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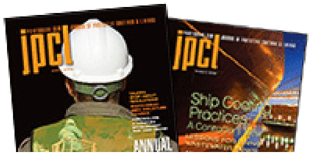

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The Buzz

From *JPCL*, July 2012 | Free Product Information

Anita Socci
JPCL

How do you feel about websites collecting more and more information about you when you’re online?

83% I don’t like it, but it’s the trade-off for being online.

8% I like it; I get more information tailored to my needs.

6% It doesn’t bother me.

3% They collect information about me?

PSN Top 10

Ben Moore CEO Axed After Island Junket

Big Dig Concrete Failing 20 Years Early

SSPC Revises Dry Film Thickness Standard

Worker Crushed at Steel Bridge Plant

Painting, Corrosion Cited in Deadly Mall Collapse

3rd Death, 2nd Fatal Fall for TX Firm

Grout Spray Kills NV Tunnel Worker

PPG Signs Chinese TiO2 Deal

Coating Makers Lose VOC Appeal in CA

50-Foot Fall Kills Worker at Power Plant

MOST POPULAR QUIZ RESULTS
(As of July 16)

Which of these strategies can improve the corrosion protection performance of organic coatings on edges?

Robert Cloutier 20/21
Ray Vickers 20/21
Wm S. Crenshaw 20/21
Lyudmil Yambolov 20/21
Willem van Gent 20/21

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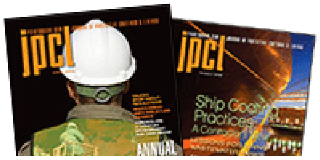

Coating concrete: Protection works both ways

From *JPCL*, July 2012 | Free Product Information

Karen Kapsanis
JPCL

I have seen concrete advertised as a substrate that, unlike steel, doesn't need to be coated and so requires little or even no maintenance.

This month's special report on the basics of concrete maintenance and protection argues otherwise, at least for concrete in some environments, especially aggressive ones.

I'd like to put forward another argument for the coating of concrete— not for its protection so much as for mine and that of other drivers.

I periodically pass through a short stretch on the Pennsylvania Turnpike that has the barriers on the curbside painted in reflective white, and I cannot tell you how grateful I am for that stretch. The Turnpike is filled with S-curves, hills, mountains, and very little lighting through the extensive rural region of Pennsylvania. I think painting the barriers in many of the areas of the Turnpike would help more drivers than me.

So I have a suggestion for the traffic engineers and DOT specifiers responsible for traffic paint: Use a reflective coating on the Jersey barriers that mark the middle and sides of many highways. (Full disclosure: I don't care whose paint is used, as long as I can see it in the dark.)

We already rely on specialty traffic marking coatings for concrete or asphalt to protect ourselves on the road: the double yellow dividing lines that mark incoming and outgoing lanes, the dotted

white lines that indicate where passing is allowed, the solid white lines that indicate no passing in the middle of multi-lane streets, and the solid white lines that mark the edge of the roadside. (One night I found myself caught in bumper-to-bumper traffic in a blizzard on a highway with no safe way to pull off. The only thing that kept me on the road was the barely visible white line marking the edge of the highway.)

I know, unfortunately, that highway departments are so underfunded that painting the barriers in otherwise dark areas might sound like a waste of resources. But I think that it is as important to protect drivers on the highway as it is to protect them on highway bridges. Whether a bridge collapses or cars collide or run off the road because of poor visibility, people get hurt, people die.

Yes, concrete in many environments deteriorates, and protecting it with coatings makes good sense to preserve our infrastructure. But in some cases, even when the environment isn't as aggressive as, say, a sewer line, coating the concrete can still have a protective function: it protects us.

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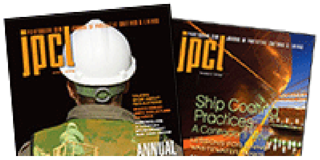

Aetna to Recoat Mt. Hope Bridge

From *JPCL*, July 2012 | Free Product Information

Charles Lange
Paint BidTracker

Photo courtesy of Wikimedia Commons

The Rhode Island Turnpike and Bridge Authority (RITBA) awarded a contract worth $6,770,650 to Aetna Bridge Company (Pawtucket, RI) to clean and recoat 183,000 square feet of steel superstructure surfaces on the north approach of the Mount Hope Bridge, a 6,130-foot-long suspension bridge that connects Portsmouth and Bristol, RI, over Mount Hope Bay. Opened in 1929 as an alternative to the ferry route that connects the two towns, the bridge was New England's longest suspension bridge for many years, according to the Authority.

The contract, which requires SSPC-QP 1 and QP 2 certifications, calls for abrasive blast cleaning the steel to a Near-White finish (SSPC-SP 10) before recoating with an organic zinc-rich primer, an epoxy intermediate, and a polyurethane finish (NEPCOAT List B.) The contract also includes coating the interiors of four cable bents. The existing bridge coatings are assumed to contain lead and will require the contractor to use containment.

10 MG Reservoir Painting Contract to Kane

Kane, Inc. (Anchorage, AK), SSPC-QP 1-certified, won a contract from the Municipality of Anchorage to clean and recoat surfaces of a 10 MG (240-foot-diameter x 32-foot-tall) welded steel water storage reservoir. Built in 1983 and originally coated in 1984, the tank's exterior was last recoated in 1999. The $2,580,709 contract includes abrasive blast cleaning interior surfaces to a Near-White finish (SSPC-SP 10) to remove the existing vinyl liner before coating the interior with an epoxy system. Use of dehumidification will be required during interior recoating. Exterior surfaces will also be abrasive blast cleaned to a Near-White finish (SSPC-SP 10) and recoated with a zinc-epoxy-polyurethane system. The contract also includes installing a new cathodic protection system.

DOT Quick Hits

- Hercules Painting Company (New Castle, PA), SSPC-QP 1- and QP 2-certified, was awarded a $2,280,107.47 from the Pennsylvania Department of Transportation to rehabilitate five bridges, including cleaning and recoating surfaces of one bridge.
- The Alabama Department of Transportation and Gulf Coast Contracting, LLC (Tarpon Springs, FL), SSPC-QP 1- and QP 2-certified, have agreed on a $1,223,386 contract to clean and recoat approximately 169,901 square feet of structural steel surfaces on nine bridges.
- Nika Contracting, Inc. (Campbell, OH) won a $421,975 contract from the Kentucky Transportation Cabinet to clean and recoat structural steel surfaces on three bridges over water.
- The North Carolina Department of Transportation issued a contract worth $1,991,961 to Astron General Contracting Co., Inc. (Jacksonville, NC), SSPC-QP 1- and QP 2-certified, to clean and recoat 151,927 square feet of structural steel surfaces on ten bridges.

Photo courtesy of Sandusky County Engineers Office

Reliant Wins Tindall Bridge Contract

Sandusky County (OH) has established a contract with Reliant Enterprises, LLC (Lawrenceburg, IN) to clean and recoat all structural steel surfaces of the historic Tindall Bridge, a 97-year-old, two-span, 334-foot-long x 16-foot-wide riveted steel through truss bridge over the Sandusky River that was last painted in 1989. The contract, valued at $729,000, includes abrasive blast cleaning the steel, with containment, to a Near-White finish before recoating with an organic zinc-rich primer, an epoxy intermediate, and a urethane finish. Sandusky County also conducted a competitive bid and is negotiating a contract with Greenman Pedersen, Inc. (Babylon, NY) to perform NACE-certified coatings inspection services.

Pro-Spec To Paint Stadium Concourse, Stairwells

Pro-Spec Painting, Inc. (Vineland, NJ) and Mercer County (NJ) have agreed on a $93,801 contract to recoat the main con-course area and two stairwells at Mercer County Waterfront Park, an existing 6,341-seat-capacity minor league baseball stadium. The stadium was opened in 1994 and is the home of the New York Yankees' Double-A affiliate, Trenton Thunder. The contractor will clean the surfaces before applying new epoxy coatings.

Photo Courtesy

of Wikimedia Commons

Tank Painting Contract Awarded to UCL

UCL, Inc. (Cincinnati, OH) finalized a contract worth $857,000 with Warren County (OH) to clean and recoat interior and exterior surfaces of the 2 MG Lytle-Five Points elevated water storage tank. The contract calls for interior wet surfaces to be abrasive blast cleaned to a Near-White finish (SSPC-SP 10) and recoated with an epoxy-epoxy-urethane system, while interior dry surfaces will be spot cleaned and touched up. Exterior surfaces also will be abrasive blast cleaned to a Near-White finish (SSPC-SP 10) and recoated with an epoxy-epoxy-urethane system, with an alternate option to recoat with an epoxy-epoxy-fluoropolymer system.

