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"Wet Abrasive Blasting: the Future of Surface Preparation and the Effects it has on Steel"

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WET ABRASIVE BLASTING: *THE FUTURE OF SURFACE PREPARATION AND THE EFFECTS IT HAS ON STEEL.*

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ABSTRACT

With more stringent silica regulations being enforced, wet abrasive blasting is becoming more prevalent in the industry. We investigated the viability of wet abrasive blasting as compared to the more commonly used dry abrasive blast. One added benefit of wet abrasive blasting is the removal of soluble salts in addition to providing the specified profile.

Our study explored the use of available additives intended to aide in the removal of soluble salts and preventing flash rust. We found the use of the additives, in tandem with wet abrasive blast standards, effectively removed soluble salts, inhibited flash rusting and did not adversely affect the performance of applied coating systems.

BACKGROUND

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

Sandblasting, also known as dry abrasive blasting, was patented in the late 1800s and is still used today to prepare steel due to its speed and cleaning efficiency. This is a process of forcing

small particles on to the surface at a high speed, concentrated pattern. Silica 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 cause 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 created.

In 2017, OSHA's new 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 µg/m3 (micrograms of silica per cubic meter of air) and the permissible exposure limit (PEL) to 50 µg/m3 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.

If the PEL is exceeded, 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.

So what does it all mean? This paper will explain how wet abrasive blasting can assist in the cleaning and preparation of steel.

WET ABRASIVE BLASTING

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; the method this paper will be going over is vapor blasting.

Vapor blasting is the 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, vapor blasting utilizes water. A reservoir of water is used to keep the tank pressurized. Vapor blasting can be used in areas not conducive to traditional dry abrasive blasting. This is because the water suppresses the crystalline silica dust produced during abrasive blasting procedures.

The downside to vapor 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.

The additives used in this study 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

The testing in this study was to evaluate the effectiveness of dry abrasive blasting compared to 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 blast methods mentioned above 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 abrasive blasting several panels to white metal in accordance to SSPC SP-5/NACE 1, removing all mil scale and staining. Half of the panels were submerged in a 2.5% w/v solution of sodium chloride for 1 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*.

Figure 1: Control and Contaminated panels before preparation.

Panel Preparation and Chloride Testing

This testing utilized a conductivity meter that gave two measurements of microsiemens per centimeter (µS/cm) and micrograms per square centimeter (µg/cm2). The measurements in this study were recorded in µg/cm2. The measurement µg/cm2 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 twelve 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 through #6 with their respective conditions.

All panels in Groups #7 through 12 were dry abrasive blast, using 16 grit aluminum oxide, in accordance with SSPC SP-5/NACE 1 White Metal Blast Cleaning. The panels from Group #7 were washed with Additive #1 Blend using a 25° fan tip at 2500 psi. This process was repeated for Groups #8 through #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*.

