lighter dust from the heavier abrasive. Some recycling systems are fitted with high efficiency particulate filters to remove very fine dust from the discharge air. Some means for controlling moisture is often built in to the equipment.
An alternative to this on-site reclaiming of abrasive is to collect the abrasive in larger amounts and send it for bulk processing off-site. The U.S. Navy has examined this approach with copper slag abrasives, claiming a 40% reuse rate. Recycling off-site is an option for other metallic or mineral abrasives having higher reuse rates.

1.7 Air Quality and Abrasive Blasting

Abrasive blasting has also changed because of local air quality regulations. State and local air quality regulations can be more restrictive than those in the Clean Air Act. One result of air quality regulations is that containment of abrasive blasting may occur.

1.7.1 Working In a Containment

Containment is often done on projects involving removal of lead-based paint or for general dust control. The state of the art in containment design is continually improving. However good the containment, you should not expect to have 100% contained blasting. Some dust will always escape. What is important is that the amount of escaped dust is below the limit set by the local air quality regulations. There are different limits for simple dust emissions and for emissions of hazardous materials, such as lead or silica dusts.
You can describe the efficiency of containment in terms of the ability to restrict emissions. To measure efficiency during a job one may use air quality monitoring equipment. This measures the number of small particles of breathable dust outside the work zone. Several air quality monitors may be needed set at different positions and distances from the work zone. The suggested positioning and use of air quality monitors are in the Code of Federal Regulations.

Aless favored option is to use visual inspection of emissions. Visual inspection relies on "Visual Determination of Opacity..., Method 9," from 40 CFR 60. This is a qualitative scale originally developed to monitor stack emissions. Experience with visual monitoring on contained blasting jobs has not been good. The scale is deemed too subjective, and the operation needs a trained observer.

1.7.2 Design Goals for a Containment

Working in a containment is not a simple matter. A containment must do three tasks. Design work and engineering are used to make sure a containment can meet each of these three tasks.

1.Prevent excessive amounts of dust and breathable particles.
2. Provide equipment for cleaning the air flowing through the containment so that the dust levels in the containment are kept to a minimum.
3. Provide sufficient recycled and make-up air flow so that the work zone in the containment meets regulations.

Too little air flow, or inefficient dust capture, can cause high levels of resbreathable dust in the containment. This would mean that a worker could not blast for very long, even if he wore the best respirator. More important, a worker could become ill. Inefficient air cleaning or containment will result in high emissions of dust. Fines or work stoppages could be one result.

1.8 Characteristics of Different Abrasives

Table 1•1, "Test Cleaning Rates with Some Abrasives," on page 16 shows the characteristics of a wide range of abrasives. Refer to Table 1•1 throughout this discussion. Typical cleaning uses are shown in Table 1•2, "Characteristics of Abrasives," on page 17. These tables also show those types of abrasive used in recycling. The most common recycled abrasives are metallic abrasives, steel shot or steel grit, aluminum oxide, and garnet. Also note the effect of different size abrasives on the anchor pattern produced. In some cases you will combine a fine abrasive with a more coarse one to scour pits on a badly rusted surface.Normally the abrasive mix used will depend on the surface profile specified. These tables can help in deciding on which abrasive to use.

Table 1•1: Test Cleaning Rates with Some Abrasives

ABRASIVE	USE RATE LBS / Sq. Ft	WORK RATE Sq. Ft. / Min.	COMMENTS
Silica Sand 16/ 40 Mesh	2.6	4.75	1.5 Mil Etch Dusty
* Garnet 36 Grit	*3.6	3.55	1.5 Mil Etch – Very little dust reusable
* Aluminum Oxide 36 Grit	*3.1	4.58	1.5 Mil Etch – Very little dust reusable
*G-40 Steel Grit	*5.5	3.06	2.5 Mil Etch – No Dust Grey Metal Reusable
Crushed Flint 12/30 Mesh	3.6	2.69	3 Mils – Reus-able
Staurolite 50/ 100 Mesh	3.1	4.85	.5 Mil Etch Smooth Surface
Coal Slag 16/40 Mesh	3.2	3.83	2.5 Mil Etch Reusable Imbedding
Copper Slag 16/ 40 Mesh	3.1	4.36	2 Mil Etch Reus-able-Imbedding

1. Use and Work Rate figured with a 3/8 inch nozzle at 100 psi to clean new plate to an SSPC-SP 10 near-white finish.

Table 1•2: Characteristics of Abrasives

ABRASIVE	TYPE	SHAPE	MAIN USE
Steel Shot	Metallic	Round	Peening
Steel Grit	Metallic	Angular	Metal Etching
Iron Grit	Metallic	Angular	Metal Etching
Alum. Oxide	Oxide	Angular	Metal Etching
Silicon Carbide	Oxide	Angular	Metal Etching
Garnet	Oxide	Irregular	Metal Etching
Mineral Slag	Mix	Irregular	Metal Etching
Flint	Silica	Sharp	Metal Etching
Sand	Silica	Irregular	Metal Etching
Limestone	Oxide	Irregular	Light Cleaning - No Etch
Walnut Shells	Vegetable	Irregular	Light Cleaning - No Etch
Corn Cob Grit	Vegetable	Irregular	Light Cleaning - No Etch
Glass Beads	Oxide	Round	Light Cleaning - No Etch

1.9 Choosing the Right Abrasive

The type of abrasive has a great affect on the volume and weight of waste produced. This is because some abrasives are more productive per pound than others. Abrasive break down rate or friability affects waste volume. The density of an abrasive will also affect the volume of waste produced. Since most landfills charge based on volume this is an important factor to consider.

The relative amounts of abrasive used for a given job can be estimated using the numbers in the middle two columns of Table 1•1. The use rate times work rate gives the pounds of abrasive used per minute of blasting work. To estimate the relative amount of abrasive needed multiply use rate by the area to be cleaned. For an estimate of the time needed to complete a job, divide the area to be cleaned by work rate. The best choice would be an abrasive which gave the lowest amount of finished waste, the highest possible productivity, and the smallest amount of abrasive. Based on these demands there is no best choice given in Table 1•1. Metallic abrasives will make the least waste. Many mineral abrasives give higher productivity, but produce more waste. Even reusable nonmetallic abrasives like garnet or aluminum oxide may not be ideal.

Note that the blaster doing the work has the biggest influence on the amount of abrasive needed.

1.9.1 Mineral or Slag Abrasives

Silica sand, mineral and slag abrasives have been the most common choice for large scale jobs of surface preparation. They are likely to remain popular for many tasks despite changes in environmental regulations affecting waste disposal.

For U.S. Navy projects, mineral abrasives must meet the requirements of MIL-A-22262(SH). This specification sets very tight limits on the heavy metal content and free silica of the abrasive.

1.10 Choosing the Correct Nozzle & Pressure

Different blast nozzles and air pressures can dramatically affect production rates. Changing nozzle diameter by half can reduce productivity by nearly a quarter. Doubling air pressure can nearly double productivity. There is a practical limit to air pressure increases. Normally industrial blasting work is performed with pressures at or near 100 psi at the nozzle.

The table below gives relative production rates using mineral abrasive at 100 psi for a number of nozzle sizes and work conditions.

Table 1•3: Nozzle Size & Cleaning Rate

NOZZLE TYPE

NOZZLE SIZE	**1/2**	**7/16**	**3/8**	**5/16**	**1/4**
CFM @ 100 PSI	350	260	200	150	90
AIR HOSE - IN.	2	1-1/2	1-1/2	1-1/4	1-1/4
BLAST HOSE - IN.	1-1/2	1-1/2	1-1/4	1-1/4	1
MATERIAL LB/HR	2250	1750	1260	900	540

SURFACE CONDITION | **SQUARE FEET PER HOUR**

WHITE METAL	**1/2**	**7/16**	**3/8**	**5/16**	**1/4**
LOOSE MILL SCALE	250	200	145	102	61
TIGHT MILL SCALE	211	164	121	84	50
PITTED PAINT	125	100	71	50	32
MULTICOATS	100	80	58	40	25
NEAR WHITE	**1/2**	**7/16**	**3/8**	**5/16**	**1/4**
LOOSE MILL SCALE	265	210	150	106	65
TIGHT MILL SCALE	220	172	125	90	55
PITTED PAINT	132	104	75	55	34
MULTICOATS	106	84	60	44	25
COMMERCIAL	**1/2**	**7/16**	**3/8**	**5/16**	**1/4**
LOOSE MILLSCALE	632	495	360	255	155

COMMERCIAL	**1/2**	**7/16**	**3/8**	**5/16**	**1/4**
TIGHT MILL SCALE	420	320	240	170	102
PITTED PAINT	316	246	181	128	76
MULTICOATS	210	165	120	85	50
BRUSH	**1/2**	**7/16**	**3/8**	**5/16**	**1/4**
LOOSE MILL SCALE	1264	990	720	508	310
TIGHT MILL SCALE	1264	990	720	508	310
PITTED PAINT	1264	990	720	508	310
MULTICOATS	1264	990	720	508	310

1.11 Surface Profile

Surface profile is an important factor in surface preparation. A surface profile is a desirable end result of blast cleaning. It helps improve coating adhesion to the metal. Profile is one measure of the roughness created on the surface by abrasive blasting. New steel has a coating of millscale on it. The metallic or mineral slag abrasive will alter the shape of the surface of the metal while

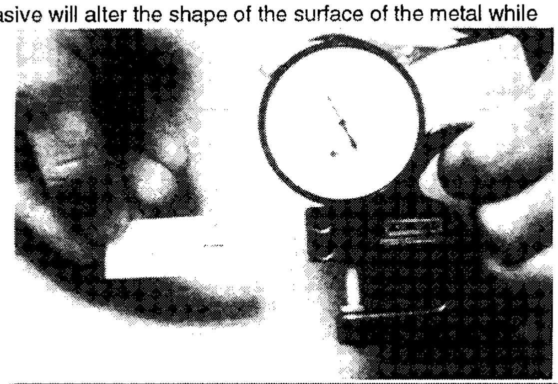


Figure 1•6:Measuring Profile With Tape Method

removing the millscale. This creates peaks and valleys on the surface of the metal. The average difference in height of the bottom of each valley and the tip of each peak on the surface is the average surface profile. The surface profile uses units of mils, one-thousandth of one inch, or microns, one one thousandth of a centimeter. Surface profile is measured with profile relief test tape or a needle profilometer. Typical profiles for many structural steel paints can range from 1.5 to 5 mils, 40 to 125 microns. The final surface profile is decided by:
•The size of the abrasive used to blast the steel;
•The pressure used to impel the abrasive from a blasting nozzle;
•The hardness of the abrasive;
•The hardness of the metal.
The final surface profile must match the desired surface profile. Desired surface profile depends on coating thickness and type. For thin film systems, between 3 and 10 mils, 75 to 250 microns, surface profile is generally no more than 25% of total system thickness. Even with thick coating systems above 20 mils, 500 microns, desired profiles rarely exceed 4-5 mils, 100 to 125 microns. Whatever the surface profile it must not exceed the ability of the primer to cover the roughened surface.

1.12 Other Cleaning Methods

1.12.1 Air/Water Abrasive Blasting

Air/water abrasive blasting gives lower dust levels in blasting work and helps with scouring the surface being blasted when the surface is very dirty. This technique covers two distinct types of blasting operation. In the first type, 1, a ring of water acts as a shroud around the blasting nozzle. A typical nozzle attachment is shown in Figure 1•7. This version can only reduce dusting levels in the work area. It has no real impact on improving the cleanliness of the blasted surface. The amount of water used is the minimum needed to reduce dusting and maintain visibility.

Figure 1•7: Water Shroud at Nozzle Type 1 Air Water Abrasive Blasting

The second type of arrangement, 2, shown in Figure 1•8, has a stream of water mixing with the abrasive at the nozzle. This method can both suppress dust and help scour salts from pitted surfaces. The volume of water used is larger than with a water ring set up. Variations on this type of equipment allow water pressures all the way up to 10,000 psig. This type of equipment is described in high pressure water jetting, Section 1.12.3, below.

Units of these types have been the subject of industry sudies. Either method is less productive than conventional blast cleaning, and the type of waste produced is difficult to handle. Type 2 air/water abrasive blasting at low pressures is less effective than very high pressure water jetting in removing salts or similar materials from a steel surface. The surface produced by air/water abrasive blasting is no cleaner and may be dirtier than that produced by conventional blasting.

The water used for air/water abrasive blasting should be potable. Saltwater is unfit for use in air/water abrasive blasting. To this clean water you will need to add some inhibitor, or the blasted surface can flash rust.

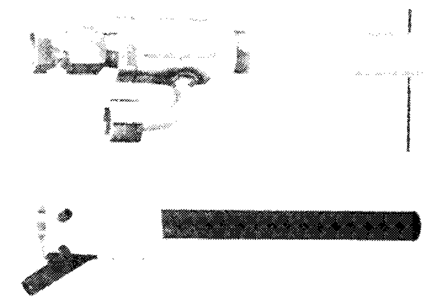


Figure 1•8:Typical Water Injection to Nozzle Type 2 Air Water Abrasive Blasting

What to do with the water used in blasting is also a problem. In shipyards you cannot just pour the waste water into the harbor. It must be collected and disposed of following environmental regulations. This is complicated because it is a mixed waste of abrasive and paint debris, forming a cake or slurry.

Because of these deficiencies and complications, air/water abrasive blasting will play only a small role in your surface preparation tasks. It may be good for specific jobs and you should be aware that specifications and guides for this type of blasting technology are under development at SSPC.

Table 1•4: Some Cleaning Rates with Wet Abrasive Blasting

SURFACE CONDITION	Water Only - W Sand Injection -SI	0-2000 PSI @ 5 GPM	3,- 6,000 PSI 6 - 8 GPM	10,000 PSI 10 GPM
Easy to clean flat dusty surface light oil or grease	W SI	150 200	350 450	500 650
Average rusty surface angles and piping	W SI	75 100	200 225	250 350
Heavily corroded surface rust scale, irregular shape	W SI	20 25	75 100	125 175

1.12.2 Water Soluble Abrasives

A recent development is surface preparation using a slurry of baking soda (sodium bicarbonate) with water under pressure. Carriage to the surface is by pressurized water or by compressed air much like conventional blasting.

Baking soda blasting of either type will remove coatings but will not produce a profile on the surface. While the abrasive is environmentally safe, the waste being produced - a slurry of the baking soda and paint chips - may or may not be safe. This technology is still in its infancy so reliable productivity numbers are not available. While slurry blasting cannot create a profile, this is an asset when cleaning surfaces such as aluminum, or plastic composites. Baking soda acts as a weak natural inhibitor so you may not need to add another inhibitor to the water.

1.12.3 High Pressure Water Jetting

Water can cut stone, metal or gems if thrown at a surface with enough force. High pressure water jetting for surface preparation uses water propelled under pressures as high as 40 -50,000 psig and no lower than 10,000 psig. At these high pressures you can strip paint from a variety of surfaces, but no profile is imparted to the surface. To improve productivity and create profiles many units allow the blaster to inject a stream of abrasive into the water jet. You need very little abrasive, and often surprisingly little water. High pressure water jetting is not for general surface preparation. A summary of expected productivity from SSPC stuudies is given in Table 1•4, "Some Cleaning Rates with Wet Abrasive Blasting," on page 24

1.13 New Surface Preparation Methods

The technology used in surface preparation is always changing. This section gives a brief overview of newer methods. Some methods may have use in future or have limited potential now but may see greater use in the future.

1.13.1 CO2 Blasting

CO_2 blasting uses pellets of solid carbon dioxide (dry ice) propelled toward the surface by a stream of compressed air. Carbon dioxide blasting has shown potential in some limited surface preparation applications. Advantages of CO_2 blasting include a drastic reduction in the total amount of waste debris generated. The CO_2 pellets evaporate, leaving behind only paint debris. The slow rate of coating removal and lack of profile characteristic of this method are clear disadvantages. A recent study at Norfolk Naval Shipyard gives some guidance as to the capabilities of the method. The results are summarized inTable 1•5

CO_2 blasting removes grease, oil and other surface contaminants from either steel or concrete surfaces. Solvent washing may be more effective in degreasing operations. CO_2 blasting will remove coatings from steel surfaces, but only very slowly, table ##. Carbon Dioxide blasting can damage delicate substrates such as composite or fiberglass materials. CO_2 blasting is quite noisy, requiring ear protection. Use CO_2 blasting with caution in confined spaces like tanks because an oxygen deficient atmosphere may occur.

1.13.2 High Intensity Light Paint Removal

High intensity light is only an experimental method for removing paints, but it shows much promise. Two divergent technologies have emerged. The first method uses light from high intensity Xenon flash lamps to fuse and vaporize a coating. The second method uses a high intensity IR laser to heat the paint to the point of ash formation. Neither method creates a profile. Removal rate information is scanty at best.

High intensity paint removal has high equipment costs, low productivity, and variable efficiency. The rate of paint removal is dependent on several factors. The most important factors are the type of resin, the thickness of the coating and whether reflective pigments are present. Reflective pigments can dissipate or reflect the intense light and reduce the efficiency of this type of method.

1.14 Power Tool Cleaning

Use of portable power tools—pneumatic and electric — is common for cleaning operations. Careful selection and use of the great variety of power tools and accessories are important. Satisfactory surface conditions for good paint life with low labor costs can result.

Table 1•5: Cleaning Rates with Carbon Dioxide Blasting[1]

Item Description	CO_2 Used	Cleaning Rate	Previous Method	Comments
Hatch/Access Cover	450 lbs/hr	20-160	Wire Brush or Needle Gun	Removes Organotin Paint,
	210 psi			previous rate 5-10 sq. ft./hr
Emergency Buoy	254 lbs/hr	5	Glass Bead Blasting	Removed Paint quickly,
	180 psi			present rate 2-3 sq. ft./hr.
Small Steel Structure	260 lbs/hr	30	Ultra High Pressure Water Jetting	Removed rust,
	100 psi			present rate equal to CO2 blasting.
Cable Degreasing	450 lbs/hr	20-30	Solvent Cleaning	Eliminates Solvent use,
	220 psi			present rate 3-4 sq. ft./hr.
Fiberglass Antenna	250 lbs/hr	10 - 40	Hand Sand or Ultra High Pressure Water Jetting	Damages composite surface,
	20-40 psi			present rate 0.5-5 sq. ft./hr.
Aluminum Antenna	450 lbs/hr	10 - 40	Hand Sand or Ultra High Pressure Water Jetting	Sometimes removed paint
	220 psi			present rate 0.5-5 sq. ft./hr.
Hydraulic Buffer	450 lbs/hr	25	Steel Shot Blasting	Removed failed epoxy paint,
	220 psi			present rate ≤5 sq. ft./hr.
Masonry Surface	250 lbs/hr	30-100	Needle Gun	Removed paint safely,
	225 psi			present rate 20-40 sq. ft./hr.

1. Results of a Test Series Performed at Norfolk Naval Shipyard

Power tools used for surface cleaning fall into three basic families:
- Impact cleaning tools
- Rotary cleaning tools
- Rotary impact cleaning tools

Tools in each family have unique characteristics that make them adaptable to different cleaning operations and requirements.

1.14.1 Impact Cleaning Tools

Impact cleaning tools include chipping and scaling hammers. This type of tool can remove heavy deposits of brittle substances from metal. These might include rust scale, mill scale, thick old paint, weld flux and slag. With these tools, an internal piston strikes a chisel, this then strikes the work surface. Chisels are also used for scraping and chipping. Typical tools are shown in Figure 1•9. Chisels can have different shapes and be made of various materials. A needle scaler is a scaling hammer with a bundle of steel needles housed and positioned forward of the striking piston. The piston strikes all needles simultaneously, propelling them against the work surface. This type of tool can handle odd shaped parts. Needle scalers at the left in Figure 1•9. They are best when used on brittle or loose surface contaminants.

Piston scalers are similar to scaling hammers, but the piston is also the chisel. This makes the tool smaller, so piston scalers are often used in tight areas. This type of tool is available in single and multiple piston types. Mounted in groups they can be used for cleaning large surface areas. Cleaning surfaces with scaling and chipping hammers is comparatively slow. When considerable rust scale or heavy paint formation must be removed, it may be the best and most economical method. Impact cleaning tools are available with various handle and throttle styles.

Power tools may cut into the surface. Avoid removing sound metal or leaving sharp burrs the paint cannot cover. Sometimes the cutting tendency of power tools is an asset. Sharp chisels can be valuable for shaping sharp edges to a rounded contour so paint does not pull away. It also removes imperfections from the surface.

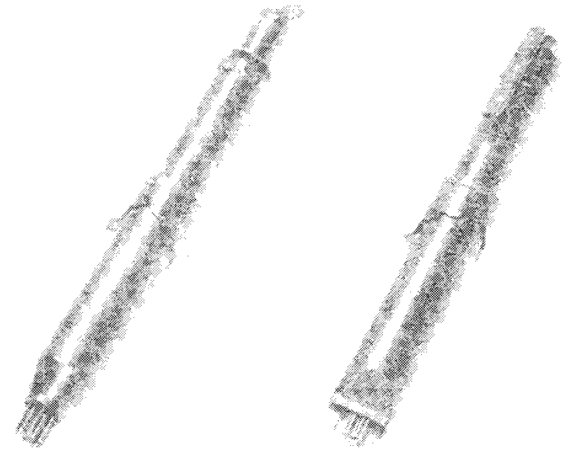


Figure 1•9:Typical Impact Power Tools

These tools are least useful when removing tight mill scale and surface rusting, because they may damage the metal surface. Tools must be sharp or they may drive rust and scale into the surface.

1.14.2 Rotary Cleaning Tools

Rotary cleaning tools do most hand-cleaning jobs rapidly. This section discusses rotary power tools and their cleaning media.

1.14.3 Cleaning Media For Rotary Tools

There are three basic types of cleaning media for rotary power tools: nonwoven abrasives, wire brushes and coated abrasives. These media fit two basic types of tools. In-line machines use radial wire brushes, coated abrasive flap wheels and non-woven wheels. Right-angle machines can use cup wire brushes, cup wheels, or discs of the non-woven or coated abrasive type.

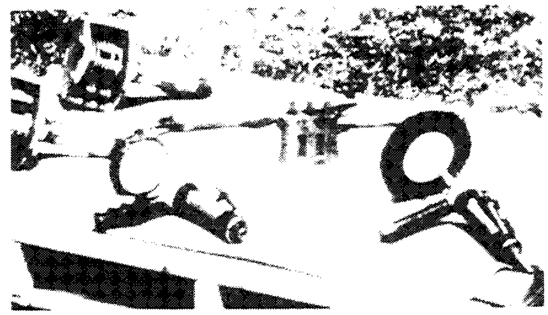


Figure 1•10:Typical Rotary Power Tools

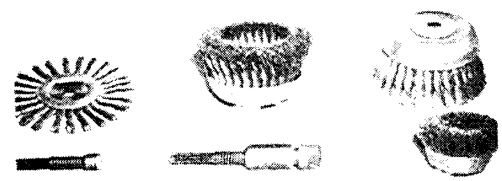


Figure 1•11:Typical Media for Rotary Power Tools, Wire Brushes

Non-woven abrasives and rotary wire brushes remove old paint, light mill scale, rust, weld flux, slag and dirt deposits. Wire brushes (Figure 1•11) may have differently shaped and sized wire bristles. Crimped or knotted bristles are common. Non-woven abrasive products (Figure 1•12) use many sizes or loadings of abrasive.

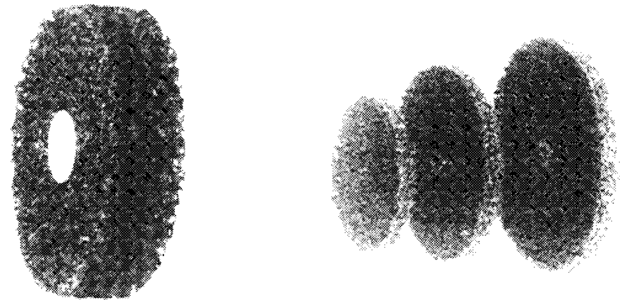


Figure 1•12:Typical Media for Rotary Power Tools - Non-woven Abrasives

Wire brushes and nonwoven abrasives come in cup and radial (wheel) form. Non-woven abrasives also are available in disc form. Through trials you can choose the style and type of bristle or non-woven abrasive composition which you need. Surface condition affects the efficiency of cleaning. Non-woven abrasives are very good for removing coatings because they are less likely than coated abrasives to get loaded with paint. Coated abrasives are available in several converted forms Figure 1•13). Discs and flap wheels remove loose mill scale, old paint, etc. similar to wire brush applications, but can remove base metal. Loading from old paints may make coated abrasive discs difficult to use.

