Problem Solving Forum

Chloride Contamination on Abrasive

This Month’s Question?

What parts per million (ppm) of extractable chlorides in blast abrasive render it unacceptable for use or “contaminated”?

From David H. Dorrow, Reed Minerals, Highland, IN:

The presence of non-visible contaminants such as chlorides or other soluble salts on an abrasive used for surface preparation may be a cause for concern, and very high levels of such contaminants may affect the quality or duration of coating performance.

It may be true that some commercially available blast cleaning abrasives will reveal the presence of soluble chlorides or sulfate salts. Such abrasive contamination may originate from various sources. One potential source could be the raw material process water containing chloride or sulfate salts in solution. Contamination may also occur during the transportation of the abrasive along the seacoast via open hopper car or barge where it is subjected to salt contaminants from the atmosphere. Another source may be contaminants on or in the blasted surface that transfer to the abrasive and, upon recycling of the abrasive, can be transferred to the substrate.

There are several ways to test for the presence of such contaminants. A sample of the abrasive can be sent to a lab for testing, but this may take several days. Or, you may want to use a conductivity test, which is more basic and will test for many constituents such as soluble salts that will increase the water’s ability to conduct electricity.

Abrasives contaminated with soluble salts were recently tested by the Federal Highway Administration (FHWA) and the National Shipbuilding Research Program (NSRP) to determine the relationship between any contamination and coating failure. It was found that abrasives having a conductivity of less than 1,000 microsiemens using the ASTM D 4940 Method showed no evidence of coating failure. Conductivity testing on a coal slag abrasive from my company supports this finding. The abrasive typically tested below the 1,000 microsiemens level using the ASTM D 4940 Method. The abrasive has been successfully used by the steel surface preparation industry for over 30 years with no known adverse effect on the coating.

The U.S. Navy has set a limit of 300 ppm chlorides in its QPL program under MIL-A-22262A(SH). My company’s experience also supports this
limit with its coal slag typically below the 300 ppm limit for chlorides and with no compromise to the quality of the coating application.

Perhaps the best approach at this time is to rely on abrasive use experience as a “real world” guide to abrasive selection. When specifying an abrasive purchase, the user might ask the following questions.

- How are various coating systems performing when used over various abrasives?
- Is there any history of poor coating performance that correlates with the use of a given abrasive?
- Are there opportunities to compare coating performance where 2 or more abrasives have been used on the same job?
- What are the opinions and experiences of abrasive user colleagues who have tried various abrasives?
- Are all correct preparation, cleaning, application measures, and specifications being adhered to as set forth by the coating manufacturer?

This subject is one of importance and concern to the entire steel preparation industry and indeed requires further study. Further study should include the development of standard testing procedures and specifications. Should an abrasive user or specifying engineer need guidance in the selection of an abrasive, it is highly recommended that the abrasive supplier become involved.

**From Wallace P. Cathcart, Trinity Industries, Pittsburgh, PA:**

My reply to the question is that even though there will be several answers printed on these pages, I believe the true and only answer today can be, “I don’t know; I can only hypothesize.”

The problem of chloride contamination of abrasives is worth pondering, along with its sister problem, the chlorides (or sulfides) on surfaces from previous exposures, such as road salt on a bridge, residual lading in or on a storage tank, or a steel structure at the seashore.

I am not aware of any study made to determine what percentage of chloride that might be in or on an abrasive would be deposited on the surface during an abrasive blast.

So far, however, we do know that some amount of any hygroscopic material such as a salt on a surface can adversely affect the performance of a coating applied over it. We know that many mineral abrasives contain chlorides and that recyclable steel grit often has chlorides present as a contaminant from previous use and/or from an inhibitor used in the grit’s manufacture. Further, we know that any of these chlorides can be transferred to the surface in the process of abrasive blasting. We also know that if the amount of contamination on the surface is small, it likely will be tolerated by the coating, and as the amount of chloride gets larger, its
detrimental effect will depend on the coating selected as well as the severity of the environment.

