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Supplement to the August 2013 *JPCL*
The Voice of SSPC: The Society for Protective Coatings

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Introduction

Three decades ago, when Volume 1, No. 1, of ***JPCL*** was published, change happened much more slowly than it happens today. Many people still used typewriters; desktop computers were just coming into the mass market; landlines were the norm for telephone service; road maps came on paper from mapmakers; and the Internet was still largely in the domain of government and university researchers.

Change, whether for better or worse, happens much faster now. Thirty volumes of *JPCL* later, we have gone from desktop computers to laptops to smart tablets and even smarter phones. You don't need a passenger to follow the roadmap when you have a GPS in your car.

In the world of protective coatings work, change has happened over the past three decades, sometimes slowly, sometimes faster, but never as fast as it has in the past few years, even since our 25-year review of changes in the industry in August of 2009.

In this supplement to our regular August issue, we don't pretend to give a comprehensive history of the industry—we wouldn't dare try.

Instead, with the help of our contributors, we try to capture a snapshot of some major trends in the industry over three decades in regulations, environmental controls, coating materials, surface preparation, coating application, and quality control. We also use a wide lens to capture changes in SSPC standards and trends in products and practices since our 2009 review.

We present this snapshot of trends because of another change—new people (but not enough) are coming into the industry while those who have been here for quite some time are retiring or moving into their encore careers. So we hope that this issue will provide an overview of the industry for newcomers and a review for industry veterans as they are passing on their considerable knowledge about the protective coatings work to their successors.

We believe that the transfer of knowledge about protective coatings work is crucial because of one thing that has not changed in the past three decades: the need to protect our public and private infrastructure from corrosion and deterioriation.

To carry out the work, it takes professionals like you. To all of you, we owe many, many thanks.

–The ***JPCL*** Staff

Regulations and Coatings Work: Key Developments over 30 Years

By Alison Kaelin, CQA, ABKaelin, LLC

Regulations on protecting workers and the environment (including the public) have driven many developments in coatings work for industrial structures, bridges, and ships. This article looks at key regulations and guidance documents affecting surface preparation, coatings, and worker protection over the past 30 years. Federal regulations and guidance documents from the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the National Institute for Occupational Safety and Health (NIOSH) are referenced most frequently, but some state and local regulations are identified as well. The article is not intended to be comprehensive.

Protecting the environment, the public, and workers from the hazards of exposure to dust from blasting with silica and other abrasives became a priority in the 1980s for EPA, OSHA, and NIOSH. iStock

Surface Preparation and the Environment

Silica

Up until the 1980s, silica sand was the primary abrasive used for abrasive blast cleaning (then called sandblasting), even though the potential health effects had been documented since the 1930s. In the mid-1980s, several civil lawsuits were filed by citizens due to alleged property damage and health effects from open abrasive blast cleaning involving silica abrasives and lead (e.g., *JPCL*, October 1985, p. 3). A case in Allegheny County, PA, resulted in local air pollution control regulations being implemented in 1987 (*JPCL*, June 1988, pp. 24–25, 235–236). This regulation included limitations on silica (free silica) in the environment of 100 µg/m³ for an eight-hour day and limitations on the amount of free silica in the abrasive to less than 5%. Texas, California, and other states implemented similar regulations on abrasive blasting (primarily to control emissions or limit free silica in the abrasive) throughout the early 1990s (*JPCL*, February 1991, pp. 55–116). The California Air Resources Board (CARB) certifies specific types of abrasive through pre- and post-testing by sieve and/or opacity.

Protecting Workers from Exposure to Silica

It has long been known that significant silica exposures can occur during blast cleaning with abrasives that contain silica. In 1975, NIOSH issued *Recommendations for a Crystalline Silica Standard.* 1979, NIOSH recommended that silica sand or other material containing greater than 1.0% crystalline silica (quartz) be prohibited as a media for abrasive blasting. Banned as an abrasive in many countries, crystalline silica sand is not prohibited in the U.S. but exposure to crystalline silica (in any abrasive) is regulated in construction under 29 CFR 1926.55, Gases, Vapors, Dusts, and Mists, and in general industry under 29 CFR 1910.1000. Essentially, these "catch-all" regulations say that if a worker exceeds the Permissible Exposure Limit (PEL), the employer must implement administrative and engineering controls followed by respiratory protection to reduce occupational exposures below the PEL. Silica is also referenced in 29 CFR 1926.57, Ventilation, which requires the use of an abrasive blasting respirator when abrasive blasting with silica.

In 1998, NIOSH issued a report, *Evaluation of Substitute Materials for Silica Sand in Abrasive Blasting*, to evaluate the surface preparation performance and potential worker exposure contaminants in silica and alternative abrasives (*JPCL*, August 1999, pp. 49–71).

While OSHA has failed to issue any comprehensive regulations for silica, it did issue a National Emphasis Program [NEP]—Crystalline Silica in 2008 (*JPCL*, April 2008, pp. 12–17 and *JPCL*, June 2008, 47-51). The NEP establishes policies and procedures for inspection and changed how the PEL for silica is calculated. The NEP specifically targeted employer classifications such as painting and paper hanging; general contractors; and highway, bridge, and tunnel construction; and it explicitly identifies abrasive blast cleaning as a high-exposure activity.

In May 2009, OSHA issued Publication 3362, *Controlling Silica Exposures in Construction*, but did not address abrasive blast cleaning. Around the same time, the International Safety Equipment Association and the Risk and Insurance Management Society petitioned OSHA to prohibit the use of silica in abrasive blasting (www.paintsquare.com, *News*, May 11, 2009).

The OSHA regulatory agenda in Spring 2009 began indicating that development of a standard for occupational exposure to crystalline was under consideration and the July 2013 OSHA regulatory agenda indicated that a proposed rule on occupational exposures to crystalline silica was expected in July 2013.

Hazardous Dust (Lead, Other Heavy Metals)

Civil lawsuits in the 1980s and increasing concerns related to lead exposures also resulted in state and local regulations for controlling emissions of lead. Additionally, the painting industry became more aware of EPA regulations required by the provisions of the Clean Air Act, Clean Water Act, and Resource Conservation and Recovery Act (RCRA) that were applicable to paint removal operations involving lead and other metals.

SSPC convened a symposium in January 1987 to discuss the impact of regulations and litigation on protective coatings (*JPCL*, June 1987, pp.59–93) and in 1988 hosted two symposiums: one on lead paint removal from industrial structures and the other, in conjunction with the FHWA, on removal and disposal of lead-containing bridge paints. In response to the above and the potential risk of litigation due to alleged exposure to lead (and silica), many transportation departments and other facility owners began to establish specification requirements for containment, environmental monitoring, and management of hazardous waste.

In 1990, EPA implemented changes to the testing procedures for hazardous waste from the EP Toxicity Test to the Toxicity Characteristic Leaching Procedure (*JPCL*, May 1990, pp. 68, 99) and introduced the Land Disposal Restrictions (40 CFR 268). Known as "Land Ban," 40 CFR 268 prohibiting the land disposal of any leachable lead-bearing hazardous levels (*JPCL*, August 1990, pp. 34–71).

In 2008, EPA revised the National Ambient Air Quality Standard (NAAQS) for lead, resulting in reduction of allowable ambient lead from 1.5 $\mu g/m^3$ to 0.15 $\mu g/m^3$ (*JPCL*, January 2009, pp. 9–13). Much of the health effects data provided with the revised NAAQS for lead appears to indicate that blood lead levels as low as 10 µg/dL can harm children and adults (*JPCL*, May 2013, pp. 44-61).

Other Abrasives

Other non-silica abrasives have also seen indirect regulation over the last few years. In June 2010, EPA published a proposed rule for Disposal of Coal Combustion Residuals (CCRs) from Electric Utilities. The proposed CCR rule is expected to impact the allowable use and disposal of CCRs. Coal slag abrasives (which are CCRs) used and disposed of in the painting industry will be impacted (*JPCL*, August 2010, 56-61).

The recent overhaul of the OSHA Hazard

Reducing VOCs in coatings continues to be mandated by the Federal Clean Air Act Amendments and by many state and local laws and regulations.
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Communication Standard to meet the Global Harmonization System also impacts abrasives used for surface preparation. Under the new requirements for hazard classification and reporting on safety data sheets, SDSs for various abrasives may now identify the presence of lead, beryllium, arsenic, manganese, and cadmium (*JPCL*, August 2012, pp. 14-23).

Beryllium is a metal found in mineral rocks, coal, soil, and volcanic dust. It has been identified in coal and copper slag abrasives and is associated with health effects of the respiratory system. OSHA has added the development of a proposed rule for beryllium exposures to the 2013 regulatory agenda with a target date of July 2013.

OSHA issued a 2008 National Emphasis program for combustible dusts that remains in effect today. Combustible dusts are fine particles that present an explosion hazard when suspended in air under certain conditions and the NEP identifies that coal and metallic dusts as potential sources.

Coatings and the Environment

Volatile Organic Compounds (VOC)

The Clean Air Act called on the EPA to establish measures to reduce air pollution. EPA focused early on six air pollutants—lead, ozone, particulate matter, sulfur dioxide, nitrogen oxide, and carbon dioxide—and set limits on their acceptable ambient levels. Acceptable levels were identified in EPA's NAAQS. States with any of the six pollutants above the NAAQS were considered "non-attainment" states and were required to develop plans to reduce air pollutant levels to the NAAQS or below. Ozone—both ground level, which is harmful to human beings, and stratospheric, which is harmful to the earth—has figured prominently in the manufacture and application of coatings (SSPC, ***Steel Structures Painting Manual, Vol. 1, Good Painting Practice***, 1993, 3rd edition, pp. 560–572).

While coatings do not produce ozone, many of the solvents and other components of coatings are ozone precursors—VOCs, which react with nitrogen oxides in the presence of sunlight and heat to form ozone. Coatings are not the only products that use VOCs. They come from many industries as well as cars. The original Clean Air Act did not require the regulation of VOC content in coatings, but EPA developed a model or control technique guidelines (CTG) that non-attainment states could (and many did) adopt or adapt to regulate VOC emissions from the coating of "miscellaneous metal parts and products," shop coating, in essence (SSPC, ***Steel Structures Painting Manual, Vol. 1, Good Painting Practice***, 1993, 3rd edition, pp. 560–572).

However, by 1990, some non-attainment states and localities, most notably, air quality districts in California, such as in Los Angeles's South Coast Air Quality Management District (SCAQMD) and San Francisco Bay's Bay Area Air Quality Management District (BAAQMD), were regulating not only coatings applied in shops, but also architectural and industrial maintenance (AIM) coatings applied to ships and stationary structures such as bridges. Similar to the EPA's CTGs, California developed model rules that its air quality districts could adopt or adapt. Other states such as Texas and New York also began to regulate AIM coatings for VOCs. By 1990, the U.S. had a patchwork of coating regulations, with limits for most industrial maintenance coatings ranging from 420 g/L to 540 g/L (*JPCL*, February 1991, pp. 55–116).

The 1990 Clean Air Act Amendments (CAAA) called for EPA to establish a national rule for VOCs in AIM coatings and marine coatings, among others. After a rulemaking and negotiating process that included much input from the public and industry, the EPA issued its rule in 1998, 40 CFR 59, National Volatile Organic Compound Emission Standards for Consumer and Commercial Products. The rule restricts VOC content in most industrial maintenance and marine antifouling coatings to 450 g/L, well above restriction in some states and districts, including those in California districts which use 250 g/L. State or local regulations can be equal to or more restrictive than federal rules. SCAQMD's 100 g/L is the tightest restriction on VOCs in AIM coatings (*JPCL*, October 2005, pp. 36–42).

The 1990 CAAA also called for the formation of Ozone Transport Commissions (OTC) to address the problem of ozone from one state drifting into the airspace of a bordering state. The New England and Mid-Atlantic states formed the first OTC, which developed model rules on VOC sources, including coatings. States within the OTC can adopt or adapt the model rules as each state deems necessary. Most OTC states (e.g., CT, DE, DC, ME, MD, NH, NJ, PA, NY, VA) have adopted the OTC rule's VOC level of 340 g/L for most industrial coatings (*JPCL*, January 2008, p. 65). Canada and Federal EPA are considering reductions to 340 g/L as well (*JPCL*, October 2009, pp. 22-23).

Many nations have signed the IMO treaty to ban organotin-containing anti-fouling coatings because organotins kill non-targeted marine species, not just the species that attach to ship hulls.
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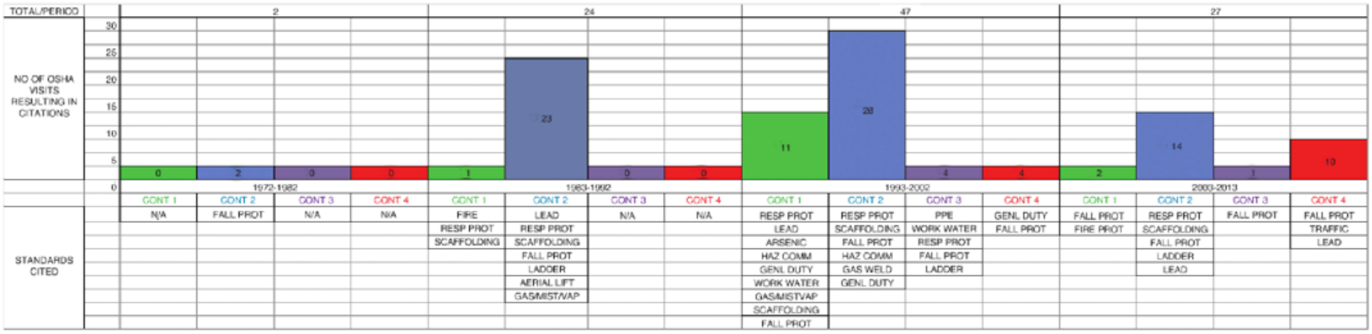
Anti-Fouling Coatings

Anti-fouling coatings, intended to prevent marine organisms from attaching themselves to a ship or other immersed structure, are regulated for the constituent that prevents fouling. Fouling increases shipping costs: It adds weight to a ship and the resultant rough surface increases drag, both of which increase the amount of fuel a ship needs (*JPCL*, June 2000, pp. 50–65).

Since the 1950s, organotins, especially the related compound, tributyltin (tbt), have been used successfully in coatings to prevent barnacles and other organisms from attaching to ship hulls. However, organotins also kill non-targeted marine species and have therefore come to the attention



ENFORCEMENT OVER TIME *by Alison B. Kaelin, CQA, ABKaelin, LLC*

A review of the OSHA Enforcement Website from 1972 to the present indicates how OSHA enforcement in the industrial painting (SIC code 1721) has evolved.

Four 1721 industrial contractors working in geographically diverse areas and construction types were selected. The OSHA enforcement website was searched under the company name during four time periods (1972–1982, 1983–1992, 1993–2002, 2003–Present). The citation history was reviewed, and the results are summarized in the graph. Where possible, the type of citation is identified.

In general, the inspection type (or trigger) broke down into five areas. Approximately 25% were planned or program related; 25% were complaint driven; 25% were referral based (likely resulting from NEP targeting); 15% non-program related (random); and 10% were the result of accidents.

Nearly every inspection/citation issued from 2000 to present was linked to a National or Local Emphasis program (N/LEP). N/LEPs listed include lead, silica, falls, bridges, construction, and small business, among others.

of governments around the world (*JPCL*, June 2000, pp. 50–65).

The U.S. Navy put a moratorium on the use of organotin-containing anti-foulings in the mid-1980s, with some exceptions (*JPCL*, April 1986, p. 19, and *JPCL*, March 1987, p. 25). Subsequently, the U.S. Organotin Anti-Fouling Paint Control Act of 1988 (33 USC Chpt 37) prohibited the use of organotin-containing coatings on ships less than 25 meters long; limited the leaching rate of anti-fouling paints on vessels; and banned, with some exceptions, the sale, purchase, and application of anti-fouling paint containing organotins in the U.S. The Act was prepared for a June 10, 2009, meeting of the House of Representatives' Subcommittee on Coast Guard and Maritime Transportation Staff. The Subcommittee heard testimony on anti-fouling systems and considered the International Convention on the Control of Harmful Anti-fouling Systems on Ships. Adopted in 2001 by the International Maritime Organization (IMO), of which the U.S. is a member, the Convention is a treaty that calls for its signatories to ban the new application of organotin-containing anti-fouling paints and to require removal or overcoating of existing organotin-based anti-foulings (*JPCL*, February 2008, pp. 48–52). As of 2013, the U.S. Congress had still not ratified the treaty.

Protecting Coating Workers from Specific and General Hazards

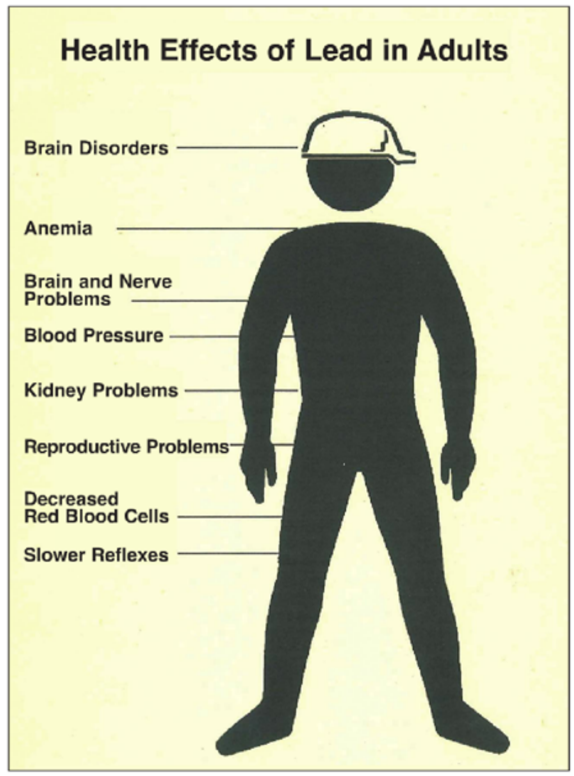
Protecting Workers from Exposure to Lead and Other Toxic Metals

In 1993, OSHA issued a comprehensive standard, 29 CFR 1926.62, Interim Final Rule—Lead Exposure in Construction (JPCL, July 1993, pp. 46–51). This regulation brought sweeping changes to the high-performance coating industry through its requirements for engineering controls (i.e., ventilation in conjunction with containment), work practices, respiratory protection, training, and medical and worker exposure monitoring.

