Wastewater Treatment Systems: Corrosion Problems and the Programs that Aim To Solve Them

Here’s a look at how 8 U.S. wastewater treatment agencies are approaching coatings maintenance to prolong the life of the facilities.

by Lori R. Huffman, JPCL

In the early 1980s, the Los Angeles County Sanitation Districts conducted an informal survey of wastewater treatment agencies in the U.S. to gather information on the condition of their infrastructures. The number of agencies that reported sewer collapses and odor problems (which indicate the presence of corrosive hydrogen sulfide gas) but that did not have active programs to prevent and remedy steel and concrete deterioration shocked John Redner, sewerage system manager for the Sanitation Districts.

Has the quality and percentage of maintenance programs improved since the 1980s? Surely, a number of wastewater treatment agencies are still trapped in crisis-driven maintenance cycles, but others have made efforts to develop preventive maintenance programs, minimize the cost of replacing structures and equipment, and add years of service to their facilities.

This article will describe common corrosion problems threatening wastewater treatment systems and the maintenance programs instituted by 8 agencies to deal with them. The article is based on interviews conducted with representatives of the agencies.

Harsh Environments Are Tough on Steel and Concrete

The service environments found in wastewater treatment systems hardly provide hospitable conditions for the prolonged life of steel and concrete.

According to John Redner of the Los Angeles County Sanitation Districts, corrosion is a serious problem that requires attention. Seawater, chemicals, and biological organisms can cause significant damage to structures over time. The use of coatings and other protective treatments is essential in these harsh environments.
Angeles County Sanitation Districts, microbiologically-induced corrosion (MIC) is the main problem affecting concrete and metal structures above septic sewage. He explains that as part of the MIC process, hydrogen sulfide gas is converted to sulfuric acid, a highly corrosive chemical.

Redner notes that the corrosivity of sewage is directly related to its age, not necessarily its content. Although many people believe that industrial effluent is responsible for spurring corrosion, Redner says that "domestic wastewater is as good as anything for corrosion." Typically, hydrogen sulfide levels are negligible at the beginning of wastewater collection systems, but as the wastewater ages and becomes more septic further along in the system, hydrogen sulfide levels jump dramatically.

Without corrosion protective systems, structures can lose as much as 1/4 in. (6.2 mm) of concrete per year. Because only 1 to 2 in. (25 to 50 mm) overlays steel reinforcement in a typical concrete application, these structures can be completely degraded in 10 years, Redner says.

Additional problems that accelerate substrate deterioration include humidity, effluent abrasion and erosion, and chemical attack. High humidity contributes to coatings failure by encouraging the growth of mold and mildew, causing delamination, and spurring MIC. Coatings can be abraded by sludge processed through the system. In addition, chemicals used for cleaning and disinfection, as well as odor control, can be extremely corrosive to substrates if accidentally released.

**Maintenance Programs Reviewed**

**Lincoln’s Program Features In-House Prep and Painting Facility**

The wastewater treatment system for the city of Lincoln, NE, serves approximately 225,000 people, says Steve Crisler, assistant superintendent. Crisler is responsible for the operation and maintenance of the Northeast Wastewater Treatment Facility, one of the city’s 2 plants; all wastewater and stormwater pumping stations; and the biosolids handling facility. A nineteen-year-old plant, Northeast handles approximately 40 percent of the waste stream generated by the city, Crisler says.

This year, the Northeast plant is bringing a new blasting and painting facility online to handle the needs of its in-house maintenance program. Crisler explains that the facility’s in-house coatings maintenance program was scaled back in the late 1980s because it could not sufficiently protect plant employees from the effects of abrasive blasting and coating application. Concerned with lead paint removal, overspray, and the atmosphere in the facility, the plant discontinued much in-house work, in favor of sending equipment such as pumps and valves to painting shops, says Crisler. Contracting the work to paint shops yielded mixed results and did not allow the facility to ensure the same level of surface preparation and the quality of coatings application that it could achieve in-house, he says.

The new facility, costing $225,000 to construct, will provide the wastewater treatment plant with a controlled environment in which to blast and paint, says Crisler. The construction of this facility is an example of the agency’s commitment to maintenance, he says. Equipped with blast cabinets, an abrasive reclamation system, and coating application areas, the paint shop will serve the Northeast facility as well as the city’s second wastewater treatment plant. Crisler hopes to train 8 to 10 workers from the maintenance departments of both wastewater treatment plants to be proficient in abrasive blasting and protective coatings application. Two or three workers will be able to use the facility at one time, Crisler says.
The wastewater treatment plant's painting program is administered in conjunction with its mechanical maintenance program, says Crisler. Thus, coatings work is usually conducted when equipment and large structures are taken off-line for mechanical maintenance.

