RECEIVED
JUL 30 2001

Opflow™

Vol. 27
No. 7
July 2001

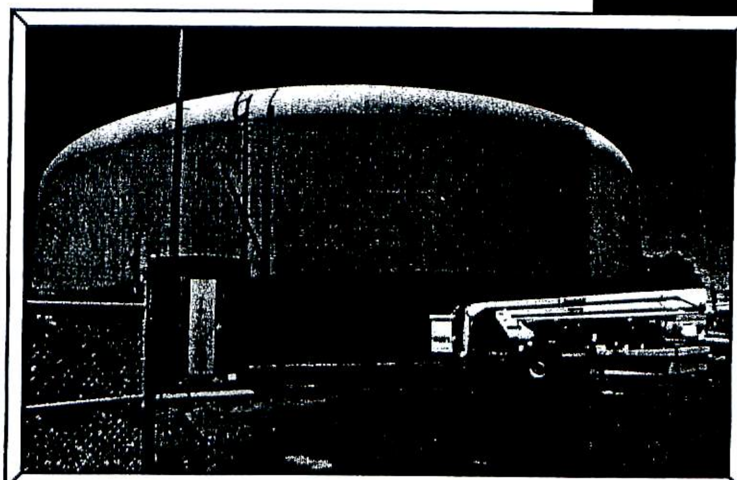
Steel Tank Reservoirs: Replacement Versus Rehabilitation

by Nicholas Irias

Almost everyone is talking infrastructure. And that's not surprising, considering that many water utilities' basic infrastructure needs—distribution pipes, pumps, and storage tanks, etc.—are decades old and will soon, or even now, need costly replacements or upgrades.

California's East Bay Municipal Utility District, which supplies water and wastewater treatment for parts of Alameda and Contra Costa counties, is one step up in meeting a crucial distribution infrastructure requirement—the rehabilitation of its steel tank reservoirs.

EBMUD serves approximately 1.2 million people in a 325-mi^2 area extending from Crockett on the north to San Lorenzo (encompassing the major cities of Oakland and Berkeley) to the south and also includes areas east of San Francisco Bay to Walnut Creek and the San Ramon Valley. The distribution system includes 122 pressure zones, ranging in elevation from sea level to 1,450 ft, and is composed of 4,000 miles of pipe, 125 pumping plants, and 176 reservoirs. The system meets an average daily demand of 190 mgd, with a record daily demand of 377 mgd.



Steel Tank Reservoir Rehabilitation

EBMUD has developed several long-term plans to maintain the distribution system, with each plan focusing on a specific category of the facility. In 1994, the Steel Tank Reservoir Rehabilitation Program was initiated

continued on page 4

Inside Opflow

System Metering Aids Leak Detection

As part of an aggressive program to reduce unaccounted-for water, Pennsylvania–American Water Co. developed a project to install significantly more system meters in the distribution system.

.... see page 8

American Water Works Association
Dedicated to Safe Drinking Water

Replacement Versus Rehabilitation

(from page 1)

100 Year Life-Cycle Costs Analysis for 150,000-Gal Tank

Year	Bolted Steel Tank Activity	Cost ($K)	PV* Cost ($K)	Welded Steel Tank Activity	Cost ($K)	PV* Cost ($K)
0	Construct	120	120	Construct	200	200
25	Replace	100	48	Rehab	170	81
50	Replace	100	16	Rehab	170	39
75	Replace	100	11	Rehab	170	19
		Total	195		Total	338

** Present Value. The amount of money in the bank today in an interest earning account in order to pay some expense at a specific time in the future.*

Figure 1

to evaluate all steel tank reservoirs and develop specific upgrade projects. Sixteen reservoirs have been rehabilitated to date, and EBMUD plans to rehabilitate 14 more during the next five years.

Historically, periodic rehabilitation has been considered the most cost-effective approach to long-term maintenance of the reservoirs. However, in recent years, the cost of tank recoating has increased dramatically. In response, EBMUD has more closely examined alternatives to rehabilitation when developing steel tank upgrade projects.

