SELECTING THE RIGHT ABRASIVE

A JPCL eBook

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Selecting the Right Abrasive

A JPCL eBook

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Introduction

This eBook consists of articles from the *Journal of Protective Coatings & Linings (JPCL)* on abrasive selection, and is designed to provide general guidance on how to determine the appropriate abrasive for various applications.

Photo this page provided by Mc Abrasivi, Italy.
Cover photo courtesy of GMA Garnet Group.

By David Dorrow,
Mineral Aggregates Inc.

Fishing for the Best Abrasive

Editor's Note: This article apeared in JPCL *in March 2011.*

Back when I was a youthful dad, I took my two young daughters down to the creek behind our house to teach them how to fish. When we opened the tackle box, their jaws dropped as their eyes scanned the many lures neatly spread out on the bottom of the box. Big and small, hard and soft, some lures were heavy, to fish on the bottom, or light, to float on the surface. My girls asked, "Daddy, which one is the best?" With a wink, I said, "They are all the best! It just depends on what fish you're trying to catch, the day's conditions, and where you're going to fish."

If you asked me a similar question about picking the best abrasive product for a job, I would give a similar answer. "It depends." It all comes down to project parameters, surface conditions, and your expected outcome. Before selecting the "best" abrasive, you must answer several questions about the surface preparation project.

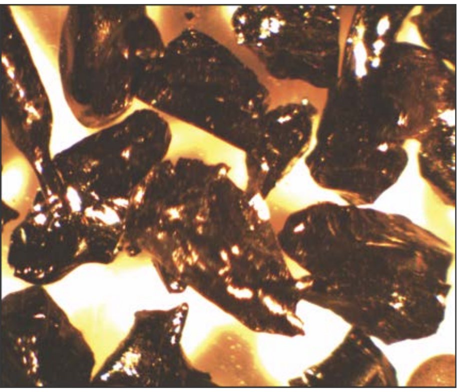
• What is the current surface condition: adhering paint, a brittle coating that is peeling, or mill scale?

• What are the goals and expectations after blasting? For example, is the surface being prepared for a new coating or cleaned to create a uniform visual finish that will be left uncoated?

• Will the surface profile need to meet the specification for the coating system or is it more important that the abrasive blast at fast cleaning rates?

Before selecting the best abrasive for a project, you must understand the characteristics of abrasives and how they affect the resulting finish. Like fishing lures, abrasives come in many sizes, hardnesses, shapes, and densities. Each abrasive's characteristics will affect the blast cleaning process and final results.

*Author with large mouth bass caught with the best lure for the "job"
Photos courtesy of the author.*



Fine iron silicate abrasive (copper slag) under magnification

Particle Size

The size of the abrasive particles affects both the productivity and surface profile. Decreasing abrasive particle size can dramatically increase cleaning rate, with more particles impacting the surface per unit time when compared with the use of a coarser abrasive. However, increasing abrasive size may be necessary to remove heavy coatings and scale. The general rule is: "Use the smallest size abrasive particle that will do the job."

Coarse abrasives generally leave a deeper and less uniform profile than finer abrasives. If a low profile is required, choose a finer abrasive. Conversely, use a coarse abrasive for a heavier profile. The normal tendency is to use a very coarse abrasive because it will knock off the paint, rust, scale, and other debris. But a coarse abrasive sacrifices coverage or cleaning rate. If a smaller abrasive will work just as well, use it because it will greatly increase cleaning rate.

Hardness

It is generally believed that the harder the abrasive is, the better it will perform. Very hard abrasives, however, tend to shatter on impact, expending most of the energy in particle disintegration and dust generation. A softer abrasive will transmit all of its energy to the surface, clean faster, and minimize dust. Similar to selecting abrasive size, select the minimum abrasive hardness that will effectively do the job. Hard abrasives will remove all coatings and surface contaminants and impart a profile on the surface. Very soft abrasives such as walnut shells and corn cobs are used to remove oil and grease and sometimes paint, leaving the existing substrate intact. In this case, the abrasive should break down on impact, carrying away the contaminants. If the intent is to remove only the coating and not disturb the substrate, use a slightly harder, friable abrasive such as soda ash, dry ice, or plastic pellets.

Productivity test, conducted under third-party guidance, on heavily pitted and rusted steel structure at a steel mill. Round and angular abrasives were tested for productivity and usage.

Shape

If the steel surface has a soft, pliable coating to be removed, an angular abrasive will be more productive than a rounded abrasive. Conversely, if the surface has a hard, brittle coating or mill scale, a rounded abrasive is preferred to pop off the coating or scale rather than pick away at it with a grit-like abrasive. An angular abrasive creates an angular and generally not very uniform surface profile. You will get a less angular but more peened surface if you use a rounded particle, such as steel shot or a heavy mineral sand (e.g., staurolite and olivine, which are naturally occurring and low in free silica). Both surfaces are acceptable, but different in appearance. Generally, angular particles work best when removing soft, pliable coatings, whereas shot or rounded particles are more effective in removing hard, brittle coatings (often aged) and mill scale. A mixture of both particle shapes is recommended for some jobs. Angular abrasives are generally used for coatings and rust removal; rounded sands are often used to remove mill scale from bare steel.

Density

Abrasive density can have a major impact on productivity. Generally, the higher the density, the better the productivity. Higher density particles impart more energy to the surface and, therefore, do more work. Application rate is the amount of abrasive required to achieve the level of cleanliness required. Generally, the denser the abrasive, the faster it will clean; thus, the denser abrasive will have a lower application rate compared to a less dense abrasive. As the mass or specific gravity of a particle increases, so does the amount of work being done by the particle. Therefore, if you change from a sand abrasive with a specific gravity of 2 to a garnet abrasive with a specific gravity of 4, you should expect an increase in cleaning rate because the higher specific gravity particle will do more work. If all else is held constant (such as nozzle pressure and particle size), productivity will increase with the garnet.

Preliminary blast cleaning trials using several different abrasive products with different sizes usually can determine the most productive abrasive product for the surface conditions. This is especially true for large surface preparation projects where productivity improvements can translate into huge increases in profits. To perform a productivity test, mark a section of the surface into grids, blast the section, and measure the area cleaned. Calculate the time required to blast the area and the amount of abrasive used. This will give you all the metrics required to calculate your surface preparation costs.

As with fishing lures, most people already think they know their "best" abrasive because they have been using it for years. However, to be a true professional, you must be willing to experiment, change, and adapt to the surrounding conditions. Surface conditions have a major influence on the type, shape, size, density, and hardness of abrasives, and you must to be knowledgeable in the art to pick the best.

And don't forget: Abrasive blasting and abrasives are subject to regulations for environmental and worker protection. Regardless of the abrasive and cleaning method for a job, you must comply with all relevant regulations.

About the Author

David Dorrow is the president of Mineral Aggregates Inc., which develops marketing solutions for mineral co-products from the steel, smelter, and other industries. With more than 30 years of experience in the abrasive markets, he is a member of SSPC and has served on its Abrasive Steering Committee; Surface Preparation Steering Committee; and Development Committee for SSPC-AB 1, Mineral Abrasive Specification.

JPCL

By Hugh J. Roper,
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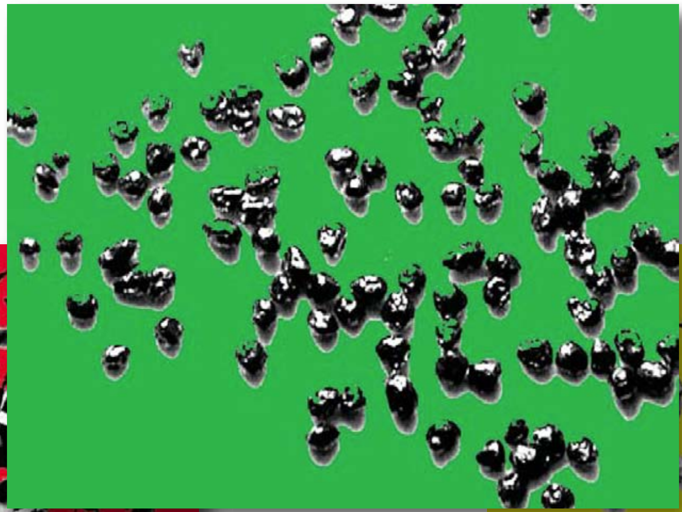
Peak Performance from Abrasives

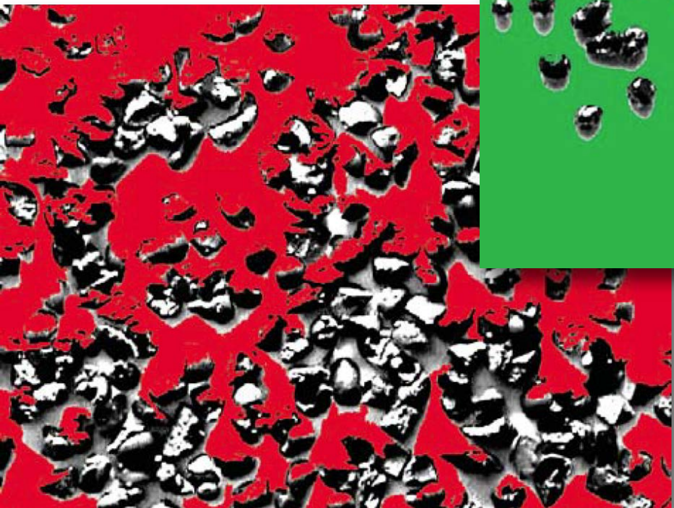
Editor's note: This article appeared in JPCL *in June 2006.*

The authors show how to control peak count and profile in abrasive blasting to optimize cleaning and coating of new steel.