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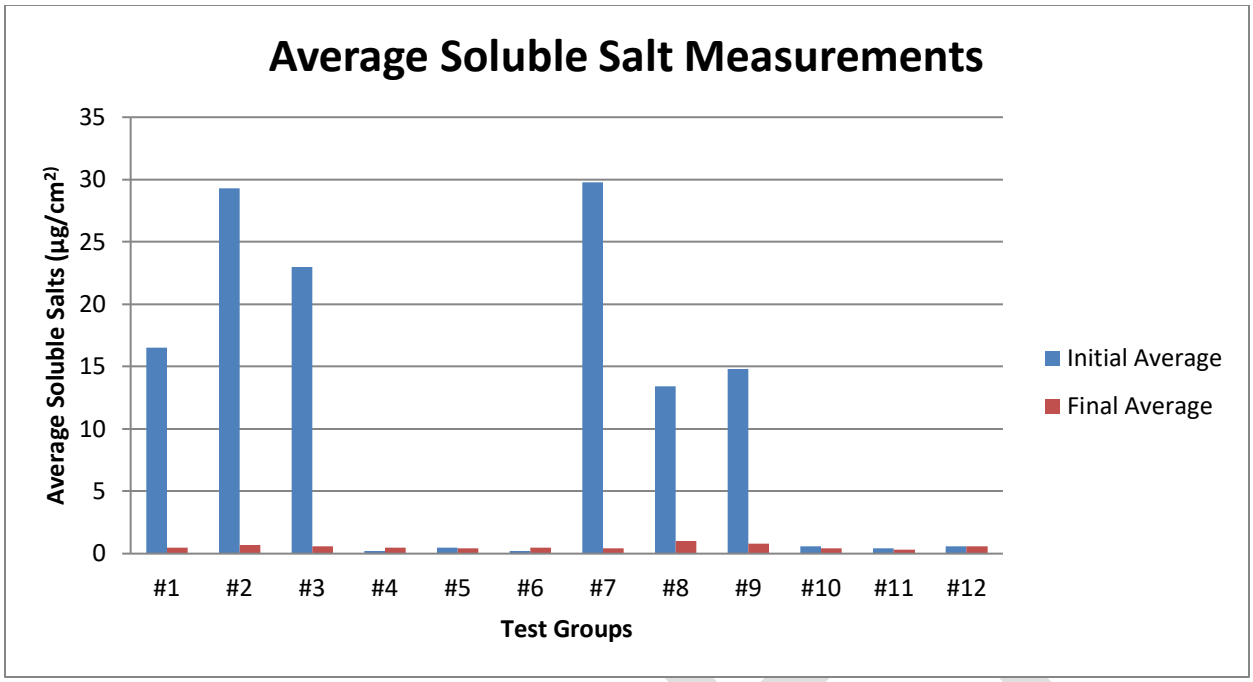

Table 1: Initial and final soluble salt measurement comparisons.

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 thereof 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 *Figure 2 and 3* it is clearly evident that without the aid of additives, corrosion will happen much sooner.

Figure 2: Flash rust comparison between Contaminated panels.

Figure 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 7 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 shown in the Test Results section and are summarized in *Table 2*.

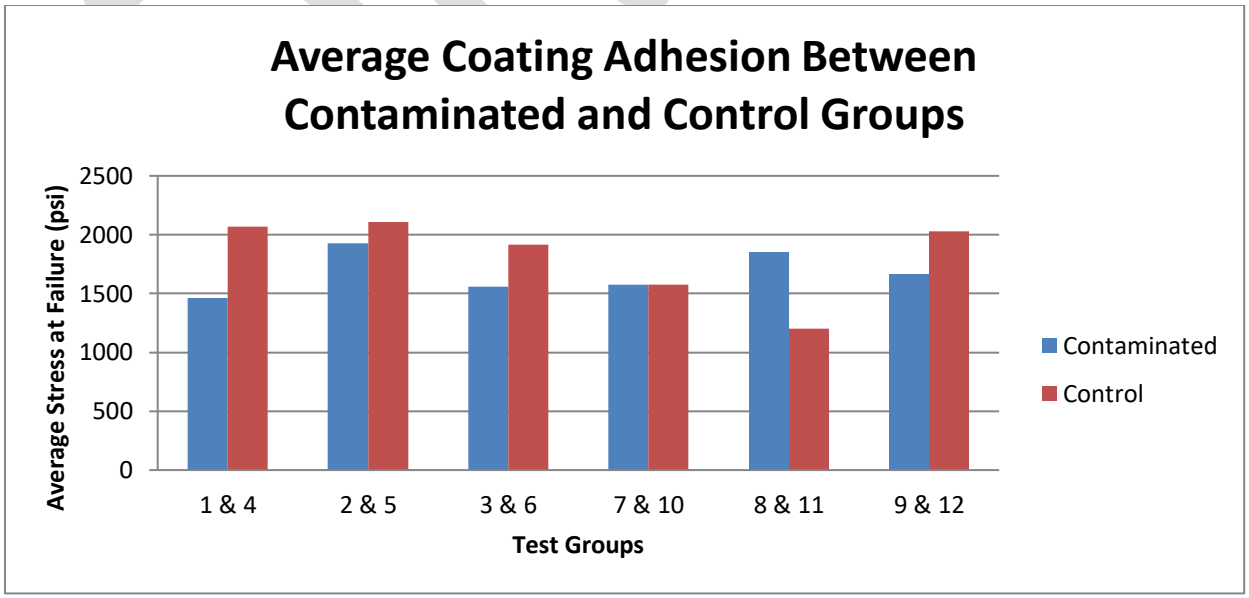

Table 2: ASTM D 4541 comparison of Contaminated and Control panels.

