Portable Swimming Pool Reverse Osmosis Systems

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A standard practice for pool owners is to periodically drain the swimming pool to reduce calcium and magnesium hardness as well as other water contaminants. A swimming pool reverse osmosis unit has been developed that can remove common impurities without replacing the vast majority of the water. The swimming pool nanofiltration unit takes the impurities from the pool water and concentrates them into 10–15% of the water. It then puts the remaining 85–90% of the water back into the pool. All contaminants are reduced including calcium, sodium, chloride, sulfates, carbonates, heavy metals, cyanuric acid as well as dissolved organics. It generally takes one to two days for an average sized residential pool to reduce the salinity level by 1000 ppm and the calcium level by 500 ppm or more. (Figures used in this paper assume an average gallon capacity of 16,000 to 20,000 gallons in an average residential pool.)

The swimming pool reverse osmosis units are built in two size configurations for use on residential pools. One size is small enough that the customer could rent one from his swimming pool supply store. He could transport it in his trunk. It would be no more difficult to use than a carpet washing machine like those that are rented every day. It would take a small unit 4 to 6 days to do an average residential pool depending on the initial quality of the water.

Larger units are currently being operated by pool service companies. The larger units are placed on a trailer. This type of unit can process the water in an average pool in 1–2 days. The large unit can service from 175 to 350 residential pools per year. In many locations it can produce a water quality that is better than the potable water used to refill the swimming pool. The unit not only conserves water (by cleaning the water rather than draining and refilling the pool...) but also avoids problems associated with draining such as what to do with the water, how to avoid plaster delamination, or floating the pool or having the sides cave in (with high ground water tables), etc. The swimming pool reverse osmosis unit was developed and patented as a result of a University of Arizona nanofiltration research program which began in 1988.

Existing units as described in this paper have been designed for residential swimming pool use. Many other configurations are being manufactured for desalination, effluent treatment, etc. New models, for unique applications or for larger (commercial) pools are being contemplated and can be discussed with the manufacturer.

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Introduction

The University of Arizona began a nanofiltration research program in the spring of 1988. Nanofiltration as used in this report is the same as low pressure reverse osmosis. As soon as the catalytic conditioner technology was combined with nanofiltration it was determined that its use on swimming pools would be practical. A nanofilter test without the catalytic conditioner ended after twelve hours with the nanofilter badly fouled with calcium scaling. The nanofilter was cleaned using a 4.0 pH acid wash. This cleaning brought the production and TDS removal back to their original values. Following the cleaning a catalytic conditioner was added as a pretreatment and the nanofilter was put in operation on the same pool without any fouling. The same elements were incorporated into a small swimming pool nanofilter unit (using three 4 x 60–inch membranes) and were used on 20 pools or more without calcium scaling even though the calcium level in some of the pools exceeded 1000 ppm, with a recovery rate of 90%. These were very surprising results, but they have been verified with two more of the three tube nanofilter units, and five larger units (described below) that have been built and operated since that time.

Construction

After being pumped from the pool, the pool water first goes through a catalytic conditioner and then a 5–micron prefilter. The conditioner prevents calcium scaling by forming microscopic calcite crystals which do not adhere to the nanofilter. The prefilter reduces the size of suspended debris going into the nanofilters to less than 5 microns. Three 4 x 60–inch cellulose acetate (CA) elements were used on the first three units built. At first one low pressure CA and two medium pressure cylindrically wrapped CA elements were used. A recirculation loop was also used so that a large flux could be maintained in the elements (4 gpm) even though the reject was less than 0.4 gpm. Because of the recirculation the first element was exposed to relatively brackish water so it was found that a better salinity and hardness removal could be achieved if 3 medium pressure CA elements were used. When the three medium pressure CA elements were used the flow rate dropped to 4000 gallon per day (GPD). It would take at least 8 days to drop the total hardness in a pool by about 500 ppm (see Table 1).

As noted in the Tables, the nanofiltration system removes much more than just calcium – including sodium, sulfates, chlorides, carbonates, heavy metals, dissolved organic material, and cyanuric acid. The membrane restricts the passing of material greater than (roughly) 0.001 microns, which includes most undesirable impurities in swimming pool water.

A local commercial pool service company, Tucson Pool Chlor, was contacted. This company performed the initial pool testing, and said that they were interested in what the unit did, but that service companies would want units that would remove calcium at least twice as fast.

A new design was developed that used four 4–inch elements and one 8–inch element. A photograph of this unit is shown in Figure 1. This latest unit utilizes schedule 80 PVC pipe and fittings to interconnect the total of 5 elements. A recirculation loop is used on the 8–inch element and on the last three 4–inch elements. The large unit is 32 inches wide, 76 inches long and 3 foot high. It weights approximately 300 pounds when dry.