In the June 2005 *JPCL,* we reported that the peak count in a surface profile can be measured and controlled and that it affects coating performance.[1] We based our findings on carefully controlled tests of coatings adhesion over profiled steel surfaces that varied only in peak count—the number of peak/valley pairs in a given unit length. The present article is a practical follow-up to the 2005 article. Here, we describe how to adjust peak count and profile height by careful selection of the basic blast parameters, especially abrasive size, hardness, and particle velocity. To show how to adjust peak count, we need to restrict as many other surface profile variables as possible. Because conditions vary widely on previously painted steel, we will limit our discussion to controlling peak count on new steel that has at least some mill scale remaining (Rust Conditions A and B). [2]

In our experience, the primary variables in controlling peak count and profile are abrasive particle hardness, density, size, and the velocity of the abrasive particles as they strike the substrate. Less significant variables are the substrate to be cleaned, the angle of impingement of the abrasive, the friability (fracturing) of the abrasive, and the degree of cleaning. In this article we will explore the relative effects of these variables and their interrelationships. We will also describe practical blast cleaning techniques and materials tests that facilitate achieving a uniform surface with the specified parameters. The concepts presented here generally apply to both air abrasive blasting and wheel blasting; differences will be noted.





Photos courtesy of Wheelabrator Abrasives

Primary Variables Affecting Peak Count and Profile Height

Defining and Measuring Peak Count and Profile Height

Peak count, P_C, is the number of peaks per linear inch (peaks per linear centimeter) recorded as a stylus moves across a fixed length of the blast cleaned surface. For simplicity, a peak can be thought of as movement of the stylus from below the mean line to above the mean line, and to below the mean line again. The mean line is halfway between the highest peak and the lowest valley in the evaluation length of the stylus instrument. A detailed description of peak count and profile height as measured by stylus instruments is given in ASTM D 7127.[3] Key words used in describing a blast cleaned surface are defined in the box and are illustrated in Fig. 1.

Effect of Abrasive Size on Peak Count

Based on our collective experience only, not on a controlled scientific study, we think that peak count is predominantly controlled by abrasive size. As illustrated in Fig. 2, only a small portion of the abrasive particle penetrates the substrate. For a given depth of penetration, the larger particle will create a greater distance between peaks, and hence a lower peak count. As will be discussed later, the abrasive size distribution must be controlled in order to control both profile height and peak count. To a lesser extent, abrasive velocity, hardness, and density also affect peak count, and other factors have a minor effect.

Key Words[1]

- **Deadband:** That distance above and below the mean line that a continuous trace line must cross in both directions (up and down) to count as a single peak. The deadband disregards small, spurious peaks due to noise. The deadband width is usually adjusted to fall in the range from 0.04 to 0.05 mils (1.0 to 1.25 µm).
- **Evaluation Length:** A sequence of five consecutive sampling lengths. The evaluation length is the part of the stylus travel that is used in computing the surface profile parameters. The two end sampling lengths are used only for calibration. The evaluation length in the experimental work done by the authors was 0.16 inch (4.0 mm), which was a common instrument setting before ASTM D 7127 was written.
- **Mean Line:** A line halfway between the highest peak and the lowest valley in the evaluation length and centered between the two lines defining the deadband.
- **P_C–Peak Count:** The number of peak/valley pairs, per unit of length, extending outside a "deadband" centered on the mean line. Because the deadband width is so small compared to the size of the peaks and valleys encountered in coatings work, the deadband region is essentially the mean line. For all practical purposes, a peak would be recorded if a continuous trace starts below the mean line, goes above it, and then below it.[2]
- **Peak/Valley Width:** The distance between crossings of the deadband region in the same direction defines the width of a peak/valley pair.
- **R_{max} :** The largest peak to valley measurement is determined from the five sampling lengths, and the largest of these five values is R_{max}. The distance from the highest peak to the lowest valley within each sampling length is measured. The largest of these five peak/valley distances is recorded as R_{max}.[3]
- **R_t :** The distance between the highest peak and the lowest valley within any given evaluation length. Unlike R_{max}, when measuring R_t, it is not necessary for the highest peak and the lowest valley to lie in the same sampling length.[4]
- **Sampling Length:** The nominal interval within which a single value of a surface parameter is determined. One fifth of the evaluation length.[5]
- **Traversing Length:** Seven sampling lengths comprising the evaluation length and the pre-travel and post-travel segments.[6] The traversing length is the total length of travel of the stylus during one trace.

1. Definitions shown in italics are taken from ASTM D 7127 "Standard Test Method for Measurement of Surface Roughness of Abrasive Blast Cleaned Metal Surfaces Using a Portable Stylus Instrument."
2. Pc is called "Peak Density" in ASME B46.1-2002 and "Peaks Per Inch Count" in SAE J911.
3. Rmax is called "Maximum Roughness Depth" in ASME B46.1-2002.
4. Rt is called "Maximum Height of the Profile" in ASME B46.1-2002.
5. The five sampling lengths within the evaluation length are also defined as "Sampling Lengths" in ASME B46.1-2002.
6. This length is also "Traversing Length" in ASME B46.1-2002.

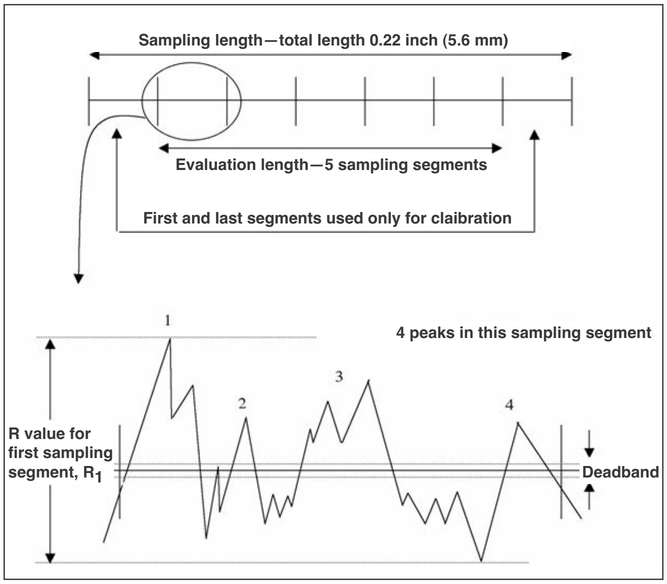


Figure 1: Schematic illustrating the profile parameters

- The vertical scale is distorted because for abrasive blast cleaned steel, the deadband is typically 0.04 to 0.05 mils (1 to 1.25 μm) while the R value is typically 2 to 4 mils (50 to 100 μm). At 100 peaks per inch (40 peaks/cm), the average distance between peaks is 10 mils (250 μm).
- The distance from the highest peak to the lowest valley in the first sampling length is R_1; the distance from the highest peak to the lowest valley in the second sampling length is R_2; and so on. The largest of R_1 to R_5 is defined as R_{max}.
- The average value of R_1 to R_5 is defined as R_z, which is not defined in ASTM D 7127.
- R_t is the distance from the top of the highest peak in the evaluation length to the lowest valley in the evaluation length. The highest peak and the lowest valley do not have to lie in the same sampling length.
- The peak count, P_c, expressed as peaks per inch (peaks per centimeter), is computed from the number of peaks counted in the evaluation length (five sampling lengths). The "peak" to the left of peak #2 is not counted as a peak since it does not cross the deadband.
- When measuring R_{max}, R_z, and R_t, "distance" is measured perpendicular to the mean line as shown in the figure.
- The mean line is halfway between the highest peak and the lowest valley in the evaluation length and is centered between the two lines defining the dead band.

The profile height is best described by R_{max}, which is the largest peak to valley measurement in any of the five sampling lengths that together comprise the evaluation length. The total trace has five sampling lengths. The procedure for measurement of surface profile with stylus instruments is described in ASTM D 7127. Profile height is more traditionally measured with replica tape per ASTM D 4417, Method C.* Currently, most job specifications that specify profile refer to ASTM D 4417. However, if peak count is measured with a stylus instrument, R_{max} is computed at the same time as P_C with no additional effort. Field trials done by the authors show that profile height as measured with replica tape and a micrometer correlates closely with R_{max}. A small systematic error usually causes the value for R_{max} to exceed the value from the tape by a few tenths of a mil (a few micrometers).

*ASTM D 4417 Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel, ASTM International, West Conshohocken, PA 19428

Effect of Abrasive Velocity and Density on Peak Count

Abrasive velocity also affects peak count, but not as much as particle size. The greater the velocity and the heavier the abrasive particle, the deeper the steel penetration and, consequently, the greater the distance between peaks (the lower the peak count), as shown in Fig. 3.

Controlling Profile Height

Profile height is also primarily controlled by abrasive size, hardness, velocity, and density. We have found that the easiest way to adjust profile in the field is by changing the velocity; changing the abrasive requires more labor and money. Other factors contribute much less to profile height. The faster the particle is moving when it strikes the steel substrate, the deeper the penetration; and thus the displaced metal will form higher peaks. In a wheel machine, particle velocity is increased by increasing the wheel speed. In dry abrasive blasting, the particle velocity can be increased by choice of nozzles (see sidebar on page 9) or by raising the air pressure at the nozzle.

According to the laws of physics, both energy and momentum are conserved in any collision. In collisions where the target (steel) or the abrasive particle is deformed, most of the energy is converted into heat. Because thermal energy is difficult to measure exactly, precise quantitative analysis of energy transfer is difficult. However, we do know generally that the heavier and harder a particle is and the faster it moves, the more work it does on the surface.

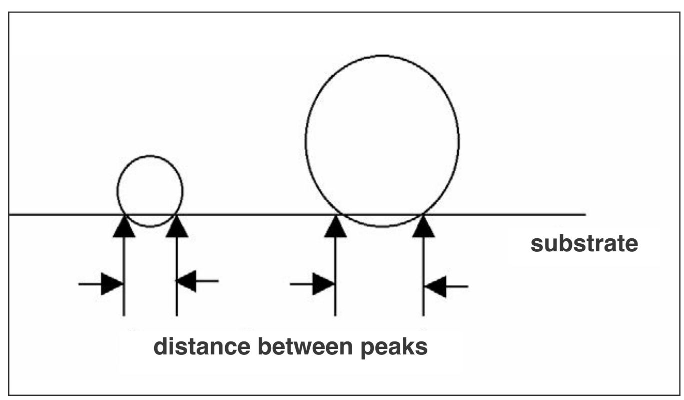


Figure 2: Effect of particle size on peak count.
The distance between peaks will be greater for larger abrasive particles for a given depth of penetration (i.e., peak height). This diagram is an idealized schematic, as the great majority of commonly used abrasive particles are not spheres but are irregularly shaped.