In cases where both interior recoating and significant structural upgrades are required, replacing a welded steel tank with a new tank can be a cost-effective solution. If a bolted steel tank can be used at the site, even more substantial savings can be realized. Currently, tank replacement is under consideration for seven of 20 steel tanks scheduled for upgrade during the next 10 years. A final decision on replacement versus rehabilitation at each site will not be made until the year each project is designed.

Steel Tank Inventory

Seventy-six of the distribution system reservoirs are steel tanks, with capacities ranging from 74,000 gal to 14 mil gal. The tanks, none of which are elevated, were constructed between 1925 and 1999, with an average age of 25 years. The design of each reservoir varies, depending on the year of construction and the best available technology at that time. Note the following design changes incorporated in the last 75 years.

- The earliest tanks are riveted steel, with steel floors and roofs.
- Tanks constructed in the 1950s and 1960s generally have concrete panel floors, with a 'C' channel embedded in the concrete footing ring and the steel shell welded to that channel.
- Tanks constructed in the 1960s to 1970s generally have wooden roofs.
- Tanks constructed after 1972 were designed with seismic anchorage details.
- Tanks constructed after 1978 generally have steel knuckle roofs.
- Tanks constructed after 1998 have aluminum dome roofs.

All but one of the steel tanks has a cathodic protection system, the vast majority of which are galvanic anode systems, although several reservoirs still have impressed current cathodic protection systems.

The interior coatings vary according to the vintage of the tank and the means last used to rehabilitate the tank. Note the following changes in coatings since the 1960s.

- Through the 1960s, hot-mopped coal tar was the standard interior coating system.
- In the 1970s, vinyl coating systems were used for new tank coatings.
- In the 1980s, high-solids epoxies were the preferred material for new interior coating and were also used for interior recoating projects.
- In the 1990s, only 100 percent solids epoxy systems were used for interior coating of steel tanks.

Evolution of Rehabilitation Practices

As recently as the 1970s, a reservoir could be drained and the hot-mopped coal tar repaired or replaced with ease. The coal tar was tolerant of poor surface

About the Author

Nicholas Irias is a senior civil engineer for the Infrastructure Management Section of East Bay Municipal Utility District. Contact him at nirias@ebmud.com or (510) 287-1076. This article was originally a presentation at the 2000 AWWA Infrastructure Conference.

preparation, excess humidity, and low surface temperature. To complete this work, the tanks usually were out of service for less than a month, and the new coal-tar coating would provide 15 to 20 years of service.

Concern over volatile organic compounds (VOCs) in drinking water led to the discontinuation of coal-tar coatings. The replacement coatings were high-solids vinyl and epoxy systems, which required significantly more thorough surface preparation, and careful mixing of the coating components and could only be successfully applied by a skilled coating applicator. Substantial deviations in applied coating thickness could result in improper cure and a compromised coating system.

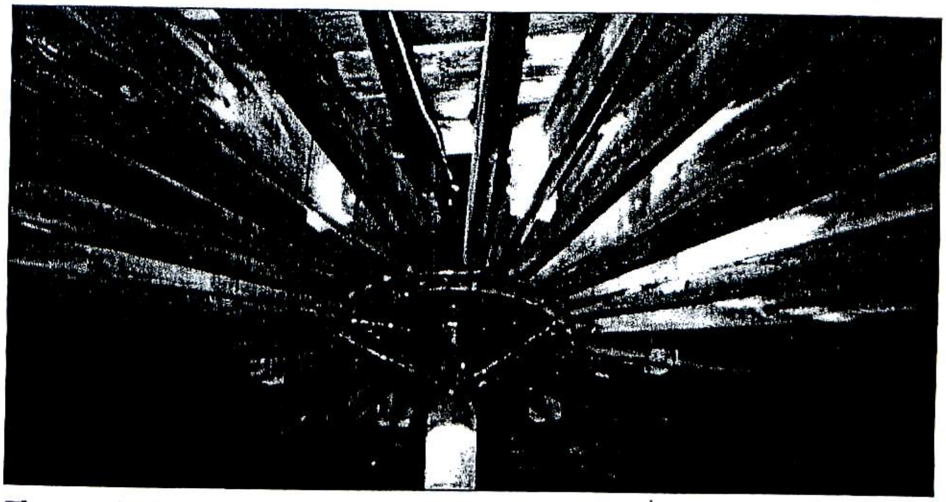
Increasingly stringent water quality regulations eventually led EBMUD to use only 100 percent solids epoxy coatings. While many high-solids epoxies are certified in accordance with National Sanitation Foundation (NSF) Standard 61, those epoxies can result in VOC levels that exceed primary water quality standards unless cured for an extended period.

