shFOCE-Enhanced SeaWater Supply System – Jim Scholfield 7/15/14

Theory of Operation

We are saturating S.W. with CO_2 at 15 psig CO_2. This provides ~4 pH S.W. to be pumped out the red 1.25" D. hose to the experiment site 15m. deep and ~275m. out from Hopkins Marine Station. The tank and other equipment is housed in the Pump House just South of the Aquarium.

The S.W. supply at Hopkins is ~12 psig. The inlet pump cycles on and off to initially fill the tank about ½ way then maintains the level within ~2". It is controlled by 2 ganged float switches in the tank and a latching relay on the wall by the plug strips. The 2 plug strips are each connected to a GFI.

The inlet spray system atomizes the S.W. to quickly saturate the S.W. with CO_2. When the tank is at the desired ½ full level, the inlet pump turns off. The recirculation pump has already started via another float switch (no relay required) and continues to atomize the S.W.

COMPONENTS OF SYSTEM

At the top of the tank-

A 2 conductor wire whip to each of 2 connectors allows power connections to devices inside the tank. Connector 1 (4 pins) has conductors for the light and the recirc pump float switch. Connector 2 (4 pins) has conductors for the 2 float switches that control the inlet pump via the latching relay. The lower float switch is Normally Closed, the upper N. Open (when not floating). The latching relay maintains power to the pump when the lower float switch Opens as the water rises. The upper float switch turns the pump off when that float rises and closes ~~the~~ that switch.

One small manual valve (V15) admits CO_2 gas to the tank.

Another small manual valve is a vent(depressurization)(V14) which has tubing to the outside of the pump house.

An overpressure relief valve(V13) is set for ~25 psi, it is also vented to the outside.

There is also a tank pressure gauge (G1)

At the bottom of the Tank-

A 1" hole in the tank bottom is directed to a manual Drain Valve(V17), a valve(V16) connected to the Hose Pressure Relief Valve (V9)and another valve(V6) to the Hose Supply System.

System Description and Operational Notes- reference the ENH SW TANK SYSTEM SCHEMATIC

Substantial topside and seaward changes, electrically, electronically, mechanically will occur when a full automated swFOCE is available. At present, we are getting the system up and running with a simpler, nearly mechanical version called quickFOCE.

All parts are plastic or Stainless Steel. The pumps are magnetically coupled so all wet parts are plastic.

The large pumps at the back of the Hopkins Pump House supply S.W.@ 12psi via 6" D. piping. A large Hopkins Isolation Valve (V1) and a smaller MBARI isolation Valve(V2) admit water to the enhS.W. System. Following the flow of S. Water thru our system:

Next is a check valve (V3) to prevent backflow when the tank is above 12 psi. The Inlet Pump (P1) is a ½ HP unit. It discharges into a 10 micron filter(F1) then a 2nd Check Valve(V4) for redundancy. Gauge(s) (G3) show the pressure before and after the filter.

A globe valve(V5) controls the flow into the tank, it is normally set ¾- 1Turn open to dampen pressure surges as the Inlet pump cycles. Inside there are about 10 garden type sprayers that admit the S.W. as a spray that falls thru the CO_2. The inlet pump is controlled by the previously described 2 ganged S.St. float switches. They operate on 120 VAC but very low current. There is also a 60W light. Both pump systems and the light are fed power by the wall switches.

The recirculation system operates nearly continuously. It is directly controlled by a 120VAC float switch which can handle 5 amps or so. It starts automatically when the tank is a little less than ½ full then runs continuously until the tank is nearly empty or is turned off. An internal spray system similar to the inlet side is fed tank S.W. via a filter and pipe which exits the tank thru (V11) then to the Recirc. Pump (P3) thru ~~the~~ a filter (F2) back to the tank thru (V12) to the sprayers. (G4) shows the pressure in that circuit and across the filter. There is an internal baffle in the tank nearer the inlet end. The ~~filter~~ inlet screen on the recirc supply is also at that end. The recirc sprayers, etc. are on the other end of the tank and that water is preferentially directed to the drain by the baffle.

The drain feeds 3 valves, previously mentioned, the drain valve(V17), a valve (V16) which readmits water to the tank from the overpressure hose relief valve(V9) and a Hose supply valve(V6). (V6) controls flow to the pH meter bypass system (V7) and (V8). The pH meter gives a reading of the low pH of the S.W. heading seaward down the hose. The bypass is for change-outs. At this point a RTD senses the temperature which is necessary for correcting the pH reading. The water is admitted to a Peristaltic Pump (P2) which meters the flow down the hose. It also acts as an intrinsic valve when off so the Overpressure Hose relief valve (V9), usually set to ~35 psi, is located here in case the hose gets clogged.