Tank Quick Hits

- George Kountoupes Painting Co. (Lincoln Park, MI) won a $1,236,000 from Baltimore County (MD) to clean and recoat four 1 MG elevated water storage tanks and one 300,000-gallon elevated water storage tank.
- Paso Robles Tank, Inc. (Paso Robles, CA) won a contract worth $1,053,900 from the City of Long Beach, CA, to clean and recoat interior surfaces and spot-coat exterior surfaces of a 3.3 MG (132-foot-diameter x 32-foot-tall) ground storage tank.
- The City of Cedar Rapids, IA, awarded a contract worth $248,000 to Champion Coatings, Inc. (Lakeville, MN) to clean and recoat interior and exterior surfaces of a 4 MG ground storage tank.
- N.G. Painting, Inc. (Kerrville, TX), an SSPC-QP 1-certified company, secured a $982,500 contract from the Town of Flower Mound, TX, to clean and recoat a 1 MG elevated water storage tank and install a new cathodic protection system.

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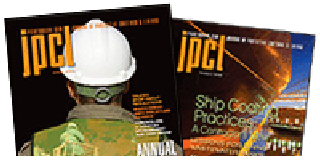

Quality Measures: A Cure for Fear of Failure

From *JPCL*, July 2012 | Free Product Information

More items for **Quality Control**

David Beamish
DeFelsko Corporation
David Beamish is president of DeFelsko Corp., a New York-based manufacturer of hand-held coating test instruments sold worldwide. He is a Registered Professional Engineer and has more than 25 years' experience in the design, manufacture, and marketing of these testing instruments in a variety of international industries including industrial painting, quality inspection, and manufacturing. He conducts training seminars and is a member of various organizations including NACE, SSPC, ASTM, and ISO.

Coated concrete is a commonly used building material, and arguably can be the most likely to experience coating failures. These failures greatly increase the potential for premature degradation of the substrate material and often result in additional expenditure of resources for repair.

The good news is that such failures are far from inevitable.

In many cases, the lack of a comprehensive Quality Control Procedure is at the root of coating failures. As with other building materials, applying coatings to concrete requires specific measures to ensure coating performance and longevity.

Assuming that the concrete surface has been determined to be sound, that it is not compromised by contaminants such as dust, oil, and grease, and that the moisture level in the concrete is suitable for painting, the following measures should be part of a quality control program for coating application.

Surface Preparation

One of the first considerations in assuring coating quality control is the compatibility of the concrete's physical surface texture (also known as the anchor or surface "profile") with the coating to be applied.

The recently issued ASTM standard D7682, Standard Test Method for Replication and Measurement of Concrete Surface Profiles Using Replica Putty, references both Method A (visual comparison) and Method B (quantifiable measurement) as means by which to determine concrete surface profile.

Given the possibility for coating failure and both preparation and materials costs, it may be desirable to have a permanent record of this profile for reference.

Quality-control measurements can play a key role in ensuring proper surface preparation, substrate moisture, environmental conditions, and coating thickness and adhesion. Restoration of the exterior of Frank Lloyd Wright's Solomon R. Guggenheim Museum, shown here, was a subject of a feature story in Journal of Architectural Coatings (now D+D) in 2009. Photo by David Heald © The Solomon R. Guggenheim Foundation, New York

One such test method that satisfies both the visual comparison and quantifiable measurement for surface profile utilizes a rapid-cure, two-part putty. By means of application and removal of the putty, a permanent relief mold of a surface sample is obtained. The relief mold may be visually compared to ICRI (International Concrete Repair Institute) CSP (concrete surface profile) coupons or measured with a specially-built micrometer at multiple areas on the mold in accordance with the testing method.

Substrate Moisture

Generally, moisture testing should be performed before painting to determine if a problem exists. Selecting proper test methods can be challenging, however, and the specific requirements of the coating manufacturer should be implemented.

A typical test is the plastic sheet method (described by ASTM D4263), where a plastic sheet (18 by 18 in.) is taped to the surface and allowed to remain for 16 hours. The sheet is then examined for any moisture that forms on the underside of the plastic. If the test indicates moisture, the wall surfaces should be allowed to dry further before coatings are applied.

Moisture meters may also be used, but these instruments vary widely in their ability to detect moisture within a concrete/masonry wall. Some meters only detect moisture on the surface of the wall, but not moisture that is present within the wall (e.g. cavity or insulation).

Meters that utilize radio frequency or electrical impendence have been found to offer more accuracy than others, and can determine the moisture content below the surface. Some instruments also possess the ability to penetrate non-destructively to 0.75 in.

Again, the coating manufacturer should be consulted for the specific instruments to be used for moisture detection, and for the associated acceptance criteria.

Environmental Considerations

The primary reason for measuring climatic conditions is to avoid rework and the premature failure of protective coatings. Recommendations and requirements are covered under various internationally recognized standards in addition to those specified by the coating manufacturer.

The ability to log results may also be important as evidence of the observation of these conditions before, during, and after the coating process.

Surface preparation and coating application should be performed under optimum environmental conditions to help prevent potential coating failure.

A major factor affecting the long-term performance of coatings on concrete is the climatic conditions during pretreatment and coating application. Handheld, electronic devices enable painting contractors, inspectors, and owners to measure and record applicable environmental conditions.

Coating Thickness

The primary purpose for measuring coating thickness on concrete is to control coating costs while ensuring adequate protective coverage. Commercial contracts often require an independent inspection of the work upon completion.

Masonry coatings are used for a multitude of purposes including cosmetic appearance, durability, abrasion resistance, and protection from elements such as moisture, salt, chemicals, and ultraviolet light. Common coatings for concrete include formulations based on acrylic, polyurethane, epoxy, silicone, and polyester resins.

Traditionally, a destructive test method is used to determine coating thickness on masonry substrates such as concrete. Coatings used on concrete range from hard to soft and smooth to textured, and span a wide thickness range. In addition, the surface of concrete can be quite rough, which can create significant variations in thickness measurements.

ASTM D6132, Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Applied Organic Coatings Using an Ultrasonic Gage, details a nondestructive test method that eliminates the need to repair the coating after inspection, saving time for both the inspector and the contractor.

Ultrasonic measurement testing equipment operates by sending an ultrasonic vibration into a coating using a probe (i.e., a transducer) with the assistance of a couplant applied to the surface.

Ultrasonic coating thickness gages are also used within the scope of SSPC-PA 9, Measurement of Dry Coating Thickness on Cementitious Substrates Using Ultrasonic Gages. The PA 9 method determines coating thickness by averaging a prescribed minimum number of acceptable (under the method) gage readings within separate spot measurement areas of a coated surface.

Coating Adhesion

Once the coating has been correctly applied to the required thickness, is it desirable to quantitatively measure the bond strength between the coating and concrete substrate. The test method for this purpose is detailed in ASTM D7234, Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.

The purpose of measuring coating thickness on concrete is to control coating costs while ensuring adequate protective coverage. Shown here is a wet-film thickness gage. Photo courtesy of KTA-Tator Inc.

Pull-off adhesion testing is a measure of the resistance of a coating to separation from a substrate when a perpendicular tensile force is applied. Portable pull-off adhesion testers measure the force required to pull a specified diameter of coating away from its substrate. This measured pull-off force provides a direct indication of the strength of tensile adhesion between the coating and the substrate.

By eliminating sources of pull-off variation, such as unintended bond failures between the adhesive and poorly prepared dollies, adhesion test results become even more meaningful and predictable.

The major components of a pull-off adhesion tester are a pressure source, a pressure gage, and an actuator. During operation, the flat face of a pull stub (dolly) is adhered to the coating to be evaluated. After allowing for the bonding adhesive to cure, a coupling connector from the actuator is attached to the dolly. By activating the pressure source, pressure is slowly increased to the actuator within the system.

When testing on concrete, the pressure in the actuator typically exceeds the internal tensile strength of the concrete itself, at which point a cohesive failure occurs within the concrete. The maximum pressure indicator of the system’s pressure gauge provides a direct reading of the pressure at which the pull-off occurred. With proper cutting around the dolly, the instrument can be used to measure the tensile strength of uncoated concrete, as well as concrete repairs.

QC: Key Contributor to Meeting Cost, Performance Objectives

As the use of concrete as a building material continues to grow, so too does the need to establish proper Quality Control measures when applying coatings. As outlined above, these measures ensure longevity of both the coating and the underlying structure and are a primary contributor to meeting cost and performance expectations.