Non-woven abrasive wheels will not remove base metal but are more aggressive than wire brushes. Non-woven abrasive wheels wear at a controlled rate. Fresh working abrasive provides a constant rate of surface cleaning with minimal loading. Non-woven abrasive wheels are useful in removing light mill scale. In many applications, nonwoven abrasives are a quicker and more effective alternative to wire brushes or coated abrasives.

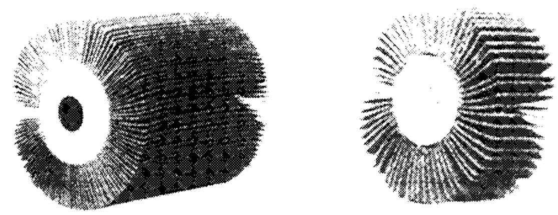


Figure 1•13:Typical Media for Rotary Power Tools - Coated Abrasives

1.14.4 Types Of Rotary Power Tools

Two types of rotary power tools are available: straight or in-line machines and vertical or right angle machines. The straight or in-line machine uses radial wire brushes, coated abrasive flap wheels and nonwoven abrasive wheels. The vertical machine style uses cup wire brushes, coated abrasive discs, nonwoven abrasive discs, cup wheels and wheels. The type of machine chosen will vary with job conditions. Often both types are useful on field jobs. Power tool cleaning can be tiring. For overhead work, small lightweight machines are useful. Pneumatic or electric motors are the most common power source. Lightweight machines operated by high frequency current are available.

In power wire brushing it is possible to cut through some mill scale by using the toe of a very stiff brush and bearing down hard. It is impractical to remove tight mill scale by power wire brushing. Don't use high speeds with rotary wire brushes and do not keep the brush on one spot for too long, or you may damage the surface. If the surface is smooth and develops a polished, glossy appearance it provides a poor anchor for paint. Clearly doing too much surface work is detrimental.

Coated abrasives are particularly useful for application where one aims to remove metal such as weld grinding. Tight mill scale withstands such media, but loose scale can be removed.

Solvent cleaning is recommended before power tool cleaning. Rotary wire brushes are particularly bad at spreading oil and grease over the surface. Coated abrasive and nonwoven abrasive products are also vulnerable to oily or greasy surfaces.

1.14.5 Rotary Impact Tools

Rotary impact tools operate on the same basic principle as other impact tools, through a cutting or chipping action. Rotary tools use a centrifugal principle where cutters or hammers rotate at high speed and impact against the surface.

Rotary chipping tools use three major types of media: cutter bundles (or stars), rotary hammers, and heavy duty rotary flaps (Figure 1•14). All three can be used on pneumatic or electric powered tools. Cutter bundles or stars consist of hardened steel star-shaped washers free to rotate individually on spindles around a powered axis. The scraping is suited for grinding concrete, surface preparation, coating removal and for generation of non-slip surfaces. Rotary hammers are a series of free swinging hammers that, through impact on a surface, remove thermoplastics, heavy coatings, non-skid coatings and heavy scales. One process, known as "Heavy Duty Roto Peening,,' employs flexible flaps attached to the ends of which is tungsten carbide shot. These flaps are loaded on a hub and its rotation impacts the shot against the work piece. This fractures old coatings or mill scale and can clean to white metal. The process leaves a good anchor pattern for coatings. It also can generate a nonslip surface. Often, it is more rapid and thorough than other types of rotary chipping tools.

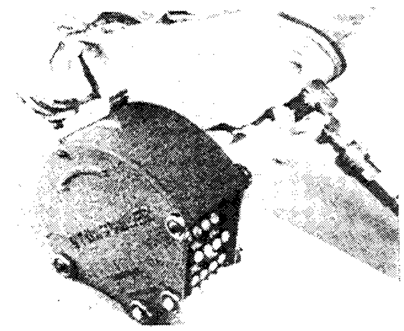


Figure 1•14:Rotary Impact Power Tools - Roto-Peen Equipment

A rotary chipper can be advantageous on large areas to remove rust and scale. The cutters should not leave metallic points that extend far above the surface. This could cause early paint failure due to insufficient paint coverage. If you use these tools to remove all mill scale and rust from the surface, it is very likely that the surface will be too rough for satisfactory painting with thin film coatings. A very thick coating, such as cold applied mastic, may mask over the peaks.

1.14.6 Tool Safety

Safety is a very important consideration when using tools. It includes proper use and maintenance of tools, and protection from air-borne contaminants. Prescribed safety practices are published by various organizations, including the American National Standards Institute, the National Safety Council, the Occupational Safety and Health Administration and the Environmental Protection Agency. Some publications are referenced at the end of this section to help users identify them, and include recommended operating procedures.

Hand tools should be properly selected for the purpose and properly maintained. Hammers should be properly heat-treated and striking faces maintained to eliminate "mushrooming" and flying fragments. You must maintain the striking and cutting ends of chisels. Only operate impact tools when the chisel or scaling tool is in position and in contact with the steel work piece. Rotary wire brushes should be run at or below manufacturer's maximum operating speed. Gloves and leather aprons are additional safeguards to avoid injury from loose wires.

Run power tools fitted with coated and nonwoven abrasives at or below manufacturer's maximum operating speed. Nonwoven abrasive wheels should be operated in the proper direction of rotation. Put the wheel or disc on the tool and tighten securely with the tool disconnected from the power supply. Proper air pressure to pneumatic tools is important. Check tool speed, rpm, with a tachometer before use. Operate rotary impact tools at or below manufacturer's maximum operating speed. When using "Heavy Duty Roto Peening," it is important to have flaps loaded for direction of rotation as recommended. These media must be tightly secured. Only run roto peen equipment when in contact with an appropriate work surface. Use respirators if contaminants in the breathing zone exceed applicable threshold limits. This is important when cleaning paints containing lead, chromate or coal tar products. Since the cleaning operations can produce sparks, exercise care when cleaning in the area of combustibles and volatile vapors. When such conditions exist only use special nonsparking tools.

For thorough information on the subject of safety, refer to the following:

"Standard for Safety of Portable Electric Tools," C33.49. American National Standards Institute, 1430 Broadway, New York, NY 10018. (Also UL45, Underwriters Laboratory).

"Safety Requirements for the Design, Care, and Use of Power Driven Brushing Tools," B165.1. American National Standards Institute.

"Standard for Occupational and Educational Eye and Face Protection," Z87.1. American National Standards Institute.

"Accident Prevention Manual for Industrial Operations," seventh edition, National Safety Council, 444 North Michigan Avenue, Chicago, IL 60611.

Various Occupational Safety and Health Association regulations may be applicable. Regulations are available from the Occupational Safety and Health Administration, U.S. Department of Labor, Washington, D.C..

1.15 Portable Centrifugal Blast Cleaning With Metallic Abrasives

There are two types of surfaces on a ship that are conveniently cleaned with portable centrifugal blast cleaning equipment, they are ship hulls and ship decks.

Ship hulls can be cleaned using a robotic adaptation of a centrifugal wheel blaster. A typical device is shown in Figure 1•4, on page 12. These can remove anti-fouling or friction reduction coatings on hulls. Ship decks can be cleaned with a portable version of a centrifugal wheel blaster. This unit will remove anti-skid elastomeric coatings on ship decks.

In either case the principle of operation is identical. The abrasive flies from the wheel blaster at high speeds by a rotating flywheel. These wheel blasting units can work without compressed air. A cutaway model showing the basic principles of wheel blasting equipment is shown in Figure 1•15, on page 37.

When preparing plate sections on ship hulls, the wheel blaster is loaded with steel grit. For preparing ship decks to repair anti-skid coatings the portable wheel blaster is loaded with steel shot.

Both types of devices recover and reuse the metallic abrasive. You will need the controls for maintaining a correct working mix and correct abrasive quality described above.

1.16 Centrifugal Wheel Blast Cleaning

Centrifugal wheel blast equipment is often the choice for preparing new steel plate or structural sections during construction or retrofit of a vessel. These units work in the same way as the portable or robotic units used in maintenance, but are immobile.

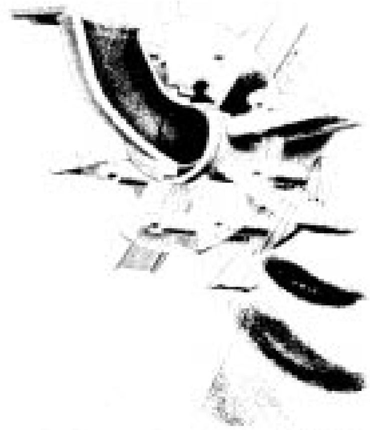


Figure 1•15:Principles of Wheel Blast Cleaning

A complete centrifugal blasting system consists of the following components:

•A motorized wheel blast unit, this provides the abrasive with the energy to work the surface;
•A recovery system for the used abrasive, this can be a vacuum or magnetic recovery system on portable units, it is typically an auger screw feed system in fixed equipment;
•A storage hopper for the metallic abrasive of choice;
•A cleaning system for the recovered abrasive, this can be a combination of air washing equipment to remove paint particles, fines or dust along with a system of sieves or heavy particle separators to keep the working mix within specified limits.

1.17 Inspection of Prepared Surfaces

Below is a checklist of the most important inspection tasks in surface preparation. The inspection process begins before any work is done.

1.17.1 Inspection Before Surface Preparation

Items to be inspected before you clean include the surface to be cleaned, is it:

•**Oily, dirty or greasy** - you need to do Solvent Cleaning as defined in SSPC-SP 1;

•**Fouled with weld spatter or flux** - you need to do Power or Hand Tool Cleaning, SSPC-SP 2 or SSPC-SP3;

•**Contaminated with salt** - you may need to remove the salts by washing;

•**A bolted connection area** - you must locate and mask off all joints as shown on the engineer's drawings;

•**A surface with deteriorated paint** - you should find out how tight the existing paint is.

1.17.2 What are the Working Conditions

Only conduct surface preparation or coating under the correct conditions of temperature, humidity and dew point. To ensure that the working conditions are appropriate make some simple measurements.

•**Temperature** - coating work will follow quickly on the heels of surface preparation, is the air temperature in the range defined by the coating manufacturer for the product specified, is the temperature of the steel too high (> 125 °F) causing poor drying of the applied coating. Is the steel temperature too low (<50°F for catalyzed coatings, <40°F for single pack coatings) to ensure curing or drying.

•**Humidity** - if the humidity is too high you may be below the dew point, flash rusting of the steel can result.

•**Ventilation** - inadequate ventilation can cause heavy dust buildup in the air making the workspace unsafe. Dust particles could also contaminate the prepared surface. Make sure the work area is well ventilated.

1.17.3 Inspect your Equipment and Supplies

This is a list of checks to make at the start of each shift.

Air Compressor

•Is the air compressor in good working order?
•Is the quality of the air to the respirator good, is it safe to breathe?
•Is the air for blasting clean, free of oil, moisture and contaminants?

Blasting Machine

•Is there a "Dead Man" safety switch on the abrasive nozzle?
•Does the blasting pot meet ASME pressure vessel codes?
•Is the volume and pressure of blasting air sufficient, is it clean?

Abrasive

•Is the abrasive clean - free of oil, moisture, fines and salts?
•Is the abrasive mix of the right size to produce the profile needed?

Hoses

•Are the hoses laid out with no kinks or sharp bends?
•Are the hose to hose couplings safely secured?
•Is the hose equipped with a static grounding wire?

Blast Nozzles and Nozzle Pressure

•Is the blast nozzle of the best size for optimum productivity?
•Is the pressure at the nozzle between 90 and 100 psig measured by hypodermic needle pressure gage?
•Is the blast nozzle worn, cracked or old? If so, replace it.

1.17.4 Inspection of the Cleaned Surface

Items to be checked after a surface is cleaned include:

The degree of cleaning

Does the surface look as clean as expected, compare the surface to visual standards such as SSPC-SP Vis 1-89 or job standards prepared on site;

Surface profile
Check the profile on the finished surface by measuring with replica tape or a profile gage, alternatively use standard replica coupons to estimate profile. See Figure 1•6, on page 20.

1.18 Removal of Surface Contamination

1.18.1 Detection and Removal of Surface Contaminants

Salts from sea water are invisible contaminants that cause steel to corrode. Salts can also deposit on the steel surface by stack emissions from a boiler. Bilges and many exterior surfaces will be contaminated with salts. Where a coating material has broken down and corrosion is active you can expect some salt to be present on the surface.

To radically reduce the amount of effort required to remove salts follow this checklist.

•Test areas will only be where coating breakdown has occurred and blistering or rusting is seen;
•Testing will be done before all the coating is removed, and;
•Confine additional cleanup or washing to these areas.

Remember, if the old coating is intact, you do not have a salt problem.

Salts on a surface will have one of the two following affects. Salts can cause earlier paint failure, underfilm corrosion and blistering. In blasting or painting operations the most noted effect of salt is to produce flash rusting; in severe cases a deep black or blue corrosion product will form. If flash rusting occurs even though steel temperature is well below dew point then salts may be the cause.

Guidance for permissible levels of salt on a surface is available in reports prepared for the Federal Highway Administration and the National Shipbuilding Research Program. Both the SSPC and the Interntational Standards Organization, ISO, are developing guidance standards for salt contamination. The levels allowed to remain depend on the service conditions of the contaminated surface and the generic type of paint material used to protect the structure or part.

The topic of salts contamination is complex and the painter/blaster is not expected to know how to measure salt on a surface. The painter/blaster should be alert to the result of having salt present. These are unusual flash rusting followed by reduced paint life. The blaster/painter should also know what techniques can remove soluble salts.

1.18.2 Removal of Salts

Blast cleaning alone will not remove salts, though it will remove much of the salt in the rust product. Salts are left behind on the metal surface. Removal techniques to get the salt off the steel work by dissolving them in water.

Sometimes it may be sufficient to rinse the surface well with good, clean, water under normal pressures. Thorough rinsing may not be enough in some cases, such as when pits are present. Here you may have to resort to alternate means. High pressure water jetting or steam cleaning has been successful. They do a good job of reducing salt levels. Reductions of 90% have been achieved with high pressure water jetting.

An alternate technique requires less labor but greater patience. Leave the blasted surface unprotected overnight and let the salts leach from the surface. The salts will migrate from pitted areas to the steel surface (see Figure 1•16, on page 42). Thorough washing or steam cleaning of the surface then reduces the salt level on the steel.

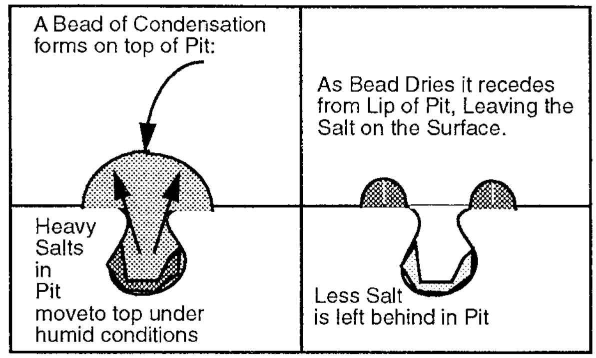


Figure 1•16:Migration of Salts from a Pitted Surface under Humid Conditions

The following description of how to detect solubleis for information only.

1.18.3 How to Identify Salts on a Steel Surface

Identification and retrieval of salts from a surface are performed by trained inspectors. One can suspect salts on a steel surface when symptoms of salt are seen, like excessive rust formation or a blistered coating. It is not easy to tell if salts are present after a surface is cleaned to bare metal. (Salts on steel form colorless compounds with iron.) Some inspectors recommend leaving the steel to rust bloom after blasting. They then examine the areas of acute red or blue rusting. It is betterpractice to do a few simple tests before a major job is in progress and see if salts will be a problem.

1.18.4 Retrieval of Salts

Most of the tests for detection of salts use retrieval of the salt from a cleaned sample area as the first step. The tests use distilled water to pull the salts from the cleaned surface. A known area is swabbed with moistened cotton balls, collecting the salts in distilled water. An alternative is to use a small cell called the Bresle cell. This sticks on the metal surface and distilled water is syringed in and out of a blister cavity formed against the surface by the cell. In either case a sample of some of the salts from the surface results. Typical swabbing and cell retrievals are shown in figures ##,and ##. Not all the salts on the surface are in your sample. Laboratory studies show that you can expect retrieval of 30% with swabbing and around 50% with cell methods.

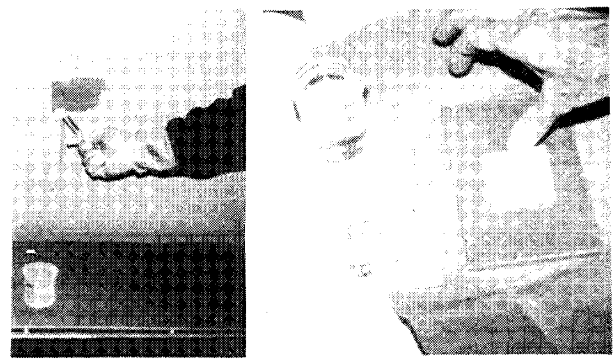


Figure 1•17:Typical Swabbing (Left) and Cell Retrieval (Right) for Salt Analysis

1.18.5 Measuring What was Retrieved

Any retrieval technique will give a sample of some salt from a surface in a known volume of water. The area sampled is known. Also known is the retrieval rate from the surface. Knowing the amount of salt in the sample an inspector can give a good estimate of the actual salt on the surface. To measure the salt in the sample the inspector can use one of many test kits. Kits are available to measure:

•Chloride content;
•Ferrous Ion content;
•Sulfate content;
•Conductivity.

Using conductivity is the simplest way to decide if surface salt levels are toohigh.

Table 1•6: Some Common Salt Analysis Methods

Item of Interest	Method Suggested
Conductivity 1 - 1000 µS (0.1 - 100 mS)	Dissolved Solids or Conductivity Meter
Chloride Content - ≥ 50 ppm	Quantab Strips dipped in solution
Chloride Content 1 - 100 ppm	Field water quality titration kits from Hach, La Motte or Chemetrics
Sulfate Cotent 20 - 100 ppm	Field water quality turbidity test kits, Hach, La Motte
Ferrous Ion	Field water quality test strips, Merck, or Hach
Phone Number for Hach	1 - 800 - 227 - 4224
Phone Number for La Motte	1 - 800 - 778 - 3100
Phone Number for Chemetrics	1 - 800 - 356 - 3072

A summary of some better test methods are shown in Table 1•6, on page 44. For a detailed description of a sampling and measuring protocol for salt on a surface, consult the references cited at the end of this section.

Table 1•7: Converting Conductivity to Salt Levels

Recovery Method	Conversion Formula for Total Salt in Sample - ppm[1]
Swabbing	Multiply conductivity in µS by 1.65, then mutiply by sample volume in mls.
Cell Retrieval	Multiply conductivity in µS by 0.825, then mutiply by sample volume in mls.

1. Assumes all retrived salt is sea salt, for other salts different formulas are used. Assumes retrieval rate for salt is 25% for swabbing, 50% for cell extraction.

Table 1•8: Some Marine Paint Systems Resistant to Salts

Contamination & Level µg/cm^2	Resistant Paint Materials [1]
Chloride 0 - 5	Oil Alkyd, Coal Tar Epoxy (Immersion)
Chloride 10 - 20	Immersion grade Epoxy or MIL-P-2441 Epoxy
Chloride ≥ 50	Inorganic Zinc

1. Based on work performed for NSRP under Project 3-84-2 and FHWA under project DTFH61-88-C-00027.

A practical compromise is to measure the conductivity of the solution, then using the conversion formula shown in Table 1•7, estimate the salt present as if it were all sea salt. The assumption that most of the salt is sea salt is likely to be the case in a marine vessel. A summary is given in Table 1•8 of maximum allowed levels that different systems may tolerate under marine conditions and immersion conditions. Take the estimated amount of chloride from the conversion formula and divide by the area sampled in square centimeters. This value is the estimated amount of salt on the surface. Note that there is a very wide range of chloride levels suggested, no one level is good for all conditions or coatings.

1.19 Preparation of Non-Ferrous Surfaces.

Preparation of nonferrous surfaces is more common on ships than on any other class of steel structure. Aluminum and plastic surfaces frequently require cleaning and coating. Composite materials are becoming more common in all construction. Special techniques must be used with these easily damaged surfaces.

In the previous discussions of surface preparation technologies suggested applications have sometimes included nonferrous surfaces. Cleaning techniques for nonferrous surfaces vary with the material. Aluminum surfaces can be cleaned with softer organic or plastic media, as can plastic surfaces. Fine abrasive pads can clean plastic surfaces, care is taken to prevent gouging of plastic or composite surfaces. One choice for plastic or composite surfaces is high pressure water jetting. This can fray composite materials, but has good production rates. For nonferrous metals a general method is chemical cleaning. Recent testing shows carbon dioxide blasting can also clean plastic and composite surfaces effectively. The reader should refer to specific sections of NAVY STM 631 for guidance on methods for preparing nonferrous metals or composite/plastic surfaces.

2. PAINTING

2.1 COATING MATERIALS

Because we paint for various reasons, there must be different paint systems or coatings to do the different jobs. There are many other reasons to use a particular paint system. No one paint system can do everything. If we paint to stop rust, then we must use a rust preventing paint. If we want to prevent fouling underwater, then we use an anti-fouling coating. The best anti-fouling paint may not be very good at stopping rust, and the best rust preventing paint may not stop fouling.

What is paint? Most paints have three main parts: pigment, vehicle and solvent. A variety of other chemicals can be put into paint. Often they are present in small quantities and are called additives. Some paints are clear finishes, they may only contain resins and solvents. Other paints have no solvents, they are called 100% paints.

2.1.1 Pigment

Pigment particles are very small solid grains suspended in the liquid part of the paint. The pigment helps form the tough surface. It may make the paint a different color. Color pigments may be complex organic compounds like dyes, or processed minerals such as red iron oxide. Some pigments play an active role in stopping corrosion, they are called anti-corrosive or sacrificial pigments. Examples of anti-corrosive pigmnts include zinc oxide, zinc phosphate and chromate compounds. The most common sacrificial pigments is zinc dust. Pigments can give body to the dry paint film, such pigments are sometimes called fillers. Some examples of filler pigments are gypsum, chalk, and talc. Sometimes special pigments are used to provide unique properties. One type of special use pigment is flake pigmentation, it limits the passage of water to the metal surface. Flake pigments can be either metallic or mineral. Atypical mineral flake pigment is mica, a typical metallic flake pigment is aluminum. A commonly encountered special use pigment in marine painting is copper oxide, this is found in anti-fouling paints.

2.1.2 Vehicle

The vehicle is really the glue that holds the pigment particles together. You can also call a paint vehicle the binder. The generic types of paint get their name most often from the vehicle type. Epoxy paint has an epoxy vehicle. Alkyd paints use alkyd vehicles. Often the vehicle includes other film forming materials that modify the base resin. These additions to the vehicle may not be a resin, they will change the properties of the paint film. One example of this non-resin vehicle modifier is the extender. An extender can impart added film thickness or chemical resistance, one example of an extender is coal tar. See the section on coal tar epoxy coatings. Another example of a film forming additive is a plasticizer. This may make a paint film more flexible. Plasticizers are used in a wide variety of coating products.

2.1.3 Solvent

A solvent is often added to the pigment/vehicle mixture to make the paint flow easily. The solvent carries the pigment and the vehicle to the surface and then evaporates. Once the paint drys, only the pigment and the vehicle remain. Thus, the pigment and the vehicle together form the solid part of the paint. Suppose someone tells you that the paint has 80% solids. Then a five-gallon bucket of paint would contain four gallons of pigment/vehicle and one gallon of solvent. To apply the paint, you might add extra solvent called thinner. Paint thinner can be a blend of different solvents. Some common solvents are mineral spirits, MEK, xylol and water.