I believe that general awareness of the effects of chlorides is where today’s knowledge ends and our speculation starts. Work has been done and published in these pages attempting to more precisely quantify these tolerances for chloride contamination. Conclusions from all of this work, with which I am familiar, are flawed because the work deals only with the amount of chloride that was able to be extracted or removed from a certain given area; or a known amount of chloride was applied to a given area, and the performance of coatings over that known was studied. We have not found a practical way to determine the total amount of chloride that is in the bottom of each pit in what might otherwise be a clean area. As we attempt to attain better coating performance and eliminate premature failures, it is the mass of the contamination in pits (small or large) that is more likely to cause our problems. Because the chlorides deposited from an abrasive are likely to be relatively small in volume and spread over a wide area, I am guessing that they are of lesser significance but are nevertheless significant.

In my judgment, the greater problem, one with so far no way to quantify, is the amount of chloride (salt) that can be tolerated in the bottom of 1 pit. This causes failure of good coating systems applied over steel previously exposed to a contaminating environment and now supposedly clean because it was abrasive blasted to an SSPC-SP 5, White Metal. It looked clean; we hurried and coated it before any trace of bloom or rust back appeared; and, therefore, we did not learn that there were non-visible contaminants left in some pits. We might even have checked many areas by an extraction process and still accepted it as clean because we did not catch the correct area or because our extraction process was not able to get enough chlorides out from the bottom of the pits to indicate that the subsequent coating would fail.

It seems to me that at this point, with our knowledge limited as it is, there is a solution, and our industry seems to be avoiding it. Any time significant chloride contamination is a likelihood, we should adopt a procedure that is known to remove virtually all non-visible contamination. If the procedure selected will get the steel clean enough that, without inhibitors, it will not flash rust or bloom in 2 or 3 days even under humid conditions, it is probably clean. When it blooms in less time without water condensing or impinging upon it, it is contaminated to a detrimental degree.

I believe that the most promising procedure is an ultra high pressure water jet (30,000 psi [2,000 MPa] or greater) followed by dry abrasive blasting with clean (low chloride) abrasive. At ultra high pressure, crusts and scale are removed, exposing even the bottoms of pits to an active flushing action, all without deforming any metal that might entrap particles of contamination. As time goes on and more knowledge is gained, we may be able to omit the follow-up dry abrasive blast because the fine clean oxide that forms from the water on clean steel may prove to be an excellent surface for many coatings in many environments.
From William C. Johnson, KTA-Tator, Pittsburgh, PA:

To answer the question, I will address 7 factors: the source of chloride contamination; the distribution of contamination; the role of chloride contamination in corrosion and pitting; contaminants that have anomalous behavior; the use of the wet adhesion test to determine contamination; the supply of abrasives; and threshold limit, a concentration level at which chlorides become detrimental. Chlorides are expressed as ppm and as microsiemen of potassium chloride.

Chlorides or salts contaminate coating systems in several ways. They can

- transfer from contaminated blast cleaning abrasives or from contaminated high pressure blast cleaning water (Johnson, September 1990 *JPCL*, pp. 54-59);
- remain in corrosion products and in corrosion pits on steel surfaces; or
- be incorporated into paints with contaminated pigments (Johnson, “Detrimental Materials at the Steel/Paint Interface,” “New Concepts for Coating Protection of Steel Surfaces, ASTM STP 841, SSPC 83-01, 1984).

Salts from previous corrosion in pits on the surface are isolated and concentrated at pits. These will form a blister above each pit by means of osmosis.

Salts transferred from abrasives are uniformly distributed on the surface, and consequently result in a uniform visual corrosion (rust back). Time is necessary under wet conditions for the anions to relocate and concentrate at a few, dominant anode sites. A layer of uniformly distributed salts at the interface would not be expected to form independent visible blisters but would be expected to destroy adhesion by water disbondment.

