Modified DeCoupled (MDC) Systems

AST Description & Technical Details

BEAD FILTER SOLUTIONS

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This is not an operation manual. This document is to be used as a description and technical guide. If you have questions on how to operate an MDC Filter, you can call AST at 1.800.939.3659 or find more instructions on our website at ASTFilters.com.

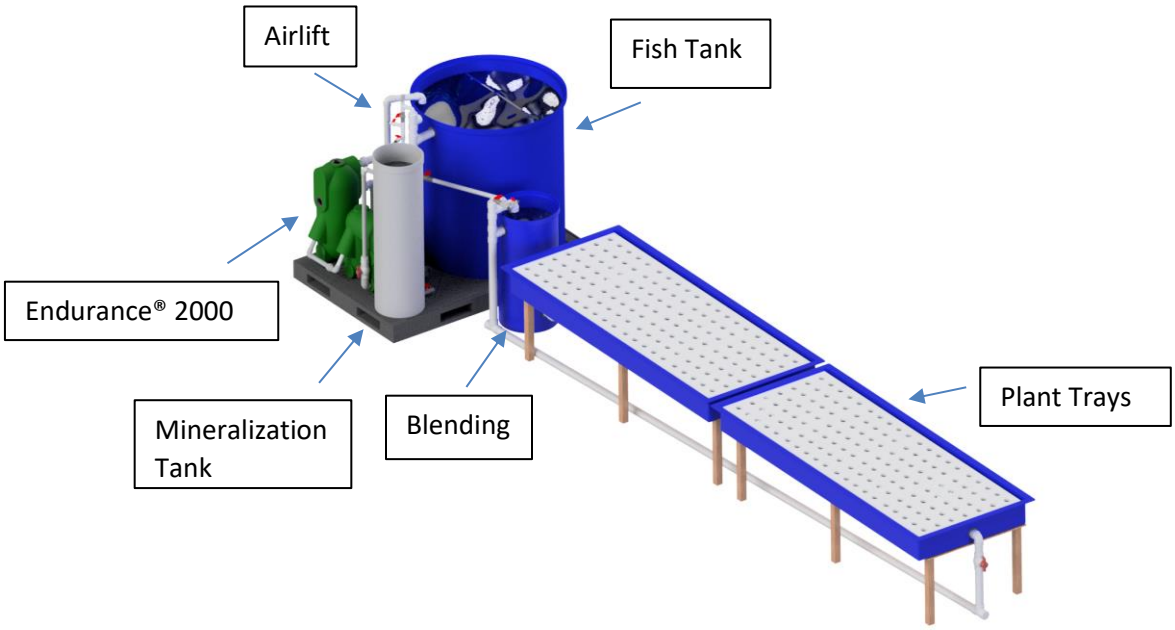

Figure 1. The MDC-2000 line is an airlifted closed recirculating system with sludge mineralization designed to support decoupled aquaponics.

MDC Model Line Description and Technical Details

The MDC (Modified DeCoupled) model line consists of a series of airlifted RAS (Recirculating Aquaculture System) systems equipped with a sludge mineralization system that was developed to support decoupled aquaponic systems. When operated as a stand-alone RAS system, the system can operate with minimal water loss making it ideal for the rearing of marine baitfish and fingerlings. The unit is also proving popular in schools where it is used to support both aquaponic and aquacultural programs.

Figure 1 illustrates the original MDC-1000 configuration used to support small scale decoupled aquaponic systems. A larger MDC-2000 or larger MDC-3000 designs are available depending on production specifications. The main components common to all MDC standard model

configurations include (a) a holding tank for live animals, (b) an Endurance® bioclarifier, (c) an airlift, (d) a mineralization basin, and (e) *optional* UV lights. The MDC RAS can be configured to discharge nutrient rich water into a blending tank that circulates via a second airlift to plant trays or other aquaponic growing configurations. Usually supported by a linear air pump, the system operates pneumatically with no moving parts or electronic controls.