Table 2•1: Some Pros & Cons of Paint Systems

PAINT	MAJOR ADVANTAGES	MAJOR DISADVANTAGES
Alkyd	Single component Inexpensive Easy to apply	Not good in immersion. Poor solvent resistance.
Latex (water-borne)	Single component Inexpensive Easy to apply Low VOC	Not good in immersion. Poor solvent resistance.
Phenolic	Hard Good water resistance Difficult to recoat	
Epoxy	Hard Durable Sol-vent resistant Chem-ical resistant	2-pkg, requires mixing Strong solvents Chalks in sunlight No cure at low temperatures
Urethane	Hard Graffiti resis-tant Resists fading	Normally 2-pkg Difficult to topcoat Special Respi-rators Needed
Vinyl	Durable Acid & alkali resistant Good for water immersion	High VOC Low build per coat
Chlorinated Rubber	Durable Chemical resistant	High VOC Low build per coat

Table 2•1: Some Pros & Cons of Paint Systems

PAINT	MAJOR ADVANTAGES	MAJOR DISADVANTAGES
Coal Tar Epoxy	Chemical resistant Water resistant Hard Cheaper than epoxy polyamide	2-pkg, requires mixing Only black or dark red Strong solvents Chalks in sunlight
Zinc-rich	Long life in marine environment Excellent protection in atmospheric environments	Must be topcoated in chemical or immersion environments Care needed in application Must be sprayed
Oil base	Inexpensive Easy to apply	Less durable than other paints Slow drying

2.1.4 Zero-VOC Formulations

Some new coatings have very little solvent present. In these cases, the vehicle often plays the role of solvent during application. Now we shall discuss the different kinds of coatings, how they differ, and where you use them.

2.2 Types of Coating Materials

Each type of coating system has benefits and can provide a painter with problems. A summary of some of the basic problems a painter may have to tackle is given in table 2.1.

2.2.1 Zinc-Rich Coatings.

Zinc-rich coatings are widely used in ship painting. The term "zinc-rich" simply means that most of the pigment in the paint is zinc dust. The vehicle or binder can be epoxy, chlorinated rubber, urethane or one of many silicates. Each paint company has their own special formula for making zinc-rich paint. Hull plates you receive from the fabricating shop often have zinc-rich preconstruction primer already applied. This thin coat of paint protects the steel from rust during storage and construction. Zinc-rich primer is also specified as the primer coat for some tank steel. These primers are also used on exterior ship components.

Rust forms when iron in the steel reacts with oxygen in the air. However, if zinc is present, the oxygen reacts with the zinc instead of with the iron. The zinc oxide then reacts further to form a tight layer on the steel that does not allow water or air to meet the steel. Without air and water, the steel will not rust.

Though zinc-rich primers are versatile and long-lasting they are Not a universal panacea. Zinc-rich primers are not resistant to high levels of acids or alkalis. Therefore, zinc-rich paints are not used in acidic or alkaline areas as a single coat system. If topcoats, like epoxy paint, are applied to the zinc-rich primer the complete system can survive in a chemical environment or in immersion.

2.2.1.1 Types of Zinc-Rich Coatings

There are two main types of zinc-rich paints: inorganic and organic. SSPC Paint Specification Number 20, (SSPC Paint 20 for short) uses this subdivision into inorganic or organic zinc-rich paint.

2.2.1.2 Inorganic Zinc-Rich Coating

Inorganic zinc-rich paints, called Type I in SSPC Paint 20, form from chemicals called silicates. The vehicle in a Type I zinc-rich primer cures by combining with water to form a very hard, glass-like compound. Inorganic zinc-rich primers are either solvent or water based. Solvent based zinc-rich primer uses a chemical called ethyl silicate as the vehicle. A water based zinc-rich primer uses an alkali metal silicate as the binder. Alkali metal silicates are very caustic compounds that require careful handling. Usually you must mix the zinc powder with the liquid portion of the paint shortly before application. Inorganic zinc primers require very good surface preparation, at least as good as commercial blast cleaning (SSPC-SP 6).

2.2.1.3 Organic zinc-rich paints, Type II

Type II zinc-rich paints have organic vehicles like an epoxy, phenoxy, chlorinated rubber, urethane or other organic binders. Their characteristics are very similar to the chosen binder. Some organic zinc-rich paints only have one part. With one-part paints the material for the primer is ready to apply, right out of the can. Usually organic zinc-rich primers have two or three parts that are mixed. Organic zinc-rich primers are more tolerant of poor surface preparation than the inorganic zinc primers. For touch-up work on shop applied zinc-rich primer, an organic primer is usually chosen because it is easier to apply. Application is by brush or in some cases from an aerosol can.

2.2.2 Epoxy Coatings.

Epoxy binders are available in three types: epoxy ester, epoxy lacquer resin and two-component catalyzed epoxy resins.

2.2.2.1 Epoxy Esters

Epoxy esters are vegetable oil-modified epoxy resins. Consequently, they are similar to alkyds except that they are more expensive and produce films that are harder and more alkali resistant. Generally, epoxy esters have less gloss retention than alkyds. Epoxy esters are sometimes used where an alkyd will not have enough alkali resistance and a two-component epoxy would be too expensive.

2.2.2.2 Epoxy Lacquers

To make epoxy lacquers a reacted epoxy resin is dissolved in a mixture of strong solvents. They are sometimes used in organic zinc-rich primers for touch-up of zinc-rich paints because they dry quickly at low temperatures. Epoxy lacquers are compatible with two-component epoxies used as topcoats. Two-component epoxy paints are often used to recoat or repair epoxy lacquers. The solvents will soften the primer slightly thus improving intercoat adhesion.

2.2.2.3 Two-Component Epoxies

Two-component epoxy resins cure by chemical reaction. The epoxy is generally combined with either one of two types of hardeners: polyamine or polyamide. Epoxy-polyamine blends are more resistant to chemicals and solvents and are often used for lining tanks. Epoxy-polyamides exhibit longer pot life, superior flexibility and durability, and have adequate chemical resistance under most conditions. Furthermore, they enable packaging of the epoxy and hardener in separate, equal size packages. Epoxy-polyamide paints are the most popular of all epoxy binders for use on structural steel. When exposed to weathering, they chalk quickly, but retain their excellent chemical resistance properties. Common shipboard uses of epoxy coatings include ballast tanks, potable water tanks, and hull coatings.

2.2.2.4 Coal Tar Epoxy Paints

Coal tar epoxy paints are a combination of the epoxy binder with a coal tar extender. The color of the resultant coating is generally brown, black or dark red. Coal tar epoxy paints are almost as corrosion resistant as epoxy-polyamide paints, but are less expensive. However, their chemical resistance is not as good. They are often used on submerged surfaces where color is unimportant. Coal tar epoxy finishes have high build, but lose flexibility as they age, so substrates must be relatively rigid. There are carcinogenic compounds present in coal tar epoxy paints. This restricts coal tar epoxy use on U.S. Navy shipbuilding projects.

2.2.3 Alkyd Coatings.

Alkyd paints are economical and available in a wide range of colors and gloss levels, from high gloss to flat finishes. They are relatively easy to apply and can, if necessary, be used on surfaces that have only been hand-tool cleaned. Alkyd coatings dry by combining with oxygen in the air. Alkyd finishes have excellent durability in rural environments, but have limited life in marine or corrosive environments. On interior ship surfaces that are normally dry, these coatings are very dependable.

2.2.4 Silicone Alkyds

Silicone Alkyds are a class of alkyd modified with silicone resin. The silicone dramatically improves gloss retention and weathering, so silicone alkyds like the Navy haze grays are commonly used for many exterior applications. A workhorse coating, haze gray silicone alkyd often is the finish coat for much exposed steel topside.

2.2.5 Urethane Coatings.

Urethane or polyurethane paints are becoming more popular as urethane chemistry advances. Urethane coatings can have a very wide range of properties. Urethane coatings are noted for their hardness and outstanding gloss and color retention. Because of this and their relatively high cost, urethanes are often the topcoats over epoxy primers or epoxy intermediate coats. Now, however, urethane primers are available that will apply to wet surfaces and to hand cleaned surfaces. You must follow the manufacturer's instructions carefully when using urethanes to avoid intercoat adhesion problems. There are several different types of urethane coatings.

2.2.5.1 Oil Modified Urethanes

Oil modified urethanes, also called uralkyds, are similar to alkyds. Their use is in similar situations and their cure method like alkyds, by reaction with oxygen in the air. However, they produce coatings that are harder and more resistant to abrasion than alkyds. Unfortunately, although uralkyds have excellent durability as clear finishes, pigmented uralkyd coatings are not durable enough for exposed structural steel.

2.2.5.2 Moisture Curing Urethanes

One-package moisture-cured urethanes (MCUs) react with moisture in the air to cure. They produce the hardest, toughest coatings available in one package. Pigmentation is extremely difficult because of their moisture sensitivity, so they are often used as clear finishes. They can be pigmented with moisture-free materials like metallic powders or flakes. MCUs demand great care for manufacture, storage, and application. MCUs are little used in ship construction or repair.

2.2.5.3 Two-Component Catalyzed Urethanes

Two-package urethanes form from the reaction of the urethane resin with products such as polyols, polyethers, polyesters or acrylics to produce extremely hard, resistant and durable coatings. These are used as topcoats on structural steel exposed in marine or corrosive environments.

2.2.6 Attributes of Urethane Coatings

Urethane polymers may have been made from polyisocyanates, which are either aromatic or aliphatic. Aliphatic urethane topcoats give the highest degree of gloss and color retention. This makes aliphatic urethanes a good choice for exterior use. Aliphatic urethanes are easier to topcoat than aromatic urethanes. Pigmented aromatic urethanes are extremely hard, tough and chemical resistant, but chalk rapidly when exposed to sunlight. Aromatic urethanes often require mechanical abrasion before recoating. High gloss urethanes are often used for exterior exposed steel topside on a ship.

2.2.7 Waterborne Coatings

Latex paints are becoming more popular for industrial and marine use because they are less toxic than most other paints. The waterborne technology has evolved to the point where very good latex systems are available. Latex paints are now easy to apply and dry by coalescence of the latex particles to form tough, durable coatings. Latex paints have little odor, are nonflammable and generally meet air pollution regulations. They are economical and generally more durable than oil paints, exhibiting less chalking and much better color retention. Latex paints have high porosity and allow moisture vapor to pass through the film. Because of this property latex paint are sometimes applied to damp, though not to wet, surfaces. On the other hand, latex paints will not coalesce properly when applied at temperatures below 50° F or at either very low or very high relative humidity. If the surface is chalky, glossy or dirty, it must be thoroughly cleaned since latex paints do not contain solvents that will readily wet or soften these surfaces. A. present, latex paints are applied primarily to interior surfaces of a ship, e.g., cabin walls.

2.2.8 Vinyl Coatings

2.2.8.1 Vinyl Coating Systems.

Vinyl coatings are extremely resistant (except to strong solvents), durable in most environments and can also find use lining tanks for water immersion service. These paints dry rapidly by solvent evaporation to form extremely durable coatings for use in marine or corrosive environments. Spray application is the only practical means to apply vinyl coatings. Brush application will result in a poor quality finish. The surface must be blast cleaned for vinyl paints to be effective.

Vinyls are low in solids, so multiple coats are usually necessary. One spray coat of vinyl may yield only one mil of dry film thickness. However, because vinyls release solvents so rapidly, you can apply as many as 4-6 in a 24-hour period. Because of the relatively large amount of solvent released, vinyl coatings do not meet many air quality regulations. Replacements for vinyl coatings have been made. Typical vinyl substitutes depend on the service of the coated steel. For immersion, epoxy coatings are a typical choice. For atmospheric exposure, waterbased acrylics or epoxy/urethane systems are just two alternatives to vinyl. Vinyl coatings are found in existing ships, but the U.S. Navy will not specify them for new construction, due to their high VOC levels. Local air quality regulations may allow the use of vinyl coatings to repair existing vinyl coatings. If no such permission is given then old vinyl coatings often demand complete removal.

Experimental repair systems for old vinyl coatings exist. One example is a flame sprayed thermoplastic coating.

A compromise, found effective in many environments, was to combine modified vinyl and alkyd resins. Surface preparation requirements were slightly less critical for this vinyl-alkyd than for a straight vinyl. Brush application was easier, total solids higher and exterior durability excellent. However, vinyl-alkyds were not recommended for highly corrosive environments or immersion. Vinyl-alkyds were used only as finish coats. Like straight vinyls, vinyl-alkyds will not meet VOC regulations.

2.2.8.2 Pretreatment Coatings.

Perhaps the most widely used vinyl coating today is the zinc chromate, vinyl butyral wash primer. This two-package primer improves adhesion between the substrate and the next coat of paint. Because it is as thin as water this pretreatment primer is also called "wash" primer. The bare steel surface is generally blast cleaned, but sometimes you can leave small amounts or rust on the surface. When applied to galvanized steel, to aluminum or to existing paint, the surface must be clean. One use of vinyl wash primer is as a tie coat between a zinc-rich primer and the topcoat. The U.S. Navy is seeking to replace the wash primer with a low-VOC, non-chromate pretreatment primer.

2.2.9 Chlorinated Rubber Coatings.

Paints formulated with chlorinated rubber resins are fast drying and very resistant to most chemicals. These paints are also good in water immersion and were common hull coatings. Their popularity has declined in recent years because of the large amount of solvents released during application. Like vinyls, chlorinated rubber paints are "low solids," which means that more of the volume of the paint eventually evaporates.

2.2.10 Phenolic Coatings

Coatings made from phenolic resin binders and aluminum pigments have very good resistance in humid environments. Phenolic coatings are very hard and have use on ship decks. Intercoat adhesion can be a problem with phenolic paints.

2.2.11 Anti-Fouling Coatings

Organotin anti-fouling paint is the finish coat for submerged areas of the ship hull. Copper and tin compounds will poison marine organisms and therefore are common pigments in anti-fouling paints. Certain resins that resist fouling can be added to the binder to create an anti-fouling paint. Anti-fouling coatings keep the hull free of animal growth, thus improving fuel efficiency. If you wash the hull, you must be careful not to remove the anti-fouling coating. Organotin coatings are never used by the U.S. Navy for new construction, but are found on older Navy ships and some commercial vessels. Organotin coatings continue to be specified for commercial construction.

2.2.12 Elastomeric Coatings

Three types of elastomeric coatings are important for construction of Navy ships: noise-deadening submarine hull coatings, anti-skid carrier deck coatings, and elastomeric coatings for radomes and other specialized surfaces.

Elastomeric coatings are unique because the dried film can stretch, usually to greater than 150% of its original length. These coatings are often rubber-like compounds, such as polyurethane elastomers or chlorobutyl rubber. They require special care in surface preparation and application. Elastomeric coatings are frequently used to coat radar domes on Navy ships.

2.2.13 Metallized Coating

Thermal spraying of zinc or aluminum powder to a prepared metal surface is called metallizing. Small metal articles subject to frequent maintenance when organic coatings are used are good candidates for metallizing. Because the metal film is initially porous, a sealant coating like a phenolic goes over the zinc/aluminum film. Metallizing of ferrous metal surfaces demands the highest level of surface preparation, SSPC SP-5, "White Metal Blast Cleaning." Metallizing operators are very highly skilled. Even with a skilled operator and good surface preparation failure of the metallized coating can occur. The most noticeable failure occurs when sheets of the metal coating detach, (delaminate), from the surface. Because of this risk the U.S. Navy has stringent quality requirements for metallized finishes. Inspection of the adhesion of metallized coatings on Navy work uses "Tensile Pull-Off Adhesion Measurement," ASTM D 4541.

2.3 Special Use Coatings

2.3.1 Heat Resistant Coatings

Some areas of a ship such as boiler piping become quite hot, up to 750°F. Coatings applied to hot areas include aluminum pigmented silicones and silicone alkyds. Heat resistant coatings are applied in very thin films. This is to reduce cracking of the coating that occurs when an applied thick film reaches high heat.

2.3.2 High temperature coatings

These coatings must be used in areas subjected to temperatures above 200°F. Silicone alkyd paints are suitable up to 500°F. For temperatures up to 900°F, aluminum pigmented silicones or inorganic zinc can be used. These high temperature coatings require very good surface preparation.

2.3.3 Fire retardant or fire resistant coatings

If steel becomes very hot, its mechanical properties can change and it can lose its strength. Fire retardant or fire resistant paints help control the steel temperature during a fire and can reduce the rate at which a fire spreads. Some of these paints contain compounds that do not burn, such as cement based compounds. Others foam up when subjected to intense heat, thus insulating the steel. Still other fire resistant paints emit a gas (usually hazardous) which will act to extinguish any flame.

2.3.4 Low friction hull coatings

An alternative approach to anti-fouling coating for maintaining optimum fuel efficiency is the low-friction hull coating. Some coatings will continually lose their outer layer as they age. This action, termed "self-polishing," leaves behind a very smooth surface Other coatings such as those based on silicone chemistry are inherently smooth and provide no "grip" for marine organisms. Low-friction hull coatings may use either type of technology. Silicone or fluoropolymer resins are most frequently used.

2.3.5 Thick-Film and Composite Materials

Some coating products are applied in very thick fims. On occasion they are composite materials containing a reinforcing fiber. The use of composite materials is becoming more common. The sections below describe some of the more common types of thick-film or composite materials.

2.3.5.1 Vinyl Ester & Polyester Materials

Vinyl ester and polyester resins have high chemical resistance to solvents or acids and bases. The resins cure by radical reaction with a catalyst called peroxide. They are two-component materials that are applied by one of two methods, trowel application, or by use of plural component spray equipment. Vinyl or polyester materials find use in heavy chemical exposures. Often these materials form the resin part of a composite material along with glass flakes or glass fiber mats, fiberglass, as the filler. A typical application of vinyl or polyester composite coatings is lining or reinforcing of fuel tank bottoms.

2.3.5.2 Phenolic or Novolac Epoxy Coatings

Thick film coatings based on phenolic epoxy are quite common. They cure by acid reaction which is sometimes accelerated with heat. Application is normally by spray. Phenolic epoxy coatings have very strong resistance to heat, acids, bases and solvents. Phenolic epoxy coatings are so named because they were originally based on a resin component called bis-phenol A. Commonly specified as tank coatings in the transportation field, phenolic epoxy paints havelittle use in marine painting.

Thick film coatings based on novolac resins are becoming more common. Novolac epoxies are often the base for 100% solids materials chosen when high chemical or heat resistance is needed. These coatings will sometimes use extensive fillers like silica or graphite. Some novolac coatings are applied by spray, heavily filled novolac coatings may need trowel application.

2.3.6 Uses for Different Paint Materials

The following table, 2.2, summarizes when common kinds of coatings are used. Note the very wide type of coating products which the painter is asked to know how to use. Not all the exposure conditions listed in the table are found on board a ship. Still, the conditions on a ship are varied enough that most of the listed coating types are found. These notations are used in the table.

* Consult the individual specifications for additional details. This table shows all materials found or used on ships.
** With proper sealing or topcoating
1. This condition is rarely encountered on ship.
2. Consult with manufacturer.

Table 2•2: GENERIC PAINTING SYSTEMS FOR ENVIRONMENTAL ZONE

Zone Conditions/	Painting	System	Suggestions *	
Dry Sealed Interior Space 1	One-coat Shop Paint	Leave unpainted.		
Dry Interior Exposed	Alkyd	Urethane	Chl. Rub.	Latex
	Phenolic	Zinc-Rich	Silicone Alk.	Thermal Spray
	Vinyl	One-coat Shop Paint		
Exterior Dry Exposure -1	Oil Base	Zinc-Rich	Urethane	Thermal Spray
	Alkyd	Chl. Rub.	Latex	Silicone Alk.
	Phenolic			
Frequently Wetted by Fresh Water	Phenolic	Urethane	Chl. Rub.	Asphalt Mastic
	Vinyl	Zinc-Rich	Silicone Alkyd	Thermal Spray

Table 2•2: GENERIC PAINTING SYSTEMS FOR ENVIRONMENTAL ZONE

Zone Conditions/	Painting	System	Suggestions *	
Fresh Water Wet - Ctd	Epoxy	Latex	Coal Tar Epoxy	
Frequently Wet by Salt Water	Vinyl	Zinc-Rich**	Urethane	Thermal Spray**
	Epoxy	Latex	Chl. Rub.	Coal Tar Epoxy
	Asphalt Mastic			
Fresh Water Immersion	Vinyl	Chl. Rub.	Zinc-Rich**	Coal Tar Epoxy
	Epoxy	Coal Tar Mastic	Thermal Spray	
Immersed in Sea-Water	Vinyl	Zinc-Rich**	Chl. Rub.	Thermal Spray**
	Coal Tar Epoxy	Anti - Fouling Coating		
Acid Exposure Chemicals	Vinyl	Zinc-Rich**	Chl. Rub.	Thermal Spray**

Table 2•2: GENERIC PAINTING SYSTEMS FOR ENVIRONMENTAL ZONE

Zone Conditions/	Painting	System	Suggestions *	
	Epoxy	Urethane	Latex	Coal Tar Epoxy
Neutral Exposure Chemicals	Vinyl	Chl. Rub.	Latex	Coal Tar Epoxy
	Zinc-Rich**	Urethane	Epoxy	Asphalt Mastic
	Coal Tar Mastic	Thermal Spray**		
Alkaline Exposure to Chemicals	Epoxy	Zinc-Rich**	Chl. Rub.	Thermal Spray**
	Urethane	Latex	Coal Tar Mastic	Coal Tar Epoxy
	Asphalt Mastic			
Mild Exposure to Solvents	Epoxy	Latex		
Severe Chemical Exposure	2			

The next table shows common specification materials for marine coating work.

Table 2•3: Common Coatings for Navy Work

PART OF THE SHIP	NAVY WORK Preferred Coating	NAVY WORK Alternates Coating
Underwater Hull	NAVSEA approved proprietary	Formulas 150, 151,154 and 121
Rudders and Struts	Formula 150 and 3M Co. EC 2216	
Anti-Fouling	Formulas 15HPN, 105 and 134	
Boottop	Formulas 150, 151, 154 and 129	NAVSEA approved proprietary
Above Boottop	Formula 150, 151 and MIL-E-24635	Formula 117, 84 and MIL-E-24635
Exterior Topside	Formula 150, 156 and MIL-E-24635	NAVSEA approved proprietary
Decks	Formula 150 MIL-D-24483	Formula 84 and 20L or 23
Non-Slip Deck	MIL-D-23003 and MIL-D-24483	
Superstructures	Formulas 150 - 156	Formula 84 or 84D
Anchor and Chain	Formulas 150, 151 and 153	TT-V-51

PART OF THE SHIP	NAVY WORK Preferred Coating	NAVY WORK Alternates Coating
Exterior Piping	Formulas 150, 151 and MIL-E-24635	Formula 84 and MIL-E-24635
Hatch Covers	Formulas 150 - 156	NAVSEA approved proprietary
Emergency Bouys	Formulas 150 - 156	NAVSEA approved proprietary
Cables/Wire Rope	NAVSEA approved proprietary	
Messenger Buoys	Formulas 150 and MIL-E-24635	
Ballast or Bilge Tanks	NAVSEA approved proprietary	Formulas 150, 151 and 152
Fuel Tanks	Formulas 150, 151 and 152	MIL-P-23236, Class 1 or 4
Sanitary Tanks	Formulas 150, 151, 156, 152	DOD-P-23236, Class 2
Potable Water	NAVSEA approved proprietary	Formulas 150, 156 and 152
Interior Hulls	MIL-C-16173	
Engine Room	Formula 111	
Equipment	Formula 111	NAVSEA approved proprietary

PART OF THE SHIP	NAVY WORK Preferred Coating	NAVY WORK Alternates Coating
Machinery	Formulas 84 and 111	
Small Steel Plate / Structural Sections	Formulas 150 - 156	NAVSEA approved proprietary
Wheels and other metallic mechanical devices	Formulas 150 - 156	
NAVSEA approved proprietary		
Bulkheads	Formulas 150 and 152	Formulas 84 and 124
Fire Stop Bulkheads	MIL-C-46081	
"Heated" Steel	DOD-P-24555 (SH)	TT-P-28
Boiler Tubes	Aluminum Metallizing*	
Motors/Housing Electrical	TT-P-28	DOD-P-24555
Steam Pipe Internal	TT-P-28	DOD-P-24555
Antisweat (topcoat)	Formula 134 and HH-I-585,Type III, Class 2	TT-C-492

PART OF THE SHIP	NAVY WORK Preferred Coating	NAVY WORK Alternates Coating
Smoke Pipes	TT-P-28	
Valve and Valve Body	NAVSEA approved proprietary	Aluminum Metallizing*
Motor Foundations	Aluminum Metallizing*	
Electrical Boards Printed Circuits	Formula 111	
Inaccessible Voids	MIL-P-21006	
Aluminum surfaces	MIL-P-23377, Formula 151 and MIL-E-24635	
Formulas 150, 151 and MIL-E-24635		
Antennae - Aluminum	Formulas 150 and 152	Formulas 150, 151 and MIL-E-24635
Wind Detectors	Formulas 150 and 152	NAVSEA approved proprietary
Radomes	Formula 151	NAVSEA approved proprietary
Antennae - Fiberglass	Formula 124	Formulas 124 - 126

PART OF THE SHIP	NAVY WORK Preferred Coating	NAVY WORK Alternates Coating
FRP Domes and other composite surfaces	NAVSEA approved proprietary	
Stainless Steel Surfaces	NAVSEA approved proprietary	
Wood	TT-V-119	TT-P-320 with Formula 80, and Formula 20
Rubber Surfaces	Formulas 133 and 134	
Masonry Surfaces	Formulas 150 - 156	NAVSEA approved proprietary
Concrete Surfaces	Formulas 150 - 156	NAVSEA approved proprietary

The next table shows some of the coating system choices made for commercial work.