Condition assessments of structures and equipment, as well as project inspection, are conducted by agency personnel, says Crisler. The inspectors evaluate the degree of corrosion and percentage of surface corroded to determine whether immediate maintenance is necessary or if painting can be deferred. On larger structures, the agency may wait until overall corrosion reaches 30 to 40 percent, as long as welded joints and connections are still being protected, says Crisler. Because the coatings have already reached a point of deterioration that will require replacement, deferring maintenance allows the facility to maximize the life of the protective systems and delay maintenance costs until they are actually necessary, he says. Coatings maintenance on smaller pieces of equipment, such as pumps and valves, is governed more often by aesthetic concerns and is less likely to be deferred, says Crisler.

Although smaller pieces of equipment may be inspected during regular maintenance, major structures like the understructures of wastewater clarifiers and large tanks are inspected on an annual or semiannual basis to assess the condition of their protective coatings, says Crisler. Coatings rehabilitation on these larger structures is then bid out to independent contractors.

Aside from requiring contractors to attend pre-bid conferences, the agency does not have a formal system of prequalification, says Crisler.

Protective coatings maintenance performed in-house is funded through the facility's operations budget, says Crisler. Averaging $20,000 per year, the budget for coatings is determined largely through the facility's experience with typical maintenance needs. Larger maintenance projects, such as coating rehabilitation for tanks and clarifiers, are not necessarily conducted each year. These projects are funded through the agency's capital outlay budget and are scheduled and projected one year in advance, says Crisler. As an example of this type of project, Crisler cites the recoating of the interior of an anaerobic digester 2 years ago, which cost the facility approximately $58,000.

Because major in-house maintenance efforts are just gearing up after a lull of 11 years, Crisler predicts that the in-house coating budget will have to increase to accommodate additional maintenance activity. “We'll probably raise a few eyebrows, I suppose,” he says.

The Northeast facility writes specifications based on SSPC standards for surface preparation and coatings application for in-house and contracted work, Crisler says. The surface preparation specified depends on the structure and the exposure conditions to which it is subjected, says Crisler. For example, steel substrates that are below the water line or at the wastewater-air interface are usually prepared to an SSPC-SP 10 (Near-White) finish. Equipment within the facility is prepared to an SSPC-SP 6 (Commercial) finish, he says. Crisler adds that most maintenance efforts are directed...
toward steel substrates, mainly because the facility has not experienced many corrosion problems with its concrete structures.

Currently, 3 coatings are used at the plant: high-build coal tar epoxies for immersion conditions, and aliphatic polyester and acrylic urethanes for above-water exposures. Although coal tar epoxies require a high level of surface preparation and can be difficult to apply, Crisler says their performance makes the trouble worthwhile. In addition, he praises the color retention, corrosion protection, and chemical and abrasion resistance of the aliphatic polyester and acrylic urethane topcoats.

With respect to large projects, surface preparation and coatings application are typically performed during scheduled outages, says Crisler.

**East Bay MUD Formalizes In-House Painting Program**

The East Bay Municipal Utility District’s wastewater treatment plant was built in the 1940s and serves approximately 800,000 people, says Ken Kaneda, plant structures maintenance supervisor for the treatment division of the wastewater department. Although some of the facility has been upgraded throughout its years of service, portions of the plant date back to its construction. The plant is in good condition, largely owing to frequent equipment upgrades, says Kaneda. When equipment retrofits occur, the in-house painters are called to prepare and recoat associated piping and surrounding areas, he says.

In the last 2 years, the wastewater treatment plant management has been trying to formalize its in-house maintenance program. The first effort has been to begin identifying the types of coatings used on various structures and equipment in the past. Kaneda’s crew is taking samples of existing coatings to identify where and if hazardous materials exist.

Another step in developing the program is to identify the seasonal requirements of the plant and determine how differences in demand will affect maintenance efforts. During the rainy season, which runs from November to April, the wastewater treatment plant needs to operate at its full capacity to process up to 400 million gallons (1,520 million L) of wastewater per day. Under normal conditions, the mid-sized plant processes 70 to 80 million gallons (266 to 304 million L) of wastewater per day. Therefore, large jobs, such as the recoating of clarifiers and digesters, are performed during the dry season, says Kaneda. The bulk of the painting budget is spent on these types of projects.

