A History of the Venice Reverse Osmosis Water Production Facility

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A HISTORY OF THE VENICE WATER TREATMENT PLANT

by John Bounissi, circa 1999

Introduction:

Venice, located on the West Coast of Florida, was incorporated in 1927. In 1928 the first Tamiami Trail was constructed from Tampa, south through Venice, to Miami. The Venice area was in a growth mode until the great economic depression of the thirties. In 1942 an army air base was established south of the existing downtown area at the site of the current airport. The base provided economic stability for the Venice area. The base was vacated in 1945. It was that same year that the City entered the Utility business. Demand in 1945 was around 12,000 gallons per day (GPD). The water source was drawn from the shallow aquifers of the upper Hawthorn region.

In 1954 the City purchased a 400,000 gpd (gallons per day) lime softening plant. This facility was later expanded to include two (2) 1.5 MGD (million gallons per day) upflow-clarifiers followed by five (5) dual media pressure filters. The raw water supply was extracted from shallow aquifer wells drilled to a depth of 125 feet. As demand grew the upper Hawthorn aquifer began to experience quality problems due to influences from surficial ground water lying just above the upper Hawthorn.

In 1972 it was becoming apparent that the current treatment technology was quickly reaching its limits relative to water quality issues. It was also becoming apparent that the current raw water source was not going to have sufficient production capacity for the near future. The City retained the services of a local consulting firm, William Lindh and Associates, to develop a plan for providing a potable water supply to meet the future needs of the City. One water treatment option was a Reverse Osmosis (RO) Water Treatment Plant.

After some extensive research it was decided that the RO water treatment process was a good choice to meet current and future potable water demand. Water treatment systems utilizing Hollow Fine Fiber (HFF) permeaters and spiral wound membrane elements were considered. Dupont offered the HFF permeaters through their licensee, Polymetrics. Spiral wound membrane elements were offered by Fluid Systems of San Diego, California. After the benefits of both technologies were presented, the City Council approved the purchase of a one MGD, HFF, high pressure RO system as manufactured by Polymetrics. The design plan was to blend one MGD of high quality permeate from the new RO plant with two MGD from the existing lime softening plant.

In 1975 the Polymetrics plant was installed. At that time the City of Venice owned the largest brackish water reverse osmosis facility in the world. The HFF system utilized 96 eight-inch diameter HFF permeaters in a two-staged array operating at 50% recovery. The systems required a membrane feed pressure of 415 pounds per square inch (PSI) to produce the required 1 MGD permeate flow. The design recovery and membrane pressure were based on raw water quality from new production wells drilled specifically to provide raw water for the RO plant. The raw well water had a high sulfate level (1500 mg/l) which limited the recovery level to 50%.

By 1982 it was time to expand the RO production another 1 MGD. Since 1975 some advances had been made regarding the configuration of the HFF. Dow Chemical had developed a permeater capable of producing high quality permeate at much lower membrane feed pressures. The expansion was approved utilizing the DOW Dowex 20K permeater. The 1-MGD system only used 52 permeaters in a single stage configuration. The initial membrane feed pressure was a remarkable 240 psi. This was 175 psi less than the start up pressure of the older DuPont Permasep system.

DuPont followed suit and developed a "low pressure" permeater to compete with the Dow Dowex low-pressure permeater. The old "high pressure" DuPont permasep permeaters, now about six years old, were replaced with DuPont's new "low pressure" permeater.

It soon became apparent that the new "low pressure" permeater technology had some design problems. Both the Dow and DuPont permeaters quickly fell short of the projected permeate flow specificatons. Modifications to each system were attempted to increase permeate flow rates. DuPont even added additional permeaters in an attempt to boost permeate flow rates to meet design permeate flow requirements. Both systems continued to drop in permeate production. Attempts to chemically clean the permeaters were less than successful. The City was gradually losing its potable water production capacity.

In the mid 1980s the city council approved an emergency rehabilitation program. A consulting firm, Camp Dresser and McKee (CDM), was retained to draw up a plan to rehabilitate the existing RO facility and to provide for an additional 2 MGD of RO production to meet potable water demand into the year 2000. The first phase of the two-phase program was to rehabilitate the two failing 2 MGD HFF systems.

Background:
In 1989 CDM proposed replacing the two HFF systems using spiral wound low-pressure brackish reverse osmosis membrane elements. Fluid Systems of San Diego, California was the leading manufacturer of spiral wound membrane elements. CDM and Fluid Systems proposed a solution to rehabilitate the two existing HFF reverse osmosis systems. Time was critical. The 1989 winter tourist season was soon to peak and current water production was not going to meet the projected demand.

