2008 Offshore Conference Still on Solid Ground

The 2008 Offshore Technology Conference (OTC.08), the world's largest event for the development of offshore resources in the fields of drilling, exploration, production, and environmental protection, will be held May 5–8 at the Reliant Center in Houston, TX.

Founded in 1969 and organized by the Society of Petroleum Engineers (SPE), the event is held annually at Reliant Park.

The conference is intended as a venue for professionals, service industries, and suppliers to gather and discuss common issues of ocean resource development. Technological innovations and forums on economic, social, and political aspects of resource development and environmental protection have been the mainstay of this worldwide conference. An exhibition of goods and services will be held concurrently with the conference.

The technical program at OTC will feature more than 300 presentations covering the latest topics, technologies, and innovations in today's exploration and production industry.

This year's event features a topical luncheon that may be of interest to professionals in the field of industrial and maintenance coatings. The luncheons are presented by experts who discuss a broad range of topics, including management, implementation, research, and technology-related fields in the offshore industry.

On Monday, May 5, interested conference goers can attend the luncheon, "Offshore Oil and Gas Turns 70: Is Rust More Evil Than Depletion?" The presenter is Matt Simmons, chairman, Simmons & Company International. Preventive maintenance of the rapidly aging offshore infrastructure will be addressed. The title refers to the fact that the year 2007 marked the 70th anniversary of when the first offshore well was drilled beyond the sight of human beings.

More than 67,000 people visited OTC.07—a 25-year high and an increase of 13% over 2006, according to SPE. The exhibition at OTC.07 expanded for the first time into the adjacent Reliant Stadium and added more outdoor exhibit space. Nearly 2,400 companies from more than 30 countries participated in the show, and SPE says it expects the number to grow for this year's exhibition.

For more information, or to register, visit the conference website at www.otcnet.org; or contact OTC customer service—tel: 301-694-5243 or 866-229-2386; fax: 301-694-5124.

Wheelabrator Names Vice President/General Manager

Martin Magill was recently appointed vice president and general manager of Wheelabrator Group and Wheelabrator Plus Commercial Operations (La Grange, GA).

Martin Magill

In this capacity, Mr. Magill is responsible for aftermarket commercial operations for the U.S., Canada, and Latin America, including business performance and execution, process improvement, market development, sales effectiveness, and regional expansion. Mr. Magill joined Wheelabrator Group in 2004 after eight years with General Electric's Plastics Division.

Wheelabrator Group offers technologies, products, and services for surface preparation and finishing operations.

Marine Coatings Conference Returns to SMM

A two-day international Marine Coatings Conference (previously the PCE Marine Coatings Conference) will take place September 24-25, 2008, during the SMM Trade Fair in Hamburg, Germany.

Organized by the MPI Group and sponsored by *Drydock* magazine, the conference will be held in association with the *Journal of Protective Coatings & Linings* and the SMM Trade Fair. It will be of interest to individuals involved in coating application, including shipyards, owners and operators, contractors, and class societies.

The conference will examine how the marine coatings industry is reacting to current and changing regulations; the problems that have been identified in implementing the regulations; and the challenges that might be encountered in meeting future legislation. Also covered will be the development of new products, equipment, and processes for surface preparation and coating application.

For more information, contact Brian Goldie: brianpce@aol.com.

On Minimizing Waterline Corrosion

To prevent corrosion along the waterline of my facility, I am using a two-component epoxy polyamide formulated for splash zones, and I am getting approximately 3 years of minimal corrosion protection. I do have cathodic protection on sheet pile and piping in brackish water. What else can I do to minimize waterline corrosion?

Al Beitelman,
U.S. Army Corp of Engineers

The question raises numerous follow-up questions, which largely may be summed up as: Why is the paint failing?

I recently evaluated some laboratory panels that I had suspended in aerated ASTM D1141 ocean water. The panels were coated with the standard paint system that we use as a control in our laboratory—3 mils of an epoxy zinc primer and 16 mils of SSPC-Paint 16, coal tar epoxy topcoat. In all cases, the score mark was corroding, but there was no rust undercutting because of the action of the zinc primer. There were no blisters or other failures on the panels, including at the waterline. The performance of the oldest panels, prepared in 1969, was no different than those prepared in the 1970s, 1980s, and 1990s. The difference between the panel studies and what is often called "the real world" is that the coatings were applied to the panels under ideal conditions. The surface preparation actually met the White Metal standard. The prepared surface was dry and had no residual salts. The selected coating system had a proven performance record and was applied according to published guidance. There was no cathodic protection.

If the Forum question relates to selecting and applying a durable coating system to piles before driving, the coating procedure I describe above for my exposure panels can serve as guidance. If the question relates to protecting piles that are already in place, one must be more innovative.

One possible approach to *in situ* application is to use a movable containment structure to dewater the piles, and then paint them while the steel is dry. Although the theory is sound, in practice, water is in the soil behind the piles and will continue to seep through joints and perforations. Coatings are available for application to wet or even submerged surfaces, but they must be able to displace the moisture from the pile surface to work correctly. Applying such a coating by brush or spray may not adequately displace the water, and better results are often achieved by applying coatings to wet surfaces with a roller or pad. Once applied, the coating must cure rapidly enough that it will not be pushed off the substrate by water seeping through the openings. Quickly immersing the newly coated section of pile after painting will counteract the pressure from the soil side and reduce the early failures.

Even though coatings can be applied to wet or submerged substrates with varying success, I personally have not seen any such application equal the performance of a quality coating applied to a dry substrate. Even when the *in situ* substrate receives a quality abrasive blast, it will quickly begin to corrode and be contaminated with salts. Most of the coatings formulated for these applications can tolerate less-than-ideal surface preparation, but long-term performance will still be affected.

The Forum question also raises the subject of cathodic protection (CP). Obviously, with a properly designed CP system, one can prevent corrosion below the waterline. Unfortunately, CP is not very effective in the splash zone, where the highest rate of corrosion is often located. Another problem with CP occurs when someone observes corrosion taking place and boosts the power to fix the problem. The excess current causes any remaining coating to blister, leaving more steel exposed.

A solution to the problem of sheet pile corrosion does exist, but it may not be easy or cheap. The search for a solution must begin by accurately identifying the cause of the coating's short service life. One must consider the quality of the surface preparation, the suitability and quality of the coating materials, the quality of the application, and any forces beyond the obvious immersion (physical impact, microbiological action, electrical effects, etc.) that may be degrading coating performance. An accurate evaluation of the problem provides the basis for selecting and applying a coating system with good long-term performance.

Al Beitelman, a researcher for the U. S. Army Corps of Engineers at the Construction Engineering Laboratory, Champaign, IL, is currently director of the Paint Technology Center. For over 35 years, he has been primarily involved with coating systems for use on locks, dams, and other navigation and flood control structures. He is a member of the SSPC Coatings and Surface Preparation Steering Committees as well as the Standards Review Committee. He has authored numerous publications, including the chapter in the SSPC Painting Manual on "Painting Hydraulic Structures."

Regulatory Update for Industrial Painting:
Current and Emerging Trends in Worker Health and Safety

By Alison B. Kaelin, CQA and Daniel O'Malley, KTA-Tator, Inc., Pittsburgh, PA

The Occupational Safety and Health Administration (OSHA) and the courts have recently taken actions that affect industrial painting contractors and other professionals involved with high-performance coatings. This article reviews several such actions.

Exposure to Hexavalent Chromium Regulated

On February 28, 2006, OSHA published a final standard for occupational exposure to hexavalent chromium (29 CFR 1926.1126); it became effective on May 30, 2006. The standard covers occupational exposure to hexavalent chromium (CrVI) in general industry, construction, and shipyards. Several court challenges were issued regarding the standard, but they have ultimately been resolved. OSHA published a compliance directive, CPL 02-02-074, Inspection Procedures for the Chromium (VI) Standards, on January 24, 2008.

Recent OSHA actions have included clarifying inspection procedures for the hexavalent chromium rule, proposing a rule for confined space in construction, and establishing a special emphasis program on silica that could affect all abrasive blasting.

CrVI is a component of anti-corrosion coatings, including chrome plating and spray coatings, and is found in compounds of chromic trioxide (chromic acid), zinc chromate, barium, chromate, calcium chromate, sodium chromate, and strontium chromate. CrVi is also found in other substances.

Exposure to CrVI is regulated because the compound is a potential lung carcinogen; can damage and irritate the eyes and respiratory tract; and, with prolonged skin exposure, can result in dermatitis and skin ulcers. Some workers can develop an allergic sensitization to chromium. Exposure routes are inhalation, ingestion and skin contact.

Unlike OSHA's lead in construction standard, which requires implementation of requirements based on exposure monitoring, CrVI has several requirements "if chromium is present or likely to be present." Requirements include providing protective clothing; storage facilities; washing facilities, and eating and drinking areas. Employees exposed to CrVI must receive training in the standard and medical surveillance requirements. Additional controls are implemented if worker airborne exposures are measured at or above the Action Level of 2.5 microgram per cubic meter ($\mu g/m^3$) or the Permissible Exposure Level (PEL) of 5 $\mu g/m^3$.

29 CFR 1926.1126 requires that an initial exposure determination be conducted to establish the eight-hour time-weighted average (TWA) exposure for each job classification. The determination requirement can be met through airborne sampling of worker exposures. Alternatively, a performance-oriented option permits the employer to characterize the employee exposure based on a combination of air monitoring, historical monitoring, or objective data. Criteria for the use of historical and objective data can be found in 29 CFR 1926.1126 (b).

Worker airborne exposure monitoring for CrVI requires the use of a PVC filter cassette (different than the cassette used for lead) and requires the submission of two blanks with each sample set.

Both facility owners and contractors should evaluate the potential for the presence of CrVI on their projects through paint chip sampling and analysis for CrVI. The analytical method for CrVI requires a larger sample area (typically 4 in. x 4 in.) than is usually collected for lead and other metals analysis, and the analytical method is different than the one performed for total chromium.

Rule on Paying for Personal Protective Equipment

In 1999, OSHA proposed to require employers to pay for their employees' personal protective equipment (PPE), with few exceptions. The agency re-opened the record in July 2004 to get input on issues related to PPE considered to be a "tool of the trade."

On November 15, 2007, OSHA issued the Employer Payment for Personal Protective Equipment, Final Rule, applicable to construction and most other industry categories.[1] Effective February 13, 2008, the rule's full implementation is required by May 15, 2008. The rule establishes the employer's responsibility to pay for PPE, but specifically

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Editor's Note: this article is based on a paper given in January at PACE 2008 in Los Angeles, CA. PACE is the joint conference at SSPC and PDCA.

exempts footwear, eyewear, and clothing that can be worn elsewhere.

Proposed Rule for Confined Spaces in Construction

OSHA recently issued a proposed rule to give construction workers confined-space protection appropriate to their environment. The Notice of Proposed Rule Making (NPRM) was originally scheduled for December 2005. OSHA published the Proposed Rule for Confined Spaces in Construction in the *Federal Register* on November 28, 2007. Comments were required by January 28, 2008. There are some significant differences between the approach used in the General Industry confined space standard and the proposed Construction Industry standard. The preamble to the proposed standard summarizes the differences (Table 1).

In addition, the proposed standard establishes four classifications of confined spaces, each with its own level of controls.

- Continuous System-Permit-Required Confined Space (CS-PRCS)
- Permit-Required Confined Space (PRCS)
- Controlled-Atmosphere Confined Space (CACS)
- Isolated-Hazard Confined Space (IHCS)

The proposed standard (like the General Industry standard) includes airborne concentrations of substances in excess of the exposure limit established by OSHA (such as lead in excess of the PEL) as a condition creating a hazardous atmosphere. The proposed standard requires such spaces to be treated as a PRCS. This requirement implies that coating removal and application projects conducted in containments may be regulated as permit-required confined spaces. Owners and contractors should also consider the implications of who is responsible for coordination of entry. The responsible party differs from that of the General Industry standard, and the proposal may shift responsibilities for control and coordination of the confined space from the entry contractor to the controlling contractor.

Comments were accepted through February 28, 2008. SSPC provided comments on behalf of its members.

National Emphasis Program on Silica Will Affect Blasting Work

OSHA published a National Emphasis Program [NEP]—Crystalline Silica (CPL-03-00-007) on January 24, 2008. The NEP suggests that its scope may extend beyond silica sand and include all abrasive blasting operations, including the following.

• Monitoring to determine employee exposure to metals, such as lead, arsenic, manganese, chromium, copper and magnesium, present in either the surface being blasted or non-silica abrasive blasting media.

• Ensuring that when an alternative abrasive (e.g., steel shot or grit, glass beads) is selected, an appropriate evaluation of its hazards has been conducted.

• Determining whether the ventilation systems for abrasive blasting room and containment structures prevent escape of dust and provide prompt clearance of dust-laden air.

Additionally, new silica sampling methods are introduced as well as a new method for calculating exposures.

Multi-Employer Worksite Policy Changes

OSHA has had a policy on citing employers on multi-employer worksites for many years. In 1999, OSHA issued a compliance directive (CPL-2-0.124) to clarify the agency's citation policy. The

Continued

Table 1: Key Differences in Regulatory Provisions between the General Industry and Proposed Construction Standards for Confined Space[2]

General Industry Standard	Proposed Construction Standard
Organization	
The standard begins with requirements for entering PRCSs.	The proposed standard takes a step-by-step approach; explaining how to assess hazards, determine the classification for the space, and how to safely enter it.
Information Exchange	
The standard requires a host employer to coordinate entry operations with a contractor when the host employer and the contractor both have employees working in or near a permit space.	The proposed standard requires the controlling contractor to coordinate entry operations among contractors who have employees in a confined space regardless of whether or not the controlling contractor has employees in the confined space.
Confined Space with Hazards Isolated	
Does not address working in confined spaces in which the hazard has been isolated.	Allow employers to establish an Isolated-Hazard Confined Space by isolating or eliminating all physical and atmospheric hazards in a confined space.
Controlled-Atmosphere Permit-Required Confined Space	
Monitoring required as necessary...	Continuous monitoring required unless the employer demonstrates that periodic monitoring is sufficient.
Permit-Required Confined Spaces (PRCS)	
No explicit requirement for entry supervisor to monitor PRCS conditions during entry.	Explicit requirement for entry supervisor to monitor PRCS conditions during entry.
Requires a written PRCS plan...	No written plan required when employer maintains a copy of the standard at the worksite.
No specific early-warning requirements for up-stream hazards.	Early-warning requirement for up-stream hazards in sewer-type spaces.

(2) Obtained from the Preamble of the Proposed Standard

essence of this directive was that on multi-employer worksites (in all industries), more than one employer may be cited for a hazardous condition that violates an OSHA standard. The CPL defined four types of employers for OSHA compliance purposes: controlling, creating, exposing, and correcting. General contractors and construction management companies, and, sometimes, subcontractors are considered to be controlling employers.[3]

The directive advised compliance officers to cite multiple employers (e.g., general, painting contractor, engineering and A/E firms [if they had or assumed roles relative to contractor safety]) on a given worksite when they are determined to be in one of the above categories.

On April 27, 2007, the Occupational Safety and Health Review Commission (OSHRC) overturned a significant component of OSHA's multi-employer policy. In the case of the "Secretary of Labor v. Sumitt Contractors, Inc.," Sumitt (the general contractor) was cited by OSHA for a scaffold standard safety violation by one of its subcontractors; however, none of Sumitt's employees used the scaffolds or were responsible for scaffolding. OSHRC concluded that the controlling employer (i.e., Sumitt) was not responsible for the OSHA compliance by its subcontractors. The OSHRC affirmed that the controlling employers (e.g., Sumitt) are responsible for compliance with OSHA standards concerning those hazards that they create or hazards to which their employees are exposed, but not necessarily those of their subcontractors. The Department of Labor appealed this decision in June 2007.

There is much debate over the potential impact of this ruling. DOL has indicated that it should not affect what OSHA does in states where the "controlling employer" aspect has been upheld; this includes Colorado, Wyoming, Utah, Kansas, New Mexico and Oklahoma. Other areas would be bound by the OSHRC's decision.

The Sumitt decision appears to be a major shift in OSHA's regulation of the multi-employer worksites. General contractors can still expect OSHA citations for safety hazards they create, or those to which their own employees are exposed (regardless of who created them). The construction industry should continue to monitor the results of this appeal.

Ruling on OSHA's Use of Threshold Limit Values for Worker Exposure

On May 11, 2007, a panel of three judges from the U.S. Court of Appeals supported OSHA in a case involving the agency's recognition of Threshold Limit Values (TLVs) as a basis for hazard determination under its Hazard Communication (HAZCOM) Standard. Issued by the American Conference of Governmental Industrial Hygienists (ACGIH), a non-governmental group, TLVs are sometimes more restrictive than OSHA's PELs and Actions Levels for given chemical hazards. ACGIH has also developed TLVs for substances not regulated by OSHA. The basis of the appeal by the National Association of Manufacturers and others was that OSHA's acceptance of TLVs allows OSHA to classify chemical as hazardous (based on TLVs) without the usual procedue for formal rulemaking under HAZCOM.

The industrial hygiene community is closely monitoring this decision.

An upcoming issue of JPCL will review recent EPA regulatory actions that affect industrial coating work.

References

1. www.osha.gov, "OSHA Employer Payment for Personal Protective Equipment," Final Rule, 29 CFR 1910, 1915, 1917, 1918, 1926, November 15, 2007.
2. www.osha.gov
3. "OSHA Multi-Employer Worksite Policy," SSPC 2000 Conference Proceedings (Pittsburgh, PA: SSPC: The Society for Protective Coatings).

Alison B. Kaelin, CQA, is the KTA Corporate Quality Assurance Manager of KTA-Tator, Inc. She is a Certified Quality Auditor (CQA) and a NACE-certified Coatings Inspector. Ms. Kaelin has over 20 years of public health, environmental, transportation, and construction management experience. She has written or co-authored more than 20 papers and articles, has previously co-chaired several SSPC committees, currently co-chairs the task group revising SSPC's QP 2 standard, and teaches widely in the industry. Ms.Kaelin received the SSPC Technical Achievement Award. She can be reached at akaelin@kta.com.

Dan O'Malley is the Director of Environmental Compliance and the Manager of the Environmental, Health and Safety Group for KTA-Tator, Inc., Pittsburgh, Pennsylvania. He has 15 years of experience as an environmental and industrial hygiene consultant in commercial, construction, and industrial settings. He can be reached at domalley@kta.com.

Coatings for Offshore Protection

By Brian Goldie, JPCL

Anti-corrosive coatings are integral to protecting offshore oil and gas structures against the severe exposure conditions of seawater environments. The types of coating systems used have changed over the years due to developments in coating technology, restrictions on the use of some raw materials, and the changing pattern of exploration and production of the oil and gas producers.

To illustrate the coating challenges that oil and gas exploration companies face, this article begins with a brief history of corrosion protection of offshore structures in the aggressive environment of the North Sea. The article then discusses the coating systems currently used by seven North Sea oil-producing companies, both established worldwide operators (including Shell, BP, Total, ConocoPhillips Norway, and StatoilHydro) and one new North Sea owner. The discussion is based on the companies' published coating specification documents and on interviews with coating experts in the industry. The article will consider the corrosion protection of only the structural steel elements of offshore installations and floating production storage and offloading (FPSO) vessels. The article will emphasize coating systems for new building. Corrosion protection of process vessels on fixed leg platforms, storage tanks in FPSOs, and water ballast tanks on FPSOs and tethered structures is beyond the scope of this article.

Changes in Oil and Gas Exploration in the North Sea

Hydrocarbon exploration and production have been taking place in the North Sea for about 40 years. The earliest offshore platforms were in the southern area of the UK sector and are still producing gas today. Over time, exploration and, ultimately, production moved north and spread to other sectors, especially off the Norwegian coast. The early platforms had corrosion protection systems based on practices on rigs in the Gulf of Mexico, but systems for North Sea platforms were enhanced because of the more severe environment. As production moved further north, the performance required from the protective coating systems increased; platforms were now in deeper waters and thus, further offshore, making maintenance painting more difficult and expensive.

Today, exploration and production are in even deeper waters and include smaller producing fields, from which commercial extraction had once been considered unprofitable. Even the smaller fields are being exploited because of the current high prices of crude oil. (The current forward price for the benchmark Brent crude is $104[1] / barrel.) Long-term

Opposite page (top): Typical fixed leg platform Courtesy of RBG Ltd.