The program is also evaluating what types of maintenance can be accomplished by in-house crews and what is more reasonably performed by contractors, says Kaneda. Condition assessment and prioritization of maintenance are achieved by visual inspection and input from plant personnel, he adds. Several large jobs have been scheduled over the next 6 to 10 years.

Currently, the facility spends approximately $108,000 per year for coating supplies used by in-house crews and $38,000 per year for contracted maintenance painting, Kaneda says. The in-house painting crew performs abrasive blasting, hand- and power-tool cleaning, confined space entry, coatings application, exterior pipe coating, sign making, pavement marking, inspection of contract work, and design review for new construction.

Kaneda says that the plant’s in-house crews have shaved costs from protective maintenance and increased productivity by performing work that used to be done by contractors. For instance, the plant’s 12 clarifiers have required repair and recoating to minimize concrete loss in the effluent channel. In some clarifiers, as much as 1/2 in. (1 cm) of aggregate has been exposed due to erosion and hydrogen sulfide attack.

Before its 2 painters came on board
in 1995, the facility spent $80,000 on one contract to protect a clarifier with a two-part elastomeric polyurethane coating. Contracted work allowed for 1 clarifier to be recoated per year, says Kaneda. In 1996, the in-house crews took on a second clarifier project, choosing a single-component high-build epoxy coating. The project cost $25,000. In 1997, 2 more clarifiers were repaired and coated using the same system. Kaneda hopes to continue painting 2 clarifiers per year.

Although the coating system applied by the in-house painters has a shorter service life than that applied by the contractor (12 to 15 years as opposed to 20 to 30 years), Kaneda says that the cost of increased maintenance for the single-component polyurethane is still less expensive than the contracted maintenance.

The in-house crew has also saved the wastewater treatment plant additional funds by offering sign making as part of its services, says Kaneda. The plant was prepared to spend $3,800 to buy 50 signs from a third-party contractor, a job that would have taken 8 to 10 weeks. The painting crew decided to spend approximately $5,000 on a sign painting machine, which would pay for itself in one year, Kaneda figured. In 4 days, the crew created the 50 signs for approximately $1,000 in labor and materials, he reports.

The maintenance program does not include a coatings evaluation program, says Kaneda. Instead, the facility consults coatings manufacturers for their recommendations and visits similar installations to review their successes with protective coatings. In addition, the program relies on the experience of its 2 painters, who have 20 years of experience in industrial coatings work. At present, the facility uses coal tar epoxies and polyurethanes.

Most maintenance efforts are currently geared toward recoating clarifiers, metal bridge towers, and digester covers. The metal on the underside of the digester covers is constantly under attack by a corrosive environment prompted by heating the sludge. If the protective coating on the underside fails, the cover could develop leaks, become unbalanced, and possibly tip. A tipped cover that is damaged beyond repair could cost between $500,000 to $750,000 to replace, so it is best to protect the cover. The facility contracts out blast cleaning but applies maintenance coatings in-house.

**Washington Suburban Sanitary Commission To Add Third-Party Inspectors**

The Washington Suburban Sanitary Commission (WSSC) is the seventh largest water and wastewater treatment authority in the nation, says Russ Sharpe, section head of the facilities maintenance Engineering Section in the Facilities Maintenance Division. WSSC serves Prince Georges and Montgomery counties in Maryland, the 2 Maryland counties bordering the District of Columbia. WSSC does not serve Washington, DC. Serving 1.4 million customers, the system includes 5 operating wastewater treatment plants, and a new plant about to be placed in service, with 3 others either on standby or out-of-service; 43 active wastewater pumping stations; a six-million-gallon (23-million-liter) closed wastewater storage facility; a composting facility for biosolids; and an extensive sewer system. The structures and equipment in the wastewater treatment plants and pumping stations range from new to approximately 40 years old, says Sharpe.

In the 20 years of the Facility Maintenance Division’s operation, its maintenance painting program has evolved mostly from available budgets and recommendations of the operations divisions, he says. WSSC’s wastewater treatment system is not considered separate from the water treatment system, and so maintenance is tied to budget constraints for both areas. The maintenance
Trends in Maintenance

Based on surveys of the 8 wastewater treatment agencies, several similarities in maintenance programs can be seen. These similarities include:

- placing maintenance painting under the umbrella (and sometimes the budget) of mechanical maintenance programs,
- the relative lack of in-house coatings evaluation programs, and
- (with a few exceptions) the marginalization of in-house painting crews.