Local RO Systems manufacturer, Harn R/O Systems Inc., of Venice, Florida, was selected to fabricate and install the new replacement systems. To speed up the manufacturing process and reduce capital cost, the new systems were to incorporate the following existing HFF system components: electrical controls, switch gear, high pressure pumps, cartridge filters, and chemical pretreatment equipment. Much of the existing stainless steel membrane feed pump discharge piping and control valves were to be salvaged and incorporated into the new system design.

The new system would consist of two 1-MGD trains. Each train would have 32 six element long pressure vessels in a single stage array. The design recovery was to be 50%. It was determined that recovery levels in excess of 50% could result in membrane element scaling with calcium sulfate.

Logistics:
One of the two trains was made ready for installation in only 86 days from issuance of notice to proceed. By this time the existing HFF systems were not meeting demand and storage tank levels were going down. Obviously the old HFF systems needed to be shut down and removed before the new systems could be installed. However, shutting down the two HFF systems would drastically reduce water production capability. Therefore the old HFF systems were removed in two phases. The Dow system was to be removed and replaced first. In one day the Dow system was removed to make room for the new spiral wound elements. The night following the removal of the Dow HFF system the first RO train containing Fluid Systems TFCL 8821 spiral wound membrane elements was set in place. Work continued through the remainder of the night and into the next day. That evening the system pressure-test was completed and the system was on line producing high quality permeate water. Recorded membrane feed pressure at start-up was 170 psi. The membrane feed pressure required to produce 1 MGD of permeate had been reduced an additional 70 psi from the "low pressure" HFF system. From 1975 to 1989 the feed pressure required to produce 1 MGD of permeate had been reduced from 415 psi to 170 psi (59% reduction).

The first train of Phase I was completed and installed in mid February 1989. Storage levels continued to fall and the peak of the tourist season (the month of March) was looming ahead,. A second emergency purchase order was issued by the City to expedite the manufacture and installation of the second 1 MGD train of Phase I. The second train was completed and installed during the peak of the 1989 tourist season. Installation required that the old DuPont "low pressure" permeaters be removed and replaced within a two day span to assure that production capacity would not fall below water production demand. Harn R/O Systems, Fluid Systems, City employees and CDM personnel all worked closely to expedite the second installation. Prior to the second train going on line, storage levels were critically low. Levels were so low that if a major fire had broken out, pressure levels might have been insufficient to effectively fight the fire. The old DuPont system was removed and the new Fluid Systems spiral wound systems was installed and online within a 36-hour interval. With the two new RO trains installed, storage levels began to rise. The situation was upgraded from "emergency" to "nominal" operation thus averting any serious low level/low pressure event. The local newspaper, *The Venice Gondolier*, noted the event in the May 17, 1989 issue with the following quotation: "The elements entirely replaced a combination of Dow-DuPont permeater system that has given the city fits since its installation more than a decade ago."

System Performance:
The two new RO systems of Phase I functioned without mishap for the remainder of the 1989 tourist season (peak demand period). As previously noted, the membrane feed pressure required to produce 1 MGD per train (2 trains) was 170 psi. Permeate quality was less than 120 mg/l for system-wide salt rejection of 95% based on a feed water of 2500 mg/l TDS. The Fluid Systems TFCL membrane elements were performing as projected. The question in 1989 was, "How long will the new membrane elements maintain their performance?"

In 1990 the City was forced to abandon the shallow wells feeding the lime softening facility. Since the raw water supply to the lime softening plant was discontinued, it became apparent that the lime softening facility was destined for the scrap pile. The land was cleared and made ready to accept the second phase of the RO expansion project. Any blend water was now going to come from the 300 foot production wells feeding the RO systems of Phase I. Due to the high TDS concentrations of the raw water wells, blend flow was only around 7% of total production.

Between 1990 and 1992, on at least two occasions, two Phase I RO systems had sand pumped into the lead elements of both trains. Remedial action was taken to remove the lead end caps. This action exposed the lead end element of each pressure vessel. Any visible sand was flushed out using a pressure hose. Next the entire system (both trains 1 and 2) were unloaded. The Fluid Systems TFCL 8821 membrane elements were flipped and the brine seals installed on the opposite end of the membrane element. The elements were then loaded in such a way that the sequence of loading was reversed – brine end to lead end. A small increase of differential pressure was noted but the increase was below 2 psi. Restoration of flow and reduction of differential pressures would have been impossible if the old HFF permeaters were still on line.