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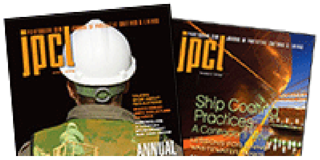

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Progress Brings Problems to Wastewater Systems

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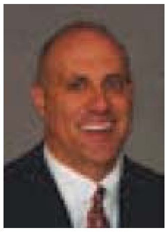
Gary R. Hall

Peter J. Jansen



Lake H. Barret

Gary R. Hall

Gary R. Hall is Manager of Research and Development at Sauereisen, Inc. (Pittsburgh, PA). He has been with Sauereisen for 44 years. Hall is active in NACE, ASTM, and the American Institute of Chemical Engineers. He is a contributing editor for JPCL and also is one of JPCL's Top Thinkers.

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Many wastewater treatment systems in the U.S. predate World War II, but some systems built after WWII have deteriorated significantly, sometimes fewer than 20 years. All photos courtesy of Sauereisen.

We are accustomed to speaking of coating and concrete deterioration in our aged wastewater treatment infrastructure, with many of the systems in the U.S. predating World War II. But some systems built after WW II have deteriorated significantly, some in as few as 20 years. In fact, wastewater collection and treatment systems face a more serious corrosion problem today than they did before WW II. There are several reasons for this. Ironically, some of reasons for the more severe corrosion problems result from advances in the U.S., from expanded industrialization to population growth and even environmental regulations.

Odor Control

Odor control consists of covering basins, chambers, and other structures to reduce the quantity of mercaptans and hydrogen sulfide (H_2S) released to the environment, and using chemical additives (natural and synthetic) to minimize offensive odors. Unfortunately, increasing H_2S in these structures increases the potential for severe corrosion by making interior conditions more favorable to the proliferation of certain microbes that secrete biogenic sulfuric acid (H_2SO_4), a metabolic waste that attacks concrete and steel. Acidithiobacillus Thiooxidans (A. Thiooxidans), the most ubiquitous of the genus, secretes sulfuric acid (H_2SO_4). This attack is known as Microbiological Influenced Corrosion (MIC). Other bacteria and some fungi secrete sulfuric acid at lower concentrations or other acids such as acetic, glutaric, propionic, and lactic, which are also involved in the MIC processes. Thus, measures to control odor also result in a more corrosive interior environment in the wastewater structures.

Reduced Inflow and Infiltration

Inflow and Infiltration (I&I) of ground water leaking into any part of the collection system can account for as much as 25% of the total amount of water that is treated at a wastewater treatment facility. Sewage treatment costs are increasing and can be more than $2.00 per 1,000 gallons. Eliminating I&I could save millions of dollars per year by reducing the amount of sewage treated, but I&I also dilutes biogenic H_2SO_4 produced, thus reducing the severity of MIC. But reducing I & I could, at least in theory, increase the risk of MIC because it increases the concentration of the acids that are secreted by the microbes, since the total amount of water has been decreased. MIC attacks concrete and the expansion joint fillers used between pipe segments and at pipe junctions. (The joint fillers are needed to meet regulations that prohibit exfiltration (leaking) of untreated sewage into the environment.)

Chemical Composition

Today's sewage not only has more H_2SO_4 and other biogenic acids, but also, it includes such compounds/mixtures as bleach, detergent, grease, oil, solvents and paints, among others. After WWII, the US industry, economy, standard of living, and population began to expand at a rapid rate, and with this expansion came increases in pollution, concentrations of the substances above, and solid waste. Some of these substances increased the corrosive potential of the sewage, but in different ways. Thus, the chemical composition of sewage itself now varies from system to system and changes daily in any given system. Many collection and treatment systems are now requiring testing for compounds such as gasoline, bleach, detergents, and other chemicals that are commonly found in today's sewerage.

Despite the variation in the composition of sewage since WW II, another change in the U.S. has had a direct bearing on the composition of all sewage. As we cleaned up our environment, we added to the corrosivity in wastewater structures. For instance. heavy metals such as mercury (Hg), chromium (Cr), lead (Pb) and cadmium (Cd), which had found their way into our wastewater systems, reduced the viability of many destructive microbes. The Clean Water Act and ensuing regulations called for the reduction, among other things, of heavy metals in the environment, so the concentration of many of these heavy metals began to decrease in wastewater systems. This decrease enhanced the viability of many microbes, including the Sulfur Reducing Bacteria (SRB) that produce the biogenic H_2SO_4 and its effects on wastewater systems.

Retention Time and Volume

In addition, as our population expanded, the U.S. became more urban and suburban, further increasing the load on sewage collection and treatment systems. This urbanization and suburbanization of America required a huge expansion of our collection and treatment infrastructure. As suburbs moved further from city centers, the collection systems had to be extended. The extension resulted in much longer retention times, thereby allowing the generation of more H_2S, increasing the growth rate of SRB, and, consequently, increasing biogenic sulfuric acid (H_2SO_4) in treatment systems.

Not only were sewer lines being lengthened, but also, the new collection systems were designed to carry sewerage loads for the next 75–100 years. That meant these systems rarely, if ever, experienced full flow. As a result, biogenic H_2SO_4 was never being diluted or washed away.

Consequently, new sewer lines were experiencing corrosion at a much faster rate than some lines that were more than 50 years old. The older lines were shorter and had significantly smaller diameters. These lines experienced larger volumes of water, which diluted the H_2SO_4 secreted by A. Th. microbes and removed some of the H_2SO_4 deposited since the last “flush.”

Change in Concrete Composition

Many Portland cements are now of poorer quality as manufactured by cement companies. They do not fire the kilns at the same temperatures as they used to, and they have made other changes to accommodate items such as fuel costs and pollution requirements that have reduced the quality of today’s concrete as compared to that which was common before the 1970s.

Practical Implications

Once SRB biosystems are established, they prolifierate and can attack the concrete (and steel) more aggressively than before and for longer periods of time. Soon, for example, the crowns of pipelines are coated with a biofilm, beneath which biogenic H_2SO_4 attacks the concrete and steel. The microbes can be facultatively aerobic or facultatively anaerobic.

One such anaerobic bacteria, Desulfovibrio desulfuricans, will migrate through the capillary pores of the concrete and lodge on wire mesh, steel rebar, or other embedded sources of iron. These anaerobic bacteria use the iron (Fe) as a catalyst to obtain nutrients from the wastewater and dissolved solids. These microbes, which do not function above the water line, secrete H_2SO_4 on the iron on which they have colonized. The ferric sulfate produced occupies 8 to 12 times the volume of the original metal, causing expansion. This expansion can exert outward pressures >800 psi, which is greater than the tensile and cohesive strength of the surrounding concrete. The concrete then cracks above the metal, and allows more microbes access to the iron. The MIC process continues, even in an environment devoid of oxygen.

Suburban Burden

Thus, because of changes since WW II, biogenic corrosion, combined with direct chemical attack from sewerage pollutants, can be extreme. In 2005, authorities in a suburb of New York City examined a 30-year-old, 84-inch diameter, 2,200-lineal foot main trunk sewer built 20 feet below grade. Extensive biogenic corrosion meant that over 4½ in. of Portland concrete overlay and rebar had to be repaired (Fig. 1). There was also extensive wear from abrasion, and the amount of inflow was measured in gallons per minute (Fig. 2).

Fig. 1: Replacement of rebar to rebuild structural integrity.

Fig. 2: Active water inflow and infiltration in tunnel.

The first step in preparing the structure was a high-pressure wash to remove the typical surface contaminants. Next, mechanical dry abrasive blasting was used to remove the weak and compromised concrete substrate. The inflow and infiltration (and potential exfiltration) were stopped using a mixture of hydro-active polyurethane expansion grouts and hydraulic cements.

Since the concrete loss was so significant, more than 14,000 sq. ft. of a steel reinforcement and cementitious gunite had to be applied before applying the first square foot of a protective lining system.

After a review of several competing technologies such as polyurethane, polyvinyl chloride, epoxies, and high-density polyethylene, a 100% solids epoxy material was chosen to maximize the life expectancy of the structure. This lining was applied via a peristaltic pump using a nozzle to minimize the downtime of the trunk line, thus saving the municipality an extensive amount of capital. Quality Assurance and Control were monitored at the factory: Sample batches were subject to standard QC tests before shipment of the product to the jobsite, where a strict application protocol was enforced. In accordance with ASTM and NACE standards, a holiday detection program was instituted to detect any voids or discontinuities in the lining system. Upon completion, the trunk sewer was placed back in service and has been operational ever since (Fig. 3).