Opposite page (below) and this page (left): Typical semi-submersible/moored platforms All photos © BP p.l.c.

protection of the structures in deep waters is important to reducing revenue costs; protective coating systems are now required to give at least 15 years of protection until the first major maintenance. In fact, it is not uncommon to see specifications for 20 to 25 years of protection.

High oil and gas prices have encouraged oil companies to continue working on new projects in the North Sea, and, in fact, worldwide. Established operators are selling some of their older production installations to fuel further exploration, whereas new owners are upgrading the acquired assets to give them life extensions of 20 or more years.

All of the investment in offshore structures must be protected against corrosion. Operators in the North Sea have been instrumental in understanding the needs of the sector and in driving performance up. For example, the Norwegian petroleum industry was responsible for the development of the NORSOK standard, which is considered the gold standard of coating performance for offshore structures. (See sidebar.) It is fitting, therefore, to look to the protective coating systems being used in the North Sea as the benchmark for worldwide offshore protection.

Offshore Structures

Various types of structures are used for oil and gas extraction offshore. The earliest and most common is the fixed leg platform, which will be the first type discussed in this article. The platforms are typically constructed from steel and attached to the seabed by piles.

There is a limit to how deep the structures can be installed, and, for deeper waters or marginal fields, FPSO vessels, the second type of structure to be discussed, are used. FPSOs are often converted crude oil tankers and can be either anchored or tethered.

The third type of offshore structure, common in deep waters, is the tension leg

Norsok Standard M-501

The Norsok standard, M-501, Surface preparation and protective coating (Revision 5), gives the requirements for the selection of coating materials, surface preparation, application, and inspection for protective coatings to be used during the construction of offshore installations. The standard has been developed by the Norwegian petroleum industry to ensure safety, value, and cost effectiveness for the industry and are intended, as far as possible to replace individual oil company specifications.

The standard covers paints, metallic coatings (TSA), and spray-applied passive fire protection systems. The aim of the standard is to obtain a coating system that ensures optimum protection, minimal maintenance, and ease of maintenance. The coating system should be easily applied; its health safety and environmental impacts should have been evaluated and are minimal.

The standard is based on recognised international standards, adding provisions deemed necessary to meet the needs of the Norwegian petroleum industry. The standard also requires that coatings (systems) intended for use must pass an extensive accelerated testing procedure. In addition, painting contractors and inspectors must meet prescribed qualifications for the standard. Contractors must be qualified to trademan level. Inspectors must be qualified to NS 476 or NACE III.

Table 1: New-Building Splash Zone Protection

Operator	Surface Prep	Roughness µm	System	Total dft µm
(1)	Sa 2½		primer / finish = epoxy glass flake 2 x 400 µm	800
	WJ-2L	50-75	primer / finish = modified epoxy 1 x 500 µm	500
	Slurry Blast		primer / finish = epoxy glass flake 2 x 300 µm	600
(2)	Sa 2½		primer = polyamide cured epoxy 75 µm finish = solvent free amine epoxy 500 µm	575
(3)	Sa 2½	75-100	primer = zinc phosphate epoxy 25-40 µm finish = epoxy glass flake 2 x 500 µm	1040
	SSPC -SP 11		primer = zinc phosphate epoxy 25-40 µm finish = epoxy glass flake 2 x 500 µm	1040
(4)	SSPC-SP 5		primer = zinc rich waterborne inorganic silicate	75-100
(5)	Sa 2½	50-75	primer = holding primer if required 1 x 50 µm finish = 2K glass flake polyester or modified epoxy 1 x 500 µm	550
			sealed thermally sprayed aluminum	250
Norsok	Sa 2½	50-85	primer / finish = 2K epoxy min 2 coats	350 min
(6)	Sa 2½	50-85	2 x glass flake polyester	1000 min
(7)	Sa 2½	50-85	as per Norsok	

1 mil ≈ 25 microns (µm)

or tethered structure. These platforms float; they are tethered to the seabed by steel cables.

Areas To Be Protected

This review of the corrosion protective systems for new building will be divided into the structural elements or areas of an offshore platform because the coating system differs depending on the corrosivity of each area's exposure environment. The areas considered are subsea, splash zone, atmospheric zone, and decks. Where necessary, an area will be subdivided in terms of operating conditions and materials of construction.

Coating Specifications

Oil and gas companies have, in most cases, developed their own

Table 2: New-Building Atmospheric Zone (Jacket) Protection

Operator	Surface Prep	Roughness μm	System	Total dft μm
(1)	Sa 2½ WJ-2L	50 - 75	primer = glass flake epoxy 1 x 600 μm finish = acrylic epoxy 1 x 50 μm	650
	Slurry blast		primer / finish = modified epoxy 1 x 500 μm	500
	light to medium flash rust		primer = glass flake epoxy 1 x 500 um finish = waterborne acrylic 1 x 50 μm	550
(2)	Sa 2½		primer = polyamide epoxy 1 x 75 μm finish = solvent free amide epoxy 1 x 500 μm	550
(3)	Sa 2½	50 - 75	primer = zinc rich epoxy 1 x 60 μm intermediate = MIO high build epoxy 1 x 200 μm finish = epoxy modified polysiloxane 1 x 75 μm	335
(4)	SSPC SP 10		waterborne inorganic zinc silicate	75-100
			inorganic zinc ethyl silicate	75-100
(5)	Sa 2½	50 -75	primer = holding primer if required 1 x 50 μm finish = glass flake polyester or modified epoxy 1 x 500 μm	550
Norsok M501 (Rev5)	Sa 2½	50 - 85	thermally sprayed aluminum or alloy 1 x 200 μm sealer = 2K epoxy (no measurable dft)	200
			Thermally sprayed zinc or alloy 1 x 100 μm tie-coat = paint manufact. recommendation intermediate = 1 x 125 μm pre-qualified finish = 1 x 75 μm pre-qualified	300
(6)			2 x glass flake polyester	1000 min
(7)			as per Norsok	

1 mil ≈ 25 microns (μm)

Table 3: New-Building Atmospheric Zone (Topsides) Protection Un-Insulated Carbon Steel

Operator	Temp Range C	Surface Prep	Roughness μm	System	Total dft μm
(1)	120	Sa 2½	50-75	primer / finish = modified epoxy 1 x 400 μm	400
		WJ-2L Slurry Blast		primer = epoxy 1 x 250 μm finish = acrylic epoxy 1 x 50 μm	300
				primer = zinc rich epoxy 1 x 200 finish = waterborne acrylic 1 x 50 μm	250
(2)	120	Sa 2½		primer = alkyl zinc silicate 1 x 75μm intermediate = MIO polyamide epoxy tie 1 x 40 μm finish = aluminum epoxy 2 x 40 μm	195
(3)	120	Sa 2½	50-75	primer = zinc rich 1 x 60 μm intermediate = MIO high build epoxy 1 x 200 μm finish = epoxy modified siloxane 1 x 75 μm	335
(4)	90	SSPC-SP 10		waterborne inorganic zinc silicate	75-100
				inorganic zinc ethyl silicate	75-100
(5)	120	Sa 3		primer = inorganic zinc silicate 1 x 60 μm tie-coat = 2K epoxy 1 x 25 μm intermediate = 2K epoxy 2 x 100 μm finish = acrylic modified polyurethane 1 x 50 μm	335
		Sa 2½		primer = zinc rich epoxy 1 x 50 μm intermediate = 2K epoxy 2 x 125 μm finish = acrylic modified polyurethane 1 x 50 μm	350
Norsok M501 (Rev5)	120	Sa 2½	50-85	primer = zinc rich epoxy 1 x 60 μm intermediate = epoxy x 2* finish = acrylic epoxy x 1	280 min
(6)	120			as per Norsok	280 min
(7)	120			as per Norsok	280 min

F = (C x 9/5) + 32; 1 mil ≈ 25 microns (μm) *dft for intermediate and finish coats are unspecified but total system dft must meet 280 μm at a minimum

Table 4: New-Building Atmospheric Zone (Topsides) Protection Un-Insulated Carbon Steel at High Operating Temperatures

Operator	Temp Range C	Surface Prep	Roughness µm	System	Total dft µm
(1)	121-200	Sa 2½	50-75	primer = phenolic epoxy 1 x 100 µm finish = phenolic epoxy 1 x 100 µm	200
				primer / finish = silicone 2 x 80 µm	160
	201-400			primer = zinc ethyl silicate 1 x 45 µm finish = silicone 1 x 20 µm	65
				primer = zinc ethyl silicate 1 x 50 µm finish = silicone 1 x 25 µm	75
				primer / finish = silicone 2 x 80 µm	160
(2)	120-200	Sa 2½		primer = alkyl zinc silicate 1 x 75 µm finish = silicone acrylic 2 x 30 µm	135
	200-450	Sa 2½		primer = alkyl zinc silicate 1 x 75 µm finish = aluminum silicone 2 x 25 µm	125
	<1100	Sa 2½		intermediate = polysiloxane 1 x 125 µm finish = polysiloxane 1 x 125 µm	250
(3)	120-200	Sa 2½	50-75	primer = epoxy phenolic 1 x 100 µm finish = epoxy phenolic 1 x 100 µm	200
	200-450	Sa 2½	50-75	primer = inorganic zinc silicate 1 x 60 µm finish = silicone aluminum 2 x 25 µm	110
(4)	93-400	SSPC-SP 10		waterborne inorganic zinc silicate	75-100
	<480	SSPC-SP 10		primer = water borne acrylic 1 x 42 µm finish =silicone aluminum 1 x 25 µm	67
(5)	120-350	Sa 3		primer = inorganic zinc silicate 1 x 60 µm finish = modified silicone aluminum 1 x 20 µm	80
				alternative, thermally sprayed aluminum	
	351-550	Sa 3		aluminum thermal spray 1 x 150 µm finish = aluminum silicone 1 x 20 µm	170
				primer = inorganic zinc silicate 1 x 60 µm finish = aluminum silicone 1 x 20 µm	80
Norsok M501 (Rev5)	>120	Sa 2½	50-85	thermally sprayed aluminum or alloys 1 x 200 µm sealer = aluminum silicone (no measurable dft)	200
(6)	>120			as per Norsok	
(7)	>120			as per Norsok	

F = (C x 9⁄5) + 32; 1 mil ≈ 25 microns (µm)

detailed coating specification documents over the years, which reflect experiences the respective companies gained from their and others' structures. Standards produced by recognised national, international and professional association bodies have also figured in companies' developments of specifications, as have national and local regulations that could affect the use of a particular coating in a particular area.

Most specifications describe coatings in terms of generic systems. Each company has its approved list of paint manufacturers from whom the systems can be purchased. However, one company (1) specifies the exact coating system to be used, and gives specific products from alternative manufacturers for each end use, while two others (3 and 5) give generic composition details of the coatings to be used.

The coating specifications also cover, in various detail, required standards and other regulatory documents; contractors' responsibilities; surface preparation; coating application; inspection criteria; and health, safety and environmental issues.

For new building, abrasive blasting is the required or preferred method of surface preparation of steel, with details given about the type and quality of abrasive, degree of surface cleanliness, and profile required. Some companies specifically do not recommend any other type of surface preparation, unless there are operational or environmental constraints, and then UHP or mechanical cleaning can be carried out only with approval from the operator.

For structural steel, the Norwegian operators (6 & 7) follow the Norsok M-501 standard while also having additional specifications that define the operators' particular requirements and that clarify their needs under M-501. In addition, Company 7 specifies application of thin-film coatings in a minimum of three coats, and the company allows only coatings with an average corrosion creep of <1.0 mm in the pre-qualifying tests. Moreover, Company 7 does not permit paint systems as alternatives to metallization

Table 5: New-Building Atmospheric Zone (Topsides) Protection Insulated Carbon Steel

Operator	Temp Range C	Surface Prep	Roughness µm	System	Total dft µm
(1)	<90	Sa 2½ WJ-2L Slurry Blast	50-75	primer = epoxy 1 x 250 µm finish = acrylic epoxy 1 x 50 µm	300
	<150	Sa 2½ WJ-2L slurry blast	50-75	primer / finish = epoxy 2 x 125 µm	250
				primer = zinc rich epoxy 1 x 200 µm finish = waterborne acrylic 1 x 50	250
	< 200	Sa 2½ WJ-2L Slurry Blast	50-75	primer = phenolic epoxy 1 x 100 µm finish = pholic epoxy 1 x 100 µm	200
(2)	–	–	–	system not available	–
(3)	< 200	Sa 3	75-100	primer = thermal spray aluminum 1 x 250 µm sealer = silcone acrylic x 40 µm	290
	>200	Sa 3	75-100	primer = thermal spray aluminum 1 x 250 µm finish = silicone aluminum 1 x 40 µm	290
(4)	< 150 < 260 > 260	SSPC-SP 10 SSPC-SP 10		epoxy phenolic 2 x 75 µm primer / finish = silicone-acrylic 2 x 25 µm coating fit for purpose	150 50 67
(5)	<120	Sa 3		primer = epoxy phenolic 1 x 100 µm finish = 2K epoxy MIO 2 x 100 µm	300
	121-350	Sa 3		primer = inorganic zinc silicate 1 x 60 µm finish= aluminum silicone 1 x 20 µm	80
Norsok M501 (Rev5)		Sa 2½	50-85	thermally sprayed aluminum or alloys 1 x 200 sealer = epoxy or al silicone (no measurable dft)	200
				thermally sprayed zinc or alloys 1 x 100 µm tie coat as per coating manufacturer intermediate = 1 x 125 µm top coat= 1 x 75 µm	300
(6)				as per Norsok	
(7)				as per Norsok	

F = (C x 9/5) + 32; 1 mil ≈ 25 microns (µm)

Table 6: New-Building Topsides: Heavy-Duty Deck Protection

Operator	Surface Prep	Roughness µm	System	Total dft µm
(1)	Sa 2½	50-75	primer = epoxy 1 x 125 µm deck coating = epoxy 1 x 3000 µm	3125
			primer = modified epoxy 1 x 900 µm deck coating = modified epoxy + aggregate 1 x 250	1150
			primer = zinc rich epoxy 1 x 125 µm deck coating = glass flake epoxy + aggregate 1 x 3000	3125
(2)	–	–	system not available	–
(3)	Sa 2½	75-100	primer = epoxy zinc phosphate 1 x 50 µm 1st coat = modified epoxy 1 x 800 µm deck coating = modified epoxy + aggregate 1 x 400 µm	1250
(4)				
(5)	Sa 2½		primer = zinc rich epoxy 1 x 50 µm deck coating = sand-filled epoxy + aggregate 1 x 3000 µm sealer = 2 pack epoxy 1 x 50 µm	3100
Norsok M501 (Rev5)	Sa 2½	50-85	non-skid epoxy screed	3000
(6)			as per Norsok	
(7)			as per Norsok	

F = (C x 9/5) + 32; 1 mil ≈ 25 microns (µm)

on jacket legs between the splash zone and the underside of the deck, or for steel >120 C (248 F) and insulated steel substrates.

None of the companies considered for this article paint non-ferrous substrates, and most do not paint stainless steels unless necessary.

New Building

Subsea Areas

Philosophies differ for corrosion protection of the underwater area of fixed platform legs. Some companies do not coat the legs but instead rely on the designed corrosion allowance and cathodic protection. Other operators coat the legs (with or without additional cathodic protection—sacrificial anode). Of the companies surveyed, only the Norwegian operators who follow NORSOK Specifiation M501 (revision 5), and one other operator specified coating systems for subsea application.

The Norsok specification calls for blast cleaning to Sa 2½ with a surface profile or roughness of 50–85 microns (~2–3 mils) and a minimum of two coats of a pre-qualified two-component epoxy to a minimum dft

Table 7: New-Building Topsides- Carbon Steel Beneath Fire Proofing

Operator	Surface Prep	Roughness µm	System	Total dft µm
(4)		SSPC-SP 6	primer = epoxy phenolic 2 x 75 µm	150
(5)	Sa 3	50-75	primer = inorganic zinc silicate 1 x 60 µm tie-coat = 2 pack epoxy 1 x 25	85
	Sa 2½	50-75	primer = zinc rich epoxy 1 x 50 µm	50
Norsok M501 (Rev5)	Sa 2½	50-85	primer = epoxy 1 x 50 µm	*
			primer = zinc rich epoxy 1 x 60 µm	*
			tie-coat = 2 pack epoxy 1 x 25 µm	85
			primer = zinc rich epoxy 1 x 60 finish = 2 pack epoxy 1 x 200 µm or 2 x 100 µm	# 260
			as per Norsok	
(6) (7)			as per Norsok	

F = (C x $9/5$) + 32; 1 mil ≈ 25 microns (µm) * under epoxy-based fire protection # under cement based fire protection

of 350 microns (~14 mils). One oil company (5) specification calls for blast clean-ing to Sa 2 ½, a holding primer(50 microns [2 mils]) if required and one coat of glass-flake reinforced polyester or modified epoxy at 500 microns (20 mils) dft.

Companies considered for this article treat the subsea areas of floating structures and FPSOs more like marine vessels, specifying a conventional corrosion protection system with an antifouling topcoat system.

Splash Zone

The most aggressive exposure of the platform, the splash zone includes the inter-tidal area and the area wetted by wave surges and spray. Typically, the splash zone extends from 3 m (~10 ft) below the lowest astronomical tide (LAT) to 12 m (~40 ft) above the LAT.

Table 1 shows typical systems used in this area. High film builds and three-coat systems are usual, and, because of their excellent corrosion and abrasion resistance, glass flake-reinforced coatings are common in this area.

Atmosheric Zone (Jacket)

On fixed leg platforms and tethered platforms, the jacket is the area from the top of the splash zone to the underside of the main deck. The systems specified for this area are shown in Table 2. Again, high-performance systems are used; epoxies, with or without finish coats, are commonly approved. Norsok calls for metal sprayed systems. One Norwegian operator has reported very good results with glass flake polyester at high dry film thicknesses, and specifies this system in place of the Norsok system.

One operator (3) specifies the use of a polysiloxane topcoat; however, the use of this type of coating is under investigation. Due to coating failures with polysiloxane topcoats reported on various structures offshore after a short time (2–5 years), the Norsok Expert Group Materials (EG M) established a task force in March 2006 to log the painting problems linked to the use of polysiloxane top coats and propose recommended actions to the Norsok EG M.

Polysiloxane topcoats had been used in the main coating systems for offshore atmospheric exposure as part of two-coat and three-coat systems; on top of intumescent fire proofing; and as a top-coat in maintenance painting on partly removed old coating and prepared substrate. The main damage to the coating appeared as breakdown and flaking of the topcoat in two-coat zinc epoxy/polysiloxane systems, but failures were also reported in the above other systems.

The Task Group noted that there are considerable variations in performance with different polysiloxane products, and that some of the latest generation polysiloxanes on the market appear to be acceptable for use and should consequently still be accepted for use in M 501. Specifiers should be careful when selecting polysiloxane topcoats and should get assurance from the paint manufacturer that its field and laboratory testing has shown that the product is fit for purpose. To minimize the risk of flaking, the applicator should strictly adhere to the paint manufacturer's application recommendations. The Task Group also recommended using an epoxy tie-coat on epoxy-based intumescent passive fireproofing before applying a polysiloxane topcoat.

Topsides

Table 3 gives the various systems used to protect structural steelwork on the platform topsides under normal conditions. Multi-coat system systems are still commonly used, but the systems vary greatly depending on the oil companies' experiences in this area and to some extent the companies' national origins.

Higher Operating Temperature Service

Table 4 gives specifications for coating systems operating up to 550 C (~1022 F) on uninsulated carbon steel substrates. Again, there is a range of commonly used high temperature coatings as found in a variety of industries/ environments. Table 5 lists coatings for use under insulation operating on carbon steel equipment operating up to about 350 C (~622 F).

Deck Coatings

Typical heavy-duty systems for steel decks operating at ambient temperature are given in Table 6. High film thickness epoxy systems and the use of non-sparking aggregate for non-skid applications are the normal systems all operators referenced for this article use. For lighter duty decks, similar systems at lower film thicknesses are used.

Fireproofing

Norsok M 501 gives detailed instructions for application of passive fire protection, including the need for wire mesh reinforcement.

