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Prepared by Lydia M. Frenzel, Ph.D, Director of Advisory Council

Recipient of SSPC John D. Keene Award of Merit

Recipient of WJTA-IMCA Pioneer Award.

Why is steel a dark gray color after Ultra-high pressure (UHP) Waterjetting (WJ)?

Does the “profile” go away when we use UHP waterjetting to remove rust?

That’s a good question. I used to include this topic in my “Water jetting is True Grit” conferences in the 1990’s, when inspectors had no idea what to expect. The dull dark gray color puzzled me when I first turned a 20,000 psi fan jet on painted, or slightly rusted (Grade C) steel surfaces in 1983.

I did not know what to expect the first time I took a 20,000 psi Waterjet (WJ) and cleaned paint or rust off surfaces. The exposed substrate was dull gray; sometimes I got a bronzing effect- a very light golden color- which stayed that color; sometimes I got a dark blue color- which stayed that color.

At the time I didn’t know if the water stream would polish or smooth out the surface, make it rougher, or just expose the existing substrate texture or profile which was under the paint or rust. I would go over and over the surface, and it didn’t change. It did not turn white and shiney.

The texture (profile) remained the same as measured by the Tator comparator disks. Replica tape didn’t exist yet.

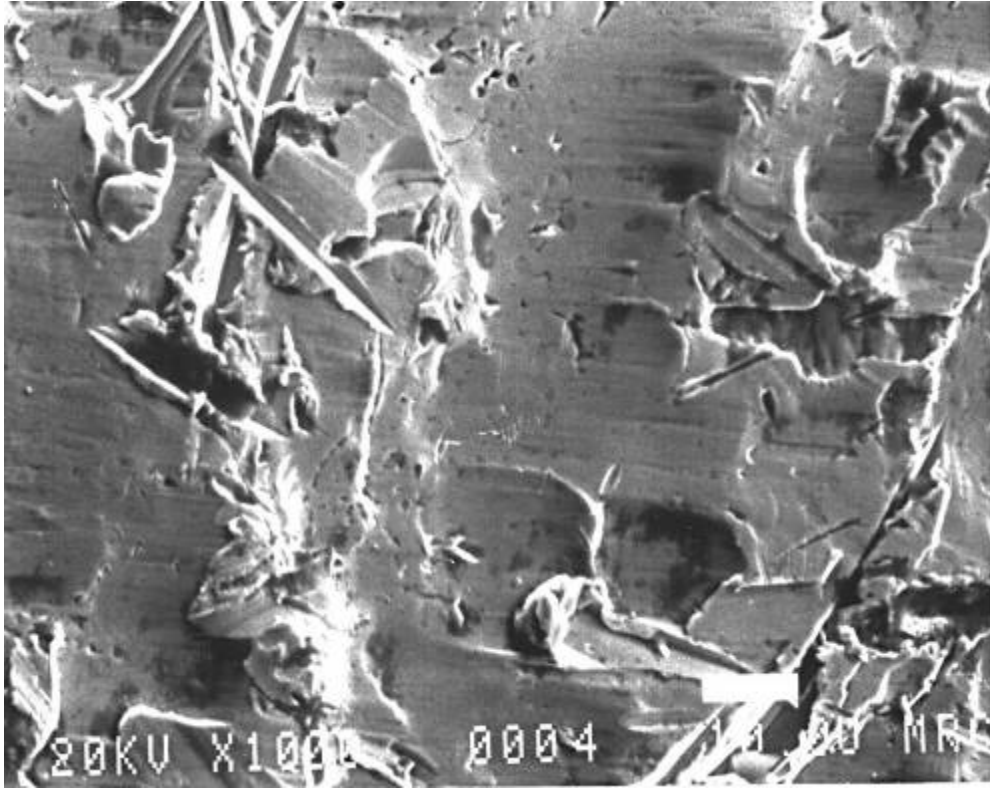
Then I realized that abrasives change the profile (texture) each time you abrasive blast. If it is “sand”, the surface turns white with crushed sand particles. If it is coal slag, the surface turned dark with crushed slag particles. If it is garnet- the surface turns reddish. In other words the color of the steel reflects the “dusting” of particles on the surface. We had been painting over dusted surfaces for years, and not worrying about it.