OSHA issued subsequent comprehensive standards regulating other heavy metals, including cadmium, 1926.1127; arsenic, 1926.1118; and hexavalent chromium, 1926.1116 (*JPCL*, April 2008, p. 12). OSHA also issued a National Emphasis Program—Hexavalent Chromium in February 2010.

The Lead Exposure in Construction standard has continuously been augmented by NEPs initiated in 2001 and again in 2008 (*JPCL*, May 2009 pp. 66–69). In the 2008 NEP, the reported blood lead level established for triggering an OSHA inspection was lowered from 40 µg/dL to 25 µg/dL. In 2012, it was further reduced to 10 µg/dL. Similarly, in 2012, the CDC reduced and redefined elevated blood lead level for children to less than 5 µg/dL. Studies by EPA and the U.S. Department of Health and Human Services have concluded that there are adverse health effects in adults and children at exposures as low as between 5 and 10 µg/dL.

In 2011, the California Department of Health/Occupational Lead Poisoning Prevention Program (OLPPP) is considering revision of its lead standard (see *JPCL*, May 2013, pp. 44-61).



Health effects of lead in adults
Source: U.S. EPA, **Air Quality Criteria for Lead,** *as reprinted in OSHA's guide,* **Working with Lead in the Contruction Industry**

Protecting Workers from Hazards of the Trade

Coating materials themselves and their application also put painters at risk. Organic solvents can harm the central nervous system. They and other chemical compounds used in painting and surface preparation can affect the respiratory system or travel into the blood stream and damage internal organs (*JPCL*, April 1992, pp. 46–54).

Typical routes of exposure for most materials used in surface preparation and painting are inhalation; ingestion; and, in some cases, skin absorption. For protection against inhalation exposures, OSHA's standard for construction workers is 29 CFR 1910.134, on Respiratory Protection. Originally, 29 CFR 1910.134 was adopted in 1971 for general industry, as was the original construction industry standard for respiratory protection, 29 CFR 1926.103. In 1998, OSHA overhauled 29 CFR 1910.134 and applied it to general industry, construction, shipyard, longshoring, and marine terminal workplaces (*JPCL*, March 1998, pp. 65–80). Updates included procedures for selecting respirators; medical evaluations and training of employees required to use respirators; fit testing procedures; procedures for cleaning and maintenance of respirators; training for employees in respiratory hazards as well as in the proper use of respirators; and development of a respiratory protection program, with an assigned administrator to evaluate effectiveness.

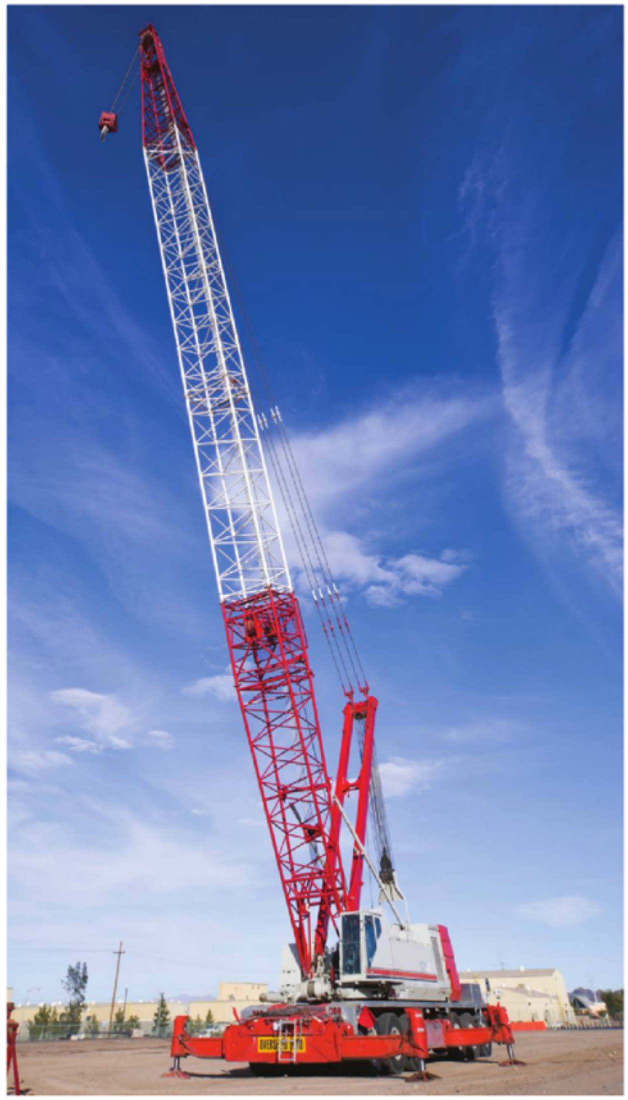
The respiratory protection standard was revised again in 2006, with the Final Rule for Assigned Protection Factors (APFs) for respirators, which eliminated inconsistencies for APFs found in various OSHA standards, and it standardized APFs by type of respirator. An April 2009 OSHA guidance document, *Assigned Protection Factors (APF) for the Revised Respiratory Protection Standard*, summarized the 2006 revisions.

Different surface preparation and painting processes create other hazards. Water jetting, when misdirected, can amputate a worker's limb or otherwise severely injure a worker. Particles from painting or blasting can rebound into unprotected workers' eyes or other parts of the face. Equipment that powers abrasive blasting can exceed acceptable noise levels and can damage workers' hearing. Chemical stripping with materials that contain methylene chloride can put workers at increased risk of cancer; damage to the heart, liver, central nervous system; and skin or eye irritation.

OSHA's 29 1926.28 (a) states: "The employer is responsible for requiring the wearing of appropriate personal protective equipment in all operations where there is an exposure to hazardous conditions or where this part indicates the need for using such equipment to reduce the hazards to the employees." The standard refers the user to subpart E for standards on Personal Protective Equipment (PPE). In 1926.95, OSHA requires employers to provide protective gear for workers, generally at no cost.

Other relevant construction industry standards in subpart E are 29 CFR 1926.96, Occupational Foot Protection; 29 CFR 1926.100, Head Protection; 29 CFR 1926.101, Hearing Protection; 29 CFR 1926.102, Eye and Face Protection. A construction standard for controlling exposures to methylene chloride (29 CFR 1926.1152) was introduced in 1997.

Many of the above standards have been updated as part of OSHA's ongoing Standards Improvement Project to identify and revise confusing, outdated, and duplicative language in its standards and to update references to ANSI, NFPA, and other industry standards.



OSHA's 2010 standard on cranes and derricks in contruction addresses four main causes of worker deaths and fatalities associated with using the equipment. iStock

Protecting Painters and Blasters in Shipyard Operations

Protection of coating crews and all other workers performing ship repair, ship building, and related operations at shipyards is regulated under the Agency's Maritime or Shipyard Standards, in particular, 29 CFR 1915, Occupational Safety and Health Standards for Shipyard Employment, most recently revised in December 2008. In addition to provisions for scaffolding and staging, confined spaces, hand tools, and other operations or equipment that pose hazards at shipyards, 1915 has standards that apply specifically to cleaning and painting work. Subpart C on Surface Preparation and Preservation includes 1915.32, Toxic cleaning solvents; 1915.33, Chemical paint and preservative removers; 1915.34, Mechanical paint removers; 1915.35, Painting; and 1915.36, Flammable liquids.

Shipyard/Shipbreaking Safety

OSHA issued a NEP on Shipbreaking in 2000, updated it in March 2005, and subsequently replaced it in 2010. The 2010 version indicated inspections of shipbreaking operations will focus on 20 worker safety and health issues, including asbestos and lead exposure, polychlorinated biphenyls, confined spaces, heavy metals, powered industrial trucks, guarding of deck edges, oil/fuel removal and tank cleaning, hearing conservation, fire prevention, scaffolds, cutting and welding, and personal protective equipment.

In December 2006, OSHA issued the guidance document, *Abrasive Blasting Hazards in Shipyard Employment*, primarily on protection against air contaminants generated during blasting.

Several Shipyard personal protective equipment (PPE) standards were updated in 2009 by OSHA to reflect consensus standards. Affected shipyard PPE standards included standards for eye and face protection, head protection, and foot protection.

In 2010, OSHA issued compliance directive CPL 02-01-049, 29 CFR Part 1915, Subpart I, Enforcement Guidance for Personal Protective Equipment (PPE) in Shipyard Employment.

In May 2011, OSHA issued compliance directive CPL- 2-01-051, 29 CFR Part 1915, Subpart B, Confined and Enclosed Spaces and Other

Dangerous Atmospheres in Shipyard Employment.

In June 2013, OSHA issued a document titled, "Ventilation in Shipyard Employment" which provides information on ventilation related to flammable materials, confined spaces and hot work.

Other Construction Hazards in Coating Operations

OSHA continues to revise other standards related to construction safety. OSHA's comprehensive revision to the Fall Protection Standards (29 CFR 1926 Subpart M—Fall Protection) in 1994 eliminated the use of body belts and expanded the scope of the standard. Revisions to the Scaffolding Standards (29 CFR 1926 Subpart L—Scaffolds) in 1996 resulted in new training requirements for scaffold users, erectors, and designers. Because many containment systems utilize suspended platforms, this standard governs their design, erection, maintenance, and use.

In 2002, OSHA updated 1926.201, Signs, Signals, and Barricades, to require that all traffic control signs or devices used for protection of construction workers comply with the FHWA *Manual on Uniform Traffic Control Devices* (MUTCD).

In November 2007, OSHA issued a proposed rule "Confined Spaces in Construction." Because of substantial comments from industries and organizations, OSHA extended the comment period through most of 2008. OSHA's July 2013 regulatory agenda indicates that final rulemaking was expected to occur in December 2013.

Cranes and Derricks in Construction

In 2010, OSHA released a final standard, addressing the use of cranes and derricks in construction. This standard replaced a 1971 standard. The rule became effective on November 8, 2010, though certain provisions have delayed effective dates ranging from 1 to 4 years.

This new standard addressed control of four main causes of worker death and injury related to cranes and derricks on construction worksites, including electrocution, being crushed by parts of the equipment, being struck by the equipment/load, and falls. Key requirements of the new rule focus on the following.

- Pre-erection inspection of tower crane parts and assessment of ground conditions
- Qualification and certification of operators of most types of cranes under one of 4 options: a certificate from an accredited crane operator testing organization; qualification from the employer through an audited employer program; qualification by the U.S. Military and licensing by a state or local government (if the program meets the minimum requirements set forth by this standard)
- Employers working under city or state operator requirements are to be in full compliance by November 8, 2010. Otherwise, employers have until November 2014 to ensure that their operators are qualified or certified.
- Employers must pay for certification or qualification of their currently uncertified or unqualified operators.
- There are no training requirements; however, operators must successfully complete both a written examination that includes the safe operating procedures for the particular type of equipment the operator will be using and technical understanding of the subject matter criteria required in 1926.1427(j), and a practical exam showing the applicant has the skills needed to safely operate the equipment, including the ability to properly use load chart information and recognize items required in the shift inspection.
- The certification requirements in the final rule are designed to work in conjunction with state and local laws.
- Employers must comply with local and state operator licensing requirements which meet the minimum criteria specified in 29 CFR 1926.1427.
- Employers must use a qualified rigger for rigging operations during assembly/disassembly.
- Procedures for working in the vicinity of power lines.

The March 2012 revision of the hazard communication standard provided sweeping revisions related to labeling, signs, safety data sheets and hazard classification that will be phased in through 2016 (See *JPCL*, August 2012, pp. 14-23).

Isocyanates

In the 1990s–early 2000s, we began recognizing that some polyurethane and polyurea coatings may contain diisocyanates, which can result in some adverse health effects if workers are not properly protected.

The most commonly used diisocyanates include methylenebis (phenyl isocyanate) (MDI), toluene diisocyanate (TDI), and hexamethylene diisocyanate (HDI).

Isocyanates are irritants to the mucous membranes of the eyes, nose, and throat, and to the gastrointestinal and respiratory tracts; they also can be allergic sensitizers. SSPC issued Technology Update No. 8, "The Use of Isocyanate-Containing Paints as Industrial Maintenance Coatings," in February 2001 (*JPCL*, April 2001, p. 3). *JPCL* published two additional articles related to isocyanates in 2001: on "Monitoring Airborne Isocyanate and Solvent Concentrations during a Bridge Painting Project" (*JPCL*, June 2001, pp. 57-61) and "Polyurea Spray Coatings: An Introduction" (*JPCL* September 2001, pp. 48-52).

On June 20, 2013, OSHA issued a National Emphasis Program—Occupational Exposure to Isocyanates (CPL-03-00-017). The NEP identifies 1721, Painting and Paper Hanging as a target for inspection. The NEP focuses on engineering controls, administrative and work practice controls, and personal protection equipment (PPE) as methods for reducing hazards. It introduces use of a colormetric wipe as a tool for determining adequacy of housekeeping and PPE.

Conclusion

The above discussion is far from comprehensive, but it does identify some of the key environmental, safety, and health issues that have figured prominently in the protective coatings industry over the past 30 years. Much more information is available. For example, all OSHA documents are available at www.osha.org. EPA documents are available at www.epa.gov. Documents from NIOSH are available at www.cdc.gov/niosh. For SSPC publications, visit www.sspc.org. For issues of *JPCL* from 1995 to the present, go to www.paintsquare.com.

Alison B. Kaelin, CQA, has more than 25 years of public health, environmental, transportation, and construction management experience in the coatings industry.

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Kaelin is a certified quality auditor and NACE-certified coating inspector. She was a 2012 *JPCL* Top Thinker, a 2012 *JPCL* Editor's Award Winner, and an SSPC Technical Achievement Award winner in 2005. JPCL

What's Trending Now in Personal Protective Equipment?

By Anita M. Socci, Managing Editor, JPCL

This article will briefly describe some of the trends in health and safety equipment, specifically, respiratory protection, protective eyewear, gas monitoring, and fall protection equipment that have been covered in *JPCL* and *PaintSquare News* over the last five years.

Respirators and Accessories

OSHA regulations promulgated in 1993 brought forth sweeping changes in the coatings industry in regard to respirator use and worker protection. Since then, respirators and associated components offer many options in the way of size, ease of use, multipurpose configurations, ergonomics, and worker comfort.

In response to OSHA's mandatory fit testing rules for respirators, equipment manufacturers are developing adjustable masks, adhesive tapes, and removable and washable padding that will improve the fit of the masks to accommodate differences in facial features and prevent leakage between the face and the respirator.

Components that make up an entire blasting assembly are being made to reduce worker downtime experienced when switching out pieces. For example, some blasting hoods now have lenses made with pull-off tabs so that a worker can tear off one lens when it becomes abraded, eliminating the need to stop and change out lenses.

Protective Eyewear

OSHA, NIOSH, and ANSI all have issued standards for eye, head, and face protection, and manufacturers have responded by making compliant products suited for different tasks and exposures.

Trends in protective eyewear include goggles with built-in microphone systems for hands-free communication. The industry also has seen the introduction of combination safety goggles/glasses with a respirator mask. New designs feature bendable temples and nosepieces to allow for easy adjusting, and lens options include special tinting and coatings to guard against scratches and fogging.

Multi-Gas Monitoring Units

Gas monitors offer personal and/or confined space/hazardous environment monitoring and detection of combustible and toxic gas concentrations that can be harmful to workers. Many detectors available today use infrared technology for gas detection. Sophisticated optical designs currently being used are factory calibrated and are virtually maintenance free.

PSN reviewed units that can detect up to six gases simultaneously; have field-replace-able sensors; long-life batteries; and the ability to transmit sensor data for use in computer-based monitoring.

Fall Protection Equipment

Trends in fall protection equipment seem to be centered on ease of use, the ability to replace components in the field, worker mobility, and fall arrest and fall restraint protection for more than one worker simultaneously.

Temporary fall protection railings can clamp directly onto parapet walls and slab floors, eliminating the need for labor-intensive stick-built wood railings that must be drilled into floors. Vertical platforms are available with safety features that include controlled descent fail-safes to lower platforms to the ground in the event of a loss of power.

There's an App for Safety, Too

Technology is helping personnel who work outdoors stay safe in the heat. Available for download to mobile devices, applications will allow personnel to calculate the heat index on a particular jobsite. Risk levels are displayed and protective measures are given. Manufacturers also have developed add-ons to existing equipment to provide UV protection for workers who are exposed to the sun.

Another application uses visual and audio signals to make it easier for workers using extension ladders to check the angle that the ladder is positioned, as well as access useful tips for using extension ladders safely.

The Next Step for PPE

There's no doubt that worker protection will always be a prominent issue in the industry. PPE development has been driven by developing technologies and changing regulations and standards on protecting personnel who perform jobs in hazardous environments and work at heights or in enclosed spaces. The development of smartphone and computer applications will deliver tips and instructions instantly and bring training to a more personal level.

Paint & Coatings—Where Are We Now?

By Brian Goldie, Technical Editor, JPCL

As with other topics in this special section, coatings developments have been covered in *JPCL* regularly since 1985. The last main review was in the 25th Anniversary issue (August 2009), where Michael Donkin summed up the changes in coating formulation for the heavy-duty protective market since *JPCL* started. He discussed the drivers for change over that time and how they had led to the introduction of new technologies. The present article will summarize Donkin's findings and then look at key developments for the protective and marine coatings since 2009. This article is not claimed to be comprehensive, but is instead a guide to some of the main continuing trends and innovations.

The 25-Year Review

Donkin's August 2009 article discussed changes in coatings formulation over 25 years and the key drivers for change. Drivers included increasing levels of legislation relating to protection of the environment from air pollution by reducing the emissions of volatile organic compounds (VOCs) from coatings, and the need to reduce the use of raw materials that can pose risks to worker health and safety and to the environment. In addition, there were higher customer expectations of performance and the need to increase the lifetime of assets while reducing life cycle costs.

In the 1980s, there were very few VOC regulations for coatings, but by the 1990s, a revision of the U.S. Clean Air Act resulted in national VOC rules, which have been getting stricter. There are also regional, state, and local VOC regulations in the U.S. In Europe, the EU solvent emissions directive was issued in 1999, but it wasn't until 2005 that the first restrictions on release of VOCs started to apply. These regulations meant the virtual end of thermoplastic coatings (vinyls and chlorinated rubbers) because their very high VOC levels would never meet the regulations. Two-pack materials such as epoxies and polyurethanes became the resins of choice, but it was (and still is) a challenge for formulators to maintain the high performance obtainable with these systems while reducing the level of solvent used and the resultant VOC emissions. Increasing the volume solids of the coating would reduce the VOC content, but this is not easy to do without affecting application, drying, and other properties of the coating, particularly if very high solids levels are needed. Alternative resins and curing agents are needed to achieve these very high solids and/or more sophisticated application equipment to apply them due to high viscosities. An alternative technology was waterborne coatings, which could be formulated with very low VOC levels. Going back 25 years, waterborne technology was limited to single-pack emulsions, principally for interior use and typically not suitable for heavy-duty because of slow drying, poor film properties, and adhesion when applied in the field. Donkin did point out that over 25 years, two-component waterborne systems, such as epoxies and polyurethanes, have been developed with performances close to their solvent-borne counterparts .