Cementitious-based fire protection should be protected externally by a coating that retards or stops the migration of carbon dioxide and moisture into the fire protection. Specifiers should pre-qualify topcoats that fireproofing manufacturers recommend.

Selection of the fireproofing coating, which should be approved for use with jet-fires, should be made in conjunction with the coating manufacturer, who can advise on the type and thickness required for the desired protection time. Table 7 shows the coating systems that some of the operators use under spray-applied passive fire proofing.

Conclusion

Corrosion prevention systems on offshore platforms rely heavily on the use of organic coatings. Coating specifications, to give long life protection with minimal maintenance, have been developed by the offshore operators over a number of years, with properly applied coatings performing in excess of 15 years in this very corrosive environment.

Health & safety and environmental concerns have already restricted the use of some systems that had a good track record in this area (e.g., epoxy coal tar), and other restrictions on product availability could occur due to further changes in regulations, e.g., REACH. However, advanced accelerated test protocols have also been developed by the standards bodies to enable new high-performance coating systems to be evaluated for this use, and give confidence to the operators about actual performance.

References

1. The Times, London, 12th March 2008

Investigating Corrosion Protection of Offshore Wind Towers

Part 1: Background and Test Program

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The installation of offshore wind energy mills in both the North Sea and the Baltic Sea is one of the most recent approaches for alternative production of energy. A number of offshore wind energy parks have already been established in these areas, and others are under consideration. An offshore wind energy mill basically consists of a foundation, the actual tower, and the turbine-rotor construction (Fig. 1).

The tower is usually mounted on the foundation by a bolted flange. This article deals with the corrosion protection of the towers and part of the foundation. These towers are ambitious engineering constructions. They can be as high as 80 meters for offshore installation; the diameter can be as large as 7 meters; and the wall thickness can be in the range of several centimeters (Fig. 2).

Offshore wind energy towers are exposed to harsh and complex stresses, including the following:

- corrosive stress,
- physical load, and
- biological stress.

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Burbo Bank Offshore Wind Farm (Liverpool Bay)
Courtesy of Siemens Wind Power

This article deals mainly with the corrosive stress, although researchers found that biological stress may also play a role in the conditions offshore. The corrosive stress includes features such as seawater exposure, wet-dry cycles, temperature variations, construction details (joints, bolts, welds), and construction materials (material combinations).

The location of steel structures several miles offshore is not a new situation. Oil and gas exploration and extraction platforms have performed in such areas for decades. The coating industry has, over the years, developed special coating systems, to protect offshore structures from corrosion. A simple approach for protecting offshore wind energy towers could be to adapt coating systems for offshore platforms to the wind towers. This approach would also allow for the use of standard assessment schemes developed by the industry and regulatory bodies.[1,2] There are, however, critical differences between platforms and towers, the most significant being that offshore wind energy towers are unmanned structures with highly restricted access. On oil and gas platforms, corrosion protection systems are generally under permanent inspection, which is not the case on offshore wind energy towers. Thus, whereas on oil and gas platforms, areas of deteriorated coating can be recognised and repaired comparatively easily, such repairs are not feasible on offshore wind energy towers.

In this article, the authors discuss a nationally funded project on the performance testing of different corrosion protection methods under site and laboratory conditions. This first part deals with the rationale behind, and the setting-up of, the test program. A second article will discuss the test results.

Corrosive Stress and Corrosivity Category

Corrosive stress depends largely on the location of a structure. An offshore wind energy tower, as a sea-based construction, has significant exposure in several zones, including the following:[2,3]

- underwater zone (UZ), the area permanently exposed to water;
- intermediate zone (IZ), the area where the water level changes due to natural or artificial effects, and the combined impact of water and atmosphere increase corrosion;
- splash zone (SZ), the area wetted by wave and spray action, which can cause exceptionally high corrosion stresses, especially with seawater.

The environmental zones above can be classified as per Fig. 1. Corrosion zones considered in this study are marked. The corrosion rate of steel in these environments can be greater than 2.5 mm per year.[4] It is already known that corrosion rates of steel are highest in the splash zone.[4] Table 1 lists results reported in reference 4. In Table 1, the splash zone, which features the flange connection between foundation and tower, seems to require particular attention for corrosion protection. However, using the values in Table 1 requires caution, because they are based on the corrosion of unprotected steel, whereas the present investigation deals with the performance of protective coating systems over steel.

Two corrosivity categories must be considered for offshore wind energy mills:[3]

- C5-M: very high, marine; coastal and offshore areas with high salinity, and
- Im2: seawater or brackish water (including offshore structures).

Selection of Corrosion Protection

Systems for Wind Energy Towers

The specification for a corrosion protection system for wind energy towers should address the following demands:

- high corrosive stress due to elevated salt concentration in both water and air,
- mechanical load due to ice drift or floating objects,
- biological stress, namely under water,
- notable variations in temperature of both water and air,

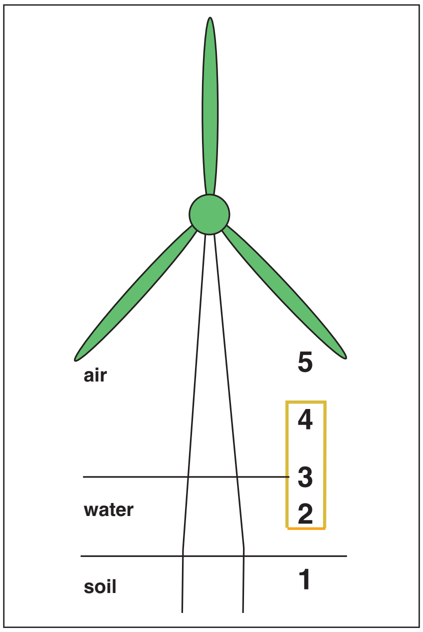


Fig. 1 (Left): Corrosion zones on offshore wind energy towers. 1= buried in soil; 2 = underwater zone (UZ); 3 = intermediate zone (IZ); 4 = splash zone (SZ); 5 = atmospheric zone
Courtesy of the authors

Table 1: Corrosion Rates of Steel in Offshore Service[4]

Environmental zone	Corrosion rate (mm/year)
Buried in soil	0.1
Underwater zone (UZ)	0.2
Intermediate zone (IZ)	0.25
Splash zone (SZ)	0.4

• long and irregular inspection intervals because of reduced accessibility, and
• high maintenance and repair costs in case of coating failure.

The formal way to select a system is to consider the corrosivity categories according to reference 3. If the categories are combined with a given durability range, general coating system schemes can be pre-selected.[5] The general scheme covers the following coating parameters: binder, primer type, number of coats, and nominal dry film thickness. A typical system that meets the corrosivity categories C5-M and Im2 would include a zinc-rich, epoxy-based priming coat (60 µm); three subsequent epoxy midcoats, and one polyurethane topcoat, with a total nominal dry film thickness of 400 µm. However, this selection process considers only organic coating systems, not the detailed application of metal coatings, which are quite common on wind energy towers. Coating systems, typically applied to traditional offshore structures, are specified in reference 2, where hot-dip galvanised and metallized steel substrates are included.

Reference 6 reviews coating systems applied to offshore wind energy towers in the past. The systems basically consisted of a Zn/Al-metallization, organic pore filler, several intermediate epoxy-based coats and a polyurethane-based topcoat. A typical total dry film thickness was about 400 µm. Reference 7 describes a coating system on offshore wind energy towers that provides high abrasion resistance.

Table 2: Qualification Tests for Offshore Coating Systems (ISO 20340)

Test	Artificial scribe	Testing duration for Im2		
		SZ	IZ	UZ
Ageing resistance*	Yes	4,200 h	4,200 h	-
Cathodic disbondment	ISO 15711	-	6 months	6 months
Seawater immersion (ISO 2812-2)	Yes	-	4,200 h	4,200 h

*See written text, pp. 34-35.

Fig. 2: Dimension of a typical wind tower construction
Courtesy of Muehlhan A/S, Vissenbjerg

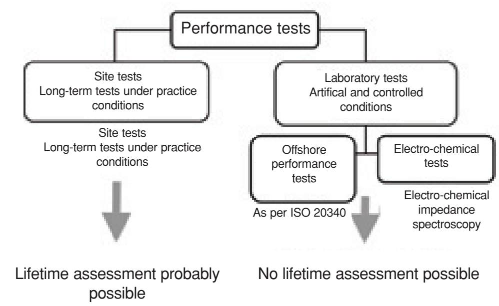


Fig. 3 (Above): Summary of performance tests
Courtesy of the authors

Test Procedures

Testing and assessment methods for corrosion protection systems may be subdivided into laboratory tests under defined artificial stress conditions and site tests under real stress conditions. Figure 3 summarizes all tests for the present study.

The site tests included long-term exposure tests in a real corrosion environment. They were performed at the seawater test site at the island of Helgoland, 70 km off the German coast. The test site featured three galleries: one for the underwater zone (UZ) environment; one for the intermediate zone (IZ) environment; and one

Table 3: Parameters of the Cathodic Disbonding Tests

Parameter	Test A, based on (9)	Test B, based on (8)
Exposure time	30 days	180 days
Applied cathodic potential	-1,450 mV_{SCE}	-1,050 mV_{SCE}
Electrolyte	Potable water; added: 10 g/l sodium chloride 10 g/l sodium sulphate 10 g/l sodium carbonate	Demineralized water; added: 23.8 g/l sodium chloride 9.8 g/l magnesium chloride 8.9 g/l sodium sulfate 1.2 g/l calcium chloride

Fig. 4 (Left): Outdoor test stand at Heigoland with specimens. Courtesy of the authors

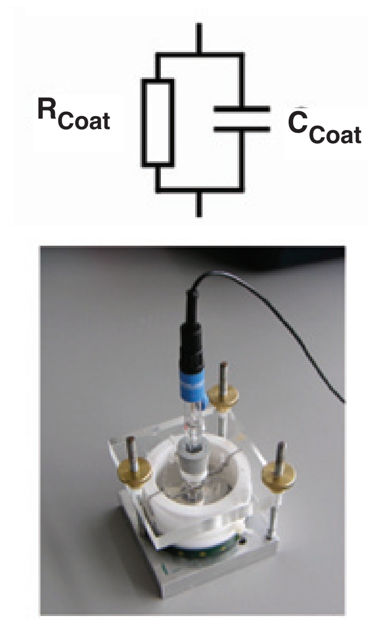


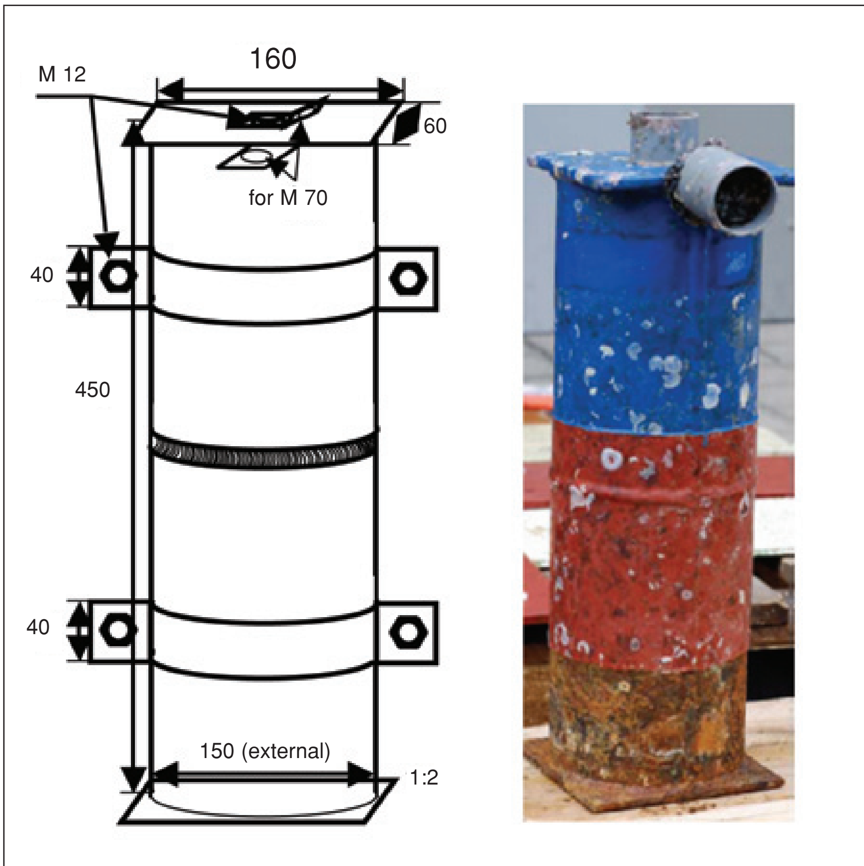
Fig. 5 (Left): Set-up for electrochemical impedance spectroscopy measurements, and equivalent circuit
Courtesy of the authors

Fig. 6 (Below): Specimen design for underwater zone (UZ); dimensions in mm
Courtesy of the authors

for the splash zone (SZ) environment. Figure 4 shows the test site, where the specimens for the SZ and the IZ can be recognized. The specimens for UZ, which are submerged, can be seen as discoloration of the water surface. All specimens were tested for three years. Part of the site test procedure was cathodic protection, consisting of an impressed current system. The applied potential was controlled to -880 $mV_{Ag/AgCl}$.

The laboratory tests were subdivided into ageing tests according to ISO 20340,[2] cathodic disbonding tests,[8,9] and tests based on electrochemical impedance spectroscopy (EIS). All tests were performed in the laboratory at IFAM, Bremen. The procedure prescribed in reference 2 includes a combination of UV/condensation, salt spray, and low-temperature exposure cycles. The exposure cycle in the procedure lasts a week (168 hours) and includes the following stresses (see also Table 2):

• 72 hours (3 days) of exposure to UV (UV [B] lamps) and water,



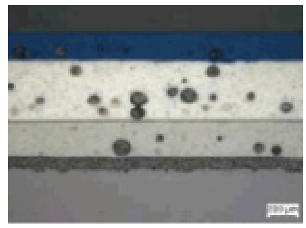
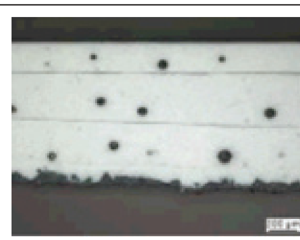
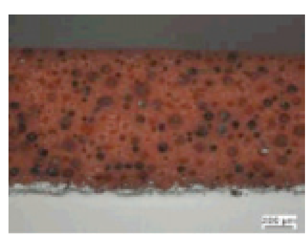
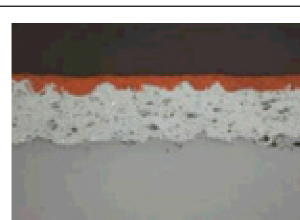
• 72 hours (3 days) of exposure to salt spray, and
• 24 hours (1 day) of exposure to low temperature (-20 C ± 2 C).

A total of 25 cycles (25 weeks) were run. Part of the assessment procedure was cathodic disbonding according to references 8 and 9. For these tests, specimens with the design shown in Fig. 10 (p. 49) were used. Holes were drilled through the coating down to the substrate, and the samples were exposed to synthetic seawater. Table 3 lists details on the test parameters.

However, these tests are plain pass/fail tests. Although they allow for a comparative evaluation of different paint systems, they do not provide information on the paint degradation processes or on corrosion progress. A promising method for gathering degradation and corrosion information on coatings for wind energy towers is EIS.[10,11] Therefore, additional EIS tests were performed on a number of laboratory samples. EIS was carried out on coated steel specimens, which had been stored in a 3% NaCl solution for up to 62 days. The measurements were performed according to the three-electrode-method with an onset cell of 8 cm diameter. The testing device is shown in Fig. 5. The spectra were measured from 100 kHz to 0.01 Hz; with a potential amplitude of 20 $mV_{Ag/AgCl}$. From the obtained spectra, barrier resistances were determined by fitting a simple RC (ohmic resistance/capacitor) equivalent circuit (Fig. 5).

In addition, probable contact corrosion between dissimilar metals was investigated. These investigations were applied to the contact between the bolt material in the flange area and construction steels. The contact areas were assessed visually.

Table 4: Coating Systems

System number	SEM cross section	System composition (DFT)				Total DFT in µm
		Primer	2. Layer	3. Layer	4. Layer	
1		Zn-EP (80 µm)	EP (300 µm)	EP (300 µm)	PUR[1)] (70 µm)	750
2		Zn-EP (80 µm)	EP (450 µm)	EP (450 µm)	-	980
3		Zn/Al (85/15)[2)] (100 µm)	EP[3)] (20 µm)	EP (450 µm)	EP (450 µm)	1,020
4		Zn/Al (85/15)[2)] (100 µm)	EP[3)] (20 µm)	EP[4)] (450 µm)	EP[4)] (450 µm)	1,020
5	No image available	EP[5)] (1,000 µm)	-	-	-	1,000
6		Al/Mg (95/05)[2)] (350 µm)	EP[6)] (40 µm)	-	-	390

1) topcoat; 2) metallization; 3) primer + pore filler; 4) particle reinforced;
5) applied in one layer; 6) (pore filler); SEM - scanning electron microscopy

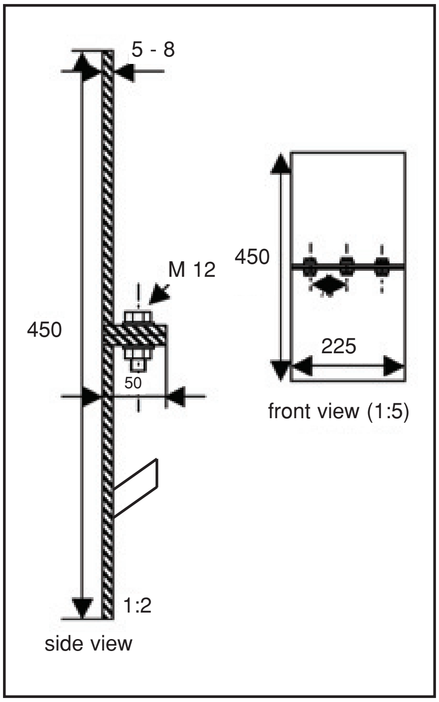


Fig. 7: Specimen design for splash zone (SZ); dimensions in mm
Courtesy of the authors

Test Samples

Outdoor Test Samples

Design rules for offshore wind energy tower follow the function of the tower. Low-corrosion design is a secondary issue. Therefore, the towers are complex structures with construction details such as bore holes, bolted connections, flanges, weld seams, bracings, steel sections, and coating overlap. Few approaches have been made in the past to consider these details. Bailey et al.[12] were probably the first to simulate construction details of offshore structures. Their specimen featured a plate with bore holes, I-beams, a pipe section, edges, weld seams, and bolts. Wilds[13] manufactured specimens containing a welded pipe section, angled parts, weld seams and I-beam, and he investigated the performance of organic repair coating systems. The author found a notable effect at the weld seams.

For the present study, researchers designed and manufactured three types of special specimens: for the UZ, for the IZ, and for the SZ (Figs. 6 to 8). The use of the specimens embodying on a small scale the typical structural features of a real offshore wind energy tower is considered a new approach in testing. All outdoor samples were made from high-strength, weldable construction steel, S-355.

The samples for the UZ were steel pipes. The pipes were filled with seawater and then sealed. These specimens contained weld seams at the uncoated and coated sections. They also featured a connection for cathodic protection (see Figs. 6 and 8). About 60% of the surface was coated. The specimens for the IZ zone were simple steel plates (Fig. 8). After an exposure for 13 months, researchers scribed the IZ-samples to promote corrosion.

The specimens for the SZ consisted of two parts bolted together (Figs. 7 and 8). The lower part embodied the end of the foundation structure where the actual tower construction, embodied by the upper part of the specimen, rests. Both parts of the specimen featured a flange end, which was welded to the main body. The flange sections were metallized but not coated. Made from high-alloyed steel (AISI 304), the bolts represented the contact between dissimilar metals. The SZ specimens also contained an angled steel panel welded to the lower part. This construction detail may characterize design that promotes corrosion (Fig. 8).