Fig. 3: Complete restoration and rehabilitation of the crown section of tunnel.

All repair materials were provided by a single manufacturer to avoid any compatibility concerns.

The Smell in the Well

A 20-year-old underground wet well in a suburb had suffered extensive corrosion and degradation due to biogenic corrosion, mild manufacturing chemical attack, and abrasion (Fig. 4). A strong, unpleasant odor accompanied the degradation and corrosion, so long-term odor control was an imperative part of the repair. Based on the physical characteristics of chemical, permeation, and abrasion resistance, coupled with extensive 3rd party testing and over 20 years of documented case histories, a hybrid polymeric lining system was selected.

Fig. 4: Corrosion and surface cracking in concrete wet well.

The structure was taken out of service briefly so it could be pressure washed and abrasive blasted to remove contaminants and provide an acceptable substrate for rehabilitation. A blend of cementitious and polymer-modified patching materials was used to restore the Portland concrete wet well to its original state. Then, 100% solids hybrid polymer lining materials were applied (Fig. 5). Since all the materials applied were from the same manufacturer, a warranty was provided to increase the end users' ability to "sleep at night."

Fig. 5: Finishing touches on a rehabilitated wet well.

Editor's Note: Based on a paper the authors gave at SSPC 2012 (sspc.org)

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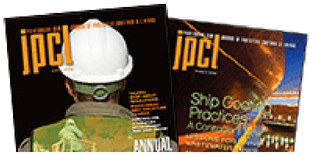

The case of…surprise blistering and rusting on a new tank lining system

From *JPCL*, July 2012 | Free Product Information

More items for **Quality Control**

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In this month's F-Files, blisters formed in a lining system installed on the interior of a raw water storage tank that was constructed at a new power plant. Because careful quality control and quality assurance inspection measures were taken from the time blast cleaning began through complete curing of the lining system, it was very surprising when blisters (as well as localized pinpoint rusting on the tank floor) were discovered during the first anniversary inspection.

Background of the Project

A new raw water storage tank was erected at the project site of the construction of a new coal fired power plant located in the east central U.S. The open top tank was 75 feet in diameter and 50 feet in height with a working capacity of approximately 1.6 million gallons. After erection of the tank was complete, hydro-testing was performed using water from a nearby creek to verify the functionality of the tank system. The interior floor and shell walls of the tank were bare rusted steel when the tank was turned over to the coating contractor for lining work.

Because of an unusually mild winter, lining work on the tank was able to begin in mid-March, and weather conditions remained favorable throughout the installation process. The contractor abrasive blast cleaned the interior tank surfaces according to SSPC-SP 10/NACE 2, Near-White metal, using a coal slag abrasive media that yielded a 2.0 to 3.0 surface profile depth. Following abrasive blast cleaning, the surfaces were coated with a three-coat, amine-cured epoxy lining system. The total dry film thickness of the lining system was specified at 12 to 16 mils. All aspects of the lining work went smoothly, as the lining was installed by a reputable SSPC-QP 1-certified contractor and was rigorously inspected by both the contractor's Quality Control (QC) Inspector and the owner's Quality Assurance (QA) personnel.

The project specification required that the tank be taken out of service and cleaned for a one-year anniversary inspection of the interior lining system. To the surprise of all parties involved in the project, blisters were observed in the lining system on the shell walls, and pinpoint rusting was evident on the tank floor.

The Site Investigation

Because the tank had an open top, a crane was used to place a lift unit inside the tank that was capable of reaching all coated surfaces. At locations where blistering and pinpoint rust were evident, visual observations were made with both the unaided eye and 50X illuminated magnification, adhesion was evaluated, lining thickness was measured, the steel surface beneath lining areas was inspected, and samples were obtained. The samples included lining chips and actual liquid that was extracted from unbroken blisters using a hypodermic syringe.

Visual Examination

Blistered areas in the tank shell lining system were isolated to a few locations and were present in concentrations of 6 to 10 blisters, which ranged in size from approximately ¾ to 1 inch in diameter (Fig. 1). Some blisters were intact, while others had a small pinhole on the surface, from which a red-colored rust stain was seeping. Blister caps were removed from intact blisters to expose the underlying steel substrate, which showed a darkened, black appearance (Fig. 2).

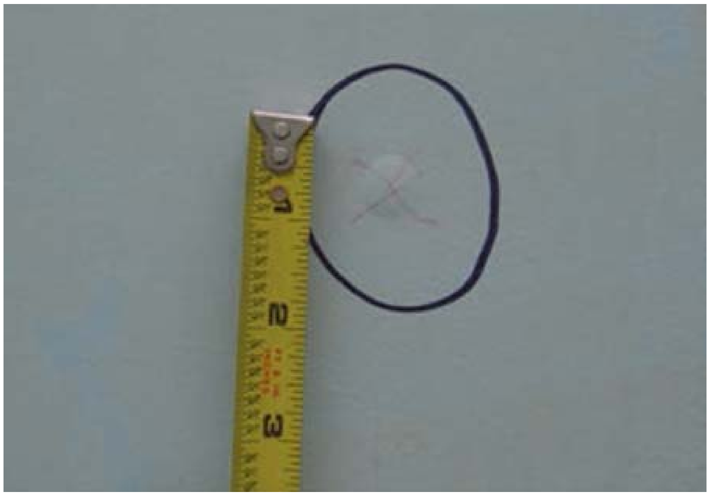

Fig. 1: Unbroken, liquid-filled blister. All photos courtesy of KTA-Tator, Inc.

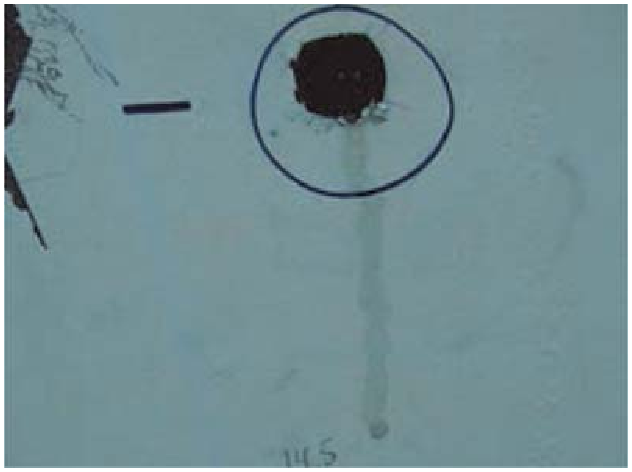

Fig. 2: After blisters were manually fractured, the underlying steel substrate showed a blackened appearance.

What initially appeared to be individual pinpoints of rust on the tank floor, upon microscopic examination, turned out to be small metallic fragments that were embedded in the surface of the lining (Fig. 3). The particles were located on the tank floor adjacent to piping that was attached by angular steel brackets to the tank shell wall. The fragments had an appearance consistent with fine shards or particles of metal that is produced by grinding, burning (i.e., torch cutting), and welding operations.

Fig. 3: What appeared to be pinpoint rust on the tank floor was actually embedded metallic fragments in the lining.

Coating Thickness

Coating thickness measurements were acquired from various locations on the interior shell. Measurements were within the specified requirements and ranged from 12.4–16.2 mils with an average of 14.9 mils.

Adhesion

Adhesion was evaluated by the tape test method (ASTM D3359, Method A). Aside from areas where blisters were present, the lining system had good (5A) adhesion. The lining in and around blistered areas had poor (0A) adhesion ratings. Starting at the blistered areas, the lining could be removed with only slight pressure from the tip of a razor knife. The area of poor adhesion extended outward from the blistered areas approximately two feet, at which point, adhesion improved (5A).

All of the steel beneath the removed areas exhibited the same black color as was observed when the blister caps were removed. The backside of the lining chips that were removed from these areas also had the same black-colored residue. At the point where adhesion improved, the appearance of the steel beneath the removed lining changed from the black color to a clean, bright metallic appearance and surface roughness that is consistent with Near-White metal blast cleaned steel.

The Laboratory Investigation

The laboratory investigation in this case consisted of visual and microscopic examination, scanning electron microscopy-energy dispersive x-ray spectroscopy (SEMEDS), and ion chromatography of the blister liquid.

Visual and Microscopic Examination

Microscopic examination (with magnification up to 200X) of lining chip samples supported the observations made in the field. The pinpoint rust observed on the floor was confirmed to be small rusted metallic fragments that were embedded in the surface of the lining.