Holding Tanks

The flat bottom polytanks, used as holding tanks, are typically 4 feet tall with a water capacity matching the tank densities and loading targets. The flat bottom of the tank is utilized to simplify shipping and installation. The tanks are designed to operate with the waterline and the midpoint of the airlift discharge pipe at 45 inches. This allows the submergence to lift ratio (S/L) to be between 5:1 and 4:1 for energy efficient operation. It is advisable to maintain air stones in the tank(s) for supplemental aeration whenever densities or feed loadings are high.

Water exchange with the Endurance® PolyGeyser® is collected from a slotted drainpipe that enters the tank a few inches above the floor. The slotted pipe inlet is designed to facilitate cleaning, fingerling harvest, and the exchange of protective meshes. Under normal operation, the slotted intake rests parallel to the tank floor. The inlet can be rotated to the vertical for cleaning operations. This inlet design appears to eliminate the need to use cone or center drain tanks. The turnover of water in the MDC design is rapid, usually under 45 minutes, and the solids capture is highly efficient, so suspended solids accumulations or tank turbidity are rarely an issue with these flat bottom tanks.

Endurance® PolyGeyser®

The Endurance® PolyGeyser® is the central component in each of the MDC designs. These "bioclarifier" filters remove suspended solids, ammonia, and dissolved organics purifying recirculating waters. The Endurance® filters are pneumatically washed floating bead filters that

recycle their backwash waters and store the sludge generated in a separate sludge compartment. The sludge compartment is configured to permit pneumatic sludge discharge into a mineralization tank where approximately two-thirds of the generated sludge is mineralized, reducing the volume that must be discharged. Clear mineralized waters from the Endurance® are returned to the holding tanks. The only water that is removed from the RAS is the stabilized sludge. Water reuse can be extended well beyond a year in most applications. However, this is reduced to 2-3 weeks when water is fed to the hydroponic trays.

Airlift

Water is recirculated between the holding tanks and the Endurance® by energy saving airlifts. No water pumps are required. The air injected into the airlifts moves the water while it is replenishing oxygen and stripping out carbon dioxide. In this configuration, water is pushed through the bead bed by gravity then passes into an embedded slotted pipe near the top of the bed. As water flows from the filter, it drops to the bottom building hydraulic pressure to push the lighter air/water mixture (created by the air injection) upwards into the holding tanks. The air/water mixture maximizes the bubble-water interaction, so gas transfer is rapid.

Mineralization Tank

The last major component of the MDC design series is the mineralization tank. The mineralization tank is directly connected to the Endurance® sludge storage compartment. The sludge storage compartment is designed to support either aerobic degradation favored for aquaponics or anerobic digestion favored for marine systems. Aerobic treatment tends to preserve nitrogen to boost plant growth, while anerobic conditions lead to nitrogen stripping (denitrification) extending water use and preserving salts. The mineralization basins are sized to provide sludge residence times (SRTs) of 10-20 days.

UV Lights (optional on MDC-1000 and MDC-3000 systems)

Optionally, any of the MDC models can be equipped with UV lights which are used to suppress disease spread, or in some cases eliminate algal blooms that cause high turbidity. It is projected that future regulations will require, for example, some sort of disinfection process between the fish and plant components in aquaponic systems. UV light is also favored in broodstock, fry, fingerling, and shellfish applications where disease control can be critical.

The MDC Series

There are three basic models in the MDC series: 1) the MDC-1000, 2) the MDC-2000 system, and 3) the MDC-3000 system. Table 1 lists the key features of each model. Figures 2 and 3 illustrate the RAS components for each model.

The MDC-1000 has its core a 260-gallon tank (roughly 1 m^3 or 1 metric ton) and an Endurance® 2000 PolyGeyser®. The unit is sized for a feed application rate of <0.75 lbs feed/day (dry weight pellets) with a peak sustainable carrying capacity in the range of 1 lb feed/day. It is presumed that the system will be operated at moderate density (perhaps 15-30 kgs fish per m^3 water). The sludge digestor (16 gallons) provides a sludge residence time (SRT) >10 days aerobically. The RAS is typically matched up with two, 8' L x 3' W deep water plant trays. The system is supported by a 60 lpm (2.1 cfm) linear air pump.