Fig. 8: Coated specimens for outdoor testing. Upper: Splash zone (SZ) specimens. Center: Intermediate zone (IZ) (originally without scribe, no effect after 13 months; scribe added after 13 months to produce mechanical damage to the systems.) Bottom: Underwater (UZ) specimens
Courtesy of the authors

Laboratory Test Samples

Three types of laboratory samples were manufactured. The first type covered the specimens for the degradation tests according to ISO 20340.[2] The dimensions were slightly modified (Fig. 9). The coated specimens were provided with two artificial scribes to simulate localized mechanical damage. Position and dimensions of the scribes

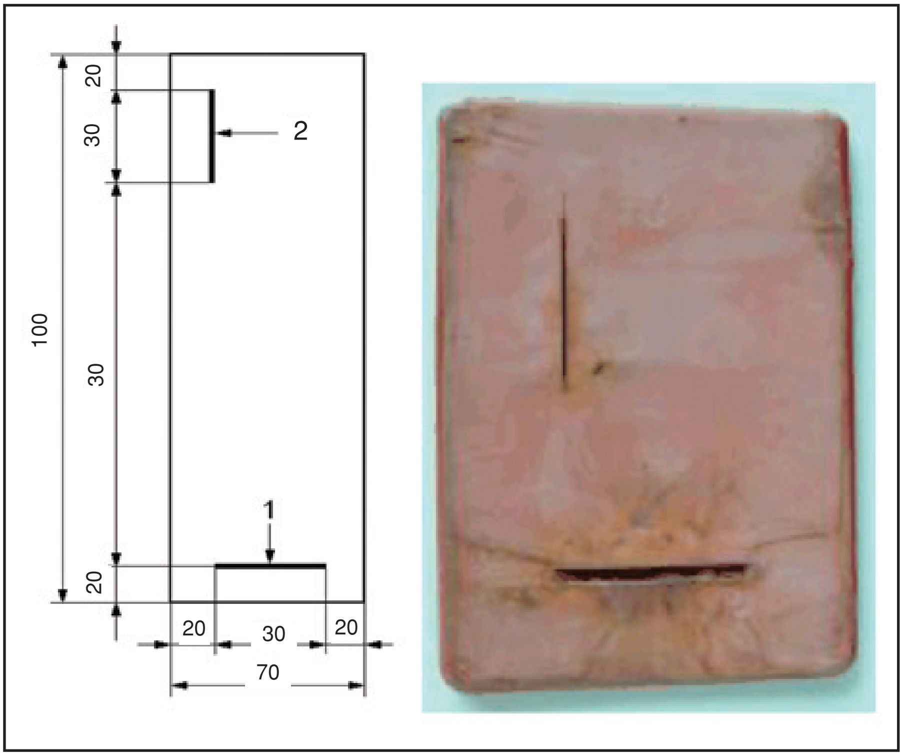


Fig. 9: Specimen design for the tests according to ISO 20340 (2); dimensions in mm
"1" = 2-mm-wide scribe; "2" = 0.05-mm-wide scribe
Courtesy of the authors

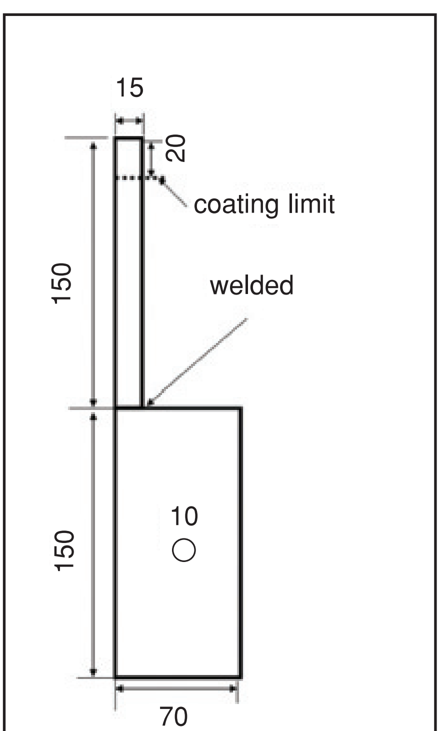


Fig. 10: Specimen design for the cathodic disbonding tests; dimensions in mm
Courtesy of the authors

can be read from Fig. 9. The second type covered the specimens for the cathodic disbonding tests (Fig. 10). The specimen consisted of a lower primary section and an upper, smaller secondary section, whereas the top part of the upper section remained uncoated. A hole with a controlled cross section (Ø 10 mm) was drilled through the coating down to the plain steel in the center of the specimen. The third specimen, used for EIS-measurements, was a simple, coated plate 30 mm x 30 mm.

Coating Systems and Coating Materials

Corrosion protection scenarios can be subdivided into three categories: active methods, passive methods, and temporary methods. Active methods include the selection of corrosion-resistant materials, designs reducing the risk of corrosion, and cathodic protection. Passive methods include applying coatings or linings to protect the steel. The methods investigated in this project included the following:

- cathodic corrosion protection of unpainted steel;
- thick, single-layer organic coating,
- multi-layer organic coating system,
- duplex system: metal-sprayed coating with organic top coat, and
- metal-sprayed coating with organic sealer.

Details of these protection methods can be found in Table 4. Systems 1 and 2 are basic inexpensive versions, whereas the systems 3 and 4 represent more advanced versions. Systems 5 and 6 were applied to the samples for the UZ only.

The systems differed not only in terms of composition and thickness, but also in terms of primer coat and type of intermediate coat. The organic coating materials with particle reinforcement were non-commercial products. Duplex systems are routinely used for onshore wind energy towers, and they have been applied to offshore wind energy towers at places[6]. Duplex systems are high-level systems because the protection of steel against corrosion can be ensured even if the organic coating fails. Multi-layer organic coating systems are standard solutions, but their performance depends on the details of the systems. Therefore, multi-layer systems with different intermediate layers have been tested. Single-layer organic coating systems are not common in the offshore industry, but they could offer advantages in terms of application. Their performance under offshore conditions has not yet been investigated systematically. The system "Al/Mg-metallization + pore filler" is an uncommon variant for offshore constructions, but it would allow for a comparison between different metallization systems, Zn/Al and Al/Mg.[14]

All samples were blast cleaned according to ISO 8504-2.[15] Abrasive material was steel grit with a particle size between 0.2 and 2 mm. Fine cleaning was performed. The surface profile was measured with a stylus instrument according to ISO 8503-4.[16] The average maximum roughness had a value of R_{y5}=69 µm, with a standard deviation of 6 µm. The surface preparation grade was Sa 2½ (for the organic systems) and Sa 2½ to Sa 3 (for the metallized systems). The weld seams were ground and cleaned to a P3-quality according to ISO 8501-3.[17] All coatings were applied in accordance with the manufacturers' specifications. The organic systems were applied with airless spray systems. The metallized coatings were applied with a special metallizing technique[18] with the sample preparation and test program this described.

The second part of this article, to be published in an upcoming issue, will discuss the results of this testing.

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Photo by Ann Akesson

Assessing Coatings & Linings for Wastewater:

Accelerated Test Evaluates Resistance to Severe Exposures

By Vaughn O'Dea and Remi Briand, Tnemec Co.; and Linda Gray,* KTA-Tator (Canada) Inc.

High-performance protective coatings often fail in the severe environment of the headspace in domestic wastewater collection and treatment systems. Coating failures are attributed to many factors, including extensive permeability to hydrogen sulfide gas (H_2S) and other corrosive gases present. Although the chemical and physical properties of coating systems can be determined in the laboratory, this is not the case for the effects of environmental conditions, such as exposure to severe environments within wastewater headspaces.

Unfortunately, specifiers for the wastewater sector are often faced with selecting from an array of protective coatings that have not been subjected to testing specifically for the wastewater environment, in large part because of inadequate laboratory tests for coating performance in all the conditions in the facility. This article discusses the advances in a novel cabinet testing protocol designed to simulate the effects of the severe conditions in a wastewater headspace. This test protocol produces data that can be interpreted in 28 days.

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Background

The U.S. municipal wastewater infrastructure is deteriorating rapidly due in part to the effects of biogenic sulfide corrosion. Biogenic sulfide corrosion is a bacterially-mediated process in which hydrogen sulfide (H_2S) is formed and subsequently undergoes biological oxidation to form sulfuric acid (H_2SO_4). Sulfuric acid attacks concrete and steel within wastewater headspaces.[1]

Domestic wastewater varies widely in composition. The main component is water (~95%) added during flushing to carry the waste to the drain. Other components of wastewater include pathogenic and non-pathogenic bacteria, organic particles, inorganic particles, animals, macro-solids, and emulsions. The typical pH of domestic wastewater is 6.0 to 9.0. Although septic in nature, the untreated wastewater itself is not particularly detrimental to the concrete or steel infrastructure. Rather, H_2S gas in the headspace above the waterline in enclosed sewer pipes and structures is principally responsible for subjecting the concrete and steel appurtenances in the headspace to highly corrosive exposures.

Hydrogen sulfide gas has always been present in collection systems up to 10 parts per million (ppm).[2,3] However, in the past few decades, as a result of changes related to water conservation, industrial pretreatment, and design philosophies, the conditions in wastewater collection and treatment have become more aggressive. The changes have produced H_2S concentrations exceeding 100 ppm (and occasionally measured upwards of 1,000 ppm). The changing conditions have contributed to rapid deterioration of the wastewater infrastructure.[4]

Traditional coatings, as well as high-build protective coating and lining technologies, are routinely failing under severe wastewater conditions, leading to a need for costly renovation of sewer networks and treatment structures.[3,5] Low permeability of coatings and linings to the corrosive gases and liquids in the wastewater vapor phase has been shown to substantially increase coating performance.[6] Although perhaps not linear, the atmospheric H_2S concentrations appear to be proportional to the rate of sewer corrosion.[7] It can also be assumed that increased H_2S concentrations contribute to greater permeation of polymeric coatings and linings. These sewer gases, particularly H_2S, compromise the barrier qualities of a protective coating. In the presence of moisture, H_2S can be biologically oxidized to form H_2SO_4, which rapidly attacks the underlying substrate.

Several notable wastewater testing programs, including the "Evaluation of Protective Coatings for Concrete," performed by the Sanitation Districts of Los Angeles County and the "Chemical Resistance Pickle-Jar Test," developed by the Standard Specifications for Public Works Construction (Greenbook), have been performed throughout the years to

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A member of SSPC and FSCT, Remi has co-authored a paper for the 2003 WEF Technical Exposition & Conference and has written for several technical publications related to the coatings industry.

Linda Gray is a Senior Materials Specialist with RAE Engineering and Inspection Ltd. and has over 20 years of experience in corrosion and corrosion control. She manages a protective coatings testing laboratory. Her technical specialties include design of custom tests, failure analysis, application of EIS in coating testing, and other consulting services for coatings. She is an SSPC Protective Coatings Specialist and a NACE Coating Inspector Level 2-Certified.

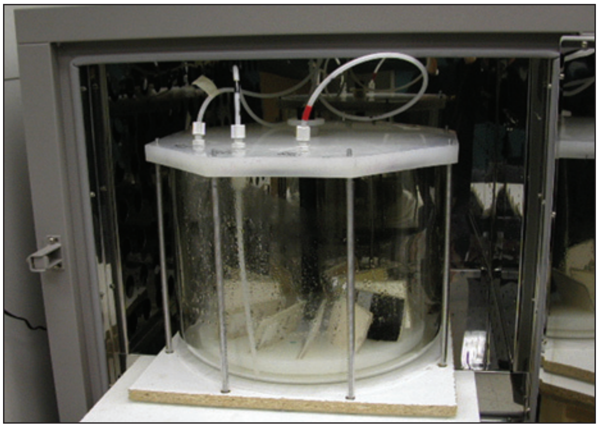


Fig. 1: The Severe Wastewater Analysis Testing chamber
Photos and figures courtesy of the authors

Fig. 2: Severe Wastewater Analysis Testing specimens. (not to scale)
(left) coated steel panel; (middle) coated cylindrical
concrete specimen; (right) molded free film sample

test the viability of high-performance protective coatings in wastewater exposures.[8,9] These testing programs provide a good qualifier for the suitability of a coating for wastewater structures. However, simulated wastewater environments have been studied mainly by using sulfuric acid (and other individual reagents) directly as the corrosive agent and may not reflect corrosive conditions found in wastewater headspaces, which include H_2S gas. In other words, the testing basis of these programs is strictly chemical immersion. Likewise, some investigations have shown that even if concrete shows a certain resistance to H_2SO_4, it does not always indicate resistance against biogenic sulfide corrosion.[10] In addition, these existing programs have no readily available means to characterize a coating and the quality of permeation resistance.

Objective of Study

In 2000, through a collaborative effort, researchers pioneered a laboratory testing protocol to rapidly evaluate the performance of coating systems for their resistance to permeation by H_2S and H_2SO_4. This testing program, named Severe Wastewater Analysis Test (S.W.A.T.), was based on a testing chamber (Fig. 1) that permits the simulation and acceleration of the conditions characteristic of severe environments in wastewater headspaces. The evaluation method allows a comparative evaluation of the performance of commercially available products intended for severe wastewater exposures. It differs considerably from other laboratory testing methods by evaluating a material's permeation resistance to elevated concentrations of H_2S gas.

For the ultimate in coating evaluation for wastewater, field exposure is still the gold standard. However, some of today's advanced high-build protective linings with low permeation characteristics often require over 10 years of field testing to generate usable data. Additionally, field conditions may be mild (relative to H_2S), inconsistent, or changeable during the test period. As a result, performance claims have often been based upon anecdotal evidence of field histories. The role of the chamber is to provide a standardized, accelerated method for the evaluation of a coating's performance in wastewater headspace conditions.

In 2003, Briand and Nixon presented data on common high-performance protective coatings subjected to the Severe Wastewater Analysis Testing program.[11] They concluded that permeation resistance is the key factor in the successful performance of coatings placed in wastewater headspaces. The authors also proposed a laboratory testing protocol as a measure of a coating's permeation resistance to these corrosive environments. This article updates the advances in the testing procedure for coatings in severe wastewater exposure.

Accelerated Testing Parameters

It is generally accepted that cabinet tests provide comparative results and not absolute results.[12] Hence, the role of the wastewater chamber is to provide an accelerated evaluation of a coating's relative performance under simulated wastewater headspace conditions. The corrosion protection of steel and concrete by a protective coating or lining may be altered by exposure to elevated gases and by the composition of the corrosive media. Exposing coated steel and con-

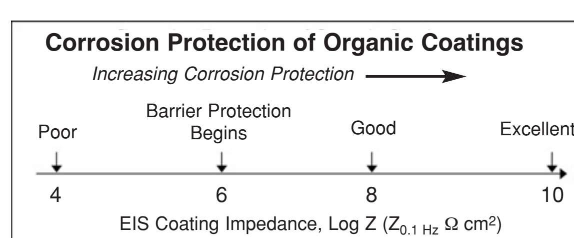
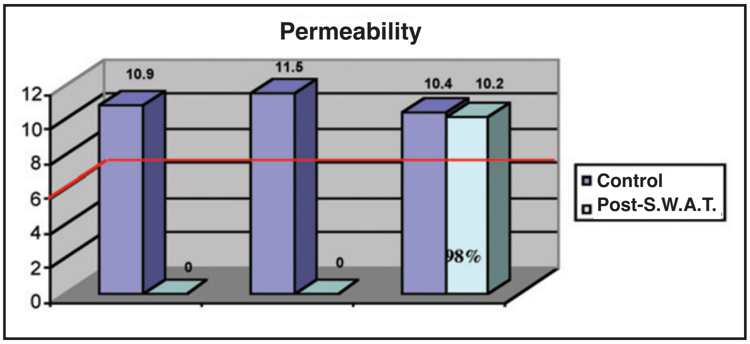


Fig. 3: Logarithmic key for interpretation of the impedance data relative to barrier protection afforded by organic coatings.



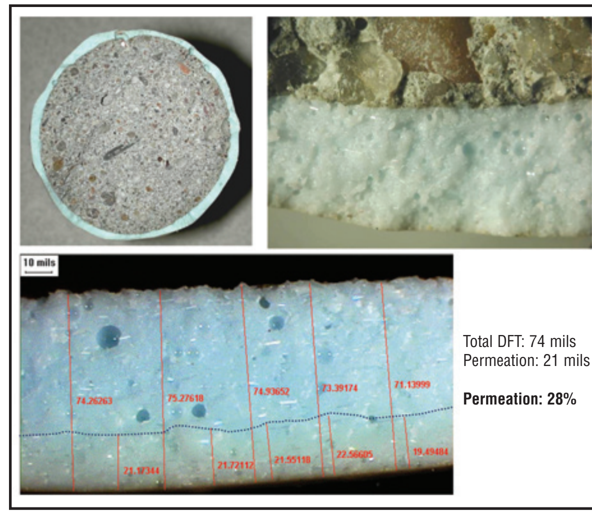


Fig. 4 (above): Summary of EIS impedance data for 3 different coatings technologies: Control, and Post-S.W.A.T. Product A (left): Coal-Tar Epoxy—no retained impedance properties; Product B (middle): Novolac Epoxy—no retained impedance properties; Product C (right): High-Build Amine Epoxy—98% retained impedance properties. Fig. 5 (right): Example of optical microscopy measurements of coating applied to concrete cylinder specimen.

crete panels to the wastewater chamber can help determine the suitability of these coatings or linings.

Severe Wastewater Analysis Test (S.W.A.T.)

The severe wastewater chamber is nothing more than a static testing vessel used to expose coated test specimens to a corrosive environment at elevated temperatures, so that the effect of such an environment can be evaluated. The test simulates severe wastewater headspace conditions by cyclic wetting of coated samples with a corrosive solution containing sulfuric acid and exposing the wetted samples to air containing high concentrations of hydrogen sulfide gas. The S.W.A.T. procedure is unique in that it simulates the headspace environment of enclosed wastewater structures, where permeation by hydrogen sulfide gas (and other gases present) alters the properties of high-performance lining systems. It is ultimately this aggressive mixture of liquid droplets in the presence of H_2S that rapidly permeates a protective film.

Chemical selection for the S.W.A.T. is based on the easily detectible corrosive species in headspaces: H_2S and H_2SO_4. (Other gases are also present in these environments and can be incorporated into the wastewater chamber.)

Prior work by Briand and Nixon established gas concentrations and testing duration by evaluating the permeation performance of various polymers at varying levels of H_2S gas.[1] It was concluded that the permeation performance of various protective coatings tested in the S.W.A.T. for a period of 28 days parallelled their performance in the field.

Additionally, preliminary studies using bare (uncoated) concrete specimens exposed to the S.W.A.T. chamber indicate a concrete mass loss of approximately 0.877 in. (2.2 cm) in a year. This mass loss parallels many documented cases of concrete paste loss of nearly 1 in. per year from walls and soffits (ceilings) under severe field conditions.[13]

The average temperature of wastewater in the U.S. is between 10 and 21 C (50 and 70 F). The S.W.A.T. operates at a temperature of 65 C (150 F) to induce an accelerated reaction rate that is approximately 3 times the actual rate for wastewater headspace conditions

The corrosion of sewers and other facilities and odorous gases in sewers are principally related to the generation of hydrogen sulfide. It has also been found that permeation by hydrogen sulfide gas (with other sewer reactants) alters film properties of protective coatings and contributes to their blistering and cracking.[11] The gas content of 500 ppm H_2S was selected for S.W.A.T. based upon earlier studies showing parallelled coating permeation results when testing with greater concentrations (10,000 ppm H_2S).[11] Therefore, the 500 ppm is used to expose samples to realistic levels of hydrogen sulfide that may be encoun-

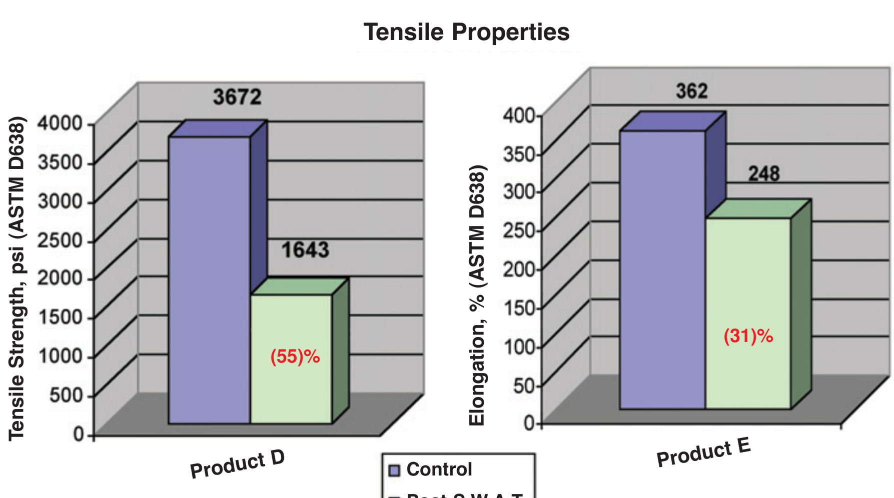


Fig. 6: Example results for testing the tensile properties. Product D, an elastomeric polyurea, lost 55% tensile strength properties (left) and 31% elongation properties (right) when exposed to S.W.A.T. cabinet.

tered under field conditions. Air containing 500 ppm H_2S is bubbled through the aqueous solution to supersaturate the solution.