Chlorides on the steel surface act (1) to absorb moisture from the air; (2) to draw moisture through a coating by means of the process of osmosis; (3) to reduce the corrosion cell resistance; (4) to establish concentration potentials; (5) to lower the pH; (6) to consume oxygen, lowering its vapor pressure and increasing the permeation of oxygen; and (7) to reverse the action of inhibitors. (See Johnson, ASTM STP 841, referenced above.)

Contaminants other than soluble salts can be transferred to a steel surface. I have found 2 abrasives having contaminants that showed anomalous behavior. One case was that of an inhibitor transferred to the steel from an abrasive that, along with whatever salts were present, gave an ASTM D-4940 reading of 313 microsiemen (approximately 72 ppm, assuming chloride as the predominant soluble contaminant), but did not rust back as expected from this level.

The other contaminant gave a low ASTM D-4940 reading of 57 microsiemen (13 ppm), but gave an unexpected low reading in a wet adhesion test. This wet adhesion test, which identified the detrimental action of this low concentration of contaminant, could be used in
conjunction with an ASTM D-4940 analysis to search for other causes of adhesion loss. Either grease/oil or an unidentified soil was suspected for the loss of adhesion after a wet exposure period.

In a comparison of inhibitors, differences were found in wet adhesion of a coating to the blast-cleaned steel surfaces. A low adhesion is an indication of water at the interface. Blast-cleaned panels were coated with 1.3 to 1.6 mils (33 to 41 microns) of a polyamide epoxy coating and cured at room temperature for 7 days. The panels were then exposed to condensing humidity at 105 F (41 C) for 335 hours, and no visible failure was detected. The panels were then tested for tensile adhesion. For one commercial abrasive contaminated with 500 microsiemen (113 ppm) of salts, the adhesion tension was only 70 percent as much as abrasives having lower concentrations (50 microsiemen/11 ppm) of salts. The contaminated abrasive disbonded at the steel/paint interface. Minimally contaminated abrasive did not disbond; instead, the glue layer broke at the maximum limit of the test. Interface corrosion has been neglected by industry until recently. (See National Shipbuilding Research Report #0329.)

Contaminated and uncontaminated abrasives are on the market. Results from the early study of salts on commercial lots of steel (56 percent) showed 9 lots having a low average concentration, 50 microsiemen (11 ppm); 3 lots averaging an intermediate to high concentration, 128 microsiemen (29 ppm); and 4 lots averaging high concentrations, 385 microsiemen (89 ppm). (See Johnson, ASTM STP 841, referenced above.) The high concentrations showed almost 10 times as much contamination as the low concentration. Sorensen has found that abrasives were either very good or very bad. (See Sorensen, August 1985 JPCl, p. 21.) Fresh new steel, which is usually not contaminated, should be blast cleaned with uncontaminated abrasive, 11 ppm or less.

The threshold limit for the ppm of chlorides on abrasives varies with the desired protection life of the coating system and the coating thickness.

I recommend a maximum limit of 100 microsiemen (23 ppm Cl) for immersion service and a maximum limit of 200 microsiemen (46 ppm Cl) for atmospheric service.

My suggested limits fall above the average concentration for good (immersion) or new, uncontaminated steel, and above the average for intermediate (atmospheric). I would avoid using the badly contaminated abrasive (+200 microsiemen).

From Simon Boocock, SSPC, Pittsburgh, PA:

This month’s question addresses a serious and complex topic. My simple answer to this question could be 250 ppm chloride, but that would not give the reader a real appreciation for the truth. Let us examine this question in more detail.
First, can an abrasive have too much salt? The answer is yes. This contention is backed up by previous work such as that reported in ASTM Standard Technical Publication 841, research for the Federal Highway Administration (FHWA) reported in SSPC publication 91-07, tests described in the National Shipbuilding Research Program Report #0329, and plain common sense. A low salt abrasive is generally better than an abrasive with lots of salt present; it will help prolong coating life.