However, the biggest trend seems to be the preference for liquid-applied protective coatings over sheet-applied lining systems.

In the 1950s and 1960s, the most common option for protecting concrete and steel in wastewater treatment environments was protective coatings, says Redner. However, with the advent of polyvinyl chloride, high density polyethylene, fiberglass-reinforced plastic (FRP), and cured-in-place pipe linings, sheet-applied linings and corrosion-resistant materials (such as stainless steels and plastics) are the only economically viable solutions to the aggressive corrosion attack when life cycle costs are analyzed, he says.

However, other representatives surveyed have not taken this position. In fact, liquid-applied coatings are largely viewed as acceptable, if imperfect, tools for corrosion protection, whereas sheet-applied linings are deemed too costly for general use.

According to Sharpe, the wastewater system’s maintenance painting program is probably driven more by aesthetics than by corrosion problems. When deterioration from corrosion is found, however, its repair is given priority over less critical work, he says.

Prioritization of maintenance painting is not a large factor in the program, says Sharpe. Condition assessment is typically left to field mechanics, who report corrosion problems as they are discovered during maintenance. In addition, the operations division takes tanks and equipment out of service at regularly scheduled intervals for cleaning and inspection. The system also benefits from input from 3 corrosion engineers employed by the civil engineering section, as well as a Principal Civil Engineer in the Facilities Maintenance Engineering Section.

WSSC places more emphasis on the use of liquid-applied protective coatings than on sheet-applied linings, says Sharpe. Typically, alkyds are used in areas exposed to wastewater; solvent-borne epoxies are used in process equipment, such as clarifiers; and water-borne epoxies are applied to interior building walls. A limited number of sheet-applied linings have been applied to pipes and underground pumps; however, says Sharpe, the cost of these materials has outweighed their benefits.

Detailed coating specifications are written on a project-by-project basis. Typically, the maintenance division specifies SSPC-SP 10 preparation for rusted areas.
and for rusted areas that exceed 20 percent of the surface area. Areas with coating thicknesses over 30 mils (750 micrometers) are completely blasted and recoated, Sharpe says.

Ninety-nine percent of maintenance painting is let to independent contractors. The agency does not use a formal system of prequalifying contractors, but rather requires that bidding firms be in business for at least 3 years and that they supply at least 3 references for consideration.

**Los Angeles Focuses on Linings**

The Los Angeles County Sanitation Districts has 1,200 miles (1,920 km) of gravity sewers, 600 miles (960 km) of which are concrete. The system also contains 50 lift stations and 11 wastewater treatment plants.

According to John Redner, sewerage system manager, 12 percent of the wastewater system is over 50 years old, 80 percent is 25 to 50 years old, and 8 percent is less than 25 years old.

The Sanitation Districts has always taken a proactive stance on preventive maintenance, says Redner. It uses $5 million annually to control the rate of corrosion in the system through the use of chemical additives. In addition, $150 million has been spent over the last 10 years on approximately 80 miles (128 km) of the Districts’ sewer system to repair piping with linings or completely replace pipe segments, he says.

As part of its general maintenance cycle, the Districts cleans the system and performs condition assessments using closed circuit television and personnel entry. The program also monitors wastewater to control its septicity.

Annual maintenance budgets vary, depending on each year’s maintenance needs. Redner says that the operations and maintenance budget averages approximately $20 million per year for the entire system, i.e., funds that are spent on all routine maintenance (including mechanical) and condition assessments. Because they are seldom used, liquid-applied protective coatings make up an insignificant part of the maintenance budget for the collection system, says Redner. Once sheet-applied linings are installed, they are considered non-maintenance items in the budget, but they are routinely examined during condition assessments.

The Sanitation Districts’ ultimate goal is to effectively protect its infrastructure. This goal is being achieved by the use of linings. Explaining why sheet-applied linings are chosen over liquid-applied coatings for the protection of his agency’s system, Redner says that “utilities think in terms of decades of protection, whereas private industry thinks in terms of years.” Unlike liquid-applied protective coatings, sheet-applied linings can offer maintenance-free service lives. As an example, Redner cites one section of the wastewater system that has been protected by a plastic liner for the last 50 years. “It still looks as good as day one,” he says.