Other gases commonly found in untreated wastewater include carbon dioxide, methane, and ammonia.[14,15,16] Like H_2S, these gases are derived from the decomposition of the organic matter present in wastewater. Since the concentrations of the latter three gases are not widely understood relative to H_2S within wastewater collection systems, they have been withheld from testing until further research is conducted. (Data collection is currently underway by the authors for future incorporation into the S.W.A.T. protocol.)

As H_2S levels have increased within severe wastewater environments, so has the production of H_2SO_4 by Thiobacillus sulfur oxidizing bacteria (SOB) that colonize in the headspaces.[4] The theoretical concentration of H_2SO_4 generated by SOB is proposed to be 5 to 7% H_2SO_4.[4,14] The S.W.A.T. incorporates 10% H_2SO_4 into the aqueous phase of testing; this concentration of acid is slightly above the maximum observed produced by the SOB. In coastal areas, salt (sodium chloride or NaCl) in water vapor can be very damaging to steel surfaces.[17] The concentration of 0.4% (or 4,000 ppm) sodium chloride was incorporated into S.W.A.T. to enhance the solute conductivity and to duplicate saltwater intrusion found in many of these coastal collection systems.[18] The aqueous solution is also saturated with H_2S by bubbling the air-H_2S gas mixture through the solution.

Testing Procedures

The suitability of a particular lining system in severe wastewater environments is based upon the retained properties of the coating with regard to permeability, physical testing, and visual inspections. This evaluation is accomplished by testing candidate lining systems on steel and concrete substrates, as well as testing mechanical properties of molded samples (Fig. 2 on p. 46).

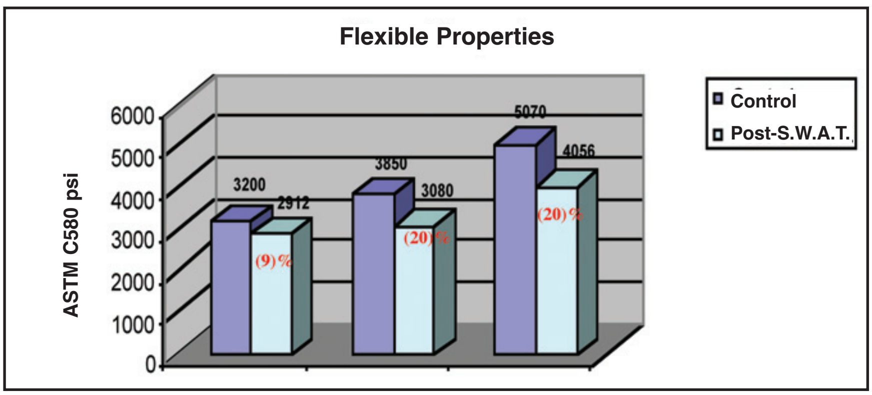


Fig. 7: Example results for testing the flexural properties of three high-build epoxy mortars. Product E (left) lost 9% of initial flexural strength; Product F (middle) lost 20% of initial flexural strength; Product G (right) lost 20% of initial flexural strength.

Permeability

Polymeric coatings act as a barrier separating the substrate from the corrosive service environment. A key attribute in the performance of the protective coating is, therefore, a low permeability to salts, water, gases, acids, and other corrosive species.

Electrochemical impedance spectroscopy (EIS) analysis is a technique well suited for evaluating a coating's permeability (barrier) properties based on the electrical resistance provided by the coating. This is referred to as impedance. The impedance of the coating is related to the nature of the polymer, its density, film thickness, and fillers. EIS has been widely used in the laboratory and field within the protective coatings industry for determining a coating's performance and obtaining quantitative information on coating deterioration.[19,20,21] When used with cabinet tests, EIS analysis acts as a quantitative detector of coating quality.[20]

When interpreting permeation resistance using EIS, the higher and more stable the retained impedance following exposure, the better the long-term permeability resistance and, therefore, the better the long-term coating performance. The logarithmic impedance scale presented in Fig. 3 (p. 46) is derived from a large body of literature on laboratory and field work.[22]

EIS control readings are taken before the coating is exposed to the S.W.A.T. and then compared to post-S.W.A.T. impedance to determine if the polymer was permeated or attacked during the test. Any polymer degradation is easily detected by a decrease in the measured impedance.

Experimentally, impedance of a coating is determined as a function of the frequency of an applied AC voltage. The data consist of a Bode plot of Log Z versus Log f, where Z is impedance in ohms • cm^2 and f is frequency in Hertz

Fig. 8: Example of two polyurethane hybrids (fast-sets) tested for adhesion using parallel knife test.

(0.05 Hz to 100 kHz). From the Bode plot, Log $Z_{0.1\ Hz}$ is determined by interpolation. The Log Z value at 0.1 Hz is tabulated and used as the basis of comparison between coatings and for monitoring the change of a coating as a function of exposure time to the test environment. Selection of Log $Z_{0.1\ Hz}$ is somewhat arbitrary but represents a compromise between speed of analysis and the selection of a frequency at which differences in coating performance can be reliably determined.[22]

An example of EIS analysis of three products commonly used in wastewater is compared in Fig. 4 on p. 49. (The red line at Log Z 6.0 is an indication of where "barrier protection begins".) Product A—a coal-tar epoxy—exhibited excellent initial impedance values. However, the product blistered and cracked during S.W.A.T. exposure and showed no retained impedance. Similarly, Product B—a high-build novolac epoxy—demonstrated excellent initial EIS impedance values. However, this product also showed no retained impedance following the S.W.A.T. exposure. Product C—a fiber-reinforced high-build amine epoxy—showed excellent initial EIS impedance. Following the 28-day S.W.A.T. exposure, the product retained 98% impedance. This is an indication of the product's low permeation to the corrosive wastewater species.

In addition to EIS analysis, permeation of a coating following wastewater cabinet exposure can also be assessed by microscopically observing the cross-section of the coating film. Permeation by the severe wastewater reagents typically manifests as discoloration when viewed with 100X microscope with digital imaging.

Figure 5 (p. 49) shows a high-build amine epoxy applied at an average of 74 mils (1,850 microns) dry film thickness (DFT) to a cylindrical concrete specimen. The concrete specimen is cut to expose a cross-section of the coating. The cross-section of the film is then measured with

Fig. 9: Example of blistering on steel panels. Coal-tar epoxy (left) and high-build amine epoxy liner (right) following S.W.A.T. exposure.

an optical microscope to determine the extent of permeation. The margin of permeation has been superimposed onto the image pictured and tabulated at an average of 21 mils (525 microns) DFT. This calculates to 28% permeation of the total film following S.W.A.T. exposure. A lower permeation percentage is tantamount to superior barrier protection under severe wastewater field conditions.

Physical Testing

In addition to the measurement of the permeation resistance of a particular lining system, the assessment of physical effects on the lining system is useful in detecting any significant changes a polymer may undergo as a result of severe wastewater exposures. For example, physical testing can reveal whether the lining system loses its tensile or flexural properties and becomes embrittled from exposure to these environmental conditions. When incorporated into the S.W.A.T., the quantitative determination of these properties can be tracked at a small fraction of the exposure time usually required for these changes to be discerned under actual field exposures. Two laboratory tests used to measure tensile strength and flexural strength can be used in a general way to assess a coating's suitability in wastewater. These mechanical properties are assessed by subjecting coatings to an applied force and determining their behavior under it. Any changes from the control (laboratory) condition are compared to the results following post-S.W.A.T exposures.

The commonly used laboratory methods to measure the tensile properties of coatings and linings are ASTM C307, Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings; ASTM D638, Test Method for Tensile Properties of Plastics; and ASTM D2370, Standard Test Method for Tensile Properties of Organic Coatings.

Tensile control properties are established for each candidate lining system using one of the aforementioned ASTM methods. For comparison, the specimens are then subjected to the S.W.A.T., and tensile strength is measured again. Figure 6 (p. 49) is an example of such tensile testing, where Product D—an elastomeric polyurea—exhibited excellent initial tensile and elongation properties. However, when subjected to the wastewater cabinet, the tensile properties of Product D were significantly reduced by 55% and elongation was reduced by 31%. A deduction can be made that this polymer technology is significantly embrittled by the severe wastewater exposure.

Fig. 10: Example of cracking on steel panels. Novolac epoxy liners following S.W.A.T. exposure.

A polymer sample has flexural strength if it is strong when one tries to bend it.[22]

Evaluating the flexural properties is important to determine the effects of severe wastewater exposures on the polymer. Like tensile properties, a significant decrease in retained flexural properties may indicate that the polymer is losing plasticity or becoming embrittled and may ultimately crack under long-term field conditions.

Figure 7 (p. 50) compares the initial and post-S.W.A.T. flexural properties of three high-build amine epoxy trowel-applied mortars marketed for severe wastewater applications. A deduction can be made, based upon this comparison, that it is not the greatest initial flexural strength (psi) that is important, but rather the retained flexural properties.

Product E lost only 9% of its flexural properties compared to Products F and G, which were reduced by 20%. This sharp decline of flexural strength in the latter two products indicates greater attack on the mechanical properties of the polymers and perhaps a greater propensity to crack under long-term wastewater field conditions.

Other ASTM laboratory testing methods are available to measure the mechanical or physical properties of coatings and may be incorporated into the S.W.A.T. to measure the effects of the wastewater exposure.

One such testing method is ASTM D4541 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers. This test method delineates a procedure for evaluating the direct tensile strength (commonly referred to as adhesion) of a coating on steel. The adhesion test consists of dollies made of aluminum, which are glued perpendicular to the coated surface of the samples. After the curing of the adhesive (glue), the testing apparatus is attached to the loading fixture (dolly) and aligned to apply the tension (normal stress) to the test surface. The force applied to the loading fixture is then gradually increased and monitored until either a plug of coating material is detached or a specified value is reached.

Another method used to assess the adhesion of the candidate lining systems is the parallel scribe method, which is often used with NACE TM0185 Evaluation of Internal Plastic Coating for Corrosion Control of Tubular Goods by Autoclave Testing. This test method is conducted by making two cuts, ⅛ to ¼ in. (3 to 6 mm) apart, through the coating to the substrate (Fig. 8 on p. 49). Adhesion of the coating between the scribe marks is evaluated by prying the coating with a utility knife and comparing the result with the rating scale below.

- A: No disbondment
- B: >50% still attached
- C: <50% still attached
- D: No adhesion
- F: Disbondment outside scribed lines

Although perhaps considered subjective, the parallel scribe adhesion method is useful in determining the adhesion effects of undercut corrosion and black rust that may not necessarily be observed using ASTM D4541 direct tensile adhesion methods.

Similar to the other mechanical testing, the testing of adhesion properties is performed prior to (control) and following exposure to the S.W.A.T. cabinet. A significant loss of adhesion is an indication that the lining material is being permeated and is affecting adhesion to the substrate at the bond line.

Visual Inspection

The last measure to determine the suitability of a candidate lining system for severe wastewater is visual inspection. Visual inspection identifies any physical alterations of a polymer following cabinet exposure to corrosive conditions. For example, the lining system is assessed for blistering, cracking, or rusting (pinpoint or otherwise) of the coated panel.

The rusting of the surface is assessed in accordance with ASTM D610, Standard Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces.

Blistering is assessed in accordance with ASTM D714, Standard Test Method for Evaluating Degree of Blistering of Paints. As seen in Fig. 9 (p. 52), many protective coatings cannot withstand the permeation of the corrosive species found in severe wastewater conditions and ultimately blister and crack.

Any checking or cracking of the film is visually identified on the steel and concrete specimens. The extent of checking or cracking can be identified as described in ASTM D660, Standard Test Method for Evaluating Degree of Checking of Exterior Paints, and D661, Standard Test Method for Evaluating Degree of Cracking of Exterior Paints. Figure 10 (p. 52) shows two novolac epoxy liners that cracked following S.W.A.T. exposure.

Summary

Asset management philosophy has municipalities and water agencies looking to protect their critical wastewater infrastructure from the destructive effects of biogenic sulfide corrosion with high-build protective linings. But where other services such as atmospheric or marine have accelerated and other lab tests available, the wastewater coatings industry has not had suitable laboratory testing procedures to evaluate coatings for wastewater environments. Instead, the industry has had to rely on anecdotal evidence as performance markers for use under these corrosive conditions, and anecdotal evidence is not considered adequate to predict product performance.

An accelerated Severe Wastewater Analysis Test has been developed to simulate severe wastewater headspace conditions. The S.W.A.T. protocol provides interpretable data for product evaluation in fewer than 30 days. Manufacturers, recognized testing agencies, and technical organizations need to incorporate this accelerated cabinet protocol into their evaluation programs when comparing materials for the protection of their critical wastewater conveyance and treatment assets.

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SSPC The Society For Protective Coatings

Thrills and Skills: Five Coating Projects Win SSPC Awards

From hair-raising to stargazing, from storing potable water to transporting goods by water, the structures SSPC recognized this year for coating excellence reflected the pride that their owners, contractors, and suppliers should take in their work. The variety of winners—an amusement park, an observatory, two water tanks, and a barge—show the important but often overlooked value of a good coating job in all sorts of walks of life.

SSPC Executive Director Bill Shoup announced the recipients of the SSPC's second annual Structures Awards at the association's Annual Meeting on January 29, 2008, at PACE 2008. SSPC gives these awards to teams of contractors, designers, owners, and other personnel for excellence on particular projects. Photos of the winning structures and representatives of the teams that completed the projects are shown on the following pages. SSPC received the nominations for the structures in 2007.

William Johnson Award: Six Flags Scream Thrill Ride

(Right) William Johnson Award: Scream Thrill Ride, Six Flags Fiesta Texas, San Antonio, TX. (Below, l-r) Doni Riddle, SSPC President; Walt Bowser, Six Flags Theme Parks; Chris Baynum, Baynum Painting; Ted Land and Steve Ross, PPG Amercoat.

Courtesy of PPG Amercoat

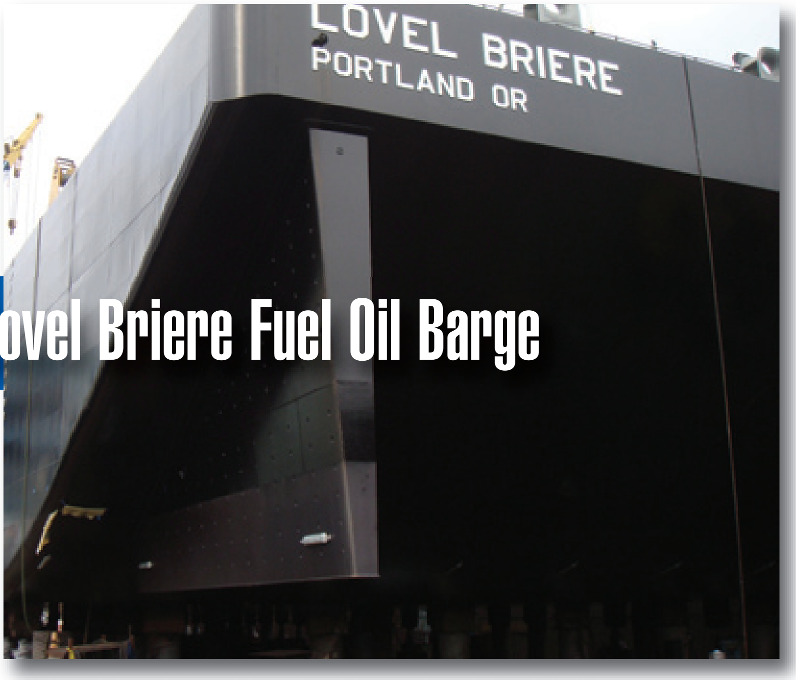
Courtesy of SSPC

Named for the late consultant with KTA-Tator whose work in coatings formulation, failure analysis, and surface preparation was instrumental in advancing the industry, the William Johnson Award honors a single, recent, outstanding achievement demonstrating aesthetic merit in industrial coatings work.

A high-profile amusement park attraction, the Six Flags Scream Thrill Ride at Six Flags Fiesta Texas sports a vibrant paint job, for which color and gloss retention are important features. Built in 1999, the 200-foot-high (61-meter) ride had never been recoated and displayed slight corrosion. The contractor power washed and prepared the structural steel with hand- and power-tool cleaning (SSPC-SP 2 and 3) and solvent cleaning (SSPC-SP 1). A fast-drying, surface-tolerant, VOC-compliant epoxy served as the spot primer, and a patented engineered siloxane was applied as the finish coat.

Location: San Antonio, Texas
Structure Owner: Six Flags Theme Parks
Contractor: Baynum Painting
Coating Material Supplier: PPG Amercoat
Start Date: February 2007
Completion: March 2007

George Campbell Award: Lovel Briere Fuel Oil Barge



(Left and Above) Lovel Briere, before and after, Courtesy of HCI Inc.

The Campbell Award recognizes outstanding achievement in the completion of difficult or complex industrial coatings projects. The award was named for the late George Campbell, founder of Campbell Painting Company in New York.

A tight schedule and an enormous task describe the scope of the Lovel Briere Fuel Oil Barge project. The owner of the barge chose the name to honor the volunteer efforts of a dear friend. According to the company, Mr. Briere was a hands-on, committed volunteer who worked to raise money to find a cure for cystic fibrosis, which claimed the lives of three of his children.

The project encompassed the surface preparation and coating of approximately 400,000 sq ft (37,161 sq m) of steel over a two-month period. The contractor performed abrasive blasting of all welds to SSPC-SP 10, which was followed by the application of industrial and marine coatings to the barge's interior double bottoms, fore and aft rakes, piping, motor room, and voids. In addition, the exterior hull was power washed, and welds and abraded areas were abrasive blasted to SSPC-SP 10. The exterior hull was coated with marine antifoulant coatings, and the deck was protected with non-skid coatings. Challenges included ventilating and dehumidifying the double hull structure, working near residential and commercial areas, and inclement weather conditions.

Location: Portland, Oregon
Structure Owner: Harley Marine Group
Builder: Zidell Marine Group
Contractor: HCI Industrial & Marine Coatings Inc.
Coating Material Suppliers: International Protective Coatings
Start Date: September 19, 2007
Completion: November, 26, 2007

Courtesy of SSPC

George Campbell Award: Lovel Briere Barge. (l-r) Doni Riddle, SSPC President; Tony Hoppe, Zidell Marine; Debra Franco, Harley Marine; Kim Hasselbalch, HCI Industrial and Marine Coatings; John Mangano, International Paint; and Per Oistein Hoem, Jotun Paints, Inc.

Crone Knoy Award: Arecibo Observatory

(Left and Below) Courtesy of PPG Amercoat

Inspired by the late founder and president of Tank Industry Consultants, the Crone Knoy Award honors a single, recent, outstanding achievement in commercial coatings work that demonstrates innovation, durability, or utility.

