Supplying DI Water for the Aquarium Industry
By Francis J. DeSilva

The Disney/Pixar summer movie hit, “Finding Nemo” has sparked new interest and sales in the marine aquarium industry. The sales of clownfish, blue tangs, and aquarium accessories have skyrocketed as a direct result of the move.

The American Marinelife Dealers Association (AMDA), a non -profit organization promoting sustainable trade in living marine organisms for aquariums, notes that:

There are more than one million marine aquariums in the United States. The estimated retail annual sales of living marine organisms totals $200,000,000. Additional sales for the non-living products and hardware total nearly $300,000,000. This equates to Americans spending half a billions dollars a year for owning and maintaining coral reef fish and organisms.

The lifeblood of any aquarium system is the water. The live organisms in the tank rely on the water for nutrient intake and transport of waste products. The chemical makeup of the water can be very critical to ensure the growth and survival of the organisms. Systems are particularly sensitive to imbalances in ammonia, nitrate, phosphate, heavy metals, and oxidizing agents (chlorine or chloramines).

Most aquarium hobbyists and pet shops source their water from municipal water supplies. The available water quality is, at best, questionable in its capacity to sustain marine life for prolonged periods.

- (Hans Baensch, Marine Atlas, Tetra Press, 1994, page 50), "In older literature dealing with marine aquaria, tap water was not considered very important. When the salt mix was correct, the make up of the water was all right. I myself wrote, "tap water and sea salt equal seawater." (1974) This can no longer be said, largely because of pollutants now found in the ground water. Higher nitrate, pesticide, phosphate, and silicic acid levels, among others, have contributed to the significant deterioration of our tap water over the last 15 years. Many hobbyists have to treat their tap water before they can use it in an aquarium."
- (Nick Dakin, The Book of the Marine Aquarium, Tetra Press, 1992, page 83), "Generally speaking, any reputable salt mix can be dissolved in household tap water to produce a satisfactory solution, ... One word of caution, however, tap water may contain undesir- able impurities in the form of nitrates, phosphates, sulfates, etc., and you may have to purify household tap water using a deionizer or reverse osmosis unit. Many advanced aquarists do this as a matter of course, if they are keeping delicate invertebrates and fish, and it is a practice highly recommended to all marine fishkeepers."
- (Julian Sprung, Aquarium Fish Magazine, June, 1996, page 46), "The composition of the water used to make artificial seawater significantly

affects its quality. Tap water and well water vary in their chemical attributes, and may compromise the quality of artificial seawater when the source of freshwater is contaminated with heavy metals, nitrate, phosphate, organic compounds or toxins. To avoid adding unknowns with the water, it is best to purify it with reverse osmosis and/or deionization systems."

- (John Tullock, Successful Saltwater Aquariums, Coralife, 1994, pps. 47-48), "Strangely, aquarists do not often give thought to the quality of the fresh water they use to prepare synthetic seawater, and most use plain tap water. I would recommend strongly against this, as, unfortunately, municipal tap water and well waters are frequently unsatisfactory for aquarium use. This is due to the presence of pollutants that, while not deemed harmful for drinking purposes, can cause problems in the marine aquarium. Algae nutrients such as phosphate and silica, toxic metals such as copper, and a host of other compounds may all be found in "pure" tap water. I recommend that all water used for the marine tank be purified in some way."

The local water treatment dealer has a potential customer at each of the pet shop locations in his territory that supply aquarium fish, both freshwater and marine. The purification of tap water for the aquarist is most commonly accomplished by reverse osmosis or deionization. The dealer can sell a reverse osmosis system with all the attendant ancillaries; carbon unit, softener, chemical feeds, etc. Or, the dealer can provide on-demand DI water by supplying portable exchange DI tanks or a cartridge based DI system.

Reverse osmosis is a continual process that requires a collection reservoir and can remove 85 to 95 percent of dissolved ions. At times, reverse osmosis effluent is treated or polished by ion exchange deionization to render an ultra-pure water.

After the removal of dissolved ions by deionization, the aquarist adds dissolved solids BACK into the water! This “reconstitution” allows the water to be made up to the desired and exact amounts of each ion such as hardness, alkalinity, etc. This delicate ionic balance is necessary to maintain the sometimes fragile ecosystem within the tank.