Lining projects are conducted by independent contractors. The majority of lining applications to existing piping are accomplished during normal operations through segmented slip lining using plastic pipe, says Redner. In other instances, operating levels are lowered to accommodate lining work, he says.

Slip lining of pipes does not require much in the way of surface preparation beyond removing blockages, says Redner. Surface preparation in treatment plants, pumping stations, and manhole shafts includes high pressure waterjetting or abrasive blasting to achieve neutral pH. If reinforcing steel is exposed, the concrete is built up with quick-setting epoxy mortar before lining is performed. Lining applications average approximately $15 per sq ft ($163 per sq m) installed, says Redner.

Although it primarily uses linings
throughout its system, the Sanitation Districts has run a coatings evaluation program for the last 14 years to look at promising new products. The program solicits coatings manufacturers to apply their coatings to sample concrete structures, which feature corroded and uncorroded sections. The coated samples are then exposed to acid solutions to evaluate their performance. The program also permits manufacturers to apply coatings in field test patches in manholes. If a coating can survive a year of exposure in good condition, it is considered for use in upcoming maintenance projects.

Unfortunately, says Redner, even those coatings that have passed initial testing have average service lives of only 5 to 7 years, unacceptably low by the Sanitation Districts’ standards.

Currently, the Sanitation Districts replaces deteriorated pipe segments with vitrified clay pipes for pipe diameters smaller than 42 in. (105 cm). Pipes over 48 in. (120 cm) in diameter are made of reinforced concrete pipe with pre-installed plastic linings, says Redner.

City of Sarasota, Florida
The wastewater system of Sarasota, FL, includes a wastewater treatment plant, a compost facility, a well field, and lift stations, says Gil Fernandez, operations supervisor. Constructed in the 1950s, the system is in pretty good shape, says Fernandez, especially the wastewater treatment plant, which was upgraded in 1985 and 1990.

Although it does not have a formalized, cycle-based maintenance painting program, the city handles protective coatings maintenance through in-house and contracted projects, says Fernandez. A five-person facilities maintenance crew numbers painting among its duties, and will perform small coatings-related projects. Work requiring the use of extensive surface preparation and application equipment is handled more cost-effectively by independent contractors, Fernandez says. In all, Fernandez is satisfied with the maintenance program. “The way we’re doing [maintenance] works really well, and we’re not spending money on things we don’t need to have done,” he says.

Maintenance painting is driven by feedback from line supervisors, who forward their requests for aesthetic and corrosion protective painting to Fernandez. Priorities are determined by comparing the areas of deterioration and assessing which projects can be deferred safely, Fernandez says. The city’s budget for maintenance painting varies from year to year, depending on the projects slated.

The wastewater treatment system is in continuous operation, and the city does not take components of the system out of service unless absolutely necessary, says Fernandez. Generally, the agency tries to schedule mechanical, structural, and coatings work together to minimize downtime, he says.

Currently, in-house maintenance efforts are focused on chemical storage tanks, which are exposed to corrosive materials. The collection system, subject to hydrogen sulfide attack, is maintained through contracted projects that are funded through bond money and are conducted every couple of years, says Fernandez. In these cases, the city hires consulting engineers to evaluate the condition of the system and recommend corrective procedures. Within
the last 8 months, the city has begun to use a cementitious, pure fused calcium aluminate coating to protect manholes subject to hydrogen sulfide attack.

Additional contract work is conducted at the system’s compost facility, which is subject to corrosive attack from ammonia generated in the composting process. The city uses epoxy coatings to protect areas in contact with the compost, but Fernandez notes that these coatings are still subject to deterioration. The city tries to keep up with coating failures by using contractors to perform large scale spot repair jobs.

The wastewater treatment agency utilizes both in-house and third-party inspection during painting projects, Fernandez says. Typically, field work, such as the coating of manholes, is inspected by city engineers. Large projects in the wastewater treatment facility are inspected by third-party consultants.

City of Columbus, Ohio
Serving a population of 1 million, the wastewater treatment section for the city of Columbus, OH, operates 2 wastewater treatment plants and a collection system including numerous pump stations and metro-wide sewerage, says Dick Morris, maintenance and construction projects manager with the Wastewater Treatment Section of the Division of Sewers and Drainage. The oldest plant was constructed in 1935 and underwent a $100 million rehabilitation in the early 1990s. The newer plant, built in the early 1970s, received a $200 million expansion in the late 1980s to increase its treatment capacity, says Morris. Morris oversees maintenance painting contracts for the 2 wastewater treatment facilities; pump stations and sewer lines are maintained by another section of the Division, he says.