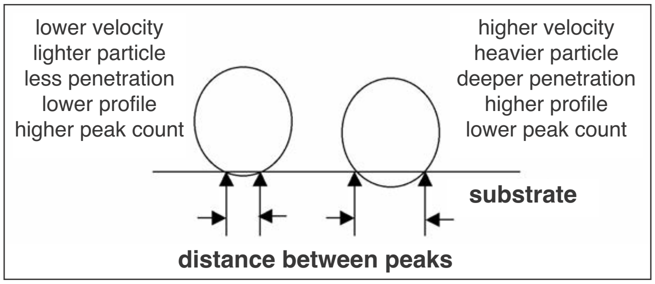


Figure 3: Effect of velocity and density on peak count.
The distance between peaks will be greater for a given size abrasive particle as the depth of penetration increases. The particle on the right has a higher velocity than the particle on the left; or the particle on the right has a greater density than the particle on the left, all else being equal. This diagram is an idealized schematic, as the great majority of commonly used abrasive particles are not spheres but are irregularly shaped.

The Effect of Specific Gravity (Density)

Specific gravities (or densities) of abrasives and their velocities determine how much work is done on the substrate. Specific gravity is the ratio of the density of a substance to the density of water. A ratio is a dimensionless quantity, i.e., it is not measured in feet, grams, or any other unit of measurement. Specific gravity is simply a number, the same number in metric or U.S. customary units. The specific gravity of steel, for example, is 7.8: It weighs 7.8 times more than an equal volume of water. Since one cubic centimeter of water weighs one gram, one cubic centimeter of steel weighs 7.8 grams.

To illustrate the effects of specific gravities of abrasives, consider a one-pound (0.45 kg) air-filled soccer ball and a one-pound solid steel ball both moving at the same speed. Both the soccer ball and the steel ball will have the same kinetic energy. Which would do more damage as it strikes the side of a wooden house? The steel ball. Why? First, its area of impact would be small, thereby concentrating the stopping force. Second, because the steel ball is hard and will not deform, most of the energy is transferred to the surface. The soccer ball, on the other hand, would not create much damage, if any, because it would absorb most of the kinetic energy internally by deforming. The larger surface impact area of the soccer ball will distribute the stopping force over a significantly larger area, thereby reducing the force at a specific point.

Similarly, consider two balls the size of baseballs, moving at the same speed. One is made of wood, and the other is made of solid steel. Clearly, the steel ball will be much heavier. Imagine both balls hitting the side of a house. Because kinetic energy depends on mass (or weight), the steel ball has significantly more kinetic energy and will do more damage when it hits the house.

Specific gravity should not be confused with bulk density of abrasive, although they are related. Bulk density is the weight per unit volume of many abrasive particles taken together and includes the air spaces between the particles. Specific gravity is related to the density of material from which the abrasive particle is made.

Relationships of Size, Hardness, Velocity, and Specific Gravity

Because of the relationships among size, hardness, velocity, and specific gravity and their relative influence on peak count and profile height, several choices must be made—abrasive type, size, and air pressure (wheel speed).

The size, hardness, and velocity needed to achieve a given peak count and profile height will be influenced by the specific gravity of the chosen type of abrasive. Here is the usual sequence of steps for selecting abrasive.

- Select a type of abrasive compatible with the available equipment.
- Because peak count depends most on size, choose the size of abrasive expected to achieve the desired peak count.
- Adjust the velocity of the abrasive to achieve the desired profile height.

With more experience, you will need to make fewer adjustments in velocity.

There are limited bands of peak count and profile height for a given abrasive type. Velocity can be increased by changing the nozzle type or increasing the pressure at the nozzle. However, there is a minimum pressure below which productivity is usu-

Table 1: Approximate Values of R_{max} (Profile Height) and P_C (Peak Count)*

Abrasive	R_{max} (mils)	P_C (peaks/inch)
G-40 steel grit	2.0 – 4.5	120 – 180
G-25 steel grit	3.0 – 5.5	90 – 120
G-18 steel grit	4.0 – 7+	50 – 75
20/40 flint silica sand	1.0 – 3.5	130 – 220
20/40 boiler slag	0.8 – 3.0	100 – 180

1.0 mil = 25 µm   100 peaks/inch = 40 peaks/cm

*These combinations can be expected for a common set of parameters under normal blasting conditions. Actual values may differ from those shown here because of differences in wheels, wheel speed, horse power, nozzle design, air pressure, hardness of substrate, hardness of abrasive, flow rate, blend of particle sizes supplied, etc.

Table 2: Classification of Peak Count as High, Medium, or Low

Classification	Peaks/Inch	Peaks/Centimeter
High	110 – 150+	40 – 60+
Medium	75 – 110	30 – 40
Low	50 – 75	20 – 30

ally not acceptable. Likewise, there is a maximum pressure for blasting, as determined by the capabilities of the equipment, the operator's comfort or ability, or the friability of the abrasive. Too high of a velocity will shatter the abrasive upon impact, thereby reducing its energy transfer and cleaning action.

Metallic abrasives are functional over a much wider range of operating pressures (velocities) than nonmetallic abrasives. Wheel blast machines use only metallic abrasives. Particle velocity is adjusted by controlling the wheel speed.

Because each job has its own peculiarities and because adjustments are limited, a rough idea of what peak count and profile to expect from a given set of conditions is needed. Table 1, compiled from random testing results from many field cleaning and profiling applications on steel substrates, provides nominal peak count/profile height combinations to expect for common blasting parameters (90–100 psi with proper nozzle selection and normal abrasive size).

The values in the Tables were extracted from our notes. Blasting was done with new abrasive, not a balanced operating mix. A balanced operating mix of steel abrasive can be expected to give values for R_{max} and P_C as much as 15% below those shown in the table. New steel abrasive has a higher percentage of larger abrasive particles than a balanced operating mix because larger abrasive breaks down faster than smaller abrasive. The suggested classification for peak count as high, medium, or low in Table 2 is based on average measurements of profiles produced from many different combinations of blasting parameters.

Much data has been accumulated on profile height for different abrasives under various conditions. The most prominent reference is A. B. Williams' *Abrasive Blast Cleaning Handbook.*[4] Because measuring peak count is a recent concept in the coating industry, no corresponding bank of data for peak count exists. However, our experience over the past fifteen years has led us to believe that peak counts between 90 and 150 peaks/inch (35 and 60 peaks/cm) are suitable for optimum performance of most industrial coatings. Although a wide range of peak counts is achievable, it is usually desirable, based on coating adhesion tests, to have the highest peak count that will allow complete wetting by the coating being used.

For a coating to perform well, it must first be able to wet the surface completely, i.e., the coating must penetrate to the bottoms of the narrowest valleys. It can be difficult to determine if a coating fully wets the surface. A reasonable guess on whether complete wetting will occur can be made based on the rheological properties of the coating. Most common solvent-borne industrial coatings, like epoxies and polyurethanes, will completely wet a high peak count surface; however, our experience indicates that some of the newer high-solids coatings do not wet surfaces as well as solvent-borne coatings.

The wetting characteristics of high-solids coatings may be altered by changing the temperature of the material or the substrate. A high-solids coating may have significantly different flow characteristics in the cool morning than it has in the hot afternoon. Similarly, a coating that performs well in the summer months in the northern states may not perform as well in the winter. However, today's state-of-the-art technology offers many methods of controlling the viscosity and wetting ability of most coatings.

Choosing a Nozzle

Several critical factors affect nozzle selection for a particular job. Nozzles come in a variety of materials, shapes, and sizes for a reason. As a general rule, long nozzles are preferred over short ones unless access to tight spaces is needed. At a given pressure, abrasive velocity depends on the design of the nozzle. Profile is affected by abrasive velocity. Hence, any test runs should be made with the nozzle chosen for use on the job.

Straight bore nozzles are used for spot blasting or cleaning welds because they have a small, well-defined blast pattern and minimal overspray. In straight bore long nozzles, the abrasive will attain the speed of the air stream. These nozzles work well at distances up to 36 inches (90 cm). Medium and short straight bore nozzles are used in tight spaces. Particle speed is lower in a medium nozzle than in a long nozzle and even lower in a short nozzle. Decreased productivity is associated with decreased particle speed.

Tungsten Carbide Long Venturi Nozzles

Venturi nozzles have a constriction that can almost double the air speed, and thus the abrasive speed, compared to a straight bore nozzle. This increased particle velocity makes Venturi nozzles more efficient than straight bore nozzles.

The long Venturi nozzle is most commonly used because it accelerates the abrasive particles to the highest speed and creates a large, uniform blast pattern. When working in close quarters, a medium or short Venturi nozzle may be used. The particle speed is lower for shorter nozzles, but the rebound is not as aggressive, making them better suited for blasting in close quarters.

Double Venturi nozzles are another variation of the Venturi principle. Most have short entries with a short flat throat section. The nozzles look like two short nozzles end to end, with a series of holes to allow entry of air into the abrasive air mixture flowing through the nozzle. The influx of air to the nozzle creates mild turbulence that makes the pattern considerably larger in the second section, with minimal reduction of the abrasive velocity. These nozzles work well with fine abrasives on large, open surfaces because the incoming air can spread the abrasive particles more easily and create a considerably larger blast pattern without decreasing the velocity significantly. These nozzles work well when fine steel abrasives are used (40 grit and smaller). These nozzles work best at pressures above 100 psi (690 kPa). Double Venturi nozzles are also used at low pressure (20-50 psi [140-340 kPa]) with low density or agricultural abrasives for stripping coatings from delicate surfaces such as those of aircraft, automobiles, and log homes.

Yet another variation of the Venturi principle is the long entry/long exit (bazooka type) nozzles, which operate at high pressures (120 to 150 psi [800 to 1,000 kPa] and can create considerably larger blast patterns than conventional Venturi nozzles. The long entry/long throat/long exit nozzle is most effective with small abrasives, especially heavy fine steel abrasives at elevated air pressures.

