Pumping Up Big John

The John Hancock building, located on Chicago's Magnificent Mile, needed to revamp its entire pumping and reservoir system without shutting off water to the building's residents.

When the domestic water supply system at "Big John," The John Hancock Center in Chicago, began to show its age, the innovative pumping/control system installed did more than simply restore the system to its original state. The cutting-edge system design improved the overall performance and versatility of the water supply system, reduced maintenance requirements, provided dual-redundancy to guarantee continued operation and also improved the quality of life for the residents.

Big John's construction started in 1965, and was completed in 1968. After more than 30 years of service, the domestic water supply system that serves the condominium portion of the building started to show its age. Although the system was continuing to operate daily, maintenance costs were climbing, and it was becoming increasingly clear that a major overhaul was imminent. The association of condominium owners, formally known as The 175 E. Delaware Home Owners Association (EDHOA), selected McGuire Engineers of Chicago to spearhead the renovation design project. McGuire's principal engineer, Richard "Dick" Kviz supervised the project, working closely with Harry Budge, chief building engineer, 175 E. Delaware Place.

From an engineer's perspective, the 100-story John Hancock Center, on north Michigan Ave. at Delaware, is actually three separate facilities. Retail stores and commercial offices occupy the space from the concourse level to the 42nd floor. The 45th floor through the 92nd floor are residential condominiums. The third facility, from the 93rd floor and above, houses elevator systems, building utilities, an observation deck, the "Signature Room" restaurant and the equipment required to operate the commercial television and radio stations broadcasting from the building's transmitter towers. Each of the facilities is responsible for its own utilities.

EDHOA is responsible for the water system feeding 703 luxury condominiums, each ranging in size from one bedroom units to ones that cover 75 percent of a given floor. As originally designed, the water supply originates in city water mains below the building, which feed two 500 gpm constant-speed pumps in the basement of the structure. These pumps pressurize the water and deliver it to a 30,000-gallon water storage reservoir located on the 50th floor, which extends to the 52nd floor. The top of the reservoir serves as a utility space on the 52nd floor, for the pumping and control systems operated by the condominium association.

The original condominium water supply system used constant-speed vertical-turbine pumps, submerged in and supported from the top of the reservoir. Four "High-Zone" pumps were designed to serve the uppermost portion of the facility, and three "Low Zone" pumps were designed to serve the lower portion. Pressure output from these pumps was controlled by individual pressure regulating valves (PRVs) on the discharge nozzle of each pump. This was a common design during the period in time when the facility was constructed. An inherent flaw in this design stems from the operation of the pumps during night-time and other low-flow periods. During those periods, the pumps operated at full-speed, with relatively no flow, creating a situation in which the internal pressures within the pumps themselves climb to their peak. This excessive pressure, commonly known as "shut-off head," causes considerable long-term stress and eventual damage to the pump casings and mechanical shaft seals. This damage results in a high incidence of costly maintenance on these pumps.

During his initial inspection of the facility, Kviz discovered a very serious problem. The interior of the 30,000-gallon reservoir was showing signs of advanced stages of corrosion, which meant that its structural integrity was at risk. Kviz realized that the reservoir was in dire need of repair. It would need to be drained, dried, cleaned and reconditioned in short order to avoid a catastrophic situation. Unfortunately, the reservoir was the only means by which the condominiums could receive domestic water, and the reconditioning operation would take months to complete.

After analyzing the system's performance requirements, the flow capacity required for the condominiums was recalculated to allow for modern convenience items such as whirlpool tubs, bidets and multi-jetted showers that were not in use at the time the original project was completed. Kviz prepared documents for the EDHOA to issue, soliciting bid proposals for the required renovations. Following a review of the responses, Kviz recommended that the association select Metropolitan Industries, Romeoville, Ill., to design and install the new pump/control system. Metropolitan recommended that the out-dated design of the original pumps be replaced by a modified version of its "System 2100" submersible-turbine pumps and energy-efficient variable speed controls. The typical System-2100 design, which Kviz has used with great success in many downtown Chicago projects including the American Dental Association building utilizes horizontally mounted submersible-turbine pumps. For this project, the pumps would be installed vertically, allowing multiple pumps to be placed side by side, submerged in the reservoir.

"Reconfiguring the horizontally mounted pumps to a vertical configuration was not a major problem. Instead of being short and wide, the system components would be tall and narrow," said John Kochan Sr., chairman of Metropolitan. "The problem was limited headroom clearance. The 52nd floor pump room had a relatively low ceiling height and the crowded room itself created many additional installation difficulties.

Due to the difficult nature of the installation caused by the limited

headroom, the need arose for closely coordinated on-site installation services. The low ceiling prevented removal of the old pumps in one piece and installing the new pumps in one piece. Instead, the old pumps would need to be cut out in sections, and the new pumps would require assembling in sections on site. With technical assistance by Metropolitan, Aspen Plumbing's crew coordinated the work with only a one-time shut down, which lasted only a few hours during a non-peak period. During no time did the residential units lose their water supply. In addition, never was the critical supply of cooling water to the roof-top television and radio transmitters ever threatened.

Metropolitan designed an innovative piping arrangement designed to allow draining of the crippled water reservoir while guaranteeing uninterrupted flow of water to all areas of the facility. This was a critical design requirement, as the water supply is necessary to the operation of this facility 24 hours per day.
To allow the reservoir to be repaired, Metropolitan designed an innovative dual-feed piping system. During normal operation, the new system will operate in similar fashion to the original system. The basement water feed system supplies water to the reservoir and the new pumps draw water from the reservoir.

Conversely, when the time comes to drain the reservoir for rehabilitation, supply water from the basement pumps will be fed directly to the new high-zone pumps, completely by-passing the reservoir. Each of the new high-zone pumps was fitted with a special suction inlet assembly. In addition, a unique reservoir by-pass piping assembly allowed supply water to go directly to the suction inlet of each pump, instead of the reservoir. Finally, a new high-zone to low-zone pressure reducing station was installed to allow the low-zone pressure reducing fixtures to be supplied with water provided by the high-zone pumps. Combined, these design features will allow the entire facility to operate without either the reservoir or the low-zone pumps.

It was crucial for the proper operation of the system that regulated pressure serve the high-zone pumps while in reservoir by-pass mode. For this reason, a temporary variable-speed control system was installed on the 100 HP basement feed pumps. This system allows for steady state flows using a transducer to monitor the system pressure and adjust the pumping rate based on system demand.

"All of the new system components are designed and sized so that the reservoir and low-zone pumps could be taken out of service for the extended time period necessary while providing an uninterrupted water source sufficient for the entire facility," Kochan said.

Because a variable-speed control system provides greater electrical efficiency and reduces maintenance costs of the pump components, the owners already have experienced substantial savings that may result in a system payback period of as little as two to three years. In addition to the pump/piping work in the 52nd floor pump room, Metropolitan also provided a programmable logic control system complete with a touch screen operator interface panel and seven variable frequency motor drives for all of the new pumps. This method of operation allows for great hydraulic control of the flow and pressure by allowing the chief building engineer, Harry Budge, to configure the system's operation and set-points when required for events such as the current tank rehab project. The new systems have met all of the requirements of the association. The variable-speed submersible pumps use less energy, require less maintenance and permit the rehabilitation of the reservoir to be accomplished without disrupting the water supply.

As an additional bonus, an unexpected benefit of the new pumps was discovered near the end of the installation. As work was being completed, a woman whose condominium is near the 52nd floor approached the crew and told them, "The old pumps were very noisy. I don't know what you did to the new ones, but they sure are quiet." WQP

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