The MDC-2000 utilizes the same 260-gallon tank and Endurance® 2000 as the MDC 1000 but is equipped with an oversized (36 gallon) sludge digestor. This sludge digestor provides a SRT of 30-40 days depending on the feeding rate. MDC-2000 RAS are normally pallet mounted and feature a 18-watt UV light on the return line to the fish tank. This configuration allows all the water moving to the plant trays (typically 4) to be disinfected. This system is configured to operate at higher feed loadings (0.75 - 1 lb feed/day) and to fully digest the sludge produced reducing sludge volumes by about two-thirds. At 3% feed, the system will hold up to 33 lbs. of fish. The system is supported by an 80 lpm (2.8 cfm) linear air pump.

The MDC-3000 moves up in size by a factor of 2-3 over the MDC-2000 line, incorporating three 260-gallon tanks, and an Endurance® 4000 (1.7 cubic foot of beads) PolyGeyser®. This three-tank configuration is excellent for the grow out of species such as tilapia where size segregation is beneficial. The maximum sustainable feed loading for the RAS is estimated at 3-4 lb/day with normal loading expected to be in the range of 1.7-3 lb/day. The MDC-3000 is equipped with a 90-gallon sludge digestor providing 10-20 days SRT depending on the feeding rate. This sizing is sufficient to support aerobic digestion or robust anerobic denitrification. The system is driven by a 160 lpm (5.6 cfm) linear air pump system supporting the airlift and tank aeration. The MDC 3000 is not normally palleted, and the UV treatment is optional. This system can be special ordered with a larger single tank (750 or 1200 gallons). The system is designed with three 2-inch air lifts collectively circulating up to 25 gpm providing a 30–50 minute turnover rate.

Standard Specifications

The MDC line is designed as a highly closed recirculating system that maximizes water reuse while minimizing sludge discharge. Table 1 compares the three standard MDC models in quantitative form. Tables 2 & 3 define the sustainable carrying capacity for each standard model across several potential species. Table 4 compares the three models in terms of their aquaponic capacities.

From Table 1 we can see that the MDC-1000 and MDC-2000 are very similar in performance indicators. The systems have the same fish tank (260 gallons) and filter capacity (0.75 ft^3) supported by a high tank turnover rate (24 minutes). They differ principally in the size of the sludge digestor, but both the MDC-1000's 16-gallon and the MDC 2000's 36-gallon units provide for sludge residence times (SRTs) well above that which is required (10 days) for sludge stabilization under completely mixed warmwater conditions. The MDC-3000 is a larger system with a volume of about 880 gallons supported by a 1.7 ft^3 Endurance® 4000 filter and a recirculation rate of 15-25 gpm. The MDC 3000 approaches sludge stabilization with an organic decay rate of 63% in its 90-gallon sludge digestor. All three systems display extremely high

cumulative feed burdens over 100,000 mg/l with maximum water reuse estimates above 300 days when operated in a closed fashion. The capacities of the systems to support the illustrative species in Tables 2 and 3 are driven by the feed capacity, the percent of body weight fed, and the ammonia/nitrite tolerance of the species for the application. The MDC-3000 is shown to have over 2 times the capacity of the MDC-1000 and the MDC-2000. With a robust species like tilapia with a high ammonia/nitrite tolerance the MDC-3000 can support about 145 pounds of fish.

Custom MDC Configurations

An MDC, like many RAS configurations, can be custom ordered at any size to meet customer needs. Custom configurations can be more expensive and ongoing (2022) supply chain issues can incur fabrication delays. A few recent examples of variant configurations follow. The larger polymer product line consisting of the PG6000 and PG12000 have been assembled in an MDC like configuration to support the production of marine shrimp (Figure 6). In these systems, the PG6000 (3 ft^3) and PG12000 (6 ft^3) are configured with a single or multiple 1200-gallon polytanks to produce shrimp at a density of 10 kg/m^3. Sets of MDC RASs are configured to produce 100-300 lbs of shrimp per week for local markets know as a "CaRASel" configuration. This variant was thoroughly tested under a USDA SBIR grant over a four-year period. This configuration is supported with a center drain. Inducing a slow circular movement with the airlift return "spins" the solids to the center of the tank for easy pick up. Elevating this configuration also raises the S/L ratio improving airlift performance. The principal disadvantages of this approach are the cost of elevating the tank and difficulties incurred servicing the intake screen at the tank center.