Approximate Service Life in Hours for Different Nozzles with Various Abrasives

Nozzle Material	Abrasive		
	Steel Grit*	Sand	Al Oxide
Aluminum oxide	20–40	10–30	1–4
Tungsten carbide	500–800	300–400	20–40
BP 2000 SiAlON	800–1,200	300–400	50–100
Boron carbide	1,500–2,500	750–1,500	200–1,000

* Stabilized workmix
From Boride catalog (used with permission)
Estimated values are for comparison. Actual service life will vary depending on blast pressure, media size, and particle shape.

Long life nozzles are made from aluminum oxide, tungsten carbide, silicon carbide composite, or boron carbide. Cost and ruggedness are the main driving forces in the choice of material. The life of a nozzle depends on both the material from which it is made as well as the abrasive that is used (see Table above). The relative lifetime of hoses and other in-line components is similar to that of nozzles, with aluminum oxide being the most aggressive and steel being the least aggressive abrasive.

The following hypothesis is beyond the scope of this article but needs to be verified elsewhere by testing: of two comparable coatings (same generic type and suitable for the same job), the one that best wets the surface should be able to outperform the other one. Over a low peak count surface, the two coatings should be comparable. Over a high peak count surface, the better-wetting coating should outperform the coating that cannot provide complete wetting. This result would be consistent with previous work of the authors.[1]

Secondary Variables Affecting Peak Count and Profile Height

Substrate: The hardness of the substrate will affect the depth of penetration of the abrasive, which in turn affects peak count and profile. The range of hardness encountered in most industrial painting operations is not that great to have much effect, although the most common structural steel, ASTM A 36, can range from 25 to 38 Rockwell C hardness. By heat treating steel abrasives, Rockwell C hardness can range from 40 for “soft” shot to 65 for hard grit.

Abrasive Hardness: The hardness of steel abrasive has a moderate effect on profile. A metallic abrasive should be at least four points harder on the Rockwell C scale than the substrate. The less the abrasive particle itself is deformed, the more energy there is available to use in deforming the substrate. If the abrasive is not at least four points harder on the Rockwell C scale than the substrate, the abrasive will not perform well and will round-up quickly (grit hardness of 45 HRC rounds up like shot quickly and is not recommended for surface preparation for coatings), and the full benefits of using metallic abrasive for coating application will not be realized.

Metallic abrasives are available in various hardness ranges. Cost is not a factor in choosing hardness because all hardness levels from one manufacturer usually cost the same. The choice of hardness in wheel machines is normally based on economic considerations of cost versus productivity. A general rule for airblast operations is that it is best to use the smallest, hardest, heaviest abrasive that will accomplish the work at the highest productivity level and the lowest cost.

Angle of Impingement: The angle at which the abrasive strikes the substrate will affect peak count and profile. If the abrasive particle hits the substrate at a glancing (oblique) angle, the momentum change of the particle will not be as great as if the particle were to strike the surface at an acute angle of 60 to 80 degrees. Consequently, the depth of penetration will be less for oblique incidence, resulting in a lower profile.

Friability: The friability (fracturing or shattering ability) of an abrasive affects peak count and profile because friability limits the maximum useful impact velocity. Energy absorbed by the abrasive during fracture is energy not transmitted to the surface. An abrasive particle that remains intact upon rebound from the surface will impart more energy to the surface than a particle that shatters upon impact. A pronounced effect of shattering is the more finely textured surface produced by nonmetallic abrasives compared to the well-defined, sharp craters produced by metallic abrasives. Metallic grit, unlike shot, produces irregularly shaped angular craters that are well defined. Scanning electron microscope images at 50 to 100X clearly show a difference in texture among surfaces blast cleaned with metallic grit, metallic shot, and nonmetallic abrasive.[5] When the abrasive particle shatters, the fragments also strike the surface, leaving craters commensurate with the size and speed of the fragments. The largest particles that do not shatter upon impact and the largest fragments from particles that do break up determine the profile height and the peak count of the surface.

Degree of Cleaning: The degree of cleaning can have a small effect on peak count and profile. Our field experience has shown that for a fixed set of blasting conditions, the highest peak count occurs in a surface prepared to SSPC-SP 10, Near-White blast cleaning. In commercial blast cleaning, SSPC-SP 6, every minute area has not necessarily been subjected to a direct impact. With Near-White blast cleaning, all of the surface has been impacted at least once, and a significant amount of the surface has been subjected to multiple impacts. Some of these "second, third, or fourth" impacts will flatten existing peaks, but some may land in a crater, further pushing up the adjoining rim to form a higher peak.

If blasting is continued to SP 5, White Metal, there will be fewer peaks and the profile height will decrease slightly. A reason for this effect could be that continued blasting has a tendency to flatten the first set of peaks but in turn produces smaller new peaks because of work hardening of the surface. Work hardening is more pronounced with steel shot than with grit. Overblasting to achieve a bright white metal surface can overwork the substrate of the steel surface and degrade the performance of the applied coating.

A Hypothetical Example

In an attempt to tie these concepts together, we offer a hypothetical example of field work. The job is to blast the interior of a tank. The job specification calls for SSPC-SP 10, Near White, a 2.0- to 3.0-mil (50- to 75-micron) profile, and a high peak count surface (P_C = 120 peaks/inch). Size #8 nozzles have been chosen and the hoses, the number of blasters, pot size, and compressor capacity have been properly matched. For a variety of reasons, Wondergrit coal slag has been chosen as the abrasive.

Here is the procedure the contractor should follow before ordering the abrasive for the job.

1. Determine the correct size of particles needed. Based on Table 1, size #20 should give a high peak count surface in the specified profile range. Get a sample bag of abrasive. Load 100 lb (45 kg) of this abrasive (WG-20) into the blast pot and conduct a field trial.
2. With flow rate and everything else adjusted for optimum performance, blast an area of at least one square foot (0.1 m^2) to SP 10. Document all blast parameters such as nozzle pressure, standoff distance, angle, etc.
3. Make five traces with the stylus instrument described in ASTM D 7127, one in each corner and one in the center of the square, as shown in Fig. 4. For each trace, move the stylus in a different direction—forward, backward, left, right, or either direction along a diagonal. Measure profile with replica tape if the specification requires it. Determine peak count, P_C, and profile height, R_{max}, by averaging the values from the five traces.

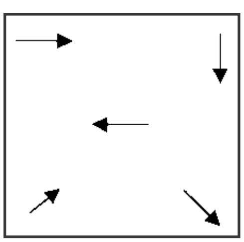


Figure 4: Five traces should be made with the direction of travel of the stylus going in different directions. The traces should be dispersed over the test area.

4. Suppose the results are a peak count of 100 peaks/inch and a profile of 2.4 mils. Because peak count needs to be 120, use a smaller abrasive. Therefore, repeat the test (Steps 1 to 3) with #30 abrasive (WG-30).
5. Suppose the new abrasive, WG-30, gives a peak count of 125 peaks/inch, but the new profile is only 1.8 mils. Since the smaller abrasive lowered the profile, compensate by increasing the velocity. Therefore, repeat steps 1 to 3 using WG-30 at a higher nozzle pressure.
6. Assuming that both peak count and profile height are now within the specified limits, order the abrasive, and instruct the blast crew what pressure to use.

In addition to finding a set of blast parameters that will meet the specification, the contractor can now begin to collect and document information about how this abrasive behaves with different nozzles under different pressures and at different sizes. After gaining some experience with common abrasives and nozzle pressures, the contractor will be able to adjust both the abrasive size, hardness, and the pressure to meet specific peak count and profile requirements for a particular job. The other side of the coin is for engineers to only specify combinations of peak count and profile height that can be achieved in the field.

Obtaining a Uniform Blast

Even though a test patch indicates that the peak count and the profile meet the specification, several factors such as those described below may complicate the task of meeting the specification on the rest of the structure.

Non-Uniform Abrasive

Perhaps the most frequent cause of a non-uniform surface is variation of particle size within the abrasive. This variation may be from batch to batch, or even from bag to bag within the same batch. During bulk storage and handling, the fines tend to separate from the coarser abrasive. As abrasive is being packaged, one bag may have a higher percentage of fines than another bag. The surface produced from these two bags of abrasive will differ, both in peak count and in peak height. Production rate will also differ.

If abrasive is delivered to the job site in a bulk carrier, some breakdown and separation by particle size will probably occur during loading, transportation, and unloading. If the abrasive is blown into the trailer at too great a velocity, the particles can break down as they hit the walls of the container. A similar effect can occur during unloading. By the time the abrasive reaches the blast pot, the percentage of fines has increased significantly from what it was when tested in the lab at the abrasive source. Contractors have sent newly delivered bulk abrasive through the separator and found much of the abrasive unusable. In short, the abrasive should be checked for size compliance not only at the point of origin but also at the point of use.

Variation in abrasive size can also occur during recycling if the dust separation system is not set up properly. In addition, the working mix should be replenished with new abrasive at the same rate as abrasive is being consumed. It is better to add a little new abrasive to the hopper every hour than to add a large quantity of new abrasive all at once at the end of the day.

An often overlooked source of size separation occurs within blast pots, especially large pots serving multiple blasters. As abrasive flows to the control valve at the bottom of the pot, fines tend to build up away from active ports and near the center of the load. Fines also tend to build up along the sides.

Eventually, these fines break loose, often all at once, and the blaster inadvertently blasts with “dust” for up to a minute. During this time, productivity decreases, profile is altered, and excessive dust is created. The best preventive measure is to use one or two blasters per pot with each automatic-fill pot holding enough abrasive for approximately 20 minutes of blast cleaning.

Blast Techniques

The worker holding the blast nozzle influences the uniformity of the surface. Blast techniques should vary somewhat to suit the nature of the abrasive. With recyclable abrasive, the nozzle centerline should be held at a 55- to 70-degree angle to the surface. Because of the high specific gravity (density) of steel abrasive, the abrasive does not slow down significantly as it travels through the air. Hence, the standoff distance using steel abrasive can be 4 to 10 feet (1.2 to 3 meters) without seriously affecting the blast profile.

For less dense recyclable abrasives like garnet, the standoff distance is the more conventional 18 to 24 inches (45 to 60 cm), but the angle should still be 55 to 70 degrees. Productivity is highest if the blaster "pulls" the nozzle along in front of the cleaned surface, while also sweeping the nozzle from side to side or up and down to blast the surface. This blast technique allows him to better evaluate the uniformity and degree of cleaning through the overspray as he is blasting (Fig. 5), rather than evaluating a larger area, sections of which may need additional cleaning.