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

TEST RESULTS

Wet Abrasive Blasting Adhesion Results

Contaminated panels (Left) and Control panels (right).

14 Day Cure – Group #1 Adhesion			14 Day Cure – Group #4 Adhesion		
Pull #1	1517	100% B/Y	Pull #1	2056	100% B/Y
Pull #2	1433	100% B/Y	Pull #2	2076	100% B/Y
Pull #3	1444	100% B/Y	Pull #3	2066	100% B/Y
14 Day Cure – Group #2 Adhesion			14 Day Cure – Group #5 Adhesion		
Pull #1	2370	100% B	Pull #1	2597	100% B
Pull #2	1266	100% B	Pull #2	1597	50% B 50% B/Y
Pull #3	2149	100% B	Pull #3	2133	100% B
14 Day Cure – Group #3 Adhesion			14 Day Cure – Group #6 Adhesion		
Pull #1	1463	100% B/Y	Pull #1	2318	100% B/Y
Pull #2	1525	100% B/Y	Pull #2	1704	100% B/Y
Pull #3	1690	100% B/Y	Pull #3	1725	100% B/Y

Wet Abrasive Blasting Adhesion Results

Contaminated panels (Left) and Control panels (right).

14 Day Cure – Group #7 Adhesion			14 Day Cure – Group #10 Adhesion		
Pull #1	1631	100% B/Y	Pull #1	1750	100% B/Y
Pull #2	1537	100% B/Y	Pull #2	1601	100% B/Y
Pull #3	1558	100% B/Y	Pull #3	1376	100% B/Y
14 Day Cure – Group #8 Adhesion			14 Day Cure – Group #11 Adhesion		
Pull #1	1943	60% A/B 40% B/Y	Pull #1	902	100% B/Y
Pull #2	1871	60% A/B 40% B/Y	Pull #2	1134	20% B 80% B/Y
Pull #3	1742	60% A/B 40% B/Y	Pull #3	1578	20% B 80% B/Y
14 Day Cure – Group #9 Adhesion			14 Day Cure – Group #12 Adhesion		
Pull #1	1631	100% B/Y	Pull #1	1750	100% B/Y
Pull #2	1537	100% B/Y	Pull #2	1601	100% B/Y
Pull #3	1558	100% B/Y	Pull #3	1376	100% B/Y

Wet Abrasive Blasting Soluble Salt Testing Results

Contaminated Groups #1-3 and Control Group #4-6

Wet Abrasive Blast Panels – Initial Chloride Testing in µg/cm2								
Contaminated Test Group #1			Contaminated Test Group #2			Contaminated Test Group #3		
C1	C2	C3	C4	C5	C6	C7	C8	C9
15.3	17.1	17.3	12.1	18.0	17.9	16.5	19.6	17.5
26.8	29.9	31.4	24.5	29.4	32.4	23.7	38.3	30.1
21.1	23.5	24.4	18.3	23.7	25.2	20.1	29.0	23.8

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Control Test Group #4			Control Test Group #5			Control Test Group #6		
U1	U2	U3	U4	U5	U6	U7	U8	U9
0.1	0.5	0.1	0.1	0.2	0.2	0.2	0.1	0.1
0.2	0.5	0.2	0.1	0.2	0.4	0.2	0.1	0.1
0.2	0.5	0.2	0.1	0.2	0.3	0.2	0.1	0.1