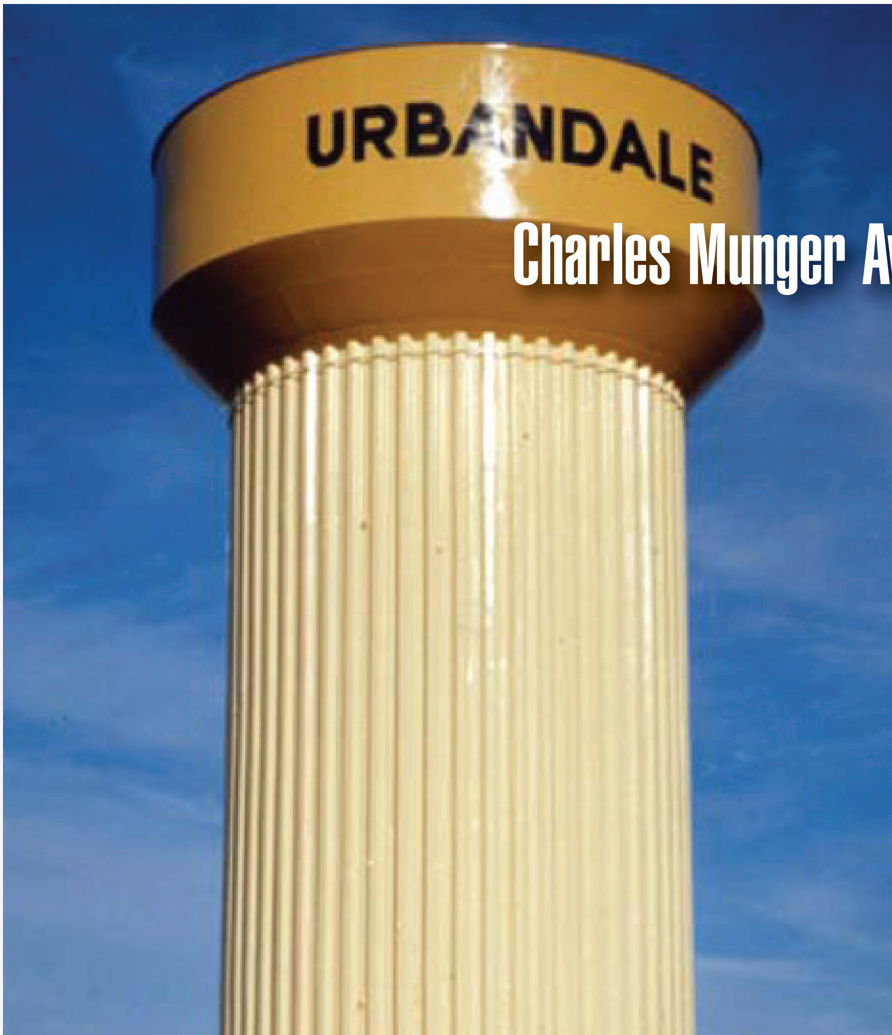
The world's largest single-dish radio telescope, the Arecibo Observatory is a major tourist destination, which attracts more than 100,000 visitors per year. The project's scope included cleaning and painting the radio telescope platform, consisting of 130,000 sq ft (12,077 sq m) of steel. The platform is suspended on cables 450 ft (137 m) above an 18-acre (72,843 sq m) aluminum dish.

In search of a humidity-tolerant, long-lasting coating system, the owner chose a high-solids epoxy primer and an engineered siloxane topcoat. The contractor faced multiple challenges, including limited access to the platform, strict time constraints, rigorous environmental regulations for the removal of lead-pigmented alkyd coatings and mill scale, and inclement weather conditions.

Location: Arecibo, Puerto Rico
Structure Owner: National Astronomy and Ionosphere Center (NAIC)
Structure Operator: Cornell University and the National Science Foundation
Contractor: John Thornberg and Company
Coating Material Supplier: PPG Amercoat
Start Date: January 2007
Completion: October 2007

Crone Knoy Award: Arecibo Observatory, Arecibo, Puerto Rico. (l-r): Doni Riddle, SSPC President; Joseph Burns, Cornell University; Carmen Spensieri, Spensieri Painting; and Al Kaminsky, PPG Amercoat. Courtesy of SSPC

Charles Munger Award (tie): Urbandale



Two structures tied for the Charles Munger Longevity Award: The Urbandale (IA) Water Works Fluted Column Elevated Water Tank and the Nederland (TX) Hardy Avenue Elevated Water Tank.

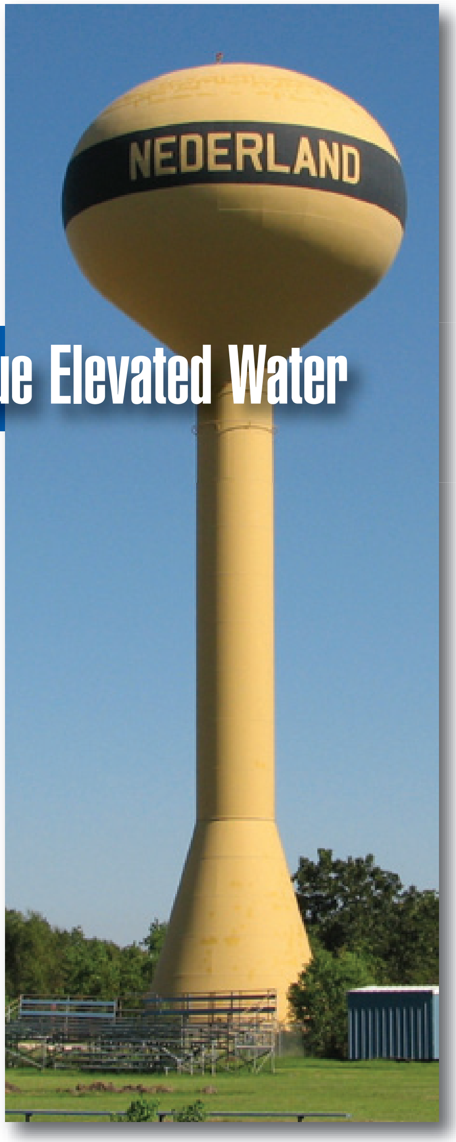
The award was named in honor of the late Charles Munger, who advanced the use of zinc-rich primers and wrote prolifically on the coatings industry. The Coating Longevity Award recognizes an industrial or commercial coatings project that demonstrates the long service life of the original coating.

The Urbandale Waterworks Fluted Column Elevated Water Tank was built and painted in 1976. The 1,000,000-gallon (378,541,178-liter) tank received a facelift in 1990 to address chalking and fading of the system. After power washing the tank, the contractor applied two coats of epoxy and a urethane topcoat. Eighteen years later, the tank shows no rusting or adhesion problems, according to the owner.

Location: Urbandale, Iowa
Structure Owner: Urbandale WaterWorks
Contractor: J.R. Stelzer Co.
Coating Material Supplier:
Tnemec Company, Inc.

(Above) Courtesy of Tnemec
Charles Munger Award: Urbandale Water Works Fluted Column Elevated Water Tank, Urbandale, IA.
(At left, l-r): Robin Hasek, Tnemec; Dale Acheson, Urbandale Water Works; and James R. Stelzer, J.R. Stelzer Co. Courtesy of SSPC

Charles Munger Award (tie): The Hardy Avenue Elevated Water



Nederland photos courtesy of Randy Reichle, DSR Associates

Also receiving the Munger Award, the Hardy Avenue Elevated Water Tank in Nederland, TX, was constructed in 1982. The exterior was prepared to a commercial blast, and a three-coat vinyl acrylic system was applied. In 1999, the vinyl system was still performing well. Following extensive compatibility and adhesion testing, a coating system consisting of an epoxy mastic and a polyurethane topcoat was selected to be applied over the existing vinyl acrylic system. The tank exterior was pressure washed and spot power tool cleaned before the coatings were applied. In 2005, winds in excess of 115 miles per hour, generated by Hurricane Rita, slightly damaged the topcoat. Another painting contractor repaired the damage by spot painting. The original paint system is now 25 years old.

Location: Nederland, Texas
Owner: City of Nederland, Texas
Contractors: Neumann Company (1982)
TMI Coatings, Inc. (1999)
S & L Painting, Inc. (2006)
Coating Material Suppliers: Original: Mobil Paint; 2006: Sherwin-Williams

Courtesy of SSPC

Charles Munger Award: Hardy Ave. Elevated Water Tank. (l-r) Doni Riddle, SSPC President; Steve Hamilton, City of Nederland, TX, Dept. of Public Works; Tracy Gilori TMi Coatings; and Larry Rollins, The Sherwin-Wiliams Co.

ACS Is Going to Carolina

Photo courtesy of Visit Charlotte

The first ever American Coatings Show (ACS) and Conference will be held June 2–5, 2008, at the Charlotte Convention Center in Charlotte, NC. The National Paint and Coatings Association (NPCA) has partnered with Vincentz Network (VN), organizer of the European Coatings Show (ECS), to create an event similar to the ECS. According to NPCA, the theme of the event, "The Next Level," refers to the goal of creating a transatlantic exchange that differs from what has been offered at any other industry show in the U.S.

The two-day American Coatings Conference will begin on June 2, providing a forum for scientific minds in the industry.

The ACS will open its doors on June 3 and will be the marketplace for the presentation of products and services for the production of high-grade and competitive coatings and paints.

NPCA is a voluntary, nonprofit trade association representing approximately 300 paint and coatings manufacturers, raw materials suppliers and distributors.

VN is a Germany-based media company, whose Coatings Division provides scientific, technical, and management information to the international paint and coatings community. VN publishes journals, books and newspapers, organizes conferences, seminars and exhibitions, and offers a range of interactive content, data, and training services for the industry.

To register for the event, visit www.american-coatings-show.com/registration. For more information on the trade show—tel: 770-618-5831; for conference information—tel: +49 511 9910-279.

Pre-Conference Tutorials

Before the start of the main conference, industrial and academic experts will present several 90-minute tutorials to update attendees on key issues in coatings technology. One of the tutorials, "Corrosion Protection," has been designed in collaboration with the SSPC: The Society for Protective Coatings, and will be led by SSPC Executive Director Bill Shoup. Principles that govern the corrosion of metals and how protective coatings can help prevent corrosion will be discussed. This tutorial will address the fundamentals of the electrochemical processes involved in corrosion. Typical ingredients and formulation characteristics of anticorrosive coatings will also be addressed.

American Coatings Conference

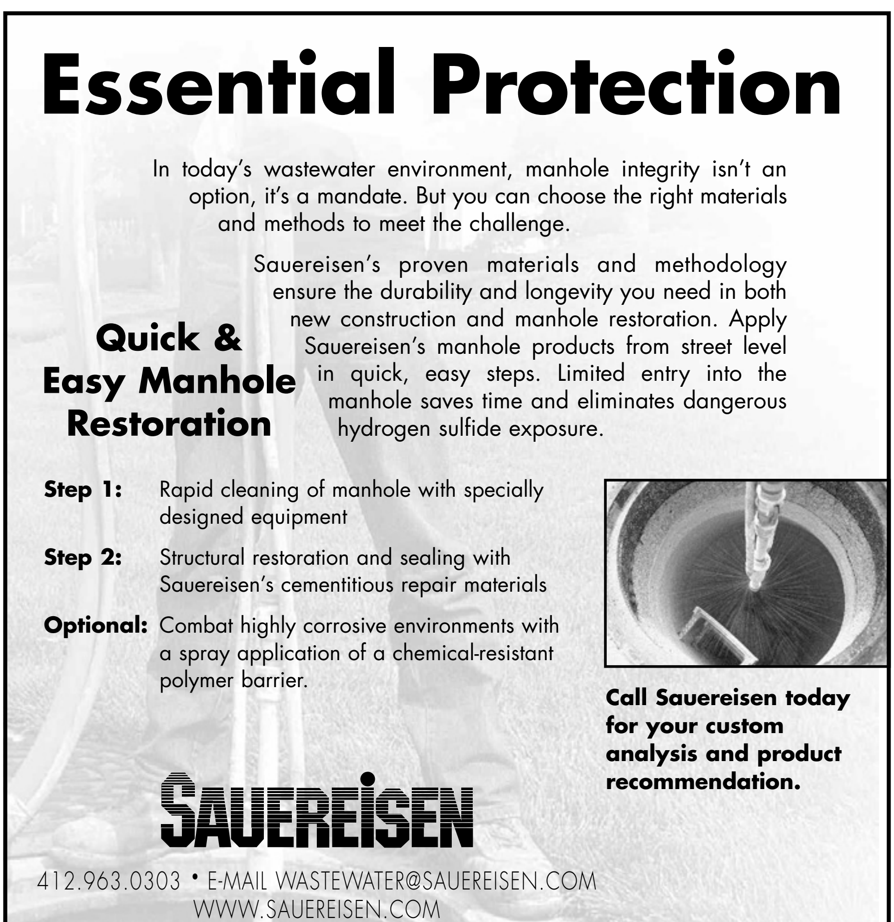
The presentations in the American Coatings Conference are divided into twelve sessions. Two of these sessions will be devoted to protective coatings and their raw materials.

Session VII: Protective Coatings

This session discusses developments that focus on all components of protective coatings, e.g., on innovative binder chemistries, novel anticorrosive pigments, new concepts for filler components, and novel self-healing functionalities that are able to react to damage.

• Properties and Performance of a New Waterborne Epoxy System Designed for Metal Protection—Alicia Wilson,

Continued



News

Bryan Naderhoff, Reichhold, Inc.

• Development of New Epoxy Resins for High Service Temperature Coatings—Fabio Aguirre, Donald Kirkpatrick, Giongyi Guylas, George Jacob, Dow Coatings Solutions

• An Organic Corrosion Inhibitor with Flash-rust/Early-rust Preventing Properties—Lars Ludwig Kirmaier, Susanne Krieg, Heubach GmbH, Germany

• New Waterborne Epoxy Resin Dispersion for Low VOC, 2-Pack High Performance Metal Primers Without Using Anti-Corrosion Pigments—Ming Tsang, Martin Geisberger, Rosemaria Grasböck, Cytec Industries Inc.

• Optimization Potential with Functional Fillers in Two-Component Polyaspartic Anti-Corrosion Coatings—Reimund Pieter, Bodo Essen, Hoffmann Mineral GmbH & Co. KG, Germany

• Evaluation of Self-Healing Polymer Chemistries for Application in Anti-Corrosion Coatings—Magnus Andersson, Gerald O. Wilson, Scott R. White, Autonomic Materials, Inc.

Session XII: Industrial Coatings

Focusing on industrial metal and concrete substrates, this session highlights developments that enhance coatings properties and ensure the protection of health as well as the environment. Topics include waterborne technology, novel acrylic emulsion techniques, and amine curing agents and performance additives.

• Concrete Coatings to Meet Performance and VOC Demands—Elizabeth Blankschaen, B. Berglund, L. Blevins, Lubrizol

• High Cross Link Density Acrylic Emulsions—Charles Rumble, Specialty Polymers

• Application of a Novel Waterborne Technology for Low VOC Industrial Maintenance Coating Systems—Peter Smith/ Leo Procopio, Rohm and Haas/ Tnemec

• Enhancing Productivity in Industrial

Maintenance Coatings—Allen Cheek, Carl Long, Eastman Chemical Company

• New Opportunities for Cycloaliphatic Epoxide Formulators—Brendan Cullinan, Joseph Mulvey, Michael Leahey, Brenntag Specialties Inc.

• Innovative Waterborne Amine Curing Agents for Epoxy Resins—David Fernee, C. Ash, J. Elmore, D. Fernee, D. Weinmann, D. Woodcock, Hexion Specialty Chemicals

Exhibitors

The following is a list, as of press time, of exhibitors at ACS that may be of interest to professionals in the industrial and maintenance coatings industry. Booth numbers are indicated after the company name and description.

• AGC Chemicals Americas manufactures, markets, and sells high-quality fluoroproducts, including Fluon® fluoropolymer resins and compounds and Lumiflon® fluoropolymer coatings. Booth 520

• Air Products and Chemicals, Inc., includes epoxy resins and curing agents for coatings among its product offerings. Booth 1439

• Arizona Instrument LLC provides precision moisture analysis instruments and Jerome toxic gas detectors. Booth 941

• BASF Corporation, the North American affiliate of BASF AG, Ludwigshafen, Germany, manufactures chemicals, polymers, automotive and industrial coatings, colorants, catalysts, and agricultural products. Booth 1421

• Bayer MaterialScience LCC produces polymers and high-performance plastics for use in coatings, adhesives, insulating materials and sealants, and polyurethanes. Booth 1545

• Buckman Laboratories Inc. manufactures specialty chemicals for the coatings, water treatment, pulp & paper, and leather industries. Booth 1415

• BYK USA Inc. supplies coatings, inks, and plastics additives for applications including architectural, general industrial, and automotive coatings. Booth 1505

• BYK-Gardner USA supplies instruments to objectively measure color, appearance, and physical properties of coatings and plastics. Booth 1505

• Cardolite uses its cashew liquid technology to make curing agents for industrial and marine coatings for a variety of applications. Booth 313

• CAS-MI Laboratories performs analytical and physical testing on many products, including polymers, paint, coatings, printing ink, plastics, adhesives, and pharmaceuticals. Booth 930

• Clariant Corporation Pigments & Additives Division produces pigments

Continued

and additives for coatings applications, including industrial, automotive, and powder coatings. Booth 1721

- Clariant Corporation Functional Chemicals Division supplies raw materials for the manufacture of emulsifiers, glycol specialties and other goods. Booth 1721
- Cognis Corporation focuses on three product lines: care chemicals, coating technology, and oleochemicals. Booth 1519
- Collano makes water-based binders for anti-corrosion coatings, silicone paints, and other protective materials. Booth 1733
- Cytec Industries, Inc is a global specialty chemicals and materials company focused on developing, manufacturing, and selling value-added products. 1529
- Dow Coating Solutions is a supplier of silicone technology for the coatings industry. Booth 1153
- Dow Corning develops silicon-based technology for coatings and other products. Booth 610
- Eckart GmbH manufactures metallic pigments for the coatings and graphic arts industries. Booth 1521
- Elcometer Inc. supplies and manufactures of a range of inspection equipment for both the coatings and concrete industries. Booth 637
- ElektroPhysik USA, Inc. manufactures coating thickness testing gauges as well as a range of products for finishing-related quality control needs. Booth 932
- Evonik Industries unites the business areas of chemicals, energy, and real estate. Its Chemicals Business Area has customers that include those in the paint, sealant, and adhesive sectors. Booth 528
- FlackTek, Inc. specializes in high-speed mixing technology for products such as silicones, inks, epoxies, and sealants. Booth 746
- Grace Davison manufactures fluid catalysts, silicas, adsorbents, and other specialty products. Booth 1331
- Halox, a division of Hammond Group, Inc., provides lead-free and

chromate-free non-toxic pigments for corrosion-resistant and tannin stain-resistant coatings. Booth 1405

• Heucotech, Ltd./Heubach GmbH manufactures organic color pigments, including pigment preparations, anti-corrosive pigments, and organic and inorganic pigments. Booth 1838

• HEXION Specialty Chemicals produces binders, adhesives, coatings, and ink resins for industrial applications. No booth number provided.

• Huntsman manufactures and markets differentiated chemicals for a variety of global industries, including paints and coatings, chemicals, plastics, and automotive. Booth 446

• Incorez Ltd. manufactures water-based polymers and resins for the paint, cementitious, sealants, and adhesives industries. Booth 1913

• King Industries, Inc. manufactures a range of additives, including catalysts and resins, used in the formulation of high-solids, waterborne, conventional, and powder coatings. Booth 329

• Kion Specialty Polymers develops and manufactures polysilazane, polyureasilazane, and polysiloxazane intermediates for products such as coatings, composites, and adhesives. Booth 1721

• LeHigh Technologies makes engineered rubber powders to give coatings durability, corrosion resistance, and other properties. Booth 410

• Lubrizol (formerly Noveon) produces and markets high-performance specialty chemicals, including additives and specialty resins for coatings. Booth 1565

• Momentive Performance Materials provides material solutions through silicon-based products and technology platforms, fused quartz, and advanced ceramics. Booth 422

• Nuplex Resins develops high-solids and waterborne coating formulations, together with traditional solvent-borne technology. Booth 440

• Paul N. Gardner Co., Inc. produces, distributes, and designs physical testing

Continued

instruments for the paint, coatings, and related industries. Booth 1047

• Peninsula Polymers, Inc. supplies functional polymers to industries such as paint, coatings, and adhesives. Booth 1810

• Q-Lab Corporation provides material durability testing equipment used to test products that include coatings, plastics, and sealants. Booth 944

• R.T. Vanderbilt Company, Inc. makes products for coatings, including mineral fillers, drier accelerators, corrosion inhibitors, fungicides and preservatives, dispersing agents, and thixotropes. Booth 1014

• Reichhold supplies unsaturated polyester resins for composites and is a leading supplier of coating resins for a variety of markets and applications. Booth 1305

• Rockwood Pigments NA, Inc. manufactures and processes iron oxide color pigments for coatings and colorants, concrete, and other industrial products. Booth 1345

• Rohm and Haas Company is active in the paint, adhesives, construction, and cleaning products industries. Booth 538

• Solutia Inc. specializes in process development and scale-up services for a range of industries, including resins and additives for high-value coatings. Booth 1219

• Southern Clay Products makes natural and synthetic additives, including rheological modifiers, for coatings and other applications. Booth 1345

• SSPC: The Society for Protective Coatings is a non-profit trade organization serving the protective and marine coatings industry with training, contractor and inspector certification, consensus standards, and other events and publications. Booth 1144

• Technology Publishing Company covers the coatings industry on-line and in print with magazines *Journal of Protective Coatings & Linings (JPCL)* for heavy-duty anti-corrosion coatings; *Journal of Architectural Coatings (JAC)* for commercial and architectural coatings; and *Painting & Wallcovering Contractor (PWC)* for the residential and commercial painting contractor; and with web portals PaintSquare.com and PaintStore.com.

