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WET ABRASIVE BLASTING - PROBLEMS AND SOLUTIONS

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INTRODUCTION

The drive to protect workers and our environment from injury by hazardous materials is changing how steel is protected from corrosion. Industry is struggling, perhaps even scrambling, to maintain the quality of corrosion protection as tried and proven methods and materials are eliminated by government regulation, litigation, and other pressures.

Dry abrasive blasting (especially with sand), acid pickling, and organic solvent based paints are endangered species. (Sand is not the only hazardous abrasive; arsenic and other contaminants have been found in silica-free abrasives [3].) Coating or plating with heavy metals (zinc, cadmium, chromium, etc.) is not far behind. Asbestos, one of the best fillers for organic coatings, is history.

Innovation is proceeding at a rapid pace to replace existing processes with new ones that are safer and more cost effective. For example, one industrial user has found that a reliable wet abrasive blasting machine eliminated an air pollution source, reduced silicosis exposure, and, when used for pre-cleaning, reduced a hazardous liquid waste disposal problem. An applicator of high performance coatings has installed wet abrasive pre-blasting to cut the time required for dry blasting (and thus the amount of dust generated) in half.

As new regulations go into effect, and insurance rates continue to skyrocket for suppliers, contractors, and owners involved in dry abrasive blasting, our industry must find ways to reduce or eliminate dust generated during surface preparation. "Wet abrasive blasting offers the potential to reduce or eliminate many of the problems associated with dry blasting" [1].

"Currently, the most practical and widely used alternatives to dry blasting are wet methods of blast cleaning. The use of water in combination with abrasives significantly reduces the amount of dust produced and the range over which it is distributed" [8].

The cleaning rates of ten wet blast systems evaluated in 1984-85 were 30% to 90% as fast as dry blasting [8]. However, at least one wet abrasive blasting system now available cleans as fast as, and sometimes faster than, dry blasting. With this technology, compressed air at 40 to 120 PSI transports a continuous stream of abrasive particles into a small propulsion chamber. The abrasive particles are then accelerated through the throat of a venturi nozzle by a medium (1500-2500 PSI) pressure water jet and, thoroughly wetted, impact the substrate at a very high velocity. This "wet jet abrasive" system effectively removes water soluble salt contaminants [2]. (The author notes that this technology does not presently fit within the equipment nomenclature of either NACE or SSPC. The phrase "wet jet abrasive" seems to convey the principal operating concepts.)

Our industry seems to have had relatively little experience with wet abrasive blasting except on small jobs. As regulations and other pressures force the use of wet abrasive blasting on larger projects, problems unique to this method of surface preparation must be addressed and solved. This paper identifies three of the most important of those problems and reviews progress to date toward solving them: blasting media quality control, the use of rust inhibitors, and inspection of wet abrasive blasted surfaces.

ABRASIVE BLASTING MEDIA QUALITY CONTROL

The pH and water soluble content are extremely important in determining if an abrasive blasting media is suitable for wet abrasive blasting. Bleile, et al, reported that the pH of ten different abrasive slag materials ranged from 5.7 to 10.1 [3]. Samples of abrasive blasting sand commercially available in the Houston, Texas, area have pH values ranging from 4.5 to 6.8.

Further studies are needed to determine whether the pH of a blasting media from a particular supplier is consistent or varies from batch to batch or from particle size distribution to particle size distribution. Similarly, additional research needs to be undertaken to determine what chemicals in the blasting media cause the pH to be either acidic or basic.

It is known is that the pH of the abrasive blasting media (ABM) significantly affects the tendency of a wet abrasive blasted surface to either form a general flash rust or to develop small, randomly located, spots of rust sometimes referred to as "pinpoint rusting". Using a blasting sand that drops the pH of the blasting water to 4.5, and a proprietary wet blast inhibitor that has no affect on pH, it was not possible to prevent general flash rusting even at inhibitor concentrations as high as 2%. Using the same sand, and an alkonolamine inhibitor which tends to raise the pH, it was possible to eliminate the flash rusting at a concentration of inhibitor in the blasting water of 0.5%. However, some randomly dispersed pinpoints of rust appeared after a few hours. It is believed that going to a concentration of 1.0% with this particular inhibitor would eliminate the pinpoints of rust, but this has not yet been tried.

Blasting sand with a pH of 6.5 to 6.8 is commercially available in the same geographic area at the same price. Both flash rusting and pinpoint rusting can be eliminated with an alkonolamine-type inhibitor at concentrations of only 0.2% using sand with a relatively neutral pH. Specifying and purchasing ABM with a non-acidic pH is preferable to increasing inhibitor concentration for technical as well as economic reasons: the lower the inhibitor concentration in the blasting water, the lower the probability that inhibitor residue can contribute to paint problems.