Beginning in 1998, the Wastewater Treatment Section began to implement a formal maintenance painting program. Until that point, Morris characterized the agency’s stance on maintenance as reactive. “We want to be preventive with equipment, process, and coating maintenance at all levels,” says Morris. “Our goal is to progress from complete recoating to only touch-up work.”

To this end, the city has hired a consultant to assist in identifying areas of the wastewater treatment plants that require painting. The initial design of the maintenance painting program will feature yearly condition assessment of structures and equipment in the plants. However, the frequency of assessment may be adjusted as the program matures, says Morris. Currently, visual assessment is performed, and written inspection records are maintained.

As part of the program, a three-year general painting contract to be funded on a yearly basis has been let to an independent contractor. The contractor will evaluate the piping and equipment to be coated, and it will work with the coatings manufacturer to recommend appropriate surface preparation and application procedures, says Morris. The contractor will also be responsible for determining labor costs, square footage costs for coatings work, and performance requirements. In addition, test patch evaluations of coatings will be applied by the contractor in the worst service environments in the plants. Although the program did not have a provision for dedicated partnering, Morris says that the city is treating its relationship with the contractor as a cooperative one.

In-house painters will perform touch-up and emergency repairs to coatings in both plants. In addition, they will perform labeling on new piping that has been painted by independent contractors. Each plant has 1 dedicated painter and 1 helper, Morris says. The majority of coatings inspection will be performed by city forces, with guidance from third-party consultants, says Morris. To this end, the city is sending one of the treatment plants’ personnel
for training in coatings inspection.

The wastewater treatment agency has set up a budget of $600,000 for this year’s maintenance painting projects, says Morris. The budget will be adjusted in the future, as more experience is gained with the maintenance painting program. Morris notes that the in-house painters have been helpful in determining potential painting expenditures, owing to their experience in working at facilities similar in size to the wastewater treatment plants.

Although the program is geared toward corrosion protection, aesthetics are also important, says Morris. Tunnels in the wastewater treatment plants have been targeted for recoating, mainly to improve their appearance, but also to provide corrosion protection to pipe exteriors. Concern for an attractive workplace also extends to highly visible control rooms and the exteriors of the wastewater treatment plants, he says.

To date, modified polyamide epoxy coatings have been specified for pipe exteriors in the wastewater treatment plants. Specifications include provisions for high-pressure waterjetting, walnut shell blasting, and hand- and power-tool cleaning of rusted areas, says Morris. Specific surface preparation requirements are determined on an area-by-area basis.

County of Sacramento, California
The County of Sacramento’s wastewater treatment system includes a 1,000-acre (400-hectare) wastewater treatment facility that is composed of 11 underground sedimentation tanks, 10 aboveground digesters, associated piping and equipment, and 20 secondary treatment ponds. Constructed in the 1960s, the plant was expanded in 1978.

Initiated in 1984, the plant’s maintenance painting program is tied to its mechanical maintenance program, says Steve Miller, supervisor of the paint shop. Necessary maintenance is identified by the 30 mechanics responsible for certain areas of the plant, and the painting department receives work orders for each project. The in-house painting crew of 5 persons, including a NACE-certified coating inspector, handles these jobs.

Miller also conducts evaluations of the whole plant on a yearly basis to identify and rank process equipment that requires coating maintenance. The entire plant is refurbished every 5 years, including building exteriors and piping exteriors, Miller says. He notes, however, that aesthetic concerns are secondary to keeping the plant’s equipment in good working order.

The agency hires contractors to perform maintenance painting projects that cost more than $25,000. Although it faced some resistance from local contractors in the past, the facility requires that contractors be certified through SSPC or other organizations to be considered for painting projects. Additional requirements are mandated by the agency’s engineering staff, Miller says.

As part of its program, the wastewater treatment agency evaluates approximately 12 coatings per year. Vendors supply candidate coatings, which are applied to test coupons. These coupons are placed in harsh environments around the plants, such as in secondary treatment tanks, digester tanks, and in the ortower, a structure that removes odors from process air. The coupons are exposed to corrosive conditions for 6 months to 1 year, after which they are evaluated for corrosion, delamination, and blistering, says Morris. Based on these results, the plant has chosen polyamide epoxies for below-grade applications and urethanes above-grade to resist ultraviolet light attack.