Part of what you visual on the abrasive blasted substrate is the sun reflecting off the dust. Part of what you see is the sun reflecting off plateaus of flattened steel. Abrasives move the steel around as it is malleable. It bends. When you magnify the substrate, you see flat surfaces. Sunlight reflects off these surfaces.

There is no flattened surface for sunlight to reflect. However, you can see everything that has happened to the substrate. In some cases you get tricked by the change in texture.

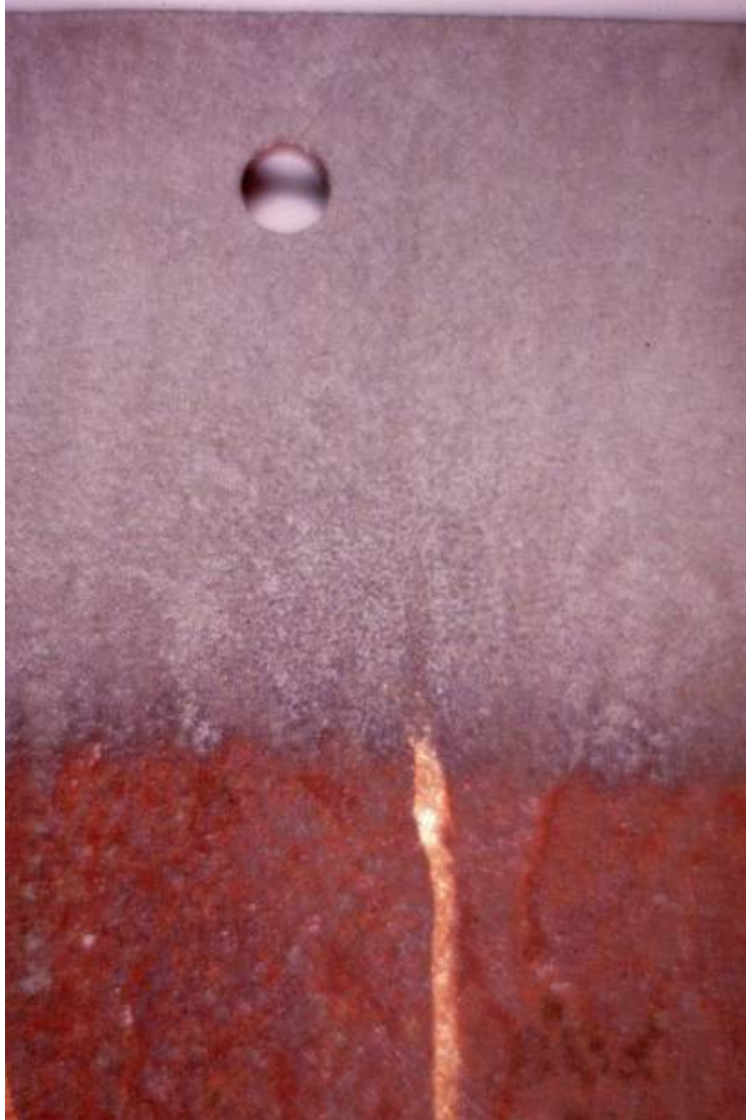
Below Photo: Courtesy of High Pressure Waterjet Lab, University of Missouri, Rolla, Dr. David Summers;

Dr. David Summers is retired now. He worked with the military on the space craft and with the air craft engine sector. Could waterjet be used to clean the substrates? What was the long term effect on the metals? This is a typical abrasive surface. Abrasives make a surface that reflects the light. Hence, abrasive cleaned steel generally (if not always) look brighter to the eye.



It is good that you can see everything that has happened to the substrate once you take the paint and rust off. In a storage tank or tank in a chemical plant, it lets you know where the active corrosion sites occur. When you abrasive blast the substrate, the action tends to abrade and erase the problem areas. Thus you can't see problem areas.

Being able to see problem areas can be good or bad. In a chemical plant, it allows you to pinpoint where the coatings have been breached. You can map those areas. On a Naval fight deck, the problem areas pointed out that the non-skid was cracking in areas of high temperature stress, and also uncovered a curing problem. The multiple black corroded areas led to adoption of a new type of coating. Unfortunately, the Navy also killed the messenger as they went back to abrasive blasting to "make it uniform." If you can't see the problems, you don't have to acknowledge the problems.