Increasing Costs of Recoating Steel

Epoxy coatings are very sensitive to surface preparation, and current EBMUD specifications call for abrasive blasting of steel surfaces to the Surface Prep Standard No. 5 of the Steel Structures Painting Council (now known as the Society for Protective Coatings). SSPC SP 5 is the most stringent abrasive blast standard, calling for a "white metal" condition. Because older coatings often contain contaminants such as lead, chromium, and polychlorinated biphenyl (PCBs), the blasting operation requires that the tank be maintained at negative pressure to contain dust. The ventilation system includes dust collectors to trap hazardous particles. Air monitoring is performed to ensure compliance with air quality regulations.

Epoxies also require fine control of coating temperature, surface temperature, and humidity. In effect, the contractor must recreate in the field the controlled environment of a coating shop, often in the thick of winter.

As EBMUD has gained experience with epoxies, specifications have become more stringent to minimize the incidence of premature coating failure. Heating and dehumidification equipment is required to ensure that the surface temperature is within the manufacturer's recommended limits and that the combination of temperature and humidity is sufficient to prevent blasted steel from reaching the dew point. Heating, dehumidification, and dust control equipment can add several thousand dollars per day to the cost of a rehabilitation project.



The wooden beam roofs of some of the tanks are difficult to blast and recoat because of their multiple surfaces and limited accessibility.

In addition to the surface preparation and environmental controls, using 100 percent solids epoxies requires exact control of plural-component mix ratios, product and line temperatures, and application method. As such, a full-time coatings inspector is essential to the successful application of these materials.

The switch to 100 percent epoxy coatings has also increased the nonmonetary costs of rehabilitation projects. The use of abrasive blast equipment dramatically increases daytime construction noise. To protect blasted steel surfaces from flash rusting, heating and dehumidification equipment must run 24 hours/day. Despite the best efforts to contain noise, construction noise is likely to disturb nearby residents. On the other hand, bolted tank construction involves only daytime noise, because there is no need to run dehumidification and heating equipment at night.

Increasing Project Timelines

Increasingly stringent regulations have made it difficult to dispose of water or sediments from a reservoir. In general, no sediments can be discharged to a surface water channel or storm drain, and sediments containing hazardous constituents cannot be discharged to a sanitary sewer. As a result, dewatering a reservoir can take several weeks to allow filtration of sediments.

Once recoating work is done, water-quality testing may take 30 to 40 days to complete before a facility is returned to service. The current timeline at EBMUD for returning a reservoir to service calls for a total of 35 days.

- 10 days: Fill reservoir to 1-ft level, perform taste-and-odor test and five-day VOC soak test
- 20 days: Fill reservoir to capacity
- 5 days: Perform bacterial test

The 20-day fill time is a worst-case duration. Actual fill time depends on the ratio of excess pumping capacity to reservoir capacity, where excess pumping capacity is the total pressure zone pumping capacity less consumer demands. Any water not consumed by customers is available to fill the reservoir in that pressure zone. If the reservoir is filled in late spring or early summer, excess pumping capacity can be small.

When the schedule impacts of removing and returning the reservoir to service are added to the timeline for epoxy recoating work, the duration of the entire project can extend to 150 days or longer. If the reservoir is in a high-fire-risk area, a temporary reservoir may be required to support such a lengthy construction schedule. In hilly neighborhoods, obtaining a

continued on page 6