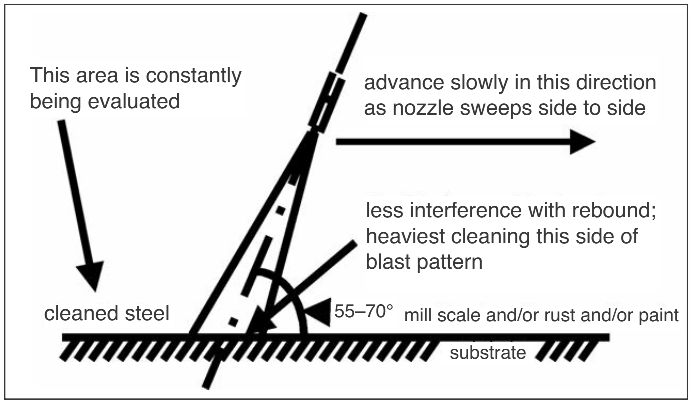


Figure 5: Proper movement and angle of nozzle when blasting with recyclable abrasive. The nozzle undergoes a back and forth sweeping motion cleaning an area about 2 ft (60 cm) wide while slowly advancing over the non-cleaned steel.

As steel abrasive rebounds from the surface, some abrasive is driven back into the surface after colliding with the incident abrasive stream. These secondary impacts also contribute to the cleaning and profiling.

If the abrasive flow rate is reduced, there will be fewer rebound collisions, and the particles will hit the surface at a higher average velocity. Having less abrasive moving through the nozzle also increases particle velocity. The increased velocity, in turn, will slightly increase the profile height and will also help the abrasive more easily remove tightly adherent foreign matter from the surface. However, productivity may be reduced slightly because of fewer impacts per unit time. Thus, when a hard-to-clean spot is encountered, the abrasive flow rate should be reduced until that spot is cleaned. Then, the blaster should readjust the flow to optimize productivity. Some modern equipment allows the blaster to control flow rate remotely by a switch mounted close to the nozzle.

When blasting with non-recyclable abrasives like sand or slag, the blaster should hold the nozzle perpendicular to the surface about 18 to 24 inches (45 to 60 cm) away. Maximum productivity occurs at a nozzle pressure between 80 and 100 psi (550 and 690 kPa).

These optimum blast angles should be determined empirically as blasters gain experience. Optimum blast angles differ because a non-recyclable abrasive usually shatters upon impact, with fragments flying in all directions. At a 90-degree angle, maximum energy is transferred to the surface. However, if a recyclable abrasive is shot directly at the surface (at 90 degrees), it will rebound intact into the incident abrasive stream. The collision between the incident particles and the rebounding particles will reduce the velocity and quantity of abrasive before it reaches the surface, thereby reducing cleaning ability.

Summary

From the authors' experience, the optimum steel profiles for a wide range of standard industrial coatings that will completely wet the surfaces are a 2- to 3-mil (50- to 75-micron) profile height and a peak count between 110 and 150 peaks/in. (40 and 60 peaks/cm). Optimum peak count for a particular coating depends on its rheological properties.

A general rule for adjusting peak count to optimize coating performance is to use the smallest, hardest abrasive that will do the job. To obtain a uniform surface, control the blast technique and the particle size of the abrasive. The coating must be able to wet the surface completely.

Although we have established that peak count affects coating performance,[1] complete detailed experimentation is yet be performed to establish the optimum range of peak count and profile height for specific coatings or coating types.

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Raymond E. F. Weaver has worked for SSPC since 1972, first as the coordinator of research projects and co-author of publications stemming from these projects—and later in the area of standards development and education. He authored the SSPC publication *Practical Math for the Protective Coatings Industry.* Mr. Weaver is currently a mathematics professor at the Community College of Allegheny County.

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JPCL

Assuring the Quality of Abrasives

Editor's note: This article appeared in JPCL *in December 2005, and is based on the original, written in collaboration with Ernestine McDaniel of the Coatings Society of the Houston Area.*

When you clean steel by abrasive blasting, you need to produce a finish that will allow maximum adhesion of the coating. Thus, you need to create the specified profile and the specified degree of cleanliness, such as SSPC-SP 10/NACE No. 2, Near-White, or Sa 2 1/2, Very Thorough (ISO 8501-1).

The abrasive itself will affect both the profile and the cleanliness of the steel. To achieve the appropriate profile, you must use the right size abrasive, and to achieve the appropriate cleanliness, you must use abrasive that will effectively cut away rust, scale, old paint, and other contaminants that may be on the surface. In addition, you must be sure that the abrasive is clean, so that it does not recontaminate the surface.

This bulletin deals with assuring the quality of the abrasive you are using. It will explain how to check for cleanliness, size, and, if you are recycling the abrasive, the proper operating mix.

Documents from the Abrasive Supplier

Your abrasive supplier will have processed the abrasive before selling it to you. This process normally involves cleaning the abrasive, testing it for chemical content, grading and separating it according to size, drying it, and preparing it for shipment in bags or bulk units. ISO standard specifications exist for abrasives: the 11124 series covers metallic abrasives, and the 11126 series covers non-metallic abrasives.

When you purchase the abrasive, you will receive a material safety data sheet (MSDS) describing its chemical makeup and the precautions you need to take when using it. You can also request documents on sieve analysis and detailed chemical content from a laboratory analysis. In addition to these assurances from the supplier that the abrasive meets your requirements, there are some simple tests you can conduct to verify that the abrasive is acceptable for use.

Abrasive Cleanliness

Abrasive needs to be clean; otherwise, the contaminants on the abrasive will be transferred to the surface being blasted. The most dangerous contaminants on abrasive are water, oil, grease, and chloride- or sulfate-containing salts. Any of these contaminants, once transferred to the steel, can cause failure of the coatings applied over them.

One simple way to detect oil and grease is to place a handful of abrasive in a clean glass jar containing clean water. Place a lid on the jar and shake it vigorously. If a film of oil appears on the surface of the water, then the abrasive is not clean enough to use.

Checking for oil and grease contamination is especially important when you are recycling the abrasive. In this situation oil and grease can easily be picked up from the steel surface or from faulty equipment, so it is useful to check for oil and grease at regular intervals during the blasting-recycling process.

This test of abrasive with water in a jar will also let you see how much dust or dirt is in the abrasive. If the water gets very cloudy or if dust rises to the surface of the water, then the overall cleanliness of the abrasive should be questioned. Excessive dust or fines in the abrasive will make you spend more time cleaning the surface before painting.

Visual inspection should let you determine if the abrasive is dry. Alternatively, ISO 11125-7 gives a method for determining whether there is moisture in metallic abrasives, and ISO 11127-5 gives the method for non-metallic abrasives. To keep your abrasive supply dry, make sure that it is stored properly, off the ground, and under shelter. Avoid using abrasive that has been exposed to the elements because of torn bags, improper storage, or other reasons. Damp or wet abrasive will clog up your blast equipment, prevent efficient operation, and cause pinpoint rusting on a steel surface.

Detection of salt or other chemical contaminants on the abrasive can be done in the laboratory or with specialized equipment in the field. If you suspect chemical contamination, you can check for contaminants with litmus paper. The abrasive should be nearly neutral; that is, it should have a pH of 6–8. If the pH is higher or lower, the abrasive may be chemically contaminated, though a higher or lower reading is not a definitive indicator.

You can do a conductimetric analysis to check for salt contamination with a minimum amount of equipment in the field. One such method is described in ASTM D 4940, Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives. In this test, you combine equal amounts by volume (300 ml) of pure water and abrasive, and after agitation, a waiting period, and further agitation, you filter the slurry and then check the water for conductivity with a conductivity meter. This test will let you know if you have ionic contaminants (i.e., salts) on the abrasive. According to ASTM D 4940, a reading of 500 µmhos/cm indicates a high level of salt contamination, while a reading of 50 µmhos/cm indicates a low level.

The use of a conductivity meter to check for salts is mentioned in SSPC's three abrasive specifications: SSPC-AB 1, Mineral and Slag Abrasives; AB 2, Cleanliness of Recycled Ferrous Metallic Abrasives; and AB 3, Ferrous Metallic Abrasive. The meter is also referenced

Fig. 1: Field kit for measuring salt content of abrasive
Courtesy of Elcometer Instruments Ltd

in ISO 11127-6 for non-metallic abrasives. ISO 11127-7 gives a method for the detection of water-soluble chlorides with non-metallic abrasives.

Field test kits are also available for the rapid determination of chloride contamination of abrasives (Fig. 1).

Abrasive Size

The size of abrasive you use will influence the speed of cleaning and profile created on the steel. The initial condition of the surface will influence the choices that must be made. Larger particles are most effective for removing old paint, layers of rust, and mill scale. However, they create a deeper anchor profile. Small particles are most effective for removing oxides. They are also needed if the steel is pitted.

A typical slag abrasive mixture is a 10–40 gradation. These numbers mean that, typically, at least 90% or more of the abrasive will pass through a #10 sieve (10 lines per inch) and be retained on a #40 sieve (40 lines per inch). Particles will be in the range of approximately 0.1 to 0.025 in. (2.5 mm to 0.6 mm) in diameter. The larger particles provide more impact energy and the smaller particles provide optimum coverage. Steel abrasives are more dense and harder than slag abrasives. Therefore, finer particles are used in making up the gradation.

The size and hardness of abrasives are two factors that will determine the profile and anchor pattern of the steel. So it will be necessary to select abrasive that creates the profile range specified in contract documents.

Occasionally, the size of the abrasive will be specified for a cleaning job, but more often, only the profile size will be specified (and is the preferred method). You can check abrasive size with sieve analysis as described in ISO 11125-2 and 11127-2 for metallic and nonmetallic abrasives respectively. Or you can check abrasive size using ASTM C 136, Test Method for Sieve Analysis of Fine and Coarse Aggregates, which is referenced in SSPC-AB 1 and AB 3. The sieve analysis is conducted with screens readily available from industrial supply houses (Fig. 2).