SEM-EDS

SEM-EDS was used to analyze the black-colored residue on the backside of sample chips obtained in and around blistered areas (Fig. 4). The analysis revealed that the black material on the backside of the samples was composed primarily of carbon, oxygen, and iron.

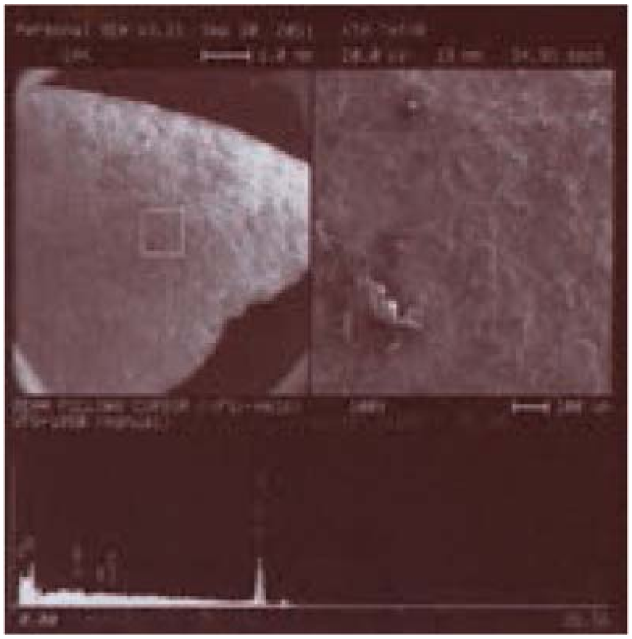

Fig. 4: SEM-EDS image of black material on the backside of sample lining chips. Upper left section shows a view of the sample; upper right section shows the analyzed sample portion; bottom section contains the spectrograph of the elemental analysis.

Ion Chromatography

Ion chromatography (IC) was performed on a liquid blister sample. The analysis revealed that the liquid contained chloride concentrations of 135 parts per million (PPM) and sulfate concentrations of 125 PPM.

Putting the Evidence to Work

The field investigation and forensic analysis yielded sufficient evidence to make conclusions as to why blistering and pinpoints of rust formed in the tank lining film.

The Blister Formation Process

There are some well-known mechanisms that fuel the process of blister formation and assist in the accumulation or concentration of moisture at given points within a lining film. Conditions that drive these forces are: contamination of the substrate by water-soluble salts, water-soluble solvents trapped within the coating film, and/or thermal gradients (temperature differences) across the coated surface.

The analysis of blister formation in the tank led the investigator to conclude that the isolated blisters formed as a result of the lining system being applied over water-soluble salts. Laboratory analysis detected chloride and sulfate concentrations in blister liquid taken from intact blisters on the tank interior shell wall. The presence of water-soluble salts beneath the lining created an osmotic cell that fueled the osmotic blister formation process and the formation of the black-colored oxide layer on the steel surface at these locations. The black-colored oxide layer was simply rust that formed in the absence of sufficient oxygen. When sufficient oxygen is present, corrosion products possess the red/orange color that is often associated with rust.

The tank was reported to have been hydro-tested using raw water from a nearby creek. Fortunately, the water from the creek was sampled on a bi-monthly basis to confirm that the construction project had no negative environmental impact on this waterway. Analysis of creek water samples taken during the hydro-testing of the tank revealed significant concentrations of chlorides and sulfates. As a result, it was concluded that the creek water was the likely source of the residual soluble salt contamination on the tank's interior steel surfaces.

Although the substrate was abrasive blast cleaned after hydro-testing, dry abrasive blast cleaning did not completely remove all water-soluble salts from the steel surface. Because water-soluble salts are invisible, they are impossible to detect before coatings are applied unless specific test methods (i.e., extraction and analysis of surface samples) are employed. In the case of the raw water tank, it appeared that some isolated patches where water-soluble salts were likely more concentrated remained on the surface and were coated over, resulting in the formation of isolated blistering.

Blisters produced by water-soluble salt contamination on the surface form by osmosis; hence, this mechanism is termed "osmotic blistering." Osmotic blistering occurs when there is ample moisture in contact with a coating film (i.e., immersion service), and there is a difference on each side of the film in the concentration of dissolved salts. This relative difference on each side of the membrane creates osmotic pressure that causes water molecules to slowly penetrate through the molecular infrastructure of the lining. As moisture penetrates, it attempts to dilute the more concentrated salt solution to reach equilibrium on both sides of the membrane. The moisture does not egress from the film as fast as it ingresses, and moisture accumulates causing a pressure build-up. As a result, an osmotic cell is created, and the driving force of osmotic pressure will accelerate the transport of water through the coating to further dilute the concentrated solution. Osmotic pressure can exceed 15,000 psi, depending on the soluble contaminants in the osmotic cell. Consequently, these pressures many times exceed coating adhesion to the substrate, and as a result, blisters form. Because the hydro-testing was done before the lining contractor and coating QC inspectors were onsite, they were not aware of the hydro-test process and the potential for surface contamination.

Pinpoint Rust Formation

Small metallic fragments that had rusted were embedded in the surface of the coating adjacent to piping that was attached to the tank shell wall with angular steel brackets. Both field and laboratory microscopic examinations indicated an appearance consistent with small (often hot), metal fragments that are produced from grinding, burning (torch cutting), and welding. When these particles fall on a coated surface, they can actually “melt” into and become embedded in the surface of the coating.

It was also reported that, after lining work was complete, other crafts performed unanticipated retrofit work on the pipe supports in the tank. The work involved grinding, burning, and welding on the pipe supports after the lining contractor had demobilized. This post lining work was fast tracked to get the tank system online, and obviously, the embedded metal fragments were not identified and removed before the tank was filled. As a result, the metallic fragments rusted, producing a pinpoint-like rust appearance on the tank floor.

Summary

In summary, while rigorous QC/QA steps were taken during lining installation process, work performed by other crafts before the lining contractor’s arrival onsite and after they had demobilized had a significant impact on the performance of the lining system. A valuable lesson was learned: the entirety of the project must be considered when an immersion-grade lining system is to be installed. What occurs before the first and after the last gallon of coating material is applied can have an unforeseen impact on the long-term performance of the lining system.

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Comment from Richard Aguillard, (9/18/2012, 12:31 PM)

So the liner specification did NOT include substrate cleanliness test, i.e. salt testing prior applying the liner?? And what tank doesn't have a hydro test after construction? It's also a great idea to check the hydro water content for contaminates regardless. And no work should be preformed after liner application without protective coverings and an "after work" final inspection to the liner! "The presence of water-soluble salts beneath the lining created an osmotic cell" has been rebuked in past research including most recent Myths about Salts,Chlorides, and Coatings. Porous films have no regards to what the substrate consists of. Its only after the water molecule reaches the substrate and have contact with the contaminate that you then have a pressure difference created (depending on the concentration of the then formed solvent and solute=solution).

Comment from Car F., (9/20/2012, 11:46 AM)

These are the perennial problems associated with "fast tracking" projects. Probably by now no one is remembring how fast and on time the project was concluded, everyone is looking for someone to pay for the repairs. I'm sure the inspectors are also being asked why do they passed that first test without being physically present ...a series of unfortunate events, most of them preventable.

Comment from James Johnson, (9/21/2012, 9:23 AM)

It is amazing that anyone writing such a specification would ignore salts as they are widely known to cause such failures, expecially in tank linings. It is even more amazing that neither contractors nor the inspector did not bring up the matter at pre-bid or pre-work conferences. It is widely known and industry acknowleged that high levels of some salts cause premature failures and that lesser levels detract from overall life spans. There are numerous published articles on the subject and both SSPC and NACE have had committees developing documents on the subject for many years. SSPC has the Guide 15 document providing information on salts testing and NACE has the 6G186 document providing information and guidance on how salts affect coatings and corrosion. Little of this information is new but has been known and discussed for about 20 years, so it amazes me that the subject is ignored when it is the known cause of a huge number of premature coating failures.

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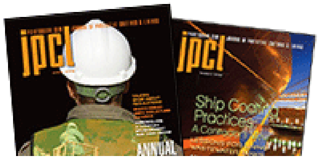

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Identifying Potential Inhalation and Noise Hazards in Abrasive Blasting Operations

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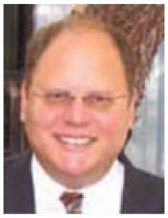
Thomas E. Enger MS, CSP, Chmm
Clemco Industries Corp.
Thomas E, Enger, MS, CSP, CHMM, has over 25 years of academic and practical experience in heavy construction and construction safety equipment manufacturing, and an extensive background in applying federal, state and local regulations as well as in using industry standards to safely prepare surfaces for today's coatings.