A second variant (Figure 4) is favored by advocates of rapid solids removal, uses the 45-degree bottom cone to assist in the movement of solids to the center pickup point. The cone bottom tank is supported by an external stand. The use of the cone bottom tank and stand increases the cost of the configuration. The AST staff is not aware of any data indicating the cone bottom tanks improve water quality.

A third variant uses an elevated, square bottom tank to facilitate a center drain. Recirculation is driven by a water pump (Figure 5). Care must be taken not to over restrict the return water flow which will over pressurize the filter and cause the mineralization basin to overflow. The water pumped systems consume more energy but are easier to operate. Aeration needs to be added to the tanks to support pumped recirculation.

Table 1. Basic Specifications for the MDC Endurance® Series				
	MDC-1000	**MDC-2000**	**MDC-3000**	**Comment**
System Water Volume	300 gal	300 gal	870 gal	Includes tank and mineralization basin
Functional Tank Volume	260 gal	260 gal	780 gal	
Functional Tank Water Depth	45 in	45 in	45 in	Measured to the centerline of the airlift discharge pipe
Sludge Digestor Volume	15 gal 0.06 m^3	36 gal 0.14 m^3	90 gal 0.34 m^3	
Bead Volume	0.75 ft^3	0.75 ft^3	1.70 ft^3	
Nitrification Capacity @ 1 ppm-N	9.5 gram-N/day	9.5 gram-N/day	23.5 gram-N/day	Decreases with concentration and varies with backwash frequency
Design Feed Capacity @ 1 ppm-N	0.75 lb. 318 grams	0.75 lb. 318 grams	1.7 lb. 772 grams	
Recirculation Rate	5-10 gpm	5-10 gpm	15-25 gpm	
Tank Turnover Rate	10 min	10 min	31 min	
HRT on MLVSS	20 days	50 days	27 days	In the mineralization tank
Projected SRT at Peak Load	>10 days days	>10 days days	>10 days days	Assumes 20^0C aerobic
Projected % VSS Decay at Peak Load	67% 23%	67% 61%	63% 25%	Assumes 20^0C aerobic Assumes 20^0C anaerobic
Projected Sludge Volume	0.7 gal/day 1.2 gal/day	0.7 gal/day 0.8 gal/day	2.2 gal/day 2.9 gal/day	Assumed 2% solids- aerobic Assumed 2% solids-anaerobic
Potential Water Reuse RAS	250-430 days	375-430 days	300-400 days	Assumed 2% solids- aerobic Assumed 2% solids-anaerobic
Cumulative Feed Burden (mg/L)	129,000 70,000	129,000 105,000	113,000 70,000	Assumed 2% solids- aerobic Assumed 2% solids-anaerobic
Length	48”	48”	74”	
Width	69”	72”	175”	
Energy @ 120 volt	46W	46W	261W	Neglects heating if required (AL-40,AL-200)
Shipping weight	230 lb.	710 lb.	750 lb.	

Table 2. MDC 1000/2000 Capacities for a Variety of Aquaculture Applications.							
	TAN or Nitrite mg-N/L)	**Max Fed Daily g/d [lb./d]**	**% Body wt. fed daily**	**Fish wt. Kg [lbs.]**	**System Density kg/m3 [lb./gal]**	**Filter Loading kg/m3-d [lb./ft3-d]**	**Comment**
Ornamental Fish Production	<0.3	<85 [0.2]	5	<1.7 [<4]	4.4 [0.04]	4 [0.25]	Neons, Discus, Angelfish,
Ornamental Fish Production-Hardy	<0.5	<170 [0.4]	5	<3.4 [< 8]	6.4 [0.04]	8 [0.53]	Oscars, Plecostomus, guppies, mollies, cichlids
Fingerling Production	<0.5	<170 [0.4]	5	<3.4 [<8]	6.4 [0.04]	8 [0.5]	Catfish, striped bass, trout, red drum, flounder
Baitfish Holding**	<0.5	<170 [0.4]	1*	<17 [<40]	20 [0.17]	8 [0.5]	Croakers, Cocahoes, blacknose dace, blue crab, bait shrimp
Broodstock Holding	<0.3	<85 [0.2]	1	<8.5 [<20]	16 [0.13]	4.0 [0.25]	Shrimp, redfish, speckled trout
Marine Shrimp Production	<.5	<170 [0.4]	1	<17 [<40]	28 [0.23]	8 [0.5]	Limited by tank size to 10 kg/m^3
Freshwater Aquaponics	<1.5	<510 [1.1]	1	<51 kg [<110]	58 [0.48]	24 [1.5]	Tilapia, channel catfish, goldfish