Is there a critical level for chloride content in an abrasive? This is difficult to answer. Salts in an abrasive that might make it unacceptable or contaminated include chloride and many other types of ions such as sulfate. All abrasives contain a mixture of soluble ionic species, not just chloride alone. The question addresses a limit on chloride alone, but I think that more than just chloride should be measured. In the FHWA research, SSPC examined many different types of abrasives. Leachates were extracted from an abrasive using ASTM D-4940, “Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives.” The most common contaminant was sulfate ion, followed by chloride ion. Many other species were also detected. The total summed concentration of all ionic components detected was closely related to the conductivity of an aqueous extract from the abrasive.

We also found that detrimental coating performance was fairly closely tied to the conductivity of this extract. Thus, in our recently issued abrasives specification (SSPC-AB 1), no set levels were given for individual contaminants, such as chloride or sulfate ion. The specification instead sets a limit for the total conductivity of the leachate from an abrasive sample, obtained using ASTM D-4940, with the limit level of 1,000 micromho/cm. You can get an estimate of the “allowed” chloride ion concentration, based on the limit of 1,000 micromho/cm.

The ratio of conductivity measured in solution and chloride ion present is very close to 4:1 throughout the conductivity range of SSPC-AB 1. If this ratio is applied to the maximum conductivity allowed in the SSPC-AB 1 specification, the maximum allowed level of chloride in the leachate would be 250 ppm.

In real life, an actual abrasive leachate giving a reading of 1,000 micromho/cm will contain less than 250 ppm chloride ion. Many other contaminants are typically present in an abrasive. If a leachate is analyzed chemically for chloride alone, the total level of detrimental materials in that abrasive has been underestimated.

As an added complication, you should keep in mind that salt present on an abrasive is only harmful to paint life if it resides on the surface after blasting. During the FHWA work, SSPC found that most of the mineral slag abrasives embedded to some extent, even after typical blowdown or vacuum procedures were used. Determining the degree of embedment and associated salt transfer demanded the use of sophisticated surface analysis. Predicting the degree of salt transfer was not always possible, based on the conductivity found for the abrasive using the ASTM D-4940 method. The general trend of enhanced salt embedment with increased abrasive
conductivity, along with the ease of use of the D-4940 method, was the reason for using conductivity as a means of qualifying abrasives under SSPC-AB 1.

Finally, I should make 4 points.

- SSPC-AB 1 only addresses mineral/slag abrasives. Some abrasives are also salts, such as sodium bicarbonate. These are not covered by the current specification.
- SSPC-AB 1 makes you measure a contributory cause of coating degradation, abrasive contamination. The primary cause, abrasive embedment with transfer of salts, is too difficult to easily measure. This is why a simple test method, ASTM D-4940, is used.
- Future abrasive specifications from SSPC will describe characteristics of smaller sub-classes of abrasive. For instance, we intend to issue specifications covering coal slags alone. It is likely that within each sub-class of mineral or slag abrasive, unique threshold limits for “allowable” conductivity can be found. My view is that these can be set only after exhaustive testing. They may be either higher or lower than those in the present specifications. These limits will depend upon the specific class of abrasive—coal slag, sand, copper slag, garnet; the contaminants native to that specific class—sulfate, chloride, others; and the degree of embedment of the abrasive, which is hard to quantify.
- I believe SSPC-AB 1 is a good step forward. For some users, the limits set therein are lenient to qualify most commercially available abrasives. Thus, your source of supply should not have to change. For services more severe than that used in the test program for the FHWA, you always have the option of setting a chloride level far below that implied in SSPC-AB 1. An example of such an environment might be found on a pipeline with a coating or lining system used in conjunction with cathodic protection. SSPC is aware of pipeline coating operations in which coatings are to be placed over surfaces far cleaner than any that passed immersion testing in the FHWA research work. By extension, they may also desire abrasives that are less conductive than those qualifying under SSPC-AB 1.

January 1992