The large unit uses two pumps that require less than 20 amps to operate. Two household circuits are used. This unit turned out to be as much as 7 times as fast as the original, dropping the total hardness level by just over 900 ppm in a 18,000 gallon pool in 48 hours (see Table 2). Four of these large units have been sold. Two units, are operating in Tucson, Arizona, one in San Antonio, Texas, the last in North Hollywood, California.

The swimming pool nanofiltration unit developed by the University of Arizona nanofiltration research program has been patented after the rights to do so were given to its inventor. Both the method of encapsulation and the combination of a catalytic conditioner that make the swimming pool nanofiltration unit practical are covered in US patent 5,112,483. A second, generic patent covering the use of any portable RO system for swimming pool purification has been covered in US patent 5,234,583. The equipment is commercially available through Clean Water Products, at 1870 West Prince Road, Suite 9, Tucson, Arizona 85705.

Operation

The large nanofiltration units (as described above) are mounted on platforms with 6–inch diameter pneumatic tires. The unit can be rolled up a ramp into a trailer for transporting. The pneumatic tires cushion the unit so that it is not damaged in transit. Whenever feasible the nanofiltration unit can be left on the trailer and hoses extended to the pool, otherwise the unit can be rolled poolside through 3 foot wide gates.

The portable nanofiltration unit is brought to the pool by the service man, who then extends three hose lines. One hose is for pumping pool water to the unit (pool water suction), the second is for returning the product water to the pool, the third is for running the reject water to a drain or other location for disposal.

In order to meet the element operation specifications the chlorine level in the pool must be reduced to a maximum of 1 ppm for the duration of the cleansing – usually from 1 to 3 days. Higher chlorine levels can be tolerated for a short period of time, however long term use of higher chlorine levels will permanently damage the membranes. If necessary, algaecides may be used to prevent algae growth during the period of low chlorine levels. For best results the pH of the pool water should be reduced to below 7 (taking care, of course, to shut down pool systems to prevent damage to them). These level changes can be quickly achieved by the addition of sodium bisulfide or sodium thiosulfate for chlorine reduction and muriatic acid or sodium bisulfate for pH reduction. After the operation is complete, the pool is rebalanced as needed.

In operation the units have gone through 20 relatively "hard" (see Tables) residential pools or more without needing cleaning. However, the cleaning of the membranes is not difficult. It requires about 45 minutes of recirculating 55 gallons of water (with a special wash detergent added) through the system. The detergent removes biological fouling. If calcium scaling occurs it can be removed by using a low pH wash. After each type of wash the unit is flushed out before being put back into service. The 5 micron prefilter needs to be changed when the pressure drop across the filter increases to 10 psi. In practice these filters have lasted for 10 pools or more on the large units. The cleaning is done at the shop by the pool serviceman.

Economics

The life of the nanofilter should be in excess of 4 years of continuous use if the filter unit is properly operated. The cost of the nanofilter unit and its operation is such that the service representative should be able to recover his investment within 4 months if he can obtain $100/day rental for the unit. The cost of the rental by the pool owner may be less in some locales than the cost of draining and refilling of the pool. At times, draining isn't even an option, such as in the case of the water rationing situations in Southern California. In addition there is an additional savings in the cost of chemicals which the pool owner would otherwise have to buy for his pool in order to prevent calcium scaling. Perhaps the greatest economic savings might be in a reduction of health costs. These are difficult to quantify.

Discussion

Nanofiltration of swimming pools, instead of draining, is a practice that should interest most pool owners. At the present pool owners tend to postpone draining and refilling for many reasons, including cost, inconvenience, worry about damaging the pool, and water conservation concerns. Occasionally, the fill water itself may be the source of unwanted contaminants. As a result the pool water becomes a chemical soup that could potentially cause health problems for some of the swimmers. Nanofiltration removes existing, unwanted chemicals (such as high salt or cyanuric acid levels) and reduces the need of adding additional chemicals to fight adverse effects of elevated dissolved solids. The bottom line is that the annual use of nanofiltration should increase the plea-

Pool: East Summertrail, Tucson AZ – ca. 18,500 gallons							
Dates	August	Tap	6	7	8	9	12	14
pH		7.80	7.2	7.5	7.4	7.5	7.3	7.7
Total Hardness		144	1048	1020	932	848	774	556
Total Calcium		124	988	972	868	796	726	518
Hard/Cal Ratio		86%	92%	95%	93%	94%	94%	93%
Total Alkalinity		130	130	112	106	105	100	84
Total Dissolved Solids		200	1740	1610	1520	1290	1200	890
Total Iron		.01	.03	.01	.00	.01	.01	.01
Total Copper		.08	2.95	2.80	2.70	2.70	1.90	1.59
Total Chlorine		0	Trace	Trace	Trace	Trace	Trace	Trace
Total Cyanuric Acid		0	100+	100+	100	90	90	80