• Troy Corporation develops and manufactures performance materials for protection against microbial degradation or defacement; mold and mildew control; and other functions. Booth 1429

• U.S. Silica Company produces high-quality ground and unground silica sand, kaolin clay, aplite, and related industrial minerals for coatings and other products. Booth 805

• VanDeMark Chemical Inc. makes phosgene derivatives, including ones for removing moisture during the manufacture of adhesives, sealants, and paints and coatings. Booth 819

Products

Coatings Materials Update 2008: Raw Materials for Higher Solids, Lower VOC Coatings

By Orville Brown, JPCL

Raw material suppliers continue to face the challenges of reducing air pollution from coatings by restricting their volatile organic compound (VOC) emissions while maintaining or improving coating performance. The most straightforward approach to reducing VOCs is to reduce the organic solvent content as much as possible.

This article summarizes a sampling of raw materials that have been launched in the past two years for formulating lower VOC coatings for the protective coatings market. Some materials have not yet been fully commercialized in the U.S. market, but instead have either been launched outside the U.S. or made available on a select basis. In some cases, such materials are now classified as experimental products. Other materials have found use in different market segments, but are not widely used for protective coatings.

The article is not intended to give a comprehensive review of raw materials for higher solids, lower VOC materials but will look at several new raw materials from the following types.

- Corrosion inhibitive pigments
- Epoxy curing agents
- Epoxy modifiers
- Isocyanate prepolymers
- Rheological modifiers

All information contained in this article was obtained from technical or marketing staff from raw material manufacturers and from supplier technical documentation. Since a few raw materials discussed might have not been fully commercialized, and detailed information on these materials may not be available in public documents, the interested reader may have to contact the supplier directly for further information.

JPCL has not attempted to confirm technical product characteristics or performance claims of the materials discussed. As is always true in coatings formulation, coating performance is ultimately determined by the formulation itself, the quality of its application, and its appropriateness for a particular specification.

It should be noted that other considerable new product development activity has recently focused on development and commercialization of raw materials for use in waterborne protective coatings and will be the subject of a future *JPCL* article.

Epoxy Curing Agents

Due to supply limitations in one of the primary families of chemical building blocks used to manufacture epoxy curing agents, the ethylenediamines, Air Products has developed proprietary amine technology to avoid the shortage and cost consequences that could affect its epoxy curing agent products. Consequently, counterparts to five standard Air Products curatives (Ancamide 220, 220X70, 260A, 350A and 700-B75) have been developed using the proprietary amine technology. These "Series 1" products (Ancamide 221, 221X70, 261A, 351A and 702-B75) are essentially drop-in replacements for their predecessor products, to minimize the need for reformulation, according to the company.

In addition, Air Products has introduced several different epoxy curing agents. Ancamide 2652 is a low viscosity (1740 cps), solvent-free polyamide adduct specifically developed to provide long overcoatability with epoxy and alternative resin technology. Recoat intervals of up to 3 months

Continued

Orville Brown has worked widely in the coatings industry. Among the positions he has held are Corporate Director of Research and Development and Purchasing, Diamond Vogel Paint Co.; Vice President, Research and Technology, North America Heavy Duty Group, Courtaulds Coatings (Now Akzo Nobel); and Corporate Technical Director, M.A. Bruder (now MAB Industrial Coatings). He is a technical editor for *JPCL*. He has published and presented a number of articles and papers on coatings technology. He holds an M.S. in Chemistry.

can be obtained for urethane finishes and 6 months for epoxies, the company says. The curing agent can be formulated into corrosion-resistant primers with a VOC of 270 g/L and a two-hour pot life with conventional spray, the company says.

New epoxy curing agents offer properties ranging from increased recoat windows, lower VOC levels, and faster cures, to improved cost effectiveness for coatings formulas.

Ancamide 2634 is a modified polyamide that the company developed to improve cost effectiveness in corrosion-inhibiting primers, compared to the product's earlier, conventional polyamide counterpart. The company reported that 2634 shows good resistance to various classes of organic solvents, and good resistance to water, allowing for formulation of coatings that can withstand water immersion service up to 190 F (~88 C). The curing agent also offers good resistance to cathodic disbondment, particularly for the pipe coatings. A starting point formula at 29% PVC and 250 g/L VOC, applied at 9 to 10 mils (~225 to 250 microns) DFT, reportedly showed no disbondment or blister failure in a 3% sodium chloride solution after 28 and 90 days immersion at 70 F and 125 F (~21 F and 52 C), respectively, with an impressed current of 1.5 volts.

Ancamine 2432 is a very low viscosity (300 cps), solvent-free, modified aliphatic amine curing agent designed for high solids and solventless coating systems. When used as the sole curing agent, says the company, it can impart exceptional chemical resistance to a wide range of organic solvents as well as concentrated, aggressive acids and bases. Also, when formulated with liquid epoxy resins, the curing agent has rapid cure rate at 77 F (25 C). It also effectively cures at temperatures as low as ~40 F (4 C). The company reports that the product is also an effective additive to accelerate the cure or lower the cure temperature of epoxy coatings based on cycloaliphatic or amidoamine curing agents.

Air Products also reported on its Ancamine 2603, a new specialty amine adduct that is a primary curing agent for high-performance, low to zero VOC coating formulations. In addition to its low VOC capability, it cures fast at low temperatures. Since the product contains low levels of free amine, coatings applied at below 40 F (~4 C) are extremely resistant to the formation of amine blush, the company says. The company will release more information on this product in the future.

Huntsman has introduced Aradur® 3447 hardener, a fast-cure, low-viscosity hardener based on cashew nut shell liquid, developed for anticorrosive marine and industrial maintenance coatings applications. The ability to cure rapidly at low temperatures is one of the benefits in comparison with standard phenalkamine hardeners. When formulated for high-solids primers with liquid epoxy resin, the hardener can reduce tack-free time at 32 F (0 C) and 70% relative humidity, from over 24 hours with standard phenalkamine hardeners to 8 hours.

Aradur® 3210 brand product, also from Huntsman, is a very low-viscosity (85 cps) modified cycloaliphatic amine curing agent for epoxies in the flooring market. With low vis-

Continued

cosity, chemical resistance, mechanical strength, light color, and good color stability, the product was designed especially for topcoat and self-leveling flooring applications. Coatings formulated with liquid epoxy resin and this hardener provide a light color, high gloss, tack- and blush-free coating that develops good cure properties overnight.

Aradur® 450 hardener is a low viscosity-formulated polyamidoamine designed for good adhesion to marginally prepared steel. It is especially effective for formulation of high-solids, corrosion-resistant products and is suitable for coating application at high humidity and to wet concrete. It is also available as 450S and 450T, an accelerated version of 450 and a version designed for application in hot climates, respectively.

New from Cardolite comes the phenalkamine epoxy curing agent, NX 5050, a lower viscosity, higher solids counterpart to the company's NC 562. The new curing agent was developed to provide a high level of corrosion and humidity resistance. It was designed for application at 32 F (0 C) or below in spray-applied primers formulated with VOC levels as low as 225 g/L. The company reports that thin film set-time at 8 mils (200 microns) is 2 to 3 hours at 75 F (~24 C) and 10 to 12 hours at 32 F (0 C). These set-times compare to 4 hours and 17 hours respectively for NC 562.

Cardolite's NC 558 is an established epoxy curing agent particularly suitable for a concrete primer with exceptional resistance to humidity. With humidity resistance equivalent to that of N 558, Cardolite's NC 566 was developed to have a faster cure, resistance to colder climates, and a faster thin-film set-time (8 mils) of 5 and 16 hours at 75 F and 42 F (~24 C and ~6 C), respectively, versus 12 and 38 hours for the earlier product. The company reports that NC 558 is also suitable for general-purpose industrial primers, especially where rapid cure, exceptional corrosion resistance, and moisture tolerance during cure are required properties and characteristics.

New Dow Business Unit Will Serve Formulators

In 2008, the Dow Chemical Company introduced a new business unit called Dow Coating Solutions. The business unit focuses exclusively on the needs of formulators serving three sectors: architectural coatings, transportation coatings, and corrosion protection and industrial coatings.

Epoxy Tougheners

Dow Chemical has recently introduced the Fortegra line of low viscosity epoxy tougheners that, when used in relatively low levels, significantly improve mechanical properties without compromising other properties. "The Fortegra line is based on specially designed self-assembling block copolymers that creates the particles needed for toughening the cured epoxy and at the same time does not result in big changes to other properties such as viscosity, cure speed and chemical resistance," the company says. The patented block copolymer is comprised of epoxyphilic and epoxyphobic blocks. The latter form domains within the epoxy resin that minimize physical stresses in the coating film. When used at levels of 3 to 10 volume percent of the coating, the tougheners improve mechanical properties such as impact resistance and flexibility.

Corrosion-Inhibitive Pigments

Halox has recently introduced another member of its family of hybrid corro-

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sion inhibitive materials, Halox 750, an inorganic/organic phosphosilicate. Halox describes the hybrid product line as "composite pigments in which inorganic corrosion inhibitors are combined with novel organic corrosion inhibitors." One intent for the development of these hybrids was to achieve the performance of strontium chromate with non-toxic materials. The new product finds use in both waterborne alkyd light-duty and heavy-duty industrial maintenance primers such as 2K epoxies. Salt spray corrosion resistance was reported to be superior to that of test primer formulas employing zinc phosphate and modified zinc phosphates at equal or in some cases higher loadings.

Pigmentan Ltd., an Israeli company, has recently announced its line of corrosion inhibitive pigments based on magnesium technology. The Pigmentan line was developed as environmentally safe, cost-effective materials that "do not contain heavy metal or other toxic components," the company says. At this time, four materials have been commercialized: Pigmentan 465M, E, EA, and EM. Chemically, these materials are "oxyaminophosphate salts of magnesium or magnesium and calcium that differ by the type of amine used in the reaction," the company says.

Pigmentan 465M is a multi-purpose material for solvent- and waterborne heavy-duty primer systems (alkyd, two-component epoxy, and urethane) for ferrous substrates. According to the company, the pigment's improved performance allows a 40 to 60 weight percent reduction in corrosion inhibitive pigment loadings in comparision to a competitive, modified zinc phosphate pigment. This benefit, says the company, is demonstrated in high-solids primer formulas based on a phenolic-modified alkyd, an epoxy ester, and a two-component epoxy polyamide. The company reports that salt spray resistance of 1000 to 1500 hours shows improved scribe creepage and underfilm corrosion resistance at 3 weight percent pigment loading versus 5 to 10 weight percent of a modified zinc phosphate corrosion inhibitive pigment.

Pigmentan E is intended for solvent-borne systems of the same vehicle chemistry as Pigmentan 465M, and end uses include application to steel as well as wash primers and other primers for aluminum substrates. The company designed Pigmentan EA primarily for waterborne systems such as emulsions and epoxies. Pigmentan EM was designed as an equal weight substitute for basic zinc phosphate in alkyd, two-component epoxy, and urethane metal primers.

Isocyanate Prepolymers

A low viscosity isocyanate prepolymer with potential for higher solids, lower VOC two-pack urethanes for the protective coatings market is Bayer MaterialScience's Desmodur XP2410, an asymmetric trimer of hexamethylene diisocyanate, the company says. The solvent-free low viscosity (650 to 700 cps) of the prepolymer is intended to make it suitable for the formulation of high solids/low VOC protective coatings. In contrast, Desmodur 3300, the symmetrical counterpart HDI trimer predominantly used for high solid protective coatings, has a considerably higher viscosity (1750 to 3750 cps).

Rheological Modifiers

Southern Clay Products Inc. (a Rockwood Specialties Inc. Company) has recently introduced Garamite 1958, a new chemistry of rheological modifiers that the company describes as mixed mineral thixotrope technology (MMT). It is designed to offer an improved performance alternative to hydrophilic fumed silica, organoclays, and wax-based rheological modifiers in both high-solids, two-package epoxy and long oil alkyd formula-

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tions. According to the company, the primary benefits claimed for MMT technology versus competing rheological modifiers are higher sag resistance potential of high-build coatings without excessive package viscosity; higher solids and lower VOC potential due to lower package viscosity; and easier incorporation of the rheological modifier during coatings manufacturing. Similar rheological benefits of MMT technology can be expected in comparision to hydrophilic fumed silica in unsaturated polyester systems and hydrophilic and hydrophobic fumed silica rheological modifiers for vinyl ester resin systems, says the company.

Summary

Several newer raw materials for protective coating systems have been launched in recent years.

Of special interest is an epoxy curing agent designed specifically for increasing the maximum recoat interval of epoxy primers and midcoats. This material need has not, until now, been adequately addressed as a design characteristic of the epoxy curing agent.

Some newer raw materials, specifically epoxy curing agents, have been designed for lower VOC and/or faster cure for specialty needs such as surface tolerance.

In some cases, the primary advantage of these materials is improved formula cost-effectiveness, with coating performance showing some improvement compared to reference materials that have been in use for many years.

Newer corrosion inhibitive pigments offer improved cost-effectiveness versus those commonly employed in protective coating primers. Other inhibitive pigments achieve such improvements with new chemistries that have low toxicity and are free of heavy metals.

A new rheological modifier described illustrates improvements in cost effectiveness and ease of processing during coating manufacture. A somewhat different rheological profile suggests the possibility of formulation at a noticeably lower coating VOC level.

Even though the improved formula attributes, cost and performance characteristics described in this article are believed to be an accurate representation of claims by the respective material suppliers, formulators must verify that the materials they select meet the individual performance requirements in a given formuation.

If suppliers wish to advise the author of new raw materials they would like to be considered for listing in future articles please forward technical information to Orville Brown, *JPCL*, email: oebrown@netins.net.

Companies

Cloverdale Paint Buys Guertin Coatings

Cloverdale Paint Inc. (Surrey, BC, Canada) has acquired of the assets of Guertin Coatings, Sealants and Polymers Ltd., according to Phil Guertin, president of Guertin Coatings.

Founded in 1947 by Antoine and Norbert Guertin, the company has been operated by brothers Phil and Charlie Guertin since 1987. Guertin Coatings produces liquid and powder industrial coatings, resins, sealants, and adhesives at its manufacturing facility at Winnipeg, MB.

Cloverdale Paint manufactures and distributes architectural and industrial coatings and related products throughout Western Canada and the U.S. Pacific Northwest.

Cloverdale intends to operate Guertin as a separate entity with existing management and to maintain Guertin's products, distribution, brands, and Winnipeg manufacturing facility.

Courses

Back to Coatings Basics at UMinn

Coatings basics are the focus of an upcoming short course from University of Minnesota to be held June 3–5, 2008, in Minneapolis, MN. Coating Process Fundamentals is intended to provide coating engineers and their colleagues with an understanding of the principles of the many processes by which liquid coatings are applied and solidified.

The course is also relevant to physical scientists concerned with formulating coating liquids for processability and microstructure developments.

For more information, visit www.cce.umn.edu/coatingprocess.

Sink or Swim Slated for May

The 51st Annual Sink or Swim Symposium, co-sponsored by the Cleveland Coatings Society (CCS) and the University of Akron, will be held at the University of Akron Student Union Building May 20–21, 2008, in Akron, OH. The technical program will consist of more than 20 technical presentations, a poster presentation from university students, and a tabletop exhibition. In addition, two workshops will be offered: Introduction to Coatings on May 20 and Design of Experiments on May 21.

For information, contact Mary Harding: 440-884-5765; email: maryharding@roadrunner.com.

Riddle and Shoup Deliver the SSPC Annual Report at PACE 2008

Doni Riddle, SSPC President, and Bill Shoup, Executive Director of SSPC, presented highlights of the Society's Annual Report at the Annual Meeting, held January 26, 2008, at PACE 2008 in Los Angeles, CA. The report below covers the society's operations from January 1, 2007 to December 31, 2007.

Part I: Introduction

This annual report gives an overview of the activities, plans, and status of SSPC: The Society for Protective Coatings from January 1, 2007 through December 31, 2007. The information enclosed gives the most current figures for all programs.

SSPC had another successful year. The third annual PACE conference (January 2007), the launching of many new training programs, and continued progress on the strategic marketing plan were the highlights for SSPC in calendar year 2007. Our ultimate goal remains to increase the number of organizations participating and make PACE the base for a mega-coatings show. We continue to discuss participation in PACE with other organizations involved in coatings. We were pleased that the PACE conference in Dallas exceeded the bottom-line that we had in Tampa. We still feel that with reduced resources, especially time, people are looking for ways to economize their activities. If they can attend one show instead of many, and return those saved days to their employer, that would be a huge benefit to their organization. The feedback about PACE continues to be positive and indicates that we again draw top professionals in the coatings industry. We are looking at moving this partnership forward by including other coatings groups and associations, but we realize it will be a long and difficult road.

Another major strategic initiative this year was the formation of two chapters, one each in Indonesia and Japan. We are excited about this and look to foreign markets as a way to expand SSPC and the message we are trying to deliver that the use of protective coatings is the best solution to corrosion control. We are exploring other potential international markets.

(l-r) SSPC Board members Robert Ziegler, Jeff Theo, Greta Smith, Bob McMurdy, and Steve Roetter listen to SSPC President Doni Riddle deliver the Annual Report. Courtesy of SSPC

We continue to move forward on our strategic marketing plan. The plan was accepted by our governing body in January 2006. Major elements of the plan are: improve SSPC technology capabilities; enhance our brand (formulating an identity or a name recognition); improve marketing (selling or promoting the identity); develop partnerships with other organizations; develop more in-house expertise and capability to develop, produce and deliver high quality and relevant programs and services; create a true Council of Facility Owners with support services; and use the chapter system as one of the delivery modes for SSPC programs and services. We have updated our database, which includes a customer relationship management module to improve member account management, a new online store (The SSPC MarketPlace), reward points tracking, and restricted member areas. In Branding, we have changed and modernized the SSPC logo to assist members and the coatings public in recognizing the products and services we offer. We have redesigned much of our advertising material, our PCS pin and other items. We have begun to remarket our certification programs as quality programs

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because the intent of the certification is to improve the quality of the coatings job received by the owner. We have continued to focus our marketing certification efforts to coating concrete and the water/wastewater industries with direct ad campaigns promoting training and certification programs. If you would like to acquire a copy of the strategic marketing plan, please contact us. It is available to our members.

Part II: Acheiving SSPC's Vision

SSPC's goals are listed below. We continue to progress in implementing our present marketing plan to achieve the Society's vision. That vision is: *"SSPC will be the worldwide acknowledged resource and authority for protective coatings technology and information."* We can report that the SSPC-C Chapter was the first real step in achieving this vision of a worldwide resource and, as previously stated, last year we added SSPC-Indonesia and SSPC-Japan.

At all Board Meetings, the Governors review our operational objectives to ensure they are in line with our strategic goals. The document that bridges our strategic plan and operational goals is the strategic marketing plan, which includes a major emphasis on technology upgrades. This upgrade in technology will move the Society ahead with the ultimate goal of making the staff more pro-active rather than reactive. We need to continue that long-term focus, so we do not stray from the mission and the purpose for which SSPC was created in 1950.

Strategic Goal 1

SSPC will be its members' primary resource for protective coatings information exchange, education, and technology.