This was a "Tator test panel" which had rusted to grade C (1983). It had a stripe of enamel paint down the center. After WJ cleaning, you can still see the path of the removed paint stripe. This path is not residual paint, it is the difference in substrate profile. The rusted areas have a difference texture than the area under the paint. Your eye will see that difference. Other examples are being able to see "weep lines" on the side of a ship, where salt water has run out the gunnels and down the side. Over time, a pattern of corrosion forms under the paint. When you waterjet the substrate and remove the paint, you can see the corrosion lines.

The WJ removed the residual dust, leaving the profile without the "sand dust" to gleam in the sun. It can expose sharp little tits of steel if they are present under the rust, again leaving a matte finish. When the threshold pressure of the steel is exceeded above 50,000 psi, WJ produces a "fractal" surface- which looks more and more angular as magnification is increased. A fractal surface has a lot of surface area per unit area.

All of these considerations lead to a dull steel substrate. The substrate is uniform if it has been protected by a paint system. If there is corrosion on the surface, then the exposed profile is whatever profile exists under the rust. The texture (profile) is not predictable and is likely not uniform. There will be crevices and high points. I suggest surface tolerant coatings on previously rusted substrates because they are formulated to work on substrates that are not new, not newly blasted to 2 mils + or – a half mil.

There are two papers with cross sections and top views on the web site Advisory Council.org.

www.advisorycouncil.org; look at “downloads” upper left tab ; look at featured library- 2015 Evaluation of 20,000 psi Water Jetting for Surface Preparation of Steel prior to Coating and ReCoating, and download the pdf article for further details.

www.advisorycouncil.org; look at “downloads” upper left tab; article 1 and article 2 (Dupuy) 1992-NACE Corrosion 1992- Cleaning Substrates with 30,000 psi. “Ultra-High Pressure Water Jetting (UHP WJ): A Useful Tool for Deposit Removal and Surface Preparation.”

Here are a couple of my “Classic” microphotographs taken in the 1980’s of substrates that have been Waterjet cleaned. Two very different profiles that were under the rust.



Here the original profile was “rounded.” Note the absence of residual dust. The next photo is a higher magnification. The “ridges” are sharp. This is dull gray.



Below photo is also dull gray. The original blast pattern was more angular.



The below photo micrograph was abrasive blasted with rounded particles. To the eye, it was “white metal.” What you can see is that there are “black” areas of rust that is under the rounded craters. They are so small that the eye doesn’t see them.



Let's go back to the color for a minute. Manually held 20,000 psi waterjets always gave a "golden hue" which remained that way for days. Below is a 1983 photo of approximately 1 foot x 1 foot from the side of a barge. We were doing time trials. The texture (profile) is very non-uniform.

It is golden. It stayed that color for days on end. The golden color is a reflection of a thin layer, like the color you see in a soap bubble. The water is moving at 1 to 2 times the speed of sound; it is hot because it has been compressed; it is filled with oxygen from the air. There is an "instantaneous" oxidation of the steel when the water hits the substrate. In the 1983-1990 time frame, I handled a lot of inquiries about that color. One coatings expert declared it was a

I measured a thin film. I think it is some kind of iron oxide, analogous to the aluminium oxide on the surface. Le Calve, in a couple of articles in JPCL, says that he observed a passivation effect and thinks that there is an instant barrier layer. The exact nature is to be left to the academics. What really astonished the engineers from Puget Sound Naval Shipyard is that they could take marine panels which had been waterjet cleaned to exhibitions for a year. The only "rusting" occurred where they placed their hands on the steel, where "salt" could be placed on the area.



Let me conclude with a fun photo. What I saw in 1983. Yellow is a “Thin Film” refraction. Courtesy of Union of American Hebrew Congregation; Temple Israel WRJ, Colonial School for the Visually Impaired



Typical Waterjet substrate (36,000 psi). Top edge is extent of corrosion. Cleaned in 1997. Put in container over water (100% relative humidity) in 2000. Photo taken June 2006.

For in depth discussion, Dr. Suslick is the guru of Sono-chemistry.

www.scs.uiuc.edu/suslick, "The Chemistry of UltraSound," by Kenneth S. Suslick

For comparison of profiles produced by Waterjet alone see VanKuiken Patent 5,626,674 & 5,380,564. Waterjet alone is used to produce profiles in automobile manufacturing in the engine block cylinders.