The amount of water soluble material (often referred to as "water soluble content") in a blast abrasive can cause it to be unsuitable for use with wet blasting equipment. Abrasive blasting media with a water soluble content of 0.5% or less, by weight, typically does not pack up on vertical and horizontal surfaces, dries out fairly quickly, and is easy to wash off. One blasting sand in the Houston area has been determined to have water soluble contents as high as 4.0%. When used for wet abrasive blasting, this sand tended to build to a thickness of 1-1/2" to 2" even on vertical surfaces. The sand stayed wet for hours, and was very difficult to wash down, especially out of corners. The longer the sand keeps the water against the freshly blasted steel, the more effective the inhibitor must be. Sometimes the inhibitor concentration must be increased to compensate for the longer wet time.

Initial testing suggested a correlation between the high water soluble content and low pH. However, additional investigation has shown that not to be true. For example, one commercially available blasting sand in the Houston area has a water soluble content of 0.2% and a pH of 4.5.

One key to success on any surface preparation and painting project is consistency. Without control over pH and water soluble content, it is virtually impossible to obtain consistency on a wet abrasive blasting project. Testing pH of each batch of abrasive as it is received at the job site is a very simple, inexpensive, five-minute procedure. It can easily be performed by the contractor or the inspector. Testing for water soluble content is more complicated and will require the development of a kit to be used at the job site. In the meantime, it is recommended that those who will use wet abrasive blasting techniques identify and patronize suppliers of abrasives with a pH of 6.5 or higher and a water soluble content of 0.5% or less.

One should be cautious of the confusion that exists regarding dry abrasive and moisture. When questioned by phone, a sand supplier reported the "water soluble content" to be 0.25% maximum on one size sand and 0.50% maximum on another size. Later he corrected the statement to "moisture content." Still later, it was discovered that the independent lab which was performing the tests was actually measuring and reporting "water absorption."

Both pH and water soluble content are measured by standard ASTM test procedures normally used to evaluate soils. It is the "water soluble content" that can result in a glue-like binder and cause difficulties in cleaning up the wet abrasive.

WET ABRASIVE BLAST INHIBITORS

A variety of chemicals can be added to the blasting water to retard the development of rusting on a wet abrasive cleaned surface. Nevertheless, some consideration should also be given to the relative merits of coating over flash rust versus coating over inhibited surfaces.

Numerous references indicate it is far more detrimental to apply a coating over a chloride or sulphate contaminated substrate than over a substrate which is contaminated with chemically pure iron oxide, similar to that found as a pigment in many coatings [4, 5, 7]. Also, many paint companies have developed primers which are specifically more tolerant to salt free rust. Wet jet abrasive blasting of the type described above very effectively removes soluble salts such as chlorides and sulphates from the surface [1, 2, 6]. The flash rusting or pinpoint rusting which forms after wet abrasive blasting with no inhibition is a chemically pure iron oxide relatively free of chloride or sulphate contamination.

Bleile, et al., found that contaminants left on the surface from dry abrasive blasting with mineral slag from two different suppliers actually contributed to premature coating failure (blisters) [3]. It would be very interesting to use these two abrasives in a wet abrasive blast system with no inhibition. It is possible that the wet jet abrasive would remove the contaminants to a level such that the blistering of the paint film would not occur, because the surface provided by wet jet abrasive blasting is chemically clean.

Nevertheless, a non-flash-rusted surface is preferred for the application of paint films. The most commonly used chemical inhibitors for blasting water are alkonolamines, sodium nitrite and/or nitrates, ammonium phosphates, sulfonates, benzoates, and numerous variations of these. There has been a lot of discussion, but surprisingly little hard data, on the affect of the above types of inhibitors on paint performance.

One set of test data, as yet unpublished, suggests that most inhibitors must be used at concentrations of 1% to 3% to prevent flash rusting. Humidity cabinet and adhesion testing of panels blasted in this program showed that the higher concentrations contributed to lower adhesion and/or increased blister size and frequency. The exception was an inhibitor based on alkonolamine chemistry that provided effective inhibition at 0.5% and did not cause blistering or a decrease in adhesion at a concentration of 5.0%. This helps explain why paint manufacturers seem to be more comfortable with the alkonolamine-type inhibitors. This chemistry is considered to be non-toxic and biodegradable in these concentrations, according to one European manufacturer.

Unfortunately, the potential effect of pH and water soluble content of the blasting abrasive used in these tests was not measured. It is therefore uncertain how much of the decreased adhesion and blistering may have been caused by the contaminants in the abrasive.

Another concern is the use of inhibitors in wet abrasive blasting around food products, such as potable water treatment and storage facilities. Naturally, every possible precaution must be taken to prevent the blast water from contacting the food product because the water contains paint, rust, and spent abrasive, any one of which may be far more dangerous than the inhibitor. At least contaminants suspended in blast water are easier to contain, collect, and remove than a dust cloud. Discussions to date with the potable water industry suggest that the inhibitor of choice for this application will likely be food grade sodium nitrite based.