In 1992 a Lakos Sand Separator was installed to reduce the chances of sand reaching the spiral wound membrane elements. This proved to be a good investment. Since the installation of the sand separator the amount of sand reaching the cartridge filters has been very minor.

Phase I trains continued to perform as predicted. Gradual increases in membrane feed pressures were recorded over the next eight years.

In 1996 the pretreatment process of Phase I was modified. Since the installation of Phase I in 1989, the pH of the raw feed water supply had been lowered by injecting sulfuric acid. It was believed that this low pH environment would reduce or eliminate the potential for calcium carbonate scale formation within the membrane elements. New polymeric antiscalants were introduce into the market place after the original DuPont / Dow HFF trains were installed. In 1985 the current antiscalant of choice, sodium hexametaphosphate, was replaced with the newer polymeric antiscalant Flocon 100. The manufacturers of Flocon 100, Pfeizer Chemical, advocated the reduction and/or elimination of sulfuric acid injection for pH adjustment. They claimed the antiscalant would effectively sequester or otherwise prevent mineral scale formation in the membrane elements without lowering the pH of the raw feed water supply. A conservative approach was to inject both chemicals to minimize the effects of mineral scaling. In 1996, after many years of reliable performance, it was decided to try eliminating the addition of sulfuric acid addition. The two trains of Phase I continued to operate as expected showing no signs for mineral scaling.

Since 1996 no significant alterations of the RO processes have taken place. However, many issues regarding postreatment of the RO permeate have been addressed. Due to the presence of hydrogen sulfide in the permeate and concentrate streams, measures have been taken to reduce and control this troublesome gas. Hydrogen sulfide has a rather pungent odor at very low concentrations. It is therefore, necessary to strip the gas from the permeate prior to storage using a packed tower/force draft degasifier. The off gases generated from the degasification process, hydrogen sulfide, then needs to be contained and neutralized to prevent foul odors and corrosion of metal surfaces in the proximity of the degasifier structure. Scrubbers were added to the degasification process to minimize the deleterious effects of the hydrogen sulfide gas. Concentrations of hydrogen sulfide gas also needs to be controlled or reduced in the concentrate stream as well. Chlorination is used to oxidize the hydrogen sulfide gas while compressors provide required amounts of dissolved oxygen prior to concentrate disposal.

Over twenty years have passed since the installation of trains 1&2 in Phase I beginning in 1989. The success of Phase I is a combination of several factors. Certainly, first and foremost, the spirit of cooperation during the installation of the two trains of Phase I was a significant factor. Without cooperation between the CDM, Harn R/O Systems, Venice Utility Department personnel, Venice City Engineer's office, and the Venice City Council this brief history would be one of tragic failure rather than resounding success. Although the membrane elements are eleven years old the permeate quality remains excellent at 40/50 mg/l TDS.

Update (by Steve Park, circa 2001):

Current plans are to install Variable Frequency Drive (VFD) devices on the membrane feed pump motors of Phase I. Currently the membrane feed pumps operate at a constant speed and the flow to the membrane trains are controlled by the use of a throttling valve. The feed pressure required to produce 1 MGD permeate from each of the two trains of Phase 1 is currently 250 psi. Since the pump motor speeds cannot be adjusted the pumps are producing more pressure than the membranes require. However, with the addition of the VFD deices, the pump speeds can be adjusted to meet membrane feed pressure requirements. Producing just the right amount of flow and pressure will save the city a significant amount of electrical energy cost. Further energy savings will be realized if the existing eleven-year-old membrane elements are retired from service. It is projected that the new membrane elements will produce the required 1 MGD permeate flow from each train at a membrane feed pressure of 130 psi. This reduction in membrane feed pressure could reduce electrical energy cost by as much as 50%. While the existing membrane elements continue to function well, the argument to replace the membrane elements to save energy cost is a compelling one.

Update (by Steve Park, circa April 2011):

Another condition of City's SWFWMD WUP renewal is to complete a study to determine the feasibility of increasing RO plant recovery from it's existing 50% to the range of 75-80%. The City has retained a consultant to oversee the condition requirements and investigate any complications that may be associated with increased recovery, including alternative methods of concentrate disposal. This study is anticipated to be completed in 2012, and will guide the City to it's next generation of potable water supply to it's citizens and seasonal visitors.