Wet Abrasive Blast Panels – Final Chloride Testing in µg/cm2								
Contaminated Test Group #1			Contaminated Test Group #2			Contaminated Test Group #3		
C1	C2	C3	C4	C5	C6	C7	C8	C9
0.6	0.5	0.5	0.7	0.6	0.9	0.4	0.7	0.9
0.9	0.5	0.7	0.7	1.0	0.8	0.7	0.5	1.0
0.8	0.5	0.6	0.7	0.8	0.9	0.6	0.6	1.0
Control Test Group #4			Control Test Group #5			Control Test Group #6		
U1	U2	U3	U4	U5	U6	U7	U8	U9
0.1	0.5	0.1	0.1	0.2	0.2	0.2	0.1	0.1
0.2	0.5	0.2	0.1	0.2	0.4	0.2	0.1	0.1
0.2	0.5	0.2	0.1	0.2	0.3	0.2	0.1	0.1

<u>Dry Abrasive Blasting Soluble Salt Testing Results</u>

Contaminated Groups #7-9 and Control Groups #10-12

Dry Abrasive Blast Panels – Initial Chloride Testing in µg/cm2								
Contaminated Test Group #7			Contaminated Test Group #8			Contaminated Test Group #9		
C1	C2	C3	C4	C5	C6	C7	C8	C9
21.6	20.1	23.4	10.0	9.9	9.7	9.2	10.9	13.8
41.7	26.4	34.2	17.9	9.5	15.6	15.6	14.3	16.5
21.7	23.3	28.8	14.0	9.7	12.7	12.4	12.6	15.2
Control Test Group #10			Control Test Group #11			Control Test Group #12		
U1	U2	U3	U4	U5	U6	U7	U8	U9
0.4	0.7	0.6	0.3	0.2	0.1	0.8	0.5	0.6
0.4	0.6	0.6	0.3	0.1	0.2	0.3	1.0	0.8
0.4	0.7	0.6	0.2	0.2	0.2	0.4	0.8	0.7

Dry Abrasive Blast Panels – Final Chloride Testing in µg/cm2								
Contaminated Test Group #7			Contaminated Test Group #8			Contaminated Test Group #9		
C1	C2	C3	C4	C5	C6	C7	C8	C9
0.4	0.3	0.5	1.9	1.0	1.6	0.4	0.8	0.6
0.7	0.4	0.6	2.8	1.2	2.1	0.7	0.9	0.9
0.6	0.4	0.6	2.4	1.1	1.9	0.6	0.8	0.8
Control Test Group #10			Control Test Group #11			Control Test Group #12		
U1	U2	U3	U4	U5	U6	U7	U8	U9
0.5	0.4	0.4	0.2	0.2	0.2	0.4	0.4	0.4
0.5	0.5	0.4	0.2	0.2	0.2	0.5	1.5	0.4
0.5	0.5	0.4	0.2	0.2	0.3	0.5	1.0	0.4

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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 study has explored many aspects of the advantages and pitfalls of wet abrasive blasting. This included 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 study shows that when wet abrasive blasting is used in tandem with additives you are able to prevent flash rust, and by doing so you 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.

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WET ABRASIVE BLASTING: THE FUTURE OF SURFACE PREPARATION AND THE EFFECTS IT HAS ON STEEL

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Kansas City, Missouri

TOPICS

- Brief History of Abrasive Blasting
- New OSHA Silica Rules
- Wet Abrasive Blasting
- The use of Additives
- Testing Procedures & Results
- Conclusion

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BRIEF HISTORY OF ABRASIVE BLASTING

- **Benjamin Tilghman patented the first dry abrasive blast unit in 1870 and it has been used to prepare metal surfaces for liquid applied coatings for 150 years now.**
- **During the early 1900's it was found that using silica as a media for dry abrasive blasting released free crystalline silica into the air, which when inhaled, can cause silicosis.**
- **This was the leading cause to Norman Ashworth inventing the first wet abrasive blasting unit to help combat silicosis in the industry.**

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NEW OSHA SILICA RULES

In 2017, OSHA implemented more stringent and new crystalline silica rules for the construction industry.

These rules limit a worker's exposure to respirable crystalline silica by administering Action exposure limits (AEL) and Permissible exposure limits (PEL).

This requires employers to monitor free crystalline silica to ensure it remains below the AEL. If the AEL is exceeded, then proper control measures must be implemented to lower the exposure.

If the PEL is exceeded, the employer is required to provide proper respirator protection and provide periodic medical examinations to ensure the safety and health of their employees.