You can check profile height with replica tape or visual comparators to see that it conforms with specifications (Fig. 3, next page). If the profile height is greater than the specified range, then you need to use smaller abrasive. If the profile height is less than specified, then you need to use larger abrasive.

Fig. 2: Screens used for sieve analysis to determine the size of abrasive
Courtesy of RETSCH GmbH

Operating Mix

When you are recycling abrasive in a centrifugal blast machine, a field portable recycling system, or a vacuum blaster, you have to deal with the problem of abrasive breakdown. As the abrasive is used, it breaks up and is worn down by impacts with the work surface. A separator in the recycling system should remove abrasive "fines," that is, particles that are too small to be useful for cleaning. You will need to add fresh abrasive to the system at regular intervals to account for the loss from breakdown and to maintain an operating mix of abrasive sizes that will effectively clean the steel and create a consistent profile.

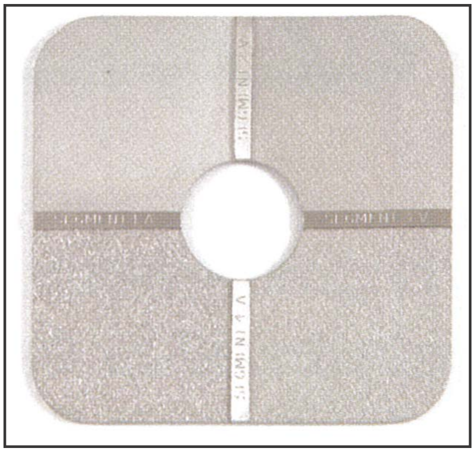


Fig. 3: Visual comparator to deternine profile height created by abrasive blasting with metallic grit.
Courtesy of Elcometer

Quality Control

You can make sure that the abrasive you use will not have a detrimental effect on coatings performance by making a few routine checks, such as testing for cleanliness in a jar of water, measuring abrasive size with a sieve analysis, and measuring profile with replica tape. More elaborate testing, such as conductimetric analysis or laboratory testing for salts, may be required in some instances.

JPCL

Checking Abrasives in the Field

Editor's Note: These responses to this forum query appeared in JPCL in November 2009.

Many SSPC and ISO standards can be used in the laboratory to check the quality of abrasives, including particle size, moisture content, and contamination. However, what are the most important quality checks to be carried out in the field when using new abrasive?

David Dorrow, Mineral Aggregates Inc.

Purchasing an abrasive from a reputable manufacturer—one who has run the gauntlet of qualification testing performed by a third-party certified lab—is the first step in the quality control process.

An experienced and alert set of eyes can be the consumer's next line of defense. Training employees to visually inspect abrasive and to diligently collect and review samples from each load is essential for jobsite quality control. When a bulk load of material is pneumatically being conveyed into a bulk storage hopper, is there a plume of dust rising into the sky? If the abrasive is generating dust during low pressure unloading, it will generate a lot of dust during high pressure blasting, causing poor visibility and decreased productivity.

Has a standard abrasive sample been kept from the start of the job to which all future samples can be visually compared? Has a sample been kept from each subsequent load for visual reference?

When samples are collected, one visual change to look for in an abrasive is a slight change in color. For instance, a sand abrasive may change from white to beige, while a slag abrasive may change from black to amber or green, indicating a potential change in product quality. Bulk density, hardness, and friability changes are most evident when color changes.

A simple test can be performed on the jobsite to check for oil contamination on an abrasive. Use a clean, uncontaminated scoop or hand trowel to collect a representative sample of the abrasive and place the abrasive sample into a glass of water. Look for a "shiny" oil slick to appear on the surface of the water, signifying oil is present on the abrasive.

This same abrasive sample and cup of water, along with a simple, inexpensive, pocketsize conductivity meter, can be used to test for non-visible contaminants like chlorides and sulfates. This concern is more significant for abrasives that are processed near the coast, as they may have been washed or quenched in brackish water or contaminated during transportation by barge on the Intracoastal Waterways. If you experience flash rusting on a freshly blasted steel surface, it is either from the chlorides on the abrasive or from preexisting chloride contamination on the steel surface.

Customers should also visually check the abrasive for impurities and contamination that can come either from the manufacturing process, the raw material, or the transportation and delivery system. While on the jobsite, a worker can easily use two quarters (or other coins) to test the friability of the impurities by rubbing a few granules between the quarters.

Mined or by-product abrasives typically contain impurities, but the important factor is that the impurities are as hard and inert as the abrasive material. Soft, friable impurities in an abrasive, on the other hand, may smudge on impact and visually spot the surface. This spotting is a concern for coating adhesion. If the abrasive contains impurities to the extent that you see the surface being contaminated during blasting, contact the manufacturer or look for a different quality abrasive.

The "quarter" test can also be used for evaluating the friability of the abrasive granules. However, this test should be viewed as only a general one for friability, as the pressure one applies to begin crushing the abrasive particles may not be consistent.

A visual inspection of the abrasive can reveal significant changes in the product gradation or operating mix; however, having a set of sieves on site to check the abrasive gradation or operating mix is useful. A sieve is an 8" or 12" round pan that has screen wire with specific size openings stretched across the bottom that can easily retain the varying sized abrasive particles. At a minimum, the abrasive should be checked with a maximum sieve size and a minimum sieve size to assure that the specific abrasive size that was selected is the same one that was delivered. A pot screen with ¼-inch openings is a must on all blast pots to catch large contaminants and oversized abrasive particles, eliminating potential downtime needed to clean out a blocked pot or nozzle.

The value of a diligent employee committed to quality verification cannot be overestimated and will go a long way in reducing on-site abrasive problems.

David Dorrow is the President of Mineral Aggregates Inc., a company that focuses on developing value-added marketing solutions for mineral co-products. He has participated in the SSPC Abrasive Steering Committee and the SSPC Surface Preparation Steering Committee, as well as the Development Committees for SSPC AB 1 Mineral Abrasive Specification.

Bud Budzinski, Reed Minerals

In most cases, a quick inspection of the abrasive before blasting can identify problems before they cause delays. Below are several quality checks that can be performed easily on abrasive materials before blasting.

- Confirm the material type and amount. Is the abrasive material on site the correct product? Don't rely on product labeling; visually check the material before use. Do you have enough material to complete the job? Inventory your material and order additional material before you run out.
- Product certifications. If a job requires the abrasive material to have a specific certification, check the shipping paperwork for this designation. In some cases, additional documentation is required and should be obtained before beginning a job to avoid being shut down upon inspection.
- Moisture. Did the material arrive in good condition? Inspect the packaging for rips or punctures that could allow moisture to penetrate the packaging and, ultimately, the material. Bulk bags that have been improperly stored can absorb moisture from the top as well as wick moisture from the bottom. Damp or wet material will flow poorly and will clump in your hand when squeezed.
- Material contamination. Whenever possible, examine the material for contamination before use. Always place a screen over your blast pot opening to catch any oversize granules.
- Material additives (liquid). If the abrasive was ordered with a liquid additive such as dust suppressant, the abrasive should be noticeably less dusty when handled and may even have a slight odor. Check if the dust suppressant was over-applied

by taking a handful of abrasive and squeezing it in your hand. If the abrasive clumps or sticks to your hand, it may be over-oiled.

• Material additives (granular). It may be necessary to use abrasives that contain granular additives such as heavy metal neutralizers. In most cases, these additives can be distinguished from the actual media by their size and color. If you are not sure if the product contains the necessary additive, contact your product sales representative or distributor before use.

• Conductivity/chlorides. Soluble salts, especially chlorides that remain on blasted surfaces, contribute to flash rusting and coating failures. These salts are found on the surface of certain types of abrasive granules and can leave a residue following blasting. Look at your abrasives closely; sometimes the salts can be seen on a granule's surface and appear as a white residue. Otherwise, blast a small area and test the surface using a portable field chloride tester before proceeding.

Anthony (Bud) Budzinski joined Reed Minerals in 1997. His main responsibilities include quality control and research and development. He also provides technical customer support.

Jeroen Keswiel, EUROGRIT BV

One of the most important on-site quality checks of abrasives is the conductivity test. This can be done in two ways, both described in ISO standard 11127.

For testing the abrasive in the field, determination of water-soluble contaminants by conductivity measurement (ISO 11127-6) is the most appropriate method, as it is a relatively simple procedure and no chemicals are needed. You only need a conductivity-measuring bridge and conductivity cell, together with some glass sample flasks and demineralized water. Determination of water-soluble chlorides per ISO 11127-7, however, cannot be done in the field because a laboratory setting is needed to handle the chemicals and procedures involved in the test.

ISO standard 11126 prescribes the limits on conductivity and water-soluble chlorides of each abrasive.

Hardness can also be tested in the field with a glass-slide test, but this may not really be necessary. Hardness will be tested once in a while in a lab or in the office; the test can easily be done in the field, but, normally, most abrasives are quite stable in hardness and the need for on-site testing is reduced.

Grain size distribution and moisture are more difficult to test in the field. For the sieve analysis, you need either a digital imaging particle size/shape analyzer or a number of test sieves with a "shaker," which makes it more difficult to do in the field. The moisture test also requires equipment that is not really portable. Normally, grain distribution and moisture are tested in a laboratory, where the necessary equipment is located.

Jeroen Keswiel has been an Area Export Manager for EUROGRIT BV (Papen-drecht, The Netherlands) since November 1996.

JPCL

Shotblasting: Tips on the Operating Mix

Editor's note: *This article appeared in* JPCL *in January 2007.*

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

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

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

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

Remember: The tips above are intended as a review or introduction to the subject of maintaining your operating mix. Consult your equipment manufacturer or manual for all procedures required to maintain the mix. In addition, read the entire SSPC-AB 5 standard as well as the documents it references before you check the cleanliness of your abrasive mix.

JPCL

When You Need Less, Not More:
Getting a Profile of Three Mils, Not Four

Editor's Note: These responses to this forum query appeared in JPCL *in October 2006.*

Specifications on old bridges that have never been blast cleaned often call for a surface profile of 3.0 mils (75 microns) maximum. To productively remove the heavy rust and mill scale, however, we use an abrasive that generates a profile of 4.0 mils (100 microns) or greater. Are there abrasive types that can be used to productively remove heavy, old coatings, rust, and mill scale without generating a profile greater than 3.0 mils?