Table 1 – Test conducted with original, smaller unit

East Paseo Grande, Tucson AZ – ca. 18,000 gallons				
Dates	July	Tap	2	4
pH		7.55	6.7	6.9
Total Hardness		292	1352	440
Total Calcium		166	1304	386
Hard/Cal Ratio		57%	96%	88%
Total Alkalinity		102	292	116
Total Dissolved Solids		550	3300	1200
Total Iron		.08	0	0
Total Copper		.12	5.9	1.6
Total Chlorine		0.976	Trace	Trace
Total Cyanuric Acid		0	100+	90

Table 2 – Test conducted with current unit

sure, both physical and psychological, derived from a swimming pool.

On a larger scale there would be an environmental improvement if this practice was widely adapted. There would be a considerable savings in water and a substantial reduction in added chemicals to the environment. An Arizona Utility interested in water conservation has agreed to insert a flyer in their water bills to let their customers know of the swimming pool RO unit.

Conclusions

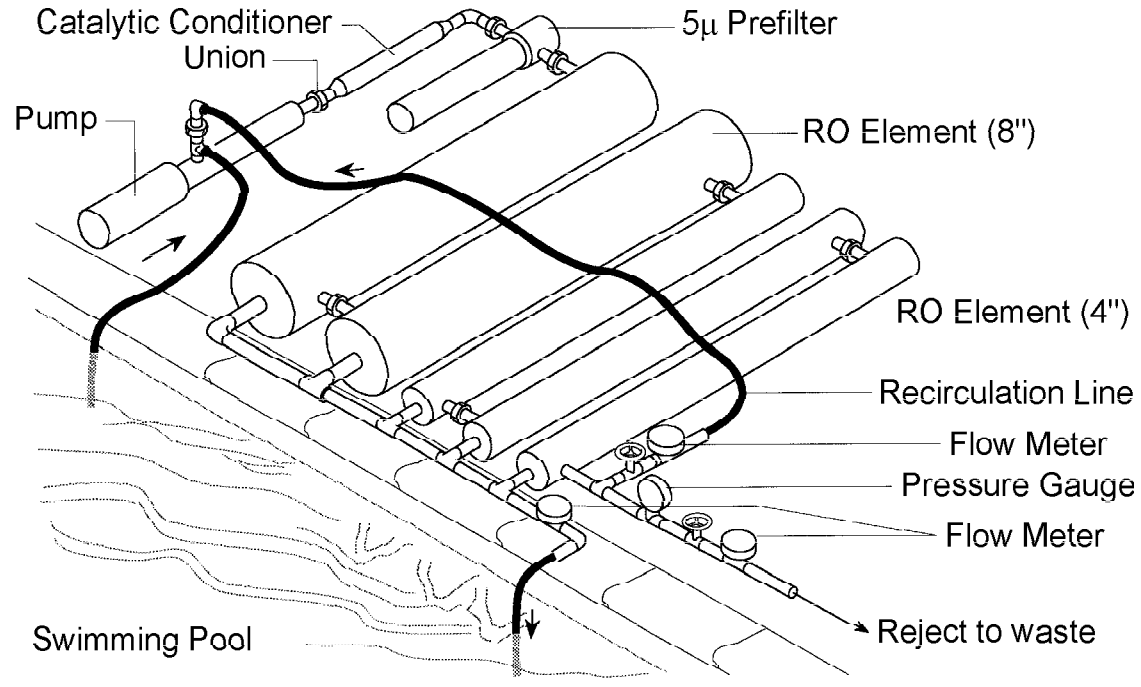
The swimming pool nanofilter system has been shown to be a practical solution for improving the quality of water in swimming pools without increasing the use of water through draining and refilling. With widespread use of this device there would be a significant decrease in water consumption as well as a reduction of chemicals presently added to the ecosystem.

About the Author

Dr. C. Brent Cluff is the owner/principal of Clean Water Products. He recently retired, after 32 years, from his position as an associate hydrologist with the University of Arizona.

Publishing Note:

A non–technical story about the swimming pool nanofiltration unit was published in Pool & Spa News, April 5, 1993, pp. 46–48.



Schematic of Portable Swimming Pool Reverse Osmosis System

U.S. Patent No. 5112483, 5234583