A Hose pressure gauge(G2) is mounted a few ft. up on the side of the tank for convenience and to keep S.W. out of the inside of the gauge. The P.P. discharges into a Flow Meter(FM) then thru the Red Hose Valve(V10). The Black hose, spare and future use, also has a shoreside valve(V18) to close off the top end. The Red and Black hoses both extend out thru the bottom of the Pump house, down a culvert, out onto the beach where they are buried to protect them from the waves. They extend out ~275 meters

offshore to water ~15meters deep. Multiple sand anchors are used to hold them in position. At the end of each is a Seaward Manifold with 3 ball valves to accommodate future growth of the shFOCE system to several chambers. At present, only one ~~a~~ ball valve ~~(V21)~~ V21) at the seaward end of the Red Hose is used~~to admit water to the~~. Back Pressure Relief Valve(V19) ~~to~~ feed, settled then water to the (for now) single experimental chamber via the Duct Mixing sections elsewhere described. This valve (BPRV) is required to maintain upstream (back) pressure in the hose to at least 15 psi so the saturated CO2 does not evolve back out of solution.

Hose Discharge A Filter (F3) is placed [illegible] along [illegible]

PRESSURES IN THE SYSTEM

The Hopkins S.W. supply is ~12 psi. The tank is 1 atm. absolute of air plus 1 atm. absolute CO2 = 2 atm abs. in the tank, ~~but shows up~~ same as 15 psig on the tank pressure gauge(G1).

Since our tank's operational pressure is ~15 psig. 2 check valves in series in the tank inlet piping preclude driving CO2 gas back into the Hopkins S.W. system.

The inlet sprayers can function up to about 7 psi in the tank because of the 12 psi supply pressure, however the inlet pump(P1) is required past that point, it adds about 20 psi so works well against the 15 psi (CO2) tank pressure. Inlet system pressure is isolated from the tank pressure.

The inlet pressure gauge(G3) between the pump and the tank inlet valve will show 12 to 35 psi.

The tank pressure(G1) will vary from 0 – 18 psi with 13-18 psi showing when operational as the water level cycles with the inlet pump maintaining the water level.

The recirc system is a 1/3 HP pump(P3) that adds about 15 psi so that gauge(G4) will show tank pressure + ~15psi so will show 0 -30 psi depending on what is running and tank status. Operationally should show ~~23-28~~ psi when recirc running and tank has CO2 in it.

25-30

Tank pressure will vary from 0 – 15 psi depending on CO2 supply.

The Hose pressure(G2) downstream of the Peristaltic Pump(P2) is the most complicated and varies the most. The Back Pressure Relief Valve (BPRV)at the seaward end of the hose is set to ~33 psi. It is vented internally(backside of spring) to the ambient water pressure so it's functionality is not altered by the depth of the water. What does determine the setting is the head pressure provided by the elevation of the Pump house above Sea Level ~7 m., approx. 11 psi. The pressure in the tank is 15psi and add 2 psi for the gravity effect (head)of the water level above the Peristaltic pump which means there is ~17psi on the inlet side of the P.P. We wish to keep at least 15 psi in the hose at all times whether it is being pumped or not. Recall the P.P. prevents flow when it is off. If the P.P. were not there, but the tank is connected to the hose, the pressure in the hose at sea level and at the end of the hose is 11+17=28psi.

This is a minimum setting for the BPRV, so we set it a little higher to ~33psi. The Hose pressure gauge (G2) should show 17- 22 psi (33-11=22) with the pump off assuming the BPRV has affected a good seal and if the pump or the tank was last used. This maintains greater than 15 psi in all parts of the hose.

Recall the Hose Pressure gauge is downstream of the P.P. so is isolated from the tank pressure when the P.P. is off but is affected by the elevation above Sea Level so the S.W. in the hose is pulling a partial vacuum at the gauge location. Sand in the hose has compromised the BPRV's sealing ability. When the P.P. is running, the hose pressure is related to the volume of water pumped, typically 0.5 to 1 L/min, and the flow characteristics of the BPRV, again sand has been a problem. A filter has been added to the hose just in front of the BPRV to deal with this fouling issue to the seals in the BPRV.

Another way of looking at this is it takes 33 psi at the seaward end to open the BPRV, 33 minus the 11 psi head pressure leaves 22 psi still required. The tank's 17 psi still leaves 5 psi required to crack the BPRV, so the P.P. needs to add 5 psi to open the valve, 17 +5=22psi. 22+11=33 psi. cracking pressure. If the desired flow rate requires an additional 5 psi (5+5=10psi)added by the P.P. then the Hose pressure gauge would show about 27 psi. (22+5=27). The 10 psi from the pump is added to 17 psi from the tank (10+17=27). When pumping, it is desirable to stay below 30 psi to reduce wear and tear and reduce leaks.