*Excretion assumed at 1 percent equivalent daily feed rate.
**Feed capacity assumed at 0.25, 0.5, 1.0 & 1.5 lb /ft^3 for target concentrations of 0.3,0.5,1.0, and 1.5 respectively for a 0.75 ft^3 filter.

Table 3. Typical MDC 3000 Capacities for Some Typical Applications.							
	TAN and Nitrite mg-N/L)	**Max Fed Daily g/d [lb/d]**	**% Body wt. fed daily**	**Fish wt. Kg [lbs]**	**System Density kg/m3 [lb/gal]**	**Filter Loading kg/m3-d [lb/ft3-d]**	**Comment**
Ornamental Fish Production	<0.3	<200 [0.4]	5	<4 [<9]	1.3 [0.01]	0.1 [0.22]	Neons, Discus, Angelfish
Ornamental Fish Production-Hardy	<0.5	<319 [0.7]	5	<6.4 [< 14]	2 [0.02]	6.4 [0.40]	Oscars, Plecostomus, guppies, mollies, cichlids
Fingerling Production	<0.5	<319 [0.7]	5	<6.4 [<14]	2 [0.05]	6.4 [0.40]	Catfish, striped bass, trout, red drum, flounder
Baitfish Holding**	<0.5	<319 [0.7]	1*	<32 [<70]	10 [0.24]	6.4 [0.40]	Croakers, cocahoes, blacknose dace, blue crab, bait shrimp
Broodstock Holding	<0.3	<200 [0.4]	1	<20 [<44]	7 [0.05]	6.3 [0.43]	Shrimp, redfish, speckled trout
Marine Shrimp Production	<.5	<319 [0.7]	1	<32 [<70]	10 [0.1lbs/ gal]	6.4 [0.43]	Limited by tank size to 10 kg/m^3
Freshwater Aquaponics	<1.5	<1191 [2.6]	1	<120 kg [<260]	21 [0.17]	24 [1.5]	Tilapia, catfish, goldfish

*Excretion assumed at 1 percent equivalent daily feed rate.
**Feed capacity assumed at 0.25, 0.5, 1.0 & 1.5 lb /ft^3 for target concentrations of 0.3,0.5,1.0, and 1.5 respectively for a 0.75 ft^3 filter.

Table 4. Typical MDC Aquaponic Values (Aerobic Mineralization)			
	MDC 1000	**MDC 2000**	**MDC 3000**
Assumed RAS Volume	300 gal	300 gal	870 gal
Filter Volume	0.75 ft^3	0.75 ft^3	1.7 ft^3
Design Feed @ 1.5% (lbs/day)	0.75 lbs/day	0.75 lbs/day	1.7 lbs/day
Mineralization Volume	16 gal	36 gal	90 gal
Basin Sizing Constant[1]	21 gal/lb fed-day	48 gal/lb fed-day	53 gal/lb fed-day
% Sludge Digestion-Aerobic	>67%	>67%	>67%
Assumed Fish Density	0.17 lb/gal 19 kg/m^3	0.17 lb/gal 19 kg/m^3	0.17 lb/gal 19 kg/m^3
Fish	50 lbs	50 lbs	113 lbs
Nitrogen Prod. [1] (grams/day)	14 grams/day	14 grams/day	29 grams/day
Plant Area Supported[2]	70-140	70-140	145-290
Projected Water Loss-Sludge[3]	0.7 gallons/day	0.7 gallons/day	2.2 gallons/day
Projected RAS Water Loss to Plants	18.5 gallons/day	18.5 gallons/day	38.3 gallons/day
Projected RAS Turnover	16 days	16 days	21 days