Raw materials identified as harmful to operators and the environment in the 25-year review included lead and hexavalent chromate pigments, coal tars, and some plasticizers for acrylic emulsions. Currently, lead anticorrosion pigments are not used; chromate anticorrosion pigments have very limited use (mainly in etch primers) in the protective coatings area; and the use of APEO plasticizers (alkyl phenolethoxylate) is very restricted. There were periodic concerns about health risks from isocyanates in coatings, but, in general, the industry knows how to handle these risks safely. In Europe, the REACH regulations began causing an area of uncertainty among formulators about what materials may disappear from the market because of toxicity, or, more probably, the cost effectiveness of screening these materials, which are often produced (and used) in small quantities.

Key Changes Since 2009

The drivers for development identified in the August *JPCL*'s 25-year review are still valid, so what major coating developments have occurred since then?

High-Solids vs Waterborne Coatings

So far, there has not been a dominant technology to meet the current environmental regulations. A good barometer of coating development is to look at the (new) raw materials being promoted at trade shows. The European Coatings Show is the largest and most important exhibition for the paint industry. At the 2011 event, the main trends were an increased emphasis on waterborne systems, rather than high solids, as a means of meeting the VOC requirements, and more attention to smart, or functional, coatings.

However, this trend has not yet transferred to the protective or marine maintenance coating mar-

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kets, where use of waterborne coatings is relatively low, still due mainly to film forming and drying problems in the field, as well as higher costs compared to traditional solvent-borne coatings. As a means of reducing VOCs, higher solids and solvent-free coatings have been making more inroads. This is due essentially to developments in curing agent technology giving faster cure times, and, to a certain extent, to improved application equipment with better control on component mixing ratios of these two-pack systems.

Waterborne Coatings

The introduction of waterborne coatings has been limited essentially to two market areas: coatings for internal use or very low and now moderate corrosivity areas, and sealants and coatings for concrete.

As metal coatings, low-VOC, two-component waterborne polyurethanes have been developed as primers and direct-to-metal systems for components for light industrial projects. For concrete and masonry applications, acrylic systems are popular as topcoat/sealers to give good weather and chemical resistance.

Waterborne epoxies have also been developed as concrete coatings, particularly for coating moisture-sensitive concrete (flooring). Systems have been developed as sealers and primers that can also be applied over green concrete and that have good adhesion without the need for a profile. Waterborne epoxy floor topcoats are also available, including antistatic versions.

High-Solids Coatings

Conventional solvent-borne coatings have volume solids contents of around 50–60%. High-solids coatings can be divided into solvent-free systems (100% solids) and those solvent-borne systems with higher solids than the traditional coatings. In this summary, high-solids coatings are defined as those with volume solids greater than 70%.

100% Solids Coatings

Developments in solvent-free systems include pure aliphatic polyurea topcoats for increased UV protection and good gloss and color retention, and flexible polyurethane systems with good waterproofing properties for concrete floors, particularly in multi-story car parks exposed to aggressive environmental conditions.

However, the most common 100% solids systems have been based on epoxy technology. Good adhesion to steel and concrete, together with improved chemical and abrasion resistance compared to the traditional solids content coatings, can be achieved with these systems.

Higher-Solids Coatings

The higher-solids protective coatings are generally based on polysiloxane resins and polyureas. High-gloss topcoats for steel, with good durability and corrosion protection as well as fast cure have been developed based on modified polysiloxanes. An even more environmentally friendly type of system, an isocyanate-free single-component acrylic-siloxane, features good abrasion and a low VOC.

Aliphatic polyurea and polyaspartic resin systems also feature fast cure and high gloss for concrete floors and for medium corrosivity steelwork protection.

High-solids epoxies with a range of curing agents, including phenalkamines, are used for immersion and atmospheric protection of steelwork and concrete floors.

Conventional Coatings

Although the trend is for higher-solids (or waterborne) coatings to meet the VOC regulations, there have also been developments in the traditional solvent-borne coatings, although volume solids have increased to nearer the 60-70% level. Again, urethanes and epoxies dominate the developments, with acrylic urethane finishes giving high durability protection to the structural steel of bridges, storage tanks, and other structures, and polyurethanes providing heavy-duty concrete floor coatings. The aggressive demands of the offshore industry are being met with high-performance zinc-rich epoxy and conventionally pigmented epoxy primers.

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Specialty Coatings

Intumescent Coatings

Fire protection has become an important subject for many raw material suppliers, as observed at the European coatings shows in 2011 and 2013, and for paint companies. For cellulosic fires, 120 minutes of protection are being provided by one-component, solvent-borne, acrylic intumescent coatings, with some systems that can be applied under shop conditions or onsite.

Marine Coatings

As with protective coatings, there have been changes in marine coating over the past 30 years. The 25-year review identified the key developments that had occurred up until 2009. These mainly involved hull coatings, resulting in two alternative high-performance antifouling technologies: tin-free polishing coatings (copper-containing), and low-energy, foul-release coatings (silicon and fluoropolymers).

Since 2009, very little has occurred, but various paint manufacturers have been making incremental changes to their products to establish differentiation among them and have been partnering with third-parties in an attempt to develop a methodology for measuring and validating claims about potential fuel savings.

However, a copper-free, high-performance antifouling has become available that is based on self-polishing binder technology and is aimed specially at keeping underwater hulls clean from fouling while vessels are stationary in seawater.

The other major concern in the shipbuilding industry has been the corrosion of seawater bal-


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last tanks and the establishment of the IMO's Performance Standard for Ballast tank coatings. The IMO requirements were essentially "copied" for a regulation describing a performance standard for cargo oil tanks. This regulation has provoked some concern about the testing of (new) coatings to meet the standard.

Polysiloxanes, which are showing increased usage in the protective coatings sector, are also starting to appear in marine coatings, with durable, aesthetic topcoats that are easy to clean and maintain, thus saving on costs

The Future

What does the future hold for protective and marine coatings? Health & safety and environmental regulations will still drive coatings development. It is most likely that the VOC restrictions will get even more restrictive. We do not know what technologies will become more dominant: waterborne or high-solids. Various industry forecasts predict strong growth in waterborne systems, and going by the products exhibited this year at the European Coatings show, the resin suppliers are all active in this area. However, when I talk to the formulating chemists in the protective coating manufacturers, they all agree that for the next 10 to 20 years, 80% of the heavy-duty and marine coatings will be solvent-borne, albeit with higher volume solids than currently.

The use of other toxic or hazardous raw materials will be banned and more environmentally sustainable raw materials will become available.

With a great deal of research being carried out in nanotechnology for coatings, it is expected that we will see new "smart" or functional coatings coming to the market. Already, we have had demonstrations of what this technology can deliver, and market acceptance should follow once new formulations have been demonstrated in the field and production methods have been scaled-up.

Performance Continues To Be Focus of SSPC Coating Standards

By the* JPCL *Staff

The earliest SSPC Paint and Paint System (PS) standards were formulation-based. As long as a company's Coating X had the right ingredients in the right proportion, it met the SSPC standard for Coating X (generic). But as new coatings were developed to meet new needs, especially regulatory requirements, performance of the new coatings to meet or exceed the ones they replaced became critical. In response, SSPC committees began developing Paint and PS standards focused on performance, but with composition requirements included or referenced.

Seven new and revised performance-based standards have been issued since 2009. SSPC provided the information below. For more information, go to sspc.org.

Coating Standards

In March 2013, SSPC revised SSPC-Paint 23, Latex Primer for Steel Surfaces, Performance-Based. Intended for coating manufacturers and specifiers, the revision has removed nearly all formulation requirements from the 1982 version, as well as requirements for wet adhesion testing, coalescence testing, wet abrasion resistance testing, and mildew resistance testing.

Requirements for dry adhesion testing have been added. In addition, the 2013 revision references cyclic corrosion cabinet testing per ASTM D 5894 (3024 hours) in place of salt fog exposure per ASTM B 117 (300 hours).

Humidity resistance testing has been retained in the 2013 version, but now references ASTM D 4585 (condensation on coated side of panel only) rather than ASTM D 2247 (condensation on both sides of panel). The number of hours of testing remains the same, but the permissible amount of blistering, evaluated in accordance with ASTM D 714, has been reduced from “8F” to “No blisters.”

SSPC-Paint 38, Single-Component Moisture-Cure Weatherable Aliphatic Polyurethane Topcoat, Performance-Based, was revised in March 2012. Substantive revisions include changing requirements for package stability to requirements for storage stability, and changing the intercoat adhesion requirement from 600 psi to a requirement that the minimum intercoat adhesion meet or exceed the cohesive strength of the coating. Editorial revisions update references to standards issued by other organizations, and improve overall organization of the standard.

SSPC- Paint 42, Epoxy Polyamide/Polyamidoamine Primer, Performance-Based, issued in July 2010, contains performance requirements for two-component epoxy primers used on blast-cleaned steel. It includes requirements for flexibility, direct impact resistance, chemical resistance, and humidity resistance as well as for rusting, blistering, and scribe undercutting after exposure in a cyclic salt fog/UV exposure test cabinet. The standard gives owners and specifiers evaluation criteria that can be used to define requirements of an epoxy primer coating submitted for inclusion in a Project Specification and/or an owner's Qualified Product List.

SSPC-Paint 43, Direct-to-Metal Aliphatic Polyurea Coating, Performance-Based, was completed in March 2012 and published in July 2012. This standard defines performance requirements of a coating for light and medium service in industrial and marine applications that require rapid throughput of shop-coated work as well as touch-up capabilities in the field. The standard calls for the coating to be applied to a steel substrate blasted in accordance with SSPC-SP 10/NACE No. 2, Near White Blast Cleaning. The resins in the coating are to be a polyamine and a polyisocyanate that react to form an aliphatic polyurea. The coating is designed to be applied at thicknesses of 6 to 9 mils.

SSPC-Paint 44, Coatings for Concrete Wastewater Structures, issued in July 2013,

continued on p. 25

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establishes minimum performance standards for coatings used over concrete in municipal wastewater facilities, based on categories of service environments and structures within the facility. The specifier identifies the structure to be coated, then determines the performance requirements for coatings for the structure's service environment based on a table included in the standard. An example of language that could be used to specify coating requirements from the standard is provided in the non-mandatory notes.

Recent Coating System Standards

Coating system standards issued since 2009 include SSPC-PS 28.01, Two-Coat Zinc-Rich Polyurethane Primer/Aliphatic Polyurea Topcoat System, Performance-Based, from April 2009, and SSPC-PS 28.02, Three-Coat Moisture-Cured Polyurethane Coating System, Performance-Based, from June 2010.

SSPC-PS 28.01 contains performance requirements for a coating system for steel substrates that consists of a corrosion-resistant, zinc-rich moisture-cure polyurethane primer meeting SSPC-Paint 40 and an aliphatic polyurea topcoat with high color and gloss retention meeting SSPC-Paint 39. The system is generally suitable for exposures in SSPC Environmental Zones 1A (interior, normally dry), 1B (exterior, normally dry), 2A (frequently wet by fresh water, excluding immersion), 2B (frequently wet by saltwater, excluding immersion), 3B (chemical exposure, neutral), and 3C (chemical exposure, alkaline). The standard is intended for specifiers, coating manufacturers, and end users.

SSPC-PS 28.02 contains performance requirements for a coating system applied to steel substrates. The system is comprised of a zinc-rich moisture-cured polyurethane primer complying with SSPC-Paint 40; a moisture-cured polyurethane intermediate coat complying with SSPC-Paint 41; and a moisture-cured aliphatic polyurethane topcoat complying with SSPC-Paint 38. Performance requirements for PS 28.02 include minimum adhesion criteria for each coat as well as minimum requirements for rust, blister, and scribe evaluation of the three-coat system. PS 28.02 also gives requirements for three performance levels based on the color and gloss retention of the topcoat.

Industry groups expected to benefit from the standard are transportation departments, water treatment operators, and operators of general industrial plants (e.g., refineries) who have coating projects in high humidity environments. It can also be used in cool-weather environments. This standard may be used to define the requirements of a coating system submitted for inclusion in project specifications and/or Qualified Product Lists. JPCL

It's All Relative–
Advances in Environmental Controls for Coating Work

By Robert Ikenberry,
California Engineering
Contractors Inc.

Painting projects use environmental controls for several purposes, including the following:

1. Containment to enclose hazardous operations like lead abatement, protecting the environment outside the work zone;
2. Containment for ventilation to provide conditions conducive to proper surface preparation, safe working conditions, and paint curing. Often combined with #1 above; and
3. Containment and ventilation with humidity and/or temperature control to retain the blasted surface until the entire space (or at least a larger portion) can be coated monolithically, and/or to allow for proper cure of reactive coatings and for worker comfort and productivity. Always combined with #2 above and often #1 as well.

The items above are not the only reasons for, or benefits of, using environmental controls. Ventilation may be required to control both flammable and toxic concentrations of solvent evaporating from high performance coatings. In extreme weather (both hot and cold), local environmental controls to the workers' headspace may be necessary for productivity and even safety.

Attention to controlling workspace environments has increased over the decades, driven by factors such as regulations, specifications, and the focus on quality. This article focuses on key equipment and practices for controlling the environment, as well as some advances in them over the past three decades.

Back in the Day

I remember my first experience with "environmental controls." It was the mid-1970s, and we had a contract to blast and paint a highway overpass on a busy freeway. (In retrospect, I'm sure the existing paint contained lead.) The steel girders extended in a sweeping curve past the active roadway as part of a complex interchange, and we could work on most of the span during the day. We wanted to put up some tarps to contain the painting operation so we wouldn't have overspray claims from paint landing on passing cars. (The San Francisco Bay Area is notoriously windy, and the paint system specified at the time was slow drying and a known overspray risk.)

The question then became: "Do we keep the tarps up while we blast?" As I recall, California had fairly recently introduced regulations limiting the amount of visible dust from outdoor abrasive blasting. Putting up containment would significantly reduce the total amount of dust in the air from blasting, but it would be coming from fewer (basically point source) locations at the ends of the containment. The regulations dealt with the obscuration of the visible dust plume (Ringlemann Scale visual test), and concentrating the dust cloud would mean we were more likely to get cited for too much (too dense a plume) dust. So we took the tarps down to blast! Regulations sometimes have unintended effects...but no containment was probably actually safer for our painters at the time. Our approach today would have to be very different.

Containment

With some exceptions, containment, in my experience, hasn't changed that much in the past 30 years, but its use has. The use of containment has often been driven by regulations for protecting the environment and the public from exposure to silica sand, as well as exposure to lead and other haz-

Environmental controls are used for many reasons, including making a jobsite suitable for painting and blasting in extreme conditions.
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ardous materials and debris. As more hazards are identified in coating and blasting materials, containment is more frequently specified. Also driving the use of containment are the need to avoid overspray, as in my first experience, and the need in many plant interiors to protect sensitive equipment, other plant workers, and products from blasting or painting debris.

My first use of it involved hanging tarps, a practice still done. There also have been, for quite some time, highly engineered containment systems, some built on sophisticated platforms for bridges and offshore structures, and others engineered for interior use. SSPC developed a guidance document for various levels of containment, SSPC-Guide 6 (CON), Guide for Containing Surface Preparation Debris Generated during Paint Removal Operations (first issued in 1992 as SSPC-Guide 6I, part of a supplement to SSPC's Volume 2, *Systems and Specifications*).[1] This document is well-known and used. Specifications for painting projects now often identify the level of containment based on Guide 6. In my experience, the application of containment has changed significantly—its use has increased over the years, not just in frequency, but higher levels of containment are now specified. Ventilation is generally needed, often including dust collection exhaust and controlled make-up air. Here is where heating and, sometimes, cooling or dehumidification, come into play. Designing and setting up the containment and its associated equipment are project-specific. It is always a balancing act with any containment, so that its use is safe for workers, the public, and the environment. We don't want to create a situation like the one in my first experience, where not using containment probably was safer for the workers, but at the expense of the unsuspecting public.

Understanding the Mechanics of Humidity: Dew Point, Water, and Vapor Pressure

Before I even start to talk about humidity and its control for blasting and coating work, I'd like to point out that in my experience, over the past 30 years, the humidity as well as its control and measurement has not been well understood. So I will try to explain the basics of the topic and its associated technology as well as note some changes in equipment and practice over the past 30 years.

For coatings, or comfort, it's usually not the total amount of water in the air (humidity) that matters; it's the Relative Humidity (RH) that's important. That is, RH is how much water is currently present in the air compared to how much water vapor the air can hold. When the air is fully saturated (100% RH), liquid begins to condense, making dew on surfaces (dew point) and even creating fog in the air. This amount of vapor capacity varies widely by temperature. At sea level, the amount of water in fully saturated air at freezing (32 F, 0 C) is about 27 grains per pound of dry air (4 grams of water per dry kilogram of air). At 75 F (24 C), it's about 131 grains (19 grams), and at 120 F (49 C), it's over 566 grains (80 grams). That's almost 20 times as much moisture capacity in really hot air! So one way to reduce RH is to heat the air. If you don't add any water, 100% saturated air at 32 F becomes much less than 10% RH when heated to 120 F. This may be an extreme case, but heating with indirect fired heaters is a very effective way to reduce RH.

Now let's focus on controlling the environment for coating work. The problem is that heating the air is a relatively ineffective way to heat the surface, and when we are talking about paint application and curing conditions, it's typically the conditions at the surface that are of interest. When we specify that temperatures need to be X degrees above the dew point, we mean the temperature at the surface of the steel.

A rule of thumb, then, is that RH changes by a factor of two for each 20-degree F change in temperature. In other words, if pressure and total moisture don't change, saturated air (100% RH) at 50 F, when heated to 70 F, would be around 50% RH; and further heating to 90 F would result in RH of approximately 25%. This same rule of thumb explains why, if you keep the dew point at least 20 degrees F below the steel temperature, you can generally hold your blast indefinitely. (You can hold the blast for days at least, probably weeks, if the air and steel are clean.) With a 20-degree F (11-degree C) dew point spread, RH at the steel surfaces will be about 50%, and corrosion (flash rusting) will be drastically reduced. To hold a blast, keep the surface of the steel 20 degrees F above the dew point.