Table 2•4: Coating Systems for Commercial Work

PART OF THE SHIP	COMMERCIAL Preferred	COMMERCIAL Alternate
Underwater Hull	Catalyzed Epoxy	Coal Tar Epoxy, Chlorinated Rubber, IOZ (primer)
Rudders and Struts	Catalyzed Epoxy	Coal Tar Epoxy
Anti-Fouling	Proprietaries	
Boottop	Catalyzed Epoxy	Coal Tar Epoxy, Urethane, IOZ (primer)
Above Boottop	Catalyzed Epoxy	Urethane, Zinc-Rich
Exterior Topside	Catalyzed Epoxy	Urethane, Alkyd, IOZ
Decks	Catalyzed Epoxy	Urethane, Alkyd, IOZ, Alkyd/Phenolic
Non-Slip Deck	Epoxy	
Superstructures	Catalyzed Epoxy	Urethane, Alkyd, IOZ, Alkyd/Phenolic
Anchor and Chain	Epoxy, Coal Tar Epoxy	Zinc-Rich
Exterior Piping	Catalyzed Epoxy	Urethane, Alkyd
Hatch Covers	Catalyzed Epoxy	Urethane

Table 2•4: Coating Systems for Commercial Work

PART OF THE SHIP	COMMERCIAL Preferred	COMMERCIAL Alternate
Emergency Bouys	Catalyzed Epoxy	Urethane
Cables/Wire Rope	Proprietary	
Messenger Buoys	Catalyzed Epoxy	Urethane
Ballast or Bilge Tanks	Catalyzed Epoxy	Coal Tar Epoxy, Urethane
Fuel Tanks	none	Catalyzed Epoxy, Urethane, Coal Tar Epoxy
Sanitary Tanks	Catalyzed Epoxy	IOZ (primer)
Potable Water	Catalyzed Epoxy	IOZ (primer)
Interior Hulls	Catalyzed Epoxy	Coal Tar Epoxy, Urethane, IOZ (primer)
Engine Room	Alkyd	Epoxy, Urethane
Equipment	Alkyd	
Machinery	Alkyd	Epoxy, Urethane
Small Steel Plate / Structural Sections	Catalyzed Epoxy	Urethane

Table 2•4: Coating Systems for Commercial Work

PART OF THE SHIP	COMMERCIAL Preferred	COMMERCIAL Alternate
Wheels and other metallic mechanical devices	Catalyzed Epoxy	
Proprietary		
Bulkheads	Catalyzed Epoxy	Urethane, Alkyd, IOZ, Alkyd/Phenolic
Fire Stop Bulkheads	Fire Resistant Coating	
"Heated" Steel	Aluminum Silicone	IOZ
Boiler Tubes	Aluminum Metallizing	
Motors/Housing Electrical	Fire Resistant Coating	
Steam Pipe Internal	Fire Resistant Coating	
Antisweat (topcoat)	Proprietaries	
Smoke Pipes	Fire Resistant Coating	
Valve and Valve Body	Proprietaries	Aluminum Metallizing

Table 2•4: Coating Systems for Commercial Work

PART OF THE SHIP	COMMERCIAL Preferred	COMMERCIAL Alternate
Motor Foundations	Aluminum Metallizing	
Electrical Boards Printed Circuits	Alkyd	
Inaccessible Voids	Flotation coating	
Aluminum surfaces	Catalyzed Epoxy	
Antennae - Aluminum	Catalyzed Epoxy	
Wind Detectors	Catalyzed Epoxy	
Radomes	Catalyzed Epoxy	
Antennae - Fiberglass	Chlorinated Alkyd	
FRP Domes and other composite surfaces	Catalyzed Epoxy	
Stainless Steel Surfaces	Proprietaries	
Wood	Epoxy	Alkyd, Phenolic, Urethane

Table 2•4: Coating Systems for Commercial Work

PART OF THE SHIP	COMMERCIAL Preferred	COMMERCIAL Alternate
Rubber Surfaces	Proprietaries	
Masonry Surfaces	Catalyzed Epoxy	Urethane
Concrete Surfaces	Catalyzed Epoxy	Urethane

2.4 Painting Application

From the above sections one can see a painter will use a bewildering number of coating types. Luckily the types of application methods facing the painter are far fewer. Application methods fall into three general classes, spray application, brush or roller application and, application by trowel or squegee. The sections following will outline some information about each application method. There are also some tasks the painter must performbefore applying the paint.

2.4.1 Actions by the Painter with the Inspector

This section will outlinesome key tasks of the painter and painter's interactions with the inspector. The details of the actual task can be found in the instructions supplied by the manufacturer or from an appropriate standard or specification. For example, the label on the paint can or the product data sheet supplied with the paint gives information on thinning, drying time, etc. A paint thickness gage is to be used according to the manufacturer's instructions and in agreement with the standard SSPC-PA 2.

In most cases, both the painter and the inspector should see that the job is done right, according to the specifications. If something unusual should occur, the painter and the inspector should resolve the issue before continuing. For most jobs, the following checklist should be helpful.

2.4.1.1 Tasks Before Applying Paint

Materials

1.Is the correct paint on the job?
2.Are the containers in good condition (lids tight, labels intact, etc.)?
3.When was the paint manufactured? If the paint is beyond shelf life, get the manufacturer or the specifier to certify that the paint is suitable for use.
4. Is the paint from the same batch ? This is important if a special color is specified.
5.Use the oldest stock first. Discard paint which has livered, gelled, or otherwise deteriorated.

Surface Preparation

6.Does the condition of the surface meet the specification at the moment you are applying the paint? If a rust bloom has occurred, prepare the surface again. The blast cleaning specification is in effect when the paint is applied. Because the surface was blasted to white metal in the morning does not guarantee that it will still be white metal in the afternoon. The inspector will decide if the surface meets specifications.
6.1Is a profile range specified? If so, the inspector will measure the profile of the blasted steel. Surface profile is measured with Testex tape or a micrometer, it is estimated with a Keane-Tator comparator. (See Figure 2•1: below).
7.When overcoating, does the existing paint need a special preparation (solvent wipe or brush blast)?

Figure 2•1:Making sure profile is correct for painting

Pretreatment

8.Is a chemical pretreatment specified? If so, let the chemical reaction finish and the surface dry before applying the primer.

Mixing and Thinning

9.The paint must be mixed well. Pigments or other heavier materials will fall out of suspension. For typical solvent-bome coatings, mix the paint by hand or with a mechanical mixer until a uniform consistency is obtained.
9.1 Paints like alkyds or latex can form skins in the can. Carefully remove skins before mixing.
9.2.With two package paints, e.g. epoxy, mix each component separately to a uniform consistency before they are blended together. Always mix multi-component paints in the proper proportion. Most manufacturers try to deliver "kits" with pre-measured components in a 1:1 ratio. Despite this the painter cannot assume a 1:1 ratio. Some coatings like urethanes have unusual mix ratios closer to 4:1.
9.3 Another complication with two-component paints is sweat-in time. Common Navy specification paints like MIL-P-24441 epoxy need an hour or more of sweat-in time. Sweat-in is a time after initial mixing when reactions begin to take place in the coating. Without sweating-in the coating film will not cure well.
9.4 Metallic pigmented coatings like zinc-rich primer need continu-

ous mixing. Without continuous mixing needed pigment falls out of suspension. This is done with a special agitated paint pot.
10.Thin paint only when necessary. In such cases use only the thinner recommended by the manufacturer. A solvent suitable for clean up may not be a good thinner.
10.1If two package paints start to thicken because the pot life has been exceeded, they should be discarded. Do not thin. On very hot days the pot life is much shorter than on a cool day.
10.2 Unused portions of two package paints should be discarded at the end of the work day. Reduce waste by only mixing as much paint as you will need in a work shift. Never mix more paint than one can apply by the end of the pot-life.

Factors Affecting Application of Paints
11. Temperature: In general, the temperature of the steel, the paint and the air should be above 40° F. For chemically cured paints (certain epoxies, urethanes, zinc-riches, etc.) the temperature required could be above 55° F. Some special coatings can be applied below 32° F.
12. Moisture: Do not apply paint in rain, high wind, snow, fog or mist. If the steel temperature is at least 5 F° above the dew point, moisture is less likely to condense on the steel surface. The inspector will tell the painter if conditions are clear to paint.
The inspector will use a sling psychrometer or other suitable instrument and appropriate tables to measure the dew point. The dew point is the temperature where water condenses on a surface.
An inspector will use a surface thermometer to measure the temperature of the steel surface.
13. Humidity: Some paints, e.g. zinc rich, water-borne and urethane, will not cure properly if the relative humidity is too high or too low. In extreme humidity conditions, make sure the coating has cured properly before applying the next coat. An unacceptable humidity range may lead to surface imperfections such as bubbling.

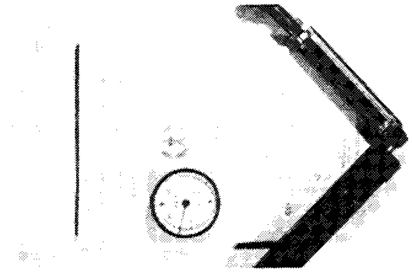


Figure 2•2:Instruments Used to Decide if Conditions are Good for Paintin, Sling Psychrometer for RH readings & Surface Temperature Thermometer

14. Cover: If a cover or enclosure is used during bad weather, the conditions inside the cover must agree with specifications.
15. Striping: Determine if the specification requires edges, bolts, rivets, corners, crevices and welds receive an extra coat of primer. This striping can be done before or after the first full coat of primer is applied.
16. Tinting: If successive coats of the same paint are to be applied, alternate coats of paint can be tinted. This is a practical means to help the painter get complete coverage.

Thickness Targets

17. The painter and inspector must agree on the wet film thickness needed to get a desired dry film thickness. Target wet film thickness will depend on paint solids. Total paint solids is affected by the amount of thinning done by the painter. To help the inspector the painter must be able to tell how much thinning has been done. For example an 80% solids paint, thinned by one pint per gallon to 70% solids requires one more wet mil to get a 5 mil thick film.
17.1 When applying the prime coat over blasted steel, the wet film thickness may have to be thicker than the calculated value to allow for paint filling the profile.

17.2 Wet film thickness is measured with a notch gage.
17.3 Wet film thickness cannot be so great that sagging occurs. If the painter notices sagging before he gets the target wet film thickness this may call for multi-coat applications.
17.4 Some paints like vinyls or zinc-rich coatings dry so fast they do not allow wet film thickness measurement.

2.4.2 PAINT APPLICATION METHODS

1. Most paint is applied by brush, mitt, roller or spray. Some paints have restrictions on the type of application method that may be used. Make sure you use an acceptable method.

Table 2•5: Application Methods for Different Paints

Paint	BRUSH	MITT	ROLLER	AIR SPRAY	AIRLESS SPRAY
Alkyd	Y	Y	Y	Y	Y
Latex	Y	Y	Y	Y	Y
Phenolic	Y	Y	Y	Y	Y
Epoxy	Y			Y	Y
Urethane	Y	Y	Y	Y	Y
Vinyl				Y	Y
Chlor. Rubber				Y	Y
Coal Tar Epoxy	Y			Y	Y

Table 2•5: Application Methods for Different Paints

Paint	BRUSH	MITT	ROLLER	AIR SPRAY	AIRLESS SPRAY
inorganic Zinc-Rich				Y	Y
Organic Zinc-Rich	Y	Y	Y	Y	Y
Oil Base	Y	Y	Y	Y	Y

Footnote 1: "Y" means this method good for the indicated paint.

2.4.3 Information on Application Methods

2.4.3.1 Brush, Mitt, and Roller

If a brush, mitt or roller is chosen as the method of application, make sure that the style, nap, size, etc. are correct for the paint and the surface.

2.4.3.2 Air Spray

Check that air caps, nozzles and needles are those recommended by the paint manufacturer for the spray equipment being used.
Check that the traps and separators are working properly by testing the cleanliness of the air supply. Air from the spray gun impinging against a clean surface should show no oil or water.
Adjust the air pressure and the pot pressure to get a good spray. Do not use more pressure than necessary.
Adjust the spray tip to produce a uniform fan of spray.
Remember your safety precautions, for example, you must wear a respirator and goggles.

Figure 2•3:Typical brush and roller application

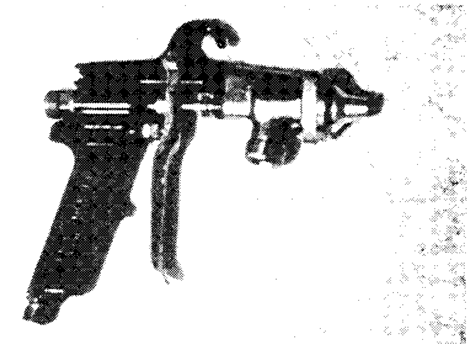


Figure 2•4:Conventional Air Spray Gun

2.4.3.3 Airless Spray

Check that fluid tips are those recommended by the paint manufacturer for the spray equipment being used.

Adjust the air pressure to the paint pump and the paint pressure to

get a good spray. Do not use more pressure than necessary.
Be sure that an electric ground wire runs from the gun to the pump. Check that the pump is grounded. Never point an airless spray gun at yourself or another person. Airless spray guns can inject paint under the skin.

2.4.3.4 Special Spray Application

In some circumstances, hot air spray or hot airless spray is recommended. Follow the checklist for air spray or airless spray.
If the pot life of a 2-package paint is very short, a special nozzle may be used to mix the two components at the nozzle. Follow the manufacturer's instructions for this type of plural component spray application.

2.4.4 ACTIONS DURING APPLICATION

2.4.4.1 Checking for Application Quality

Depending on yard policy, either the painter or the inspector will measure wet film thickness in several places soon after application begins. If the wet film readings are incorrect then adjust your spray pattern accordingly.

The painter must make sure that spraying is not done too far from the surface. Large gun to surface distances will lead to dry spray or overspray. Spray with ventilating air to your back. This spreads overspray into the unpainted area.

Spray passes should overlap because more paint is applied in the center of the spray cone than the outer edges. Some high solids coatings require multiple passes to achieve high film build. A cross-hatch spray pattern is preferred to limit the amount of pinhole formation.

For brush application the painter must remember to work the paint into crevices and around bolted connections. Make multiple strokes to reach your target film thickness.

Table 2•6: Air Spray Patterns to Avoid

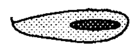
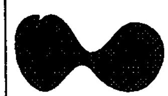
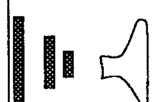
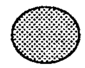
Pattern	Cause	Correction
	1. Dry Paint in side port of air nozzle	Dissolve paint in side hole with thinner. Do not use probes harder than brass in air nozzle.
 Heavy Side Center	1. Fluid build up on side of fluid nozzle. 2. Damaged fluid nozzle	1. Remove air nozzle, wipe off fluid nozzle. 2. Replace damaged fluid nozzle.
 Hourglass	1. Air pressure too high. 2. Spray pattern too wide. 3. Fluid pressure too low	1. Lower air pressure. 2. Lower fan width. 3. Increase fluid supply.
 Heavy Center	1. Air pressure too high. 2. Fluid supply too high.	1. Increase air pressure. 2. Use smaller tip or lower fluid pressure.
 Spitting	Air is entering fluid supply at: a. Loose fluid nozzle b. Loose packing/ packing nut c. Loose fluid connection.	a. Tighten nozzle or clean nozzle seat area. b. Tighten packing nut or replace bad packing. c. Tighten all fluid connections to spray gun.

Table 2•7: Airless Spray Patterns to Avoid

Problem	Cause	Solution
 Tailing	1. Not enough fluid. 2. Poor atomizing 3. Low fluid velocity. 4. Material too thick.	1. Raise fluid pressure. 2. Go to a smaller tip size. 3. Thin or heat the paint. 4. Clean gun and filters. (5). Lower no. of guns at pump. 6. Check sapphire insert is matched.
 Heavy	1. Worn Tip 2. Fluid won't spray with airless.	1. Replace tip 2. Change to air spray method.
 Odd Shape	1. Plugged or worn nozzle tip.	1. Clean or change nozzle tip.
 Surging	1. Pulsing fluid delivery. 2. Low air supply to pump. 3. Leak in suction tube. 4. Pump capacity too low. 5. Paint too thick.	1. Go to smaller tip size. 2. Drain pulsation chamber or add new one. 3. Reduce no. of guns. 4. Raise air supply. 5. Clean or remove screens & filters; use bigger hose/pump. 6. Check tube for leak. 7. Thin the paint.

Table 2•7: Airless Spray Patterns to Avoid

Problem	Cause	Solution
 Round	1. Worn Tip. 2. Fluid too heavy for tip. 3. Fluid will not spray with airless.	1. Replace worn tip. 2. Raise fluid pressure. 3. Thin the paint. 4. Change nozzle tip. 5. Install sapphire insert. 6. Go to air spray.
 Hour-Glass	1. Fluid too cohesive - like glue. 2. Cannot spray paint with airless.	1. Raise fluid pressure. 2. Thin material. 3. Install sapphire insert. 4. Go to air spray.

Some guidelines for improving spray quality are given in Table 2•6, "Air Spray Patterns to Avoid," on page 37 and Table 2•7, "Airless Spray Patterns to Avoid," on page 38. Shown below are ideal air and airless spray patterns.

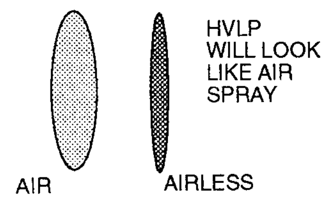


Figure 2•5: Correct Spray Patterns for Air and Airless Spray

2.4.4.2 Clean-up of Application Equipment

At the end of a painting shift the application equipment is cleaned according to the manufacturers instructions. For air spray equipment thoroughly clean all parts of the spray-gun with a compatible solvent. Airless spray equipment demands complete cleaning of fluid feed lines and gun-tips. It is essential that spray equipment is kept in good working order. Inadequate clean-up will greatly lower production rates in subsequent applications.

2.4.5 Special Precautions

2.4.5.1 Tocoating of Zinc-Rich Coatings

A zinc-rich coating may be dry to touch but may not be cured enough to topcoat. The painter must not topcoat a zinc-rich primer before it is cured. Most of the zinc-rich primer a shipyard painter will encounter is preconstruction primer. Normally this will have had more than enough time to cure. If in doubt, the inspector can decide if the primer is ready for topcoating by a coin or solvent rub test.

2.4.6 PROBLEM & SUGGESTED REMEDIES

The following is a list of some commonly encountered application problems. It is far from from being all inclusive. If the painter encounters a problem not described below then consult the coating manufacturer.

Typical problems a painter can encounter with any coating are dry spray,, runs or sags in the paint, pin holes and fish eyes, and poor cure of a coating. With zinc-rich coatings the painter will also have to control coating thickness to avoid mudcracking.

Table 2•8, "Common Problems and Their Remedy," on page 41 describes how to tackle these common problems. More difficult to detect are problems caused by inadequate drying of a coating. One end result of inadequate drying is solvent trapped between layers of a coating system. This can lead to dramatic blistering failures in tank linings. The painter can help control this type of failure by keeping to recoat windows and schedules.

Table 2•8: Common Problems and Their Remedy

Problem	Possible Remedies
Dry spray	Add thinner.
	Move the gun closer to the work.
	Wait for cooler temperature.
Runs and sags	If caught when wet, runs and sags can be brushed out.
Runs and Sags Ctd.	Apply a mist coat first, then the full coat.
	Do not thin the paint as much.
	Apply less paint per coat.
Pin holes and fish eyes	Check for oil or grease on the surface.
Mudcracking	Blast off defective area and reapply paint.
	Do not exceed maximum thickness recommended.
Epoxy will not dry	Wait for the temperature to rise above 55° F.
Zinc will not cure	If the weather has been very dry, spray the coated surface with water.

2.4.7 Comparison of Different Spray Methods

Each spray method uses different equipment set-ups. Some more common set-ups are shown in the figures below. The most common types of equipment will be air spray or airless spray equipment. Air spray is the method most painters are familiar with using. Airless spray is now more used as it is suited to modern heavy bodied low-VOC coatings.

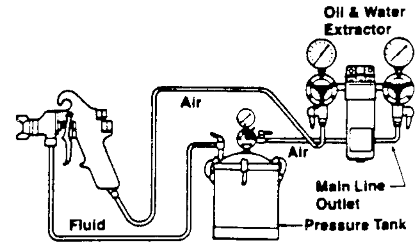


Figure 2•6:Typical Air Spray Equipment

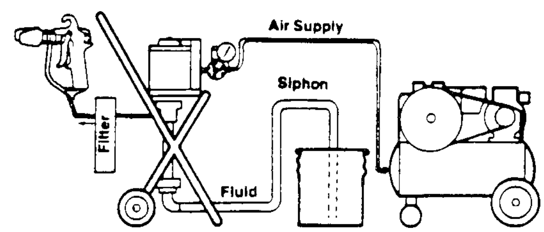


Figure 2•7:Typical Airless Spray Equipment

In addition to typical air spray or airless spray set-up a painter may use High Volume Low Pressure Equipment, HVLP Spray. This is similar to air spray with the main difference that HVLP produces much less rebound and fog. There is a net improvement in transfer efficiency, the fraction of sprayed paint that actually reaches the surface.

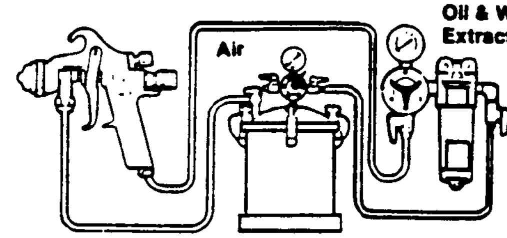


Figure 2•8:Typical HVLP Spray Equipment

Each of the three most common methods of spray application are suited to different types of coating materials.

Air Spray

Air Spray is the original method of spray painting, it is also called conventional spray. Air spray can apply most lower viscosity coating systems. It is not suited to application of very thick bodied, solvent-borne low VOC systems. Air spray is very wasteful of paint, as little as one-third of the sprayed paint will stick to the painted surface. Air spray has very low transfer efficiency, TE.

Airless Spray

Most coatings which apply with conventional spray will apply with airless spray. Airless spraying is also good for most of the thick bodied, low-VOC coatings on the market today. Productivity with airless application is often higher than air spray. This productivity comes at a price. The painter has to become skilled in airless spray application. It is very easy to apply too much paint in a small area with airless spray, because the fan from airless spray is much narrower than air spray.

Water-borne coatings may pose a different application problem with airless spray. Though often thick bodied, water-borne coatings will apply as thinner films. To achieve good film build the painter must apply the coating in multiple passes, building up the film with each pass. Airless spray can give higher TE than air spray.

High Volume Low Pressure, HVLP, Spray
HVLP spraying requires less training than airless spray because the equipment behaves a little like air spray equipment. There are some limits to HVLP equipment but also some clear benefits. HVLP equipment does not produce a great deal of wasted coating, it has the highest TE of any non-electrostatic method. Up to two-thirds of the applied coating reaches the surface. HVLP produces little fog or rebound spray because the fluid is forced from the spray nozzle at lower speeds than either air or airless spray. HVLP has difficulty in atomizing some heavy body low VOC coatings.