There are two basic pieces of information that are essential for any demineralizer selection. It is necessary to know the flow rate and to know at least something about the inlet total dissolved solids. With only these two pieces of data (flow rate and inlet conductivity), it is possible to provide a demineralizer. However, the more information available about the characteristics of inlet water, requirements for the DI water and the range of flows that are going to be used, the more accurate the design will be.

REQUIRED INPUT DATA

- ESSENTIAL
  - FLOW RATE
  - INLET CONDUCTIVITY
- HELPFUL
  - ION COMPOSITION
  - SEASONAL ION VARIATIONS
  - FEEDWATER CHARACTERISTICS
    - RANGE OF FLOWS
    - TEMPERATURE
    - PRESSURE

Selecting the demineralizer

A two-bed demineralizer system, strong acid cation followed by strong-based anion, is the classic demineralizer setup. A cubic foot of anion resin inherently has less capacity than a cubic foot of cation resin. This means for a PEDI two-bed system where the tanks are the same size, the cation unit will always have more capacity than the anion unit. The anion unit being the weak link in the capacity determination should be the tank that governs the total throughput of the two-bed system. This actually works out to be a good arrangement since some endusers can overrun the units past the design cutoff point. Overrunning a two-bed unit with equal sized tanks means that the extra cation capacity will prohibit raw water from contacting the anion resin. Raw hardness-bearing tap water that contacts an anion unit can hardness foul the anion resin if there is still hydroxyl capacity left in the resin.

A mixed bed unit will provide a higher quality effluent, but offer less capacity. If the treatment scheme at the customer's is RO followed by DI, a mixed bed might be a good idea since it is treating a low TDS RO effluent water.

Chlorine and chloramine

Chlorine and other oxidizing chemicals must be totally removed from the water, as the organisms have virtually zero tolerance for these substances. It has become increasingly difficult to remove these oxidants, especially as more and more municipalities have started to use chloramines instead of chlorination.

Chlorine also has the potential to damage ion exchange resins. Long-term exposure to low levels of chlorine is very detrimental to resin. Furthermore, the organic chemicals that are released from decomposing cation resin are known to organically foul anion resin. This is an even worse problem than the slow deterioration of the cation resin capacity. The safest thing for the DI resin and for the aquaria, is to avoid all oxidizing agents in the feed water. A chlorine level of less than 0.1 PPM will not generally harm ion exchange resin while a residual over l.0 PPM almost certainly will damage the resin over time.

Chlorine and chloramines can be removed by activated carbon. The activated carbon unit should preceed the RO or the DI system. Typically, chlorine is a parameter that is regularly tested for by the aquarist.

Phosphates and nitrates

Phospates and nitrates are two anions that are closely monitored by the aquarist. The removal of these ions during the preparation of tank makeup water is important. Phosphates are very tightly held by anion resin and are difficult to remove during regeneration. Therefore, they tend to gradually accumulate on the resin, stay there, and occupy a portion of the exchange sites. The recent increase in the practice of adding zinc orthophosphate to municipal water supplies (to control corrosion) has increased the incidence of phosphate fouled anion resin.

Nitrates are easily removed by anion resin and easily eluted off during regeneration.

Ammonia

Ammonia can be present in water in two forms, either ammonium hydroxide (NH_3) or as the ammonium ion (NH_4). When the pH of the water is less than 7 the ammonia is present as the ammonium ion. As pH increases above 7, more of the ammonia is present as ammonium hydroxide.

The ammonium ion is readily removed by cation resin. Good removal capacity can be expected in waters low in hardness. Waters that are high in hardness will have decreased capacity due to the simultaneous affinity and removal of calcium, magnesium and the ammonium ion.

There are selective zeolites that will preferentially remove ammonia in high hardness waters. Monovalent cations, like sodium, will reduce its effectiveness somewhat. Regeneration requires sodium chloride, at a dosage up to 10 lbs/cu.ft.