For painting, two additional dew point considerations generally apply. To paint, you need to avoid condensation on the surface of the steel so that you don't paint wet surfaces. You also typically want to avoid dew (liquid water) condensing on the wet paint. Keeping the steel surface about 5 degrees F (3 degrees C) above the ambient air dew point assures that you avoid both of these undesirable conditions. (Dew won't condense on steel surfaces until they are at or below the dew point, but starting painting when there is a 5-degree F spread accounts for the inevitable variations in conditions from place to place or over short intervals of time. What you measured may not reflect the "worst case" conditions on the project.)

Dehumidification is somewhat analogous to creating a vacuum. You're trying to suck just one component out of the air—the water. With gases and solutions, the partial pressure (in this case, vapor pressure) can be considered a bit like actual pressure, say in a tank. Vapor pressure is just another way of expressing dew point temperature. Both are absolute measures of the water vapor in the air. When one changes, so does the other. The water vapor very much wants to equalize the "partial pressure" and will flow from areas of high vapor pressure to low vapor pressure with surprising rapidity. Consider first a transparent box, like a fish tank, with a removable divider down the middle. You might at a gut level consider the situation somewhat like filling one side of the tank with red colored water and the other side of the tank with clear water. Carefully remove the divider, and the color will mix into the other side, eventually making everything a uniform pink, but it will take a while (Fig. 1a).

Unfortunately, dehumidification is really more like taking our divided tank and, with our red air in one side, trying to vacuum out most of the air from the other side. If we have any significant containment leaks, it's as if we just started to remove the barrier… and wham! Instant pink air, all over the tank (Fig. 1b).

The air will impede the flow of the water vapor a little bit, but, remember, water molecules are actually smaller and lighter than nitrogen or oxygen molecules, so the flow of water vapor from areas of high moisture content to areas of low moisture content is a strong wind. It's difficult to restrict. This frantic desire by gasses to equalize pressures of all components, including RH (water vapor), is one reason most successful dehumidification applications are on tanks or vessels where there is already a solid mechanical barrier between inside and outside air, and the make-up vents are highly controllable. Humidity control is possible in a well-constructed, well-sealed containment, but unlike ventilation for lead dust control, where negative air pressure inside the space is desirable, for dehumidification you want to maintain a positive pressure inside the dried space. Therefore, sometimes these goals are in conflict.

Dehumidification: Types and Advances

The fundamental technology underlying desiccant dehumidifiers hasn't changed much in the past 30 or 40 years. Units that perform the same basic functions were available in the 1970s. In fact, my prior employer used a twin tower desiccant dehumidification system on our compressed air supply on a project in Hawaii in 1978. Conceptually the same as dehumidification for ventilation air, this

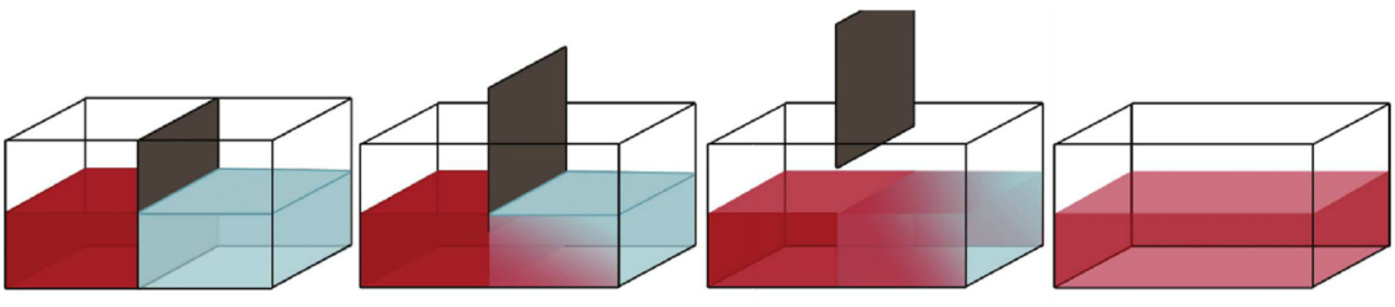

Fig 1a: We expect dehumidified areas (pale blue) and saturated areas (red) to mix like water in a fish tank—when you remove the divider, one color water slowly diffuses into the other.

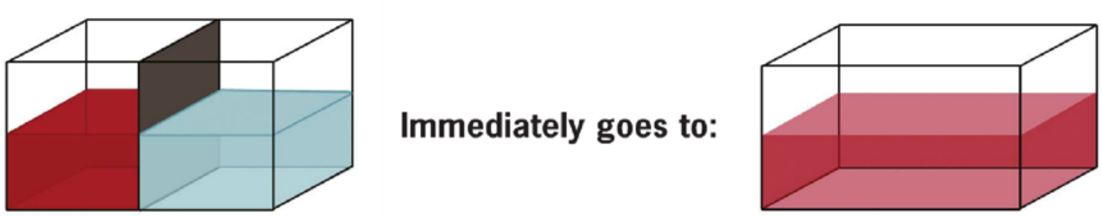

Fig 1b: In reality, it's more like one area has a vacuum (pale blue) and the other side has normal air pressure (red) …and when the divider is pulled away, the water instantly changes color. Graphics: Lisa Tseng

compressed air system provided -40 F dew point air for blasting.

There are two basic types of dehumidification equipment: desiccant and refrigeration. While the basic principles of operation haven't changed much, we will see that the need to increase energy efficiency and the electronic age have brought changes to dehumidification equipment.

Desiccant dehumidifiers generally use a large wheel containing a desiccant material, which can absorb moisture from the air. Most of the wheel is exposed to the incoming air to be dried. A smaller portion of the wheel (±25%) is subjected to a reverse flow of heated air, which dries out and reactivates the desiccant. By slowly rotating the wheel, the dehumidifier can operate continuously. Residual heat in the wheel after reactivation tends to heat the dried air going into your space.

The latest technology uses a small portion of the wheel to create a pre-heat/post-cool energy capture loop to reduce the energy demand of reactivation. This pre-heats the drying section of the wheel as it rotates into the purge area and cools the desiccant before it enters the process section, so the dry air coming out of the unit isn't heated as much, and more heat stays to reactivate the desiccant.

The other technology for dehumidification uses refrigeration dehumidifying units, or, more accurately, condensation dehumidifying units. Refrigeration dehumidifiers seem (to me) to operate a bit counter-intuitively. In order to dry the air, they cool it, driving up the RH. In fact, to work, they have to keep cooling the air until it exceeds 100% RH, or total saturation. At that point, the excess moisture collects on the cooling coils as condensation. After the condensed water runs off the coils, the air exiting the condensing section of a refrigeration dehumidifier is always saturated, or at 100% RH. Most units use electric heaters on the air exiting the condenser section to raise the temperature and lower RH. Since compressors on refrigeration units generate a lot of excess heat, some units use this heat to warm the cool air coming from the condensing section, saving energy over those that only use electric heat. Note this reheating does not change the dew point, which depends solely on the total amount of water vapor, but it does lower the RH of the discharged air.

The theoretical limit for refrigeration dehumidification would be an exit dew point of 32 F. When refrigeration DH units get close to a 32 F dew point, ice builds up on the cooling coils, so a realistic lower limit for drying air using a refrigeration dehumidifier is about 40 F dew point air.[2] If ambient temperatures are above 60 F all day, this provides the minimum 20-degree F dew point spread you need to hold your blast. Where there are large swings in temperature, such as the San Francisco Bay area, this can be problematic. With a 70 F daytime high temperature followed by a 50 F nighttime low, using a refrigeration dehumidifier under those nighttime conditions might result in a dew point spread of only 10 degrees F or less. This is not enough to ensure that flash rusting cannot occur, and you may come in the following morning to find that your blast has turned. Also be aware that steel surfaces exposed to clear nighttime skies can cool below the ambient temperatures due to the heat-sucking characteristics of the cold sky.

For both types of DH units, the major cost of operation is energy. Anything that reduces the total amount of energy required to remove a fixed quantity of water from the air is a plus. Recent technology advances focus on lowering the total energy costs of operation. Units described above scavenge heat that was previously wasted, improving the efficiency of current units. Advances in electronic controls and data sensing can also come into play. Using sensors that detect the temperature of the reactivation air exiting the desiccant wheel, current units can be set to adjust their operational cycles to turn off their reactivation heaters when not needed, the equivalent of cycling your air conditioner compressor. This avoids the cost of over-processing the air, or running the compressor section or reactivation heaters when they aren't required.

In some equipment, combined-cycle DH units may use both principles in a single unit, particularly where ambient temperature and humidity are both high, and lots of water has to be removed. While industrial applications don't generally recycle the air inside the conditioned space and therefore may not see as much savings, a study published in 2006 by the Florida Solar Energy Center testing a hybrid refrigeration/desiccant dehumidification system found that it used only about 25% as much energy as a refrigeration unit alone.[3] Incorporating a special blend of desiccants, these combination units first cool the air using typical refrigeration/condensation and then send the saturated, cool air through a desiccant. Since the RH at this point is high, it's relatively (no pun intended) easy for the desiccant to grab a substantial portion of the water. The waste heat from the refrigeration compressor is then used to regenerate the desiccant wheel, resulting in much greater efficiency.

Another of the recent high-tech advances for field industrial humidity control is remote sensors that can be placed in the conditioned space. They report continuously and wirelessly back to the dehumidifier and to the web. These monitors can provide two advantages.

- By continuously monitoring conditions in the space, they can act as a hygrostat (humidistat) to efficiently control the DH units and to alert the contractor when there is a problem like a generator running out of fuel and shutting down.
- More often, the units' primary purpose is to demonstrate that appropriate conditions were maintained throughout surface preparation, coating, and curing. They give the owner assurance that the specification requirements were met and are often instrumental in preserving the long-term warranty from the coating supplier. Warranties may be subject to challenge or dispute if the owner and contractor can't show that the application conditions were adequately controlled.

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Cleaner, drier surfaces are also more resistant to flash rusting. SSPC's Technical Report 3 (SSPC TR3/NACE 6A192)[4] indicates that RH and surface cleanliness are both critical factors in flash rusting. For perfectly clean iron, corrosion doesn't start until about 90% RH. But if there is a bit of sulfur dioxide (SO_2—a component of smog) present, rusting will occur, beginning at about 65% RH. Salt (sodium chloride—NaCl) will lower the level at which rusting can occur to 55% RH. So the cleaner the surface (and the air) are, the more resistant the steel is to flash rusting, and RH levels below 50% will prevent rusting in the presence of some of the more common contaminants. Technical Report 3 is a good follow-up to this introductory article if you are looking for more information on dehumidification and temperature control.

Many contractors are intimidated by calculations (math!) for dehumidification (DH) and ventilation, but they don't have to be that complicated. First, suppliers will be happy to assist with calculating requirements and sizing equipment. Second, a few basics will help you understand the calculations. The sidebar, "Not Getting Psyched Out," will show you the basics of determining RH and reading those mysterious charts for RH (p. 32). Third, there are instruments that will help you monitor RH, wind speed, and other conditions on your jobsite.

Portable instruments for wet and dry bulb temperature measurement are readily available and much faster and more user friendly than old sling psychrometers with their wicks and thermometers. Manufacturers have adapted digital technology to all kinds of measurement instruments for environmental control. For example, one manufacturer's line of instruments adds wind speed measurements (although they are usually not sensitive enough for the low 10–50 fpm [0.1–0.5 mph] flows generally found in containments) and put a portable weather station in the palm of your hand for a few hundred dollars. Wind speeds, dry bulb, wet bulb, dew point, RH, even barometric pressure are all instantly available. Just add a surface temperature thermometer and you are fully instrumented.

What's more, if you want to keep track of environmental conditions on your project, or calculate how much DH capacity you need, numerous free smartphone apps are available. Just run a search on your phone or tablet.

Environmental Controls for Workers

Holding a blast and ensuring proper coating curing conditions are not the only reasons to consider environmental controls. Worker safety and productivity can also dictate controlling the environment. Making the job environment safer and more comfortable usually makes workers more productive.

First, ventilation is often needed for visibility. Abrasive blasting, especially when using mineral abrasive or preparing concrete, can generate high levels of dust. Respiratory protection can reduce exposures to silica and heavy metals, but if workers can't see, especially for exiting in an emergency and knowing where their coworkers are, then the conditions are unsafe.

Few objective guidelines exist for field dust extraction ventilation. The one set of published values often adopted by CIHs as a recommendation for lead work areas is 100 linear feet per minute cross draft and 50 linear feet per minute downdraft.[5] These guidelines apparently originated with blast and spray booth design and are very hard to achieve in normal-sized work enclosures (and usually impossible in large tanks). In my experience, these ventilation rates are overkill and can't easily be achieved in practice on most jobs (particularly if heating or DH is in place).

NFPA 33 is sometimes referenced as ventilation guidelines for field enclosures for painting.[6] This is clearly an inappropriate reference, because the standard is intended for spray application using flammable materials in permanent structures. Section 1.1.5 states, "This standard shall not apply to spray processes or applications that are conducted outdoors." Section 1.1.6 further states, "This standard shall not apply to the use of portable spraying equipment that is not used repeatedly in the same location." Annex A's Explanatory Material on section 1.1.5 further clarifies: "This standard does not cover … bridges, tanks or similar structures."

Further, these rates generally aren't needed for visibility control. For example, consider a typical steel structure work enclosure, 15 feet high by 25 feet wide by 100 feet long; it has a face area of 375 ft^2. Ventilating the length of this containment at 100 linear feet per minute would require 37,500 CFM, and would result in one air change every minute. In this instance, a ventilation rate of 10 to 12,000 ft^3 per minute is probably more achievable, and reasonable, and results in 16 to 20 air changes per hour. For large tanks, it may be practical to get only 4 to 6 air changes per hour during blasting. You do still need some air movement for visibility—for structure containments, airflows of less than 10 linear feet per minute will generally not be effective and will result in an excessively dusty environment.

In addition to visibility, real-world ventilation measures need to ensure an environment with solvent vapor levels of less than 10% of the LEL (Lower Explosive Limit) at all times whenever flammable solvents are sprayed. Consideration should also be given to using ventilation to reduce exposures to toxic solvents to levels below PELs (Permissible Exposure Limits) whenever possible. Note that PELs can be 10 to more than 50 times lower than the flammability guideline of 10% of LEL. There can be a lot of confusion about using dilution ventilation to eliminate fire risks and reduce toxic exposures. The exact calculations are complex, and the mixing of airflows around complex structures and even in open

spaces like tanks makes it very difficult to model exactly. Note well: the best way to ensure levels below 10% of the LEL is to monitor with a calibrated meter. Use your CIH for specific advice. But there are some simple rules of thumb that can be applied to give a reasonable assurance of fire and worker safety, as described in the second sidebar, "General Planning for Ventilation (p. 34)."

Another aspect of worker comfort also impacts safety and productivity. Heavy exertion in a hot and humid environment may be dangerous, especially to those who aren't acclimated to the heat. Special consideration should be given to blasters because their protective suits can increase heat exposures significantly. Heat illness risks have been a recent special focus of safety regulators, with California's Cal/OSHA leading the way.

A heat index risk chart is shown on p. 35. Many combinations can be risky. Note that the "Danger area" encompasses 96 F at 50% RH (feels like 108 F), or 90 F at 70% RH, or 86 F at 95% RH. Reducing 86 F air from 95% RH (feels like 108 F) to 50% takes conditions out of the Danger zone all the way down to a relatively comfortable "feels like" 88 F. DH can be a big comfort and heat safety bonus. Actual cooling, of either the air in the entire enclosure or the air fed to the worker's hood, can be effective as well. To cool just workers, the most effective methods are probably vortex air coolers, which split a compressed breathing-air stream into hot and cold portions so that cool air can flood the worker's blast helmet. There are other lower-tech ways to cool workers too, from wearing vests with pockets for freeze-packs, to running coils of airlines through coolers filled with ice and water.

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Not Getting PSYCH'ed Out—How To Read Psychrometric Charts

By Robert Ikenberry, California Engineering Contractors Inc.

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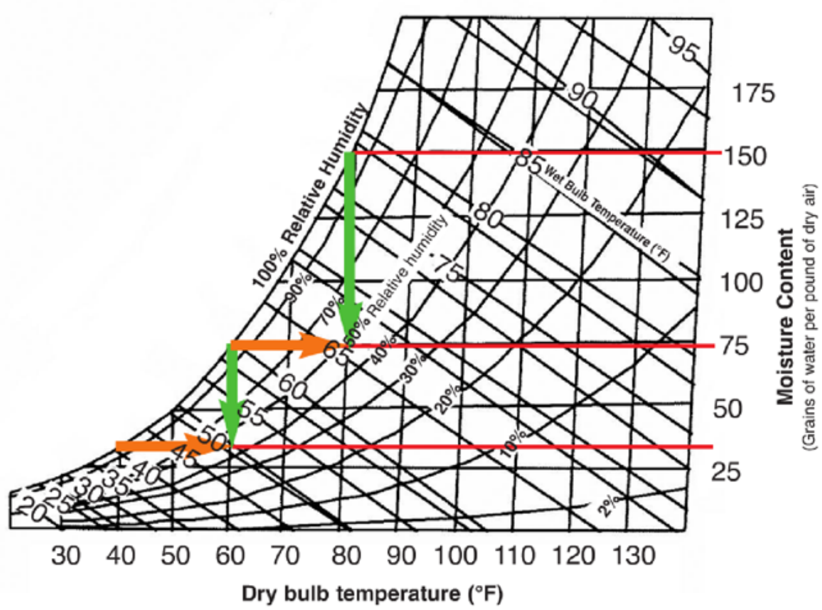
Notice that hot air can hold a lot more water vapor. If the steel temperature is 20 degrees F above the dew point, the RH is about 50%. The psychrometric chart shows why. Look at the total amount of water in 40 F *saturated* air. It's about 35 grains of water per pound. Now look at the amount of water in 60 F *saturated* air. It's about 74 grains of water. So if the temperature is 60 F and the same amount of water is present as in saturated 40 F air, the RH is just under 50%. Moving up to 80 F air, it can hold about 155 grains of water, just over twice as much as 60 F air. Put it another way, if we heat saturated 60 F air to 80 F without adding water, the RH goes down to just under 50%. Moving to the right on the chart indicates heating without changing water content (the grains of water stay the same). Moving down on the chart indicates removing water while the temperature remains the same (dehumidification).