This continued activity is the cornerstone of SSPC's plan and is our number one goal. It provides a direct link to our vision. Another strategic step we took to enhance the goal was the launching of the Protective Coatings Inspector Course in August. This is an intensive one-week course giving the students the information they need to know to be first-class inspectors.

In 2007, SSPC courses were recognized by three outside agencies, American Institute of Architects (AIA), American Board of Industrial Hygiene (ABIH), and the Florida Board of Professional Engineers (FBPE). This validates the training we do by an independent assessment.

Strategic Goal 2

SSPC will be a proactive public policy advocate for the protective coatings industry.

SSPC partnered with AISC to provide comments to EPA on Areas Source

Rule to be published in June 2008.

SSPC's Government Affairs Committee submitted formal comments to EPA NESHAP on Paint Stripping.

SSPC Government Affairs is also compiling formal comments to OSHA Confined Space Rule for construction that is due January 28, 2008.

Strategic Goal 3

SSPC will be the spokesperson for the protective coatings industry and a public source of information about protective coatings.

We had over 565 technical information inquiries last year. We remain a resource for our members and the industry.

Part III: Member Programs

SSPC is a member-based organization. We are evaluated on how well our programs and services meet the needs of our members and the protective coatings industry.

Standards and Publications

- Standards completed in FY 2007 are listed below in Table 1. In the publications area, SSPC completed the book, *Selecting Coatings for Industrial and Marine Structures*.

Certification

- The past year saw an increase in the total number of certified contractors under the PCCP and certified individuals under the Protective Coatings Specialist Certification program. Two hundred thirty-one contractors have achieved certification, an increase of 4.5%. We have three companies QP-5 certified, no change since 2005. In the Protective Coatings Specialists Certification (PCS) program, we have 232 participants certified, an increase of 6.9%.

Continued

Table 1: Standards and Publications Completed in Year Ending December 2007

Specifiers Guide for Determining Containment Class and Environmental Monitoring Strategies for Lead-Paint Projects
Measurements of Dry Organic Coating Thickness on Cementitious Substrates Using Ultrasonic Gages
SSPC PS 12.00 Guide to Zinc-Rich Coatings (Revision)

Training

• The PCS certification has continued to spur an increased interest in the two courses on Fundamentals of Protective Coatings (C-1) and Specifying and Managing Coating Projects (C-2) with over 267 students trained during the year. The C-1 eCourse trained 106 personnel. The C-2 eCourse had 53 students trained. For Lead Supervisor/Competent Person Training, (C-3 and C-5), 1094 students received training. The C-7 Abrasive Blasters course had 221 personnel trained. The NAVSEA Basic Paint Inspector training course had 253 students complete the course. For the NBPI course, graduates receive a certificate, which is good for four years, qualifying them to be paint inspectors for that agency. Marine Plural Component Applicator Certification (MPCAC) had 103 students trained. Coating and Surfacing Concrete for Contractor Personnel had 92 trained. Concrete Coating Inspector Program and Certification had 59 trained and certified. The Bridge Coatings Inspection Course had 122 students trained. The Quality Control Supervisor Course had 67 personnel trained and finally, the Lead Worker course had 74 students trained. Other training programs developed this year are the Marine Coatings course, the Applicator Train-The-Trainer program and the Applicator Course.

Table 2: Board of Governors

Name	Company	Representing
☞ **Doni Riddle** **President**	The Sherwin-Williams Company Cleveland, OH	Coating Material Suppliers
☞ **J. Bruce Henley** **President-Elect**	The Brock Group Beaumont, TX	Coating Contractors
☞ **Steven Roetter** **Vice-President**	Tank Industry Consultants, Inc. Indianapolis, IN	Other Service Providers
☞ **Danny McDowell** **Immediate Past-President**	Northrop Grumman Newport News, VA	Facility Owners
Russ Brown	Munters Corporation Indianapolis, IN	Other Product Suppliers
Stephen Collins	Air Products and Chemicals, Inc. Thomaston, GA	Coating Material Suppliers
L. Brian Castler	Connecticut Department of Transportation Newington, CT	Facility Owners
Steven Hagman	CanAm Minerals/Kleen Blast Abrasives San Ramon, CA	Other Product Suppliers
Bob McMurdy	R.P. McMurdy Enterprises LLC Houston, TX	Other Product Suppliers
Greta N. Smith	Kentucky Transportation Cabinet Frankfort, KY	Facility Owners
Jeff Theo	Vulcan Painters, Inc. Bessemer, AL	Coating Contractors
Robert Ziegler	Ziegler Industries Nauvoo, IL	Coating Contractors
Carl Angeloff, P.E. Ex-Officio	Bayer MaterialScience LLC Pittsburgh, PA	Coating Material Suppliers

Table 3: Revenue Versus Expense (Unaudited)

Revenue	FY 06	FY 07
Memberships	$1,058,000	$1,087,000
Standards and Publications	$532,000	$476,000
Conferences	$767,000	$692,000
Certification & Training	$1,879,000	$2,115,000
Other*	$196,000	$248,000
Total Revenue	**$4,432,000**	**$4,618,000**
Expense	**FY 06**	**FY 07**
Memberships	$641,000	$695,000
Standards and Publications	$420,000	$405,000
Conferences	$710,000	$529,000
Certification & Training	$1,660,000	$1,936,000
Other**	$647,000	$767,000
Total Revenue	**$4,105,000**	**$4,332,000**
Net Surplus (Loss)	**$327,000**	**$286,000**

* Includes revenue from royalties, interest and external projects.
** Includes expenses for SSPC chapters, governance, regulatory advocacy, external projects, general administration, and strategic plan implementation.

Website

• SSPC's goal is to enhance and maintain SSPC Online for the benefit of its members. We continue to offer the popular Tech Features (excerpts from SSPC publications), "Ask SSPC" questions and answers, downloadable standards on our Online Standards Store, regulatory news as it happens, SSPC certification (PCCP and PCS) news and information, up-to-date information on SSPC training, and the new downloadable standard benefit mentioned previously.

• We continue to offer Featured Links on the homepage for "data mines" where individuals from transportation agencies can readily find coatings information. We have enhanced the system enabling members to set their own password and user ID and fill out individual

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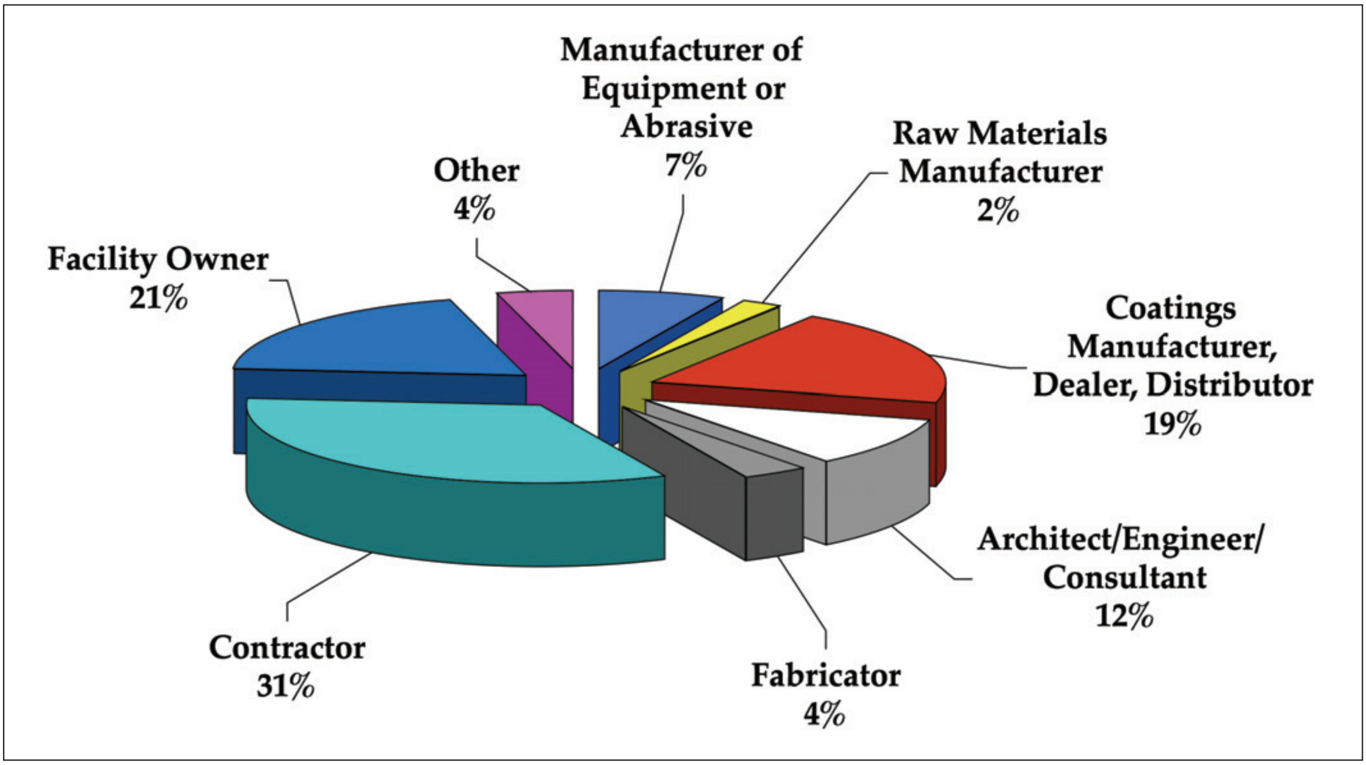

Fig. 1: Breakdown of SSPC individual member demographics

profile information. During the year, we have made easier access to *JPCL* via PaintSquare, added lists of individuals who have completed C-7, M-PCAC, PCS and NBPI, added PACE information to the home page, and updated the Members' Only Technical Committee sector content.

- Many of the online forms offered by SSPC have been revised to accommodate newer Internet capabilities and several of the forms are now offered in downloadable PDF format. We also added an Onsite Training request form to enable individuals to bring SSPC training courses to their own facilities. New forms for PCS, NBPI and PCCP have been added for member convenience. We've also updated the online Tools and Links section, and email groups targeting specific market interests.
- The number of unique visitors to our site tops 11,742 per month.

Part IV: Membership and Administration

Membership

- Individual membership increased

from 7698 in January 2007 to 8185 in December 2007, a 6.3% increase. During the reporting period, SSPC organizational membership (OM) grew to 755, an increase of 2.3%. A breakdown of individual members' demographics is shown in Fig. 1; however, it remains nearly the same as the previous year. We are pleased with the progress in increased individual membership and will continue to push organizational membership.

Governance

• The Board of Governors changed in 2007. Carl Angeloff, P.E., was elected as an Ex-Officio. The Board welcomed Mr. Steve Collins from Air Products and Chemicals, Inc., representing the Coating Material Supplier's demographic. The present Board is shown in Table 2.

Administration

• Key staff members remained the same. They are: Bill Shoup, Executive Director; Michael Damiano, Director of Product Development; Barbara Fisher, Controller; Mike Kline, Director of Marketing; and Terry Sowers, Director of Member Services.

Part V: Finances

We are pleased to report that SSPC again met its financial goals for the FY, which ended December 31, 2007. The reserve fund now stands at $1,854,000, which represents about 40.1% of the average annual operating revenue. The surplus is up 5.6% from last year. SSPC has met its financial goals by increasing revenue by $186,000. This was a 4.2% increase from last year. We must be cautious since expenses rose 5.5%, so they must be managed more closely. As noted previously, the Society is anticipating growth based on the increased interest in training caused by all of our new training programs. The financial details for the last fiscal year and the prior fiscal year are presented in Tables 3 through 5. Those charts demonstrate that SSPC continues to be a financially sound organization and all of our financial indicators are healthy.

Respectfully submitted:
William L. Shoup, Executive Director

Table 4: Statement of Financial Position as of 12/31/07 (Unaudited)

	Total all Funds	General Operating Fund	Reserve Fund
Assets - Current Assets			
Cash	$292,000	$292,000	$1,854,000
Investments	$3,706,000	$1,852,000	
Accounts Receivable	$98,000	$98,000	
Inventory	$142,000	$142,000	**$1,854,000**
Total	**$4,238,000**	**$2,384,000**	
Furniture, Fixtures and Equipment			
Equipment, Leasehold improvements at cost less: Accumulated Depreciation	$501,000 <$267,000>	$501,000 <$267,000>	**-0-**
Inventory	**$234,000**	**$234,000**	
Other Assets			-0-
Prepaid expenses	$115,000	$115,000	**$1,854,000**
Total Assets	**$4,587,000**	**$2,733,000**	
Current Liabilities			
Accounts payable	$60,000	$60,000	
Accrued expenses	$298,000	$298,000	
Defferred revenue	$488,000	$488,000	**-0-**
Total Liabilities	**$846,000**	**$846,000**	**$1,854,000**
Net Assets - Unrestricted	**$3,741,000**	**$1,887,000**	**$1,854,000**
Total Liabilities and Net Assets	**$4,587,000**	**$2,733,000**	

Table 5: Changes in Net Assets (Unaudited)

	Total all Funds	General Operating Fund	Reserve Fund
Unrestricted net assets - December 31, 2006	$3,455,000	$1,886,000	$1,569,000
Change in net assets as a result of current operation	$286,000	$178,000	$108,000
Transfer from general operating fund to reserve fund		<$177,00>	<$177,000>
Unrestricted net assets - December 31, 2007	$3,741,000	$1,887,000	$1,854,000

Southwest Industrial Coatings To Repaint Flagstaff Water Tank

By Brian Churray, PaintSquare

Southwest Industrial Coatings, Inc. (Cottonwood, AZ) was awarded a contract of $262,650 by the City of Flagstaff, AZ, to repair and recoat an existing 2 MG ground storage tank. The interior surfaces of the steel tank will be abrasive blast-cleaned to a Near-White finish (SSPC-SP 10) and lined with an epoxy system. The exterior surfaces will be hand- and power-tool cleaned (SSPC-SP 2 and SP 3), brush-off abrasive blast-cleaned (SSPC-SP 7), spot-primed, and overcoated.

Photo courtesy of the City of Flagstaff

Bay Town Painting Awarded Pipe Painting Project

Bay Town Painting (Baltimore, MD) won a contract of $45,500 for Harford County, MD, to clean and recoat existing piping at Abingdon Water Treatment Plant. The piping, which is located in a 66.5-foot-long x 48.5-foot-wide x 22-foot-high finished water area, will be abrasive blast-cleaned to a Commercial finish (SSPC-SP 6) and coated by brush or roller with an epoxy spot-primer, an epoxy intermediate, and an epoxy finish. The contract includes testing the existing coatings for the presence of lead.

Photo courtesy of Harford County.

American Suncraft Secures Tank Lining Contract

American Suncraft Construction Company (Fairborn, OH) was awarded a contract by the City of Columbus, OH, to clean and recoat the interior surfaces of a 1 MG water tank and a 2 MG water tank. The interiors of the steel tanks will be abrasive blast-cleaned to a Near-White finish (SSPC-SP 10) and lined with an elastomeric polyurethane system. The contract is valued at $630,740.

F.D. Thomas Wins Treatment Tank Repair Project

F.D. Thomas, Inc. (Seattle, WA) was awarded a contract of $315,400 by King County, WA, to perform corrosion

Continued

Town Hall Painting Wins Tank Repair Contract

Town Hall Painting (Virginia Beach, VA) was awarded a contract of $319,830 by Chesterfield County, VA, to repair and recoat a 1 MG ground storage tank. The project includes removing and containing the existing lead-based coatings, as well as recoating interior and exterior surfaces. The interior will be abrasive blast-cleaned to a Near-White finish (SSPC-SP 10) and lined with an epoxy system. The exterior will be abrasive blast-cleaned to a Commercial finish (SSPC-SP 6) and coated with an epoxy-urethane system.

repairs on six dissolved air floatation thickener tanks at a wastewater treatment plant. The project includes recoating ferrous metal surfaces and repairing wall linings in four 55-foot-diameter x 17-foot-deep tanks and two 65-foot-diameter x 17-foot-deep tanks. The work will be phased to complete three tanks in 2008, two tanks in 2009, and one tank in 2010.

Alabama DOT Lets Bridge Painting Project

The Alabama Department of Transportation awarded a contract of $418,500 to Poseidon Construction (Clearwater, FL) to recoat structural steel surfaces on six existing bridges in Baldwin and Mobile counties. Approximately 85,583 square feet of steel will be abrasive blast-cleaned to a Near-White finish (SSPC-SP 10) and recoated with an inorganic zinc primer, an epoxy intermediate, and a urethane finish. The contract requires full containment of surface preparation waste, which is presumed to contain lead.

Blastech Enterprises to Recoat Patuxent River Bridge

Blastech Enterprises, Inc. (Baltimore, MD) was awarded a contract of $1,134,380 by the Maryland State Highway Administration to clean and recoat structural steel surfaces on a 480-foot-long by 73-foot-wide steel bridge over the Patuxent River. The steel will be abrasive blast-cleaned to a Near-White finish (SSPC-SP 10) and recoated with an organic zinc primer, an epoxy intermediate, and an aliphatic urethane finish. The contract, which required SSPC-QP 1 and QP 2 certification, includes erecting a Class 1A containment structure (SSPC-Guide 6) to control the emission of the existing lead-bearing coatings.

Amstar Secures Tank Rehabilitation Contract

Amstar of Western New York, Inc. (Cheektowaga, NY) was awarded a contract of $271,500 by the Town of Shrewsbury, MA, to rehabilitate an existing 1 MG steel ground storage tank. The contract includes cleaning and coating the interior and exterior surfaces of the steel tank. The interior will be abrasive blast-cleaned to a Near-White finish (SSPC-SP 10) and lined with an epoxy system. The exterior will be abrasive blast-cleaned to a Commercial finish (SSPC-SP 6) and coated with an epoxy-urethane system. The existing coatings contain lead, which will be neutralized with a lead-stabilizing abrasive additive.

Wisconsin DOT Awards Bridge Painting Project

The Wisconsin Department of Transportation awarded a contract of $827,430 to North Star Painting Company, Inc. (Youngstown, OH) to perform surface preparation and coatings application on a 6-span, 839-foot-long bridge over the Eau Claire River. Approximately 104,000 square feet of steel will be abrasive blast-cleaned to a Near-White finish (SSPC-SP 10) and recoated with a moisture-cured urethane system. The contract includes supplying a negative pressure containment system to handle the existing paint waste, which will be treated as lead-based.

US Coast Guard Lets Fuel Tank Painting Project

The United States Coast Guard awarded a contract of $18,400 to FAB Construction, Inc, (Mt. Laurel, NJ) to recoat fuel tanks and appurtenances at the Coast Guard Training Center in Cape May, NJ. The exterior surfaces of four 5,000-gallon tanks and associated steel piping, valves, ladders, walkways, and cabinets will be recoated with a zinc-rich polyamide epoxy primer, a polyamide epoxy intermediate, and an aliphatic acrylic urethane finish.

L.C. United Takes On Elevated Tank Painting Project

L.C. United Painting Company (Sterling Heights, MI) won a contract let by the City of West Bend, WI, to recoat an existing 1 MG single-pedestal elevated water storage tank. The interior will be abrasive blast-cleaned to a Near-White finish (SSPC-SP 10) and lined with an epoxy system. The exterior will be abrasive blast-cleaned to a Commercial finish (SSPC-SP 6) and coated with an epoxy-urethane system. The contract is valued at $435,000.

West Florida Maintenance Secures Water Plant Coating Contract

West Florida Maintenance, Inc. (Apollo Beach, FL) has secured a contract of $18,363 by the City of Lake Wales, FL, to perform surface preparation and coatings application on new and existing water treatment plant surfaces, including structural steel, CMU block, concrete, tankage, piping, bins, chutes, conveyors, duct work, stacks, and equipment. The contract includes applying an epoxy-urethane system to metal surfaces and an acrylic system to CMU and concrete surfaces.

Seneca Valley Wins WWTP Deck Sealing Project

Seneca Valley (Midway, GA) was awarded a contract of $10,450 by the City of Savannah, GA, to perform high-pressure washing and sealant application on deck surfaces at a wastewater treatment plant. Approximately 8,300 square feet of concrete deck surfaces will be sealed with a two-coat epoxy system.