[1]Assumes 35% protein @13.6 g-N/lb plus VSS decay contribution
[2]Based upon lettuce @ 3 grams feed/ft^2-day
[3] Sludge at 1% solids and about 50% degradation at full load

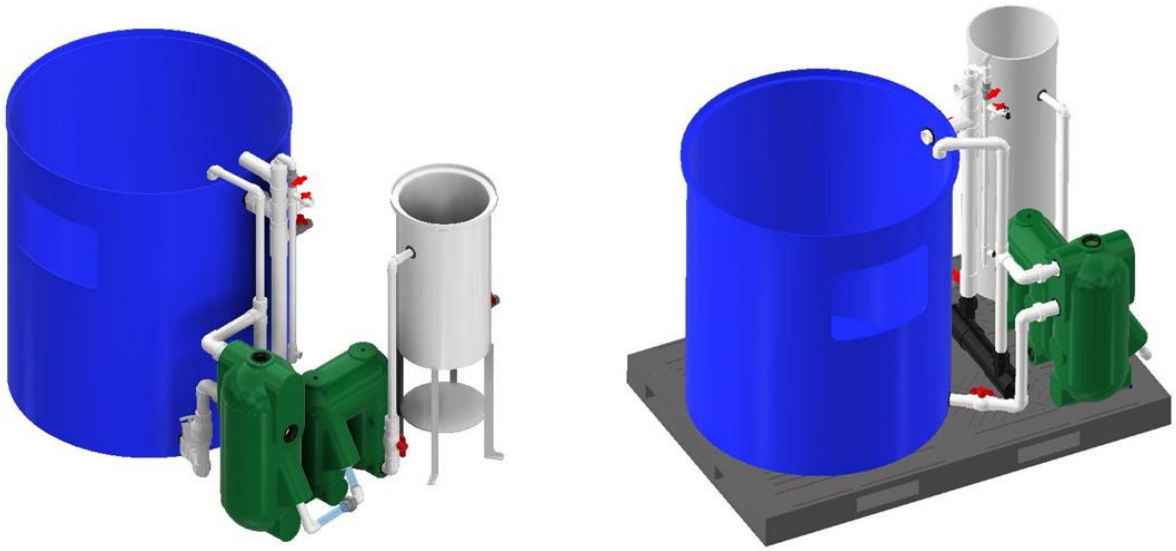

Figure 2. The MDC-2000 (right) is a pre-plumbed palleted system that has a larger mineralization tank and UV light compared to the MDC-1000 (left)