Graph courtesy of SSPC, from SSPC-TR 3/NACE 6A192.[4]



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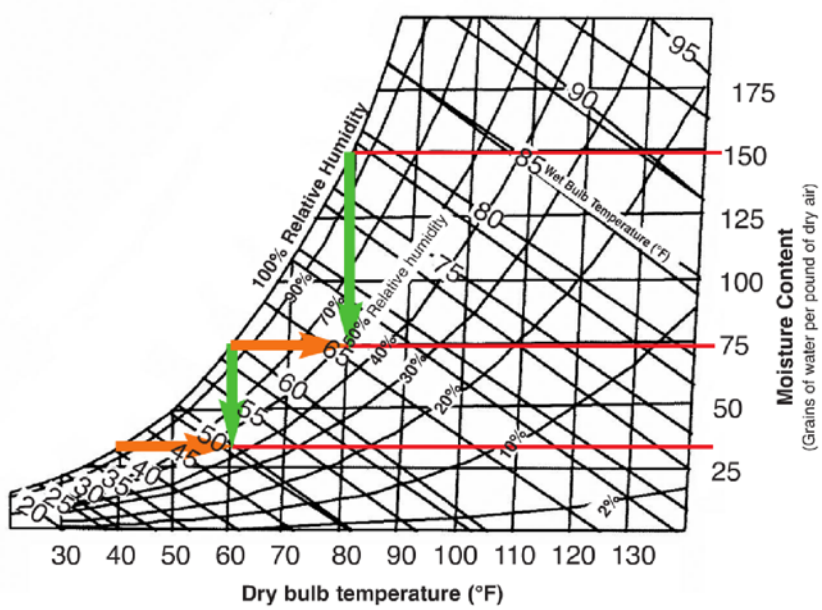

General Planning for Ventilation

By Robert Ikenberry,
California Engineering Contractors Inc.

The following is for illustration purposes only and is not to be relied upon for worker or property safety, nor is it intended to represent legal or expert advice. Anyone working with flammable or toxic materials needs to consult the advice of appropriate experts (a certified industrial hygienist—CIH—or equivalent) to ensure regulatory compliance and adequate worker safety.

Let's pick a typical example: say that painting out the blast cleaned steel surfaces at the end of the day takes 10 gallons of epoxy with 80% solids by volume and all the volatiles are flammable solvents. That puts 2 gallons of solvent into the air, and, to be conservative, we assume that it all evaporates in the hour it takes to apply it.

Here's a simple calculation for a first approximation: with 2 gallons of solvent, each gallon will create about 23 cubic feet of solvent vapor (consider this a constant for typical paint solvents) at 100% solvent vapor, or 46 cubic feet, total. Typical LELs are about 1% by volume of solvent in air or a bit higher, so we assume that diluting the solvent vapor by 100 will put us below the LEL. That takes 4,600 cubic feet of ventilation air. The 1% is assumed to be the LEL, so to get to 10% of the LEL, we need to dilute by 10 times again, giving us 46,000 cubic feet. In order to assure complete mixing, without dead spots, we should apply a safety factor. Four to six times is often considered a reasonable range to take care of incomplete mixing, so we multiply our current value by 5 and get a final fire-safe ventilation value of 230,000 cubic feet. Dividing our hour by 60 means we need to ventilate our paint area at the rate of 3,833 cubic feet per minute for the entire hour.

Two gallons of solvent, evaporated, fills half a typical portable toilet; dilutes at the LEL to fill two each 40-foot shipping containers; and to be fire safe, should be further diluted to fill an Olympic-sized pool.

X 23 CF/Gal =

46 CF X 100 =

4,600CF X 10 X 5 =

Flushing our 2 gallons of solvent with 230,000 cubic feet will eliminate fire hazards, but what about personal exposure safety? Let's say the flammable solvent was MEK (Methyl Ethyl Ketone or 2-Butanone). With an LEL of 1.4%, our calculations for fire risk were presumably conservative. The OSHA PEL for MEK is 200 ppm. Remember that 1% is 10,000 ppm, so when we got down to 10% of the PEL we are still at 1,000 ppm. To make the air safe for workers to breathe (assuming the same mixing safety factor), we have to add ventilation to bring concentrations down by another factor of 5 to 1,150,000 cubic feet of dilution ventilation in an hour. Now we have to move almost 20,000 CFM. And if our solvent were more toxic, like cumene, with a PEL of 50, we'd need almost 80,000 CFM to ensure our painters didn't need to wear respirators. To summarize:

Gallons X 23 = 100% solvent, X 100 = 100% LEL, X 10 = 10% LEL (theoretical), X 5 = 10% LEL with allowance for incomplete mixing. Total = 230,000 CF, a bit more than enough to fill a typical Olympic sized swimming pool. To get down below the PEL, 5 times more…

Heat Index Risk Chart

Air Temperature	Relative Humidity 40	45	50	55	60	65	70	75	80	85	90	95	100
80°	80	80	81	81	82	82	83	84	84	85	86	86	87
82°	81	82	83	84	84	85	86	88	89	90	91	93	95
84°	83	84	85	86	88	89	90	92	94	96	98	100	103
86°	85	87	88	89	91	93	95	97	100	102	105	108	112
88°	88	89	91	93	95	98	100	103	106	110	113	117	121
90°	91	93	95	97	100	103	105	109	113	117	122	127	132
92°	94	96	99	101	105	108	112	116	121	126	131		
94°	97	100	103	106	110	114	119	124	129	135			
96°	101	104	108	112	116	121	126	132					
98°	105	109	113	117	123	128	134						
100°	109	114	118	124	129	136							
102°	114	119	124	130	137								
104°	119	124	131	137									
106°	124	130	137										
108°	130	137											
110°	136												

Apparent Temperature

"Feels like:"

- 80-90°F – Exercise Caution
- 91-103°F – Extreme Caution
- 104-124°F – Danger
- 125°F + – Extreme Danger

Adapted from noaa.gov[7]

continued from p. 32

Conclusion

In summary, many more projects deal with environmental controls today compared to projects conducted three decades ago. Some of this change has been driven by regulations, particularly lead safety OSHA requirements; some of the increase has been driven by specifications, as owners recognize quality improvements result from dehumidification on tank linings; and some of the increases have been voluntary, as employers recognize productivity improvements from increased worker comfort. New technologies have particularly improved measurement of temperature and humidity and controls of equipment.

New technologies on the horizon promise still more sophistication in electronic controls, allowing 'set-it-and-forget-it' options for contractors who want their field crews to be able to focus on production. Nanotechnologies may offer enhancements in desiccants with improved zeolite formulations that are much more efficient absorbers of vapors and gaseous materials, including organic vapors. It may even be possible to allow recirculation of conditioned air during painting, with the proper scrubbers and air "conditioners." Stay tuned—more advances are surely on the way.

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Robert Ikenberry, PCS, is a Project Manager and Corporate Safety Director for California Engineering Contractors, Inc., of Pleasanton, CA, with 35 years' experience on protective coatings projects and construction management. He has been a contributing editor for *JPCL* for over a decade, and a member of SSPC for over 20 years. JPCL

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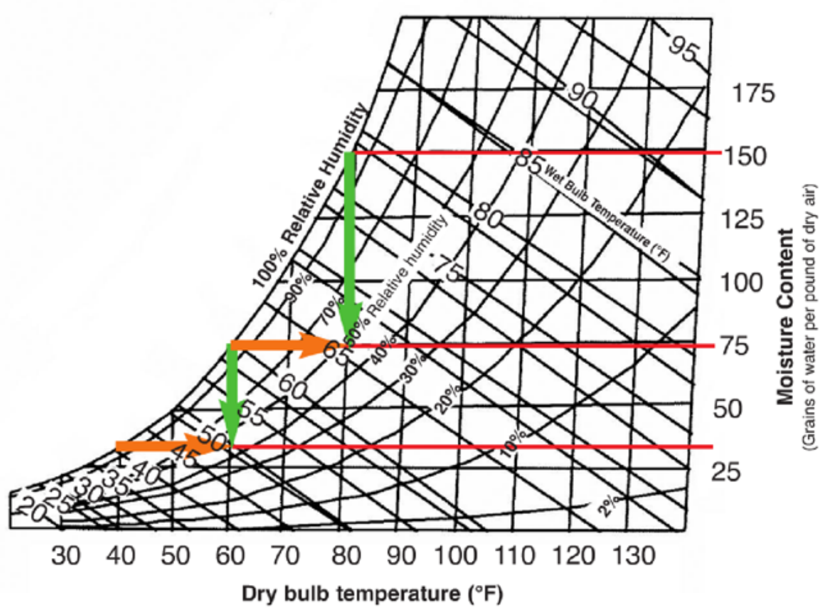


A Sampling of Trends in Product Development for Environmental Control

By Anita M. Socci, Managing Editor, JPCL

In the June 2004 20th Anniversary issue (pp. 66–103) and again in the August 2009 25th Anniversary issue (pp. 38–77), *JPCL* reported on changing regulations, standards protecting workers and the environment, and technological advancements in coatings and equipment in the industrial coatings industry. The following is a sample of trends in environmental control equipment that *JPCL* and *PaintSquare News* (*PSN*) have covered since 2009. It is not meant to be comprehensive.

Containment Then and Now

As Robert Ikenberry points out in his article (pp. 26–35), "Attention to controlling workspace environments has increased over the decades, driven by factors such as regulations, specifications, and the focus on quality." Years ago, containment structures (as a form of environmental control) usually consisted of tough fabric stretched around wire frames or loose and leaky tarps connected to wooden platforms (*JPCL*, January 1988, p. 33). Today's engineered containment structures contain equipment to heat and cool the air, and some have remote data monitoring of surface temperature and humidity.

Among recent advances in temporary portable containment are retractable abrasive blasting and painting enclosures designed to help companies save workspace and comply with air quality standards.

Dehumidification Units Get Smaller

Dehumidification (DH) units are designed to remove humidity from the air, keeping condensation away from the surface of the steel workpiece as well as contributing to worker comfort. DH units can be used inside or outside of containment structures. DH units brought to market since 2009 are often smaller in size than their predecessors, offer higher efficiency in water vapor extraction, higher output capacity, and a wider climatic range of operation compared to similar products used for dehumidification in hazardous environments.

Trends in DH equipment that *JPCL* and *PSN* have reported on include mobile DH units for smaller jobs that are lightweight and compact for easy maneuverability in small spaces. Portable and stackable units are becoming popular, some less than three feet high. Larger units for big-scale jobs obviously are still in existence; advances in these units include built-in digital controllers, global remote monitoring capabilities, and fully grounded housings for use in combustible environments.

Vacuum Shrouds and Dust Collection

In the August 2009 *JPCL* 25th Anniversary issue (p. 58), it was reported that as the desire for alternatives to abrasive blast cleaning grew, so did the product line for power tools. Vacuum-shrouded power tools are used for drilling, grinding, cutting, and sanding surfaces while simultaneously collecting dust and debris during small-scale coatings removal and surface preparation work. Advances in these units include more efficient filtration systems to ensure that particles even as small as 3 microns can be captured and prevented from escaping to the environment. Newer safety features include fully grounded housings for use in hazardous environments where combustible dusts are present.

Lighting Options Get Brighter, Safer

Over the years, new technologies, as well as OSHA safety standards on lighting, have brought about many advances in lighting options for blasting and painting work. *JPCL* and *PSN* have reported on lights that are more energy efficient than previous lighting options, and are brighter and safer for use in hazardous and combustible environments.

For example, the industry has seen the introduction of several models of induction and LED explosion-proof lights for use in confined spaces and environments containing flammable and/or explosive dusts and gases. Other advances include compact sizes, portability, magnetic bases for versatile mounting options, waterproof and vapor proof, and the ability to withstand abusive conditions found in media blasting applications. Most have high-visibility LED bulbs that operate longer and are more energy efficient than typical fluorescent fixtures.

What's Next for Environmental Control Products?

Changing regulations on environmental and worker protection and technology advances have contributed significantly to the development of environmental control products. Advanced, remote monitoring devices, currently used today, will continue to record and report jobsite condition data and transmit it globally. Computers, smartphones, and tablets will be an integral part of site condition monitoring. Shrouded power tools will likely continue to deliver good performance while effectively capturing small particles from entering the environment. Portable, efficient products that use less energy will continue to drive product development.

Surface Preparation: A Continuing Evolution

by Charles Lange, JPCL

If you're in the coatings industry, then you're well aware of just how vital surface preparation is to any protective coatings-related endeavor. Whether it's a matter of removing and containing existing lead-based paint from a structure, or providing a clean substrate and a uniform surface profile to ensure proper coating adhesion, surface preparation is every bit as important as the actual coating application, and it requires strict attention to detail, clear and concise regulations and standards, and the most up-to-date equipment to get the job done right. According to Fred Goodwin, from an article in the July 2012 *JPCL*, "Proper surface preparation is one of the most important stages in achieving successful coating installation." (p. 45)

The 25th Anniversary issue of *JPCL* (August 2009) provided a general summary of surface preparation practices, equipment, and standards dating back to the publication of *JPCL*'s first issue in 1984. Industry growth hasn't ceased since then; in fact, surface preparation methods and equipment continue to develop. In conjunction with these developments, SSPC has adapted its standards along the way, providing a clear point-of-reference to surface preparation work and resulting in better execution of the work.

This article will take a look at some of the advances in surface preparation, with particular attention paid to the last four years. While it is not intended to be comprehensive, this article can serve as a framework for some of the trends and continuing developments in the surface preparation field. Trends identified are based on product developments reported by *JPCL*, *PaintSquare News*, and individual companies.

1984—2009: A Brief Review

The August 2009 *JPCL* summarized and detailed the ongoing developments in surface preparation practices, equipment, and standards between 1984 and 2009. Trends highlighted in the summary include the advances made in abrasive blast cleaning, as well as the establishment of new standards to ensure quality during blasting operations and selection of abrasive materials (pp. 56–57). Advances in standards for power tool cleaning (pp. 58–59), as well as the emergence of visual standards (p. 61), were also explained.

The August 2009 summary also touched on the emergence of waterjetting, an alternative to dry blasting, and the establishment of the original SSPC waterjetting standard in 1995 (pp. 59–60). Wet abrasive blasting methods were also discussed (p. 60), as were techniques and standards for preparing concrete surfaces (pp. 62–63).

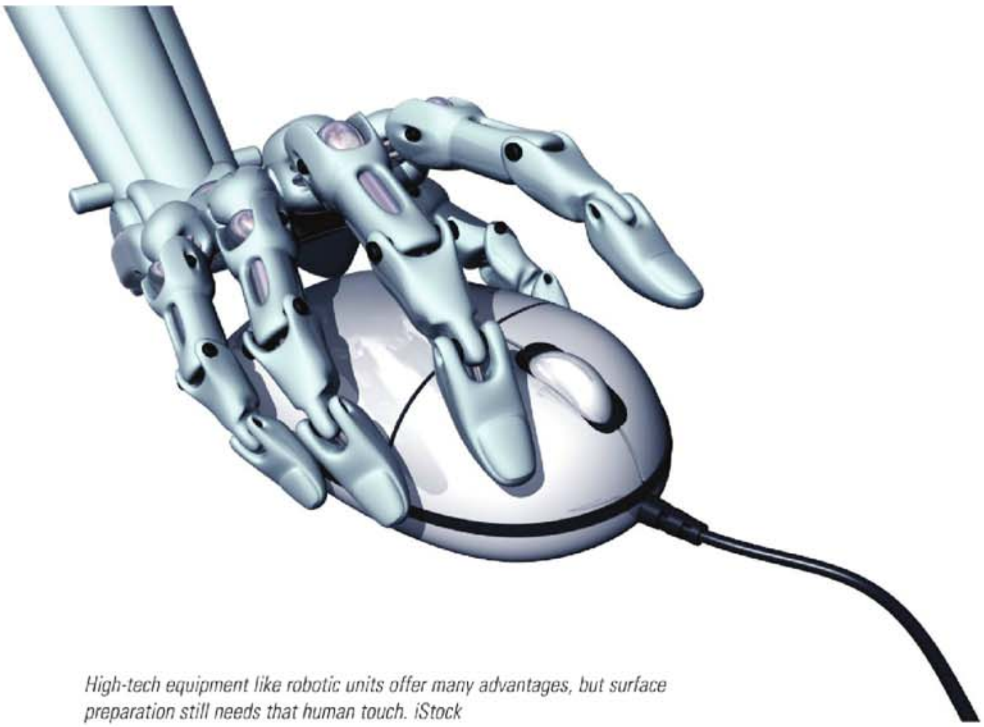
The equipment and practices covered in the August 2009 *JPCL* haven't disappeared, just changed to adapt with technological advances and the constant need for corresponding standardization. Some of the trends discussed in the 25th Anniversary summary are still prevalent in the industry today. While there has certainly been plenty of new innovation in the surface preparation field, it is more common that past methodology is developed and tweaked for use in the future. Pay attention to how some of these older methods have been modified to reflect the changes in the industry, while others have been outright replaced by the new tools of the trade.

Equipment & Practices: 2009—Today

Robotics Revolution

One of the most visible trends in surface preparation equipment and practices is the automation of surface preparation processes through the emergence of new robotic equipment. Debuted primarily during marine coating endeavors, robotics usage has expanded across several different industries, and few technologies have had such far-reaching effects in these industries as robotics. These new components have a wide range of benefits, helping contractors increase efficiency; reduce negative environmental impacts; and, because robotics equipment can prepare dangerous or nearly inaccessible areas, often keep workers out of harm's way.

Over the past five years, we've seen a number of robotic waterjetting machines put to use for surface preparation jobs on vessels and storage tanks. These machines include features such as increased coatings removal rates, mobile or radio-controlled operation, magnetic attachment systems for horizontal or vertical surfaces, both



High-tech equipment like robotic units offer many advantages, but surface preparation still needs that human touch. iStock

vacuum effluent and vacuum-less containment systems, and various safety devices.

Robotics aren't just for waterjetting. Some new robotic gritblasting machines are designed to store blast process parameters for different blasting operations, ensuring an even profile and consistent stand-off distances, nozzle angles, and surface speeds. In addition to enhanced productivity, these features are intended to ensure quality control and consistency, as well.