The in-house paint shop is given an annual budget of approximately $700,000 for labor and materials, says Miller. The budget for contracted work is in the millions, Miller estimates, but only 10 percent of this work is tied to maintenance paint-
Programs Have Critical Components

Maintenance painting programs can benefit from incorporating the following points, according to the representatives of wastewater treatment agencies.

- The maintenance program should be designed to make sense to the people who must carry it out, Holden says.
- Understanding the need for adequate surface preparation and specific requirements for high performance coatings is critical, says Crisler.
- Personnel skilled in corrosion prevention are essential to the operation of a maintenance program, says Sharpe. His agency can afford to have corrosion engineers on staff, but he recommends that smaller wastewater treatment authorities with smaller budgets look to third-party consultants for advice.

- Approach maintenance logically, says Redner. It is important to know where corrosive conditions are located in the system and to concentrate maintenance efforts in these areas.
- Redner recommends that maintenance needs are best evaluated through real-time assessments using closed circuit television equipment and photography to document areas of deterioration. These methods also provide an effective means of evaluating sewer cleaning processes, he adds.
- Open lines of communication to plant personnel permit optimal scheduling of maintenance, says Kaneda.
- Paint manufacturers can be good sources for advice on surface preparation and coatings selection, says Morris. He also recommends utilizing the expertise of consultants for coatings specifications, if possible.
- Aesthetic improvements don’t make money, says Miller. A maintenance painting program should focus on process equipment, where 90 percent of corrosion problems are found, he says.
- The program must be useful for estimating costs in terms of labor hours, in-house work, equipment rentals, and material purchases, Holden says.
- Another useful aspect of a maintenance program is to allow comparisons between costs of maintenance as performed by in-house crews and by a contractor, says Holden.
- Documenting the results of your maintenance program will support its further development and justify maintenance budgets, says Kaneda.

Monterey Regional Water Pollution Control Agency

Monterey Regional Treatment Plant initiated a formal maintenance painting program approximately 2 years ago, says Bob Holden, plant engineer. The program covers the maintenance of 10 pump stations and the sewage treatment plant, a $150 million facility that houses 30 different types of structures, including buildings, concrete tanks, steel equipment, trickling filter units, and sand filtration units.

Before the program began, maintenance was handled in a somewhat haphazard way, says Holden, through work orders or by observing isolated failures during normal operation of the plant. Eight years ago, the wastewater treatment authority abandoned its 5 existing treatment plants and opened a new facility. The new facility suffered a 40,000 sq ft (3,600 sq m) failure of a high-performance coating, which cost the agency $1.5 million to repair. Building on this experience, the agency hired a painter/coatings inspector and began allotting $30,000 per year for contracted maintenance painting. This amount has slowly increased to $60,000 per year, says Holden. In 1997, the facility added a half-time helper and a half-year, part-time helper to the painting crew.

The maintenance program has begun performing condition assessments, dividing the wastewater treatment plant and pump stations into different areas by service environment for ease of inspection. Once all the areas have been assessed, Holden hopes to move the maintenance program to a 10-year maintenance cycle, with touch-
ups and inspections conducted on a more frequent basis. According to Holden, the program gives priority to areas of the plant that are in fair to good condition to head off corrosion. Maintenance of failed areas that are not critical are deferred, because “major repairs will still have to be major repairs [later],” says Holden.

Currently, several types of coatings are being used to maintain the plant and pump stations, including epoxies, polyamine epoxies, moisture-cured and plural-component polyurethanes, and zinc-rich primers. Fiberglass reinforced plastic (FRP), foaming polyurethanes, polyvinyl chloride sheet liners, and specialty non-corroding grout materials have also been used, says Holden. As a general rule, the first time a maintenance coating is to be applied, the substrate is prepared to a white metal finish, he says. Most coating specifications are project-specific, but some specifications can be used for similar projects, such as manhole rehabilitation, says Holden. The maintenance program has also placed emphasis on using non-corrosive materials, such as FRP, stainless steel, and polyvinyl chloride, says Holden.

Computerized databases and spreadsheets have helped the program track and prioritize maintenance, says Holden. The database separates structures and equipment by service areas and includes photographs that document coating and substrate conditions. The painter’s estimate for materials, labor, and equipment for touch-up and complete recoating are also included. Reports of earlier inspections and schedules for future assessments are listed, along with recommendations for maintenance. The database also documents special considerations for certain areas of the system, such as manholes, says Holden.