Water Specifications for Reef Tanks	
Temperature	75-80°; stable
Specific Gravity	1.021 - 1.024; stable
pH	8.1 - 8.3; stable
Alkalinity	>3.6 meq/l
Ammonia	-0-
Nitrite	-0-
Nitrate	<5 ppm
Phosphate	<.05 ppm *
Calcium	> or = 400 ppm
Heavy Metals	-0-

Water Specifications for Fish Only Tanks	
Temperature	75-80°; stable
Specific Gravity	1.022 - 1.024; stable
pH	8.2 - 8.4; stable
Alkalinity	>2.5 meq/l
Ammonia	max concentration .05 ppm (some specify 0)
Nitrite	.05 ppm; concentrations above .1 ppm are critical
Nitrate	max 200 ppm - <50 ppm is better (some specify as low as 20 ppm)
Phosphate	max 2-3 ppm <.05 ppm is best *
Heavy Metals	-0-
Iron	0.1 to 0.3 ppm

Sizing the DI system using a Portable Exchange Service

The DI Tank Sizing Guidelines (see chart) gives the total capacity available for common DI tank sizes. The capacity numbers are stated in grains. To calculate the gallons available for an application, divide the grains capacity per tank by the grains per gallon as calcium carbonate ($CaCO_3$) (gpg) of the water being treated. To arrive at the grains per gallon, divide the Total Dissolved Solids (TDS) as parts per million (ppm) of the water by 17.1.

DI Tank Sizing Guidelines

Tank No.	Dia. (in.)	Resin Volume (cu. ft.)	Flow Rate (gpm)	Cation Capacity (grains)	Anion Capacity (grains)		Mixed Bed Capacity (grains)
					Type 1	Type 2	
618	**6.5**	**.25**	**0.75**	**7500**	**3750**	**4500**	**2250**
818	**8.4**	**.5**	**1.5**	**1500**	**7500**	**9000**	**4500**
942	**9.2**	**1.4**	**5**	**42000**	**21000**	**25200**	**12600**
1242	**12.8**	**2.5**	**8**	**75000**	**37500**	**45000**	**22500**
1252	**12.8**	**3.**	**8**	**90000**	**45000**	**54000**	**27000**
1447	**14.0**	**3.5**	**12**	**105000**	**52500**	**63000**	**31500**

Approximate Capacity Numbers for PEDI Resin

Resin	Capacity (grains/cu. ft.)
Strong Acid Cation	**30,000**
Strong Base Anion	
Type 1	**15,000**
Type 2	**18,000**
Mixed Bed	**9,000**

The flow rate is determined by the water usage demand. Does the system flow to a storage tank or will water be needed only on an instant demand basis? Water for aquariums can be used to top off tanks suffering from evaporative losses, or for maintenance partial tank turnover, or for complete new tank filling. Topping off fish or reef tanks can use DI water while larger volumes of water added to tanks will need to be "reconstituted" with the appropriate salt mix. The salt mixes are proprietary chemical mixes sold by specialty fish and reef supply companies.

Some pet supply stores sell DI water or premixed salt water to customers. These locations can turn out to be larger consumers of water than others and would require a properly sized DI tank system and a DI water holding tank or a salt mix tank.

Potential for other business

While the DI water demands for a pet shop require an RO or DI system serviced by the dealer, the DI water requirements for the home aquarist are much less. There are a number of manufacturers that offer RO/DI systems for these low flow applications. Many of these systems use an RO systems similar in size and design to an under-the-sink unit, with options for the RO effluent water to be polished by DI mixed bed cartridges. Commonly, the DI mixed bed cartridges are in clear housings and use a dyed resin that changes color as it exhausts to indicate the need for cartridge replacement.

The water treatment dealer should be aware of the business potential for this growing segment of the point-of-use marketplace. Whether selling equipment such as softeners, RO or DI, or simply selling DI water, this opportunity for increased sales should be explored.

References

Hans Baensch, Marine Atlas, Tetra Press, 1994, page 50

Nick Dakin, The Book of the Marine Aquarium, Tetra Press, 1992, page 83

Julian Sprung, Aquarium Fish Magazine, June, 1996, page 46

John Tullock, Successful Saltwater Aquariums, Coralife, 1994, pps. 47-48

Peter Meyers, DEMINERALIZER DESIGN CONSIDERATIONS, 1996 Liberty Bell Conference, Sept. 10, 1996

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