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WET ABRASIVE BLASTING

Wet abrasive blasting in the introduction of water to a dry abrasive before it comes in contact with steel.

The water saturates the abrasive dust causing it to becoming heavier and fall, instead of remaining suspended in the air.

There are several methods of wet abrasive blasting.

Unfortunately using water in the blasting process can cause flash rust depending on environmental conditions.

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ADDITIVES

An additive is a material that is introduced, in small quantities, to improve specific characteristics or a process.

There are numerous types of additives that perform specific functions depending on the desired result.

These can range from a demulsifier that remove oils or grease, to surfactants that remove soluble salts and delay the onset of corrosion of steel.

TESTING PROCEDURE AND RESULTS

Our testing was an evaluation of dry abrasive blasting compared to wet abrasive blasting as it pertained to efficiency, surface cleanliness and coatings performance.

We took freshly blasted steel panels and treated them with a soluble salt solution and measured that contamination with an industry accepted conductivity meter.

The panels were then prepared utilizing both dry and wet abrasive blast with a variety of additives and evaluated for the presence of flash rusting, salt contamination removal and coatings performance.

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Contamination

Panel Breakdown

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.

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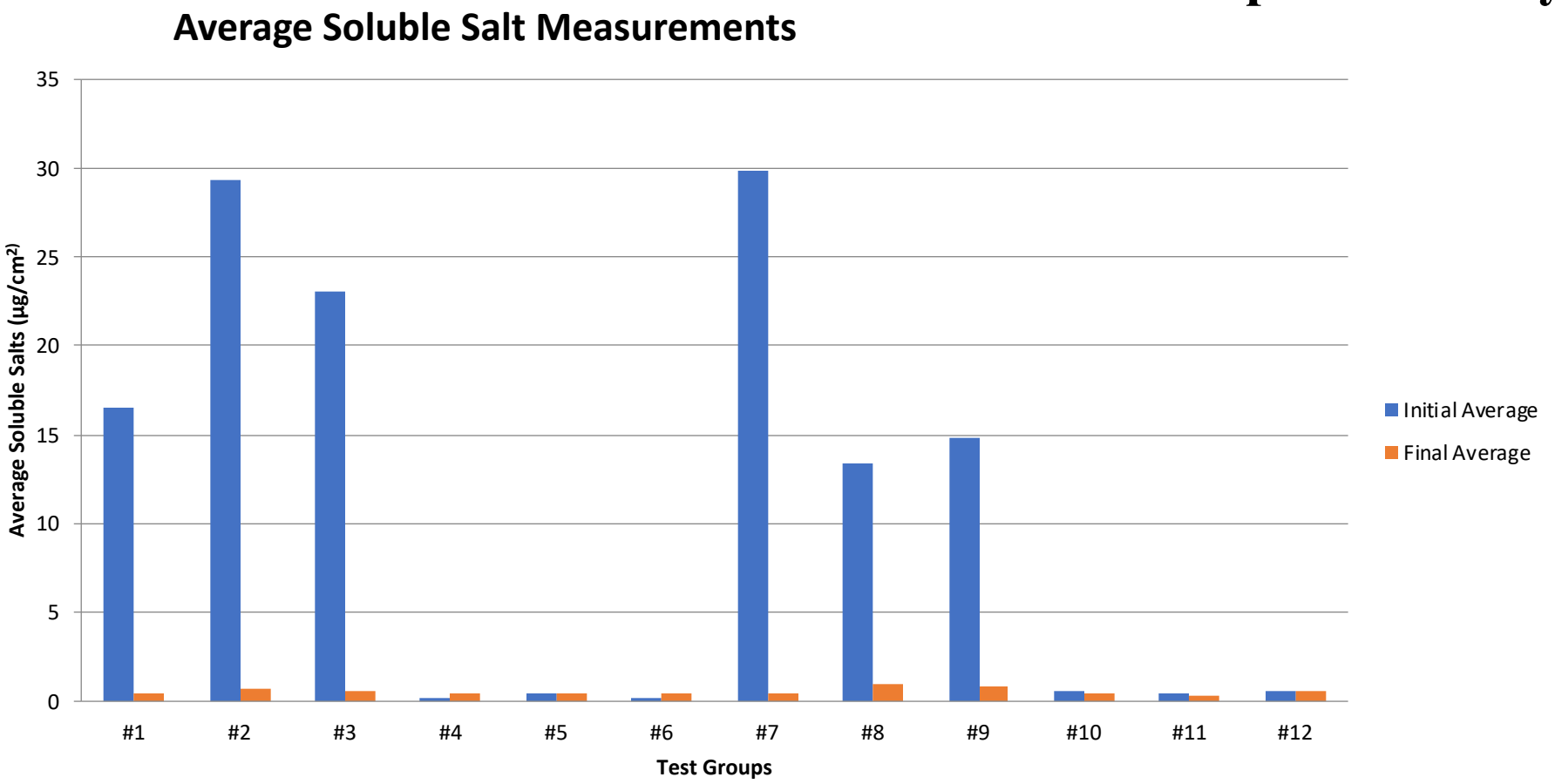
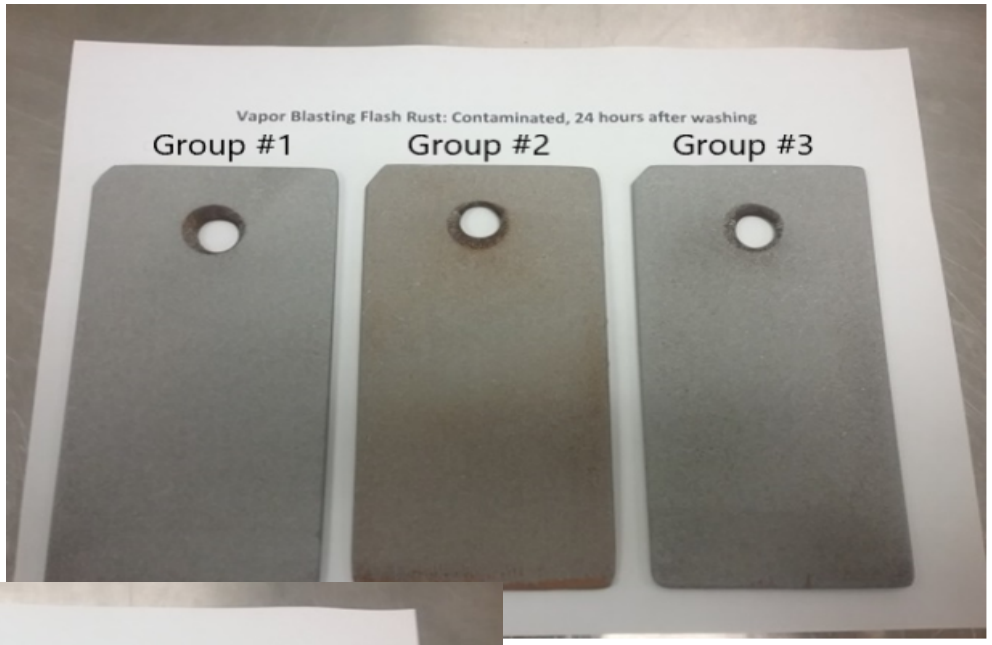
Chloride Testing

The results we received from close to 300 individual salt tests show that each test group was capable of removing the contamination below the accepted industry standard.



Flash Rust Evaluation

All panels that were not prepared using an additive flash rusted within 24 hours. this show that regardless of the type of preparation, an additive is needed to prevent flash rust. The other panels would rust within 48-72 hours.



Adhesion Performance

Coating performance was evaluated using an epoxy direct to metal and a zinc epoxy system.

Of the 216 individual adhesion tests that were performed, aside from the occasional glue failure, the coating's tensile adhesion strength remained above the recommended psi.

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

CONCLUSION

It was evident that all methods of preparation in this study were capable of reducing the levels of chlorides on the surface of steel below the accepted industry standard.

Unfortunately, without the use of appropriate additives, the steel started flash rusting within 24 hours.

It can also me surmised that coatings performance was not adversely affected by the additives when used in accordance with the manufacturer's instructions.

Q&A

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