Thomas E. Enger, MS, CSP, Chmm, Clemco Industries Corp.

Abrasive blasting can create many health and safety hazards for abrasive blasters and other workers on the jobsite. This article discusses two common types of hazards and protection against them: inhalation hazards and hearing hazards.

Under inhalation hazards, the article gives an overview of the following.

- Inhalation Hazards from the Treated Surface
    - Paint, Epoxy, Heavy Metals
- Inhalation Hazards from Abrasives
    - Sand, Coal Slags, Steel Grit
- Inhalation Hazards from Breathing Air
    - Carbon Monoxide, Oil, Odors, Mist
- Breathing-air Requirements
- OSHA Requirements for NIOSH-approved Supplied-air Respirators Under hearing hazards and protection, the article gives an overview of the following.
- Noise Generated by Blasting
- Understanding Noise Reduction Ratings (NRR)
- OSHA Guidelines for Calculating Hearing Protection

INHALATION HAZARDS

Inhalation Hazards from Treated Surfaces

Sources of inhalation hazards from surfaces being treated are

- the base surface—commonly metal, concrete, plastic, composite, or wood; and
- the protective coatings or surface contaminants present on the surface—rust, primer, etc.

29 CFR 1910, Subpart Z, "Toxic and Hazardous Substances" describes the OSHA standards for protecting workers from inhalation hazards. To fully understand the OSHA regulation, the reader should visit http://osha.gov, click on the "Regulation" tab and page down to Section 1910 of the General Industry Standard.

Contractors using abrasive blasting to prepare surfaces for coatings can expect exposures to many inhalation hazards from the base surface. The hazards are described in the sections of 29 CFR, Section 1910, Subpart Z and are shown in Table 1.

Coatings and surface contaminants also present inhalation hazards. The best method to determine what these hazards are is to obtain the Material Safety Data Sheet (MSDS) for the coatings to be removed. Frequently, a contractor does not or cannot obtain the MSDS. In such cases, general knowledge or chemical analysis must be used. The most common inhalation hazards associated with coatings and contaminants are listed in Table 2.

TABLE 1
Inhalation Hazards from the Base Surface

Base Surface	Inhalation Hazard	OSHA Subpart Z Citation	PEL
Concrete	Silica Sand	1910.1000 Table Z-3	10 mg/m^3/%SiO$_2$+2
	Asbestos	1910.1001 &1926.1101	0.1 f/cm^3
	Portland Cement	1910.1000 Table Z-1	5 mg/m^3
	Silicates(<1%Silica)	1910.1000 Table Z-3	20 mpp/ft^3
	Mica		
	Soapstone		
	Talc		
	Nuisance Dust	1910.1000 Table Z-3	5 gm/m^3
Marble	Marble	1910.1000 Table Z-1	5 mg/m^3
Metal	Aluminum	1910.1000 Table Z-1	5 mg/m^3
	Beryllium	1910.1000 Table Z-2	2 µg/m^3
	Cadmium	1910.1027	5 µg/m^3
	Chromium II or III	1910.1000 Table Z-1	0.5 mg/m^3
	Chromium IV	1910.1026	5 µg/m^3
	Cobalt	1910.1000 Table Z-1	0.1 mg/m^3
	Copper	1910.1000 Table Z-1	0.1 mg/m^3
	Lead	1910.1025	50 µg/m^3
	Magnesium	1910.1000 Table Z-1	15 mg/m^3
	Nickel	1910.1000 Table Z-1	1 mg/m^3
	Silver	1910.1000 Table Z-1	0.1 mg/m^3
	Tin	1910.1000 Table Z-1	5 mg/m^3
	Titanium	1910.1000 Table Z-1	5 mg/m^3
	Uranium	1910.1000 Table Z-1	0.25 mg/m^3
	Vanadium	1910.1000 Table Z-1	0.5mg/m^3
	Zinc	1910.1000 Table Z-1	5 mg/m^3
	Zirconium	1910.1000 Table Z-1	5 mg/m^3
Stone	See Concrete		
Composites	Must obtain MSDS to determine components of composite		

TABLE 2

Common Inhalation Hazards from Coatings or Surface Contaminants

Surfaces	Inhalation Hazard	OSHA Subpart Z Citation	PEL
Contaminants	Nuisance Dust	1910.1000 Table Z-3	5 mg/m^3
	Oils, Mist, Minerals	1910.1000 Table Z-1	5 mg/m^3
	Oxidation (Rust)	Listed as Nuisance Dust	5 mg/m^3
Coatings	Lead	1910.1025	50 µg/m^3
	Cadmium	1910.1027	5 µg/m^3
	Chromium II or III	1910.1000 Table Z-1	0.5 mg/m^3
	Chromium IV	1910.1026	5 µg/m^3
	Zinc	1910.1000 Table Z-1	5 mg/m^3

Inhalation Hazards from Abrasives

Surface treatment operations commonly employ many types of abrasives that present specific hazards to the worker. These hazards are identified on the Material Safety Data Sheet. The majority of construction and outdoor surface preparation operations use only a few different types of abrasives, commonly, those shown in Table 3.

TABLE 3

Common Abrasives and Their Inhalation Hazards

Abrasive	Inhalation Hazard	OSHA Subpart Z Citation	PEL
Sand	Free Silica	1910.1000 Table Z-3	10 mg/m^3/%SiO$_2$+2
Crush Glass	Nuisance Dust	1910.1000 Table Z-3	5 mg/m^3
Garnet	Nuisance Dust	1910.1000 Table Z-3	5 mg/m^3
Coal Slag	Aluminum Oxide	1910.1000 Table Z-1	10 mg/m^3
	Ferric Oxide	1910.1000 Table Z-1	5 mg/m^3
	Amorphous Silica	1910.1000 Table Z-3	80 mg/m^3/%SiO$_2$
	Calcium Oxide	1910.1000 Table Z-1	5 mg/m^3
	Magnesium Oxide	1910.1000 Table Z-1	10 mg/m^3
	Titanium Oxide	1910.1000 Table Z-1	10 mg/m^3
Nickel Slag	Silica as SiO3^{2-}	1910.1000 Table Z-3	10 mg/m^3
	Magnesium Oxide	1910.1000 Table Z-1	10 mg/m^3
	Iron Oxide	1910.1000 Table Z-1	10 mg/m^3
	Aluminum Oxide	1910.1000 Table Z-1	10 mg/m^3
	Calcium Oxide	1910.1000 Table Z-1	5 mg/m^3
	Nickel	1910.1000 Table Z-1	1 mg/m^3
	Chromium Oxide	1910.1000 Table Z-1	10 mg/m^3
Copper Slag	Iron	1910.1000 Table Z-1	10 mg/m^3
	Amorphous Silica	1910.1000 Table Z-3	80 mg/m^3/%SiO$_2$
	Aluminum Oxide	1910.1000 Table Z-1	10 mg/m^3
	Calcium Oxide	1910.1000 Table Z-1	5 mg/m^3

The permissible exposure limit (PEL) for inhalation hazards affecting abrasive blasting operators as a general rule is 5 mg/m3 — except for the following.

1. Sand: when used as an abrasive, the PEL is reduced to 10 mg/m3/%SiO$_2$+2
2. Coating containing lead: the PEL is reduced to 50 µg/m3
3. Coating containing cadmium: the PEL is reduced to 5 µg/m3
4. Coating containing chromium II or III: the PEL is reduced to 0.5 mg/m3
5. Coating containing chromium IV: the PEL is reduced to 5 µg/m^3
6. Coating containing asbestos: the PEL is reduced to 0.1 f/cm^3

Inhalation Hazards from Breathing Air

29 CFR 1910.134(i) addresses Breathing Air for Supplied-Air Respirators. This section states: “Compressed breathing air shall meet at least the requirements for Grade D breathing air described in ANSI/Compressed Gas Association Commodity Specification for Air, G-7.1-1989 to include:

- Oxygen content of between 19.5% and 23.5%,
- Hydrocarbon (Oil Mist) content of less than 5 mg/m^3,
- Carbon monoxide (CO) content of less than 10 ppm,
- Carbon dioxide (CO_2) content of less than 1000 ppm,
- Lack of noticeable odor, and
- Compressor is situated so as to prevent entry of contaminated air into the air supply system and minimize moisture content so that the dew point at 1 atmosphere pressure is 10 degrees F (5.56 degrees C) below the ambient temperature.”