Electrostatic Spraying
All the above methods of spraying can be used with electrostatic application. For current marine coating electrostatic spraying is not often encountered. Coatings for electrostatic spraying can require special pigments, possibly incompatible with other desirable coating qualities. Pigment substitution by the manufacturer could overcome this problem. A more dfficlcult problem is the Faraday cage effect. When spraying into voids or recesses a counter charge can build up. This would prevent the coating from reaching the surface. As voids, recessess and enclosed spaces are found everywhere on a ship this limits uses for electrostatic spraying in marine coating. Electrostatic spraying will coat all sides of irregular shapes evenly, a "wrap-around effect of the method.

Transfer Efficiency
A measure of the amount of sprayed paint that sticks to the surface, transfer efficiency, TE, is an important factor in spray coating. A high TE application method is desired when the aim is to limit coating waste. A high TE method can also be compatible with high pro-

ductivity of coating application. In some areas of the country a high TE method benchmark has been established. A painter may have to become trained in high TE applications as marine VOC rules tighten across the country. A summary of TE levels for different methods is shown in Figure 2•9: on page 45

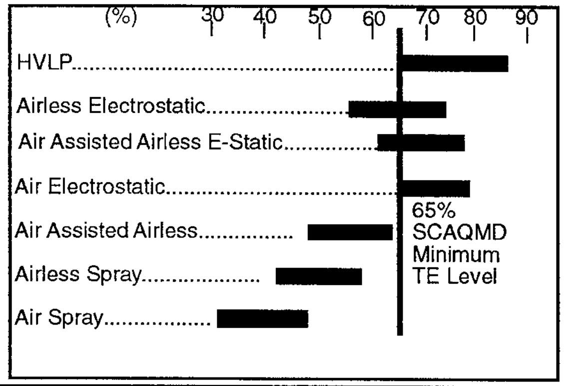


Figure 2•9:Comparing Transfer Efficiency of Spray Methods

3. HOUSEKEEPING

3.1 Introduction

This chapter provides a general review of housekeeping related to surface preparation and painting. Housekeeping refers to maintaining a surface preparation and painting work environment that:
•protects personnel from accidental exposure to hazardous materials and unsafe conditions
•protects the structures from damage
•ensures that operations do not violate environmental regulations.

GOOD HOUSEKEEPING IS SYNONYMOUS WITH SAFETY.

3.2 General Housekeeping Rules.

General Rules are posted notices that clearly describe to all workers the shipyard requirements for:

a.Workplace cleanliness
b.Storage, transportation, and disposal of hazardous materials
c.Hazardous material or waste spills
d.Location of information related to material hazards (Material Safety Data Sheets)

3.3 Housekeeping Requirements

This paragraph will discuss those aspects of industrial housekeeping applicable to both surface preparation and painting. This paragraph will not discuss those aspects of housekeeping required of facilities to assure compliance to building, fire, OSHA or environmental codes, laws or regulations.

You should take the following actions in any workarea to assure good housekeeping.

(a)Management should post housekeeping requirements in the work area. Supervisors should delegate duties to personnel for work space housekeeping. For example, assign individuals the responsibility for shift or job end inspection tours of the work area. They should assure that:

•all hazardous materials are properly stowed,
•debris has been picked up and disposed of properly,
•all hazardous wastes have been disposed of in the appropriate waste container and,
•if appropriate, utilities (compressed air lines and electrical service), equipment and structures are secured.

(b) Materials -
•Bring only that material which will be used during the work shift into the work area.
•Containers of liquid or hazardous materials should be kept closed. Keep flammable solvents in the work in small (less than 5 gallon), self closing, vented steel containers.
•Cover or seal open paint containers or mixing facilities when not in use. Hazard communication, (warning) labels on containers must be easily read. Replace damaged warning labels. Hazard warning labels should always reflect the actual container contents. If the can contents change, then change the hazard warning label.

•If hazardous materials are spilled, perform cleanup as required by the Material Safety Data Sheet (MSDS) for the product quickly and carefully. •Cleanup of small solvent or paint spills sometimes wait until immediate work permits cleanup.
•Larger spills of solvent or paint that can spread to other areas need immediate clean-up. Large spills are diked or covered with absorbent materials. Clean up very hazardous material spills immediately according to the directions on the MSDS. (See Section 4.)

(c) All work areas should have metal waste containers appropriate to the waste generated. Typical categories of waste are hazardous

liquid flammable waste, hazardous solid waste and nonhazardous waste.
•Use self closing, flammable hazardous liquid metal waste containers for used clean-up solvents and excess materials that are waste.
•Provide separate waste containers for solvent, excess paint, and paint cans, either emptied or with less than one inch of paint.
•Label waste containers with hazardous waste warning labels. If waste is flammable the waste containers must have flammable warning placards or stenciled labeling.
•Flammable liquids have a flash point of less than 140°F (60°C). Almost all solvents many solvent based paints used by painters can fit this description.
•Provide a log and require all persons disposing of hazardous wastes to list the material name, estimate of quantity, date and the individual's initials or name.
•There should be an established schedule of periodic pickup of hazardous waste from shops. Waste is then transported to the shipyard collection point for disposal. Collection intervals for hazardous waste pickup will vary with quantity generated, but must not exceed that allowed by law. Shop sites should clear hazardous waste to the shipyard collection point at a maximum of every 30 days.
• To reduce disposal problems and costs, employees should not mix hazardous and nonhazardous wastes.

(d) Personnel must keep all accesses and passageways in the work area cleared.
•Supervisors should immediately require removal of anything restricting passage on fire escape routes or obstructing access to fire alarm stations or fire extinguishers.
• Neatly run and secure all temporary services, compressed air lines, electrical cables, and ventilation ducting. This practice will help to prevent obstruction or tripping hazards.

(e)Supervisors should inspect new job sites before work begins

and permanent sites periodically to ensure that all necessary housekeeping equipment is on hand and posted information is accurate.
•Cleaning equipment includes: brooms, mops, rags, spill clean-up kits and absorbent materials, high efficiency particulate air (HEPA) filtering vacuum cleaners and waste containers.
•Dispose of collected debris and HEPA as hazardous waste.
•Never use compressed air to clean clothing being worn or to clean up the work site.

3.4 Surface Preparation Housekeeping

Surface preparation for the average painter will involve doing many cleaning related operations. In shipyards, surface preparation can require the use of abrasive blasting equipment, mechanical surfacing equipment, solvents or chemicals to achieve a required level of surface cleanliness and profile. Each of these approaches to surface preparation has unique housekeeping requirements.

3.4.1 Abrasive Blasting

The basic principle of housekeeping for abrasive blasting operations is containment of abrasive blasting media, dust and debris. Abrasive media, being large and dense is not difficult to contain. The fines and dust from abrasive blasting pose a more dfficult challenge.

Abrasive fines or dust are generated by:

(a) fines in the abrasive,
(b) abrasive media shattering on the surface being blast cleaned,
(c) the paints or other materials removed from a surface by abrasive blasting.

The dust is dispersed widely by the ventilation sources, the compressed air being used and outside by winds. Prompt removal of debris restricts dispersal of what is almost certainly hazardous waste.

You can help reduce housekeeping problems by carefully choosing the abrasive. For example, if steel grit or MIL-A-22262 conforming media are used, dust from new grit spilled during storage, transporting or loading hoppers is merely a nuisance dust not a hazardous waste. Painters should request a determination from the shipyard compliance office to classify new steel grit and MIL-A-22262 abrasive blast media as a nonhazardous material for storage and disposal purposes. For housekeeping purposes, consider all other sources of abrasive blast media hazardous until told otherwise. Test all used abrasive blasting debris containing paint residue from known hazardous or unidentified paint as hazardous waste. Be aware of the storage, transportation, spill cleanup and disposal requirements of the specific media you are using.

Good housekeeping dictates that abrasive blasting media storage must be closed and covered to prevent rain water or wind from spreading the media. (Rain can also leach contaminants onto surrounding land or into surface waters.) All transportation of abrasive blasting media should be in closed containers. To limit spillage, load hoppers in the storage area, seal to prevent spills during transport, and dump abrasive directly into pressure pots. Load used abrasive into sealable containers and transported to the shipyard hazardous waste storage sites. If the used media is hazardous, any spills are hazardous spills. These spills will need to be cleaned up.

3.4.2 Abrasive Blasting in the Shop.

In the shop environment, good housekeeping requires use of those engineering controls such as small closed blast booths or large steel shot ("Wheelabrator") cabinets with negative pressure draft dust collectors. Blast cabinets will be equipped with dust collectors such as a tornado separator or a dust bag house. Each of these units must be checked regularly (frequency depends on type, capacity and work load) and dust loaded into sealable collector drums. Spills of abrasive media should be cleaned immediately, preferably with a HEPA filtering vacuum cleaner. You should transfer this material to the shop container for solid hazardous waste. Unused MIL-A-22262 abrasive would not usually be considered a nonhazardous solid waste, but direction at individual shipyards may vary. All items blast cleaned in a booth must be blown down with compressed air before removal from the blast cabinet to prevent dragging out of hazardous dust into the shop. Instruct personnel operating blasting cabinets to observe for leakage around doors and other openings and report the cabinet for repair if necessary. Used steel shot ("Wheelabrator") media requires the same treatment as other used abrasive and must not be disposed of without determining if it is hazardous.

3.4.3 Abrasive Blasting in the Field.

Housekeeping during field blast cleaning operations has some unique requirements. Because field blast cleaning in shipyards is "open," often unconfined, plate blasting in dry docks or on waterborne berthed ships, housekeeping by painters must ensure that:

(a) the dust generated does not create a visible dust plume that violates air quality management regulations; and

(b) dust does not blow into the structure being blasted, surrounding shipyard buildings, or neighborhoods, exposing unprotected people to hazardous dust or contaminating the structures.

For the most part, large steel shot ("Wheelabrator") units have replaced field blasting of plate. But, if encountered, good housekeeping requires temporary containment to confine media and dust, and that used media be cleaned up quickly.

Unconfined blast cleaning in the dry dock of the underwater hull structure is unavoidable. Good housekeeping for U.S. Navy contracts requires protection of equipment, control boxes or electrical service from dust intrusion and covering or plugging of underwater hull openings. Before blasting or painting cover or turn off vents to the interior of the vessel. Use of wet blasting can control dusting but will create runoff. Good housekeeping requires the construction of dams to prevent water run off, collection of the water for analysis to learn if the water is a hazardous waste and, finally, disposal. If the water waste meets the discharge requirements of the dry-dock discharge NPDES permit, it can be discharged by the dry-dock pump. If the water waste does not meet discharge permits then pump or vacuum the water into tanks for hazardous waste disposal. The wet dust is also a hazardous waste, collected and transferred to the shipyard hazardous waste storage site.

To ensure good housekeeping for dry blasting use a low dusting abrasive media meeting MIL-A-22262. If not, temporary, fire resistant drapes (Herculite or canvas tarpaulin) should be used.

If allowed by the shipyard dry dock discharge permit, wetting down the dry dock floor is good practice. If the dry dock floor allows it, use motorized (HEPA) vacuum cleaning equipment. Cleaning of the dry dock floor should be scrupulous. Discharge of used media contaminated with paint debris into navigable waters may violate the dry dock NPDES permit limits, particularly if the antifouling paint is an organotin.

3.4.4 Surface Preparation by Portable Power Tools

Good housekeeping when using power tools is similar to that when abrasive blasting. The choice of tools affects the housekeeping problem. When possible, use needle guns or other impact tools to reduce dusting. You must use impact tools for power tool cleaning when the paints removed contain lead, chromate or cadmium. In permanent structures, equip each work station where power tool paint removal is done with its own suction dust collecting duct. In either shop or field, use a HEPA vacuum to pick up debris. Vacuum all surfaces in the adjacent area, including drop cloths and isolation barriers. Treat the vacuum filters as hazardous waste.

3.4.5 Solvent and Chemical Cleaning

For good housekeeping confine all solvent and chemical cleaning requires products to the area being cleaned. Clean up all solvent or chemical spills and runs immediately to prevent spread of the agents to areas where another worker or equipment might be harmed. Only the quantity of agent needed should be in the work site, in an unbreakable container. Solvent or chemical cleaners should not be left unattended. At the end of the job or shift changes, either return the cleaner to secure storage or deliver directly to your replacement. Never leave the item being cleaned without removing residual cleaner and paint debris and neutralizing the surface, unless the item is inaccessible and properly labeled.

3.5 Painting Housekeeping

Much, if not, all painting related housekeeping is intended to meet at least one of these three purposes:

(a) fire safety
(b) personnel safety
(c) environmental regulation compliance

3.5.1 Designate Mixing and Solvent/Paint Storage Areas.

Never put a paint mixing area interior to a ship. Bring only that volume of solvent and paint needed for the planned daily schedule or shift to the mixing area. Cover the mixing site with a drop cloth. (Some shipyards spread sand on the dry-dock floor to soak up spills.) Check grounding of all mixing equipment that might generate a spark. Only authorized personnel are to be in the mixing area and allowed to handle the materials. Keep all containers covered.

Reseal containers when done. Do not accumulate empty containers; dispose of them in the appropriate waste container. Large spills should be cleaned immediately. You may let small spills (less than 4 ounces) on the drop cloth dry. At the end of the job or shift, clean-up solvent, any mixed two-component paints, empty cans, drop clothes, used cleaning rags, etc., shall be placed in waste containers. Reseal usable paint and solvent and return it to the storage facilities.

Take only that quantity of paint to be used during the shift to the application area. Position paint containers to reduce the risk of accidental spillage. Pressure pots should be secured. Tape hoses (air service and feed) together and run to the spray area to prevent tripping. Check that all spraying equipment that might generate a spark is grounded. Cover areas not to be painted to reduce clean-up. Unauthorized personnel must be kept away from the painting area. Spilled paint should be cleaned up as soon as possible unless it is on a drape or drop cloth. All spills not confined to a drop cloth or drape should be cleaned immediately. Dry overspray on surfaces should be cleaned or vacuumed with an HEPA vacuum. Put clean-up solvent and non-reusable, excess paint in hazardous waste containers. If required by the air quality management district, use closed cleaning facilities for guns, hoses, brushes, etc.

Good housekeeping in shops requires that paint mixing and application areas, other than spray booths, have exterior exhaust ventilation to prevent spread of vapors.

Shop and field sites should provide a location for personnel to change into work clothing, lockers for off-site clothing, required personal and clean-up facilities (toilets, showers, basins, soap and water) and collection bins for contaminated clothing.

When drawing paint from a paint storage area check the shelf life indicator. If the shop operates a paint store, the attendant should follow a first in/first out rule. The paint store operator is responsible for checking shelf life before issue.

3.6 Miscellaneous

Be observant and report needed facility repairs that affect the work environment. Examples of such housekeeping reports include:

(a) Warning signs or hazard markings;
(b) Repairs to the shop structure or machinery. For example, ventilation that is not adequate to changed work load; stairs or ladders needing repair; or a slippery floor or deck.

4. SAFETY AND FIRE PREVENTION

NOTICE

THIS SECTION IS PROVIDED FOR INFORMATION ONLY. PAINTERS SHALL CONSULT WITH SHIPYARD FIRE DEPARTMENT, SAFETY OFFICE AND INDUSTRIAL HYGIENE OFFICE FOR INFORMATION CONCERNING SHIPYARD AUTHORIZED AND REQUIRED OCCUPATIONAL HEALTH AND SAFETY AND FIRE PROTECTION INSTRUCTIONS OR STANDARDS.

4.1 Introduction

This section contains general guidance for fire safety, personnel safety and occupational safety and health for surface preparation and painting. You can assume the use of head (hard hat), eye (safety glasses or goggles), ear (plugs or muffs) and foot protection (safety shoes). Federal law (OSHA) and by State and local entities (fire department) regulate employee working conditions and hazardous material exposure in the shipyard. This section provides painters an overview of typical safety requirements. Nothing written here can replace the careful review of and adherence to the specific guidance issued by the painter's individual shipyard. Violation of safety rules can harm you and expose your shipyard to severe financial penalties such as OSHA fines and legal actions.

4.2 Definitions

You will find the following terms in this section:

(a) **NIOSH** - National Institute of Occupational Safety and Health.

The government organization which assesses work methods to see how safe they are. NIOSH provides reports to OSHA so that OSHA can write rules for workplace safety.

(b) **OSHA** - U.S. Dept. of Labor Department of Labor, Occupational Safety and Health Administration (alternatively, the Occupational Safety and Health Act). OSHA issues rules which govern workplace safety. OSHA can inspect a workplace. If OSHA finds poor or unsafe work practices in the workplace they can fine the business.

(c) **Explosion proof** - This is a special type of electrical equipment which has no open sparking capability. Explosion proof equipment lowers the risk of fire or explosion when a painter works with flammable solvents. To be termed explosion proof the equipment, (lights, blowers, flexible extension cables, switches, etc.) must meet the National Electrical Code for Class I, Group D atmospheres.

(d) **Normal safety equipment** - See Figure 4•1, on page 3. Equipment needed wherever there are hazards from falling objects, where equipment can throw off particles, or where cleanliness is compromised. Normal safety equipment means: hard hat, eye protection (safety glasses with side shields), steel toe safety shoes with non-slip, non-sparking (rubber) soles, cloth coveralls and leather gloves.

(e) **Elevated work platforms** - Equipment, such as hydraulic boom lifts, scissor lifts, scaffolds and staging, crane suspended scaffolds, etc., where there is a danger of falling.

4.3 Responsibility for Safety

The two most important factors to ensure a safe worker environment are responsibility and training. They must be clearly understood and practiced by all personnel involved in surface preparation and painting operations. Trained instructors will have the responsibity to educate the painter/blaster about safety. Painter/blasters are not just willing pupils but also participate to keep the workplace safe.

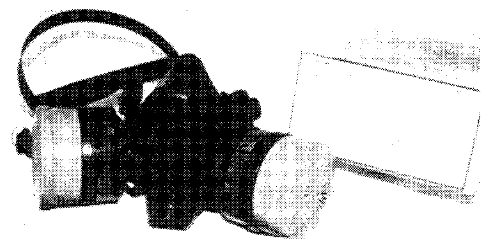


Figure 4•1: An Assortment of Normal Safety Equipment

At the level of actual operations, line supervisors are responsible for all operations. The Gas Free Engineer, and industrial hygiene, safety and environmental compliance personnel are responsible for staff assistance to the line supervisor. Responsibility is particularly important at those points where surface preparation and painting operations overlap and must be coordinated with other types of work being done in the same area.

Inform all personnel connected with or potentially exposed to surface preparation and painting operations of the potential hazards associated with the processes and materials. This includes health hazards and fire safety for flammable materials. Tell all personnel about the material safety data sheets (MSDS), their right to review them and their location. Enroll workers exposed to or participating in abrasive blasting or painting operations in a mandatory shipyard health tracking program.

4.3.1 Actions Before Beginning Work

Before work begins be sure that all safety measures are taken before work begins. These actions are a mental checklist for anyone working around surface preparation and painting.
Typical measures to check include:

1. When using flammable materials are "NO SMOKING" signs posted?

2. Are warning signs or tag-outs posted?

3. Do you have the right safety gear, such as protective clothing, safety shoes, eye protection, ear plugs, hard hat and appropriate respirator (if needed)?

4. Will a "buddy" system be used?

5. Is any necessary safety harness, safety belt, and tending lines on hand?

6. Where is the location of the nearest fire alarm box or telephone?

7. For use of flammable materials,do you know the right type of fire extinguisher to use, do you know where the extinguishers are placed?

8. For work in tanks or other enclosed spaces, has the Gas Free Engineer given the approval for human access?

9. Have you checked elevated work platforms erected or controlled by support shops (crane supported scaffolds), for obvious faults prior to use? For use of self-propelled, mobile, elevating work platforms, is the painter licensed by shipyard for operation of the vehicle.

10. Do not start a job if there are any unanswered questions about safety.

Additional details on safety topics are described below.

4.4 Safety Topics Applicable to Both Surface Preparation and Painting.

4.4.1 Respirator Safety.

The shipyard must have a complete respiratory protection program following 29 CFR 1910.134. At a minimum, a respiratory protection program should include regular training, fit-testing, periodic environmental monitoring, respirator maintenance, inspection and cleaning. The program must also assure that the air supplied to airline respirators meets NIOSH quality (Compressed Gas Association Commodity specification G7.1 Grade D) and flow volume requirements. (Note: Naval shipyards should use Federal specification for breathing air BB-A-1034.)

From the painter's point of view the most frequent checks are on respirator fit and respirator condition. The painter must know how to perform a qualitative check on respirator fit. A typical example of one method of checking by alternately blocking passage of air into and out froma quarter-mask respirator is shown in Figure 4•2. This is something the painter should do every time the resirator is worn. Checking respirator condition is vital to a painter/blasters safety. There are many sealing surfaces in a respirator and several working parts.

Before use, and after each use, check the respirator to see if the seal to the face is worn, dirty, scratched or otherwise damaged. Check any valves in the respirator leading to cartridges or air inlets. Make sure these valves are clean. Do not use a respirator if the valve flaps or closures are bent or not sitting snugly on the valve seat.

For cartridge type respirators make sure the protective cartridges fit snugly in the screw threads of the mask. Are the seals at the bottom of the cartridge clean and undamaged?

Figure 4•2:Typical Checks on Respirator Fit with Cartridge Mask - Checking Air Intake Valves

Being ready to use a respirator is important. For male workers it is essential that no facial hair interrupt the mask sealing area. This will mean most male painter/blasters are clean-shaven. For all workers hair from the head must not interrupt the face to mask seal.

The painter/blaster must not share respirators with other workers. Because different paints may require stronger respiratory protection this means the painter may have to maintain or check more than one type of respirator. Correctly maintained the respirator can help keep a painter healthy. Poorly maintained or used a respirator can be deadly.

Figure 4•3:Typical Checks on Respirator Fit with Cartridge Mask - Checking th Air Outlet Valves

4.4.2 Elevated Platform Safety

If work involves a fall hazard from an elevated work platform, provide workers with a body belt or harness. The body belt/harness class shall reflect the degree of fall hazard of the specific job site:

Class I - used to restrain a person in a hazardous work position and reduce the probability of a fall. In a fall, the body belt and lanyard shall provide a stopping force of no more than ten times gravity.

Class II - used where there are limited fall hazards (no vertical free fall hazard). A Class II belt/harness cannot be used where free fall can occur.

Class III - used for the most severe free fall hazards. Harness and lanyard shall produce a stopping force of no more than 35 times gravity.

4.4.3 Safety for Working in Confined Spaces

A confined space is one having the following characteristics (a) limited openings for entry and exit, (b) poor natural ventilation or (c) not designed for continuous occupancy. Examples would be a ship's hold, tanks or double bottom.

The confined space must be checked for oxygen content (19.5% minimum), flammable vapors and toxic atmospheres. Have the Gas Free Engineer certify the confined space for entry before any worker goes in. A safe to enter and work permit is issued before the painter/blaster can go into such a space.

Ventilate confined spaces that will be cleaned or painted. Ventilation should be by exhaust blowers located outside the space with the ducts placed to suck the atmosphere from the lowest parts of the space. Exhaust system discharges should be placed so that the discharge does not reenter the work space or can cause a health problem in surrounding areas.

All operating electrical equipment (lights, portable tools, etc.) in the confined space shall be explosion proof. When abrasive blasting or painting in the confined space, the space shall be isolated by:

(a) Locking out electrical sources at the disconnect switch remote from the service line or equipment with a "DO NOT OPERATE" warning tag that physically prevents energizing the switch;

(b) Blanking off and bleeding pneumatic or hydraulic lines.

(c) Disconnecting all belt or chain drives or remotely actuated mechanical linkages, and;

(d) Securing mechanical moving parts with latches, chains, chock blocks or other devices.

The painter/blaster must wear the right respirator and check it as discussed in section 4.4.1 “Respirator Safety.” on page 5

The “buddy” system must be in effect. Assign a standby person (“buddy”) to remain outside the confined space and be in constant contact (visual or speech) with the workers inside. This standby person should not have any other duties but to serve as standby and notify emergency rescue personnel in case of need. The standby shall not enter the confined space until help arrives. These warnings are not given lightly. **Fifty percent of workers killed in confined spaces were attempting to rescue other stranded workers!**

4.4.4 Health Hazards General

Since many paints currently used in painting ships or currently in place on ships contain hazardous ingredients (solvents, lead, chromium, nickel, etc.), the painter should assume all paints are hazardous unless:

(a) the products being applied or removed are known and the MSDSs do not list hazardous ingredients, or;

(b) laboratory analysis verifies paint is free of hazards.