Better Ways to Waterjet

JPCL's 25th Anniversary review of surface preparation techniques was published as waterjetting started gaining ground as a preferred technique. As contractors looked for alternative preparation methods for jobs in which dry abrasive blasting was not the best option, ultra-high pressure (UHP) waterjetting emerged as a suitable substitute. The first waterjetting standard, published by SSPC and NACE in 2002, was expanded a decade later to reflect the technical and practical changes and developments that took place. (For more information on the revised waterjetting standard, take a look at the Surface Preparation Standards article, p. 44.) To go hand-in-hand with the revised waterjetting standards, equipment and practices have been modified, with increased efficiency and user ease taking the lead as the driving forces behind new innovation.

Some of the aforementioned robotic waterjetting machines have the ability to tackle a variety of surfaces and substrates. But a thorough surface preparation job can't be completed by robots alone—it needs that human touch, so to speak. Recent man-powered waterblasting machines have been designed with a keen eye on ergonomic design and other considerations that could help increase efficiency and productivity, as well as more portability and better access for usage across a variety of structures.

The past five years have seen several new versatile waterjetting components introduced, including water jet pumps that contain multiple operating pressures and engines that run up to 1,000 hp. Others include new convertible waterjet units; new multi-gun valves; new ergonomic equipment designed to make waterjetting easier; and revamped control gun handles, designed to be easier to hold and operate, helping the worker complete the job in the most efficient manner possible.

Conquering Concrete

If you've ever picked up and read a copy of *JPCL*, chances are you don't need to be reminded that concrete surfaces require different methods of surface preparation than steel and other materials—but we'll mention it, anyway, just to drive the point home once more. Concrete demands a surface preparation and coatings application plan tailored for its unique composition, porosity, and possible surface defects.

Concrete needs surface prep and coating application tailored to its unique makeup. iStock

Protecting workers and the environment during surface prep is as important as properly cleaning and profiling the substrate. iStock

The 25th Anniversary *JPCL* described some early steps to establishing more tried-and-true concrete surface preparation methods, including the establishment of and revamping of SSPC-SP 13/NACE No. 6, Surface Preparation of Concrete. With this standardization as the foundation, surface preparation equipment and practices for concrete continue to develop.

Tracy Glew authored an article in the January 2013 *JPCL*, "Preparing Concrete Floors for Coatings," which highlighted some of the most common techniques for preparing concrete floors before coatings application. The methods Glew touched on include multi-stripping, planing, grinding, and shotblasting—which Glew says is one of the most cost-effective methods of preparing concrete, given proper conditions (p. 32).

Not surprisingly, there have been plenty of developments in the equipment aiding these processes, such as new self-propelled or walk-behind shotblasting machines intended to strip

previous coatings and compounded residues from concrete at high production rates. Other developments include new multi-level grinding kits and upgraded pneumatic surface planers, designed for use in marine and other industrial settings.

Going Green

Nowadays, it's impossible to ignore the negative impacts that industry has had on the environment. Among pollution, depletion of natural resources, and the negative health effects on humans, it has become increasingly obvious that every industry needs to rededicate itself to making sure the harm to the environment and people is kept to an absolute minimum, and the coatings industry is no exception.

Some of the aforementioned technological developments have environmentally friendly features, such as vacuum blasters, and so on. Indeed, preparing surfaces that leave large quantities of blasting dust and residue, or removing existing lead-based paint, always poses a risk to the environment and requires the use of containment and other measures to make sure these harmful byproducts do not enter into the ecosystem.

While water jetting to avoid abrasive dust and waste has become an increasingly popular method of avoiding said byproducts, dry blasting hasn't gone by the wayside. Instead, manufacturers have been hard at work developing more "green" abrasives that leave behind less debris and pose considerably fewer threats to the environment.

> "The vast majority of the new products we've seen popping up in the marketplace now come equipped with features that increase efficiency and productivity, allow for maximum portability, lessen harmful impacts on the environment, and keep workers safe."

In the October 2012 *JPCL*, David Dorrow answers the question, "What is a Green Abrasive?" Dorrow describes the different kinds of recyclable abrasives, including steel, garnet, glass, and others. Dorrow says that these recycled, green abrasives can reduce the overall waste generated by a project, and advises contractors not only to consider cost and convenience considerations when selecting an abrasive material, but to also think about sustainability and effects on the environment. He also explains the ways of producing abrasives from industrial byproducts, such as mineral aggregates (or "slags"), and post-consumer materials like recycled household plastic and glass waste. The "green" abrasive products on the market today reflect Dorrow's school of thought—putting environmental considerations at the forefront of the selection process.

Abrasives aren't the only surface preparation materials that have been modified for better sustainability and less environmental impact. Machines that use heat to remove coatings have been around for many years and continue to be developed, with focuses on features such as reduced environmental harm, improved portability, and ease of access. Paint strippers also continue to evolve. Old solvent-based versions had put workers and the environment at risk. Today, paint strippers come to market in formulations free of solvents and other hazardous compounds.

Portability & Access: It's All in Reach

Not all surface preparation jobs are created equal. While some jobs require one or two straightforward processes to clean uniform, easily accessible surfaces, others present more complicated and challenging areas to prepare. Coating jobs often require especially small or large surfaces, or hard-to-reach areas, to be prepared and coated with the same attention to detail and quality as the easier parts of the structure. If these surfaces do not receive adequate preparation before coating application, the performance of the entire structure's coating system is put at risk. With this in mind, several new innovations in the industry have been designed with the intent of helping contractors cover these crucial areas.

New blasting machines, designed to prepare surfaces of steel and concrete storage tanks, ship hulls, and other horizontal or vertical surfaces, can disassemble to fit inside of a tight storage tank

More equipment is coming to the market to improve the efficiency, quality, and safety of preparing ship hulls. iStock

access hole, keeping workers out of dangerous areas. There have also been developments in handheld units for dry and wet surface preparation. Such tools are designed to remove coatings from steel structures that are too large for manual surface preparation, but too small for fully-automated equipment.

From the tools and machines created for small spaces where access is difficult, to self-attaching units that prepare large, vertical surfaces at extreme heights and hand-held tools aimed at completing medium-sized preparation jobs, surface preparation equipment is changing to meet the demands of the industry.

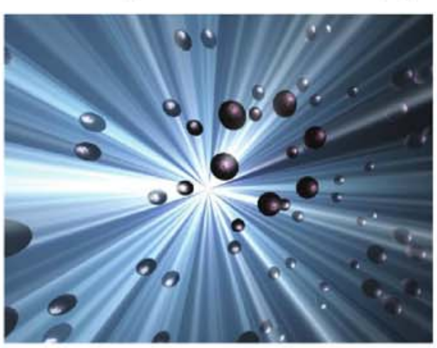
What's Next?

So where does surface preparation go from here?

It's hard to predict innovation—if we could, we'd all be millionaire inventors, after all. It is, however, possible to study the trends we've discussed in surface preparation equipment and practices, and try to make an educated guess as to what developments the future may hold.

Take a look back on the past five years. We've seen the emergence of new robotic surface preparation machines, versatile, multifaceted waterjetting units, cleaner recycled abrasive materials, and new methods and machines for cleaning concrete. The vast majority of the new products we've seen popping up in the marketplace now come equipped with features that increase efficiency and productivity, allow for maximum portability, lessen harmful impacts on the environment, and keep workers safe.

It's safe to say that these goals will continue to drive innovation in the surface preparation field. Efficiency and productivity, in a certain sense, will always be one of the top motivations for development, but they can't come at the expense of any of the other benefits contractors strive for. It will certainly be interesting to see which considerations will take front and center as the development of surface preparation equipment and practices continues. JPCL



Waterjetting, once a novel method of surface preparation, has become much more popular, and development of its standards, practices, and equipment continues to meet new demands. iStock

Recent Developments in SSPC Surface Prep Standards

By the JPCL Staff

In the past five years, SSPC has added, replaced, and revised several standards for surface preparation and abrasives in response to changes in the industry.

The documents cover power tool cleaning; blast cleaning galvanized steel, stainless steels, and non-ferrous metals; water jetting of metals; mineral and slag abrasives; and encapsulated abrasives. The information below was provided by SSPC.

Power Tool Cleaning

SSPC revised two power tool cleaning standards in 2012: SSPC-SP 11, Power Tool Cleaning to Bare Metal, and SSPC-SP 15, Commercial Power Tool Cleaning.

The types of power tools described by SP 11 and SP 15 have been reorganized and reclassified into grinding and impact categories. The impact category now includes wire bristle impact tools, which were introduced to the U.S. market after the earlier SP 11 and SP 15 were developed. In both standards, the default method for measuring profile is ASTM D 4417, Method B (depth micrometer) unless otherwise specified. Other methods (replica tape or portable stylus instrument) may be used if permitted by the project specification. Feathering of remaining intact coatings is required unless otherwise specified. Compressed air used in power tool cleaning must be verified to be free of oil and water in accordance with ASTM D4285, Standard Test Method for Indicating Oil or Water in Compressed Air.

Non-mandatory notes have been added to both standards to caution against damaging surfaces, and to alert users that characteristics of individual tools and variations in the steel may affect the appearance and depth of resulting profile.

For both standards, what did not change is as noteworthy as what did change, according to SSPC. The 2012 revisions have not changed existing requirements for surface cleanliness and minimum surface profile in either standard.

Surface Preparation and Abrasives

In 2010, SSPC issued SSPC-SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.

According to SSPC, this standard covers surface preparation of coated or uncoated metal surfaces other than carbon steel before application of a protective coating system. Surface preparation in this standard is used to uniformly roughen and clean the bare substrate and to roughen the surface of intact coatings on these metals before coating application. Substrates that may be prepared by this method include, but are not limited to, galvanized surfaces, stainless steel, copper, aluminum, and brass. For the purpose of this standard, the zinc metal layer of hot-dip galvanized steel is considered to be the substrate, rather than the underlying steel. This standard is intended for use by coating specifiers, applicators, inspectors, or others who may be responsible for defining a standard degree of surface cleanliness.

SSPC-SP 16 is not to be used for cleaning coated or uncoated carbon steel substrates. The standard represents a degree of cleaning similar to that defined for carbon steel substrates in SSPC-SP 7/NACE No. 4, Brush-Off Blast Cleaning, except that SSPC-SP 16 requires a minimum surface profile depth on the bare metal surface.

SSPC-AB 1, Mineral and Slag Abrasives, was revised in 2013, its first revision in 22 years. The standard was developed to establish quality benchmarks for non-metallic abrasives and to provide a classification scheme that would allow users to select the appropriate size distribution (work mix) for a given project.

Key changes to the standard begin with the scope. It has been expanded to include manufactured, non-metallic abrasives that meet the requirements of the standard, such as silicone carbide and other abrasives that are neither naturally occurring minerals nor slag byproducts.

The revision also clarifies the responsibilities for testing the abrasives to determine initial qualification to the standard, conformance testing for continued compliance, and testing for field quality control. The supplier is responsible for third-party testing to determine initial qualification. The requirements for documentation of initial qualification testing include requirements for the credentials of the laboratory performing the qualification testing of the abrasive.

The supplier is also responsible for conformance testing of material for continued compliance when such testing is required by the purchaser.

The contractor is responsible for field testing for oil and soluble salt contamination of delivered new media before initial use, and, if the use of recycled work mix is permitted by project specification, the contractor is responsible for testing the work mix before field use. The standard calls for the latter testing to be done once every work shift or eight-hour period, whichever is shorter.

Also new to the standard is an appendix with additional requirements for non-metallic abrasives used by the U.S. Navy. This appendix is non-mandatory unless specified by the purchaser, and it includes additional requirements for friability, radioactivity, and inspection that are currently required by MIL-A-22262(SH).

In 2009, SSPC issued a new abrasive standard, SSPC-AB 4, Recyclable Abrasive Media (in a compressible cellular matrix), developed to help those who use these composite abrasives to reduce dust generation and ricochet damage when blast cleaning steel and other surfaces. The standard includes requirements for selecting and evaluating the encapsulated media (e.g., steel grit, aluminum oxide) as well as requirements for quality control of new and recycled encapsulated media.

Four Waterjetting Standards Replace Existing Standard

The 2012 revision of the 2002 version of SSPC-SP 12/NACE No. 5 standard, Surface Preparation of and Cleaning of Metals by Waterjetting Prior to Coating, replaced the single standard with four separate documents, each addressing a different level of surface cleanliness. There were several reasons for the changes, according to SSPC, but much of the material in the new standards was drawn from SSPC-SP 12/NACE No. 5.

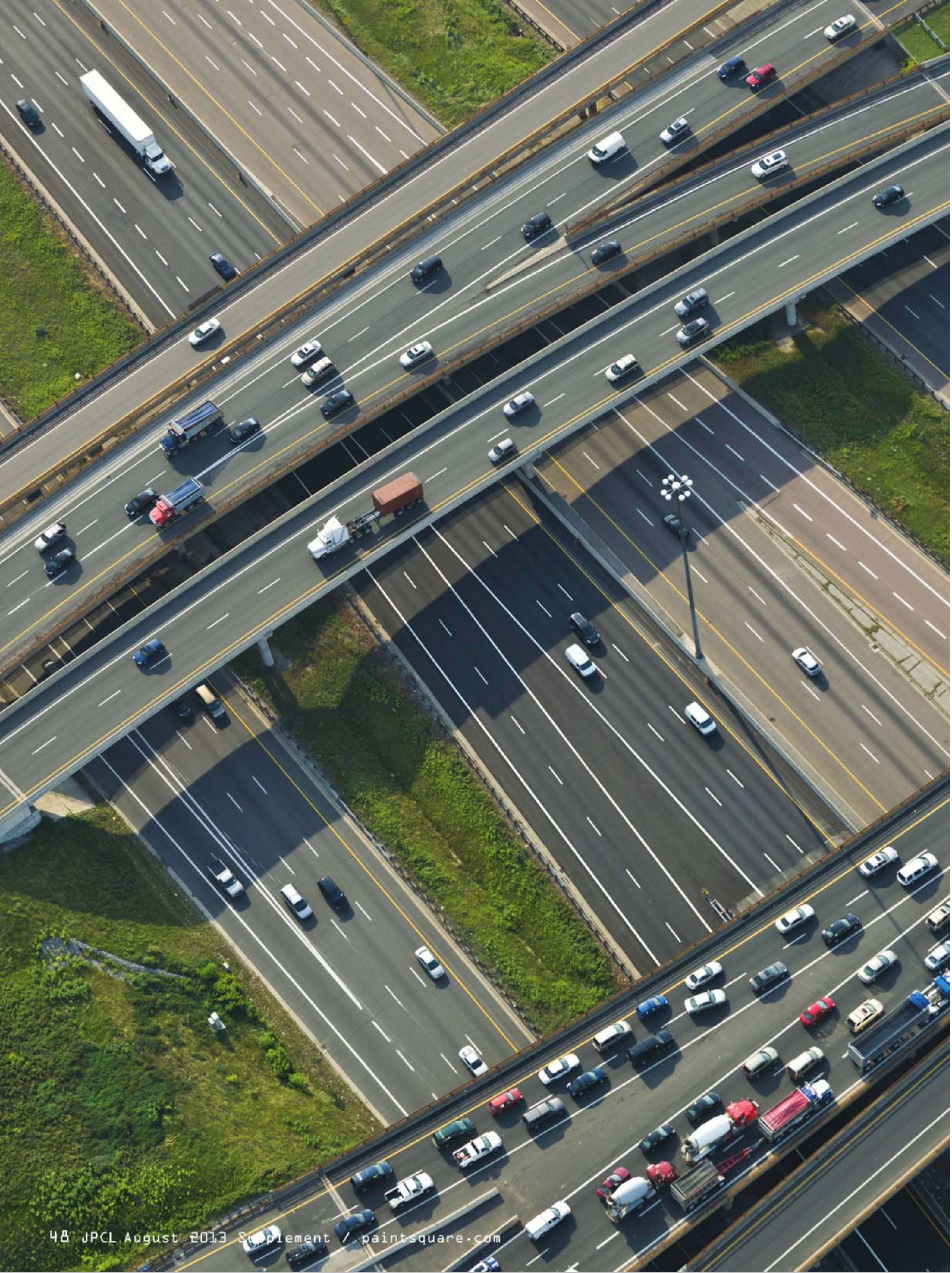
The organization of the four resulting standards has been revised to more closely parallel the organization of the dry abrasive blast cleaning standards, and allows the specifier to specify levels of cleanliness for waterjetting by use of separate standards, as is done when specifying levels of dry abrasive blast cleaning.

The titles of the new standards are:

- SSPC-SP WJ 1/NACE WJ-1, Waterjet Cleaning of Metals—Clean to Bare Substrate (WJ-1);
- SSPC-SP WJ 2/NACE WJ-2, Waterjet Cleaning of Metals—Very Thorough Cleaning (WJ-2);
- SSPC-SP WJ 3/NACE WJ-3, Waterjet Cleaning of Metals—Thorough Cleaning (WJ-3); and
- SSPC-SP WJ 4/NACE WJ-4, Waterjet Cleaning of Metals—Light Cleaning (WJ-4).

The definitions of the four surface cleanliness levels have changed very little from the definitions in the 2002 version of the standard. Clarification that permissible staining or tightly adherent matter must be evenly distributed over the surface has been added to WJ-2 and WJ-3. In addition, a clarification of "tightly adherent" (cannot be lifted with a dull putty knife) has been added to WJ-2, WJ-3 and WJ-4 definitions.

As in the original standard, descriptions of three degrees of flash rusting are provided in each of the revised waterjetting standards. These descriptions are based on the degree to which the rust obscures the carbon steel substrate and the degree of adhesion to the substrate. The color of the rust is no longer addressed. JPCL



The Changing Face of Coating Application Equipment

By Anita M. Socci, Managing Editor, **JPCL**

Throughout *JPCL*'s history, we have reported on the state of the coatings industry, taking a look at the people, regulations and standards, health and safety issues, and advances in coatings and equipment technology that have shaped the industry from the early days.

This article will give a brief history on *JPCL*'s coverage of coating application equipment and practices over the past 30 years. Also included is an overview of some of the trends in application equipment as reflected in examples of the types of products reported on in *JPCL* and *PaintSquare News* over the past few years. Changes in high-performance coatings, including their formulations and fast cure rates, have been the driving factor in the development of the methods and the equipment used to apply them.

