Wet Abrasive Blasting: The Future of Surface Preparation and the Effects it Has on Steel

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Fig. 1: Control (left) and contaminated panels (right) before preparation. *Figures courtesy of the authors*

Steel and protective coatings have been used in modern construction for more than a century. Due to the continued development of high-performance coatings, proper surface preparation of steel has become increasingly vital.

Sandblasting, technically known as dry abrasive blast-cleaning, was patented in the late 1800s and is used today to prepare steel due to its speed and cleaning efficiency. This is a process of forcing small particles onto the surface at a high speed in a concentrated pattern. Sand was—and in some areas, still is—a common abrasive used in the dry abrasive blast process.

Due to concerns over silicosis, a lung disease caused by respirable crystalline silica, Britain and other European nations banned the use of sand in abrasive blasting. During this time, the first wet abrasive blasting unit was developed.

In 2017, OSHA's crystalline silica rule went into effect for the construction industry. This rule limits a worker's exposure of respirable crystalline silica by setting the action level to 25 $\mu g/m^3$ and the permissible exposure limit to 50 $\mu g/m^3$ in an 8-hour work day.

The new crystalline silica rule requires employers to implement control methods to limit workers' exposure to free crystalline silica or monitor the level to assure it is lower than the action level. The employer is required to provide proper respiratory protection and provide periodic medical examinations such as chest X-rays to ensure the safety and health of their workers if the PEL is exceeded.

Though it still requires careful operation, use of personal protective equipment and adherence to standards and regulations, wet abrasive blasting is just one alternative to dry blasting for cleaning and preparation of steel.

HOW IT WORKS

Wet abrasive blasting is the introduction of water to a dry abrasive before it comes into contact with the steel. The water will saturate the abrasive dust, causing it to become heavier and fall, instead of remaining suspended in the air.

There are multiple methods to wet abrasive blasting—this article will highlight one method involving a process of pressurizing a slurry of water and abrasive, then injecting it into airflow. Unlike traditional dry abrasive blasting that uses air to pressurize the tank, wet blasting utilizes water. A reservoir of water is used to keep the tank pressurized. Wet blasting can be used in areas not conducive to traditional dry abrasive blasting, because the water suppresses the crystalline silica dust produced during abrasive blasting procedures.

The downside to wet blasting is one of the things that make it so beneficial: water. Because water is being used, the steel is susceptible to flash rusting. This can be mitigated by the use of specific additives.

ADDITIVES

An additive is a material that is introduced, in small quantities, to improve specific characteristics of a material or a process. They can consist of anything from a type of oil to a soap or detergent. There are numerous types of additives that perform specific functions depending on the desired result. It should be noted, however, that not all coating manufacturers will recommend application to a surface that was been wet blasted with additives, in case they remain on the surface and cause adhesion problems.

The additives used in this article were purported to provide two benefits to wet abrasive blasting. The first benefit was to increase the cleaning efficiency of the water by allowing it to better wet out the steel surface and remove as many soluble salts as possible. The second, due to the use of water for suppression of crystalline silica dust, was to delay the onset of corrosion on the surface of the substrate.

TESTING

Tests were performed to evaluate the effectiveness of dry and wet abrasive blasting regarding efficiency, surface cleanliness and coatings performance.

The tests involved treating freshly blasted panels with soluble salts, and analyzing the initial salt contamination of the surface. The panels were then prepared utilizing the two aforementioned blast methods with a variety of additives and observed for the presence of flash rusting. The efficiency of salt contamination removal was evaluated. Coatings were then applied to the panels and subjected to testing to evaluate performance.

Contamination

This procedure involved blasting several panels to White Metal in accordance with SSPC-SP 5/NACE No. 1, removing all mil scale and staining. (The standard for wet abrasive blasting to White Metal is SSPC 5 (WAB)-NACE WAB 1.) Half of the panels were submerged in a 2.5% w/v solution of sodium chloride for one minute, then hung and allowed to dry. The other half of the panels were not submerged to act as controls. The effects of the contamination can be seen in Figure 1.

Panel Preparation And Chloride Testing

This testing utilized a conductivity meter that gave two measurements: μS/cm and $\mu g/cm^2$.