A good general rule to follow is shown below.

UNLESS OTHERWISE VERIFIED, TREAT ALL USED ABRASIVE AND PAINT DEBRIS AS A HAZARDOUS MATERIAL AND A HAZARDOUS WASTE

A painter may have to be fitted with a personal protection monitor to make sure exposure to hazardous airbome dusts do not exceed legal limits. See

4.5 Surface Preparation.

The procedures to ensure personnel safety during surface preparation depend on the surface preparation method being used. The following paragraphs discuss in brief special requirements for common types of surface preparation activity.

4.5.1 Abrasive Blasting - Dry

The safety actions discussed in 4.4 "Safety Topics Applicable to Both Surface Preparation and Painting." on page 5, are applicable to blasting operations in ship interior spaces where abrasive blasting is permitted (tanks) and on the ship's exterior.

Before abrasive blasting operations do the following things.

•Notify personnel in the area of the intention to begin abrasive blasting.
•Visually inspect the entire blasting work area.
•Assume all paints removed contain hazardous ingredients, such as lead, chromium or nickel, unless support laboratories have sampled and analyzed the paint, showing it to be nonhazardous.
•If you know the type of paint, the MSDS sheet will list hazardous ingredients.
•Decide if blasting will cause damage to heavily corroded or perforated metal or piping.
•Ensure that temporary shields are in place to prevent abrasive from entering machinery, pipes, sea water inlets, pump wells and vents to ship's interior.
•Identify blasting hoses traversing ship compartments with signs posted in each compartment warning against damaging hoses.
•Each abrasive blasting hose and attendant control line should be color coded on the ends so that hoses do not become cross-connected and inadvertently activated, causing injury or contamination.
•All blasting hoses to ensure must come equipped with deadman on-off controls, audiovisual signaling devices and manually operated air supply valves.

•The deadman control must be the type that requires continuous pressure by the blast hose operator to operate. It should stop the air pressure to the blast nozzle automatically in the event the nozzle becomes unattended.
•The high pressure air supply choke valve must be kept closed by the machine operator or pot tender always except during actual blasting.

The blast operator or the crew supervisor should do the following check before beginning work. (Post a check list similar to this list at the blasting pot.)

1. Check that each abrasive blasting hose and nozzle is in satisfactory condition. Hose and nozzle shall be free of any indication that abrasive wear through is imminent. If you observe wear, replace the hose or nozzle. The nozzle shall be electrically grounded through hose or by separate grounding line.

2. Blasting operators should check to see that the equipment support shop does normal maintenance. If the equipment appears damaged or to need maintenance, notify paint shop office staff to arrange service according to shop procedures.

3. Be sure color codes on both ends of each blasting hose and control line are identical.

4. Check that deadman controls are attached to blast hose before deploying hose to the worksite (taping control line to blast hose is recommended) BLASTERS SHOULD BE WARNED THAT DEACTIVATING (TYING DOWN) THE DEADMAN CONTROL IS A SERIOUS SAFETY HAZARD SUBJECT TO PENALTY.

5. Check that deadman control and audiovisual signals operate correctly before positioning hose to worksite. Make sure an audiovisual signal notice is on pressure pot.

6. Post noise hazard, abrasive blasting and other required warning signs according to shipyard policy.

4.5.2 Audio-Visual Operating Signals

Shipyards must have a standardized set of audiovisual signals. Post a placard on each blasting unit detailing the meaning of all signals. At a minimum, the signals for "close choke valve", "open choke valve", "more abrasive" and "emergency" should be detailed. The blaster supervisor should review signals with the blasting crew to ensure that all personnel understand the signals. Use a horn, buzzer or light mounted on the pressure pot connected directly to the nozzle where there is no visual contact. You may use hand signals when there is direct visual contact. The emergency signal should allow resetting only at the operator's location.

4.5.3 Protective equipment

All blast operators must wear an abrasive blasting NIOSH certified respirator Type CE. A type CE is an air line, supplied-air respirator, it is intended for entry into and escape from atmospheres not immediately dangerous to life or health. The Type CE hood must have a faceplate and devices to protect the wearer's neck, shoulders and upper body from rebounding abrasive material. The hood must have shielding material to protect the window of the facepiece. The facepiece shielding material shall not interfere with vision or access to the window for cleaning.

Support personnel involved in clean up of blasting debris should wear NIOSH approved Type H High Efficiency Particulate air filtering respirators. The actual respirators available at any individual shipyard will be those approved by the safety and OSH support offices. Other mandatory safety equipment includes rubber or leather gauntlet gloves, protective cloth head covers and coveralls. If work is performed on staging, scaffolding, mobile elevated or crane suspended platforms, blast operator and all other personnel must wear a safety belt or safety harness.

Figure 4•4:Typical Personal Protection Monitor

Personnel other than blast operators, including machine operators and personnel engaged near the abrasive blasting operation, must wear full eye protection and NIOSH approved dust respirators. Above 90dB noise levels OSHA requires use of hearing protection. At higher levels of noise double ear protection ,ay be required.

4.5.4 Blasting Operating Safety Precautions

Never point the blasting nozzle in the direction of or in a ricochet line of another person, even if the pressurized air and abrasive stream are shut off. When working on elevated platforms, secure (tie or tape) the abrasive-air feed hoses to the platform, leave only that whip length that the operator can handle safely. When hose couplings are found where a sudden parting would be hazardous, wire the coupling together or secure both coupled hoses to a strong support or to each other.

Figure 4•5:Typical Safety Gear for Abrasive Blasting - Air Supplied Blasting Hood with Shield, Full Mask, Protective Body Wear

Whenever practical, position pressure pots and reloading hoppers on top of the dry dock walls rather than in the basin. This reduces the number of people in the dock basin. Never use compressed air to blow dust from skin or clothing being worn or to clean up a work area. After manual removal of most of the used blasting abrasive and paint debris, use high efficiency particulate air vacuums to complete cleanup of dust and debris. Woven protective head covers and coveralls should be supplied by the shipyard and laundered to prevent exposing non-employees to potentially hazardous dust.

4.5.5 Abrasive Blasting Safety With Alternative Blasting Media.

Most of the dry abrasive blasting done by a painter will be with an inorganic media (mineral grit, slag, sand, steel grit). Other blasting media require additional precautions to those detailed above.

4.5.5.1 Organic Media

Organic blasting media comes from many sources (walnut shells, almond shells, corn cobs). All organic media dust clouds generated during blasting operations can ignite and cause dust explosions. For use of organic media, remove all sources of sparking and ground all metal items.

4.5.5.2 Carbon Dioxide Pellets

Another possible blasting media are frozen CO2 pellets. Because the carbon dioxide gas generated by the pellets when they sublime is heavier than air, it could flow and puddle in low pockets remote from the blasting site. One study has shown that with CO2 pellets, used at standard compressed air blasting pressures, sufficient volumes of air and the turbulence of blasting kept the CO2 content to safe levels, though noise levels are very high. The safety of blaster and other personnel will require monitoring of CO2 levels in the work and surrounding site and the use of ear protection.

4.5.6 Abrasive Blasting – Wet

Blasting with high pressure water, with or without abrasive, or dry abrasive blasting units with low pressure water for dust suppression, uses some different safety requirements from dry abrasive blasting. The safety actions discussed in 4.4 "Safety Topics Applicable to Both Surface Preparation and Painting." on page 5 are applicable to wet abrasive blasting operations.

4.5.6.1 Protective equipment

Despite the lack of dust, blast operators must wear full face shields to protect against splash back of water and/or wet abrasive. Support personnel involved in clean-up do not require respirators so long as debris is wet and you see no dusting. If dusting is seen in clean up, see the requirements under dry blasting. The actual respirators required is an individual shipyard determination by the safety and OSHA support offices. Other mandatory safety equipment includes wet weather gear, rubber or leather gauntlet gloves, shoes with nonskid soles and coveralls. Personnel other than blast operators, including pump operators and personnel engaged near the blasting operation, must wear full eye protection. Above 90dB noise levels OSHA requires use of hearing protection. At higher levels of noise double ear protection ,ay be required.

Figure 4•6:Typical Ear Protection, Ear Plugs - Ear Muffs are Added for Double Protection

4.5.6.2 Blasting Operating Safety Precautions

Assign a minimum of two workers to each nozzle. The assistant is required to keep hoses clear of obstructions, support hose weight, observe for potential hazards to the nozzle operator and relieve the nozzle operator as needed. The high pressure water pump shall be manned at all times the unit is in operation to monitor water level and respond to audiovisual signals for operation changes. The main danger from high pressure water is the cutting action of the water stream if it hits a worker directly. This cutting action can severely injure a worker. Therefore, never point the blasting nozzle in the direction of another person, even if the pressurized water and abrasive stream is shut off.

For work on elevated platforms, secure (tie or tape) the high pressure feed hose to the platform, leave only enough of the hose length that the operator can handle safely. When hose couplings are placed where a sudden parting would be hazardous, secure both coupled hoses to a strong support or to each other.

Whenever practical, the pump unit and all hose subject to high pressure should be positioned in the dry dock basin and hose length should be kept as short as practicable for the job. This improves safety by reducing the number of people exposed if a hose parts under pressure. Coveralls should be supplied and laundered by the shipyard to prevent liability from exposing non-employees to potentially hazardous dust.

4.5.7 Power Tool Surface Preparation

The safety requirements for surface preparation using power tools are far simpler than when blasting. The worker must still visually inspect the entire area to be cleaned by power tools. The worker must still either assume all paints on the ship contain hazardous ingredients, such as lead, chromium or nickel, or have support laboratories sample and analyze paint. If the type of paint is known, the MSDS sheet will list hazardous ingredients. Decide if mechanical cleaning will cause damage to heavily corroded or perforated metal or piping or equipment being cleaned. If working in ship interior compartments, confined spaces or in exterior locations enclosed by four or more bulkheads, ensure that hazardous dust containment measures are in place to prevent spread of hazardous dust.

Hazardous dust containment precautions for ship interior compartments or reduced air flow spaces include:

(a) Secure all deck drains and ventilation openings in the space. Isolate the area as much as possible with drop cloths or sheets of plastic.

(b) If available, use power tools having a vacuum attachment. Another choice is to use vacuum blasting equipment.

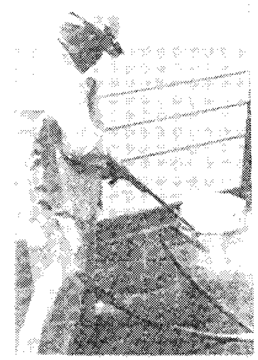


Figure 4•7:Minimal Protection for High Pressure Water Jetting Protective Boots, Water Resistant Coveralls and Face Shield

(c) Avoid the use of power tools that generate a fine dust (sanding, grinding, wire brushing equipment). Use needle guns or other impact tools.

(d) Vacuum all debris using high efficiency particulate air vacuums. Wipe down all tools, protective equipment, and surfaces in the area, including drop cloths and plastic isolation barriers using rags or sponges dampened with fresh water. Clean and disinfect respirators according to shipyard procedures. Vacuum coveralls and gloves before removal.

(e) Treat debris as hazardous waste, and transport it to the shipyard disposal storage site for ultimate disposal.

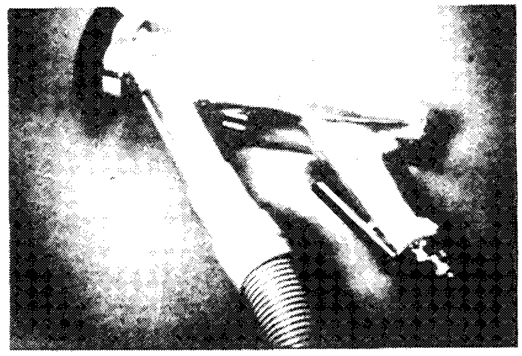


Figure 4•8: Vacuum Equipped Power Tool Equipment, a Needle Gun

4.5.7.1 Protective Equipment

Since all paint being removed must be treated as hazardous, all power tool operators must check with the supervisor or safety office that the correct protective equipment is worn. Abaseline requirement is to wear a NIOSH certified respirator Type C. A type C respirator is air line supplied and intended for entry into and escape from atmospheres not immediately dangerous to life or health. Air flow to hoods should be a minimum of six cubic feet per minute (cfm). Supplied air must conform to Grade D of Compressed Gas Association Commodity specification for Air G7.1. Support personnel involved in clean up of blasting debris should wear NIOSH approved Type H High Efficiency Particulate air filtering respirators.

The actual respirators available at any given individual shipyards will be those approved by the safety and OSH support offices.

Other mandatory safety equipment includes eye protection and coveralls. If work is to be done on staging, scaffolding, a mobile elevated or a crane suspended platform, the tool operator and all other personnel must wear a safety belt or safety harness. Power tools can be noisy. Above 90dB noise levels OSHA requires use of hearing protection. At higher levels of noise double ear protection ,ay be required.

4.5.7.2 Power Tool Operating Safety Precautions

All portable power tools must be equipped by a safety lockout to prevent accidentally or inadvertently starting-up. A safety lockout device is any operating control demanding positive action by the operator before the tool will turn on. The lockout device must positively lock the throttle in the off position when the operator releases the operating switch. Two consecutive actions by the same hand are required to start the tool, one to disengage the lockout, the other to start the tool. Lockout devices must be integral with the tool and not easy to bypass or remove.
The following is a checklist for safe use of power tools.
•Inspect tools should before use; all switches must work.
•The power lines, plugs and hoses on the tool must be sound and free from defects.
•Tools must be off when attached to power or pressurized air supply.
•Electrical tools having metal cases must be grounded either through a three-pronged plug or by a separate grounding line.
•Double insulated plastic cased tools are designed to be electrically safe and do not require a three-prong grounding plug.
•Only use electrical tools with three prong plugs with three prong receptacle flexible extension cords and three slot grounded power receptacles.
•For use of a separate grounding cable, it should be directly

attached to the electrical ground, such as the ship's structure. Separate ground power tools use is not recommended.

Electrical power tools with brushes emit sparks. Do not use such tools where flammable vapors, gases, liquids or explosives are present. Operators of electrical portable power tools must take care that power cords do not kink or are left where they can be run over. Do not let power cords contact sharp edges, hot surfaces, oil, grease, water or chemicals. Return tools with damaged power cords to the tool issue for repair.

Label pneumatic portable power tools as hazardous noise sources and make operators wear ear protection. Fit pneumatic power tools with a quick disconnect fitting and, when not in use, disconnected from the air supply hose. Air supply hoses must be rated for the pressure required by the tool and be free of defects and leaks. Hoses should be fitted with quick disconnect fittings. Air supply pipe sources must be fitted with a shut-off valve, a pressure regulator and quick disconnect fitting.

Route electrical power cords and air supply hoses to the work site without creating tripping hazards. This is most important on steps, ladders, elevated work platforms, and walkways. Protect electrical power cords and air supply hoses running through doorways or hatches from damage by the door or hatch edge and accidental closure. Never point an air supply hose at another person, even if not pressurized. Never use compressed air to clean clothing being worn or to clean up the area after using a pneumatic tool. For work on elevated platforms, secure (tie or tape) the electrical cords or air supply feed hoses to the platform, only leave a length of hose the operator can handle safely. When air supply hose couplings are found where a sudden parting would be hazardous, wire the coupling together or secure both coupled hoses to a strong support or to each other.

Portable power tool operators should check that equipment is returned to tool issue for normal maintenance or for repair of damage.

4.5.8 Chemical Methods of Surface Preparation

Since there are many solvents, chemicals and commercial paint strippers available, this discussion will be limited to general safety pertinent to the method. This discussion will not deal with surface cleaning related to plating or chemical conversion techniques (aluminum chromating, iron phosphating, etc.) not normally done by painters. Use eye and skin protection for all work with chemicals. In particular, do not wear contact lenses unless specifically authorized by the shipyard OSHA office. Prescription safety glasses are preferred.

FOR PROPER SAFETY USING SOLVENTS, CHEMICALS OR COMMERCIAL PRODUCTS CONTAINING SOLVENTS OR CHEMICALS, CONSULT THE MSDS (MATERIAL SAFETY DATA SHEET), CONTAINER LABELS AND YOUR OCCUPATIONAL SAFETY AND HEALTH SUPPORT OFFICES.CONSULT YOUR LOCAL FIRE DEPARTMENT FOR ANY SUPPLEMENTAL REQUIREMENTS TO THOSE RECOMMENDED BY THE MSDS. I

4.5.8.1 Solvent Cleaning

Solvent cleaning refers to the use of pure solvents to remove contaminating substances from a surface. Common contaminants include oil, grease and mold releases. The process usually involves using a rag, soaked in solvent, and rubbing it across the surface to be cleaned to dissolve and remove the contaminant.

One good rule for solvent cleaning safety is to only use solvents having no flash point or a flash point above 100 °F. Another rule is to use solvents only if the Maximum Allowable Concentration (MAC) of vapor in the air is more than 100 ppm. Representative solvents that a shipyard painter can expect to encounter include: aromatic hydrocarbon solvents (toluene, xylene, naphtha), chlorinated non-flammable aromatic solvents (1,1,1- trichloroethane) or oxygenated solvents (ketone or alcohols) to remove water from a surface. The safety requirements needed are specific to the particular solvent being used and the ventilation available (interior or exterior).

Whatever the location, for use of flammable solvents, fire safety requires the presence of portable carbon dioxide (CO2), dry chemical or foam extinguishers. All non-explosion proof electrical service must be off and only use explosion proof electrical lighting, service and tools must be in the presence of solvent cleaning. For use of small amounts of solvent and there is good ventilation (equivalent to working outside), the requirement to use only explosion proof equipment can be modified. Solvents used in the shop or at the job site must be in small metal containers equipped with self acting, vented closures.

The choice of a respirator

A good respirator choice would always be a continuous flow, airline supplied-air respirator approved by NIOSH for use with paints, lacquers and enamels. NIOSH approved TC23C paint, lacquer, enamel cartridge and filter type masks should only be chosen for short duration uses at vapor concentrations of not more than 100 ppm. This demands training to recognize when the cartridge is saturated and passing vapors. NIOSH limitations on approved cartridge/filters respirators include: (a) not for use in atmospheres immediately dangerous to life or health; (b) not for use in atmospheres containing less than 19.5% oxygen. (c) not for use with organic vapors giving poor warning of seep through (low odor) and (d) not for use at organic vapor concentration exceeding 1000 ppm by volume.

Other typical safety equipment required for using solvents would include eye protection (goggles or face shield), coveralls and solvent proof synthetic rubber gloves. Other than fire prevention, the main goal of solvent safety is to prevent eye and skin contact or ingestion. A typical solvent MSDS is attached at the end of this section.

4.5.9 Chemical Paint Strippers

Shipyard painters will encounter two types of paint stripper for small area paint removal: caustic (alkali) based paint strippers for alkyd (oil) based paints and chemical mixture strippers for epoxy type coatings. Each stripper is a proprietary mixture of ingredients and the label, or MSDS sheet, instructions for safety, use and disposal should be followed. Strippers can be either flammable or non-flammable types, but all are toxic hazards. Many release vapors that are heavier than air which will collect in low areas (bilge pockets, etc.). This creates a breathing hazard for personnel not directly involved in their use. In general, paint strippers present the same safety hazards as detailed above for solvent cleaning, and a chemical skin burn hazard. General safety required for paint strippers is as follows:

(a) If a respirator is required, a NIOSH/OSHA Type TC23C paint, lacquer, enamel chemical vapor respirator or a continuous air flow, airline supplied Type CE would be appropriate for use with most paint strippers. The choice will depend on the specific vapors being released and on the ventilation available.

(b) Workers should wear impervious clothing and gloves (synthetic rubber, neoprene or chemically resistant) appropriate to the chemical and required by the MSDS. Remove and launder protective clothing wetted by the stripper before reuse. If paint remover contacts the skin, flush off with large quantities of water. If remover enters the eye, flush with running water for at least 15 minutes and get immediate medical attention.

(c) Contain the spread of the strippers beyond the area being cleaned.

(d) Safety showers and eyewashes must be installed in areas where caustic or chemical strippers are in use.

Alkaline strippers for oil-based alkyd coatings usually contain trisodium phosphate, caustic soda (lye) or alkali silicates. These chemicals present the danger of a chemical skin burn or eye damage. Paint strippers for chemically resistant coatings can contain very hazardous materials, such as phenol, creosol, and chlorinated solvents like methylene chloride. Workers must wear full rubber framed eye protection or face shields, chemical vapor respirators, and impervious gloves, clothing and footwear. Evacuate non-essential personnel from the paint stripping area. All strippers and their residues are hazardous wastes. Contain and dispose of safely according to local regulations.

4.6 Safety for Painting Operations.

Painting has many potential sources of danger. Painting involves the use of toxic and flammable materials, pressurized equipment, elevated working platforms (ladders, staging, scaffolding, and rigging), often in combination one with the other. These dangers can be aggravated by working conditions such as confined spaces having poor ventilation.

Review of Potential Hazards. Painting personnel must review the potential hazards of the specific job.

(a) Review the hazards, dangers and safety recommendations in the MSDS for the products being used. Seek the advice of shipyard OSH offices and fire department for additional local requirements.

(b) Follow this checklist to decide on equipment needs.

•Review the equipment required for the job.
•Request support shops to install required support equipment, such as explosion proof lighting,
compressed air service (if not available),
safety equipment (showers, eyewashes, fire extinguishers, etc.),
any elevated work platforms needed.
•Arrange for needed rigging and crane support.
•Draw needed application equipment and inspect for obvious safety problems, such as badly worn pressurized air supply and material handling line.
•Draw needed safety equipment (respirator, eye protection, clothing) required by the MSDS and shipyard safety office.
•If more material is to be staged into the work site than you will use during that work period, arrange for a secure storage facility.

(c) Review the work environment for unique hazards and safety requirements. For example, work done in a tank requires a "buddy" exterior to the tank in contact with the painter by a signaling line. A painter must never work alone in a hazardous area.

General Safety Measures. Invoke these general safety measures for painting operations:

(a) Make all painters working with lead, chromium, and hazardous solvents or chemicals part of a health review program that includes blood tests for lead, chest X-ray, respiratory loss, hearing impairment, developed chemical sensitivities and general health status at least annually.

(b) If ventilation is required for a job, outside air must be supplied at a minimum number of air changes per hour required to bring exposures below the Permissible Exposure Limit for the material in use. If ventilation cannot maintain a safe, use a life supporting environment and respiratory equipment. Supply ventilation by using exhausting, not blowing, equipment. Arrange exhaust hose so they pull air from the lowest point in the confined space. The point of exhaust for the evacuated air/vapor mix must not be near the air induction pick up. Venturi-type exhaust blowers are preferred for safety to electrically driven centrifugal exhaust blowers.

Painters must inspect respiratory equipment for proper operation and anything that might impair function (filters, cartridges, rubber parts for deterioration) before entering the work site. Respirators should be cleaned immediately after leaving work site.

Ventilate newly painted spaces, which ship personnel will occupy, until the paint is cured and solvent vapor no longer is a health or fire hazard. Ventilate freshly painted, unoccupied confined spaces (tanks, voids, etc.) until the paint is cured. It is all right to stop ventilating unoccupied confined spaces if the presence of vapors is not a hazard, for example: a tank that will be filled with fuel or water.

(c) All operating electrical equipment in the painting area shall be explosion proof. All other electrical equipment and sources of ignition must be off. There shall be no sources of open flame. Areas having hot metal (engine rooms, fire and pump rooms) must be in the cold iron condition. Instruct personnel to leave all sources of sparks (matches, lighters, steel belt buckles, knives, rings) in lockers.

(d) A painter should have the normal safety equipment: hard hat, eye protection, steel-toe safety shoes with non-slip, non-sparking rubber soles and protective clothing. Protective clothing should fit snugly at the ankles, wrists and neck (taping is recommended). If working over water, a life jacket should be worn. For work on elevated platforms, issue a safety belt or harness.

(e) If work is to be done in tanks, voids or other enclosed or poorly ventilated hazardous spaces, obtain certifications from the Gas Free Engineer that these spaces are free of noxious fumes and flammable gases and is not oxygen deficient.