  The standard also adds the following requirements when providing breathing air from a compressor.

- Have suitable in-line air-purifying sorbent beds and filters to further ensure breathing air quality. Sorbent beds and filters shall be maintained and replaced or refurbished periodically following the manufacturer’s instructions. The filters must be tagged to document the most recent filter replacement date and the signature of the person authorized by the employer to perform the maintenance.
- For compressors that are not oil-lubricated, the employer shall ensure that carbon monoxide levels in the breathing air do not exceed 10 ppm.
- For oil-lubricated compressors, the employer shall use a high-temperature alarm or carbon monoxide alarm, or both, to monitor carbon monoxide levels. If only high-temperature alarms are used, the air supply shall be monitored at intervals sufficient to prevent carbon monoxide in the breathing air from exceeding 10 ppm.
- Ensure that breathing air couplings are incompatible with outlets for non-respirable worksite air or other gas systems. No asphyxiating substance shall be introduced into breathing-air lines.

OSHA requires users of Supplied-Air Respirators to use an in-line “Sorbent Bed Filter” (Fig. 1).

Fig. 1: Supplied air respirators must be used with an in-line sorbent bed filter. Photos courtesy of Clemco Industries Corp.

The sorbent bed removes the objectionable oil odors and mists mentioned in the OSHA standard. It contains a replaceable filter that enables the user to comply with the standard, which requires maintenance of such a filter.

Unless using a compressor which specifically states it is a “Breathing-Air” compressor, the

employer must install a carbon monoxide monitor in the air-supplied system. Historically, there were two types of carbon monoxide monitors: a permanently installed type (Fig. 2), and a portable type (Fig. 3).

Fig. 2: Permanently installed carbon monoxide monitor

Fig. 3: Portable carbon monoxide monitor

In early 2011, OSHA issued a letter of interpretation stating that the CO monitor shown in Figure 4 may be used as an individual CO monitor, meeting the standard stated in 29 CFR Section 1910.134(i), provided NIOSH would approve its placement inside the respirator. Figure 5 shows the only approved respirator and the monitor's placement.

Fig. 4: CO monitor that may be used as an individual CO monitor

Fig. 5: CO monitor placement in the only respirator approved for the monitor's use

This new carbon monoxide monitor provides assurance that the operator who uses it is independently alerted when the CO level inside the respirator rises to 10 ppm. This direct alert to the operator wearing the monitor means that the blast operation no longer requires an additional employee to monitor the CO alarm, which is customarily placed out-of-sight and beyond the hearing range of the blast operator served by the monitor.

OSHA Requirements for NIOSH-Approved Supplied-Air Respirators

The final element needed to protect the operator and other employees exposed to inhalation hazards in excess of the permissible exposure limits is an OSHA-compliant respirator.

29 CFR 1910.94(a)(5)(i) states: "Employers must use only respirators approved by the National Institute for Occupational Safety and Health (NIOSH) under 42 CFR Part 84 to protect employees from dust produced during abrasive-blasting operations," and 1910.94(a)(5)(ii) states: "Abrasive-blasting respirators shall be worn by all abrasive-blasting operators."

This standard is repeated in 29 CFR 1926.57(f)(f)(i), which states:" Employers must use only respirators approved by NIOSH under 42 CFR Part 84 for protecting employees from dusts produced during abrasive-blasting operations," and 1926.57(f)(5)(ii), which states: "Abrasive-blasting respirators shall be worn by all abrasive-blasting operators."

An abrasive-blasting respirator is shown in Fig. 1.

The supplied-air respirator shown in Fig. 1 includes the hood, lenses, cape, air valve and yellow respirator air hose connected to the point of attachment (POA) located on top of the sorbent bed filter. While the respirator assembly begins at the POA, this attachment is mandated by 42 CFR Part 84, Subpart J.149 and shown in Fig. 6.

Fig. 6: Point of attachment on top of sorbent bed filter

42 CFR Part 84, Subpart J.149 sets the following requirements for the POA.

- o POA - Point of Attachment: A pressure gauge, regulator, relief valve, and congruous fitting are necessary to be considered a POA.
- o Regulator allows adjustment of air pressure to manufacturer's specified pressure range based on range of hose length used (see 84.149 (b)).

- o Pressure gauge allows verification of this pressure setting at the point of attachment (see 84.149 (b)).
- o Pressure relief valve prevents pressure from exceeding 125 psi (see 84.149 (d) (1)).
- o Congruous fitting allows connection of "detachable couplings" as part of NIOSH-approved respirator system (see 84.131 (5)).
- o The maximum length of hose allowed from the "Point of Attachment" to the worker is 300 ft. (91m) for type-C Supplied-Air Respirators. This hose must be provided in multiples of 25 ft. (7.6 m). (*Reference: 42CFR Part 84 Subpart J.149 - Table 8, Air Supply-Line Requirements and Tests*)

The supplied-air respirator discussed above must be worn by the person doing the blasting. However, employees performing work adjacent to the blasting operation, such as pot tenders or cleanup workers, often erroneously believe they are adequately protected without such protection and compliant with this OSHA standard. These employees are at serious risk of exceeding the PELs as well as being in violation of the OSHA standards.

Many employees working around abrasive blasting operations use a standard dust mask (Fig. 7). These masks most often have an Assigned Protection Factor of five (5), which means the employee may be exposed to inhalation hazards up to five times the PEL. When inhalation hazards, such as free silica, lead, cadmium, asbestos, and chromium, are present, these dust masks are inadequate. While these workers are not required to wear supplied-air respirators, employers should seriously consider providing them to employees working in the vicinity of blasting operations.

Fig. 7: Standard dust mask

29 CFR 1910.134(d)(3)(i)(A) addresses the Assigned Protection Factor (APF) of respirators, including the abrasive blasting supplied-air respirator, continuous flow mode. As shown in Table 4, the APF for continuous flow supplied-air respirators is either 25 or 1000.

Assigned Protection Factors (APFs): Employers must use the assigned protection factors listed in Table 4 to select a respirator that meets or exceeds the required level of employee protection. When using a combination respirator (e.g. air-line respirators with an air-purifying filter), employers must ensure that the assigned protection factor is appropriate to the mode of operation in which the respirator is used.

Notice that in the fourth column of Table 4, "Helmet/Hood," the SAR and PAPR have a "dual" APF rating of 25/1,000, and have foot-note number 4. This dual APF rating is confusing until you decipher the footnote of the Table. To simplify, let's just consider the discussion of SARs in the footnote.

Footnote number 4 to Table 4 states that all abrasive blasting supplied-air respirators have an APF of 25. This APF is adequate when working in an environment where nuisance dust with a PEL of 5 mg/m3 is present. However, when abrasive blasting involves free silica, lead, cadmium, asbestos, chromium or other inhalation hazards with low PELs, the APF of 25 is inadequate. Footnote number 4 goes on to state that the respirator may provide an APF of 1000 if the employer can produce a copy of a report by an independent third party indicating that during rigorous testing the respirator exhibited a protection factor of more than 1000. A simple statement from the manufacturer is insufficient. Most manufacturers of supplied-air respirators have this report on their websites. An example of one such report may be found at: http://www.clemcoindustries.com/safety_showitem.php?item_id=11121.

To adequately protect abrasive blasting workers, employers should always provide supplied-air respirators that have the official documentation of testing proving the APF of 1000.

TABLE 4

Assigned Protection Factors[5]

Type of Respirator [1, 2]	Quarter Mask	Half Mask	Full Facepiece	Helmet/Hood	Loose-Fitting Facepiece
• Air-Purifying Respirator	5	[3]10	50	....	....
• Powered Air-Purifying Respirator (PAPR)	....	50	1,000	[4]25/1,000	25
• Supplied-Air Respirator (SAR) or Airline Respirator					
• Demand mode	....	10	50	....	....
• Continuous flow mode	....	50	1,000	[4]25/1,000	25
• Pressure-demand or other positive-pressure mode	....	50	1,000	....	....
• Self-Contained Breathing Apparatus (SCBA)					
• Demand mode	....	10	50	50	....
• Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	....	....	10,000	10,000	....

Notes:

[1] Employers may select respirators assigned for use in higher workplace concentrations of a hazardous substance for use at lower concentrations of that substance, or when required respirator use is independent of concentration.