The measurements in this study were recorded in $\mu g/cm^2$. The measurement $\mu g/cm^2$ is the surface density of soluble salt expressed as sodium chloride.

The testing was used to evaluate the efficiency of removing soluble salts from the surface of the panels by the preparation methods applied. The testing was performed before and after the preparation to determine the amount of soluble salts removed as well as the amount still remaining.

After the initial chloride testing results were recorded, the panels were separated into 12 different groups:

- Wet Abrasive Blasting
  - Test Group 1 – Contaminated Panel – Additive #1/Potable Water Blend
  - Test Group 2 – Contaminated Panel – Potable Water Only, No Additive
  - Test Group 3 – Contaminated Panel – Additive #2/Potable Water Blend
  - Test Group 4 – Control Panel – Additive #1/Potable Water Blend
  - Test Group 5 – Control Panel – Potable Water Only, No Additive
  - Test Group 6 – Control Panel – Additive #2/Potable Water Blend
- Dry Abrasive Blasting, then Power Washing
  - Test Group 7 – Contaminated Panel – Additive #1/Potable Water Blend
  - Test Group 8 – Contaminated Panel – Potable Water Only, No Additive
  - Test Group 9 – Contaminated Panel – Additive #2/Potable Water Blend
  - Test Group 10 – Control Panel – Additive #1/Potable Water Blend
  - Test Group 11 – Control Panel – Potable Water Only, No Additive
  - Test Group 12 – Control Panel – Additive #2/Potable Water Blend

The two additives used in this study were prepared in accordance to their respective technical data sheets.

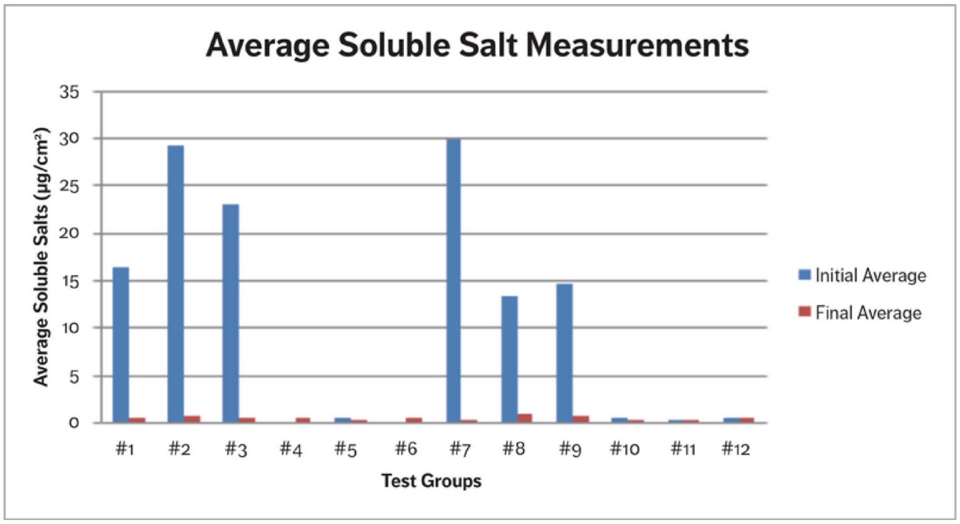
The wet abrasive blasting unit was filled with a 40-60 blend of garnet and Additive #1 Blend. The wet abrasive blaster's reservoir was also filled with the Additive #1 Blend. Each panel in Test Group 1 was then wet abrasive blasted to SSPC-SP 5 (WAB)/NACE WAB-1, White Metal Wet Abrasive Blast Cleaning.

This process was repeated for Groups 2–6 with their respective conditions.

All panels in Groups 7–12 were dry abrasive blasted, using 16-grit aluminum oxide, in accordance with SSPC SP-5/NACE No. 1, White Metal Blast Cleaning. The panels from Group 7 were washed with Additive #1 Blend using a 25-degree fan tip at 2,500 psi. This process was repeated for Groups 8–12 with their respective conditions.

After all test panels were prepared, chloride testing was used to determine the amount of salts removed. The average removal of chlorides is shown in Table 1.