(f) Tell painters that there is no eating, drinking or smoking in the work area. Personnel should be taught that, because paints and solvents are hazardous, hands and faces are washed before smoking, eating, drinking or using the toilet.

(g) Define paint operations using signs or barriers. Where the paint is applied by brush or other low volume method, the local safety office should define the boundaries of area requiring warning signs. For spray painting, danger zones should extend at least 25 feet from the painter. Barricade or rope off the danger zone, post warning signs such as "NO SMOKING, DANGER AREA--SPRAY PAINTING." You may need to post warning signs for specific hazards, such as "ORGANOTIN PAINTING."

(h) At the end of the job or work period, clean all equipment of residual paint, both inside and out. Return still usable paint and solvent to the storage facility. Put clean-up solvents, used rags, empty solvent or paint containers and any other flammable waste in closed-top metal hazardous waste containers for disposal.

4.6.1 Paint Mixing

General safety precautions for the mixing of paint include:

(a) Ventilate the paint mixing area well to prevent over-exposure of personnel to solvent fumes and to keep the fume concentration below the lower explosive limit. At non-shop work sites, provide a temporary structure for paint mixing for storage of the flammable materials, and consumables, such as paint buckets, rags and brushes. Permanent structures for paint mixing and storage should have automatic sprinkler systems.

Signs saying "NO SMOKING IN OR AROUND THIS BUILDING" shall be posted inside and outside buildings where paint use, mixing or storage occurs. Fire fighting equipment shall meet local fire regulations. Clearly, prominently and permanently mark all escape routes and exits. Mixing personnel should be trained in fire safety. This includes the location of the closest fire alarm, the use of fire extinguishers and the evacuation of endangered personnel. Personnel not trained or authorized to fight a fire must quickly evacuate the area.

(b) Painters and paint mixing personnel should understand the idea of flash point and how it affects their safety. A flash point is the lowest temperature at which the vapors above a volatile liquid (vapors in the empty portion of a can containing solvent or solvent based paint) can ignite. This is important because solvents have different flash points and the danger of igniting the air/vapor mix varies with temperature. Solvents and paints used by painters are usually classified as low flash point, if the vapor/air mixture can be ignited below 95 °F (35 °C), or high, if the vapor/air mixture can be ignited above 95 °F (35 °C). As a result, use of low flash point paints in compartment or tank painting is forbidden because of the fire hazard at ordinary temperatures. If temperatures are below the flash point of a specific solvent or solvent mix, ignition does not occur if, for example, there is a spark. When there is a temperature rise that same solvent may become a fire hazard.

(c) Mixing personnel should wear chemical vapor respirators if ventilation is inadequate to keep solvent vapors below the allowed PEL limit values for an 8-hour day.

4.7 Safety Requirements of Generic Paint Types

This section provides general safety information for using various generic types of paints.

4.7.1 Alkyd and Oil Based Paints

Alkyd paints are probably the largest category of paints a painter will encounter. Marine painting uses many alkyds and modified alkyds, such as silicone or urethane modified alkyds. Alkyd paints range from the familiar yellow primer (TT-P-645), the haze gray exterior topcoat (TT-E-490 and its replacement MIL-E-24635), the interior compartment finishes (MIL-E-24607) and the various deck and marking paints. Alkyd paints are easily identified one-can systems that air dry in two to eight hours at normal temperatures. Alkyd resins, on which the alkyd type paint is based, are pretty safe to handle. However, alkyd paints can still contain hazardous ingredients, such as lead, chromate, and toxic, flammable solvents. Currently, most of the alkyd paints no longer contain these hazardous ingredients. However, still review the MSDS for a particular product. Alkyd paints do not require any additional special safety precautions.

4.7.2 Vinyl and Vinyl-Alkyd Paints

Vinyl and vinyl-alkyd paints are represented by paints such as pretreatment primer Navy Formula 117 (MIL-P-15328), vinyl red lead primer Navy Formula 119 (MIL-P-15929) and the Navy Formulas 121 and 129 antifouling paints (MIL-P-15931). Vinyl paints are characterized by a very fast dry and use of low flash point solvents. Vinyl resins have no inherent hazards. Paints using vinyl resins can have specific hazards. Some vinyl paints are pigmented with toxic pigments like red lead or zinc chromate. All vinyls use very flammable, low flash point solvents. Personnel working with vinyl and vinyl-alkyd paints should wear coveralls, gloves and hoods that protect the head, neck and face and a NIOSH airline, constant flow Type CE respirators. Ideally, cover exposed skin with protective cream. Unless they are integral to the respirator, do not wear approved goggles. For work is done on the exterior, a NIOSH type TC23C organic vapor respirator can replace the Type CE airline, continuous flow respirator.

4.7.3 Epoxy Paints

Epoxy paints are represented by the Navy Formula 150 series paints (MIL-P-24441). Epoxy paints are two-component (two-can) systems, which require mixing to cure (set). The MIL-P-24441 paints do not contain any hazardous pigment, but do contain toxic and flammable solvents. Commercial epoxy coatings may contain lead or chromate pigments; consult the product's MSDS. Some people develop skin inflammation and allergy reactions to epoxy coatings. When epoxy coatings contact the skin, promptly wash away with soap and water. Do not use solvent to clean skin, as solvents spread the paint over the skin and enhance penetration into the skin. Obtain medical attention if allergic reactions or a skin rash develops. Personnel working with epoxy paint should wear coveralls, gloves, hoods that protect the head, neck and face, and a NIOSH airline, constant flow Type CE respirators. Cover exposed skin with a protective cream. Wear goggles if they are not part of the respirator.

4.7.4 Coal Tar Epoxy Paint

Coal tar epoxy resins contain cancer-causing ingredients. Take care to protect skin from contact with coal tar paints. Since the Navy does not allow use of coal tar epoxy coatings, only painters doing commercial work should encounter this type of product. Personnel working with coal tar epoxy paint should wear coveralls, gloves, hoods that protect the head, neck and face, and a NIOSH airline, constant flow type CE respirator. Cover exposed skin with a protective cream. Wear goggles if they are not part of the respirator.

4.7.5 Polyurethane Paints

Polyurethane paints, like epoxy paints, are two-component (two-can) systems that must be mixed to cure. The degree of hazard inherent in polyurethane paint varies with the type of polyisocyanate resin in the paint. During application, polyurethane paints pose special problems because they can release of free isocyanate vapors. These vapors can cause irritation of any part of the body with a "dermal layer." Target areas include skin, eyes, and respiratory tract. Exposed persons can be sensitized, making them allergic to isocyanates. Subsequent exposures to even a small quantity of isocyanate vapor can cause a severe allergic reaction. The symptoms may feel like those of an asthma attack. Prevent exposing sensitized workers to isocyanate vapors as sensitization appears permanent. Refer personnel developing symptoms of cardio-respiratory problems, skin irritation or eye irritation to the shipyard medical office for attention. Medical staff should note the sensitivity in the employee's medical record.

The paint industry has conducted long and detailed study of hazards from the use of polyurethane paints. Urethane manufacturers maintain using correct safety procedures can limit or prevent isocyanate sensitization. They also claim that the amount of free isocyanate in a well made polyurethane paint is vanishingly small. Despite this, for shipyard work, it is recommended to use a standard suite of safety procedures. Safety precautions for using polyurethanes include:

(a) Assume the presence of free isocyanate in polyurethane paints unless advised by the MSDS or shipyard OSH office.

(b) The shipyard OSH office must make a survey of polyurethane work sites, at least once a year, to ensure that safety precautions are enforced and to interview personnel for problems.

(c) Enrol personnel exposed to free isocyanate in a medical evaluation and surveillance program with twice yearly examinations. The medical monitoring program should provide, at a minimum, for the following:

1. Review of medical history, with special attention to eyes, skin, allergies, cardiovascular and respiratory systems.

2. A posterior-anterior X-ray (once per year)

3. Complete blood count, including hemoglobin or hernocrit, white blood cell count and differential.

4. Pulmonary function tests, including Forced Expiratory Volume (FEV-1) and Forced Vital Capacity (FVC)

4.7.6 Organotin Antifouling Paint

Organotin antifouling paints require special safety attention due to the extreme hazards involved in application and removal of such coatings. The Navy does not now use organotin antifouling paints. Painters involved in commercial ship underwater hull painting and paint removal may encounter this paint. A few Navy ships still have organotin paint, applied between 1980 and 1987. Special safety requirements required for organotin painting or removal include the following:

1. Workers should receive specific training in the hazards of working with organotin paints. Workers should be informed of the physical symptoms of exposure and the need for special attention to proper use of their personal safety equipment. Workers should be informed of the purpose of the medical surveillance program and the benefits to the worker of the program.

2. Personal safety equipment for organotin paint application varies with the degree to which workers are involved in the application.

(a)Respirators. For workers directly involved at the work site (sprayers, blasters, paint mixers and other personnel within 50 feet) use one of the following respirators:

•a NIOSH self contained breathing apparatus with full facepiece, operated in the pressure demand mode, or;

•a Type CE combination airline, supplied air, full facepiece respirator having an auxiliary self contained, pressure demand mode air supply.

Workers in the fringe of the work zone (50 to 100 feet away) should wear a full facepiece NIOSH TC23C high efficiency filter and pesticide cartridge respirators.

Firefighters should wear a NIOSH approved self contained breathing, full facepiece, pressure demand mode respirators.

(b)All personnel in the work zone and fire fighters should wear appropriate impervious clothing, including gloves, aprons, suits, hoods and boots. Disposable coveralls, boot covers and hoods with taped wrists and ankles are recommended for use by paint sprayers and mixing personnel to avoid contamination of laundering facilities.

(c) Place special signs at the heads of all accesses to dry dock basins warning that organotin painting or blasting is occurring. The signs should include requirements for access (personal protective equipment), hazards information (avoid breathing dust; avoid skin, eye and clothing contact) and first aid information.

(d) Safety equipment at the work site should include an ANSI A358.1 type eye wash (0.4 gallons per minute potable water/15 minute capacity, which can wash both eyes at once).

(e) Cover all ship intake ventilators within 50 feet of painting or removal with FILTER FAB or equivalent. Close all hatches within 50 feet of the work area.

(f) After painting or removal is completed, put all debris (cans, used abrasive, etc.) and contaminated clothing into a hazardous waste container. The dry dock should be wet swept or vacuumed and that debris also deposited in the hazardous waste container. Remove all paint from equipment, dock blocks, staging, the dock floor, etc.

4.8 Fire Safety.

This section describes a safe working environment for handling and storing flammable liquids (paints and solvents) in a shop or at a job site in the dry dock basin and aboard the ship. Safety in the dry dock basin typifies most field work. Painters must realize that they do not dictate fire safety. To meet the requirements for fire safety is the responsibility of the shipyard safety office together with the shipyard or local fire department. However, since painters are responsible for working safely, fire safety when working with flammable materials should be understood.

4.8.1 Fire Safety - Flammable Materials

Fire safety for handling and storing flammable solvents and paint, includes, at a minimum, the following:

(a) Fully equip all permanent structures, where painting is accomplished or where paint or solvents are available or stored in quantity, with an automatic fire alarm and sprinkler systems. Automatic sprinkler systems usually consist of piping with fusible link-activated sprinkler heads installed over the work and storage areas. Normally, sprinkler systems dispense water, but can use other fire suppressant materials, like Halon or carbon dioxide. Also, equip permanent buildings with fire alarms the personnel can start. The alarms will have a red and black on white background sign containing the words “FIRE ALARM” with a pointing arrow.

To store large solvent containers and large quantities of paint, use a secure separate storage facility. If the storage area is attached to the shop, it should have one exterior wall for explosion relief. Other walls will have a minimum two-hour fire rating. The entire area will be well ventilated. Easy access for fire fighting equipment is important. Provide a dike or floor drain system to confine leaks in attached or separated storage facilities. Size the drainage system to handle any fire fighting water used in an actual fire.

Rooms used for solvent/paint storage, paint mixing and application should be free of ignition sources. Utilities should include compressed air for explosion proof pneumatic mixing and explosion-proof electrical service and fixtures (lights, electrical receptacles).

Field flammable storage should use a temporary structure that can be locked (secured). The field storage structure must have good ventilation (wind turbine exhaust fans, louvers, etc.). Ideally, equip the field storage structure with a Halon or carbon dioxide compressed gas flood system with automatic activation. Large quantity solvent storage can also be an open, secured fenced yard or a building. In either case, the storage facility must spill containment that can handle the total storage capacity and any storm or fire fighting water that might accumulate.

(b) Have appropriate warning signs at all entrances to working sites and structures for use or storage of solvents or paints. For example, post signs like "DANGER - FLAMMABLE LIQUIDS" and "NO SMOKING IN OR AROUND THIS BUILDING." Also display appropriate warning signs, such as "FLAMMABLES - NO SMOKING," in interior rooms and at exit signs or marked escape routes. Post signs on the exterior explosion wall of permanent solvent storage areas, on fire fighter entrances and personnel fire escapes or fire-fighter entrances: "DANGER - FIRE REGULATIONS REQUIRE THAT THIS AREA BE CLEAR AT ALL TIMES" and "NO PARKING AT ANY TIME."

(c) Solvents used in the shop or at the job site must be in metal safety containers equipped with self acting, venting closures. Never use open buckets.

(d) Shop or field storage of small containers of solvent should be in sheet steel cabinets that meet OSHA regulations and NFPA Code 30. These are double walled, all welded sheet steel cabinets with an electrical ground connection. They have a raised lip to contain spills, and a manual or fusible-link self closing door. NFPA Code 30 cabinets are painted yellow with a stencil on the front: "FLAMMA-BLE - KEEP FIRE AWAY."

(e) Large solvent containers like 55 gallon drums for flammable solvents dispensing must be electrically grounded, and equipped with a flame/spark arresting vent. Large containers and their racks must have an electrical ground and provision for electrical bonding to the receptacle to which the solvent is dispensed. Use self closing dispensing valves. Drum pumps are safer than gravity feed valves. Only move the drums with the right equipment. Correct equipment includes barrel trucks, fork lift slings, or drum lifters. Drums moved on standard pallets should be secured.

(f) Mark all containers shall be with the appropriate labels, such as "FLAMMABLE" and a OSHA Hazard Communication Act label. A suggested hazard communication act label would conform to ANSI Z129.1 (See 6.5.1). Label all containers of solvent or paint. OSHA regulations only allow unlabeled containers if a worker is drawing small quantities of solvent for his own immediate use.

(g) Paint spray booths require dedicated, explosion proof exhaust systems. The exhaust system must generate a minimum air velocity of 150 feet per minute. Monitor air flow regularly and equip booths with air velocity indicating instruments like manometers. Fit spray booths with automatic fire system sprinkler heads within the booth working area.

All operating electrical equipment in spray booths shall be explosion-proof. There shall be no sources of ignition within a distance of 10 feet horizontally or 3 feet vertically from the open face of the spray booth. All spray booth metal parts, including ducts and spray piping, must be electrically grounded. Personnel working in a spray booth must leave all sources of ignition (matches, lighters) or personnel effects that could cause sparking (rings) in lockers.

Have only the amount of solvent or paint for one work shift present in the spray booth. There must be a least one 18-pound Class B or C fire extinguisher within five feet of the spray booth opening. If the booth is a dry filter type, then change filter pads whenever the required air velocity is not achived. Also replace filter pads if they are visibly loaded with paint. Walls, overheads, baffle plates and water nozzles should be examined before each shift for paint accumulation and stripped of paint as necessary. Dispose of dry filter pads, water-wash sludge, and any paint residue from cleaning work, as flammable hazardous waste.

(h). Place all debris from painting operations that might be flammable, such as paint or solvent soaked rags,in closed-top, metal containers for disposal.

4.9 Fire Fighting

(Note: This section is intended to give a painter a basic understanding of fire extinguishers encountered in a shipyard. This section does not deal with the information needed by professional fire fighters.)

Equipall work sites, where use or storage of flammable solvents and paints occurs, with portable fire extinguishers. If attached to the structure, mark their location with a red and black on white sign containing the words "FIRE EXTINGUISHER" with an arrow pointing to the extinguisher. At a minimum, to assure the proper use of the fire extinguishers, a shipyard should provide the following:

(a) Painters expected to use the fire extinguisher must receive training in proper use of the equipment.

(b) The extinguishers placed in the work area must be the proper type for the expected fire type.

(c) The shipyard must have an extinguisher maintenance program.

The most common extinguishers that a painter needs to find in a shipyard are those for Class B and C fires. A Class B fire involves a flammable liquid, grease or similar material, while a Class C fire involves a live electrical source. A typical Class B and Class C extinguisher would be the carbon dioxide, dry chemical, or halogenated chemical ("Halon") types. These fire extinguishers both look like a bottle with an attached hose having a bell mouth nozzle. In fact, extinguishers approved for Class B or C are good for use on either type of fire or even on a Class A fire that involves ordinary combustible material, like wood or paper.

Normally, in a permanent shop, Class B and C extinguishers would be a maximum of 30 feet away. The extinguisher station would have a sign on a red and black on white background with the words "FIRE EXTINGUISHER" and a pointing arrow. It is common sense to place an extinguisher near the maximum hazard site. Also place at least one in each working space or where movement to the fire extinguisher station is restricted or obstructed. The number of extinguishers immediately available must be sized to the amount of flammable material in use. At field sites, fire extinguishers should be no further than 30 feet from the work site, clearly visible with unobstructed access.

Painters are not trained fire fighters and, except for small fires easily put out with an extinguisher, should only:

(a) Warn other personnel in the area of the fire.

(b) Sound the nearest fire alarm or call the fire department.

(c) Stand by at a safe distance and prevent any other personnel from entering the fire danger zone.

4.10 Safety Information Available to Painters.

The main sources of information available to the painter on a shipyard are generally the shipyard safety and occupational hygiene support offices. Booklets are available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402, Department of Labor - Occupational Safety and Health Administration (OSHA) and many state OSHAs operate regional offices offering information. A most useful source of information about the dangers of the materials is the Material Safety Data Sheet (MSDS) mandated by the Federal Hazard Communication Act.

4.10.1 The Hazard Communication Act (HCA)

The federal Hazard Communication Act requires your employer to provide information about any hazardous materials to which a worker is exposed. The HCA requires an employer to identify all the hazardous chemicals in the work place. Examples of such hazardous material include: material in pipes, containers, welding fumes, and dust generated by work. The employer must provide a Materials Safety Data Sheet (MSDS) for each material or chemical. The MSDS is a comprehensive document containing nine sections. Make the MSDS available to the employee, do not just interpret the MSDS nor have it read to the employee.

The MSDS is divided into these nine sections.

SECTION I -MATERIAL IDENTIFICATION: Product name, description of product, name and location of manufacturer.

SECTION II -INGREDIENTS AND HAZARDS: Names of ingredients, percentage in material and the exposure limits (TLV-TWA and

OSHA PEL) of the ingredients.

SECTION III -PHYSICAL DATA:
Appearance, odor, boiling point, etc.

SECTION IV -FIRE AND EXPLOSION DATA: Flash point, explosive limits, ANSI label codes, extinguishing media, unusual fire or explosion hazards, special fire fighting procedures.

SECTION V - REACTIVITY DATA:
Chemical incompatibilities, conditions to avoid, hazardous decomposition products.

SECTION VI -HEALTH HAZARD INFORMATION:
Summary of risks, medical conditions which may be aggravated by contact, target organs, primary entry route, chronic effects, first aid information.

SECTION VII -SPILL, LEAK AND DISPOSAL PROCEDURES:
Spill and leak requirements for action, waste management and disposal requirements.

SECTION VIII -SPECIAL PROTECTION INFORMATION:
Personal protection equipment and work place considerations.

SECTION IX -SPECIAL PRECAUTIONS:
Storage requirements, special handling, engineering controls, other precautions.

The MSDS is a complete inventory of the information a worker needs to know about the materials in the work place. For a painter, MSDS Sections II, IV, VI, VIII and IX provide the most pertinent information. MSDS Section II provides TLV-TWA and PEL values. TLV-TWA stands for Threshold Limit Value (TLV)-Time Weighted Average (TWA). The TLV-TWA is the highest concentration of the chemical allowed in the work space air for up to a 10-hour work shift during a 40-hour work week. If the TLV-TWA is exceeded engineering control of the vapors or personal protective equipment is required. Engineering control often means use of ventilation or air filtering equipment. It can also mean that a switch is made to a less hazardous material or process. If a worker's air contains less than the TLV-TWA, no serious health effects are thought to occur.

The PEL is the Permissible Exposure Level. It is a TWA concentration above which you cannot go during any 8-hour work shift of a 40-hour work week. The PEL sets an upper level on concentrations to which a worker can routinely be exposed. In interpreting the TLV-TWA or PEL number, the important thing to remember is that the smaller the number, the more dangerous the chemical. The easiest way to use the numbers is to look up several familiar materials and compare them to the new product.

Besides providing the MSDS, the employer must label all containers of hazardous chemicals. A typical label must contain the information about health hazards, fire hazards, reactivity information, and required personal protection equipment. OSHA does not require a specific label, but many organizations, including most of the paint companies, have adopted some variation of the American National Standards Institute label (ANSI Z129.1). The information supplied by this container label is easily recognized. These labels are not a replacement for the detailed safety information available in the MSDS.

The employer must provide hazard information and training to the employee before the initial assignment to work with the material and whenever the hazard changes. The training makes sure that employees use the hazard labels and MSDS and so are following the appropriate protective measures.

4.10.2 Other Sources of Information

Information vital to the health and safety of painters in the ship building and repair industry comes from many sources. USGPO refers to: The Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402.

U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226 (313-533-8287)

NIOSH Pocket Guide to Chemical Hazards
(USGPO Stock number: 017-033-00448-0 $7.00)

NIOSH Respirator Decision Logic

NIOSH Certified Equipment List

A Guide to Safety in Confined Spaces
(USGPO Stock number: 017-033-00432-5 $1.00)

NIOSH Recommendations for Control of Occupational Safety and Health - Manufacture of Paint and Allied Coating Products

Occupational Safety and Health Guidelines for Chemical Hazards - Supplements 1 and 2
(Suppl 1 - USGPO Stock number: 017-033-00439-1 $11.00)
(Suppl 2 - USGPO Stock number: 017-033-00441-2 $10.00)

U. S. Department of Labor (DOL), Occupational Safety and Health Administration, Washington, DC

General Industry Digest OSHA 2201
(USGPO Stock number: 029-016-00112-3 $1.50)

Construction Industry Digest OSHA 2202
(USGPO Stock number: 029-016-00115-8 $1.75)

Hazard Communication - A Compliance Kit
(USGPO Stock number: 929-022-00000-9 $18.00)

Hazard Communication Guidelines for Compliance
(USGPO $1.00)

Shipboard Ventilation for Hazardous Atmospheres
(DOL)

29 CFR 1910, Occupational Safety and Health Administration
Industrial Ventilation [American Conference of Governmental and Industrial Hygienists]

American Conference of Governmental Industrial Hygienists, 6500 Glenway Ave, Bldg. D-5, Cincinnati, OH 45211

5 - ENVIRONMENTAL

5.0 Introduction

Environmental regulations have a significant impact on the way in which all business is conducted in the U.S. and the shipbuilding industry is subject to these regulations. Shipbuilding requires some unique responses to envirnmental rules because the business of shipbuilding is different from any other. This section describes the way in which environmental regulations affect the surface preparation and coating of a ship during construction or repair. As a rule the paint department and environmental office at the shipyard will work together to help limit the impact on painting/blasting of environmental regulations.

5.1 Approaches to Environmental Issues

There are many ways to approach the topic of the effect that keeping a clean environment has on ship coating and surface preparation. One approach would look at "vector" analysis, where does your waste come from and go to ? From which you can ask, how do I stop the waste from getting to that point ? A first step could be to classify the environment into air, water, and soil, then you consider likely sources of pollution from typical surface preparation and coating activities, solvents from paint, debris from surface preparation. The third step would be to show how these pollutants can affect or migrate to each environmental area. Then some changes in work process could be proposed so the work is done according to environmental regulations. This approach is used to a limited extent in the current section.

The majority of this section will focus instead on the known sources of pollution from ship surface preparation and coating. Facts will be presented to you about what activities or emissions are allowed. Options will be presented showing how you can reduce or control waste generation. Clear distinctions will be drawn between the methods of past shipyard operation and those methods which are gaining currency because they are "environmentally friendly." Our first step in this exercise is to define our terms.