There is a surprising lack of information in the literature on inhibitors for wet abrasive blasting. A major project has been initiated to test several types of paint systems from the world's leading paint manufacturers over five types of surface preparation: four wet jet abrasive blasted panels and one dry blasted panel as a control. These results will provide the basis for a paper in 1988.

INSPECTION OF WET ABRASIVE BLASTED SUBSTRATES

The dry abrasive blasted surface is always darker in color (even when white blasting sand is used) and lower in reflectivity than a wet abrasive blasted surface. This is because there is a uniform layer of powdered abrasive, powdered old paint, powdered chloride and sulphate contamination, and powdered anything else that was on the surface prior to blasting. This powder is deposited in a uniform layer over the blasted surface. This uniform layer of contaminants firmly adheres to the substrate. Attempts to wash it away with a 2500 PSI water jet still would not produce the same sheen and reflectivity as that developed with wet abrasive blasting. This would indicate there is still some contaminant present on the surface that was not present when the surface was cleaned with the wet abrasive device.

These results would also lead one to question the validity of dry blasting followed by rinsing or water jetting as a method of preparing simulated wet abrasive blasted test panels. For example, the author has observed that a particular concentration of sodium nitrite inhibitor in the blasting water will very effectively prevent flash rusting, while the same concentration used in water to wash off a dry blasted surface will not prevent flash rusting.

The presence or absence of the powdered layer of contamination on the surface further fuels a major conflict in this industry: inspection and acceptance or rejection of a surface as ready for painting.

What is seen by an inspector is the light reflected from the surface. What is generally accepted as "white metal" is a gray color of uniform reflectivity with no darker areas or spots. The color of the dust generated by breakdown of the abrasive is normally uniform. If a layer of powder of uniform color is on the surface, the color of light reflected from that surface will naturally be uniform and the probability of acceptance greater.

If that layer of powder does not exist because the steel was wet abrasive blasted, the appearance of steel is bright silver as opposed to a neutral gray. The bright silver surface reflects more of the light that shines on it; therefore, minor imperfections are far more apparent and the probability of acceptance is lower.

There has been considerable discussion of the difficulty in developing visual and/or written standards for inspection of abrasive blasted surfaces. Perhaps the basis of the difficulty is that a single visual criterion is being used to judge surfaces covered with a layer of white powder (sand), a layer of black powder (slag), and now, with wet abrasive blasting, no powder. These three types of surfaces <u>cannot</u> look the same.

Inspectors have had to relearn their trade as a transition is being made from silica sand to slag-type abrasives. As wet abrasive blasting replaces dry blasting in many applications, inspectors will again have to relearn their trade. Development and acceptance of a quantitative chemical test for determining surface cleanliness will help eliminate much of the subjectivity of the inspection method. In the meantime, owners, contractors, and inspectors must accept that clean steel simply does not look the same without all that dust on it.

One simple technique which has been useful in demonstrating the actual cleanliness versus the apparent cleanliness of substrates involves the use of strong, white filament tape. A two-inch length of the tape is pressed on the surface and into the anchor profile, then removed with a sharp jerk. The powdered dust, rust, and old paint adhere to the tape and are much easier to see against the white background. Spots or pinpoints of rust which were hidden by the layer of powder are also pulled off by the tape and are easy to see against the white background. While not very scientific, this method helps educate inspectors who are not accustomed to looking at substrates cleaned with water wetted abrasive.

CONCLUSIONS

* A new era of abrasive blast surface preparation is dawning - one in which the use of water wetted abrasive will become the norm rather than the exception.
* The change to water wetted abrasive to reduce or eliminate dust is being driven by powerful safety, environmental, and economic forces.
* Water wetted abrasive is effective at removing water soluble salts and producing a higher level of chemical cleanliness than dry abrasive blasting.
* Chemical cleanliness of the blasted surface is crucial to good paint adhesion and long-term paint performance.
* Control of the pH and the water soluble content of the abrasive is essential to successful surface preparation with water wetted abrasive.
* Technology is now available that should make blasting with water wetted

abrasive (and thus reduction or elimination of dust) technically and economically feasible on most surface preparation projects.

* Quantitative techniques presently under development to inspect abrasively cleaned surfaces will help to resolve inspection conflicts caused by the differences in reflectivity of dry blast (dust covered) versus wet jet abrasive blasted (dust free) surfaces.

* Chemicals are available for the blast water to effectively prevent flash rusting. However, considerable testing and investigation is needed to determine their affect on paint performance.

* The following are interrelated and interdependent and must be considered together as a whole:

    - Water wetted abrasive blasting equipment.
    - Inhibitor chemistry.
    - Inhibitor concentration.
    - Abrasive pH.
    - Abrasive water soluble content.
    - Abrasive contaminants.
    - Skill level of the equipment user.
    - Skill level of the inspector.

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