Paint Application Equipment Finds Its Way

In a March 1999 *JPCL* article, contractor John Conomos put development of spray application, from air to plural-component, in a 50-year historical context. In "A Contractor Looks at the History of Spray Equipment" (pp. 98–100), Conomos commented on the development of air, airless, plural-component, HVLP, and electrostatic spray and how these developments affected his company. According to Conomos, air spray technology was used on ships and storage tanks during the Second World War, but it was not widely used on other structures until the 1950s, when the number of bridges increased as part of the interstate highway system expansion during Eisenhower's presidency. Contractors realized that air spray application was not only faster than application by brush, but it was also more economical, yielded finer finishes, and could coat complex substrates with numerous angles. In the late 1950s, plural-component spray was primarily used to apply urethane foams, Conomos said, but the advent of heavy-duty multi-component coatings in the 1970s led to the use of plural-component spray systems for industrial coating operations.

Other *JPCL* articles before and after the March 1999 article looked at application equipment over shorter periods. In its first anniversary issue, June 1985, *JPCL* published the results of a

Air spray application increased significantly in the 1950s as the U.S. interstate highway system expanded and the number of bridges increased.
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Equipment makers continue to design units to increase efficiency in application. iStock

survey on the state of the technology. Here is the 1985 summary of survey responses about coating ("paint") application equipment:

"Very few complaints were registered in the survey on the quality of paint application equipment. In fact, both conventional air and airless spray equipment were cited consistently for their reliability. In addition, recently developed application equipment, such as electrostatic spray, air-assisted airless, spray guns capable of mixing plural-component paints, and arc spray equipment for metallizing, were described as important and helpful innovations" (p. 23).

In 1992, a follow-up survey in the September *JPCL* 100th issue showed that changing regulations had become a major force behind changes and advances in coatings work in general. For coating equipment, regulations on lead paint as well as on volatile organic compound (VOC) levels in coatings and in coatings application influenced equipment development.

In a separate article in the 100th issue of *JPCL*, contractor Tom Dunkin, II, focused on the impact of regulations on equipment; while most of his attention went to surface preparation equipment, mainly because of the advances in regulations on lead paint removal and disposal, he too noted that VOC regulations have influenced application equipment. Whereas plural-component had been considered an advance in technology in 1985, Dunkin described its use by 1992 as "commonplace" but added, "its use may be a bit on the wane as higher solids materials are being formulated that can be applied with 'standard' airless or conventional equipment." He also commented on the limited use of high-volume low-pressure [HVLP] spray equipment, noting that it "has not yet gained industry-wide use" (p. 118).

By the mid- to late-1990s, the application methods of choice for most contractors were conventional air spray and airless spray.

In a June 2004 article, "That Was Then, This Is Wow," Lori Huffman interviewed several industry experts on technological changes in maintenance painting over 20 years. For coating equipment, she reported that changes in coatings continued to drive changes in application equipment. The use of conventional air and airless spray equipment dominated, but the need for better transfer efficiency had further increased the use of HVLP and electrostatic equipment. Of what many considered relatively novel in 1985—plural-component equipment—she reported this: "Perhaps the greatest advance, however, has been the development of plural-component pumps to handle coatings with accelerated cure times."

Wolfgang Pucken elaborated on plural-component technology in the October 2004 *JPCL*. In "Developments in Plural-Component Spray Equipment," (pp. 51–57), Pucken discussed the advantages and disadvantages of plural-component equipment. Of the disadvantages, Pucken listed, "equipment cost, less flexibility and portability, the high cost of spraying small areas, colour changes for small batches, and complicated and time-consuming set up."

In Pucken's opinion, the most economical and environmentally responsible answer to the application of the high-solids, short pot life products was the plural-component spray system. Contractors began to recognize the advantages of plural-component application equipment, which include reduced costs for coating materials and labor, improved coating quality, and reduced adverse impact on the environment.

Training Changes with the Times

SSPC has always recognized that advances in spray equipment meant that workers had to be trained on the proper use of it. In 2004, the Society published its *Basic Spray Application Manual*, designed to provide novice painters and more seasoned workers with a review of surface preparation through coating characteristics, spray application equipment and operation, and application basics.

As specifiers recommended plural-component coatings in immersion and marine applications, SSPC developed its Marine Plural Component Applicator Certification Program (MPCAC) in 2006. According to the Society, the program was designed to certify craft workers operating plural-component spray equipment and applicators of protective coatings on steel in immersion service using airless plural-component spray equipment. The program offers three categories of certification: Equipment Operator, Spray Painter, and Spray Painter/Equipment Operator.

As for *JPCL*, numerous articles, tips, and training bulletins focused on plural-component equipment, especially with the use of polyureas as an emerging coating for industrial and marine applications.

What's Changed?

The equipment used to take coatings from a can and apply them to a substrate has taken on many forms and has increased in complexity throughout the years, from brushes to rollers to sophisticated spray application equipment. Advances in coatings technology have driven developments in coatings application equipment. In our August 2009 25th anniversary issue, plural-component equipment was again listed as one of the top product developments (pp. 65–70). Plural-component equipment obviously is not new to the industry, but according to Eric Rennerfeldt, plural-component sprayers have changed drastically over the past 10 years. In his May 1, 2013, SSPC/*JPCL* Webinar presentation entitled, "Advances in Plural-Component Equiment Technology," Rennerfeldt explains that today's plural-component equipment is easier to use compared to earlier equipment. In addition, some models shut down automatically if the mix is off-ratio.

But other types of spray equipment continue to advance, also. Manufacturers are bringing to market coatings application equipment that deposits paint faster; saves money; is versatile; increases productivity; and has applicator comfort in mind.

The following section describes some examples of trends in coating application equipment covered by *JPCL* and *PaintSquare News*. The section is not meant to be comprehensive.

Spray Equipment, Pumps, and Tips

Lightweight, multi-functional sprayers are designed to make painting faster and easier for industrial and commercial painters. Heavier latexes, enamels, and acrylics, as well as thinner stains, lacquers, and urethanes, all can be sprayed using the same tool, simply by changing the front end assembly. Two-in-one tools like these save time, money, and material. This trend also applies to spray tips that offer both narrow and wide orifices to apply coatings quickly, without losing precision and efficiency.

Spray equipment is also becoming more compact and portable for difficult-to-access areas and tight spaces. Pumps, hoses, compressors, guns, and remote controls can all fit in a single assembly. Versatile units are capable of dispensing various materials such as fireproofers, waterproofers, and other materials, and are available in manual (crank) and electric versions. Quick change options allow easy conversion from cart- to skid-mount.

Portable and lightweight equipment for coating pipeline has also come out to make application faster and easier.

Productivity and Ergonomics Go Hand-in-Hand

In order for workers to be productive, they need to be able to perform tasks comfortably. The shape of spray guns and brushes for manual paint application is improving with operator comfort and safety in mind. Manufacturers are developing brushes with longer handles for more comfortable and safer application of protective coatings.

Automated Application Equipment

Advances in powder coating technology have enabled manufacturers to make application products smaller, smarter, and more efficient. Programmable automatic powder spray machines with integrated controls offer efficient coating transfer. User adjustable settings control spray patterns, film thickness, and other parameters with the goal of optimizing application efficiency and reducing operator costs.

What's Next?

Advancements in coatings technology have driven developments in coatings application equipment. The industry has seen coatings application equipment that deposits paint faster; saves money; is portable; increases productivity; and has applicator comfort in mind. It's likely that these trends will continue.

Applications for mobile devices are multiplying even as we go to press. By the time you get this issue of *JPCL*, there will likely be new apps for paint application.

Operator training for coating application has entered the market over the past ten years, with 3D simulators to help operators train for real-life coating projects, environments, and processes.

As long as the demands on the protective properties of coatings increase while production and space requirements call for shorter curing times, less solvent, and lower environmental burdens, two-component materials and plural-component spray technology will continue to develop. JPCL

Saving time in application also means saving money.
iStock

SSPC's Latest Paint Application Standards Meet Field and Lab Needs

By the JPCL *Staff*

SSPC issued four new Paint Application (PA) standards and one revised PA standard between 2009 and April 2013. The five documents reflect the growing use of plural-component application equipment, an increasing capacity to determine compliance with application specifications, and a long-standing need to eliminate variability in evaluating and presenting scribe undercutting data on coated test panels. For a complete list of SSPC Paint Application standards, visit SSPC's store on sspc.org, where all standards are available. SSPC provided the information that follows.

Applying Polyureas and Polyurethanes by Plural-Component Spray

SSPC issued a new standard on using plural component spray equipment: SSPC-PA 14, Field Application of Plural Component Polyurea and Polyurethane Thick Film Coatings to Concrete and Steel Using Plural-Component Equipment (September 2012). PA 14 addresses application of thick-film polyurea/polyurethane hybrid coatings in its scope. PA 14 defines thick-film coatings as "… coatings specified to have greater than 500 micrometers [µm] (20 mils) dry film thickness." The standard also addresses surface preparation, pretreatments, machinery requirements, and application parameters.

PA 14 was developed to provide specifiers and contractors with information on best practices when applying coatings that use plural-component spray application equipment. The standard gives "default" information on best practices for plural-component spray application that may not be found on a coating's product data sheet or application instructions, and may not be called out in project specifications. At first glance, some of this information may seem to be common sense; however, specifiers may find it useful when preparing project specifications, and contractors can use it when preparing their work plans.

Assuring Compliance with Job Specifications

Two other recently issued PA standards—one new and one revised—relate to assuring compliance with job specifications crucial to successful coating application: SSPC-PA 17, Procedure for Determining Conformance to Steel Profile Roughness/Peak Count Requirements, and SSPC-PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.

First issued in September 2012 with editorial revisions in November of that year, PA 17 is intended to be used with two ASTM standards. As noted in its scope, PA 17 "describes a procedure suitable for shop or field use for determining compliance with specified profile ranges on a steel substrate using Methods A (visual comparator), B (depth micrometer) and C (replica tape) as described in ASTM D4417, and the portable stylus method used to determine surface roughness and peak count as described in ASTM D7127."

Although test methods for evaluating profile existed before SSPC-PA 17, there was no procedure for ensuring that the profile over the entire prepared surface complied with project requirements.

SSPC-PA 17 requires averaging multiple profile readings taken within 6-by-6-inch areas at a minimum of three locations on each surface prepared using a specific piece of surface preparation equipment. Therefore, if some areas are blast cleaned but others are power tool cleaned, the profile of the blast-cleaned areas must be evaluated independently from that of the power tool cleaned areas, and both blast-cleaned and power-tool cleaned areas must meet the specified profile range.

A detailed discussion of PA 17 is given in the December 2012 *JPCL* article by Aimée Beggs and Heather Stiner, "New SSPC Standard Helps Determine Compliance with Surface Profile Requirements," pp. 36–41.

SSPC's widely used standard for measuring dry film thickness on steel was most recently revised and retitled in May 2012: SSPC-PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.

The scope and title of PA 2 were changed to reflect the 2012 revision of ASTM D7091-12, Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals. Several key changes include the following.

- Much of the descriptive language about operation of the gages has been eliminated from the revised PA 2. Descriptions of gages and their operations are included in the revision of the ASTM D7091 standard. The 2012 revision of PA 2 contains procedures for determining compliance with project requirements for dry coating thickness, and procedures for performing accuracy checks to ensure that the gages are reading accurately.
- Section 9, on determining compliance with the specified DFT, has been rewritten to allow the specifier to reference a greater or lesser "coating thickness restriction" than

the default requirement, which requires that an acceptable spot reading must be within 80% of minimum, 120% of the maximum specified DFT).

• New language has been added for determining and documenting the extent of nonconforming areas. This language is found in Section 8.2.4 and subsections.

• Revisions to the non-mandatory notes in PA 2 address measuring DFT on overcoated structures, coatings on edges, and coated steel pipe exteriors.

"Measuring Dry Film Thickness According to SSPC-PA 2" (April 2013 *JPCL*, pp. 20-37) explains the basic steps in using the revised standard.

Coatings on Test Panels

Two other new PA standards published since 2009 relate to the process of applying coatings to test panels for the purpose of evaluating coating performance. SSPC-PA 16, Method for Evaluating Scribe Undercutting on Coated Steel Test Panels Following Corrosion Testing, was issued in September 2012, and SSPC-PA 15, Material and Preparation Requirements for Steel Test Panels Used to Evaluate the Performance of Industrial Coatings, was issued in March 2013.

Until 2012, no procedure existed for determining the location and number of data points to be used for determining the average amount of scribe undercutting on a steel test surface. Issued in September 2012, PA 16 fills this gap. It contains requirements for evaluating scribe undercutting data, including requirements for number and collection of data points, and for calculating the average undercutting from the data points.

PA 15 is intended for use by coating manufacturers and owners who perform in-house performance testing of coatings, and by third-party testing laboratories that prepare panels for testing. It was developed to reduce the potential for misinterpretation of corrosion test data due to variation in the chemical composition of steel test panels and number of scribes per panel.

PA 15 contains requirements for material and preparation of steel test panels used for coating performance evaluation testing. It includes requirements for the corrosion index of the steel panels and for preparation of test panels prior to coating application, including degree of cleaning, and number and direction of scribes made on the panel.

PA 16 is intended to be used in conjunction with SSPC-PA 15 to eliminate variability in the ways scribe undercutting data is evaluated and presented, but PA 16 can also be used independently of SSPC-PA 15 to evaluate panels scribed in accordance with procedures in ASTM D 1654.

QA/QC:
Some Things Are Old; Some Are New

By Warren Brand, Chicago Coatings Group, LLC

When *JPCL*'s editor invited me to write a piece about changes in quality assurance and quality control (QA/QC) in the industry over the past 30 years, I was honored and motivated. I love our industry and enjoy writing and learning as much about it as I am able to.

The editor also suggested that the piece not be a "year-by-year account, but something that will be a review to veterans and an easy introduction to newcomers."

And I liked that challenge. As I was thinking about the article, my mind wandered to what was really fundamental to QA/QC for coatings. There are, of course, all the cool tools of our trade: gages, meters, electronics, comparators, etc. But I wanted to know what was really, really fundamental, which led me to evaluate how I work for my clients.

What if I were being paid by a client to provide this type of presentation?

One of the things I try to focus on in my consulting business is root-cause analysis. That is, let's say we've been hired to design a coating for the inside of a sulfuric acid tank. Instead of just picking a coating system, we would also look into keeping moisture out of the carbon steel tank. If we could set up a dehumidification system, the tank would not actually need to be lined.

A better and real-life example of looking at corrosion (which is why we're all here in the first place) from a truly fundamental lens is the dome being built to cover the nuclear reactor at

Chernobyl nuclear reactor: The decision to use air conditioning instead of coatings to prevent corrosion of steel in the extraordinary dome that will protect the reactor was based on root analysis, fundamental to QA/QC for all coating issues. iStock

Chernobyl. As some of you might recall, Chernobyl was the single worst nuclear power reactor disaster in history.

Dozens of countries contributed to the development of the "new safe confinement" (NSC). This is an unimaginably huge arch, measuring 110 meters high, 250 meters wide, and 150 meters long, and weighing in at 30,000 tonnes. The NSC is being built 600 meters away from the damaged reactor and will be slid in place, over it, in 2015. The NSC is designed to last for at least 100 years and to cost an estimated $1.2 billion dollars.

The arch is made of carbon steel and is hollow—in order to provide monitoring of the interstice in case there should ever be an internal breach. Well, the question was, how do you internally protect this interstice from corrosion? Painting, of course, is an option, but too dangerous in this situation, because of the proximity of deadly radiation and access. How did they solve the problem?

Easy. Engineers are going to keep the interstice air-conditioned—through dessicant dryers—to keep the humidity below 40%, below which carbon steel cannot corrode, due to the absence of the electrolyte, humidity.

So in thinking about my current task of what is new, I first started thinking about what was old and what was really fundamental to, or at the root of, all coating issues.

Way Back Then and Now: Coatings and QA/QC

I thought about a video I had recently seen on the design of ancient byzantine floor mosaics. These mosaics, many of which are thousands of years old, were designed to last well, for thousands of years. They were on floors, so they were, for example, walked on, rained on, and cleaned (one presumes).

And many of them are in excellent condition today.

What's different about an ancient mosaic and a modern-day floor coating application? Fundamentally, not a darn thing.

The video showed that the mosaic surface, which is all we see, is actually on a bed of layered terra-cotta and other fill, in order to provide a sound base. This would correspond to our concrete floor or secondary containment today.

Then a thick plaster of lime, plaster dust, water, and other materials was mixed and troweled onto the bed, and small pieces of glass and other durable materials were placed, by hand, into the parge coat.

The plaster was designed to take a long time to cure, so that the artist would have plenty of time to place the mosaic tiles into the material.

How is this different, say, from an epoxy broadcast floor system? Well, again, it's not.

In both cases we're dealing with a solid substrate. With the mosaic, it would be a layered bed of stone with a solid parge coat. Today, the solid substrate would be our concrete floor. (We are assuming that both are new and clean.) Then, a material (today, a clear epoxy resin—then, a plaster parge coat) is applied—and aggregate placed inside the uncured material.

Did the artisans and contractors thousands of years ago have the tools that we do today to conduct inspections? Of course not. Did that prevent them from successful coating applications? Same answer—of course not.

But let's look back even further, say, 40,000 years. According to a June 14, 2012 *National Geographic News* article (news.nationalgeographic.com), "World's Oldest Cave Art Found—Made By Neanderthals?" there are some caves along Spain's northern coast that contain paintings that are more than 40,000 years old—so far, the oldest in the world. Located at El Castillo, these paintings were made by some type of "mineral-based paint."

(Don't even get me started on Roman frescoes, or ancient cisterns and viaducts that are as water-tight today as they were when they were first specified and built, by contractors wielding camel-hair brushes and wooden trowels, and wearing loin cloths, and of course, baseball caps.)

There are even products that have their ties to these same types of products used thousands of years ago. A company out of Europe has been making a product to protect and beautify masonry since 1878. When I was working on a project not too long ago, I asked the technical rep what the anticipated service life was, and he said something like, "I think there's a church in Southern Italy that's about 110 years old that's still in good shape."

There are hundreds of similar ancient examples, but suffice it to say that we humans have been in the business of painting and coating for quite a while. After all, when the pyramids were built, they were originally lined and covered with marble.

So, in looking back and obsessively thinking about this topic, I've concluded that, fundamentally, the only shift in the past 40,000 years has been from one of qualitative QA/QC to quantitative. That shift continues today, and, certainly, is the biggest difference in the past 30 years as well. We are simply honing our quantitative tools and training.

Was there QA/QC during the time of the pyramids and before? Of course. But back then, it was, for the most part, qualitative. It was the legacy of the tradesman-apprentice relationship that maintained the quality. It was the pride one took in his work. Or, if slavery was a part of the mix, it was the fear of the repercussions for shoddy workmanship.