5.2 Definition of Terms

Environmental Regulation - Any federal, state or local law or ordinance requiring measures to be taken to protect air, water, or soil from pollution.

Pollution - Any material added to air, water, or soil.

Waste - Any unused/unusable material resulting from surface preparation or coating.

Hazardous Waste - Any unused/unusable material which requires treatment before disposal in a licensed facility. Hazardous wastes contain, or are suspected to contain one or more "listed" components deemed hazardous by the EPA. All waste materials are considered hazardous before they are subjected to a TCLP test, see below.

Industrial Waste - Any unused/unusable material which may be directly disposed of in a licensed facility.

Hazardous or Listed Materials - Any material which is deemed hazardous to human or animal life by ingestion or exposure. The listing as a hazardous material means that the chemical is either toxic, carcinogenic, flammable, corrosive or a radiation source.

Toxic Characteristic Leaching Procedure, TCLP Test - A means to tell if what you have as waste is hazardous or simple industrial waste. The TCLP test is intended to mimic the effect upon a waste of burial in a landfill. It consists of suspending the suspect waste in an acidic medium, then measuring the amount of the suspected listed material(s) which leach from this waste within a set period of time. If your waste fails the TCLP test it is hazardous and must be treated before disposal.

Treatment -A method of stabillising the waste involving a chemical chnage to the waste. Treatment limits the amount of the listed material(s) which leach during a TCLP test, it makes wastes safe for disposal. Treatment options vary. Treatment can involve adding other chemicals to your waste such as cement, rendering the waste safe for burial. Other options include recovery of useful listed components from the waste stream or incineration in a licensed power generating facility. Each treatment option has its benefits. Stabiliization is less costly than receovery methods but should the waste escape from the disposal site the shipyard will still be held responsible for the resulting clean-up. Recovery may produce a larger volume of waste than is put into the recovering process. Incineration is most costly, but you will have no further waste to worry about, the fine ash produced is solely the responsibility of the incinerator owner. Some materials cannot be sent to an incinerator because they produce too high a level of toxin in the ash by-product.

Resource Recovery and Reuse -The optimum approach for most operations is to try and reuse as much material as possible. For instance solvents from paint spraying can be recovered, distilled on site, then reused as thinner or for solvent cleaning.

Emission Allowance -All shipyards are fixed facilties, by law if the shipyard is in an air quality attainment zone it is only allowed to emit a set quantity of organic solvents per day. This is termed the emission allowance. Organic solvent emissions from operations other than paint spraying or surface cleaning will also be deducted from the emission allowance. An emission allowance means you can only do so much coating work per day. Other types of emission allowances may also apply. For instance, if a generating facility is on site for SOx and NOx emissions.

Emission Levels - The actual amount of a class of material or waste emitted from the site into the air, water, or surrounding soil.

Storage - A fixed facility is allowed by law to request temporary storage of waste on site prior to eventual anlysis, treatment and disposal. Separate storage will be maintained for different types of waste, e.g. all solvents in one area, all abrasive blasting debris in another.

VOC -Volatile Organic Content, VOC, is a measure in weight per unit volume, lbs per gallon, g/L, of the amount of organic solvent in a thinner, paint, or surface cleaning agent.

Transfer Efficiency - A measure of how much paint or coating goes from the can to the article being painted. Used as a factor in determining the total amount of paint application which can be done each day at a controlled facility.

5.3 Wastes & Emissions from Ship Coating Activities

There are many facets to the process of cleaning and coating a ship, each will generate a stream of waste. The way in which each part of the shipbuilding or repair is done will change the type of waste produced. The following sections outline some of the more typical wastes.

5.3.1 Wastes from Surface Preparation

Surface preparation will produce solvent vapor emissions from solvent cleaning, waste or solid debris from abrasive blasting and mechanical cleaning, solid paint powder or debris may also be generated. Water-borne, aqueous, waste containing oils and greases may be produced from detergent cleaning. Aqueous waste contaning paint debris will be produced from water assisted blast cleaning of previously painted surfaces. Metal salts will be produced by chemical cleaning of metal surfaces.

5.3.2 Wastes from Painting

Painting activities will also produce waste products, e.g. excess solvents used for clean-up of application equipment, unused paints or components of paint and their containers.

5.3.3 Emissions from Surface Preparation

Surface preparation will normally produce dust emissions. Limts are set on the total amount of dust which can be emitted from any shipyard. Finer limits are also set on emission of dusts when it is suspected that the dust contains a listed material. Other emissions from surface preparation will include solvent vapors from solvent degreasing and water used for dust suppression in abrasive blasting, or as the surface preparation agent in detergent cleaning or water jetting.

5.3.4 Emissions from Painting

These are mainly volatile organic emissions from paint applications. Some paints will also contain materials which are considered hazardous materials, such as lead, chromium, or organic monomers. Each individual hazardous material will have a set emission level.

5.4 Emission Levels by Environmental Area

5.4.1 Water -

A good rule of thumb is that no emission of a solid waste, any organic solvent, nor any process water containing waste material, to any natural water such as a stream, lake, river or the ocean should be permitted. This is not a simple thing to accomplish in a shipyard, especially when dry dock work is being undertaken. Specific emission levels for commonly encountered materials are shown in table 1.

5.4.2 Air -

Emissions to the air are inevitable, they must meet specific levels for organic and commonly encountered mineral materials shown in table 2.

5.4.3 Soil -

Emission levels to the soil for commonly encountered solvents and mineral materials from shipyard painting work are shown in table 3.

5.5 Effect of Environmental Regulations on Surface Preparation

5.5.1 Solvent Cleaning

Solvent cleaning requires the removal of greases, oils and other dirt from steel. The primary effect of environmental regulation on solvent cleaning is to limit the use of organic solvents by substituting other materials, or to attempt their recovery. Two approaches can be taken for solvent recovery, the use of self contained vapor degreasing equipment, or recovery of solvent from a large painting shop using activated carbon air cleaning units as an integral part of the HVAC system. Self contained vapor degreasing equipment is only really useful for small metal parts. Failure to limit the use of organic solvents in cleaning of steel can quickly eat into your emission allowance. Substitute materials for solvent cleaning can be detergent based, but care must be taken to make sure all waste water is passed through a grease trap or sump before disposal to the sewers. Limits may be set on the total organic content of materials disposed of in this manner, see table 1.

5.5.2 Abrasive Blasting

5.5.2.1 Maintenance & Repair

The effect on abrasive blasting of metal surfaces during maintenance and repair of a ship with metallic or mineral abrasives is two-fold.
First dust emissions from a blasting operation must be kept within specified limits, see table 2, second the total volume of waste from the operation must be reduced. The problems encountered in surface preparation are made worse when dealing with removal of a paint known or suspected to contain a hazardous ingredient, lead, chromium, or organo-tin. Recovery of all waste blast media used in such removal is required. Storage of the blast media must be done in accordance with local environmental regulations. No blasting waste should be allowed to get into the waters adjoining the shipyard.

To meet these dual aims blasting work now focusses on the use of recyclable or recoverable media. Most of the time this will be metallic media. This means the volume of waste produced during surface preparation is reduced, but it will take longer to clean a surface as metallic abrasives are less productive than common slag abrasives. Manpower for surface cleaning is also increased by the extra effort needed to recover and separate the reusable metal abrasive from the fines and paint debris.

When it is important to reduce dusting levels, or maintain efficient media recovery while abrasive blasting, a containment may be used. Working in a containment may be less productive because of poorer visibility. If the containment is not well engineered the dust levels may exceed personal protection levels, this will cause work shift rotations to be increasingly frequent.

5.5.2.2 Working on Plane Surfaces

When working on plane surfaces such as ship decks or the hull plates it will be increasingly common for automated media recovery systems to be used. These are portable centrifugal blast cleaning machines which use metallic media. They are the best choice for reducing worker and environmental exposure. Portable centrifugal blast cleaning reduces waste volume by separating and cleaning the reusable media. Because the equipment recovers the blast and paint debris at the point of attack, worker exposure is also reduced.

5.5.3 New Construction

The majority of steel prepared for painting during new construction will be cleaned using fixed centrifugal blast cleaning equipment, wheel-blaster. These fixed units are equipped with media recovery and cleaning systems. There is the potential for most of the blasting work to be performed in an enclosed area, duat emissions to the environment are consequently minor.

Inevitably, some steel used in new ship construction is not fit to be sent through a wheel-blaster. Often touch-up of prepared steel from wheel-blasting is required before painting to remove the last traces of stains or millscale, to prepare edges or finish weld areas. In these cases either power tool cleaning or abrasive blasting with recoverable media can be performed.

5.6 Alternate Means of Waste Reduction & Dust Suppression

Attention has been paid to achieving adequate surface preparation without noxious environmental emissions. Several solutions exist for alternate means of dust control:

5.6.1 Air/Water/Abrasive Blasting -
A stream of water at pressures equal to or below nozzle pressure is used to control dusting. Air/water/abrasive blasting will drastically reduce but not eliminate dust emissions. The waste produced is a slurry mixture of paint debris, mineral abrasive, paint chips and water. The waste is difficult to handle. Productivity is lower than conventional abrasive blasting, see section 1. The prepared surface may be subject to flash rusting if no inhibitor is used in the water stream. The inhibitor must be compatible with the coating system.

5.6.2 Slurry Blasting /Sodium Bicarbonate Blasting -
A slurry of a water soluble abrasive is used for surface preparation. The most common type of abrasive is sodium bicarbonate. Slurry blasting will remove paint but will not make a surface profile. Sodium bicarbonate blasted surfaces do not seem to flash rust quickly. Productivity is lower than typical abrasive blasting and a second step may be needed to impart a profile. A promising use for this type of technique is layer by layer removal of hull coatings. Fine control of the blasting stream means that the AF coating can be removed leaving the undercoats intact. The waste from this operation will be a mixed slurry hence difficult to handle and clean up.

5.6.3 High Pressure Water Jetting -
A stream of high pressure water, 10K psig to 25K psig or higher, is used to dislodge coatings from a steel surface. Like slurry blasting fine control makes possible layer by layer removal of a single coat but no surface profile is produced. The waste stream consists of paint and rust particles suspended in water. Filtering, treatment and reuse of the water is

possible. Productivity with this type of blasting is far lower than abrasive blast cleaning, see section 1. High pressure water jetting is quite effective in removing thick elastomeric coatings.

5.6.4 Carbon Dioxide Blasting -
A stream of pellets of carbon dioxide is impelled at high velocity onto the painted surface. The impact and freezing action cause existing coatings to fracture and become dislodged from the surface. Layer by layer removal of the coating system is possible but productivity is very low indeed, as little as 5 square feet per hour might be removed. No surface profile is created by carbon dioxide blasting. The primary benefit of this method is that all the waste produced is the solid paint and rust debris from the failing coating system.

5.6.5 Vacuum Abrasive Blast Cleaning -
A blast cleaning nozzle with a recovery venturi under constant negative pressure continually removes blast media and debris from the work zone to a separator and cleaning unit. Vacuum blast systems are heavier than conventional systems, they are tiring to use and efficiency is reduced. Because the blast media is travelling at very high speeds some of the media and debris can escape the vacuum shroud surrounding the blast nozzle. This problem becomes particularly severe when cleaning complex shapes, or if the worker tires and does not maintain good contact of the blast nozzle and shroud to the work piece.

5.6.6 Power Tool Cleaning with Vacuum Recovery -
Various manufacturers now offer needle gun arrangements which boast near instant recovery and clean up of the paint and rust debris from a surface. Integrated systems are available which clean the recovered debris through a dual HEPA filter system and automatically bag the debris. Recovery is more efficient than vacuum blasting because the energy imparted to

the removed paint and rust is low, so little debris reaches a speed at which escapoe from the vacuum zone is possible. This type of method has been used in decontaminating surfaces coated with very hazardous materials such as PCB's or radioactive matter. During use the productivity of this method is lower than abrasive blasting. Economies of effort are realized because the recovery and clean-up are integral with the surface preparation. If near-white metal cleaning is required abrasive blasting may still be required though the dwell time needed is closer to that of brush-off blast cleaning.

5.6.7 Chemical Paint Removal -
A caustic or agressive solvent paste softens then lifts the paint from the steel. Final removal of the paint is achieved either by hand tool cleaning, scraping, or by washing down the surface with water. Some chemically resisitant or thick coatings may need several applications of remover for complete cleaning. No surface profile is created so a second blasting step is required unless existing profile is sufficient. Light blast cleaning may still be done because some chemical removers leave an active or inert oxide layer on the metal. Because most of the paint will have been removed the dwell time for this last step is quite low, close to that of brush-off blast cleaning. Note that a different type of waste product is created with chemical stripping. The waste may be a mixed liquid/solid slurry. The touted advantage of this method is to reduce, not eliminate waste.

5.7 Effect of Environmental Regulations on Paint Application

5.7.1 Solvent Emission Control

Keeping volatile organic emissions low is the universal requirement for paint application. This can be achieved through a combination of means.

5.7.1.1 Low-VOC Coatings

Most coating manufacturers now supply low-VOC versions of marine coating products. These are either water based, or more commonly high solids coating systems. The national marine coating VOC rules are under development by the EPA. The painter should know that the rules mean the VOC level of the applied coating, including thinner. It is often the case that high solids coatings cannot be applied effectively using coven-tional air assisted spraying. For that reason painters are becoming more familiar with airless, high volume low pressure and other efficient spray systems for high solids coatings. New spray equipment and high solids coatings can provide a learn-ing experience for a painter. They tend to quickly form very thick films, the painter will have to learn to control applied film thickness.

5.7.1.2 Closed Loop Painting Systems

In new construction many metal sections can be coated in a shop environment. By equipping the shop with solvent recov-ery systems it is possible to reduce the emssions of solvent to the air low. The result is that a shipyard could coat far more steel in one day without exceeding the emission allowance.

5.7.1.3 Solvent Substitution

Solvent substitution can be as simple as the manufacturer increasing his use of an exempt solvent, one that is not counted in the VOC figure for the coating. A more extreme approach is to subtitute liquid carbon dioxide for any solvent, resulting in dramatic reductions in emitted solvents. Paints applied using liquid CO2 tend to finely atomize. This can reduce transfer efficiency, but can produce very dense applied films. Liquid CO2 application will also require a significant investment in new paint sotorage and application equipment. A more general method of solvent substitution is to use water-borne coatings wherever and whenever allowed.

5.7.1.4 Paint Waste Reduction

Paint wastes can take three forms, particles of dry paint resulting from overspray, solid/liquid waste from used paint containers, and waste from clean-up of application equipment.

5.7.1.5 Overspray Control

The most effective means of controlling overspray is to improve transfer efficiency, see below. Overspray is problematic for other reasons and some overspray is inevitable.

Certain paints may contain pigments or chemicals that are considered hazardous or are viewed as pollutants. To reduce the incidence of polluting overspray the U.S. Navy is actively working to change all specifications so that paints pigmented with heavy metals like lead and chomium are not used. Despite these efforts some workhorse coating systems may still present a problem. For instance, inorganic zinc rich coatings contain high levels of zinc dust. Around waterways it may be that zinc dust overspray must be limited. In fact it is probably wise to view all overspray sources as potential pollutants and respond accordingly. This means that paint application will be conducted in a shrouded if not contained work zone. Efforts will be taken to make sure that overspray does not come in contact with the waters surrounding the shipyard.

5.8 Reducing Paint Waste

All paints can be bought in a range of container sizes. Not all coating jobs require a standard gallon or five gallon quantity of paint. If a piece only requires four gallons and you have five gallons of paint, you potentially have a full gallon of waste. You can control waste by combining jobs so that all the paint is used. Alternatively the unused portion of a coating could be placed in a smaller container for reuse later. This latter approach is only safe when dealing with one component coatings. Care must be taken when batching two component coatings. This can be quite a chore else an inexact mixture of the two component coating may result when the saved coating is later used. This can cause the applied film to cure with poor protective properties. Regardless of the number of batches made from a larger can of paint, the painter is still left with solid waste in the form of the paint cans to dispose of a the end of the day. Some other alternatives for reducing paint use and waste are described below.

5.8.1 Transfer Efficient Painting Systems

As the total number of gallons of coating which can be applied is limited it makes sense to get the greatest productivity from each sprayed gallon. The more paint you can transfer from the can to the steel, the higher your transfer efficiency. Transfer efficiency can improved by modifying application methods. High volume low pressure application equipment is touted as being nearly twice as efficient as simple airless spray, itself considered more efficient than conventional air assisted sparaying.

5.8.2 Plural Component Proportioning Equipment & Batch Tanks

An alternative method for reducing paint waste is to use large batch paint containers which may hold hundreds of gallons of product. The reusable tanks may be refilled with the same paint, or cleaned and made ready for a large batch of another coating when emptied. The advantage of this system is elimination of the need for frequent recanning of small batches of product. The disadvantage is that only as much coating should be stored as can be used within the shelf life of the coating or coating component. Dual batch tanks are needed to handle two-component materials.

The paint is delivered to the spray gun by proportioning pumps. Metering and mixing of the coating can occur in-line. This method has difficulties with coatings that require a sweat-in period.

5.9 Storage and Handling of Waste

All operations generate waste. The discussion given in this paragraph is based on federal regulations. State or local regulations may be more stringent than federal regulations. Careful control of waste helps reduce the cost of waste disposal. A coordinated approach to waste handling is required to make your job easier and to save the shipyard money. There are rules, some of them clear, which tell you what you can and cannot do with storage of waste. The basic assumption is that waste material is handled as if it is hazardous unless it has been tested and shown to be free of or below statutary limits for characteristic hazards. This means that any temporary storage or accumulation of waste must be done in accordance with the Code of Federal Regulations, 40 CFR Part 262 - STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE.

The first step in the CFR is to determine if the waste is excluded from regulation under 40 CFR 261.4. For all intents and purposes this is unlikely to be the case. Only specific items are excluded, common surface preparation debris is not excluded, nor is common paint waste or waste solvent.

The second step is to determine if the waste is listed as a hazardous waste as defined in Subpart D of 40 CFR 261. If the waste does not contain or is not inherently a hazardous waste it is deemed a solid waste which is subject to the RCRA rules, resource conservation and recovery. To determine if the waste is hazardous may require that a representative sample be subjected to the Toxic Characteristic Leaching Procedure. Some states, like California use a related set of test methods given the acronyms TTLC and STLC. TheTCLP tests to see if the waste contains listed heavy metals and other materials considered hazardous. Primary candidates for testing would include lead, chromium, barium or other heavy metals, organo-tin, and most solvents. Only if the leachables from the waste do not exceed stipulated minima shown in 40 CFR 261.24 does it pass the TCLP test. As discussed earlier there are many other ways in which a waste can be determined to be hazardous they include :

- Ignitable wastes;
- Corrosive wastes;
- Toxic wastes;
- Reactive wastes;
- Acute hazardous wastes.

If the waste is shown to be solid waste it must handled in accordance with RCRA rules. If the waste is deemed hazardous then it cannot be diposed of unless it has been treated so as to be non-hazardous. Prior to such treatment a generator has a maximum of 90 days during which the waste can be accumulated. After 90 days are up if you continue to accumulate waste you are a storage facility operator and need a license to operate.

Storage of the waste during the ninety day accumulation period must be done in a container that meets the requirements set forth in 40 CFR Part 265. In simple language this means the waste is placed in a container from which no leaks can take place.

Unless the shipyard wishes to go into the waste treatment business the next step is transporting the material to an approved waste treatment site. This must be done either in containers meeting the requirements of 49 CFR Parts 173, 178, and 179. Usually 55 gallon drums are used for transportation of waste, but larger containers or dumper rigs can be used, as long as they meet the 49 CFR Part s 173, 178, and 179 requirements.

It is useful to separate different waste streams from one another. This can reduce the cost of eventual disposal by limiting cross contamination of different waste sources. Separating waste streams also means you must know which bin a type of waste should go. This is no different from separating glass and plastic waste in domestic garbage.

5.9.1 Disposal

All waste must be disposed of or reused in accordance with federal, state and local regulations. The best approach is to try and reuse a process waste stream. If no reuse of the waste stream is possible it has to be treated as a waste. Disposing of waste products is a costly business. Waste is handled by waste treatment contractors on a volume basis. Typical costs for disposal of a drum of mixed paint abrasive waste may run up to $ 600 per 55-gallon drum.

In common with other businesses across the states, shipbuilding has to try and reduce the cost of waste disposal. After TCLP or other state mandated testing has characterized the waste there are only a few options for disposal.

1. If the extraction tests like TCLP show no sign of a listed hazard then the waste can go to an approved landfill.

2. If the extraction tests show a listed hazard above legal limits one of two options is open:

a. Either treat the waste so it passes the extraction procedure, then dispose of in an approved landfill, or;
b. Send the waste to a facility that will accept it as a feedstock or fuel for another process. The key thing here is that the process must chemically convert and immobilize the detected hazardous material.

The ideal approach if a material shows a hazardous ingredient is option 2 b. One example of such an approach is to send recovered stripping solvent to an incinerator for use as fuel. Another example would be to send paint debris to a facility which will exract the heavy metal or other hazardous component. In such a process the waste is treated as a low-grade ore.

In any case it is unlikely that shifting the problem to another group will come at no cost to the shipyard. The best method for reducing disposal costs is to reduce the volume and variety of waste the work generates.

Corrections and Addenda

to NSRP 0412, Handbook on Surface Preparation and Coating
Comments from letter to SSPC from A.R. Parks, Head, Corrosion Control Division, NAVSEA, Dec. 7, 1995.

p 1-3; 1.2.1.3: a) Federal Specification TT-490 is TT-C-490. b) Chapter 631 is: "Naval Ships Technical Manual," Chapter 631, Vol. 1, S9086-VD-STM-010/CH-631 V1 "Preservation of Ships in Service, General;" Vol. 2, S9086-VD-STM-020/CH-631 V2 "Preservation of Ships in Service, Surface Preparation and Painting;" Vol. 3, S9086-VD-STM-030/CH-631 V3 "Surface Ship/Submarine Applications."

p 1-45: Table 1-8: "MIL-P-2441" should be "MIL-P-24441"

p 2-1: Paragraph 2.1.1: Do not cite chromate compounds as good anti-corrosive pigments since they are now recognized as human carcinogens and no longer used by NAVSEA.

p 2-2; 2.1.3: Solvent; a) in general, Navy paints do not require thinning in that thinner will cause the paint to exceed VOC limits; b) MEK and xylol will not be used in Navy shipyards and should not be used in confined spaces due to low flashpoint.

p 2-4; 2.2.1: Zinc-Rich Coatings: The Navy's use of zinc-rich is minimal at best. Suggest the wide use of zinc-rich coatings is limited to "commercial" ship painting.

p 2-9; 2.2.6: This gives the impression that urethanes are used on Navy ships which is not the case at all. The Navy's use of urethanes is limited to depot level activities.

p 2-11; 2.2.8.1: This gives the impression that the Navy repairs vinyl coatings. The Navy does not use vinyl paint, thus they do not repair it and thermoplastic spray is not allowed.

p 2-11; 2.2.8.2: Wrong information. The Navy does not allow chromates or wash primer. Navy is not looking for a wash primer replacement since its use has been discontinued.

p 2-12; 2.2.11: Anti-Foulant Coatings: the following are not addressed: 1) Ablative AF paints; 2) Elastomeric Silicone easy release paints; 3) Underwater husbandry efforts.

p 2-12; 2.2.12: Elastomeric coatings are not used on aircraft carrier decks. Epoxy non-skid is used.

p 2-12; 2.2.13: Thermal spraying of metal coatings such as aluminum should cite MIL STD 2138. Navy does not seal with phenolic, but uses either thinned epoxy or heat resistant aluminum paint.

p 2-19; Table 2.3: a) underwater hull, anti-fouling and boottop should all cite MIL-P-24647; b) non-slip should cite MIL-D-24667; c) formula 117 should not be specified; d) for tanks the 23236 classes are wrong – use types I, III or IV; e) sanitary tanks do not use 23236 – at this time use 4-coat MIL-E-24607; g) anti-sweat formula 134 should be 34; h) aluminum surfaces do not use 23377 since it contains chromates; use epoxy; I) fiberglass antennae – do not use formula 124; probably use epoxy.

p 4-30; 4.7.2: The Navy no longer specifies vinyl formulas 117 and 119 or vinyl alkyds.

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National Shipbuilding Research Program
please visit:

http://www.nsrp.org/

or

http://www.USAShipbuilding.com/