Maintenance painting contracts are let to the low bidder, but the agency typically sends bid solicitations to contractors with experience at the plant, says Holden. To assure contractors’ safety, the maintenance plan will soon include reviewing worker compensation ratings for each contractor. The contractor’s safety manual, site safety plans, and safety orientation for workers are now required of all contractors.

As part of the condition assessment, the facility’s painter has estimated labor, equipment, and materials costs for each area, which are used to project future budgets for maintenance painting. The painter also works with Holden to determine whether particular projects should be conducted by in-house crews or third-party contractors.

Monterey Regional’s maintenance painting program also has a provision for coatings evaluation, says Holden. Begun in 1991, the program has evaluated approximately 40 different coatings. Coated coupons of a standard size are suspended in polyvinyl chloride hangers and exposed areas where sulfuric acids (generated by MIC) are present. Recently, the evaluation program has added provisions for weighing the coupons for weight gain or loss, for photographing color changes in coated samples, and for measuring the pH of the samples. Coatings that withstand these harsh exposures are slated for further evaluation in actual service.

In the next 5 years, Holden hopes to expand the maintenance program to encompass the entire system. The treatment plant will receive the most attention, followed by pump stations and highly visible manholes, he says. An additional consideration for the maintenance program will be the completion of Monterey Regional’s reclamation plant, which will recycle up to 30 million gallons (114 million L) of sewage per day for the purpose of crop irrigation. Special provisions will be necessary for performing maintenance in winter at the reclamation plant and on the distribution pipeline, says Holden, because the demand for crop irrigation in the summer may be
too high to permit shutdowns. Therefore, tenting and dehumidification of structures will have to be figured into the costs of maintenance, says Holden.

**City of Houston, Texas**

A chief feature of the City of Houston’s maintenance program for its wastewater treatment system is a coatings test program administered by the Wastewater Design Division of the Public Works and Engineering Department. The program focuses on the coatings for the wastewater lift stations’ wet wells, which are subject to severe corrosion with subsequent concrete loss as a result of hydrogen sulfide attack (MIC), high ambient temperatures, and high external hydrostatic pressure caused by Houston’s high ground water table, says Dara Umrigar, an engineer with the Wastewater Design Division. The program was spurred by the agency’s experience with protective coatings. In short, says Umrigar, “almost every coating the agency has used in the last 5 to 10 years has failed.”

Coatings considered in the testing program are strictly for the rehabilitation of concrete/brick structures, says Umrigar. Candidate coatings are tested at the University of Houston’s (U of H) laboratory for 4 to 6 months to evaluate their resistance to blistering and delamination from the high external hydrostatic pressure. Testing is also conducted for chemical resistance, adhesive strength, and holidays (spark tests).

Coatings that pass the initial U of H laboratory tests are applied to lift station wet wells by third-party contractors as demonstration projects, says Umrigar. A third-party consultant visits the demonstrations to inspect the surface preparation, observe coating application, and perform field tests including adhesion (bond) strength, coating thickness measurements, and holiday tests. A lift station is then put into service 6 months to 1 year before it will be inspected again. So far, says Umrigar, some epoxies have shown promise. However, he notes, none of the 17 coatings tested has yet been approved for use by the Standard Wastewater Products Committee. Of Houston’s 350 lift stations, approximately 58 have been rehabilitated in demonstration projects over 5 years.

In addition to the testing/evaluation program, the wastewater treatment agency’s maintenance program extends to the inspection and maintenance of the system’s 6,000 miles (9,600 km) of collection lines. These sewers are cleaned with high-pressure waterjetting and inspected with TV cameras to evaluate them for rehabilitation. Small diameter pipes (less than 48 in. [120 cm]) are rehabilitated with slip lining, cured-in-place lining, pipe bursting or remove-and-replace, says Umrigar.

Lift station wet wells, junction boxes, and gravity and force main sewers are maintained by independent contractors through the city’s Capital Improvement Program, says Robin Green, Chief Engineer of the Wastewater Operations Division of the Public Works and Engineering Department. Lift stations are typically rehabilitated every 20 years, he says. The work is inspected by manufacturers’ representatives and NACE-certified inspectors engaged by the city.

**Benefits of Coatings Programs**

All represents surveyed say that maintenance painting programs offer practical advantages, including the following.

• Consistent performance of structures and processes with little unexpected downtime
• Improved aesthetics
• Protection of the environment and public health
• Realistic portrayals of budgeting needs and justification of budget requests
• Optimization of labor, time, and money
• Selection and application of suitable protective systems