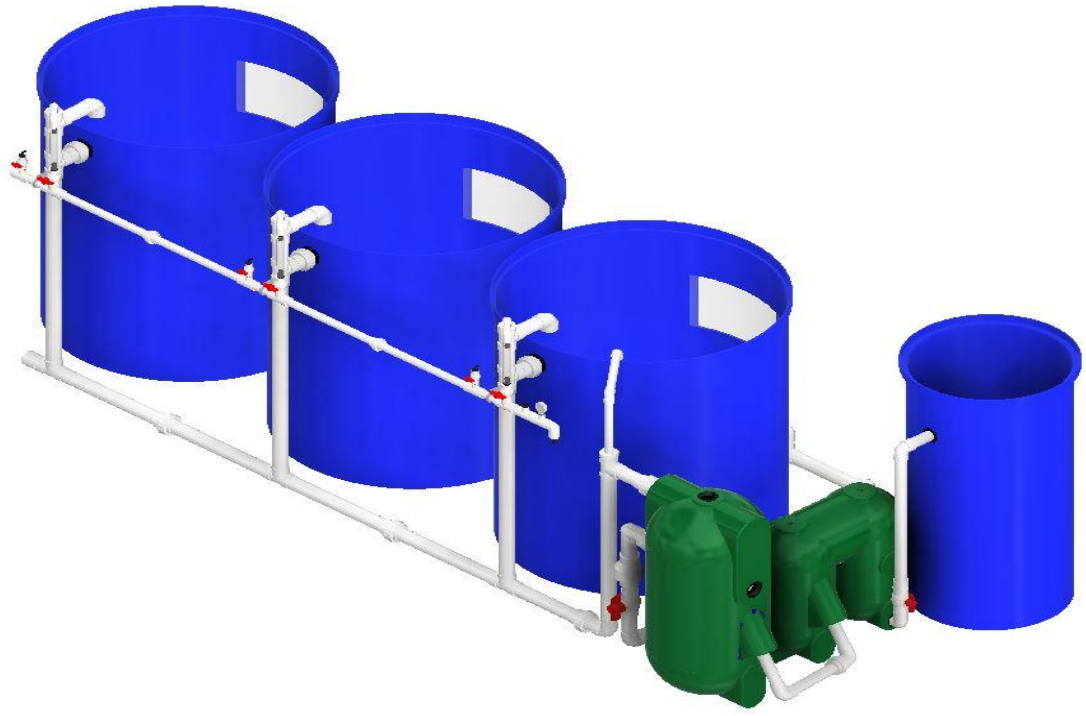

Figure 3: The MDC-3000 supports three tanks with an Endurance® 4000 filter and a large (90 gallon) mineralization Basin

Figure 4. A special order MDC-3000 configured with cone bottom tanks under hydraulic testing. Three airlifts return water to the tanks powered by the larger linear air pump (upper right).

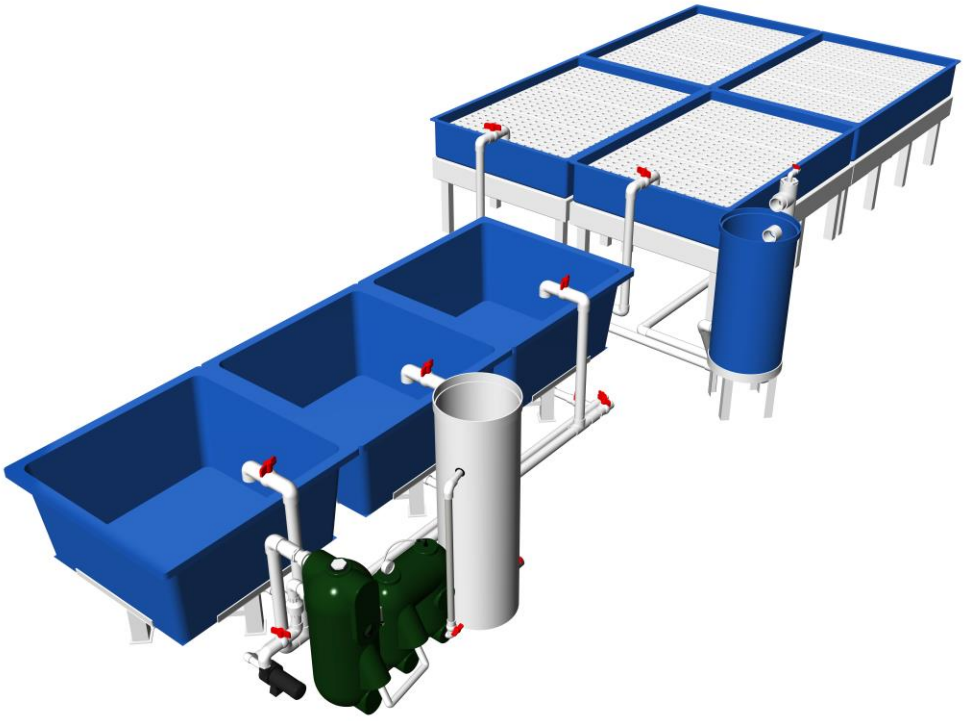

Figure 5. An MDC 3000 design with elevated cone-bottom square tanks driven by a water pump. The MDC 3000 can easily support 8-16 trays.

Figure 6. Three MDC systems assembled with a PG6000, 1200-gallon tank, and 3-inch airlift are supporting marine shrimp (*L. vannamei*) at a density of 10 kg/m^3.

Additional Readings:

Malone, R. and L. Beecher. (2000) Use of Floating Bead Filters to Recondition Recirculating Waters in Warmwater Aquaculture Production Systems, *Journal of Aquacultural Engineering*. **22**, 57-73.

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