James D. Hansink, Garnet Services, Inc.

The simple answer to this question is "yes," but a more important point would be missed if one merely suggested a mix of grain sizes, types, and nozzle pressures that should yield the desired results.

Go back and read the question again with the word "productively" highlighted.

The contractor is seeking a solution that maximizes the money in his pocket at the end of the job—certainly a worthy goal in itself!—but he needs to be sensitive to the buyer's needs. Profiles greater than 3.0 mils tend to consume excess volumes of the first coat, and deep profiles often yield hackles and oversized embedded grains that may promote corrosion and, later, failure. The fact that very coarse abrasive media may clean the surface quickly and might yield additional profit to the contractor should not be considered if the outcome is a 4.0-mil profile.

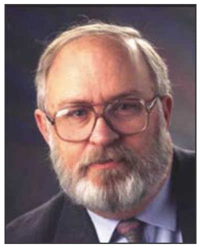
It is often critical to be the low bidder, but we hope contractors keep the buyer's needs uppermost.

In my experience, I have seen two different blasting techniques used to address the problem of achieving a 3-mil profile while removing old coatings. Both were effective and both used high-quality mineral media such as garnet.

I recommend using a blend of good quality garnet media consisting of at least 10% +30 mesh material and at least 60% -30 mesh grains. The coarser fraction tears off the thicker coatings with minimal effect on profile, and the finer fraction cleans the surface and leaves a profile of 2.5–3.0 mils. The operator will want to experiment a bit with blend ratios, air pressure, media flow rates, etc. to insure the highest level of "productivity"—cost-effective surface preparation. Partial recycling and adding coarse media as blasting progresses is also an option.

I might also consider a two-stage blasting process. In this case, the operator uses his favorite coarse material in a sweep/commercial blast to loosen and disrupt the thicker coatings and rusty scale. Cleaning and imprint of a 2.5- 3.0-mil profile is completed during a second near-white blast with a finer, high quality media. Again, I would suggest a limited test period to determine the optimum parameters.

The problem is a common one, and facility owners should encourage contractors to "think outside the box" in order to develop new methods and procedures to ensure compliant and cost-effective performance.



James D. Hansink has been active in the mining and manufacturing of mineral abrasives and other products for nearly 25 years. He has served in executive and management positions with a number of companies with interests in North America, Asia, and Europe. Mr. Hansink has been an active member of SSPC for 20 years and has served as chairman of the Abrasives Committee and as a member of the Surface Preparation Steering Committee. He has contributed a number of articles and technical notes to *JPCL* and other publications. He holds degrees from St. Louis University and from the Mass. Institute of Technology. He currently is president of Garnet Services Inc., a business development and environmental compliance firm.

Don Sanchez, Chesapeake Specialty Products, Inc.

I will answer this question in two ways: either the owner should change the profile specification, or the contractor should find a suitable abrasive and adjust the mix.

The common blasting practice for years generally has produced a 3- to 5-mil (75- to 125-micron) profile, particularly with non-metallic abrasives. Why now has this 3-mil (75-micron) maximum become such a significant issue?

John F. Kennedy once said, “Belief in myths allows the comfort of opinion without the discomfort of thought.”

Myth#1: Less profile is better!

If you have kids, you know that chewing gum dropped on a smooth surface can be peeled away with minimal effort. But when that same gum gets in the carpet, it is almost impossible to remove. Because the carpet has a much deeper profile, there is more surface area to which the gum can adhere. Paint works the same way—without profile, paint will not bond well. In the case of a bridge, insufficient profile can occur when the paint to be removed is an overcoat and the surface is not prepared properly. In this scenario, paint typically fails within a very few years. Peak count and profile height determine surface area. To maximize surface area, you would blast with smaller particles at higher velocity (higher pressure 130–150 PSI).

But the optimal profile for one coating may not be optimal for another. Different paint manufacturers have different profile recommendations on their data sheets. A product information specialist at one the largest paint companies said, “The surface preparation recommendations on (our) product data sheets reflect the minimum requirements for a successful coating system.” For instance, the data sheet of one of that company’s more popular urethane paints recommends a 2-mil (50-micron) minimum, with *no mention of a maximum*.

The product specialist I spoke with added that, “Blast profiles that exceed the minimum recommendation, within reason, could be acceptable, provided that the coating is applied at sufficient dry film thickness to cover the profile and still be within the recommended dry film thickness range as stated on the product data sheet for that particular coating/coating system.”

Bid documents seldom dictate sole source supplier of the coating system. Different paint manufacturers have differing profile recommendations for their products; therefore, *rather than an arbitrary maximum*, would it not make more sense for the bid document to state blast profile shall comply with manufacturers’ recommendations?

Myth #2: Rogue peaks are created by deeper profiles

Bridge owners and paint manufacturers in general seem to be worried that larger profiles can create the dreaded “rogue peak.” The myth is that too deep of a profile can cause a peak to be so high that paint will not cover it. Luckily, SSPC has created specs for steel and iron grit manufacturers that ensure standardized particle sizing based in part on the relationship between particle size and profile. The largest particle creates the deepest profile. For example, SSPC-AB 3, Ferrous Metallic Abrasives, maintains that all 40 abrasive particles must pass completely through an 18 mesh screen. Thus there results a consistent range of profiles and there can be no particle in the grit that can create an aberration of a deeper profile than the norm for that abrasive size. Ferrous metallic abrasives sized in accordance with SSPC-AB 3 will not create rogue peaks.

Certain blast conditions require either larger grit or higher nozzle pressures to remove pack rust, heavy coating systems, or hard-to-reach angles. The hard-to-reach angles require ricochet to get to the inaccessible areas. Ferrous metallic abrasives provide unique ricochet ability to access these areas and remove heavy rust and coatings in hard-to-reach areas. In addition, an engineered advantage of ferrous metallic abrasive is that it uniquely yields quantum increases in productivity with higher nozzle pressure. Higher nozzle pressure reduces the quantity of grit required, improves productivity, and reduces cleanup time. Restrictive profiles increase the cost of the job by prohibiting the inherent benefit of these engineered improvements available with recyclable metallic abrasive. The contractors know that there are trade-offs when blasting with larger grit and higher pressures because there will be a deeper profile, which requires more paint to obtain the specified dry film thickness. This is because dry film thickness must be measured from the top of the peaks. Because the owner's specifications call for a certain dry film thickness, the contractor should be allowed more leeway in the profile, as long as the dry film thickness is met. Remember, DFT is measured from the peaks and DFT is typically specified as a minimum, not a maximum.

SSPC-AB 3 states that "The profile depth (or height) is dependent upon the size, shape, type and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of recycling, and the proper maintenance of working mixtures of grit and/or shot." So to obtain a profile of less than 3 mils, you can use smaller size grit, use a softer grit, reduce air pressure, or reduce the angle of impact. You can also use a sub-angular grit that imparts a scouring action, which provides more profile control. Any one, or combination, of these will produce smaller profiles but in many cases, only with forfeiting some of the inherent advantages of ferrous metallic abrasive will they remove heavy mill scale, pack rust or thick coatings.

When forced to maintain a lower profile, the most common solution is to use a smaller, irregular shaped, sub-angular steel grit. Sub-angular ferrous metallic abrasive grit sized G50 or finer has been used successfully on many bridges that require a 3-mil profile or less. The shorter service life of finer grit and its potential lower productivity are necessary trade-offs. We recommend the contractor beware of restrictive profiles in bid documents when bidding a project.

Don Sanchez is the president of Chesapeake Specialty Products Inc. (Baltimore, MD), a manufacturer of granular metallic abrasive and iron oxides for a host of applications. He is a Patron Member of SSPC and has consulted on many bridge profile issues. Don can be reached via email at dsanchez@chesprod.us.

Hugh Roper, Wheelabrator Abrasives

Compared to typical protective coatings, many new industrial protective coatings are applied as thinner films that require less profile to provide optimum service life. The demands of using these new coatings can be met with a little forethought, planning, and preparation to complete the project at reasonable costs. Remember, you want to use the smallest, hardest abrasive that will clean a surface and create the specified profile in a cost-efficient manner with the equipment available for the project.

For removing old and deteriorating coatings from unblasted steel bridges to obtain a three-mil profile, in most cases, I would choose a full, hard abrasive, such as garnet or steel, of a 40/50 blend. Depending on the equipment available, I would use several nozzle types and sizes to take advantage of each one's particular efficiencies for the different cleaning techniques and applications of the job site: long Venturis for general work, short Venturis for close quarters, and, for large open areas, the new extra long Venturi type for extra speed in cleaning with metallic abrasives at constant elevated air pressures at the nozzle of 120 to 150 psi. I would always reduce the size of the nozzle to use a smaller abrasive at a higher air pressure and velocity with more cleaning power.

Now let us review the process and discover how a required low profile can be generated. We know that the substrate is profiled by the abrasive particle striking the surface, transmitting energy in the form of work, indenting the surface being prepared. The transfer of energy is regulated by the velocity, mass, weight, shape, hardness of the particle, angle of impingement to the surface, and hardness of the surface being prepared.

We also know that we can vary velocity, weight, hardness, shape, and friability of the abrasive particle to create different levels of available energy to transfer from the abrasive particle to the surface being prepared. We know, too, that different angles of impact create different levels of energy transfer to the surface.

Now that we have all the details that affect the profiling process identified, we can select the appropriate abrasive type size and hardness to suit the equipment available for the application.

If you find that a higher nozzle pressure is required to remove the existing coating with a smaller abrasive, and you do not have a larger compressor, in most cases you can reduce the nozzle size from a #8 to a #7 and gain the required continuous nozzle pressure. Smaller nozzles will consume less CFM and not have the same higher back pressure generated by the large nozzles. In most cases, reducing the nozzle size, thus increasing the nozzle pressure, will result in higher productivity because you have a higher particle velocity from the nozzle for faster work and deeper cutting. There is less back pressure as well as a lower fatigue factor for the operator, resulting in better productivity overall.

Prior to starting full production, you should always run an actual test using the chosen abrasive to ensure that you have selected the correct abrasive and nozzle for the equipment to be used.