The basic processes for laying ancient floor mosaics and modern day epoxy broadcast flooring are similar; QA/QC for the mosaic was largely qualitative, while for modern flooring QA/QC is largely quantitative. iStock

Not Nearly as Far Back and Now

When I first started out in the coatings industry at 15 (1977), a gentleman named Vic Johnson worked in our company. His nickname was "Rail" because of the unusually elongated shape of his head. Vic was large and kind. (In fact, he took me to pick up my first car—an AMC Gremlin—from a junkyard when I was 16.) And Vic knew coatings as well as anyone. He could barely read but when it came time to abrasive blast, Vic could tell by looking and touching the surface whether or not it had the right mil-profile and correct visual appearance for proper coating. I'm certain if Vic were around today, he could tell the difference between a 1 mil profile and a 2.5 mil profile by touch. I know there are people reading this article who could do the same.

So if qualitative inspection was sufficient for so many thousands of years, what's all the fuss, rush and research pertaining to quantitative inspections? (For those seasoned folk reading this, yes, there are still qualitative aspects to some of our testing protocols, such as the use of comparators and SSPC-VIS standards)

It's about one thing, and one thing only: consistency.

Today, you don't have to have an apprentice painting contractor with thirty years of experience to apply a challenging tri-coat system. Because of advanced training techniques and highly effective testing tools and techniques, we can apply coatings around the world, in the most challenging of environments and situations in a consistent, predictable, and quantifiable manner.

What Vic had learned from blasting millions of square feet of every material possible, we can now deduce and measure by using visual standards, comparators, replica tape, and electronic as well as mechanical gauges to determine what Vic knew in an instant.

And yet, with all of our tools and training, we still get situations like the Sable Offshore Energy Project in Canada. The offshore oil platform had a coating failure so profound that it was mentioned in a March 8, 2011 article on *PaintSquare News* (www.paintsquare.com) as, "What may be the world's priciest botched paint job [that] could cost hundreds of millions dollars to repair."

Back in the day, when I was spraying thousands of gallons of different paints and coatings, I was able to tell, within a couple of mils, the WFT by

For the ancient pyramids, QA/QC was a matter of pride in craftmanship or fear of retribution for poor work (or both). iStock

appearance. As I applied the coating (either conventionally or airless), I could see the profile of the substrate disappear and the sheen, texture and appearance of the coating change. Of course I would use a wet mil gage to ensure my instinctual hunches, but more times than not, I was spot on.

So, for beginners, I think it is critical to understand why we inspect. And for the more seasoned of us, I am hoping this was an interesting read and, perhaps, put what we do in a different perspective.

So, now that we've established what we do (quantitative inspection protocols) and why (for consistency), let's discuss what has changed over the past 30 years.

And, in keeping with the theme of fundamentals, we're going to talk about two dimensions: Training and Equipment.

First, let me explain why we're sticking with the fundamentals and painting the changes with very broad brush strokes (pun intended). The reason is that any attempt to speak specifically about either Training or Equipment will fall far short of doing either topic justice. For example, let's take a look at the April 2013 issue of *JPCL*. There is an excellent and informative article entitled "Measuring Dry Film Coating Thickness According to SSPC-PA 2."

The article is roughly 10 pages long and more than 4,000 words—and it's just about checking the thickness of a coating after it has cured. The primary focus of the article is on SSPC-PA 2, the intellectual and training aspect of the duo, but, of course, it deals with the tools of our trade. But without even discussing the difference between a Type 1 gauge (magnetic or banana gauge) and a Type 2 gauge (an electronic gauge), the article goes into exquisite and appropriate detail about all of the fundamentals of testing a cured coating.

So, speaking too specifically about either aspect will dilute the importance of either.

Training

When I asked Pete Engelbert, a well-qualified inspector, what had changed the most in the past thirty years, he did not hesitate: "Smarter inspectors. The biggest change has been with the level of sophistication of the inspection—not the equipment," Engelbert said.

Engelbert has a keen understanding of the industry, and he teaches NACE courses around the world. (His credentials include CSP, RPIH, CHST, CET, CIT, CSSM, NACE Certified Coatings Inspector—Level 3 [Nuclear/Bridge], BIRNCS Senior Nuclear Coatings Specialist #12 NACE Protective Coating Specialist, NACE Corrosion Technician, and NACE instructor.)

I asked him to describe a typical inspection scenario from thirty years ago until today. So, we started with a pipe inspection job (which Pete is currently handling).

"Thirty years ago there were very few standards to measure conformance. Now we have multiple standards," Engelbert said.

He also said that thirty years ago during a pipe coating project, it would not be uncommon for an inspector to stand at the top of a the excavation and watch the contractor slop on some "stuff." It would not be uncommon to have a contractor brush on petrolatum, tar, or other materials; wrap it with heavy paper; and bury it. Often, the inspector wouldn't even look at the bottom portion of the pipe to see if it had been addressed. Surface prep wasn't even on the radar.

Today, pipes come shipped, typically, pre-coated with fusion-bonded epoxy (FBE). The inspector's job is to monitor the joint coating process.

Engelbert said that there are roughly 15,000 to 16,000 NACE 1 inspectors worldwide. And the demand for inspectors, particularly overseas, is huge, with SSPC rapidly growing as well.

"Training has taken off overseas," he said. "The next standard (for inspectors) will shift from NACE 1 to a NACE 2 or NACE 3."

Training and development of new standards and guidelines are universal. There are, of course, SSPC and NACE, but there are also IMO, ISO, ANSI, STI, and subsets to all of these. I am currently working on a project for a major oil company pertaining to CUF (corrosion under fireproofing) and related issues. There is a whole universe of guidelines, standards, nomenclature, and tools that are different for the CUF job than, say, a bridge coating project, even though the common denominator remains corrosion.

Another broad example of improved training is SSPC's cutting-edge Quality Programs (QP) and the Painting Contractor Certification Programs (PCCP).

As summarized on SSPC's website (sspc.org), the training is relevant to all aspects of a coating project."…the selection of suitable materials is just one aspect of a successful coating project. It is critical that work is done according to sound specifications, with correct surface preparation and proper application techniques. Facility owners need to find top quality people to provide these services—trained people who know the current standards and practices and have a proven track record of success."

SSPC's QP series is extensive and has modules for contractors, owners/specifiers, and inspection companies.

The trend toward smarter inspectors is profoundly obvious in the introduction to the SSPC-QP 5sm program, "Certification for Coating and Lining Inspection Companies." "QP 5 is a certification for Inspection Companies whose focus is the industrial coating and lining industry. QP 5 evaluates an inspection company's ability to provide consistent quality inspection of coatings & linings for its clients."

Engelbert said another major shift in terms of training has been documentation. Thirty years ago, there was very limited documentation and even less that was standardized. "Many of the daily forms we use today are an offshoot, a progeny, of one of the originals, which was an ANSI standard for coatings in nuclear power plants."

In fact, one of the hallmarks of the SSPC-QP certification programs is an emphasis on documentation.

I think most would agree that the intellectual advances in guidelines, standards, practices, recommendations, etc., move at a relatively slow, predictable pace. That is, a two-mil profile is a two-mil profile. But not so for the tools of our trade. In contrast, there are changes in technology that will change more in the next ten years then they've changed in the last 40,000.

Tools

When speaking with Engelbert about tools, I mentioned that I thought the biggest advance was the ability of the electronic gauges to gather and store data and then network the data directly to other devices.

He laughed and quipped, "Hey, I was just happy when they came out with batteries."

The introduction and continuing development of digital equipment for QA/QC has dramatically changed quantitative inspection of coatings. "Smart" technology meets today's smart inspectors, who have benefitted from QA/QC training, certification, and standards not available 30 years ago. iStock

He said that thirty years ago it was unlikely to get a trained coating inspector on a job in the first place. Very often, "inspection" work was designated and assigned to an individual who might be an inspector for another trade, perhaps a welder, or structural engineer. "You had welding inspectors or others signing off on coatings almost as an afterthought."

He said if a job was fortunate enough to have a coating inspector on site, and he was tasked, say, to measure DFTs, "You'd have one inspector taking measurements with a banana gauge and another walking behind him with a clipboard taking notes."

Now, modern gauges can store almost limitless inspection points and then download them for evaluation.

"Fundamentally, it means the inspector has to get smarter. You have to know how to use a computer and, if you don't, find an eight-year-old to teach you," he said.

Suffice it to say that the fundamental focus of inspection tools in the past thirty years has been in ease of use, storage capacity, and data sharing (USB, Blue-Tooth, wireless), etc.

But the most exciting and most important advances are the cutting edge developments we are seeing now.

The breadth is breathtaking.

I attended a conference about eight years ago in conjunction with the National Center for Manufacturing Sciences (NCMS). One of the latest (at the time) technologies for surface preparation of aircraft was the use of lasers to remove paint. With wings being designed to unimaginable tolerances, the use of an abrasive was impossible because it might damage or warp the wing. The typical means of paint removal was through highly toxic and dangerous paint removers, oftentimes methylene chloride. The technology was in its infancy at the time but is now being widely used to remove paint from aircrafts.

Then there's a November 30, 2011 article from the United States Naval Research Laboratory entitled, "NRL Researchers Develop 'Streamlined' Approach To Shipboard Inspection Process" (http://www.nrl.navy.mil/media/news-releases/2011).

The article talks about inspecting the condition of exterior shipboard coatings. In the case study reported, the work was performed on the USS Aircraft Carrier, the Nimitz.

In a quote from the article, "The manual method required a 65-man-day effort to perform the inspection of the entire topside coating with results taking an additional four weeks to complete. By contrast, we were able to perform the same inspection using digital hand-held cameras with the new process in less than four days including immediate access to over 3,000 images depicting the ship's surface condition for in-depth inspection."

Briefly, the new process includes highly-detailed photographs downloaded and analyzed by algorithms used to quantify the condition of the existing coating.

Going even a step further, we haven't even touched upon the changing technologies pertaining to coatings and how those changes will interact with, and change, technologies for inspection services.

For example, it is not uncommon to use a conductive primer on concrete in order to be able to use a holiday detector on the subsequent topcoat. There are talks of nanoparticles that may communicate with various devices, the use of fluorescent additives to indicate DFT, etc.

Conclusion

Are we far from the day when new coating systems will work in concert with new technologies to speed and improve our ability to quantify and control coating applications?

"I am working with an engineering company that is developing a visor that, using different light frequencies, can see the depth of profile, DFTs, number of coats, wet and dry. After that, who knows? A paint ball gun that could paint an entire water tower tank? It's only a matter of time," said Mr. Engelbert.

Warren Brand is the founder of Chicago Coatings Group, LLC, a consulting firm he formed in 2012. Before opening his consultancy, Brand was the president of Chicago Tank Linings. He has more than 25 years of experience as a coatings contractor, is an SSPC-certified Protective Coatings Specialist and a NACE-certified Level 3 coatings inspector, and holds an MBA and a BA in Journalism. JPCL

SSPC Standards Build on Foundation for Quality in Coatings Work

By the *JPCL* staff

Since the end of 2009, SSPC has made major revisions to three of its Qualification Procedures (QP) standards for contractors and inspection companies, issued a new joint QP standard, and amplified a Technology Update (TU) on inspection. SSPC provided the information below. For more on the standards, go to sspc.org.

Revision of Three QP Standards

A 2012 revision of SSPC-QP 1, Standard Procedure for Evaluating Painting Contractors, clarifies requirements for training and experience for Quality Control Inspectors and Quality Control Supervisors, and the contractor's Environmental Health and Safety Manager. It also requires that the contractor comply with the Coating Application Specialist (CAS) QP 1 implementation plan in effect at the time of the audit for eligible products.

At the end of 2009, SSPC announced several major revisions to SSPC-QP 2, Standard for Evaluating Painting Contractors (Hazardous Coating Removal). The requirements of this procedure are intended to supplement the general requirements of SSPC-QP 1, QP 3 for shop painting (now SSPC-QP 3/AISC 420-10), QP 6 for thermal spray contractors, and QP 8 for contractors that install polymer coatings and surfacings on concrete. The scope has been expanded to cover qualification of contractors who perform hazardous coating removal on marine structures. Requirements for the training of a contractor's Safety Coordinator now include 30 hours of OSHA-approved construction industry safety training not specific to lead-paint removal, in addition to C-3 lead removal competent person training or its equivalent.

In 2012, SSPC overhauled its standard for qualification of inspection companies. The revision of SSPC-QP 5, Standard Procedure for Evaluating the Qualifications of Coating and Lining Inspection Companies, makes the organization of the standard consistent with that of the other QP standards.

In addition to the reorganization, substantive changes were made to the standard.

One of the biggest changes is that QP 5 has been expanded to include companies that inspect coatings on concrete. The 1999 version addressed only companies that inspected coatings on steel. Under the 2012 revision, companies that inspect coatings on either steel or concrete (or on both) may apply for the certification.

Also significant in the revision are changes to the 1999 education and experience requirements for the Technical/Quality Manager and for QP 5 Level 1, 2, and 3 coating inspectors. All have been revised to credit the appropriate inspector certification level from SSPC or NACE toward required training as an alternative to the education and experience requirements for inspectors that were included in the 1999 version.

The 2012 revision also requires inspectors to have experience in protective coating inspection as employees of the firm applying for QP 5 certification. This change assures the inspection company's customers that the inspection company is monitoring its inspectors and that the inspectors are aware of corporate policies and procedures.

New Joint Standard for Shop Painting

In 2010, SSPC and the American Institute of Steel Construction (AISC) issued the joint standard SSPC-QP 3/AISC 420-10, Certification Standard for Shop Application of Complex Protective Coating Systems. This standard incorporates requirements from SSPC's SSPC-QP 3 standard issued in April 2006 and the AISC Sophisticated Paint Endorsement. Although AISC and SSPC will continue to maintain separate qualification programs, applicants to either program will be audited to the requirements of the same joint standard. The standard qualifies shops that apply complex coating systems to new steel. In addition to meeting administrative and document control requirements, qualified shops are required to assign a key person to oversee coating operations, establish a Quality Management System that includes a trained coating inspector, and set up a program to qualify craft workers.

Inspection Document Revised

In 2010, SSPC revised its document, SSPC-TU 11, Inspection of Fluorescent Coating Systems.

Originally issued in 2006, TU 11 discusses the technique and the equipment required to inspect a coating system that incorporates fluorescent properties, the light wavelengths generated by inspection equipment, and the selection of appropriate PPE to protect inspection personnel. The use of fluorescent coatings in a coating system permits faster identification of holidays and areas with low film thickness. The fluorescing properties may also enable the inspector to detect incomplete removal of coatings.

Most of the changes in the 2010 revision consist of editorial clarifications, but the revision includes additional precautionary information on eye and skin exposure and a caution that some defects visible under white or yellow light may not show up under ultraviolet or violet light. TU 11 is referenced in the NAVSEA Standard Item, Cleaning and Painting Requirements, 00-932 FY 13.

Quality Control Equipment and Practice Trends: 2009–Today

By Charles Lange and Brian Goldie, *JPCL*

Quality control is an active process that needs to be a part of any protective coatings plan—from the specification stage, through surface preparation and application, and after the coatings have been applied.

This should be kept in mind as we study the most recent trends in developments in quality control equipment and practices, including faster, more efficient, and ergonomically designed measurement tools, wireless digital equipment and software that cuts out all the paperwork, and thorough and decisive standards and inspection tests. The goal is to supply the contractor or inspector with the tools needed to ensure that the highest-quality quality coatings job is completed. The sampling of trends in development below is primarily based on reporting in *JPCL* and *PaintSquare News*. It is not intended to be comprehensive, and it supplements the article by Warren Brand and the staff articles on recent SSPC standards.

Thickness Gages: In the Thick Of It

Over the past five years, the industry has seen several developments in coating thickness gauges—most instrument manufacturers have either upgraded their existing thickness gauges or released new models with state-of-the-art features designed for use on a variety of substrates and industrial applications. Some of these features include built-in storage memory, high-contrast LCD display, onscreen statistics, USB mass storage, WiFi technology, and others.

Software and Digital Equipment: Goodbye, Paperwork!

As in just about any industry today, protective coatings quality control methods are shifting towards a more digital, computer-driven direction. Many new or updated thickness gages and other inspection instruments have been designed to work with new software and technology, as well.

Manufacturers have released data management software that can download and upload results and images directly from the products and organize them into customized reports from which the user can easily draw conclusions. Most of this software works hand-in-hand, or is built into, the aforementioned new and improved thickness gauges and other field instruments.

Inspection isn't the only part of the quality control process that has inspired new software and technology. New cloud-based applications with features not only dedicated to coatings inspection, but also safety, time management, and accounting functions, have appeared in the market, and allow for immediate storage and analysis of results, cutting down on some of the hazards and human errors that may be involved in taking or reading measurements.

Standards and Test Methods: Does It Pass?

Of course, the measurements and numbers taken with the above tools mean nothing without context, or something to compare them to as a means of quality control. Contractors and inspectors need the most up-to-date, concise, and easily applicable standards and test methods to be able to analyze the results taken from the field.

One of the most important points of reference for any individual in the coatings industry was updated in December of 2011, 16 years after its last edition. ASTM's *Paint and Coating Testing Manual: 15th Edition of the Gardner-Sward Handbook* is the newest comprehensive guide to paint and coatings topics, test methods, procedures, and standards.

Other Measurement Tools: Everything Counts

Quality control pertains to much more than just measuring coating thickness. Like any protective coatings-related undertaking, there are countless factors to consider in order to ensure the highest quality possible.

New quality control instruments and gauges have proliferated the market, including a new soluble salt testing kit, a dolly drill adhesion tester, a dust test kit, a pre-treatment test kit, a dewpoint gauge, a surface profile and thickness gauge, a wet film comb, and a hull roughness gauge developed to test and report on corrosion and biofouling-related roughness on a ship's hull.

The Quest for QC: What's Next?

Increased knowledge of the many factors dealt with during a coatings project has no doubt led to better-trained inspectors performing the job, and that level of sophistication has been the influence behind the equipment developments and practice trends of the past five years. Quality control demands more, and today's equipment has been able to provide it. There's no reason to think this level of sophistication will top off on the inspection end, so equipment should continue to develop hand in hand.

Perhaps most importantly, though, is that these methods and equipment will be employed by better-trained, smarter inspectors and contractors—because even with all of these new technologies, quality control still needs the human touch.