[2] The assigned protection factors in Table 1 are only effective when the employer implements a continuing, effective respirator program as required by this section (29 CFR 1910.134), including training, fit testing, maintenance, and use requirements.

[3] This APF category includes filtering facepieces, and half masks with elastomeric facepieces

[4] The employer must have evidence provided by the respirator manufacturer that testing of these respirators demonstrates performance at a level of protection of 1,000 or greater to receive an APF 1,000. This level of performance can best be demonstrated by performing a WPF or SWPF study equivalent testing. Absent such testing, all other PAPRs and SARs with helmets/hoods are to be treated as loose-fitting facepiece respirators, and receive an APF of 25.

[5] These APFs do not apply to respirators used solely for escape. For escape respirators used in association with specific substances covered by 29 CFR 1910 subpart Z, employers must refer to the appropriate substance-specific standards in that subpart. Escape respirators for other IDLH atmospheres are specified by 29 CFR 1910.134 (d)(2)(ii).

HEARING HAZARDS AND PROTECTION

Noise Generated by Abrasive Blasting Another direct hazard to abrasive blasting workers is noise. The blaster is regularly exposed to noise in excess of 120 dBA. OSHA has set the duration of noise exposure in 29 CFR 1910.95(b)(2) shown in Table 5 (1) When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: C(1)/T(1) + C(2)/T(2) C(n)/T(n) exceeds unity, then, the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level, and Tn indicates the total time of exposure permitted at that level. Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

Understanding Noise-Reduction Ratings and Calculating Hearing Protection

As far as noise is concerned, an unprotected abrasive blasting operator is limited to less than 15 minutes per day of blasting. In reality, abrasive blasting requires hearing protection at all times.

The standard provides a calculation method for determining how long an operator may blast using hearing protection. 29 CFR 1910.95, Appendix B, provides the employer with a simplified version of calculating the adequacy of hearing protection attenuation. Noise is measured using an instrument called a dosimeter. Dosimeters use an "A" scale or a "C" scale to measure noise. While it is recommended that the reader review this section of the OSHA standard to fully understand it, a general calculation to use follows.

1. If your dosimeter is measuring on the "A" scale, subtract seven (7) from the stated Noise Reduction Rating (NRR) on the hearing protection, then subtract the result from the measured reading.

a. IE: If your hearing protection has a 33 NRR and your dosimeter is reading 121 dBA on the "A" scale, the resulting noise exposure calculation will be:

121-(33-7) = 95 dBA
and by using Table 5, your worker will be able to blast for 4 hours a day, provided he is exposed to noise under 85 dBa for the remainder of the shift.

2. If your dosimeter is measuring on the "C" scale, subtract the stated NRR on the hearing protection from the measured reading.

a. IE: If your hearing protection has a 33 NRR and your dosimeter is reading 122 dBC on the "C" scale, the resulting noise exposure calculation will be:

121-33=88 dBA
and by using Table 5, your worker will be able to blast for 8 hours a day, provided he is exposed to noise under 85 dBA for the remainder of the shift.

(Note: Most dosimeters read on the A scale, and the first calculation is normally used.)

NIOSH Publication No. 98-126, titled *Criteria for a Recommended Standard Occupational Noise Exposure*, states in part: "It is important to note that using such double protection will add only 5 to 10 dB of attenuation [Nixon and Berger 1991]." Using secondary hearing protection such as muffs over earplugs or a supplied-air respirator with an ANSI 3.19 Noise Reduction Rating, like the one shown in Fig. 8, can add an additional 5 dBAs of hearing protection.

Fig. 8: Supplied air respirator with an ANSI 3.19 Noise Reduction Rating

Using the most common dosimeter "A" scale measurement and calculating the hearing protection attenuation, it is possible to add an additional 4 hours of blasting to the blast operator's workday, provided the abrasive blasting operator wears a supplied-air respirator with an ANSI 3.19 NRR of above 5 dBa as shown below.

1. If your dosimeter is measuring on the "A" scale, subtract seven (7) from the stated Noise Reduction Rating (NRR) of the primary hearing protection then add 5; subtract this result from the measured reading.

a. IE: If your hearing protection has a 33 NRR and your dosimeter is reading 121 dBA on the "A" scale the resulting noise exposure calculation will be:

121-[(33-7)+5] = 90 dBA
and by using Table 5 the worker will be able to blast 8 hours.

EAR, Inc., one of the largest manufacturers of hearing protection, performed and published the Environmental Noise Levels of common activities. As shown in Fig. 9, abrasive blasting is approximately 115 dBA. Adding outside construction noise, it is not uncommon for the blasting operation to exceed 120 decibels, and the use of secondary hearing protection is strongly encouraged.

TABLE 5

Permissible Exposure Limits(1)

Duration Per Day, Hours	Sound Level dBA Slow Response
8	90
6	92
4	95
3	97
2	100
1½	102
½	105
¼ or less	115

Environmental Noise Levels

140 dB	Space rocket at blast-off
130 dB	Jackhammer
120 dB	Ambulance siren Amplified rock band Thunder clap
115 dB	Abrasive blasting
110 dB	Woodworking shop
100 dB	Pneumatic drill Chainsaw
90 dB	Lawn mower Disco dance music Shop tools Truck traffic Noisy restaurant
80 dB	City traffic Loud music from radio
75 dB	Kitchen appliances
70 dB	Crowded restaurant
65 dB	Conversation speech
60 dB	Sewing machine Typewriter
50 dB	Average home interior
40 dB	Quiet residential community
30 dB	Whisper at five feet
20 dB	Leaves rustling in a breeze
10 dB	Normal breathing
0 dB	Faintest sound heard by a human ear

Fig. 9: Environmental noise levels of common activities

This listing is a guide to common acronyms related to inhalation hazards associated with abrasive blasting. These acronyms and relevant definitions may be found on the OSHA website (http://osha.gov), on the NIOSH web-site (http://www.cdc.gov/NIOSH), and on www.clemcoindustries.com.

Conclusion

The information provided in this article covers only the most common inhalation and noise hazards associated with abrasive blasting, and the article offers general recommendations for methods to reduce operator exposures to these hazards through the use of appropriate respiratory and hearing protection. For the most current and complete information and guidelines, consult the OSHA standards.

Acronyms

This listing is a guide to common acronyms related to inhalation hazards associated with abrasive blasting. These acronyms and relevant definitions may be found on the OSHA website (http://osha.gov), on the NIOSH web-site (http://www.cdc.gov/NIOSH), and on www.clemcoindustries.com.

ACGIH:	American Conference of Governmental Industrial Hygienists
AIHA:	American Industrial Hygiene Association
ANSI:	American National Standards Institute
APF:	Assigned Protection Factor
APR:	Air-purifying Respirator
Ci:	Concentration measured inside the respirator face piece
Co:	Concentration measured outside the respirator
DOP:	Dioctyl phthalate
DFM:	Dust, fume, and mist filter
EPF:	Effective Protection Factor
HEPA:	High efficiency particulate air
IDLH:	Immediately dangerous to life or health
LANL:	Los Alamos National Laboratory
LASL:	Los Alamos Scientific Laboratory
LLNL:	Lawrence Livermore National Laboratory
MSHA:	Mine Safety and Health Administration
MUC:	Maximum Use Concentration
NFPA:	National Fire Protection
NIOSH:	National Institute for Occupational Safety and Health
NRC:	Nuclear Regulatory Commission
OSHA:	Occupational Safety and Health Administration
OSH Act:	Occupational Safety and Health Act of 1970 (29 U.S.C. 655, 657, 665)
PAPR:	Powered air-purifying Respirator
PEL:	Permissible Exposure Limit
PPF:	Program Protection Factor
QLFT:	Qualitative fit test
QNFT:	Quantitative fit test
RDL:	Respirator Decision Logic
REL:	Recommended Exposure Limit
SAR:	Supplied-air (or airline) Respirator
SCBA:	Self-contained Breathing Apparatus
WPF:	Workplace Protection Factor
TLV:	Threshold Limit Value
SWPF:	Simulated Workplace Protection Facto

Editor's Note: This article is a supplement to "The Use of Personal Protective Equipment and Regulations and Standards Affecting Safe Abrasive Blasting," published by Clemco Industries Corp., appearing on www.clemcoindustries.com (© 2011 Clemco Industries Corp.) and adapted for the November 2011 JPCL. This article focuses on protecting *workers from exposure to inhalation and noise hazards during surface preparation work in coating operations. A version of the article was given at SSPC 2012 Featuring GreenCoat, held January 30–February 2, 2012, in Tampa, FL (sspc.org).*

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