Table 1: Initial and Final Soluble Salt Measurement Comparisons



Flash Rust Evaluation

One problem that can arise with the use of water in the preparation of steel is a tendency to quickly corrode the surface of the substrate. Even if most of the soluble salts that were present on the steel have been removed, water can still act as an electrolyte facilitating corrosion. We held back test panels from being coated to evaluate if the presence or lack of additives aid in the prevention of surface corrosion. It appears the use of additives when compared to the use of potable water only aided in the mitigation of the surface corrosion. In Figures 2 and 3, it is clearly evident that without the aid of additives, corrosion will happen much sooner.

Fig. 2: Flash rust comparison between contaminated panels

Fig. 3: Flash rust comparison between control panels

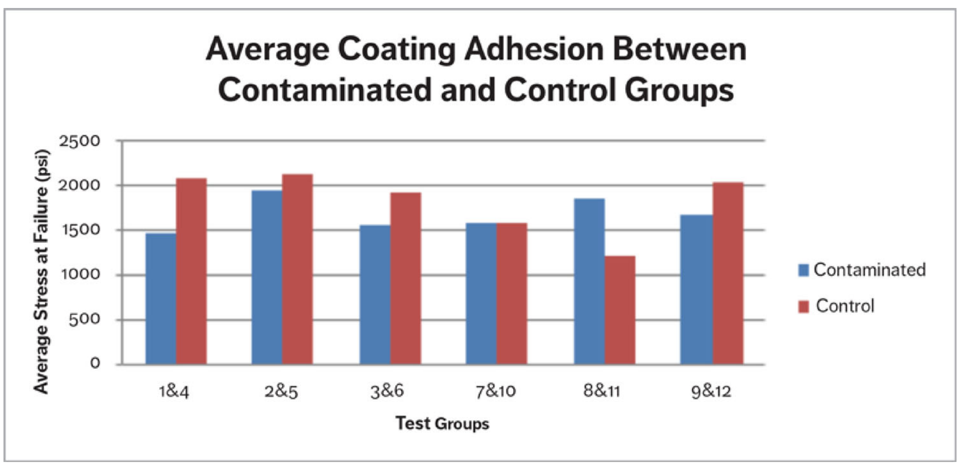
Coatings Application

After the panels were prepared by the various methods above, two panels from each group were coated with a polyamide epoxy direct to steel at approximately 4.0 mils' dry film thickness. All panels were allowed to cure a minimum of seven days at lab ambient conditions prior to testing.

Adhesion Testing

Three 20 mm dollies were glued to a panel from each group. The dollies were pulled with a Type V Self-Aligning Tester in accordance to ASTM D 4541 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Tester. The results are summarized in Table 2.

Table 2: ASTM D 4541 Comparison of Contaminated and Control Panels



The results of the adhesion testing were almost identical between the contaminated and control panels with the highest average deviation being 600 psi.

CONCLUSIONS

With the growing need for healthier methods of abrasive blasting, research was needed to find out how efficient new methods would be compared to traditional dry abrasive blasting. This article has explored many aspects of the advantages and pitfalls of wet abrasive blasting, including soluble salt removal, flash rust inhibition and coating performance.

Based on the results from this testing, it was evident that all methods of preparation in this study were capable of reducing the levels of chlorides on the surface of steel to below the accepted industry standard. Unfortunately, without the use of appropriate additives, the steel started to flash rust within 24 hours. It could also be surmised that coating performance was not adversely affected by the additives when used in accordance with the manufacturer’s instructions. Coating adhesion met or exceeded the performance criteria regardless of the method of surface preparation used.

Advantages of using additives in tandem with wet abrasive blasting allows for both the removal of salts from the steel and preventing flash rust, ultimately extending the blast profile life. Some would argue that wet abrasive blasting is inefficient in terms of coatings removal and creating a blast profile. This article shows that when wet abrasive blasting is used in tandem with additives, one is able to prevent flash rust—and, by doing so, provide a security blanket to the job in case of delays. This coupled with the reduced amount of media used in the blasting process, less airborne particles and the ability to wet abrasive blast in areas normally not accessible clearly outweighs the efficiency of dry abrasive blasting.

ABOUT THE AUTHORS

Joshua Bell joined Tnemec in 2015 after serving for 10 years in the U.S. Armed Forces. After a short time in production, he joined Tnemec's technical department in 2016, where his responsibilities include job startups, new product evaluations, failure analysis, product testing and customer testing projects.

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