Hugh Roper has worked for Wheelabrator Abrasives since 1989, where he has been responsible for technical services for all of North America and special assignments in South and Central America. He is a certified SSPC Coating Specialist and a NACE level 3 Coating Inspector Technician and is active in ASTM International, SSPC, NACE International, and the National Association of Pipe Coaters.

JPCL

By David Dorrow,
Mineral Aggregates Inc.

What is a Green Abrasive?

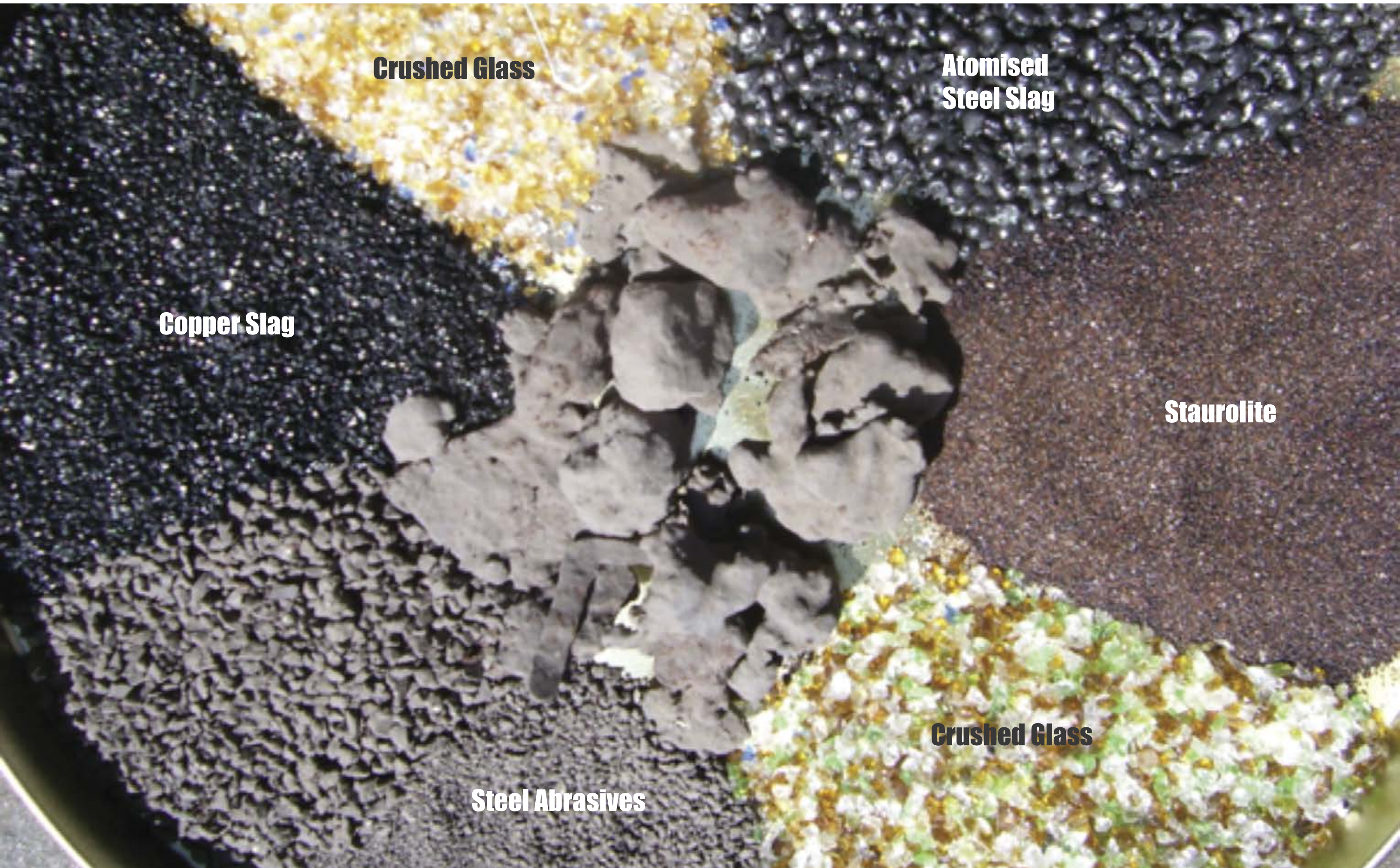
Do YOU consider a "green" abrasive when planning for your surface preparation project?

Editor's note: This article appeared in JPCL *in October 2012.*

On the market today are a multitude of abrasives that are described as "green," but what actually is a green abrasive? Generally, the use of "green" is a kind of shorthand term referring to the effect of the abrasive on the environment. More specifically and practically, the question that really should be asked is: "What environmental impact and sustainability of our natural resources will my selection of abrasive for my next surface preparation project produce?"

Our society has become more and more focused on how we are affecting the world we live in with our everyday behavior as our population continues to grow. We should all be accountable to future generations for decisions we make today, including our activities in the surface preparation industry. Our focus should be on using the best practices available that prevent pollution of our environment, use

Photo courtesy of the author.



sustainable technologies, and eliminate waste that crowd our already brimming landfills.

The surface preparation industry has made some tremendous strides over the past two decades in improving the environmental footprint of a blasting and painting project. Some of these changes have centered on the abrasive blasting segment of the project. Increased use of containment, improved engineering controls and a focus on proper abrasive waste characterization and reduction have all produced significant environmental strides in the right direction.

With today's multitude of abrasives and surface preparation technologies, making a choice can often be confusing. Coupled with all of the different claims about reduced environmental impact that manufacturers are making about their surface preparation products, decision makers may become overwhelmed. If the abrasive you have selected can reduce waste generated, be recycled, be produced from an industrial byproduct or a post-consumer waste stream, or be beneficially reclaimed, should it be considered a sustainable abrasive technology with reduced environmental impact? Of course, the answer is "yes," depending on the perspective one is taking.

Recyclable Abrasives

The ability to recycle an abrasive for more than one use can be viewed as an environmentally sensitive technology because of the reduction in waste generation. If an abrasive has the characteristics that result in limited breakdown after the initial use, it should be collected and processed for reuse as an abrasive.

Steel abrasives have been used for many years in fixed site facilities—fabrication and paint shops—that are set up to recycle the abrasive hundreds of times. In the early 1990s, with the increased awareness of protecting the environment from the impact of lead paint removed from structures, the development of portable/mobile recycling equipment expanded the use of steel abrasives to projects in the field such as bridges and water towers. A project using recyclable steel abrasives reduces the amount of total waste that is generated. This abrasive recycling process may also produce a potential waste concern because the removed paint waste is concentrated during the cleaning of the abrasive. Proper characterization and handling of the collected waste product with the intention to protect the environment is a prerequisite to maintaining an environmentally responsible position.

High-quality garnet is also an environmentally responsible abrasive selection because it can fall into the recyclable abrasive category. Along with recyclability, the fast cutting rates and low consumption rates achieved when using garnet abrasives can also reduce their environmental impact.

Producing Abrasives from Industrial Byproducts

The focus of the industry on developing additional market applications for byproducts generated during production processes continues to increase. Industrial byproducts are evaluated for chemical and physical characteristics and targeted for corresponding markets that can beneficially use the materials as abrasive as an alternative to immediately disposing of them after they are produced.

Coal-fired power plants, metal smelters, and steel mills generate byproduct mineral aggregates (slags) that have been successfully used as abrasives. Sometimes the generation processes of these byproduct minerals are engineered to produce enhanced byproduct characteristics. The use of these materials to produce abrasives can be viewed as a green application because a material originally destined for a landfill can be used to add value to the surface preparation industry.

Other byproduct minerals are generated during the mining and recovery process of valuable earth minerals. The mineral staurolite is a co-product separated during the refining process of mineral deposits containing high value metals and minerals. This material is a sought-after abrasive for certain blasting applications and can also be viewed as green.

Producing Abrasives from Post-Consumer Materials

Many of us participate in recycling of our household waste: paper, plastic, or glass. These materials that were originally destined for a landfill are now finding beneficial uses in various products. Several companies in the surface preparation market are offering post-consumer recycled glass as an abrasive product. The glass bottles that we leave at our curbside are collected, crushed, cleaned, and processed, enabling the green label to be applied to this reuse technology.

What's Next?

It can be noted that once the value as an abrasive is used up, the used abrasive and accompanying paint and rust debris from the blasting project typically become a waste and will likely end up in a landfill. Sometimes the waste is hazardous and will have to be treated before disposal; other times, the waste will not be hazardous but will still require disposal.

There are, however, some in the industry taking the next step by beneficially using the spent abrasives as raw materials for alternate industries. This additional green step is regionally dependent, and this technology has not yet been developed to its full potential.

In parts of the country, the lead-bearing paint debris from steel grit recycling systems has been successfully introduced back for beneficial reuse to the smelter industry. Slag abrasives continue to have value even after use as abrasive because they have a chemistry desirable to the Portland cement industry. Perhaps because of economics or logistics or indifference to being green, this final important step in closing the loop has lost momentum in the abrasive market.

Closing Thoughts

Making the correct decision in selecting a green abrasive technology reminds me of the following fable. Three blind monks were walking down a familiar path when they happen upon a sleeping elephant that was blocking their way. Having never experienced an elephant before, the three eagerly spread out and began to touch different parts of the elephant. One wrapped his arms around the sleeping elephant's front leg; the second grabbed a hold of one of the elephant's ears, while the third took hold of the elephant's trunk. Sensing that the elephant was beginning to wake, the three quickly ran off. When they stopped to rest, the three monks began to talk about the elephant and what the elephant looked like. The first man said, "An elephant is round like a tree trunk with no branches." The second man said, "No, an elephant is flat and leathery like a drum skin." Then the third man said, "No, no, no—you are both wrong! An elephant is long and thick and strong like a snake."

Each individual has his or her own perspective when it comes to selecting a green abrasive, and each of us has assigned a different importance associated with each abrasive technology. The significance for all of us as an industry is increasing our awareness of and focus on future sustainability by using the best available technology and minimizing our environmental impact. The abrasive selection should not be based solely on cost, convenience, or what we have always done in the past, but should also include an evaluation of how we are affecting our environment for future generations.

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